

**PRODUCTIVITY ANALYSIS OF PRIVATE AND SOCIALIZED  
AGRICULTURE IN ETHIOPIA**

by  
Mesfin Mirootchie

Dissertation submitted to the Faculty of the  
Virginia Polytechnic Institute and State University  
in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy  
in  
Agricultural Economics

APPROVED:

~~\_\_\_\_\_~~  
Daniel B. Taylor, Co-Chair

~~\_\_\_\_\_~~  
Brady J. Deaton, Co-Chair

~~\_\_\_\_\_~~  
George W. Norton

~~\_\_\_\_\_~~  
Tom G. Johnson

~~\_\_\_\_\_~~  
Barbara J. Craig

~~\_\_\_\_\_~~  
William A. Leuschner

February 1989  
Blacksburg, Virginia

**PRODUCTIVITY ANALYSIS OF PRIVATE AND SOCIALIZED  
AGRICULTURE IN ETHIOPIA**

by

Mesfin Mirotschie

Daniel B. Taylor, Co-Chair

Brady J. Deaton, Co-Chair

Agricultural Economics

(ABSTRACT)

The system of cereal grain production in Ethiopia has been stratified into private, cooperative and state farms since the 1975 land reform. The private farms are being gradually replaced by the cooperative farms while the state farms are receiving increased technical and budgetary assistance by the Ethiopian government. It is, however, not clear if these policies are consistent with the technical characteristics of these three modes of production. This study, therefore, evaluated technical efficiency, impacts of known and latent input factors, and returns to scale parameters for each farm type.

Sample data were collected from Ethiopia on five cereal crops, namely, barley, corn, sorghum, *teff*, and wheat and several input factors, including labor, land, oxen, traditional farm implements, tractors, machinery services, modern yield-increasing inputs, livestock, education and rainfall over 77 *awrajjas* for the 1980-1986 production period. A covariance regression model was applied with these data to determine an appropriate functional form between the Cobb-Douglas and translog production functions. The Translog functional form was selected for the analysis on the basis of statistical tests.

Results of the analysis suggest that the producer cooperatives collectively appear to have a potential to generate increased gross income per hectare at a declining rate with respect to an equiproportionate increase in all inputs, except land, upon an increasing average cost of production per unit of cereal output. The private and state farms appear to be operating with a close to fixed

proportions type of production technology with a constant average cost of production per unit of cereal output per hectare. Moreover, the range of substitutability between input factors tends towards a complementary relationship as the institutional transformations and management techniques of the cereal producing farms shift from the traditional to a more advanced and centrally managed state mode of production.

Partial income elasticity parameters suggest that (a) the private sector's gross income per hectare is most responsive to traditional hand tools, fertilizer, labor, human capital at primary level of education, and rain in August and September; (b) the cooperative sector's gross income per hectare is most responsive to the use of tractors and September rain; whereas (c) gross income per hectare of the state farms is most responsive to the use of traditional labor, machinery services and rain in June and August. Thus, Ethiopia's agricultural income production per hectare is likely to be revitalized by: (a) qualitative changes in the traditional inputs, water management, and introduction of modern technical inputs such as fertilizer and farmer education in the private sector; (b) increased traditional labor employment, improved management of water, machinery and modern yield-increasing inputs on the state farms; and (c) a better usage of tractors and collaborative input factors, improved water management, and a substantial increase in capital investment to achieve full employment of the seemingly redundant labor and oxen input factors on the cooperative farms. It seems unlikely that the producer cooperatives will achieve the goal of maximum cereal output per hectare with the most prevalent composition of the redundant traditional input factors which contribute insignificantly at the margin without a major change in the current production techniques and structural policies of the sector.

# Acknowledgements

I have received helpful advice and criticism from Brady Deaton, Dan Taylor, George Norton, Tom Johnson, Barbara Craig, and Bill Leuschner, members of my Dissertation Committee. Each one brought unique expertise and commitment to this effort that was indispensable to the completion of this study. I am particularly indebted to Dan Taylor and Brady Deaton who have been my co-advisors. This dissertation includes numerous modifications made as a result of their, especially Dan's, suggestions on reading the original drafts.

I wish to acknowledge and thank many other individuals and institutions in the United States, Canada and Ethiopia for their contributions to this study.

*United States* : Research for this dissertation was performed under a fellowship from the African Development Foundation (ADF) and separate grants from Winrock International (WI), SIM International (SIM), and the Graduate Research Development Program of Virginia Tech's Graduate Student Assembly. I would like to thank \_\_\_\_\_ of ADF,

and \_\_\_\_\_ of WI and Mr. Don Stelwell of SIM for their foresight and leadership in coordinating approval and transfer of the research funds to be used for this study. Dr. George Norton, member of my Committee, was instrumental in making the initial contact with WI. I thank him for the important role he played.

I would like to thank Dr. Bernard E. LaBerge who had an "open door" policy for me. His advice both on immigration and academic matters was essential to my stay in Blacksburg. Especially, it was a privilege to work with him when I was elected president of the International Club during the 1985/86 Academic Year.

I would like to thank \_\_\_\_\_ and \_\_\_\_\_ for their friendship and moral support, specially during the final stages of this study. They established a "foraging" social program and provided excellent leadership to its success in achieving its objectives. Also, especial thanks go to \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_, and \_\_\_\_\_ for their valuable friendship and moral support.

I thank fellow graduate students, Data Lab staff, and many other staff and faculty of the Agricultural Economics Department of Virginia Tech for making my stay in Blacksburg a rewarding experience.

*Canada* : The first time I really left home was in September 1977 to attend Trinity Western University (by then a two-year liberal arts college) in British Columbia, Canada. \_\_\_\_\_, my Canadian friend whom I met during the period I was involved with relief and rehabilitation program for the 1975-77 famine victims of Ethiopia, was the one who introduced me to that University. I would like to thank him for his advice and unselfish friendship.

During the two years I spent at Trinity Western University, I established some long lasting relationships with a few good friends whose contributions I would like to acknowledge. My hearty thanks are due to \_\_\_\_\_ and to their entire family for giving me the benefit of their moral and financial support, prayer, love and care in almost all aspects of my academic and cultural journey throughout the last ten years. They have been an inspiration both to me to and my family. It was through \_\_\_\_\_ that I came to know them and others in the family. I would like to acknowledge an immense debt of friendship and brotherhood to him. Then, the memories

of "Gramma" Wall and her unselfish care that was passed along to me compel me to deeply appreciate her contributions to my maturity.

Also special thanks go to \_\_\_\_\_ and members of their family who shared their time and resources, and above all, their valuable friendship.

*Ethiopia* : \_\_\_\_\_ deserves special thanks for making important initial contacts with ministers and general managers of various Ethiopian government institutions from which research data were collected. I am aware that \_\_\_\_\_ was instrumental in obtaining initial consent of the Ethiopian government for me to go there for data collection. I would like to give him special thanks for the role he played. \_\_\_\_\_ his family provided useful counsel, encouragement and valuable friendship, particularly at times when nothing seemed to go right, for which I am deeply grateful.

Special thanks go to the staff of Ministry of Agriculture, Ministry of State Farms Development, Ministry of Education, Central Statistics Office, and Meteorological Services of Ethiopia for their invaluable cooperation during the data collection phase (October 1987 - December 1987) of the study.

I am grateful for the assistance rendered by Azeb and her staff of the library of the International Livestock Center for Africa (ILCA). They simplified cumbersome task of transporting research information by converting it to microfiche from paper.

It is with a sense of deep gratitude that I acknowledge the love and support of my father-in-law, \_\_\_\_\_. I also thank him for accepting me as his son. \_\_\_\_\_ devoted a good portion of his time from his studies to work with me as a Research Assistant during my stay in Ethiopia. I gratefully acknowledge his patience, thoughtfulness, and meticulous assistance in the nitty-gritty aspects of the data collection. \_\_\_\_\_ also devoted many hours of her valuable

time to gather information on enrollment in rural schools from the Ministry of Education for which I am deeply grateful.

I had a privilege of using office, lodging and medical facilities at the head quarters of SIM Addis Abeba. I would like to thank the entire staff at the head quarters for making my stay in Addis Ababa a rewarding experience.

Most importantly, I would like to thank my wife, \_\_\_\_\_, and acknowledge her enormous contributions to this study. Through the past five years, her love, patience and understanding have served as a priceless source of support. Furthermore, she assisted in typing, library research, proof reading, and cataloging research information in proper order. Thanks again for putting up with me and with my unusual hours of work!

My greatest indebtedness is to my parents, \_\_\_\_\_, for their love and support during the years of my studies. They have given me the gift of education, have shared from their meager farm income, have taught me values of hard work, and have encouraged me to pursue my dreams. *I WOULD LIKE TO DEDICATE THIS DISSERTATION TO THEM!*

# Table of Contents

<b>List of Illustrations</b> .....	<b>xiii</b>
<b>List of Tables</b> .....	<b>xiv</b>
<b>CHAPTER ONE: INTRODUCTION</b> .....	<b>1</b>
I.0 Introduction .....	1
I.1. Focus of the Study .....	4
I.2. Objectives of the Study .....	7
I.3. Production Relationships to be Examined .....	7
I.4. Justification .....	8
I.5. Summary of Procedures .....	13
I.6. Contributions of the Study .....	14
I.7. General Organization of the Study .....	15
<b>CHAPTER TWO : ECONOMIC SETTING OF ETHIOPIAN AGRICULTURE</b> .....	<b>16</b>
II.0. Introduction .....	16
II.1 The Role of Agriculture In Economic Growth .....	17
II.2. Economic Geography of Ethiopian Agriculture .....	22
II.2.1. Physiographic Characteristics of Ethiopia .....	22
II.2.2. Economic Elements of Agricultural Practices .....	25

II.2.3. Traditional Land Management Practices .....	34
II.2.4. Resource Extraction, Scarcity and Migration .....	35
II.2.5. Recurrent Record of Drought and Famine .....	43
II.3. Agriculture and Land Tenure Before 1975 .....	47
II.3.1. Kinship Tenure System .....	48
II.3.2. Village Tenure System .....	50
II.3.3. Private Tenure System .....	51
II.3.4. Church Tenure System .....	52
II.3.5. Government Tenure system .....	53
II.3.6. Strategies for Agricultural Development in Pre-1974 Ethiopia .....	54
II.3.6.1. Commercial Farms Strategy .....	56
II.3.6.2. Package Projects Strategy .....	59
II.4. Agriculture and Land Tenure in Post-1974 Ethiopia .....	62
II.4.1. Rural Institution Development .....	64
II.4.1.1. Farmer Associations .....	65
II.4.1.2. Service Cooperatives .....	69
II.4.1.3. Producer Cooperatives .....	70
II.4.1.4. State Farms .....	71
II.4.2. A Cursory Assessment of Post-1974 Agricultural Development .....	73
II.4.2.1. Farm Input Allocation .....	74
II.4.2.2. Income Production .....	84
II.4.2.3. Income Distribution, Taxes and Prices .....	92
II.5. Summary .....	101
<b>CHAPTER THREE : ANALYTICAL METHOD .....</b>	<b>103</b>
III.0. Introduction .....	103
III.1. Variance Components Estimation Method .....	104
III.2. Production Functions .....	109
III.2.1. Cobb-Douglas Production Function .....	111

III.2.1.1. Functional Form .....	111
III.2.1.2. Technical Efficiency, Average and Marginal Productivities .....	112
III.2.1.3. Marginal Rate of Substitution .....	113
III.2.1.4. Elasticities .....	113
III.2.2. Transcendental Logarithmic production Function .....	115
III.2.2.1. Functional Form .....	115
III.2.2.2. Technical Efficiency, Average and Marginal Productivities .....	117
III.2.2.3. Marginal Rate of Substitution .....	119
III.2.2.4. Elasticities .....	119
III.2.2.5. Limitations in Empirical Application .....	122
III.3. Functional Form Selection Criterion .....	125
III.4. A Procedure for Hypothesis Testing .....	131
III.5 Summary .....	131
<b>CHAPTER FOUR : REGIONS, VARIABLES AND SOURCES OF DATA .....</b>	<b>133</b>
IV.0. Introduction .....	133
IV.1. Characteristics of Agro-ecological Regions .....	133
IV.2. Production Variables .....	137
IV.2.1. Aggregate Cereal Output .....	137
IV.2.2. Farm Labor .....	139
IV.2.3. Work Oxen .....	146
IV.2.4. Traditional Farm Implements .....	150
IV.2.5. Education .....	151
IV.2.6. Modern Yield-Increasing Inputs .....	153
IV.2.7. Mechanical Power .....	154
IV.2.8. Livestock .....	156
IV.2.9. Rainfall .....	159
IV.2.10. Land Planted to Cereal Crops .....	162
IV.2.11. Normalization of the Variables .....	162

IV.3. Descriptive Summary of Data .....	164
IV.3.1. Output-to-Land Ratio .....	166
IV.3.2. Labor-to-Land Ratio .....	167
IV.3.3. Oxen-to-Land Ratio .....	167
IV.4. Sources of Data .....	169
IV.5. Summary .....	171
<b>CHAPTER FIVE : ECONOMETRIC PROBLEMS OF ESTIMATED MODELS .....</b>	<b>173</b>
V.0. Introduction .....	173
V.1. Towards Specification of Empirical Models .....	174
V.2. Statistically Estimable Models .....	182
V.2.1. Functional Form Selected .....	186
V.2.2. Translog Regression Specification Error Test .....	189
V.2.3. Efficiency of the Translog Coefficients .....	190
V.2. Summary .....	191
<b>CHAPTER SIX : INTERPRETATION OF RESULTS .....</b>	<b>192</b>
VI.0. Introduction .....	192
VI.1. Overview of the Results .....	193
VI.1.1. Goodness-of-Fit .....	197
VI.1.2. Technical Efficiency .....	198
VI.2. Impacts of Input Resources .....	201
VI.2.1. Impact of the Traditional Labor .....	202
VI.2.2. Impact of Draft Oxen .....	207
VI.2.3. Impacts of Modern Yield-Increasing Inputs .....	208
VI.2.4. Impacts of Traditional Farm Implements .....	209
VI.2.5. Impact of Education .....	211
VI.2.6. Impact of Mechanical Technology .....	212
VI.2.7. Impact of Livestock .....	214
VI.2.8. Impact of Monthly Rainfall .....	215

VI.3. Hypothesis Testing .....	219
VI.4. Elasticity of Substitution .....	221
VI.5. Policy Implications .....	227
<b>CHAPTER SEVEN : SUMMARY AND CONCLUSIONS .....</b>	<b>237</b>
VII.1 Summary .....	237
VII.2 Conclusions and Policy Implications .....	245
VII.3. Limitations and Suggestions for Future Research .....	247
<b>REFERENCES .....</b>	<b>250</b>
<b>VITA .....</b>	<b>258</b>

## List of Illustrations

Figure II.1. Map of Ethiopia Showing National Boundaries and 14 Provinces .....	23
Figure II.2. Map of Agricultural Systems in Ethiopia .....	26
Figure II.3. Spatial Distribution of Commercial Farms in Ethiopia .....	57

## List of Tables

Table II.1. Distribution of Land and Population Resources Among 14 Provinces of Ethiopia, 1984 .....	24
Table II.2. A Sample of Major Ethiopian Agricultural Crops .....	29
Table II.3. Contributions of Major Ethiopian Agricultural Crops (Percent of Tonnage) ...	30
Table II.4. Selected Economic Indicators for Ethiopia and Neighboring Countries .....	31
Table II.5. Historical Time-Table of Drought and Famine In Ethiopia .....	44
Table II.6. Allocation of Cultivated Land Area and Farm Labor Employment Among Three Farm Types in Ethiopia (1982/83) .....	76
Table II.7. Average Land Holding by Region in Ethiopia (Hectares Per Holding, 1983/84) .	79
Table II.8. Input Credits Transferred by MOA to Traditional Farm Sector (X000 Birr) ...	81
Table II.9. Land and Improved Seed Allocation in Ethiopia (Percent of Total by Farm Type)	82
Table II.10. Indicators of Rural Income Change Since Land Reform in Ethiopia .....	85
Table II.11. Cereal Production and Area Cropping Pattern in Ethiopia (Percent) .....	87
Table II.12. Changes in Cereal Area, Output and Productivity of Land in Ethiopia (all farms)	88
Table II.13. Changes in Cereal Area, Output and Productivity of Land in Ethiopia (by farm type) .....	89
Table II.14. Agricultural Tax Structure of Socialist Ethiopia .....	95
Table II.15. Cost Competitiveness of Private and State Farms in Ethiopia (1983/84) .....	98
Table IV.1. Descriptive Summary of Data for Private, Producer Cooperatives and State Farms (Per Awrajja) .....	165
Table IV.2. Summary of Variables, Units and Hypothesized Signs. ....	172
Table VI.1. Translog Function Estimates for Cereal Production on Private Farms with Output Measured in Birr Per Hectare .....	194

Table VI.2. Translog Function Estimates for Cereal Production on Producer Cooperatives with Output Measured in Birr Per Hectare .....	195
Table VI.3. Translog Function Estimates for Cereal Production on State Farms with Output Measured in Birr Per Hectare .....	196
Table VI.4. Translog production Elasticities and Related Statistics for Cereal Production on Private Farms .....	203
Table VI.5. Translog production Elasticities and Related Statistics for Cereal Production on Producer Cooperatives .....	204
Table VI.6. Translog production Elasticities and Related Statistics for Cereal Production on State Farms .....	205
Table V.7. Substitutability of inputs in Translog Production Function for Cereal Production	222
Table VI.8. Marginal Revenue Product at 10 Percent Above and Below the Mean .....	230

# CHAPTER ONE

## INTRODUCTION

### *1.0 Introduction*

In 1986, the World Bank noted that the growth in Ethiopian agricultural production was about 1.2 percent per year from 1973-84 compared to a 2.1 percent growth rate per year from 1965-73. So the growth rate in Ethiopian agriculture has declined by about a half since the 1974 revolution. The decline in agricultural growth rate has been exacerbated by an increase in the population growth rate. Population growth rate went up to 2.8 percent per year during the 1973-84 period compared to 2.6 percent per year during the 1965-73 period. The combination of rapid population growth, the relatively slow growth rate of food production, and drought have contributed significantly to the severe famine crises Ethiopia has experienced in the recent past. The 1984/85<sup>1</sup> drought had a major negative impact on the agricultural growth rate. The World Bank (1987) noted that during the 1984/85 drought crisis, Ethiopian agricultural value added (that is, the difference between gross revenue of the agricultural output and the value of all input factors purchased outside the sector) declined by about 26 percent. The decline in the value added was, among other factors, due to a decline in cereal production. Compared to relatively "good" cereal production of 7.3 million tons in 1982/83, the 26 percent decline in the agricultural value added was a consequence of a consistent decline in cereal output to 6.2 million tons and 5 million tons in 1983/84 and 1984/85, respectively.

---

<sup>1</sup> Note that this is a common notation for a single year of the Julian Calendar from *Meskerem* (or September) to *Pagumie* (13<sup>th</sup> month of 5 or 6 days right after *Nehasie* (or August) ) in Ethiopia which overlaps with the Gregorian Calendar year of January to December.

Despite the decline in value added, agriculture contributed about 48 percent to the 1986 Gross Domestic Product (GDP) of Ethiopia compared to 58 percent in 1965. The substantial share of agriculture, as a percent of the GDP, shows that Ethiopia's economic growth, especially in its early stages of economic development, will be determined by the performance of the agricultural sector. If food production does not increase at a faster rate than population growth, both short and long-term consequences are fairly predictable: (unregulated) food prices will rise, the rate of industrial capital accumulation will be choked off by a soaring "free market" wage bill, food imports will increase, balance of payments will deteriorate, and in the worst scenario, famines may become inevitable.

Increasing farm output and factor productivity to meet food security needs and to enhance agriculture's contributions to overall economic development presents challenges to Ethiopia's agricultural policy. A systematic inquiry into the agricultural sector would make it possible to devise strategies to meet these challenges. An examination of the sector is important in light of, first, the risk of arable land degradation resulting from erosion, deforestation and intensive crop and livestock production activities. Second, due to drought and a series of famines, the government of Ethiopia is introducing changes in cultivation practices (such as terracing and conservation tillage) that may change farm output and productivity of rural land and labor. Third, a rapid reorganization of the agricultural sector that has been occurring since the 1975 agrarian reform has: (a) stratified Ethiopia's food production system into private farms, producer cooperatives, and state farms; (b) abolished the rural land market; and (c) restricted mobility of rural labor outside of agriculture.

Stratification of the food production system raises the policy question of a "rational" allocation of scarce resources among various types of farms. Not only rational allocation of resources, but also sustained use of the scarce resources is important for: (a) Ethiopia's long-term economic security and (b) revitalizing agriculture's potential to become a leading sector with surplus to support national economic development.

Ethiopia's food supply comes primarily from small farms operated by private households. For the most part, the households employ their own labor and cultivable land combined with oxen drawn implements and hand tools. The cultivable land resource upon which food production is so dependent is regarded as a form of capital by farm households. Attributes such as location, size, productivity (or fertility) of the cultivable land are important concerns of the farmers. Productivity of the cultivable land resource has, however, been severely affected by erosion and population pressure on a fixed supply of land. About 60 percent of the available crop-land is subject to severe soil erosion due to topographic factors and traditional cultivation practices. The most productive land, which is being intensively cultivated, is losing a total of 500 million tons of soil a year (Relief and Rehabilitation Commission, 1985). The decline in productivity leads to crop yield uncertainty and leaves a smaller margin each year either for human error in production decisions or further environmental deterioration. Crop yield uncertainty makes agriculture a risky business for many farm households who rely heavily on a limited source of farm income for sustenance. ✓

As indicated previously, mobility of rural labor in search of employment within and outside of traditional agriculture was stabilized (or restricted) following the 1975 land reform. There are three major reasons for this: first, many farm households who were landless prior to the reform now possess some land-use rights for their own production; second, the reform has made it illegal for the households to use hired labor; and third, farmers are not allowed to transfer land through sale, mortgage or lease (Ghose, 1985). The legal restrictions on rural labor and land markets are not without options: some members of farm households can seek employment on the state farms, join producer cooperatives, and/or work on their own farms. Prior to the restrictions, households had flexibility to strive for efficient management of their labor by responding to economic incentives: they rented services of their land and labor, or purchased extra farm land and labor services when needed, or they migrated seasonally or even permanently to non-farm sectors. In this way, households could try to minimize the opportunity cost of any surplus labor on the family farms. If there exists surplus labor due to the stabilization policy, then marginal productivity of rural labor can be very low, even close to zero. Thus, in the long run, an interaction between the fixed supply

of land and increasing supply of labor may develop a pattern which will be hard to alter: land and labor productivities decline, alternative sources of food supply for the farm households will become increasingly limited since labor can not freely migrate out of agriculture, food productivity per unit of labor further declines with the surplus labor "stored" mainly in the traditional sector, and a vicious circle may be set in motion.

It is, thus, imperative to increase farm output and factor productivity of Ethiopian agriculture. This requires examining the technical structure of the existing farm organizations that influence food supply and the productivity of resources currently employed in food production. This chapter, therefore, begins this productivity analysis of the private farms, producer cooperatives and state farms by: identifying the major focus of the study in Section (I.1); presenting the objectives of the study in Section (I.2); identifying technical relationships to be examined in Section (I.3); justifying the scope of the objectives and technical relationships in Section (I.4); and summarizing procedures and potential policy contributions of the study in Sections (I.5) and (I.6), respectively. The chapter concludes with a general outline of this dissertation in Section (I.7).

## ***1.1. Focus of the Study***

AS pointed out in the previous discussion, the Ethiopian agricultural sector has been undergoing rapid institutional and organizational changes since the 1974 revolution. Following the 1975 land reform, producer cooperatives and large state farms were established. These two farm types currently coexist with the traditional privately operated small-holder private farms. The producer cooperatives are farm organizations of private households that operate on the basis of a collective use of means of production such as land and labor. The state farms consist of both new state farms and private commercial farms that existed prior to the 1975 land reform. The private commercial farms were nationalized and brought under state ownership during the land reform. Furthermore,

larger private estates (mostly non-commercial farm estates) were nationalized and were rapidly redistributed among the traditional farmers (Rahmato, 1985). The land reform thus gave the legal right to previously landless private households and others to obtain land-use rights to up to ten hectares per private household.

The view expressed in the new agricultural policy is that producer cooperatives and state farms are a better alternative to the small-holder private farms for organizing agricultural production based on socialist principles. Both the producer cooperatives and the state farms represent a transition to a socialist mode of agricultural production. Accordingly, the small-holder private farms are expected to be gradually replaced by the producer cooperatives. The state farms are intended to be a major means of agricultural production and to set examples of rationally organized large modern farms for the small-holder private farms and the producer cooperatives (Abegaz, 1982). The overall goal of the farm sector transformation is to: increase food production to meet domestic food security needs; expand agricultural exports to finance imports of modern technical inputs; and enhance the ability of agriculture to contribute to capital formation and industrial goods consumption.

The transformation of the private farms and producer cooperatives is pushing ahead rapidly without an in-depth understanding of the technical input-output relationships of the two farm types, which makes the evaluation of the farm types quite important. In the short run, rapid mobilization and reorganization of institutional and economic resources may not produce the expected growth in food production. Massive reorganization of resources rapidly invested over numerous agricultural development programs and projects may, in fact, reduce sectoral growth and even create short-term shortages until a gestation period has passed. On the other hand, the changes may never produce the expected benefits. The transformed farms are technically different from private farms and may be subject to increasing, constant, or decreasing returns to inputs. Understanding the economic consequences of the current agricultural policy, that is, replacing private farms with producer cooperatives while concurrently investing in the state farms, will provide a basis for establishing priorities for resource allocation among the three farm types.

Agricultural resources are scarce and the food production problem is too vast to allow decision makers to continue to be unaware of the consequences of the transformation policy.

What is needed, therefore, is an in-depth examination of technical characteristics of the three farm types and an evaluation of variations in Ethiopian cereal grain production due to factors related to differences in regions and historical events. It is important to ascertain the extent to which national food production can be increased given the limited resources of Ethiopia. Output responsiveness of each farm organization in food production with respect to land, labor, and capital, and productivity of the inputs employed by each farm type will be examined. Most importantly, the study will generate quantitative estimates for evaluating the technical efficiency of each farm type and for a "rational" allocation of the scarce resources among the three farm types. Also, the information generated from this study will help Ethiopian policy-makers to formulate strategies to deal with any existing regional inequalities and technical inefficiencies in food production.

Research attention needs to focus on cereal production. Cereals have long been the dominant food crops. The key cereal crops include *teff*,<sup>2</sup> maize, barley, sorghum, and wheat. These crops represented about 86 percent of Ethiopia's total food production in the last seven-year (1979/80-1985/86) period (World Bank, 1987). An in-depth understanding of the cereal grains production function with respect to input factors will play an important role in guiding allocation of resources among different modes of production.<sup>3</sup> The technical efficiency/inefficiency may not be identical among different modes of cereal production. Thus, it will be useful to identify any agro-ecological regions in which the modes of production are relatively more technically efficient than in other agro-ecological regions. The mode of production that is capable of producing cereal

---

<sup>2</sup> Luther (1958) defines *teff* as "a very fine grain cereal of the lovegrass variety" (p. 75).

<sup>3</sup> The term mode of production is used here in the Marxian sense to mean different systems of farm organization. In the case of Ethiopia, the system of farm organization includes resettlement farms in addition to the private farms, producer cooperatives and state farms. Resettlement farms have just been established by the government of Ethiopia. The farms are run mainly by previous landless persons relocated from indigenous communities and by urban unemployed labor. The resettlement farms will not be considered in this research.

output in a technically more efficient way than others, can be targeted to stimulate growth within and outside the agricultural sector. In particular, the analysis of the cereal production relationships will be helpful in examining technical efficiency of the farm types, in determining the returns to the input factors, marginal productivities of the input factors, marginal rates of substitution, and the degree of substitutability between the input factors. Such analysis depends on the availability of accurate production data and the extent to which inputs and output are specified completely.

## *1.2. Objectives of the Study*

Specific objectives of the study are two-fold: (1) to evaluate technical efficiency and impact of regional and temporal latent factors on cereal crop production and (2) to examine marginal productivity, output elasticities with respect to input factors, and the substitutability of the inputs in each farm type.

## *1.3. Production Relationships to be Examined*

A study in agricultural productivity involves, among other things, examining relationships between inputs and output. The examination of the production relationships within the three modes of production underlies the theoretical and empirical methods of this research. Thus, it is hypothesized that the results of this research will indicate returns to scale that are: (1) increasing (that is, crop output increases proportionately more than a proportionate increase in input factors) in the private farms and producer cooperatives, and (2) decreasing (that is, crop output increases proportionately less than a proportionate increase in input factors) in the state farms. The ✓

elasticities of output with respect to farm inputs are expected to vary with the level of factor intensities employed within each system of production. The elasticities of output with respect to input factors will indicate technological properties of the production processes of the three modes of production.

### ***1.4. Justification***

Throughout its history, Ethiopian agriculture has experienced, and still does, disparities in food production from region to region and from year to year. If the same level of farm inputs are used in two different regions, for example, there might be differences in food production. Differences in the technological, ecological and historical factors of the agricultural regions can influence any difference in grain production. Production of the cereal grains in Ethiopia depends heavily on natural factors which are beyond the control of the producers. Inter-temporal supply of food is therefore sensitive to fluctuations in the natural factors. Such fluctuations can lead to severe instability in the supply of food which will adversely affect the overall economic growth. Even if the fluctuations in the natural factors are removed, farmers probably do not always produce maximum output from a given combination of inputs. Failure to produce at an attainable maximum level of output from a given combination of inputs constitutes technical inefficiency. Apart from regional and temporal factors, technical inefficiency can result from a number of factors such as farm managers' inability to use the right amount of inputs (that is, over-vestment or under-investment in such inputs as labor time, fertilizer, oxen's time, etc.), failure to undertake field operations (sowing, weeding and harvesting) in a timely fashion, obsolescence of production techniques, breakage of farm implements, delays in the delivery of inputs by resource distributing (foreign or domestic) agencies, and finally, due to institutional and economic limitations on obtaining obtain additional input factors.

As indicated previously, Ethiopian agriculture is undergoing a substantial transformation due to changes in the institutional and structural nature of the overall economy. Sizable quantities of chemical and mechanical inputs are being imported annually. For instance, FAO records show that about \$34.8 million worth of fertilizer and pesticides and a total of \$43.3 million worth of agricultural machinery (mostly tractors) were imported during the 1965-1974 period. Imports of these modern inputs reached substantial levels over the following period (1975-1983), when a total of \$204.2 million worth of fertilizer and pesticides and \$99 million worth of machinery were imported. Put differently, relative to the period before the revolution, combined expenses on fertilizer and pesticides during 1975-83 increased by about 500 percent, whereas expenses on imported machinery increased by about 130 percent. The increase in the import of modern technical inputs seems to suggest that the agricultural sector, as a whole, has experienced increased access to modern technical inputs, and greater institutional and budgetary attention from the Ethiopian government since 1975 than prior to this date. This may not, however, mean an "equitable" and/or a technically justified distribution of the resources among the three modes of cereal production.

Rahmato notes that most of the new technologies have been (and still are being) allocated to the state farm sector. Because the state farms are heavily mechanized, they provide relatively few possibilities for permanent employment of traditional (unskilled) labor. It will be instructive to examine such policy choices in terms of the sector's responsiveness to factor substitutions. Griffin and Hay (1985) evaluated relative performance of the private farms, producer cooperatives and state farms.<sup>4</sup> They used five criteria: (1) relative capacity to absorb labor, (2) rate of return on capital, (3) crop productivity (yield), (4) potential for capital accumulation, and (5) capacity to produce marketable surplus food. Their results indicated that the relative performance of the private farms is the best in three of the criteria: labor absorption capacity, generating returns to investment capital, and crop yields, but least effective in producing marketable surplus food. Producer

---

<sup>4</sup> The authors do not show how and what evaluation techniques were applied to make these comparisons, and it is not clear at what level of confidence the results are significant.

cooperatives showed the best potential for capital accumulation. They ranked second to the state farms in producing marketable surplus food and third in crop productivity. Also, the producer cooperatives were second to the private farms both in labor absorption and rate of return on capital. The state farms performed worst in three cases: capacity to absorb labor, rate of return on capital, and potential for capital accumulation. These observations indicate that substituting machinery power for labor and traditional implements may decrease the amount of labor employed in agriculture, especially in the subsistence economy of rural Ethiopia where a high proportion of the labor force exists and low wage rates prevail. Perhaps there are other investment alternatives in agriculture that are more consistent with the resource endowments and physical conditions of the farm sector than the choice of heavy mechanization.

The introduction of new technologies (fertilizer, improved seed varieties, pesticides, and machinery) into the agricultural sector can change factor proportions of the production systems. The changes in the factor proportions may lead to an increase in farm output and factor productivity. The long-term implications of the changes in the quantity of farm inputs for changes in technical efficiency of the food producing sector should be of concern to the formulators of national economic policy. This is because the rate of change in farm output is a weighted function of the rate of change in the quality and quantity of individual farm inputs. The weights are elasticities of output with respect to each farm input. These elasticities indicate the technical input-output relationships that exist in the production process of each farm type. [Elasticity of output measures the relative increase in farm output from a proportional increase in the quantity and quality of the controllable farm inputs. If the elasticity of output is greater than, or less than, or just equal to unity, it indicates that the production process is characterized by increasing, decreasing, or constant returns to the factors of production, respectively] Each of these production relationships can be important for long-term agricultural development policies. ✓

First, if the returns to scale are increasing, the farms operate below an "optimum" size and level of output. Farm operators should increase input use and thereby output. Farms which experience

increasing returns to scale face an average cost of production which may decline for some time per unit of additional output. In the long-run, the savings on the unit cost of production realized through output increases will provide additional impetus to farm operators to produce more output with more inputs and to invest in modern inputs to further enhance agricultural output.

Second, if farms are faced with decreasing returns to scale, efforts to increase farm output and factor productivity might be constrained by declining marginal productivities (of some inputs). Decreasing returns to scale may suggest difficulties, for example, in improving labor productivity which is accumulated within the traditional agricultural sector partly due to national policy restrictions on labor mobility and partly due to traditional constraints such as lack of skills and “modern” experience.<sup>5</sup> Lack of labor mobility and the subsequent difficulties in improving the labor productivity are more likely the case with the small-holder private farms and producer cooperatives than with the state farms. If the returns to scale are declining in the private farm sector, current policies to replace the private farms with the producer cooperatives may overcome the difficulties of the declining returns to scale. On the other hand, the rapid cooperativization process and seemingly an “over-investment” in the state farms may engender the declining returns to the factors of production in both the cooperative and state farm sectors. But, this cannot be known with certainty before empirically evaluating the causal relationships between inputs and output. Other factors such as investing in farmer education, research and extension services can also influence productive quality of the agricultural labor force. Educated and better-informed farmers are more likely to achieve technical efficiency: among other things, better educated farmers should be able to produce more output with the same quantity of inputs or a given level of output with fewer quantities of farm inputs.

---

<sup>5</sup> Some (for example, Abegaz (1982), and Griffin and Hay (1985)) have observed diseconomies of scale (size) in the state farms for structurally different reasons such as high concentration of modern capital (material and financial) and management inefficiencies. The three farm types are different in size, employment potential, resource endowment, and use of modern inputs. The differences are becoming even more accentuated due to the immediate problems of population pressure on fixed cultivable land, low level of per capita income and growing domestic demand for food.

Third, if constant returns to scale prevail in the structure of the three farm types, no efficiency gain or loss may be observed from replacing small-holder private farms with larger producer cooperatives or from replacing large farms with small farms. Returns to scale in Ethiopian agriculture have not been studied in-depth. There is no *a priori* reason (except a single study by Cornia) at this point in time to expect constant returns to scale (or any specific technical relationship) to exist in the Ethiopian agriculture. Cornia (1985) attempted to estimate elasticities of scale and partial output elasticities with respect to land, labor, capital stock, and intermediate inputs such as fertilizer for a group of fifteen countries from Africa, the Middle East, Asia, and Latin America.<sup>6</sup> Results of the study indicated constant returns to scale to prevail in four of the fifteen countries including Ethiopia.<sup>7</sup> The elasticity of scale for Ethiopia is estimated to be 0.99 which is not significantly different from one at the 90 percent level of probability. Partial elasticities of output with respect to land, labor, capital stock, and intermediate inputs were found to be 0.14, 0.35, 0.20, and 0.30, respectively. Cornia based his estimates on FAO cross-sectional farm data converted into 1970 US dollars and on an aggregate country level Cobb-Douglas production function. These results can have useful implications for agricultural development policies, but they must be challenged by other studies that will examine the validity of Cornia's coefficients with different techniques such as disaggregate studies on private, cooperative and state farms. Furthermore, it is not clear if the Cobb-Douglas production function is the appropriate functional form to study the productivity of Ethiopian agriculture.

As discussed previously, small-holder private farms are relatively more labor intensive than the other two types of farms. This may create the possibility of a high labor-to-capital ratio and low marginal productivity of traditional labor. If this is the case and the labor-to-capital ratio is not reduced either by increasing capital use on the private farms or by reallocating surplus labor to other economic segments such as state farms and/or the non-agricultural sector, it may be difficult to

---

<sup>6</sup> The countries included in the study are Barbados, Mexico, Peru, Ethiopia, Nigeria, Tanzania, Uganda, Syria, Sudan, Bangladesh, Burma, India, Nepal, Korea, and Thailand.

<sup>7</sup> The other three countries are Barbados, Burma and Nepal

improve per capita net income of farm households mainly due to a high cost of production per unit of output. If elasticity of substitution of capital for labor is more than unity, capital may be substituted for labor easily. If it is lower than unity, it may be an indication that private farms do not easily respond to changes in current level of capital use. An introduction of modern technology is, however, likely to change the nature of the elasticity of substitution.

A low elasticity of substitution could be the result of many factors such as regional economic fragmentation, risk and uncertainty and lack of knowledge about the use of modern capital inputs. Regional economic fragmentation exists in Ethiopia and it is responsible for the lack of market integration (Saith, 1985). Current government programs of farmer training, technological innovations such as the introduction of improved seed varieties, irrigation schemes in regions where rain water supply is sparse, and integration of regional markets can improve the traditional sector's responsiveness to capital use.

## *1.5. Summary of Procedures*

Cross-sectional time-series data (1980-1986) for the state farms, 1985-1986 data for the producer cooperatives and 1983/4 production year data for the private farms were collected from various Ethiopian government institutions for major cereal crops (maize, *teff*, barley, sorghum, and wheat) produced by the three types of farms in 9, 67, and 77 out of 102 *awrajjas* (districts), respectively, (in Arsi, Bale, Gemu Goffa, Gojjam, Gondar, Illubabor, Harerge, Sidamo, Keffa, Shewa, Wellega, Wello administrative regions). The agricultural crop-mix of these districts consists mainly of cereals and livestock, produced at an average altitude of between 1500 meters and 3000 meters and the most common soil types are *cambisols*, *nitosols*, and *regosols*. These characteristics of the districts can be found in the 1985-1994 Ten-Year Plan of Ethiopia pages 155-7 and the 1981 National Atlas of Ethiopia page 13.

Collection of the research data at the district level provided sufficient disaggregation to capture detailed regional variations in food production. In addition, consideration of 1980-1986 period, during which time so many social, technical, and organizational changes have occurred, helps to evaluate temporal (historical) effects on the technical efficiency of the three farm types with respect to grain production. Also, consideration of a cross section of the agricultural districts highlights regional effects on grain production. The information collected includes data on cereal crop outputs, input-output prices, labor, oxen, operating costs of machinery, land, modern yield-increasing inputs, livestock, weather, and other factors. With these data, factor productivities, elasticities, and the extent of regional and temporal difference in grain production will be evaluated. The method of study involves, among other procedures, selecting and fitting an appropriate econometric (Cobb-Douglas or translog) production function for each mode of cereal production, approximating regional and temporal effects on the technical efficiency of the grain production system, estimating and comparing output responses with respect to inputs for each mode of production, and testing the hypotheses of the study.

## *1.6. Contributions of the Study*

The findings of this study will provide some important implications for Ethiopian agricultural development policy. The results can be used to enunciate broad guidelines to increase domestic food production that will help to reduce dependence on foreign sources of food. In particular, with the findings of this research, the government of Ethiopia will be able to: better understand the existing nature of technical efficiency and productivity of the grain production system. Policy implications of this research may provide useful guidance for: developing resource distribution policies which are consistent with the nature of the responsiveness of farm output to currently known input factors within each mode of cereal production; and initiating regional-level agricultural development projects consistent with the regional and temporal impacts on agricultural output.

## ***1.7. General Organization of the Study***

The remainder of this dissertation consists of six chapters. In Chapter Two, the economic setting of Ethiopian agriculture is discussed in some detail. The analytical framework for the study is developed in Chapter Three. Chapter Four describes research variables in some detail and provides sources of the data. Chapter Five summarizes empirical issues of the models estimated with production data collected from Ethiopia. In Chapter Six, results of the empirical analyses are presented. And, finally, Chapter Seven summarizes the dissertation and discusses findings and policy implications of the study.

## **CHAPTER TWO**

### ***ECONOMIC SETTING OF ETHIOPIAN AGRICULTURE***

#### ***II.0. Introduction***

The agricultural sector of Ethiopia has been experiencing rapid economic and institutional transformations over the last decade. This is due to the policies of the socialist Ethiopian government which hopes to bring about fundamental improvements in the rate of national economic growth and development. The policies of the government are partly aimed at establishing large-scale agricultural enterprises (such as state farms and producer cooperatives) and partly at strengthening the industrial sector. These policies have been adopted by the socialist leadership since the 1974 overthrow of the feudal policies that had neglected agricultural development for a long period of time. This chapter, therefore, reviews agricultural policies before and after 1974. The chapter provides basic information about Ethiopian agricultural sector and serves as a frame of reference for the analysis in later chapters. It consists of four major sections. Section (1) begins with a conceptual note on the role of agriculture in economic growth. In Section (2), the economic geography of Ethiopian agricultural sector is examined. Also, the discussion includes a brief review of the agricultural practices of economic importance, traditional land management practices and some concerns about extraction and scarcity of agricultural resources. The discussion on resource extraction is extensive because of the seriousness of the problem as evidenced by the 1983-1985 famine catastrophe. Although the problem of resource extraction is not the major focus of this dissertation, it is hoped that the discussion here will stimulate future research on the problem.

In the pre-1974 traditional agriculture, the availability of desirable cropland for a given farm household depended on many factors. These factors included physical and productive viability of

the land, the size of the household, production technology, inheritance, social status, acquisitions, and historical patterns of settlement. Physical characteristics (such as stoniness, soil acidity, slope, erosion) of the land also played, and still do, a role in limiting the availability of land to the farm households for agricultural purposes. However, a single factor that had a significant impact on land availability and the production and distribution of its produce was the land tenure system that existed before the 1975 land reform. Section (3) presents a synopsis of various tenure systems and their influences on the agricultural development strategies of the feudal system. Section (4) focuses on the new agricultural policies since 1974. The nature of the changes in the institutional and agricultural infrastructures are examined. Also, the basic features of the three types of farms (that is, small-holder private farms, producer cooperatives, and state farms) are explored briefly. Section (5) summarizes the chapter.

## *II.1 The Role of Agriculture In Economic Growth*

Successful development of agriculture is a process that occurs over time. In countries such as Ethiopia where possibilities for economic development are mainly conditioned by the preponderance of agriculture, many, for example Gunnar Myrdal, believe that "it is in the agricultural sector that the battle for long term economic development will be won or lost" (quoted from Todaro (p. 251). According to Schultz (1964), agriculture is often viewed as a "powerful engine of growth" (p. 5). A large proportion of the Ethiopian population depends on agriculture for its food and fiber. Getahun (1978) describes the role of agriculture "to the extent that little material progress can be made unless agriculture is attacked directly" (p.281). Generally, agriculture stands foremost in the economic development process in at least four major ways.<sup>8</sup> It: (1) provides

---

<sup>8</sup> Economic development is a complex concept that no single definition can adequately describe. The term as used in this research may be understood to mean an improvement in the standard of living of a society over time.

food and fiber to the growing needs of the population; (2) supplies its share of both human and material capital needed to support industrial development; (3) provides a large market base for goods and services produced by non-agricultural sector; and (4) employs a substantial proportion (about 90 percent) of the Ethiopia's 42 million people.

Development of agriculture involves economic, institutional and technical transformations. Also, it involves 'equitable' distribution of resources and cultural and political responsiveness to modern technical alternatives to overcome problems of economic underdevelopment.<sup>9</sup> The political response may require at least two elements of leadership. First, the response may require conscious and deliberate actions to identify traditional, institutional, technical and economic factors that impose limitations to agricultural growth and, second, it may require policy commitment to improve social welfare of rural communities and to develop rural resources through scientific innovations. The way in which resources are distributed among Ethiopian farmers and their command over the resources may, therefore, determine the paths of economic growth in general and agricultural development in particular.

The concept of resources (such as land, labor, capital, and leadership) is transient with time, culture, technology, and stages of economic development. According to Randall, resources are considered to have multi-attributes such as "quantity, quality, time, and space dimensions" (p. 14). Economically viable commodities such as land, forests, oil, air, etc. can be described as natural resources. So is the stock of human labor with its attributes to reproduce itself and to produce consumption commodities. Availability of the natural resources at any given point in time is usually measured in terms of stock (or inventory) and the flow of useful services from the stock such as land. A commodity to be considered a useful resource may, however, depend on the circumstances "inherited from the past, present, or foreseen technologies, economic conditions, and tastes" (Howe, p. 1). For example, the land area contained by the current Sahara desert was

---

<sup>9</sup> Poverty, illiteracy, poor health conditions, sub-standard housing, incompatible population and income growths, unemployment are some examples of the problems of economic underdevelopment.

agriculturally productive several millennia ago. Today this land is reduced to a wasteland. Natural fertility (or productivity) of the land has been exhausted and it has become an undesirable resource for agricultural purposes. Perhaps this is due to environmental changes, soil erosion, over cropping and poor land management practices of the past (Dasgupta and Heal, 1979). It is conceivable, however, that scarcity of renewable resources, such as Sahara desert land, can be mitigated and the flow of their services can be increased through changes in technology and discovery of new methods of utilization (Howe, 1979).

Small-scale traditional agriculture dominates most of Ethiopia's rural economic system. Land and labor are principal factors of production. The rural communities represent an economically complex agrarian society in which the village market facilitates the exchange of goods and services. The majority of farmers are self employed in the mix of subsistence crop and livestock production activities. The relationship between land as a form of productive capital and the farm household as a unit of economic organization articulate the structural foundation for the traditional agricultural economy of Ethiopia. As Woldemariam (1984) notes, the importance attributed to land is often indicated in proverbs such as the following: 'to be landless is to be sub-human'. In the process of using agricultural land as a basic factor of income production, farm households act as laborers, entrepreneurs, consumers, and producers. The farmers are primary agents of the agrarian economy. The supply of and demand for labor on the farm is, therefore, mainly bounded by the farm households' command over productive cropland, farm technology and other resources.

Ethiopian's traditional agricultural sector develops on the basis of the same economic laws that govern other sectors of national economy. Agriculture, however, differs fundamentally from other sectors in a number of ways. For example, agricultural production (of both crops and livestock) mainly depends on land and productive viability (fertility) of the soils. Almost without exception, agricultural production is characterized by production lags (or seasonality in decision making),<sup>10</sup>

---

<sup>10</sup> That is, the time period of harvesting of coffee, for example, does not coincide with the time period that labor and other inputs are expended in planting the crop. Sufficient time is needed for the crop to germinate, to grow, to mature, and to be ready for harvest from the time it is planted.

resource fixity (that is, lack of alternatives for resources of production), plant disease, biological cycles of output (that is, fluctuations of output from year to year), and the influence of exogenous factors such as weather. At the same time, it is important to note that the speed with which the traditional agriculture can develop may depend on the conditions of the prevailing social, institutional and political systems. These, in turn, determine ownership of the factors of agricultural production, such as land, and relations among the agents of the agrarian economy in terms of production and allocation of farm surplus output.

In view of the commonly accepted two-sector model economies of many developing nations, socialist or non-socialist, the role of agriculture is often attributed to making a net surplus contribution to the growth of the industrial sector. The method of transferring the surplus contribution may vary from system to system. Non-socialist nations, oriented towards a market system, usually rely on supply and demand to change terms of trade in favor of industrial commodities. Most socialist countries such as Ethiopia, however, resort to direct interventions in markets and output and input allocations. Abegaz (1982) notes that Ethiopia's agricultural policy environment consists of four different approaches: (1) agricultural 'disinvestment', (2) modernization of agriculture, (3) introduction of a socialist market system, and (4) surplus production. The agricultural disinvestment policies use coercion to squeeze the surplus out of agriculture which may sometimes be more than what the producers culturally set-aside for current sale and/or future investment. These policies often impose various techniques of which most common ones are: (a) compulsory deliveries in the form of grain quotas; (b) unfavorable terms of trade; and (c) regulation of income generating activities such as migrant labor employment for wage within the agricultural sector except on state farms. Investment priorities emphasize development of the industrial and social infrastructure. Agriculture would be neglected sometimes even to the extent that its underdevelopment begins to impede the growth of the industrial sector. This may cause a major policy shift toward agricultural modernization in which over time modern technical inputs will flow into sections of agriculture (for example, state farms and producer cooperatives) with a potential for a rapid increase in surplus food production. Also, output and input market

regulations will be relaxed in the interest of linking macro- and microeconomic planning through a flexible socialist market operation. That is, supply and demand tools of the economy will be let 'loose' selectively and managers of state farms may make farm input purchasing decisions without state intervention. This may result in an intensive use of inputs and introduction of improved production techniques thereby leading to a net surplus production. The net surplus production policies are designed to expand agricultural exports and enhance agriculture's capacity for capital accumulation and sustained modernization by reinvesting a portion of the surplus.

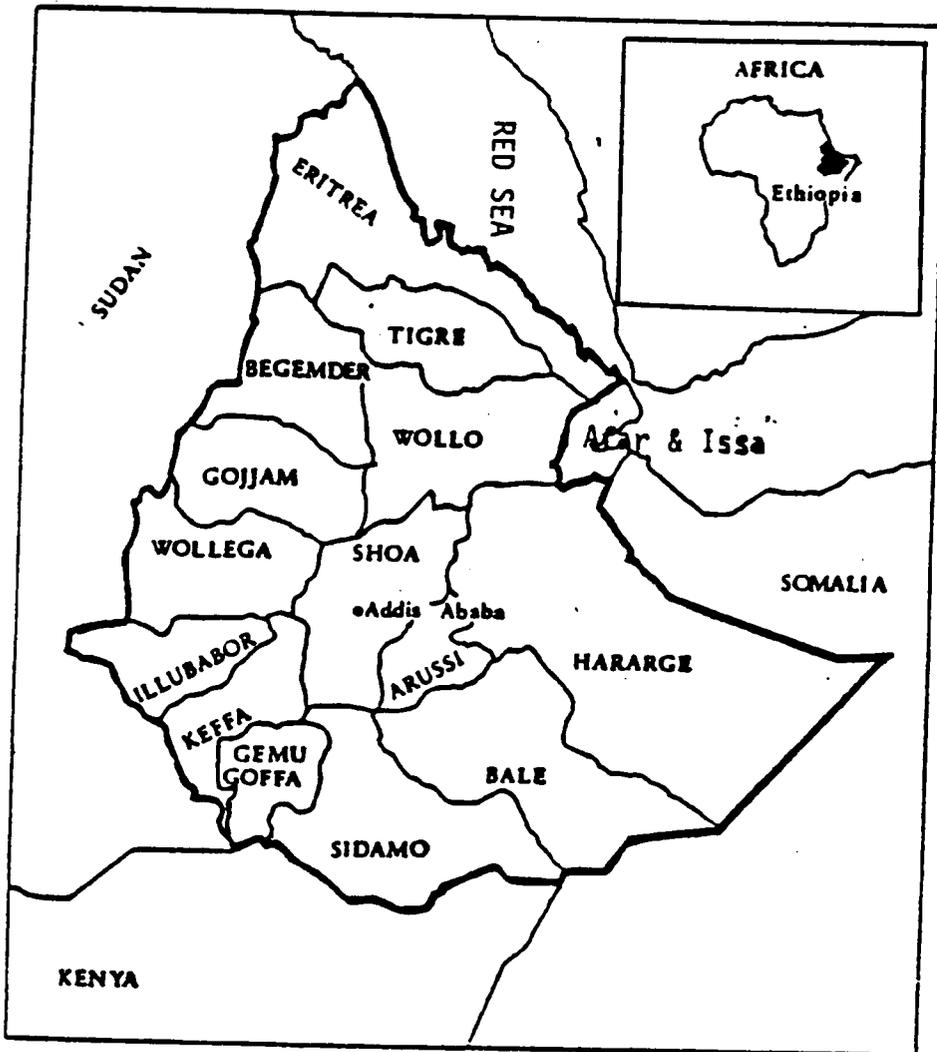
Assuming active inter-sectoral linkages between agriculture and industry, the net agricultural surplus will be the sector's unconsumed residual (surplus) that remains after accounting for non-agricultural trade flows from the industrial sector. On the other hand, if there exists none to very little flow of industrial trade, the unconsumed surplus may uniquely determine agriculture's net contribution. As Millar (1970) notes, the net surplus contribution can be increased and squeezed out of agriculture either through: (1) a planned increase in agriculture's unconsumed surplus that is marketed (or coerced); (2) an internal growth in investment and marketable surplus without the flow of the industrial trade into agriculture; or (3) restraining non-agricultural consumption of farm sector while transferring real output that will become available for industrial consumption. These policy options are not significantly different from those indicated by Abegaz. But Millar's policy arguments, based on the management of agricultural surplus, provide some explanation how agricultural disinvestment, modernization and socialist market system may operate to extract surplus production out of agriculture.

## ***II.2. Economic Geography of Ethiopian Agriculture***

### **II.2.1. Physiographic Characteristics of Ethiopia**

Ethiopia occupies an area of approximately 1,223,500 square kilometers. The country is divided into provinces, each province into *awrajjas*, (or districts) and each *awraja* into *weredas* (or sub-districts). Figure II.1 shows that there are a total of 14 provinces, namely, Arsi, Bale, Begemder, Eritrea, Gemu-Goffa, Gojjam, Harrage, Illubabor, Keffa, Shewa, Sidamo, Tigre, Wellega, and Wello. Also, there are a total of 102 *awrajjas* and 571 *weredas*. The *wereda* represents hierarchically the lowest administrative unit in rural communities. Distribution of land and population (both rural and urban) resources among the provinces is illustrated in table II.1. It is shown in the table that the overall population density (that is, persons per square kilometer) is 34.3. The number of provinces that have the population densities below and above the national average tends to be evenly distributed.

Most of the agricultural land is on the highlands with elevations between 1,000 meters to 3,600 meters above sea level. The highlands extend from the province of Eritrea in the north to the borders of Kenya and Sudan in the south and southwest, respectively. Approximately 56 percent of the total land area is comprised by the highlands. They (the highlands) are densely populated relative to other regions of the country. According to the 1984 population census, the highland regions support an average of 92 persons per square kilometers whereas the lowland regions support not more than 20 to 30 persons per square kilometers (Relief and Rehabilitation Commission (RRC), 1985). In normal years of good supply of rains, the highlands receive mean annual precipitation of 700 to 1240 millimeters (Donahue, (1972)).



**Figure II.1. Map of Ethiopia Showing National Boundaries and 14 Provinces**  
 Source : Cohen and Weintraub (1975), (front page).

**Table II.1. Distribution of Land and Population Resources Among 14 Provinces of Ethiopia, 1984**

Provinces	P o p u l a t i o n			Area (X000 Sq.Km.)	Density/Sq.Km.
	Rural	Urban	Total		
Arsi	1,529,098	133,135	1,662,233	24.6	67.6
Bale	929,284	77,207	1,006,491	128.3	7.9
Begemder	2,681,800	223,562	2,905,362	73.4	39.6
Eritrea	2,207,605	407,095	2,614,700	117.4	22.3
Gemu-Goffa	1,174,781	73,253	1,248,034	40.1	31.1
Gojjam	2,981,495	263,387	3,244,882	64.4	50.4
Harrage	3,837,105	314,601	4,151,706	254.8	16.3
Illubabor	897,156	66,171	963,327	50.8	19.0
Keffa	2,299,530	150,839	2,450,369	53.0	46.2
Shewa*	7,341,303	2,161,837	9,503,140	85.5	111.2
Sidamo	3,541,401	249,178	3,790,579	116.7	32.5
Tigrai	2,211,666	198,034	2,409,700	65.7	36.7
Wellega	2,226,301	143,376	2,369,677	69.8	34.0
Wello	3,418,038	281,180	3,699,218	79.0	46.8
<b>Total</b>	<b>37,276,563</b>	<b>4,742,855</b>	<b>42,019,418</b>	<b>1,223.5</b>	<b>34.3</b>

\*Includes Addis Ababa population which is about 2,000,000.

Source: World Bank, *Ethiopia: Agricultural Sector Survey*, Annex 3, Table 52

Altitude and temperatures vary inversely with elevation and potential for rainfall. The variation in altitude is responsible for three distinct climatic conditions and environmental regions. They are: (1) *dega* (or cool highlands) regions of elevation approximately between 2600 and 3600 meters above sea level, (2) *wayne dega* (or temperate) regions of medium elevation between 2,000 and 2,600 meters, and (3) *qolla* (or hot lowland) regions of elevation between 1,000 and 2,000 meters. Temperatures vary between 0 Celsius - 16 Celsius in *dega* regions, 16 Celsius - 27 Celsius in *wayne dega* regions and 27 Celsius - 50 Celsius in *qolla* regions (Nelson, et. al., (1980), Belete, (1978), Pankhurst, (1968)).

## II.2.2. Economic Elements of Agricultural Practices

As illustrated in Figure II.2, the common agricultural practices of Ethiopia can be categorized into two major systems:<sup>11</sup> (1) traditional agriculture; and (2) modern (or large-scale commercial or state farms) agriculture. These two classifications are based on such factors as ecological elements (for example, climate, soil type, and natural vegetation), farm practices used by agrarian households for generations in accord with the norms of the environment, and a potential for modern agricultural development (Getahun, 1980). The traditional agriculture is composed of highland mixed agriculture, valley and low plateau mixed agriculture, and pastoral agriculture. The highland mixed agriculture is characterized by diverse horticultural and agronomic crops and livestock production practices. For instance, cereals, pulses, oil crops, *enset*, and coffee are common horticultural crops, whereas livestock production usually consists of cattle, sheep, donkeys, horses and mules. The available farm land is used quite intensively to support highland population, crops, and livestock production. The highlands are confronted with internal population pressure, resource degradation, and lack of sufficient modern social infrastructure such as all-weather rural roads.

---

<sup>11</sup> See Getahun for more detailed discussion on the agricultural systems found in Ethiopia. The following three paragraphs have greatly benefited from Getahun's work.

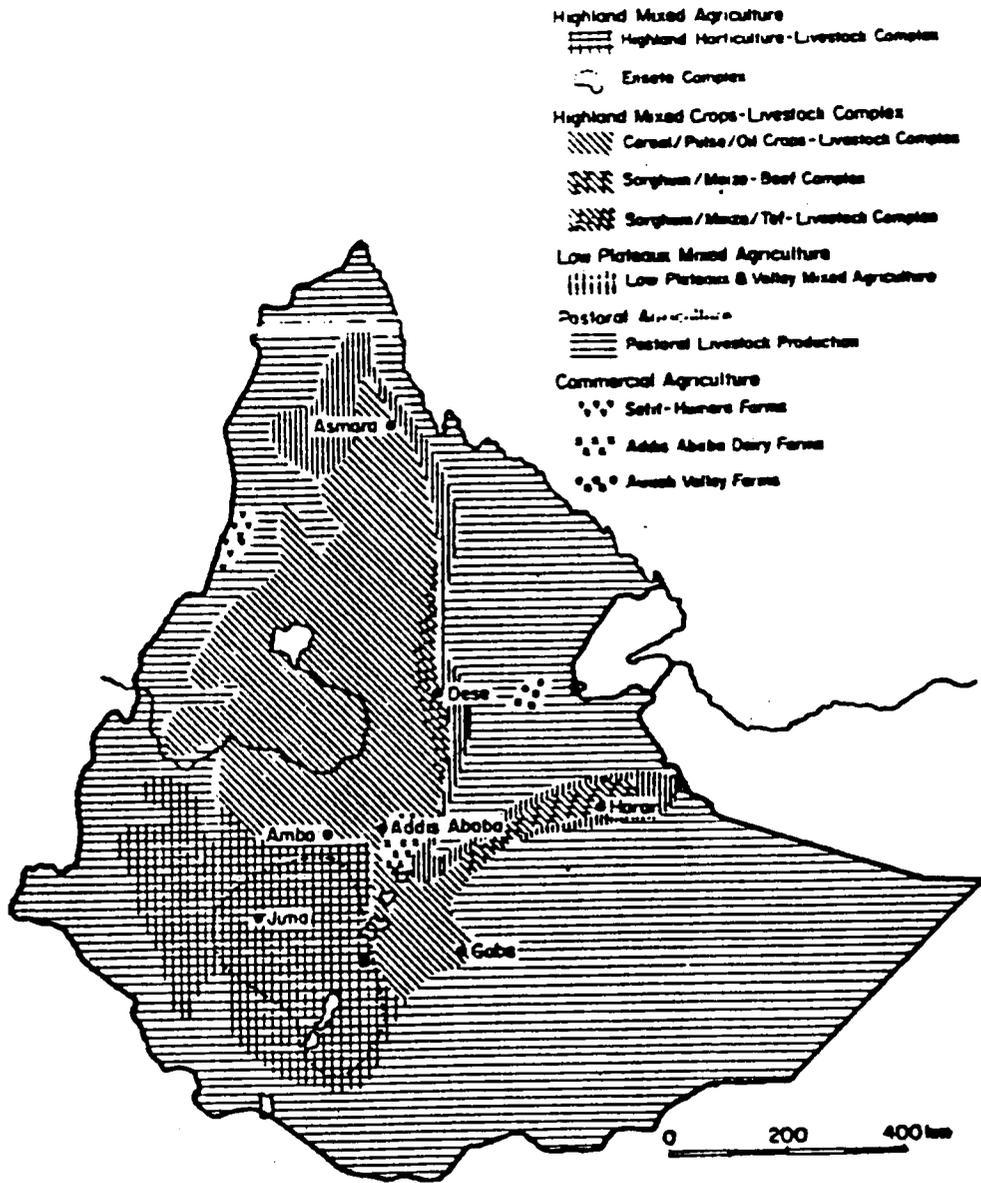


Figure II.2. Map of Agricultural Systems in Ethiopia

Source : Getahun (1980) p. 283.

The valley and low plateau agricultural complex consists of some economically viable livestock and low altitude crop varieties of sorghum, maize, wheat, *teff*,<sup>12</sup> and some oil crops. The practice of agricultural production is mostly dictated by environmental factors such as altitude that normally ranges between 1500 and 2000 meters, and annual rainfall of 450 to 800 millimeters. However, as Getahun notes, "the diversity of crops grown and the degree of integration of crops and livestock production is more pronounced" (p.285) than it is in the highland mixed agricultural system. The potential of the valley and low plateau regions for agricultural development is constrained mostly by internal limitations such as resource degradation.<sup>13</sup> The problem of resource degradation is not unique to this region. The problem is a common feature of almost all the traditional agricultural regions mainly due to overgrazing, soil erosion, deforestation, and poor land management practices.

The pastoral agriculture, as illustrated in Figure II.3, is suitably spread around the foot-hills of the central highlands of Ethiopia. Pastoralism is prevalent in arid and semi-arid lowlands where altitude and rainfall do not exceed 1500 meters and 450 millimeters, respectively. Perhaps, among other things such as range development, the most limiting factor of agricultural production is the of/supply water. Due to great variations in the availability of range and water, Getahun notes that the pastoral mode of agricultural production is usually stratified into semi-sedentary (or semi-nomadic), transhumance, and and nomadic pastoralism.<sup>14</sup>

---

<sup>12</sup> Luther (1958) defines *teff* as "a very fine grain cereal of the lovegrass variety." (p.75)

<sup>13</sup> See Section II.2.4. for more discussion on resource degradation problem and its impacts on rural income and labor allocation.

<sup>14</sup> Getahun does not explain the terms: semi-sedentary, transhumance, and nomadic pastoralism. Krader's (1968) article on "Pastoralism" that appeared in the *International Encyclopedia of the Social Sciences* was consulted from which the following illustrations were extracted. It should be, however, noted that the explanations may not totally pertain to the conditions of the Ethiopian pastoralism perceived by Getahun. First, according to Krader, nomadic agriculture survives on the efforts of pastoralists who are not confined to a specific sedentary (settled) community of villages but who move with their herds over time and space. The nomads specialize in animal production and seasonally move to locations where pasture is available. The nomads follow regular routes predetermined by traditional wisdom and experience. Second, semi-sedentary pastoralism is generally exhibited in the practice of mixed agriculture. That is, the semi-sedentary pastoralists mix animal farming with crop production. As Krader notes, these pastoralists do not specialize "in either herding or farming, but individuals and certain families ... move back and forth from one occupation to the other" (p.457). Third, transhumant pastoralism is practiced by communities that are sedentary. Transhumant farmers "traditionally send their herds of sheep, goats, and cattle to summer upland pasture" (Krader, p.457).

Rural cottage and handicraft industries are also an integral part of the traditional agricultural complex. There are approximately 210,000 farm household enterprises in which about 250,000 entrepreneurs are engaged. The enterprises are often grouped into food, textiles, leather, wood works, ceramic ware, and metal works. Specific enterprise production varies regionally throughout rural Ethiopia. For example, Sidamo and Gemu Gofa provinces tend to specialize in pottery, tannery, and weaving (Woldesemait, 1979).

A variety of crops are produced through out the country. As discussed previously, what grows where varies mainly with ecological and environmental factors. Agricultural production, however, consists of grain crops, livestock, forestry, and fisheries. The major crops of agricultural production are cereals, pulses, oilseeds, and industrial (cash) crops (table II.2). Different varieties of wheat, barley, *teff* (*Eragrostis abyssinica*), *enset* (a plant sometimes called false banana), beans, peas, sorghum, maize, millet, oats and coffee are typical of the environmental and agronomic adaptations.

The relative importance of each crop category is illustrated in table II.3. The table shows that cereals are most dominant crops. Based on a seven-year averages (1979/80 - 1985/86), for instance, cereals contributed about 86 percent to total tonnage of crop production. Pulses and other crops contributed approximately 12 percent and 2 percent, respectively. These results clearly indicate that cereal production is more prevalent than the other crops and cereals are major source of income for most of the farm households.

Crop production operations are generally conducted in the following sequence: land (or seed bed) preparation between April and June, planting between June and September, weeding, and harvesting activities between September and January. Specific time periods for field operations, however, vary from region to region.

Ethiopia exports mostly primary products such as coffee, pulses, oilseeds, sugar, hides, skins, live animals, fruits, vegetables, raw cotton, and so on. Of all the export commodities, coffee is the

**Table II.2. A Sample of Major Ethiopian Agricultural Crops**

CEREALS	PULSES	OILSEEDS	CASH CROPS
<i>Teff</i>	Horsebeans	<i>Neug</i>	Coffee
Maize	Chickpeas	Flax	Sugarcane
Barley	Haricot Beans	Fenugreek	Sugar
Sorghum	Field Peas		Cotton
Wheat	Lentils		Tobacco
Millet			
Oats			

Note : *Neug* is Niger Seed (or *Guizotia abyssinica*)

Source: World Bank, *Ethiopia: Agricultural Sector Survey*, Annex 3, Table 2

**Table II.3. Contributions of Major Ethiopian Agricultural Crops (Percent of Tonnage)**

	Cereals	Pulses	Others	Total
1979/80	85	13	2	100
1980/81	85	13	2	100
1981/82	86	13	1	100
1982/83	86	12	2	100
1983/84	87	11	2	100
1984/85	86	11	3	100
1985/86	89	9	2	100
Average	86	12	2	100

Source : World Bank, *Ethiopia: Agricultural Sector Survey*  
Annex 3, Table 4

**Table II.4. Selected Economic Indicators for Ethiopia and Neighboring Countries**

	Ethiopia	Kenya	Sudan
<i>POPULATION (millions)*</i>			
1984	42.2	19.6	21.3
1965	22.7	9.4	13.5
<i>GROSS DOMESTIC PRODUCT (GDP)(million dollars)</i>			
1984	4,2703	5,140	6,730
1965	1,180	920 ↑	1330
<i>POPULATION GROWTH RATE PER YEAR (percent)</i>			
11973-84	2.8	4.0	2.9
1965-73	2.6	3.8	3.0
<i>GDP GROWTH RATE PER YEAR (percent)</i>			
1973-84	2.3	4.4	5.5
1965-73	4.1	7.9	0.2
<i>SHARE OF AGRICULTURE AS A PERCENT OF GDP</i>			
1984	48	31	33
1965	58	35	54
<i>AGRICULTURAL PRODUCTION GROWTH RATE PER YEAR (percent)</i>			
1973-84	1.2	3.5 ✓	2.7
1965-73	2.1	6.2	.03

\*Figures for 1965 are mid year estimates from FAO Production Yearbook, 1970  
 Source : World Bank, *World Development Report 1986*, various tables

biggest cash crop (Bezzabeh, .et. al., 1978). The majority of the agricultural exports go to countries in Europe, Asia, Africa, and North America (Nelson, et. al., 1980).<sup>15</sup> According to the 1986 World Bank's *World Development Report*, Ethiopian agriculture contributed 48 percent of production to the 1984 Gross Domestic Product (GDP).<sup>16</sup> As illustrated in table II.4, the share of agriculture is, however, gradually falling over time. In 1965, for instance, agriculture contributed 58 percent of the GDP. In real value terms, Ethiopia's GDP was \$1,180 million and \$4,270 million in 1965 and 1984, respectively. Between 1965 and 1984, Ethiopia suffered a sharp decline both in growth rates of GDP and agricultural production while the rate of population growth increased moderately.

It may be instructive to briefly compare what has happened to agricultural production since 1974 compared to the ten years or so before 1974. The statistics of the *World Development Report* summarized in table II.4 show that the growth rate in agricultural production has been about 1.2 percent per year from 1973-84 compared to 2.1 percent per year from 1965-73. In other words, since the 1974 revolution, the growth rate in agriculture has dropped by about a half. Population growth rate has gone up to 2.8 percent per year during the 1973-84 period compared to 2.6 percent per year from 1965-73. This (population growth) may have contributed significantly to the severe crisis situation Ethiopia has experienced in the recent past. It must be realized, however, that the drought has had a major effect on the agricultural production growth rate. The 1987 study of the World Bank, *Recent Economic Development and Proposals for Recovery and Growth of Ethiopia*, notes certain additional factors that contributed to the decline in the growth of agriculture: agricultural pricing and marketing policies; control over domestic resource mobilization; fixed exchange rate

---

<sup>15</sup> For example, *The Economist Intelligence Unit* (1986), notes that the major Ethiopia's trading partners are "Djibuti, France, East Germany, West Germany, Italy, Netherlands, UK, USSR, USA, Japan, and Saudi Arabia" (p. 36).

<sup>16</sup> GDP is often defined as a measure of aggregate value of final goods and services produced in a given production year by an economy of a nation-state. Normally, GDP is contrasted with GNP, where GNP is (roughly, GDP minus income from foreign sources) defined as a measure of actual final product of goods and services produced within the economy of a nation-state without income from foreign sources.

(US\$1 = 2 Birr) regime despite unstable domestic and foreign economic developments; and internal political unrest that has consumed substantial amounts of human and material resources.<sup>17</sup>

The gap between the growth rates of population and agricultural production was 1.6 percent (that is, 1.2 percent - 2.8 percent) during the 1973-84 period and 0.5 percent (that is, 2.1 percent - 2.6 percent) during the 1965-73 period. It should be noted that the 1.6 percent gap is larger than the gaps of 0.5 percent and 0.2 percent suffered by Kenya and the Sudan, respectively, during the same 1973-84 period.

Livestock production is an integral part of the subsistence agricultural complex. Livestock are produced in all the altitude regions. In normal times (that is, when not affected by drought), the country raises plenty of cattle, horses, donkeys, mules, camels, goats, and sheep. For instance, prior to the 1972-74 drought, there were about 26 million cattle, 12 million sheep, 11 million goats, 2.8 million horses and mules, 3.8 million donkeys, and one million camels (Cohen and Weintraup, 1975).

Livestock are regarded by most farm households as a sign of wealth and prestige. Both animals and their products are important sources of family income, nutrition, ceremonial savings, and transportation. Butter, for instance, is used extensively for cooking, milk for drinking, hides for making sacks, and so on. Cattle, especially oxen, provide draft power for plowing crop fields. Oxen and horses are used for threshing grains under their feet after the crops are harvested. Horses, mules, donkeys, and camels are often used for transportation and as pack animals (Pankhurst, 1968).

---

<sup>17</sup> In 1984, for example, the World Bank cited reasons for the decline in the agricultural growth rate, some of which included: domestic trade policies that restricted free flow of grains and prices between regions. The restrictions might have depressed prices in grain surplus regions and inflated prices in grain deficit regions. Other causes of the decline are drought, low investment level, exogenous economic climate that deteriorated foreign demand for export market, notably for coffee, capacity constraints in non-agricultural sector and so on.

Animals graze intensively on rain-fed grasses, straw, and grain stubble on harvested fields. Many farm households maintain a small plot near their homesteads in pasture to supplement the grazing of the animals. The pastures are, however, often reserved for plow oxen during the intensive field work season (Hoben, 1973). As indicated previously, in regions where rain is seasonal and scarce, pastoralists often move their herds to locations with a good supply of pasture and water. Such a method of managing animal husbandry (particularly through extensive grazing) has been greatly influenced by changes in vegetation, land resource, population, and environmental factors (see Sections II.2.4 and II.2.5)

### II.2.3. Traditional Land Management Practices

Traditional farm technology is primitive compared to modern mechanical, biological and chemical technologies. Agricultural implements generally consist of a plow, spades, sickles, hatchets, sieves, oxen, and so on. Farm lands are left fallow when productivity is perceived to be declining.<sup>18</sup> It is not uncommon for these lands to produce weeds, grasses, and woody shrubs over the fallow period. In regions where modern yield increasing inputs such as fertilizer and pesticides are not commonly used, farmers rely on traditional land management practices to prepare these lands for crop production. Pankhurst notes that shifting cultivation and burning of grasses, shrubs and weeds are normal practices of the traditional land management.

The practice of burning vegetation on croplands is harmful to the long term productivity of the croplands.<sup>19</sup> Farmers have used it in the past (perhaps still do) because of the short term economic gains from increased crop output by minimizing crop loss. According Pankhurst, burning of

---

<sup>18</sup> Donahue claims that croplands are often fallowed for 5 to 15 years. But the length of fallow period might be greatly reduced in recent years due to population pressure, especially on the highlands that are densely populated.

<sup>19</sup> Productivity is often defined as total output per unit of inputs engaged in the production process or as a marginal change in total output resulting from a unit change in an input such as land.

vegetation was useful to “clear the land for cultivation, to prevent rapid growth of bushes, to destroy rats and mice, moles or insect pests, or to fertilize the soil” (p. 189). In addition to controlling insects, disease, and weeds, Donahue found that burning of vegetation improved land productivity by increasing plant available nutrients such as phosphorus and soil pH. In an experiment conducted near Debre Berhan in Shewa province, for instance, burning increased soil pH from 5.85 to 7.10, plant available phosphorus from 3.81 milligrams to 18.45 milligrams per 100 milligrams of soil, and sand content from 34 percent to 78 percent. However, the same experiment found that percent soil contents of organic carbon, silt, and clay were reduced after burning (Donahue, 1972). ✓

#### **II.2.4. Resource Extraction, Scarcity and Migration**

In this section, the problem of resource extraction in rural Ethiopia is illustrated by focusing on soil erosion. The discussion is extended to examine linkages of soil erosion to rural labor allocation decisions. Migration is discussed to illustrate how soil erosion can influence labor allocation decisions. Traditionally, farm households responded in many ways to the erosion problem. Labor migration to urban centers and other rural regions has been, however, a common way of mitigating farm income decline due to erosion and subsequent scarcity of croplands.

Historically, agrarian communities settled and evolved mostly on lands where the soil resource was fertile and the climate was conducive. Fertile soil, ideal climate and plenty of sources of water are essential resources both for farmers of today and farmers in prehistoric times. The use of farm lands excessively or intensively over a period of time without skillful land management programs can deteriorate the quality of the soil. If such a period of excessive utilization is long enough, the farm land can become unsuitable for agricultural practices, having been reduced to wasteland (just as the the Sahara desert). Such a reduction of farm land into wasteland may influence the rate of social capital formation in agrarian communities that rely on cropland as factor of production. If

farm land is managed properly and negative externalities such as erosion, drought and deforestation are adequately controlled, the land can generate itself over the production cycle.

The process of land degradation by erosion is gradual. It can, however, cause scarcities in the chain of agrarian livelihood before it is noticed and mitigated. Erosion depletes soil nutrients, diminishes river flows by sedimentation, reduces rooting depth which inhibits plant growth, limits water infiltration, and reduces plant-available water holding capacity of the soils (Langdale and Shrader, 1982). It is an irreversible (at least, in the short run) form of soil deterioration by wind and water. If left unchecked for a long period of time, it can result in the loss or impairment of the physical productivity of croplands (Bunce, 1950). Stated simply, erosion is the flight of soil capital with no return ticket to the place of departure.

The soil degradation problem is a continuous process around the world (Kramer, 1983, FAO, 1983). It is common knowledge that countries in tropical Africa, South and Central America, Asia, the Pacific, and islands of the Caribbean, are subject to severe denudation of surface soils by erosion (El-Swaify and Dangler, 1982). Historically soil erosion has been blamed for the destruction of such ancient world civilizations as the Mayan (FAO, 1983). Such civilizations emerged primarily in locations where fertile soils and water resources were available in abundance. Destruction of these civilizations was perhaps exacerbated over time by the degradation of croplands due to erosion, population pressure on fixed land, and poor land use management practices such as deforestation. Therefore, the forces of erosion and deforestation might have greatly reduced availability of cropland productivity to the extent that no communities of the civilizations could survive for a long time.

Ironically, if soil erosion was the cause for the destruction of the Mayan civilization, it appears to some to have helped the Egyptian and Mesopotamian civilizations to evolve around the deltas of the Nile and the Euphrates-Tigris Rivers, respectively. Some historical and anthropological inquiries lead to an observation that "...the attribute of the Nile valley, which it shared with the

Euphrates-Tigris delta, and which assured to the Egyptian and Mesopotamian peoples their long lead in the progress towards civilization, was surely the one which enabled them to settle down and exploit the soils of their countries as soon as they had learnt to till them, and having to find a way of remaking the soil every year" (Edward Hyams, (1952) p.46). The soil of the Nile delta is transported mostly from the Ethiopian agricultural highlands by water erosion. The minerals, organic materials and fertility of the Nile delta were, therefore, an unintentional contribution of the Ethiopian farmers to the Egyptian farmers. Hyams again notes that "since prehistoric time, and the practice still continues, ... Abyssinian highlanders...provide Egypt with the most fertile soil in the world" (p. 46).

Currently, erosion by both wind and water has reached critical levels on the Ethiopian highlands, especially where forests are almost completely depleted. Approximately 60 percent of the available cropland is subject to erosion . It has been estimated that the highland regions under intense cultivation are losing a total of 500 million tons of soil annually to erosion. About 20 percent of the eroded soils gets washed away by rivers across national borders while the other 80 percent gets deposited in the lowland regions of the country. The factors causing erosion may vary with geophysical and environmental elements. But, according to the Ethiopian Relief and Rehabilitation Commission (RRC) (1985)), the most critical causes of soil erosion include: (1) mountainous terrain; (2) torrential rainfalls and protracted periods of high humidity over the highland plateaus; (3) deforestation of watersheds; (4) settlement pattern; and (5) poor soil management techniques such as the burning of vegetation and over grazing of croplands. Moreover, the RRC estimates that approximately 200,000 hectares of forest land are being cleared annually. Factors that are responsible for deforestation are numerous. The common ones include expansion in demand for croplands, shifting cultivation, increase in demand for fuel and construction wood, livestock needing more pasture land, and fire hazards.

Until recently, the problem of soil erosion and its impact on the agrarian economy of Ethiopia continued without being recognized by the agricultural policies of the past. Consequently, some

rural communities have become uninhabitable. The over-utilization of agricultural land, deforestation, soil erosion, and changes in environment have forced the rural communities to transfer their herds to new locations with adequate food. The RRC reports that even the new locations have become under increasing pressure to support human and livestock population on the scarce land based resources.

Most Ethiopian farm households depend on land for food and fiber. Severe soil erosion creates a conflict between this relationship. The conflict can weaken the link. It (the conflict) tends to have a direct impact on labor allocation, and on the household's consumption and production decisions. The households adjust family labor allocation in response to the conflict. This, in turn, influences income consumption and production decisions. The adjustment is not an unusual response to changing resource levels. In the past, the households responded in either of the following ways: (1) they brought more marginal lands into cultivation, and/or (2) they shifted some or all of the land into non-crop production activities such as grazing, and/or (3) they ceased to cultivate the land in search of off-farm sources of income. The length of departure in search of non-farm income depended on the severity of soil degradation and its effect on farm income generation. If the available cropland was severely eroded and members could not maintain family income at or above a subsistence level, the move might have been permanent. On the other hand, if the cropland was relatively less eroded but presented a threat to the welfare of the family, some members of the household left the farm temporarily or even permanently in search of alternative sources of income.

Exactly how land degradation influences the agrarian economy of the Ethiopian highlands in general and labor allocation decisions of the farmers in particular is beyond the scope of this study. But it is a complex empirical issue that deserves scientific research. The Institute of Development Research (IDR) and FAO jointly conducted a sample survey of the Ethiopian highlands Farmer Associations in 1983 with an emphasis on the households' perception and their evaluation of: (1) erosion, (2) land degradation, (3) crop and livestock production activities in light of resource

scarcity, and (4) their response to the problem. One of the conclusions of the study summarized by Admassie, *et. al* (1983) reads as follows: "The main causes of degradation are over-cultivation, lack of organic fertilizer, lack of crop rotation, lack of mulching, burning soils, illegal charcoal burning, public works, strong winds, lack of reforestation, traditional farming....The effects on life are reduced yields, poverty, food scarcity, emigration and drought. The responses that people take are ... use of chemical fertilizer ... emigration, building check dams, and using ditches" (p. iv). Findings of the study do not provide statistically quantified measures for the variables of the major impact on degradation. Thus, the study has limited use for establishing conservation priorities and guiding policies aimed at mitigating resource degradation. Nevertheless, it is instructive to note that the study identified labor migration as one of the rural adjustment responses to the degradation of resources.

Rural labor migration may not take place at all levels (or degrees) of erosion. It may happen even when soil erosion is minimal (or cropland is infertile). That is, migration can occur in either of the following circumstances: (1) for a given size of farm household, a decline in the value of the land output below a subjective 'safety margin' of income induces migration of some members of family labor; or (2) migration may occur as income elasticity of demand for food falls while land productivity increases; or (3) farm household members migrate in order to minimize the opportunity cost of staying on the farm. The underlying motivation for migration in each of these circumstances is a pursuit of some economic goal by the farmers.

In the first circumstance, for example, farm families may adjust consumption and production decisions as if there is a minimum level of income on which the household depends for its sustenance at the margin and below which some members decide to leave the farm. The decision to migrate will not improve cropland productivity, unless corrective measures (such as soil conservation) are implemented. But the decision will improve income share of the remaining family members due to fewer members remaining to feed. The adjustment process may persist over time making it necessary for the remaining members to work longer hours until the marginal

contribution of the last working member just equals or exceeds the level of subsistence or safety margin income.<sup>20</sup>

The second circumstance in which migration can occur despite an increase in the cropland productivity may initially sound unreasonable, but it is not. When the farm labor situation in developed countries (for example, the USA) is considered from a historical viewpoint, it is a common knowledge that labor migration out of agriculture increased as the farm families became financially more well-off due to improvements in farm technology which increased productivity of the sector. They could afford to migrate and to consume a greater mix of non-agricultural commodities not included previously in their standard consumption bundle.<sup>21</sup> In other words, the income elasticity of demand for food becomes smaller after a certain level of farm income is achieved. Such a desire to substitute non-farm commodities for food can be an economically useful change in the traditional tastes and preferences over time. It can be an engine for the long-term rural industrial development by capturing some of the material and human capital within the rural economy which otherwise may leave the farm sector. The rural industrial development, in turn, can facilitate economic integration of the farm sector with the rest of the economy while supporting the growth of the non-farm sector through increased consumption of industrial commodities, employment and supply of capital.

The third circumstance indicates that labor migration may occur if the return to labor and management efforts invested in crop production becomes short of the opportunity cost. That is, if the value of labor drudgery (or self exploitation) exceeds the value of average share of real income

---

<sup>20</sup> 'Safety margin' is given various meanings in the literature. For example, Berry and Soligo (1969) define it as "the minimum subjective level of food consumption" p.233; or it is defined "in terms of income level or the degree of home consumption of the output of farm or both" (Tang, 1969, p.190), or as an "...absolute minimum income standard or minimum level of living, whose content is admittedly difficult to specify in absolute or in relative terms" (Wharton, 1969, p.16). There is no standard mechanism that determines a universal income level of safety margin across various households. It may vary from family to family with socio-economic, institutional and resource endowment characteristics.

<sup>21</sup> Also, it may be noted that structural changes in the farm sector contributed to the plight of rural population into the urban centers. For example, some farmers, especially small ones, went out of farm business when they could not economically compete as productivity increased and farm prices fell.

from a given piece of cropland, then a member of the Ethiopian rural household may reduce the amount of hours invested on the farm and eventually migrate elsewhere outside the family farm.<sup>22</sup> The share of real income is an average amount of 'food wage' that accrues to the individual member of the household labor force working on the family farm. Income share is, therefore, one other factor that can provide a partial explanation to the linkage between erosion and labor migration in rural Ethiopia.

Labor migration out of the traditional agriculture can be viewed as another form of resource extraction. This is because migration tends to be selective. It has a potential to exacerbate deterioration of the well-being of the rural communities. Some economists (for example, Schuh (1976)) agree with the view that migration is selective in that it extracts the most effective, industrious and productive human resources from agriculture. Usually those who remain on the farm tend to be older men and women and children who do not have physical ability to perform intensive field work especially during critical seasons. Completion of the critical crop production activities (such as land preparation, sowing, weeding, harvesting, threshing, etc.) in a timely fashion may be curtailed by a shortage of labor due to migration. The labor shortage combined with a diminishing productivity of land due to erosion, can have a worsening impact on the long-run welfare of the rural communities.

Prior to the 1974 revolution and the 1975 land reform, farm households with a large farm size and relatively small family size often managed seasonal labor shortages through traditional means of 'hiring labor' for an intrinsic wage, or by increasing family labor force through reproduction over time.<sup>23</sup> If this was not possible, portions of the farm land would be rented out to tenants under mutually agreed terms of share-tenancy. Farm households with large family size and relatively small farm size either entered share tenancy in local agriculture or exported some of the labor to locations

---

<sup>22</sup> See Chayanov (1966) for the concept of labor drudgery

<sup>23</sup> Intrinsic wage may be defined as a reciprocal compensation in kind for services rendered in the realm of communal dependency established by culture or tradition. The level of the intrinsic wage may over, just or under compensate market value of the labor services.

where work was available for a money wage, or intensified their work by working longer hours on the family farms. Family labor's intensification would continue until the household could not tolerate a decline in its welfare due to a decline in the share of income from crop production below the subjective safety margin. In other words, the more intense was the work relative to the share of income, the lower was the level of welfare at which point the working member of the family either reduced working hours or discontinued to work on the farm.

Others (for example, Ranis and Fei, 1961, Lewis, 1954) viewed migration as a mechanism to lessen population pressure from the scarce resources of rural farm sector. It (migration) was once heralded as a precursor of rapid industrial development due to a low cost of labor to the sector. The hypothesis was based on the assumption that the industrial sector would reinvest accumulated capital and would grow fast enough to absorb the influx of migrant labor to the urban centers. A balanced economic growth was assumed to occur between the modern industrial sector and the backward traditional sector. Perhaps it was due to such thinking that many developing countries including Ethiopia were influenced to adopt rapid industrialization policies. Also, it was likely that the industrialization policies were influenced by the Harold-Domar type models of one sector which stressed the importance of capital accumulation in the industrial sector more than they stressed the importance of the agricultural sector. The industrialization policies were quite successful in attracting a large amount of rural labor to urban centers which resulted in the creation and expansion of urban subsistence class (Sisaye and Stommes, 1980).

This view of labor migration as a precursor of rapid industrial development was viable in its own right. But seemed to neglect institutional rigidities, scarcity of the initial investment capital which is characteristic of many entrepreneurs in most developing countries, and incompatibilities of the skills of the migrant labor with the immediate needs of the industrial sector for skilled labor. Todaro (1976), asserts that migration is being viewed as "...the major contributing factor... [to the] growing economic and structural imbalances between urban and rural areas" (p. 2). In the case of Ethiopia, some elements of the imbalances could be seen in terms of worsening urban

unemployment, food price controls in favor of urban consumers, and a shift in policy emphasis from rural problems (such as erosion) to urban concerns (Teclé, 1975).

Since the 1974 revolution, the Ethiopian government has introduced policies aimed at controlling rural to urban migration. The labor migration control policies are augmented by the 1975 land reform legislation which abolished traditional tenancy arrangements and distributed land-use rights for up to a maximum of ten hectares per farm household.<sup>24</sup> Both of these policies (that is, control over farm labor mobility and the limit on land holding rights per farm household) may, however, present a new challenge to the agricultural sector. In the long-term, fragmentation of the household farms may increase and make the subsistence food production system costly thereby having implications for a cost-push type of labor migration. Also, it is conceivable that topsoil productivity will be damaged as the fragmented farm lands will be overworked due population pressure on fixed land resource. The population pressure may come from two major sources. First, it may come from increases in rural labor reservoir due restrictions on migration and, second, it may come from the natural population growth, perhaps as a result of *incremental improvements* in rural health services and *incremental changes* in the overall quality of rural life. ✓

## II.2.5. Recurrent Record of Drought and Famine

Drought is a natural phenomenon that results in insufficient water supply to meet water requirements for mankind and other lives in the ecological chain. A cumulative impact of drought extended over time can deplete soil moisture, rivers, streams and lakes. Widely spread major drought and famine incidents, and many minor ones, have been common in Ethiopia for 800 years. Table II.5 summarizes critical drought and subsequent famine years. Each incident of the drought

---

<sup>24</sup> One hectare is about two acres.

**Table II.5. Historical Time-Table of Drought and Famine In Ethiopia**

Time Periods	Critical Drought/Famine Years
1200s	7
1400s	3
1500s	6
1600s	12
1700s	9
1800s	6
1900s	6

Note. specific drought and famine years are:

1252, 1258-1259, 1272-1273, 1274-1275

1435-1436, one other between 1454 and 1468

1520, 1543-1544, 1559, 1567-1568

1611,1618-1619, 1623, 1625, 1633, 1634-1636, 1650, 1653, 1678

1700, 1702, 1747-1748, 1752, 1783, 1789, 1796-1797

1800, 1888-1892

1972-1974, 1983-1985. 1951

Source : RRC (1985), Woldemariam (1984) P. 31-35, and Pankhurst (1966)

has resulted in prolonged damage to both urban and rural economies of the country. Urban and rural communities are often affected directly or indirectly by drought induced reduction in economic activities. The damages have been, however, severe on the agricultural sector, which historically has been a major source of income and rural employment. Interestingly, there have only been four periods of drought since 1800, but two of these periods have occurred during the last two decades.

Each occurrence of drought appears to be followed by famine and diseases such as smallpox, typhus, and cholera. Also, changes in tastes and preferences, a technology, and demographic composition have been unavoidable consequences of drought. For instance, during the 1888-1892 period of great drought and famine, famine victims were said to consume non-traditional sources of food such as human beings. The loss of livestock, hence the loss of oxen technology, forced many farmers to revert back to hoe agriculture. Unusual social practices such as sale of children by parents, slavery and suicide were some of the common responses in those regions severely affected by the drought. A large number of rural famine victims migrated (especially, from the northern regions) in various directions. According to Pankhurst, some victims of famine travelled to the east where they sought aid of imported food at the shores of the Red Sea, and some migrated to the south where limited food distribution was available in locations such as Addis Ababa, seat of Menelik II's government.

Traditionally, drought and famine were regarded as acts of some supreme power. In most cases, the supreme power was God. But, Woldemariam writes that "famine is neither the work of God nor that of nature, but of man and his institutions" (p. 15). Despite the recursive nature of drought, careful documentation and evaluation of its effects on the welfare of the Ethiopian people remained neglected for centuries. No comprehensive national drought policies were developed. Institutional responses were limited to the cases of emergencies.

"Drought management" requires commitment of the national leadership to administer controlled use of critical resources such as water, soils and forests. For instance, today per capita

wood consumption is estimated at 1.15 cubic meters or at a total of 48.3 million cubic meters per year. As discussed previously, activities such as shifting cultivation and fires are depleting forests at an approximate rate of 200,000 hectares a year. The RRC estimates that forest cover presently is estimated to be only 3.5 percent of the land.

Ethiopia exports about 11,018 million cubic meters of water to the Sudan through the Nile River. Based on this water supply, Sudan produces about 3 million acres of irrigated crops (D'Silva, 1986). Regardless of the potential political repercussions between the two countries, Ethiopia could save the same amount of water for irrigated income production within the Nile River basin. Proper technology and institutional leadership is, however, necessary to achieve this goal.

Generally, drought of any length of time (weeks, years) can impose severe penalties on agricultural development and rural wealth. According to Woldemariam and the RRC, the 1973-1974 drought resulted in the loss of 93 percent of the sheep, 90 percent of the camels, 60 percent of the donkeys, and 95 percent of the mules in the province of Wello. In the seventeen-year period (1957-1974), approximately 1.1 million persons died due to famine. Economic penalties suffered by Ethiopia through livestock loss, human death and loss of vegetation are not readily recoverable. Even reorganization of resources to mitigate drought penalties creates an opportunity cost by shifting scarce resources away from other uses. A lesser of the two types of penalties will have to be chosen in order to prevent a greater deadweight loss to the society. The deadweight loss of production and consumption occurs when value of the lost resources (such as trees, livestock and human beings) in one sector can not be recovered elsewhere in the economy. Foreign aid may mitigate some of the loss, but the aid may never be large enough to fully compensate social welfare losses suffered by the Ethiopian people. Thus, the value of the lost resources by drought disappears thereby creating a deadweight welfare loss to the society.

The institutional response to the drought problem needs to be expanded beyond weather and crop production management. That is, in addition to assessing crop production and meteorological

information, Ethiopia needs to identify problems that can not be solved locally without state intervention. Investments in farmer training, population growth control, grain storage, reforestation, soil conservation, crop diversification, irrigation technology, and rural road systems will be viable strategies for drought management. In the long-run, this may mean strengthening the ability of the rural economy to survive drought shocks without massive reorganization of resources when severe drought and famine come-by again!

### *II.3. Agriculture and Land Tenure Before 1975*

The Ethiopian land tenure system was quite complex prior the to 1975 land reform. The system was composed of a series of complex relationships between rural production and consumption, social status, state and private institutions, wealth, and political power. On the basis of scholarly observation and an in-depth analysis of the land tenure system, Pankhurst (p.135) wrote: "The system of land ownership was of crucial importance to the country's economic and social life, for besides determining questions of social class it was the basis of administration, taxation and military service. Two threads, those of uniformity and diversity, can be clearly discerned. On the one hand the existence of a strong and highly centralized monarchy had established certain basic institutions throughout most of the realm, while on the other, geography and history combined to produce immense regional variations." Many Ethiopian land tenure studies, such as Cohen and Weintraub (1975), Bezzabeh, Debabu and Derso (1978), Pankhurst (1968), Markakis (1974), and Abate and Kiros (1983) have tried to unravel the intricacies into five major systems:<sup>25</sup>

1. Kinship Tenure System
2. Village Tenure System
3. Private Tenure System
4. Church Tenure System
5. Government Tenure System

---

<sup>25</sup> More detailed information can be found in these references. This section of the dissertation has benefited a great deal from the studies.

Cohen and Weintraub suggest the following general principles to bear in mind when studying the Ethiopian tenure system. First, individual land occupants were identified only by their rights to hold the land rather than to actually possess it. This stemmed from a traditionally held view that the universe of land belonged to the king in much the same way that the kingdom of heaven belongs to God. Second, tenure transfers were wealth transfers from individual right holders to the crown. Finally, tenure tributes were wealth transfers to assignees of the crown from individual right holders.<sup>26</sup>

### II.3.1. Kinship Tenure System

The kinship tenure system was more prevalent in the northern provinces than other parts of Ethiopia. The major types of kinship tenure system, *rist*, *gult* and *rist-gult* were found in Eritrea, Tigre, Begemder, Gojjam and in some sections of Shoa and Wello provinces. Land distribution and holding rights were administered and controlled by kinship groups. Leadership was provided by elders of the kinships. The elders often oversaw decisions concerning who cultivated how much land within the traditional norms of kinships. Proof of kinship was the only means to claim a piece of land. Thus, individuals who were able to establish kinship rights through either parent could request a share of the land from the elders.

Interlinking of the kinship rights to land distribution was afforded by genealogically established tradition under the *rist* tenure system. Essentially, *rist* was the right to claim a piece of land on the basis of a kinship to a historical ancestor in the kinship. The location of the land was not fixed as long as it was within the kinship regime. Therefore, "what was inherited was not a particular plot of land with a permanently fixed location, but rather the right to a share of larger land held

---

<sup>26</sup> Also note that tenure names are given in Amharic (Ethiopian official language) due to lack of comparable English translations that can preserve original meaning of the tenure concepts.

corporately by the descendants of the first holder of the estate as *rist*" (Abate and Kiros (1983) p.147). As Hoben (1973) writes "*rist* rights do not die" (p. 23). The actual allocations generally varied with the claimants political skills, status, and influential ability when dealing with the kinship's judicial system. Nevertheless, due to the fact that allocations lacked in location specificity and boundary, it was not uncommon for the kinsmen to be engaged in conflicts and prolonged litigations. Abate and Kiros note that the conflicts and litigations sometimes resulted in "bloody family feuds and vendettas that could go on through several generations" ( p.147).

While the system of *rist* tenure was a right to hold a piece of land, tenure taxes and tributes were transferred through the system of *gult*. The *gult* was the right to tax and receive tribute from land. The *gult* could be established by the monarch in any part of the country on a temporary or permanent basis. It was one of many methods used by the monarch to transfer (or grant) tax revenue (be it in kind, cash or labor) rights to a third party of individuals and/or institutions such as members of the royal family and churches. The rights took a form of *rist gult* when *gult* grants were inherited. Hereditary *rist gult* grants were often transferred to royal family members, provincial nobilities and favorites in substitute for wages for services rendered. The basic tenancy arrangement in any given area of kinships system remained intact despite such transfers of taxation rights.

Several social, economic and political problems are implicit in the kinship tenure system. First, since the distribution of *rist* rights was based on inalienable hereditary rights, proof of the genealogical linkages of a claimant to the kinship's judicial system always depended on oral rather than written tradition. If a claimant felt the land or the neighborhood did not appeal to him, then he would go anywhere else in the kinship and initiate a claim for a piece of land. As Hoben notes, if the claimant were capable of convincing the kinship elders, he could greatly improve his economic and political status by accessing to resources in several descent groups at once. Second, land was intensively cultivated and fragmented into small plots due to continuous allocations, population pressure and tax obligations. This might have resulted in severe soil erosion and deforestation problems over time. Interestingly, the northern region where the *rist* tenure system was dominant,

historically experienced problems of soil erosion, deforestation, migration, cyclical drought, and famine. Research is needed to examine how the kinship tenure system contributed to these problems. Third, since farmers had to protect their share of land against claimants, they spent money and time in conflict resolution and litigation processes. Hence, it is conceivable that the kinship tenure system fostered the judicial relations marked by venality. The possibility of threats and uncertainties to the ownership of land, might have discouraged the *ristegnas* (*rist* right holders) from caring for the soil and forests. Brietzke (1976) also observed that the kinship tenure system “generated excessive fragmentation, greater tenure insecurity, and less of an incentive to improve the land in a part of Ethiopia that is relatively over populated” (p. 642). Finally, Bezzabeh, *et. al.*, indicated that farmers in the regions of kinship system were not encouraged to participate in the agricultural credit programs because they were not considered a good credit risk.

### II.3.2. Village Tenure System

The village tenure system was found only in a few northern (for example, Eritrea, and Tigre) regions. The right to hold a piece of land was not a function of the inalienable hereditary as in the kinship tenure system. What was required was a proof of a residence in a village in which an individual was claiming a piece of land. Cohen and Weintraub claim that land was equally (both in quality and quantity terms) distributed by lot among the residents regularly intervals of about 5 to 25 years. Land holding rights would be forfeited only if the resident left the village. The resident, however, could resume his holding rights (not necessarily the same estate) upon return to the village (Bezzabeh, *et.al.*, 1983). Because of its basic character of egalitarian distribution of land, and thereby income, the village system also (like the kinship system) encouraged land fragmentations into small plots and intensive farming due to population pressure over time, as changes in the population density altered the size of the household estates.

### II.3.3. Private Tenure System

Unlike the two tenure systems discussed in the preceding sections, the private tenure system was of recent nature and was prevalent mostly in the southern regions. It was created in the last half of the 19th century as a result of the conquest of the southern provinces (Arssi, Bale, Gemu Goffa, Illubabor, Keffa, Sidamo, Wellega, and even some parts of Shoa and Wello) by Menelik II. He was an Emperor from 1874 to 1896. The consolidation of the southern region was quite rapid. The region was (and still is) different from the northern region in many respects, some of which include climate, ethnic mix, language, culture, and most importantly, rights of land ownership.

Menelik's basic strategy was to quickly assimilate the new southern provinces with the northern provinces. The assimilation was achieved mainly by implementing a rapid redistribution of the rights to land ownership in the occupied territories. Pankhurst notes that the redistribution of the land rights took many forms in which a portion of the land was: (1) reserved for future allocations; (2) given to tenants working directly or indirectly under the government or its agents; (3) allocated to the Northerners (mostly to those who belonged to Amhara ethnic group) as an inalienable heritable *rist* land; (4) assigned to the Northerners as *gult*; (5) distributed as *madereya*--a piece of land granted to individuals (often times soldiers) on a temporary or permanent basis in return for their services. Many writers, especially Cohen and Weintraup, would agree that land allocations "were made to soldiers, northern civil servants who came to administer the new areas, peasants moving because of land pressure in the north, local tribes that did not resist the conquest, local village and clan chiefs to gain their support, church officials and institutions to facilitate the expansion of the Coptic religion, and a host of central and provincial elites close to the crown" (p. 35).

The private tenure system was generally characterized by: (1) a skewed distribution of land; (2) a shift of property rights from many subsistence farmers to a few landlords most of whom did not

live on the farm, and most interestingly; (3) a new form of tenancy was created as the result of the conquest. The majority of the cultivated land was either totally rented or partially rented and partially owned.

While the system had almost all the characteristics (for example, *rist*, *gult*, *rist gult* and taxation mechanism) of the northern tenures, it had an additional element of tenancy. The tenancy arrangements took many (for example, wage, share, and rent) forms of contracts and varied from area to area. Share cropping was, however, a common form of tenancy in most parts of the southern region. The terms of share cropping were favored the landlords. The share tenancy arrangements involved allocating agricultural output in a manner so that either a quarter or sometimes even three-quarters of the output was transferred to the landlords. Also, it was not uncommon for share tenants to be assessed transaction costs such as a premium to enter the tenancy arrangements and renewal fees and services to the landlords.

#### II.3.4. Church Tenure System

The church tenure system started as the result of land grants from the crown to the Ethiopian Orthodox church and its clergy in various regions of the country. The purpose of the grants was to provide a reliable source of income to maintain the church institution. The government did not levy taxes or tributes on these lands. The church, therefore, had institutional autonomy to collect tributes, to allocate the land among local churches, monasteries, clergy, and secular individuals.

The church tenure system was more prevalent and more developed in the northern regions than in the southern regions. It also had different forms of tenures. The most common ones were *samon* and *samon gult*. The *samon* tenure identified all the land grants under the ownership of the church, whereas the *samon gult* was a tax right assigned by the crown to the church or church officials.

The system of church tenure provided a conservative institutional basis loyal to the state and it opposed any form of agrarian reform. The long term goal of the church was to maintain institutional status quo since land was the main source of income and institutional power.

### II.3.5. Government Tenure system

As noted previously, the traditional belief (or perception) always indicated that all the lands of Ethiopia belonged to the crown or state monopoly which essentially made it a landlord and everybody else a tenant. The state possessed numerous marginal and fertile lands that were under its direct control. A measured inventory of the government land holdings was not undertaken, but some observers (for example, Bezzabeh, *et. al.*) estimated that about 42 percent (or 50.9 million hectares) of the total land area was under the government tenure system. Out of the 42 percent, approximately 77 percent was in rangelands, 17 percent was under crop production, 3 percent was cultivable but unoccupied, and 31 percent was of unknown quality. In addition, it was always assumed that those lands traditionally used by nomadic pastoralists belonged to the state.

The government tenure system consisted of many types of tenures including palace tenure, *madereya* tenure and *Gebretel* tenure, to name just a few. Those lands under the palace tenure were carefully selected agricultural lands for their potential for raising animals and food production planned for palace consumption. *Madereya* lands were the ones granted to some civil servants as a pension allowance or as a substitute for wages. Possession rights of this tenure were not transferable to a third party either by sale, gift or inheritance. However, the land could be leased out to tenants. The tenants could retain the revenue generated from the lease. Tenants of the *madereya* tenure were required to pay all taxes except land tax. The *geberetel* tenure consisted of all lands confiscated by the state from delinquent taxpayers.

Land based taxation was quite complex and burdensome since it was the principal source of public finance.<sup>27</sup> Its complexity grew out of the the complex tenure systems and its burdensomeness to the taxpayers was the result of limited sources of income and low wages paid to administrators, officials, clergy, and soldiers. Several types of taxes and tithes were collected from a vast majority of subsistence farmers, traders and handicraft workers. The taxes were paid both in cash and in-kind. Cash tax revenues were collected on agricultural products, livestock, mineral rights, handicrafts, commodities traded over internal and external borders, and commodities exchanged in village markets. In-kind taxation existed until the 1930s and included labor services, minerals (such as sulphur and salt), military service, obligations of hospitality (that is, room and board in private homes) to soldiers, state and church officials. Observers have noted incidences of tax burdens causing depopulation of some villages. Villagers were said to migrate to different locations before local tax officials came and confiscated their possessions. The local officials were primary agents of the feudal system. Their duty was to maintain law and order in all levels of rural leadership while 'mining' taxes, tributes and rents from farm output.

### **II.3.6. Strategies for Agricultural Development in Pre-1974 Ethiopia**

The historical tenural systems discussed previously, for the most part, created a society of classes based on the manner with which rights of land ownership were distributed. In the wake of the industrialization of the 1950s and 1960s, however, social and economic legacies of industrial development policies of the first two Five-Year Plans (1957-1961 and 1962-1967) accentuated the gap between a few modern urban enclaves and the vast traditional agricultural sector. Both Plans promoted the development of the urban sector through a rapid industrialization backed by active government interventions in product and factor markets. For example, the government controlled

---

<sup>27</sup> See Pankhurst and Luther pp. 504-544 and 59-70, respectively.

urban food prices thereby turning terms of trade against agriculture. Sisaye and Stomme (1980) write that both capital and labor prices were maintained at low levels, and tax exemptions were granted to foreign investors.

The industrial sector depended on the traditional agricultural sector for the supply of both low wage labor and low cost food. Since agriculture had surplus labor, the industrialization policies presented off-farm opportunities to rural labor in the urban centers. Towards the end of the 1950s, however, the country began to experience economic and social problems resulting from unemployment and food shortages. Abate and Kiros claim that it was during this time that Ethiopia started importing food grains such as wheat. This was also the period that the role of agriculture in the production and distribution of national income began to occupy the interest of the state.

Some types of policies for agricultural development and agrarian reform were informally contemplated in the two Five-Year Plans to deal with the problems of unemployment and food shortages. The leadership, however, could not commit itself to any specific policy because it realized an agrarian reform could lead to a social and political disorder. The rural tenure system was still regarded as a key factor in sustaining political equilibrium. The leadership was mainly interested in promoting subsistence agriculture as long as it was able to extract farm income through taxes, tributes and rent. It was also concerned that agrarian changes would shock the equilibrium and might create a conflict between the state and its traditional allies (Cohen, Goldsmith and Mellor, 1976).<sup>28</sup>

The slowly emerging crises in the agrarian economy, urban unemployment, and food shortages combined with a mounting pressure from various sources (for example, liberal Ethiopians, foreign aid agencies), convinced the Haile Selassie government to incorporate provisions for agricultural

---

<sup>28</sup> The allies include the church, landlords, local government officials, merchants, and other landed gentry.

development and agrarian reform in the Third-Five Year Plan (1968-1973).<sup>29</sup> The plan did not indicate much confidence in the potential of small scale traditional agriculture to rapidly expand domestic food supply. The traditional sector was seen as constrained by the small size of farms, fragmented markets, and the traditional technology. The sector consisted of (and still does) randomly scattered plots of small farms that were not large enough for tractorization. Had the traditional sector been considered for the type of agricultural development contemplated by the Plan, it would have required basic transformations in the structure of the agrarian economy. That is, it would be necessary to introduce changes such as land reform, farmer education, a credit system, and a supply of modern technical inputs. Thus, in view of these bottlenecks, the policies and programs of the Plan bypassed the subsistence sector and promoted capital intensive modern commercial agriculture (Abate and Kiros (1983), Brietzke (1976), Cohen, Goldsmith and Mellor (1976)).

### *II.3.6.1. Commercial Farms Strategy*

Figure II.3 illustrates spatial distribution of the commercial farms development in Ethiopia. As shown in the figure, the commercial farms were established in the southern, western, northwestern, and eastern regions where topographic characteristics were suitable for machine technology and irrigation schemes. Until 1974, commercial farms claimed a total of about 60,000 hectares of agricultural land. The farms were owned mainly by members of the royal family, landlords, and private entrepreneurs who got into the farm business by purchasing rural lands. Some of the large-scale farms and processing plants were, however, partially owned by foreign corporations. Structural expansion of the farms (in terms of size, number and capital use) was vigorously promoted through favorable credit policies and through legally unprotected access to inexpensive

---

<sup>29</sup> For example, Paul Brietzke (1976) noted that "...Sweden refused to finance the second stage of the Chilalo Agricultural Development Unit until substantial land reforms were enacted..." p.645)

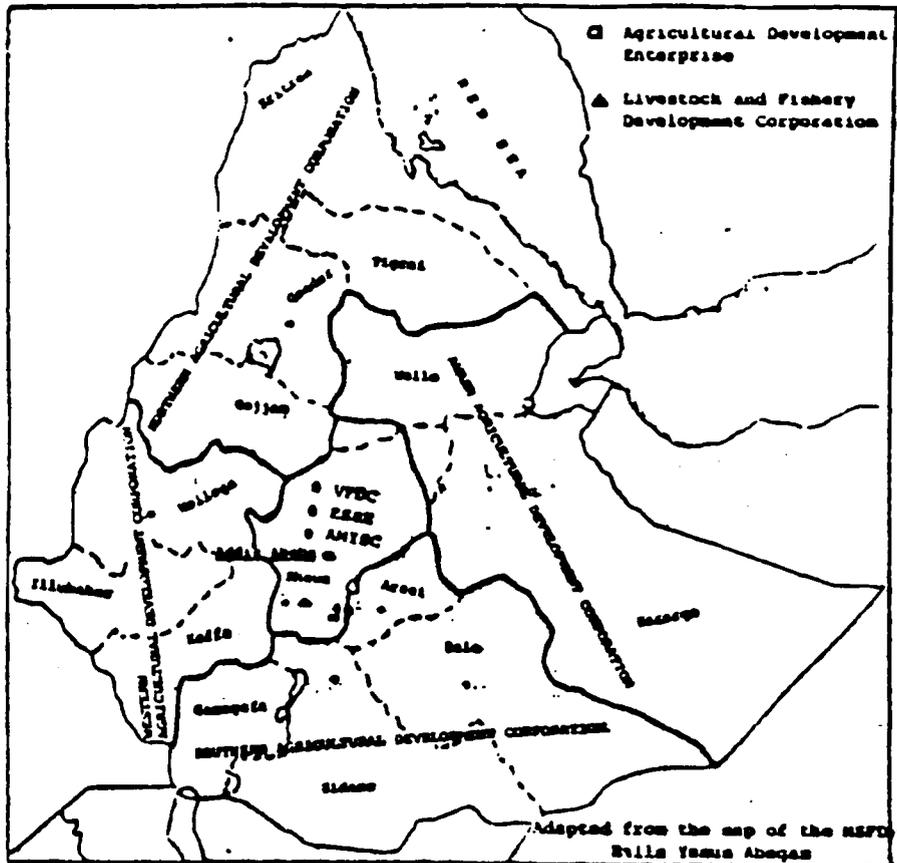


Figure II.3. Spatial Distribution of Commerical Farms in Ethiopia

Source : Abegaz (1982) p.129.

rural land and labor resources. The access to land was facilitated partly by concessions given to the large scale commercial farmers (both expatriates and national entrepreneurs) by the feudal leadership and partly by evictions of sedentary tenants and nomadic farmers.

The modern commercial farms were composed of intensive crop or livestock production either in the highlands or in the lowland regions, and extensive mechanized rain-fed crop production in the lowland regions. The intensive commercial farming concentrated on a limited number of dairy farms (such as Sholla dairy farm), irrigated crop production (such as sugar cane<sup>30</sup> and tobacco), tree plantations (of coffee and tea farms), and tropical fruit production. Getahun writes that the extensive commercial farms were developed for lowland agricultural production of rain-fed crops such as sorghum, sesame, and cotton.

The commercial farms became the symbol for rural modernization contrasted with the traditional farms. They were established on state lands designated for such development schemes and/or lands that were farmed by traditional methods (Green, 1974). The investment capital was mostly provided by foreign investors (such as Britain, Holland, Israel, and Italy) and by a few national entrepreneurs who responded to the government's promotion policies such as tax holidays, and duty free import of farm machinery. An overall *ex-post* evaluation of the abilities of the modern farms to improve the production and consumption patterns of the traditional sector, to alleviate the problems of food scarcity, unemployment and foreign exchange shortages indicated that they contributed very little. Some argued that this was due to the liberal promotional policies of the government and the way the government negotiated investments and capital accumulation with foreign investors.<sup>31</sup> The farms were mostly capital intensive. They provided employment to only a few skilled and semi-skilled workers. Profits were not plowed back into the farms, instead they were repatriated to foreign countries. A greater share of the commercial farm enterprise was

---

<sup>30</sup> H.V.A Metahara and H.V.A. Wonji sugar farms

<sup>31</sup> See, for instance, a document presented by the Ethiopian Delegation (1981) at the Soviet-African Conference "For Peace and Social Progress" at the African Institute of the USSR Academy of Science, October 14-16, 1981.

owned by the foreign investors than the share owned by the government. Bondestam (1974), for example, notes that British and Dutch corporations controlled 51 percent and 80 percent, respectively, of the value of the large scale commercial farms in the Awash Valley agricultural development. The majority of the commercial farms focused on export crops, such as cotton and sugar, that contributed very little to the expansion of domestic food production.

The failure of the policies of the industrialization and modern commercial agriculture to make a significant progress in the national economy, influenced the government to acknowledge that it would be necessary to modernize the traditional agriculture in order to increase farm output and to improve quality of the rural life. This time, however, the strategy was to introduce regional development programs known as 'package projects'.

### ***II.3.6.2. Package Projects Strategy***

The package projects were established with technical and financial assistance from foreign (for example, The World Bank, Swedish International Development Agency (SIDA), and United States Agency for International Development (USAID)) sources. The first program, Chillalo Agricultural Development Unit (CADU), was established in 1967 in cooperation with SIDA. Soon after, CADU was followed by similar projects including Wollayita Agricultural Development Unit (WADU), Ada District Development Project (ADDP) and Humera Agricultural Development Project (HADP). The overall goal of these projects was to improve traditional agricultural output and productivity by importing green revolution technologies and adapting the technologies to various conditions of different regions of Ethiopia. Applied research was conducted on agricultural crops, animal husbandry, forestry, and farm implements. Modern technical inputs such fertilizer, pesticides, improved seeds, and services of the farm implements were distributed. Unlike the modern commercial farms, the package projects helped to improve farm output and productivity, and

contributed, however marginally, towards increased domestic food supply (Dejene (1987), Aklilu (1980)).

Complementary programs such as low cost credit and import subsidies on tractors, spare-parts and fuel were made available to the commercial farmers. Since the package projects were established with the financial resources and agricultural experience from the western donors, the development of privately operated family farms was encouraged. This was further enhanced by the prevailing socio-political environment and the land tenure system. Moreover, the package projects gradually tended to deliver the major services of the program to a relatively small class of farmers who owned large plots of land and were commercially motivated. This class of farmers had some level of education, urban exposure and entrepreneurial motivation to invest in a potentially profitable farm environment.

Compared to the subsistence producers in the project areas, the newly emerging farmers had more initial capital and were not as risk averse as the traditional farmers. The majority of absentee landlords, motivated by emerging economic opportunities, resumed personal cultivation of lands on a part-time basis thereby evicting and employing their tenants as wage laborers. Others who did not own agricultural lands or did not have large enough plots of land for a large-scale operation, got into the business by purchasing and developing new lands (Ellis, 1973).

Sisaye and Stomme noted that while the package projects had the potential to benefit the poorest of the rural poor, they resulted, like the commercial farms, in unexpected shortcomings such as evictions and disparities in regional distribution of income, technology, and rural infrastructural development. Both policies of the modern commercial farms and the package projects became an engine for rural contradictions between the "old" tradition of tenancy based on small fragmented farms and the "new" or modern farming practices which sought growth by expanding agricultural land area.

The agrarian contradictions were facilitated by the socio-political system that was feudal in its basic tenet. The system was not quite prepared to implement institutional changes required to diffuse potential benefits from the modern technical innovations into the traditional farm sector. In other words, the modern technical innovations were implemented without concomitant provisions for land reform, a change in the existing political power structure, and an improvement in the system of social justice. As Dunning (1970) notes, the plan appeared to lack "the necessary legislative approval, the requisite funds and, most importantly, the will at top levels of the government" (p. 287). to promote sustained agrarian transformations. Economic historians like Simon Kuznets (1973) generally agree that if modern "technology is to be employed efficiently and widely, and indeed, if its own progress is to be stimulated by such use, institutional and ideological adjustments must be made to effect the proper use of innovations generated by the advancing stock of human knowledge" (p.247).

In many cases, the contradictions created socio-political dynamics that were not fully understood by the central leadership and the landed gentry on the periphery.<sup>32</sup> The complex land tenure system was still intact, the feudal socio-political equilibrium remained unchallenged, the resource extraction and scarcity problems continued to expand, the overall conditions of urban unemployment and food shortages were not substantially improved. It was this conflict between the shortcomings of the agricultural development programs and the elements of the feudo-capital system that partly activated social motion until the system was compelled to yield to the 1974 revolution and to the consequent land reform in 1975.

---

<sup>32</sup> For example, with the introduction and expansion of the cash-crop production in the Awash Valley, Bondestam writes that "some of the Afar were forced to leave the river-watered pastures - where they had lived for more or less permanently since the 16th and 17th centuries - to become increasingly dependent on the availability of rain. This has led to a relative overpopulation of the less fertile areas to which they had to move, with consequent over-grazing and livestock starvation, followed by diminishing herds and malnutrition" pp. 428-9.

## *II.4. Agriculture and Land Tenure in Post-1974 Ethiopia*

The traditional feudal foundations of the economic structure and social consciousness of the Ethiopian society have been undergoing transformations within the ideological framework of the *Hibrete-sebawinet* (Ethiopian Socialism) that was declared on December 20, 1974.<sup>33</sup> Perhaps no greater change has ever occurred in the nation's ideological orientation than the transformations that occurred (and are still occurring) since the 1974 revolution. Policies of the socialist state are generally geared towards promoting institutional development, large-scale agriculture, and mixed ownership of resources. Numerous new institutions have been created.<sup>34</sup> Resources of urban and rural sectors have become properties of the "people". New economic plans, projects and programs have been initiated. However, The degree to which the *Hibrete-sebawinet* political model is a Pareto economic improvement over the previous feudal system will be revealed inter-temporally by its record of economic growth and development.

Some of the notable influences of the revolution pertain to a restructuring of the socio-political, economic and institutional relations. State monopoly was instituted over almost all aspects of formal decisions. A centralized planning apparatus was created to generate macro-economic policies that would establish consumption and production norms for all households, firms, and government sectors. Since its inception, the system has evolved to the point where the state influences forces of development (be they economic, political, or social), distribution of the means of production and market relations. The central planning apparatus hopes to improve social welfare by resolving several conflicts: policies are challenged by conflicts between economic development and underdevelopment, between classes of proletariat and farmers, between private and collective

---

<sup>33</sup> *Hibrete-sebawinet* was defined to mean equality, self-reliance, dignity of labor, supremacy of common good, and indivisibility of Ethiopian unity. For a full textual explanation of the *Hibrete-sebawinet* concept, see a major policy statement in Scholler and Brietzke, (1976), pp. 141-150.

<sup>34</sup> For instance, some of the major new institutions are farmer associations, urban neighborhood associations (or *kebele maheber*), All-Ethiopia trade Union, and so on.

ownership of resources, between market competition and state monopoly, and between forces of production, consumption, investment, and exchange. As Pevsner (1978) once wrote about the Soviet system of leadership, "the state has become an inalienable part of the production process" (p. 9).

The declaration of the *Hibrete-sebawinet* was followed by the 1975 land reform proclamation. It nationalized and shifted the proprietary rights to all rural lands to the collective ownership of the Ethiopian people<sup>35</sup>. The reform became a vehicle through which rural institutional development was promoted. The institutional development was designed to facilitate the achievement of socialist goals some of which include nationalization of rural means of production, economic and political advancement in the traditional rural communities. Implementation of the reform provided for the establishment of key institutions such as farmer associations. The farmer associations have assumed a collective power over many facets of the rural environment. The associations, for example, confiscated properties of the previous landlords and redistributed rural land among the farmers (Markakis and Ayele, 1978).

The reform had numerous effects on almost all aspects of rural relations including termination of: (1) the complex feudal land tenures, (2) landlord-tenant relationships, (3) dues and litigations pertaining to land, and (4) feudal extraction of farm income through taxes, tributes and rents. The changes occurring in the rural regions were extended to the urban regions. For example, urban land, rental houses, banks, factories, and enterprises owned by foreign investors were nationalized. Approximately three million urban residents were organized into urban associations, commonly known as *kebeles* (Nelson, 1980). These changes (that is, nationalization of the means of production, institutional development and so forth) provided an environment in which traditionally peripheral members of the society could become an integral part of the national economy.

---

<sup>35</sup> The declaration does not provide clear intentions and implications of the 'collective ownership of the Ethiopian people'. It could possibly mean that since the state is a *de facto* substitute of the people, it would have the final authority over the ownership and redistribution of the rural land. The farmer would have only use-right or usufructuary possession of land (Rahmato, 1985)

Both rural and urban institutions have become potential agents for regional change. The institutions function in an economic environment classified into three categories of the ownership of the means of production: (1) state, (2) group (or cooperative) and (3) private sectors. Following the Marxian characterization of the social ownership, state ownership represents a relatively more advanced form of the socialization of resources than the other two forms of ownership. Group ownership represents a cooperative (or collective) choice of small producers and consumers who liquidate private ownership of the resources in the interest of the group. Even though anomalous to the stated objectives of the *Hibrete-sebawinet*, private ownership of goods and services (though to a limited extent) coexists with the collective and state ownership.

The extent to which the institutions can be effective in their participation in the overall economic development may depend on factors such as: (1) investments in developing human capital; (2) ability to generate social surplus for savings and investment; (3) the degree of a link between input and output markets, and between the agricultural and industrial sectors; and (4) the ability (as well as autonomy) of the local leadership to initiate community development projects. Some of these factors are briefly elaborated below. Specifically, discussion is provided on, first, the rural institutions of farmer associations, service cooperatives, producer cooperatives, and state farms, and second, this is followed by a cursory assessment of the agricultural development since the 1975 land reform. Farm input allocation, agricultural income production, distribution, taxes, and prices are the major focuses of the second sub-section.

#### **II.4.1. Rural Institution Development**

Farmers were provided with a legislative direction to organize themselves under farmer associations. The farmer associations were to gradually establish service cooperatives and producer cooperatives (or collective farms). The basic difference between these institutions is in the degree

of the socialization of the factors of production such as land, labor and capital. These institutions are the focus of the following four sections.

#### ***II.4.1.1. Farmer Associations***

The farmer associations are organized throughout the rural regions on the basis of approximately 800 hectare-areas. They (farmer associations) are the smallest unit of rural institutions and are intended to provide the organizational foundation for agrarian development. As of 1983/84, there were about 20,000 farmer associations with a total membership of 5,541,000 households.<sup>36</sup> They are vertically interlinked with higher level of associations in *wereda*, *awraja*, provincial (*kiffle-Hager*), and national farmer association, which have been established since 1975.<sup>37</sup> Each level of the institutional development (from the smallest unit of the area farmer associations to the highest level of the national farmer association), represents hierarchically higher stages of leadership and organizational structure. Each association is provided at each level with specific goals, objectives and functions. ✓

Among other functions, the area farmer associations are required by proclamation to: (1) allocate land among members of the associations; (2) adhere to land-use policies to be issued by the state; (3) administer conservation of public goods such as soil, water and forests; (4) set-up judicial tribunals to litigate land cases; (5) establish marketing and credit cooperatives; (6) initiate community development programs such as education and health services; (7) undertake villagization; and (8) preserve mining, forest and properties of a historical significance.<sup>38</sup>

---

<sup>36</sup> Unless specified otherwise, the numbers used in this and the following sections come from unpublished *Agricultural Sector Survey* of Ethiopia, by the World Bank, (1986). ✓

<sup>37</sup> *Wereda*, and *awraja* are units of administration, perhaps equivalent to a county and a district, respectively.

<sup>38</sup> See Proclamation number 31 of 1975 published in Bezzabeh, et. al. pp. 164-5.

The *wereda* farmer associations consist of representatives from the area associations in each *wereda*. The *wereda* farmer associations can (1) coordinate duties of the area farmer associations within their jurisdiction; (2) have power to change land boundaries so that farm households shall have equitable share of land-holdings; and (3) establish *wereda* judicial tribunals (or autonomous rural courts) to settle land disputes.

Similarly, the *awrajja* farmer associations are formed by member delegates from the *wereda* associations in each province. Their objectives are to: (1) coordinate functions of the *wereda* associations; and (2) establish *awrajja* judicial tribunals which provide final judgement in land dispute cases transferred from the lower level tribunals. Also, the provincial farmer associations are established at each province level. They consist of elected delegates from the *awrajja* farmer associations. The provincial associations then delegate elected members to the All-Ethiopia farmer association. Various functions of the national farmer association are outlined, some of which include: (1) coordinating economic and social services for the farmers in cooperation with state organizations; (2) communicating state policies to the farmers and farm issues to the state; (3) cooperating with development agencies to increase farm production; (4) expanding cottage industries which complement agricultural production and agrarian economic growth; (5) preserving natural resources and economic infrastructure for future generations; and (6) assisting service and producer cooperatives.<sup>39</sup> The All-Ethiopia farmer association concludes the vertical evolution of the institutional development of the farmers.

The underlying purpose of the associations is to promote a pursuit of collective welfare through collective choice. This was one of the declared principles of the *Hibrete-sebawinet* ideology which stated that: "The boundless idolatry of private gain which has chained our people to poverty and which has so humiliated our country in the eyes of the world will be eradicated. Henceforth, the interests of the community will be paramount" (Scholler and Briertzke, p. 146).

---

<sup>39</sup> Details can be found in the Proclamation number 130 of 1977 published in Bezzabeh, et., al.

The organizational structure of the associations possesses a bureaucratic character whereby the higher leadership is increasingly isolated from the foundations of the institution. The structure, however, seems to imply that the farmer associations embody a dual personality. First, (1) as a mass organization, they represent the interest of the farmers and second, as agents of the national leadership network, they represent an administrative link between the state and the farmers. In the latter capacity, they are entrusted with functions such as collection of tax and land use fees, delivery of food quotas at centrally determined prices, and maintaining accounts of holdings and incomes declared by farm households. As Rahmato notes, a failure to undertake these functions and to transfer what is required in a timely fashion may lead to governmental scrutiny.

The notions of socialized agriculture, communal ownership of the means of production, localized community government, and delivery of predetermined farm output quotas to the state at centrally regulated prices are relatively new ideas to the farm households. The current 'wave' of the economic and political changes is making them increasingly aware of the goals of the centrally regulated rules. With the exception of the general duties previously mentioned, however, the specific role that the farmer associations can play in rural economic development is vaguely defined and their political role is not obvious either. Some doubt the effectiveness of the institution in defending (advocating) the interests of the farmers before the state. Rahmato, for instance, asserts that the farmer associations "are not in a position to influence government policy with regard to agricultural prices, credit and related services. They are thus merely bureaucratic set-ups, and they have no role whatsoever in matters concerning rural development" (p. 84).

The establishment of the farmer associations provides a new institutional frontier with an unknown potential. If fully incorporated into the national economy (through marketing, communication, agricultural services, etc.), they are likely to provide institutional infrastructure capable of generating surplus farm income in excess of rural consumption. The scope of their leadership is, however, not prepared to undertake planning for a complex economic community that is much larger than the traditional household. Rahmato identifies four types of limitations

experienced by the farmer associations with regard to their ability to initiate plans for rural development. First, the majority of the farmer associations are constrained by the overall elements of rural underdevelopment such as malnutrition and poverty. Second, the quality of leadership lacks experience and expertise in planning for collective activities. Third, some farmer associations believe that their role is nothing more than carrying out government directives and dealing with community conflicts. Hence, they remain indifferent to rural development programs unless the programs are exogenously initiated; and finally, since the farmer associations are a state 'enterprise' created by the *new* political authorities, the general attitude is to expect the state to nurture the needs of rural economic development.

Collectivization of the means of production is gradually gaining momentum. But, as indicated previously, most farm households still practice private ownership of some resources such as draft animals and land use-rights. In view of the need to build strong economic relations among the farmers, the non-socialization of the means of production seems desirable at the initial stages of rural development. It will provide a period for readjustment and reorientation of the traditional producers to a centrally planned and socialized agriculture. Private holding of the resources can be an incentive to the farmers to improve the traditional methods of production if modern technical inputs are available at favorable relative prices.

The farmer associations are ideologically viewed as temporary institutions. In the long-run, they will be replaced by producer cooperatives. In the short run, however, the farmer associations can "provide a growing locus of the institutional interface" (Cohen, *et.al.*, p. 17) between the agricultural development policies and agents of rural change. Cohn, *et.al.* suggest three priority functions for the farmer associations: (1) establish technical service institutions such as rural credit institutions, extension and marketing programs necessary for development; (2) raise resources for building physical infrastructure of rural development; and (3) determine priorities for social infrastructure such as schools, health and water development programs. These functions may require an able leadership that can initiate internally consistent programs. They may need to simplify

internal structure by reorganizing into different sub-units of "optimal" management groups. These groups will assume leadership responsibilities for maintaining various community development functions such as education, health. Achievement of their objectives can be monitored by (1) establishing standards, (2) linking accountability of the management units to higher level agencies and ministries, and (3) allowing farmers, as a group, to play a responsible role in generating resources and strategies for the development of their communities (Cohen, *et.al.*).

#### ***II.4.1.2. Service Cooperatives***

According to the 1983/84 estimates, there are 3,903 service cooperatives with a total membership of 17,074 farmer associations. They provide various types of services to 4,474,000 farm households. At least three but not more than ten farmer associations can form a service cooperative. The service cooperatives are controlled by fee-paying members. ✓

The service cooperatives have many goals some of which include: (1) procuring crop services; (2) providing marketing, credit and storage services; (3) supplying services of farm implements and grain mills; and (4) promoting the *Hibrete-sebawinet* objectives of producer cooperatives.

Potentially, the service cooperatives are useful for motivating basic community development services and linking the farm sector to the industrial sector. For example, from the time they began operation up to 1983/84, the service cooperatives purchased consumer goods worth of 113 million ✓  
Birr,<sup>40</sup> established 177 clinics, 269 schools, 2025 grain mills and 2476 stores. These facilities are owned collectively by members of the service cooperatives. The stores sell consumer goods such as cooking oil, sugar, salt, matches, clothing, footwear and some farm implements. They had a total capital of 157 million Birr collected from membership dues.

---

<sup>40</sup> US\$1 = 2.07 Birr

### II.4.1.3. Producer Cooperatives

The producer cooperatives represent a stage of the agrarian transformation in which almost all the means of production are collectively owned by the members of the cooperatives. The institutional transformations of the farmers developed thus far lead towards a consolidated system of farmer associations under the producer cooperatives. By the end of 1983/84, there were a total of 1,489 producer cooperatives. They controlled 313,085 hectares of land, 76 tractors, 82,166 oxen, and a capital of 45.8 million Birr. Labor input is provided by a membership of 94,368 farm households.

The 1975 Proclamation No. 71 outlined the following major objectives for the producer cooperatives: (1) socialize the factors of production (2) organize member farmer associations into small production groups (*habre* or brigade) of specialized agricultural cooperatives, (3) remunerate member producers according to the quality and quantity of their work,<sup>41</sup> and (4) strive for democratic rights, institutional unity and maturity of the political consciousness of their members.

The process of establishing the producer cooperatives is stratified into three stages: *malba*, *welba* and *weland*. Each stage of the cooperative development signifies a gradually diminishing private ownership of the means of production. For instance, *malba* is an elementary producer cooperative stage in which the members transfer up to 80 percent of a hectare<sup>42</sup> to the cooperative. The members, however, still possess private holding rights over the remaining 20 percent of a hectare and other resources including farm implements and drought animals. The private resources (such as drought animals) are paid rent for services rendered to the cooperative's income production activities. In the second stage of the cooperatives, *welba*, all the resources become communal

---

<sup>41</sup> It is possible to compute labor quantity of work perhaps in terms of average productivity of labor (measured either in man-hours or man-days), but it is not clear from the Proclamation how labor quality of work is determined.

<sup>42</sup> 1 hectare = 10,000 square meters.

property except 10 percent of a hectare retained for private household production. The *welba* cooperatives compensate their members for the farm implements and the drought animals that would become collective resources. The third stage of the resource socialization, *weland*, represents a higher stage in which the *welba* cooperatives unite in groups of up to 2,500 member households to establish specialized producer *habre* or brigade on the basis of 4,000 hectare-areas (or 5 farmer associations). The *weland* cooperatives are, for the most part, communes of the farmer associations with emphasis on division of labor and specialization in the production of agricultural commodities of a comparative advantage. A brigade may specialize, for instance, in the production of certain crops such as wheat or maize or in animal husbandry.

The efforts to establish the production brigades in Ethiopia appear to be fashioned after similar experiences of other socialist countries such as the USSR. However, no systematic analysis of the current and future development paths are available for the Ethiopian producer cooperatives.

#### ***II.4.1.4. State Farms***

The state farms are not totally new innovations of the current socialist government of Ethiopia. Majority of the farms are previous commercial farms that have been nationalized and have become state farms since the 1975 land reform. Institutional infrastructure and legal status of the state farms are centrally administered by the Ministry of State Farms Development (MSFD) that was established on May 2, 1979.<sup>43</sup> Some of the objectives of the MSFD are to: (1) organize farms that may specialize, for example, in cereals, fruit and vegetable production, livestock, poultry, and fisheries; (2) establish model state farms that will lead the producer cooperatives into modern farming; (3) produce agricultural commodities for domestic consumption and export market; and (4) produce sustainable raw materials (such as cotton, oil seeds) for domestic processing agro-industries. The organizational set up of the MSFD exhibits an institutional structure that

---

<sup>43</sup> This section on the development of the state farms draws from a discussion in Abegaz pages 111-209.

appears to have a "progressive" leadership in the areas of applied research and extension, planning, engineering, horticultural sciences, organization and systems development, administration and personnel management, and administration of financial resources. The MSFD is formally charged with responsibilities to administer eight categories (or functions) of the state farm corporations or enterprises: (1) Northern Agricultural Development Corporation (ADC), (2) Southern ADC, (3) Western ADC, (4) Vegetable and Fruits Development Corporation, (5) Livestock, Poultry and Fishery Development Corporation, (6) Awash ADC, (7) Agricultural Machinery and Implements Service Corporation, and (8) Ethiopian Selected Seed Enterprise.

The state farms experienced a rapid expansion in total cultivated land area in the 1980/81 production year. Abegaz, for example, notes that the total number of hectares planted to various crops by the state farms increased from 64,000 hectares in the 1975/56 production year to 293,000 hectares in the 1980/81 production year. These hectares were planted to cereals, pulses, oil-seeds, industrial crops, and cash crops. Out of the total hectares managed under the state farms scheme, for example, about 21,500 (or 33.7 percent) hectares and 206,200 (or 70.4 percent) hectares were planted to cereals in the 1975/76 and 1980/81 production years, respectively. ✓

Also, the farms enjoy relatively easy access to the sources of financial credit. Financial credit is obtained mainly from the Agricultural and Industrial Development (AID) Bank, a public financial intermediary of Ethiopia. For instance, Abegaz noted that between 1975/76 and 1978/79, the state farms received a total loan of 288,048,000 Birr from the AID Bank. The Bank charges up to 10 percent on the credits disbursed to the state farms. In addition to the financial resources, the AID Bank provides technical assistance in the areas of project planning and evaluation.

The state farms are distinctly different from farms in the traditional sector (that is, small-holder private farms and producer cooperatives) in many ways. First, organization of the state farms represents a centralized institution with which agricultural development can be accelerated on the basis of socialist principles. Second, the farms focus on a modern system of agriculture that may

increase demand for advanced knowledge and institutional innovations within a predominantly traditional agricultural sector. Third, the state farms have a potential to facilitate diffusion of modern science and technology into the traditional sector. If there is an effective link between the state farms and the private farm sector, the state farms may offer positive externalities (such as advances in agricultural technologies and reductions in the cost of production) with which the traditional sector can achieve internal economies of size. Furthermore, it may be speculated that the link between the modern and traditional components of the farm sector can improve the momentum of the overall agricultural development of Ethiopia. The next section will evaluate the relative influences of the state farms, producer cooperatives and small-holder private farms in input allocation, income production, structure of taxes and farm prices in Ethiopia.

#### **II.4.2. A Cursory Assessment of Post-1974 Agricultural Development**

Ethiopian agricultural development is 'inseparably' linked to the rest of the economy through centralized policies with which the state influences consumption and production activities. Agriculture has a potential to generate social surplus useful for the growth of the rest of the economy. Realization of this potential may depend on factors such as input allocation policies and price policies. These policies may impact upon household income production and consumption, rural employment, food security to the nation, and the overall process of national economic development. Farm inputs are allocated between two broad categories of agricultural sectors: (1) traditional sector and (2) state sector. As discussed previously, the traditional sector consists of small privately operated traditional farms and producer cooperatives. Producer cooperatives are collectively operated farms by groups of farmers who have socialized the productive resources such as land, labor and capital. The three types of farms (private, cooperative and state farms) tend to be structurally (in terms of size, number, capital, and so on) different from each other. The following two sections illustrate how some key input resources are allocated, farm income is produced and surplus is extracted from agriculture.

### *II.4.2.1. Farm Input Allocation*

Government policies so far have secured the predominance of the state farms in terms of the flow of modern farm inputs. Rahmato notes that both state farms and producer cooperatives "are large scale enterprises, use more improved methods and modern inputs, and are given more attention and encouragement than private farms" (p.72). Due to this policy, differences may exist between factor proportions, factor productivities, farm efficiencies, and between the composition of output and capital formation.

The rate of capital formation and the potential of the farms to support sustained growth of social surplus may depend on: (1) farm input supply and demand relationships; (2) factor productivity and; (3) input concentration. Usually, in an environment where the state does not intervene, the interaction between supply and demand reveals the value of the products and payment to the factors (land, labor, capital) for their services. Rural land and labor markets do not exist due to the new state law. These markets are substituted by a state monopoly responsible for allocating resources and products of the society. The state also manages prices for these commodities. It is not clear what method is used for allocating resources and determining prices. It, however, appears that the state relies on "cost-plus" method to determine producer prices. discretion. Based on limited observation, it also appears that more resources are directed to state farms and producer cooperatives. These two farm types promote socialist objectives of the state and are "perceived" to have a higher potential for output production than the private farms.

The coexistence of the private, cooperative and state farms indicates that they are interlinked in, at least, two ways: (1) through state policies that govern allocation of agricultural resources and (2) through the farm "labor market." Table II.6 shows how cultivated land area and farm labor were allocated among the private farms, producer cooperatives and state farms in the 1982/83 crop production year. About 94 percent of the total land area planted to annual food-grains in 1982/83 was operated by the private farms, whereas approximately 2 percent and 4 percent of the area was

cultivated by producer cooperatives and state farms, respectively. State farms are small in number, but they are relatively much larger than the farms in the traditional sector. Also, it should be noted from the table that the private farms employed about 98.7 percent of the farm families engaged in annual food-grain production. The producer cooperatives employed 1.3 percent of the farm families. Relative to the other two farm types in the traditional sector, the state farms are capital intensive and the demand for farm labor is met by unskilled workers from the traditional farm sector. Ghose (1985) noted that the state farms with about 4 percent of the cultivated area consumed 76 percent of chemical fertilizer and 95 percent of improved seeds in the 1981/82 production period.

The nationalization of the rural land was accompanied by a provision for free distribution of up to ten hectares to farm households including previous tenants, landless persons, agricultural wage labor, and landowners of less than ten hectares. Pensioned persons who are willing and able to personally (that is without a help of hired labor) cultivate are also entitled to ten hectares. Individual farmers have the right to use the land as long as they wish to farm, but they can not transfer the land to a third party either through sale, lease, or mortgage. The ten-hectare allotment imposes an upper limit on the private holdings of land. In combination with restrictions on the land market and wage labor employment (except in the state farms), the ten-hectare limit is likely to prevent the sector from gradually developing into a capitalist mode of production.: The establishment of such a limit on private land holdings is, however, not unique to Ethiopia. Historical records of other socialist countries, for example, show that private land holdings were limited to a maximum of 100 hectares in German Democratic Republic, 20 hectares in Poland, 50 hectares in Hungary, Rumania, and Czechoslovakia (Stanis, 1976).

In practice, the availability of the agriculturally suitable land and economically active agrarian population engaged in the agricultural production may influence the actual size of land holdings. Despite the efforts to bring about an egalitarian distribution of rural land, there seems to exist negligible improvement between the pre- and post-reform private land holdings. For the most part,

**Table II.6. Allocation of Cultivated Land Area and Farm Labor Employment Among Three Farm Types in Ethiopia (1982/83)**

	Hectares		Farmers Employed	
	(X000)	%	(X000)	%
Private Farms	5546	94.4	7106	98.7
Producer Cooperatives	114	2.0	94	1.3
State Farms	213	3.6	--	--

Source : Ghose (1985) p. 131

land distribution is still unequal. Ghose notes some reasons for sustaining uneven land holdings: (1) regional differences in the man/land ratios, (2) farm households who traditionally produce permanent crops, such as *enset*, are allowed to retain relatively large farms, and (3) since land is distributed on per person basis, the differences in land-holdings indicate differences in the size of farm households.

Abate and Kiros, on the other hand, studied the private land holdings in a sample of four *weredas* (Ada, Welmera, Dangla and Dodota) and indicated average size of land holdings before and after the land reform generally remained the same.<sup>44</sup> Prior to the land reform, for example, average land holdings per farm household in Ada, Welmera, Dangla and Dodota were 3.27, 2.45, 3.29, and 3.72 hectares, respectively. The average land holdings in each *wereda* after the reform were 2.36, 2.6, 2.85, and 3.38 hectares, respectively. The authors suggest three possible explanations for the no-change situation in the average land holdings relative to the pre-reform ownership of land. First, since the farmer associations are established within the 800 hectare-areas, the available land is distributed among members of each farmer association. In other words, no additional land was brought into production outside this upper bound. Second, even though some lands previously owned by landlords came under the collective ownership of the members of the farmer associations, the maximum land area still remained within the legal limit of the 800 hectares. Finally, since land had to be 'equally' allocated, the redistribution of relatively large and small holdings averaged out the potential differences in private land holdings. But, both Abate and Kiros and Ghose do not explain why post-reform land-holdings have slightly declined relative to the pre-reform holdings. Two reasons can be postulated based on land measurement practices and changes in rural population.

First, since there is no uniformly documented measurement of land-holdings, it might be difficult to know precisely how much land is allocated to the farm households. In other words, the

---

<sup>44</sup> Both Ada and Welmera *weredas* are in Shewa province whereas the other two are found in Gojjam and Arssi provinces, respectively.

before and after reform land-holdings might be guesstimates made without adequate information. Due to lack of nationally established uniform standards for land distribution, farmers have developed different criteria which vary from location to location. They consider such factors as quality and quantity of the allocable land, landlessness of their members, previous social status and land holdings, and individual ability to effectively till the land. At least, two methods are used by farm leaders responsible for land distribution: (1) traditional justice combined with culturally tolerable mixes of fairness and partiality, and (2) visual estimates which are often challenged by farmers on the basis of favoritism and nepotism.

Second, there might be an increase in demand for land due to changes in demographic factors including return-migration and eligibility of new members of age 18 and above. Some landless farmers who out-migrated prior to the reform in search for off-farm employment have returned to their indigenous localities. Those who have attained a minimum of 18 years of age can claim a portion of land thereby increasing demand for the limited but allocable agricultural land. Since the majority of the new entrants into the farming profession are young and may not have initial capital nor adequate traditional wisdom, they are reluctant to move into new areas unless enlisted in a resettlement program. They prefer to remain within their farmer associations where family and community assistance is readily available. This may lead to a cyclical redistribution of the land which is likely to result in the reduction of individual land-holdings. Rahmato writes that some localities have already implemented as many as four redistributions since 1975.

Nationally, the average size of land-holdings appears to be smaller than the holdings reported by Abate and Kiros. For instance, as shown in table II.7, the average holdings vary from the lowest of .58 hectares in Sidamo province to the highest of 2.16 hectares in Arsi province. Land appears to be scarce relative to the population in the first four provinces while it looks relatively abundant in the remaining ten provinces.

**Table II.7. Average Land Holding by Region in Ethiopia (Hectares Per Holding, 1983/84)**

Region	Holding
Gamu Goffa	0.86
Sidamo	0.58
Harrage	0.91
Keffa	0.86
Wello	1.57
Illubabor	1.09
Bale	1.18
Shewa	1.39
Wellega	1.59
Arsi	2.16 ✓
Gojjam	1.80
Gondar	1.90

Note : Table doesn't include Eritrea and Tigray provinces

Source : Table 54 in World Bank,, *Ethiopia: Agricultural Sector Survey*

The redistribution and fragmentation of the limited land will continue as long as population pressure exists. Lack of off-farm employment and/or low labor values outside the traditional sector confine the farmers to subsistence production. It is possible that continued redistribution, fragmentation, and population pressure will result in diminishing returns to labor. The law of diminishing returns can prevail regardless of the political ideology unless prevented from operating by reducing additional application of labor to the fixed land. When the traditional agriculture is at the stage of diminishing returns and if it is required to produce a larger volume of output by employing more labor, the cost of production may overwhelm farm revenue thereby reducing income of the farm community. Ramifications of the reduced farm income are likely to be noticed in terms of rural malnutrition, poverty, and, generally, low level of social welfare.

The traditional sector employs relatively small amounts of non-traditional inputs such as credit and improved seeds. If readily available and widely used, these inputs may help the farmers to remove limitations to agricultural production. The input credit extended to the traditional sector by the Ministry of Agriculture between 1978/79 and 1983/84 is shown in table II.8. At least three observations can be drawn from the table. First, average credit consumption by the private sector appears to be increasing in each region. Second, regional differences in agricultural output and productivity are implied by an uneven distribution of the input credit among the regions. Finally, three (Shewa, Arsi and Gojjam) out of five traditionally prominent surplus food producing regions (the three plus Gondar and Wello) together received over 70 percent of the total credit outlays extended to the farmers. The table is not discrete enough, however, in terms of credit allocations between the two types of farms contained in the traditional sector (private farms and producer cooperatives). Given the general policy emphasis on promoting a socialist mode of production, it is conceivable that the producer cooperatives were beneficiaries of most of the input credits.

The Ethiopian Improved Seed Corporation distributes improved seeds among the private, cooperative, state farms, and settlement farms (table II.9). The settlement farms are relatively new. Generally, the settlement farms are operated by farm households trans-located from their

**Table II.8. Input Credits Transferred by MOA to Traditional Farm Sector (X000 Birr)**

Region	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
Arsi	2912	3220	5669	5071	4456	6000
Bale	448	562	556	866	288	101
Eritrea	140	519	39	79	87	87
Gamu Goffa	32	70	87	37	84	76
Gojjam	1322	3297	3442	2416	910	2098
Gondar	94	447	537	167	249	244
Harrage	383	2124	246	275	178	407
Illubabor	80	83	108	77	62	88
Keffa	1243	1493	1801	1661	1074	1120
Sidamo	305	628	324	223	158	110
Shewa	5178	10972	15377	14352	11878	14647
Tigray	4	253	162	151	--	1
Wellega	1000	1330	1257	1016	996	704
Wello	--	--	82	196	36	11
<b>Total</b>	<b>13141</b>	<b>24998</b>	<b>29687</b>	<b>26587</b>	<b>20456</b>	<b>25984</b>
Shewa	39%	44%	52%	54%	58%	56%
Arsi	22%	13%	19%	19%	22%	23%
Gojjam	10%	13%	12%	9%	4%	8%
<b>% of Total</b>	<b>71%</b>	<b>70%</b>	<b>83%</b>	<b>82%</b>	<b>84%</b>	<b>87%</b>

Note : MOA = Ministry of Agriculture

Source : Table 37 in World Bank,, *Ethiopia: Agricultural Sector Survey*

**Table II.9. Land and Improved Seed Allocation in Ethiopia (Percent of Total by Farm Type)**

Farm Type	1980/81			1981/82			1982/83		
	Seed	Land	Output	Seed	Land	Output	Seed	Land	Output
State Farms	79	2.6	3.9	80	3.5	4.6	66.9	3	3.4
Private Farms	16.4	95.9	95.1	14.4	94.3	94.2	26.9	94.4	95.3
Producer Coops.	0.6	1.5	1.0	1.6	2.2	1.2	2.5	1.9	1.3
Settlement Farms	4	-	-	4	-	-	3.8	-	-
Total	100	100	100	100	100	100	100	100	100

Note : Seeds are measured in tons, land in hectares but the source does not specify units for output.

Source : Seed %--Table 43 in World Bank, *Ethiopia: Agricultural Sector Survey*  
Land and Output %--Ghose (1985) Table 2, P. 132

indigenous localities perhaps due to environmental degradation (such as soil erosion, drought), and/or population pressure on limited land resource. Categorically, they belong to the private farm sector. In the three-year period (1980/81-1982/83), 60-80 percent of the total improved seed allocation went to the state farm sector. During this period, the state farms cultivated 3 percent of the total land area planted to major food-grains. On the other hand, The private farms and the producer cooperatives, cultivated 95 percent and 2 percent of the crop area, respectively. But the state farms contributed an average of 4 percent of the total food-grains output whereas the private farms and producer cooperatives contributed 95 percent and 1.2 percent of the food-grains output, respectively. Based on these statistics, a few observations are in order. First, private and cooperative farms appear to be relatively less 'efficient' than the state farms in the sense that the state farms produce 4 percent of total output from 3 percent of land. Second, allocation of more modern technical inputs to the state farm sector than the traditional sector can have a "taxing" effect on the traditional sector. Third, despite limited access to modern technical inputs, the traditional sector still contributes relatively the largest share of agricultural output.

A rational combination of an investment in private farm labor development and a supply of modern inputs is likely to improve labor productivity. Increased labor productivity can be postulated to have at least three important effects. First, it can increase farm household income thereby gradually freeing the farmers from the deadlock of subsistence and drudgery. Second, agriculture's capacity to support national economic development can be enhanced and, third, intensive land and labor employment might become a viable possibility. Based on experience in India, Kanel (1967) notes that, "intensive use of self-employed labor on small farms is desirable in countries experiencing population pressure. The whole labor force can not obtain wage employment at a subsistence wage, if the ratio of population to resources is so high that the marginal productivity of labor is less than subsistence. In such cases, it is the more intensive organization of family farms which offers access to income to many of those who do not find wage employment, and helps to maintain wage levels in the labor market" (p. 35).

Kanel is assuming a competitive environment where wage is determined by the interaction of supply of and demand for labor (see Chapter 6). This is different in the case of Ethiopia where wages are centrally determined by the state. The state farm sector relies on wage-labor imported from the traditional sector. It pays a fixed wage rate of 1.92 Birr per man-day. Existing literature does not show whether this wage rate is different from the marginal value product of farm labor. Some have observed a decline in the flow of labor into the state farm sector because of the low wage rate (perhaps even lower than its marginal value product) relative to what the workers can generate if employed in the state farms. Others (for example, Abegaz, 1982) note that the major causes of the decline in farm labor supply are: (1) an increase of labor employment within the traditional sector as a result of the land reform and intensive use of it, (2) farmers ability to earn more income from self-employment on their farms, (3) low labor value per unit of time and unfavorable living conditions offered by the state farm sector, and (4) environmental conditions that expose workers to tropical diseases.

#### ***II.4.2.2. Income Production***

The land reform has resulted in many economic advantages to the rural population. The most notable impact has been an increase in rural income production. A study (by Abate and Kiros) of economic changes in rural regions since the land reform by indicated that income, consumption, and production activities have increased for a majority of the traditional producers. Nearly 70 percent of a random sample of 295 farmers in Ada *wereda* responded that they were consuming, saving, and selling more of their output and buying more non-agricultural goods than before the land reform. Summary of the study is illustrated in table II.10.

As indicated previously in table II.3, cereal production is the main source of income for most of the rural Ethiopia. The relative shares of output and land use trends of cereal crop production between 1979/80 - 1983/84 are illustrated in table II.11. Three cereal crops, maize, sorghum and

**Table II.10. Indicators of Rural Income Change Since Land Reform in Ethiopia**

Indicators	Response Number	% of Total Response
Consume more of own produce	276	93.6
Buy more non-agricultural goods	201	68.1
Save more grain	204	69.2
Sell more grain	200	67.8
Sell less grain	33	11.2
produce less grain	12	4.1

Source : Abate and Kiros in Ghose (1983) p.178

*teff*, together contributed nearly 67 percent of total output realized from 65 percent of total land area planted to all cereal crops. Relative contribution of individual cereal crop, however, oscillated between the lowest of 3 percent for millet/oats in 1979/80 production year and the highest of 28 percent for maize in 1983/84 production year. Put differently, the relative contribution of the crops varied by an annual average factor of 2 percent for each crop over the five year production period. The share of land use, however, varied by an average factor of about 1.4 percent annually.

The cereal grain production trends are further illustrated in table II.12 in which the changes in land use, output, productivity, and output elasticities with respect to land are shown for all farms (private, cooperative and state farms). The table indicates that both total output and total land area planted to the cereal crops declined by about an average of 2.9 million tons and 143.4 thousand hectares, respectively, during the 1979/80 to 1984/85 production period. The overall marginal and average (inverse of land & output ratio column) physical productivities of land are computed to be 27 and 12 tons of cereals, respectively. The overall cereal grain responsiveness averaged at about a 2 percent change in output for a 1 percent change in cultivated land area.<sup>45</sup>

The above examples illustrate changes in aggregate cereal production in Ethiopia for all farm types. Changes in the production activities have, however, not been uniform among the farm types. Between 1979/80 and 1983/84, total land area planted to the cereals by the private sector declined by an average of 90,750 hectares. This resulted in a loss of nearly 2.3 million tons of cereal production (table II.13). During this period (that is, 1979/80-1983/84), the producer cooperatives and state farms, expanded average land area by 3500 and 11000 hectares, respectively. Consequently, cereal production by the producer cooperatives increased by nearly 13,000 tons and that of the state farms increased by nearly 96,250 tons between 1979/80 and 1983/84.

---

<sup>45</sup> The decline in cereal land and total product is perhaps the result of such factors as drought, farmers time reallocated to internal institutional development, and land redistribution.

**Table II.11. Cereal Production and Area Cropping Pattern in Ethiopia (Percent)**

	1979/80		1980/81		1981/82		1982/83		1983/84		Average	
	pdn	lnd										
<i>Teff</i>	22	29	23	29	20	29	20	28	20	28	21	29
Barley	16	16	19	16	17	14	17	16	15	17	17	16
Wheat	9	17	11	18	13	17	14	18	12	17	12	17
Maize	24	9	17	11	22	15	24	14	28	13	23	12
Sorghum	26	25	25	21	22	18	20	18	22	19	23	20
Millet/Oats	3	4	5	6	5	7	5	6	4	6	4	5
<b>Total</b>	<b>100</b>											

Note : Pdn = Percent of total cereal production  
Lnd = Percent of total cereal land area

Source : World Bank, *Ethiopia: Agricultural Sector Survey*  
Annex 3, Tables 3 and 8.

**Table II.12. Changes in Cereal Area, Output and Productivity of Land in Ethiopia (all farms)**

(A) Production Period	(B) Change in land (X000 ha)	(C) Change in Output (X000 tons)	(D) Marginal Product	(E) Land & Output Ratio	(F) Output Elasticity with respect to Land
1979/80-1980/81	-311	-7911	25.44	.081	2.0635
1980/81-1981/82	-83	-2175	26.20	.085	2.2262
1981/82-1982/83	+ 400	+ 13231	33.08	.087	2.6406
1982/83-1983/84	-313	-11842	37.83	.0796	3.0124
1983/84-1984/85	-410	5589	11.63	.086	1.1717
Average	-143.4	-2857	26.84	.0837	2.2200

Note : Values shown under columns D, E, and F are computed as follows:

$$D = C/B, E = \text{land/output}, F = D \times E$$

Source : Computed from Table 5 in World Bank, *Ethiopia: Agricultural Sector Survey*

**Table II.13. Changes in Cereal Area, Output and Productivity of Land in Ethiopia (by farm type)**

(A) Production Period	(B) Change in land (X000 ha)	(C) Change in Output (X000 ton)	(D) Marginal Product	(E) Land & Output Ratio	(F) Output Elasticity with respect to Land
<i>Private Farms</i>					
1979/80-1980/81	-362	-8329	23.01	.081	2.86
1980/81-1981/82	-23	-2581	112.2	.086	9.65
1981/82-1982/83	+ 350	+ 13396	38.27	.081	3.1
1982/83-1983/84	-328	-11620	35.43	.08	2.82
Average	-90.75	-2284	52.23	.082	4.36
<i>Producer Cooperatives</i>					
1979/80-1980/81	-29	-420	14.48	.081	1.17
1980/81-1981/82	+ 9	+ 75	8.33	.085	0.71
1981/82-1982/83	+ 1	+ 109	109.0	.080	8.72
1982/83-1983/84	+ 33	+ 288	8.73	.081	0.71
Average	3.5	+ 13	35.14	.082	2.88
<i>State Farms</i>					
1979/80-1980/81	+ 80	+ 838	10.48	.082	0.86
1980/81-1981/82	+ 33	+ 331	10.3	.085	0.88
1981/82-1982/83	-51	-274	5.37	.081	0.43
1982/83-1983/84	-18	+ 510	28.33	.08	0.54
Average	+ 11	+ 96.25	13.62	.082	1.12

Note : Values shown under columns D, E, and F are computed as follows:

$$D = C/B, E = \text{land/output}, F = D \times E$$

Source : Computed from tables 11, 17, 18, in World Bank, *Ethiopia: Agricultural Sector Survey*

It is interesting to note that cereal output that was lost by the small-holder private farms was not fully recovered by the remaining two types of farms. Both the producer cooperatives and the state farms combined recovered only about 5 percent of the 2.3 million tons of the cereal production foregone by the private farms due to the inter-farm transfer of land. Thus, based on these cursory observations and assuming that land is the only variable factor of cereal production, it can be asserted that cereal income production declined by about 90 percent on the average during the 1979/80-1983/84 period.

Perhaps another way of studying the relative importance of the farm types is to analyze productivity indicators such as marginal and average productivities and output elasticity of cereal production with respect to land. The information summarized in table II.13 indicates that the average product of land is uniformly consistent among the farm types. The private farms appear to realize relatively more marginal product for every additional hectare of land than the other two types of farms. That is, the marginal productivity of land planted to cereal crops under the private farming system is 52.23 tons, whereas it is about 35.14 and 13.62 tons under the producer cooperatives and state farming system, respectively.

Cereal output appears to be 2 to 4 times more responsive to a 1 percent change in land area cultivated by private farmers. If cereal land area cultivated with all farms is increased by 1 percent, for example, private farm output is likely to increase by an average factor of 4.36 percent, whereas it may increase by 2.88 percent and 1.12 percent if the same hectare is cultivated with the cooperative and state farming techniques, respectively. If, as before, both the private farms and the producer cooperatives are categorized in the traditional sector, cereal output in this sector is about 3 times more responsive with respect to land than the state farm sector. It should be noted that significance of the above values is not statistically established and they must be interpreted with caution.

While an economic potential exists for Ethiopian agriculture to generate a net marketable food surplus, the actual realization of the potential is limited by its (agriculture's) internal structure and external factors. For the most part, the internal structure is made up of many small producers who exhibit dual behavior of producing and consuming their own labor, small plots of land, and low level of traditional technology. Other things being equal, output production and consumption activities of the farmers are influenced mainly by changes in the stock of labor, valued at relatively low wages. The low labor value, however, is the likely feature of low labor skills and lack of mobility. Also externally, factor allocation decisions of the agricultural policymakers and technical developments in the non-agricultural sector have not been capable of bringing substantial cost reduction to the production and movement of both agricultural inputs and outputs. The traditional sector has not been independent of the institutional externalities (in the sense of socialist government interventions) in order to fully influence the national market for its labor and agricultural commodities. Partly due to these internal and external limitations, neither has the traditional sector been successful in modernizing its mode of production.

The production and consumption behavior of the Ethiopian private producers appears to be consistent with that of the private producers in other developing countries. That is, most farmers in Ethiopia still exhibit a high income elasticity of demand for their own output. A large proportion of their output is devoted to ensuring internal security of subsistence consumption. Deme (1979) reports that in 1973/74, the traditional sector consumed about 65.5 percent of the total farm output. But Ghose recently noted that the agrarian sector consumed about 88.8 percent of the gross agricultural output in 1977/78. The increase in consumption is perhaps the result of an increase in rural income due to the land reform. It is likely that rural consumption will decline in the future due to a change in the rural income growth. A combination of at least two factors will play a major role in the change of rural income growth. First, current income growth may level off because of a faster population growth relative to food production. Second, (as it will be discussed below) efforts of the state to coordinate large transfer of agricultural surplus to the non-agricultural sector are likely to constrain rural income accumulation within the agricultural sector.

### ***II.4.2.3. Income Distribution, Taxes and Prices***

The size of the marketable agricultural surplus production may depend on a combination of: (1) gross income production; (2) marginal propensity of the farmers to consume food; (3) availability of non-agricultural consumer goods; (4) tax policies; (5) relative prices of farm output and purchased inputs; and (6) commonly used options to invest and/or to save unconsumed surplus. Since the 1975 land reform, most of the agricultural surplus is transferred to the urban sector at least in three ways.

First, the state requires compulsory deliveries of predetermined food-grain quotas at prices fixed at low levels compared to free market prices. The service cooperatives deliver the food-grain quotas from private farmers to a state institution, the Agricultural Marketing Corporation (AMC). In 1981/82, wheat producers received 31.00 Birr per 100 kg AMC price whereas the same unit of wheat was paid 40.00 Birr at local markets. Also, AMC purchases directly from the merchants, producer cooperatives and state farms with fixed prices.

Second, a certain portion of the remaining food-grains after the quota is sold to independent merchants who offer relatively higher market prices than the AMC. Third, what the state does not collect through direct quota system, is transferred through a newly established agricultural tax system. At least three forms of taxation --land-use rent, agricultural income tax and expansion of state farm sector-- are used within the system.

A fixed but slightly differentiated amount of land rent is levied on traditional and state farm sectors. Deme notes that private farmers who have not joined socialized agriculture (such as producer cooperatives) pay a land use-fee of 4.00 Birr per hectare whereas the producer cooperatives and the state farms pay 3.00 Birr per hectare. Collection of the rent by the state (similar to the old system within which landlords, but not the state, collected rent) is justified on the grounds that farm land has become state property. Rent, therefore, measures the value of land or a premium payment

for its services leased by the producers from the state. The likely goal of the higher land-use rent levied on the private sector than on the socialized sector is to discourage private production. But, it is not clear how the rent is determined.

If the rent is based on what the producers can afford to pay, then the policy acknowledges, at least implicitly, that the traditional sector is relatively more well-off and even more productive than the socialized sector. If it is determined on the basis of the natural characteristics of farm land (such as fertility, stoniness, slope, level of development), then the state believes that privately operated land is more valuable and more productive than the land cultivated by the socialized sector. Certainly, all lands do not deserve equal premium because there would be marginal lands which produce very little in the absence of land substitute inputs such as fertilizer. Marginal lands should deserve very little rent. There are other types of lands capable of yielding 'generously' with minimum effort and deserve a higher rent than the marginal lands. There might be another category of land that is neither marginal nor generous (fertile) that should be paid an average rent. In addition, location factors such as proximity to urban centers and access to modern transportation facilities can influence the level of land rent.

Farm lands in Ethiopia are not thoroughly studied and classified. The two levels of land rent (3.00 Birr and 4.00 Birr) might have been determined without adequate information. Perhaps other than politically motivated objectives such as to encourage individual farmers to join the producer cooperative, reasons for the higher rent charge to the private farm sector and lower rent to the socialized sector are not obvious. It would be economically rational choice for farmers in the traditional sector to "migrate" to the socialized sector only in response to differences in real income between the two sectors. Thus, forcing farmers to join the producer cooperatives by charging higher land-use rent may primarily serve a political objective while creating a deadweight loss in farm income and state revenue which may not be captured in other sectors of the national economy.

The private farmers who possess use-rights for the marginal lands may become a “new” class of farmers victimized by unwritten policies of disinvestment. As discussed previously, the goal of such policies seems to be transferring agricultural “surplus” without much concern as to how that surplus is generated within the sector. The impact of such policies can be felt through a decline in consumption by this (marginal) class of farmers mostly due to: (1) an adjustment in consumption behavior to meet legal obligations to pay the rent; (2) relatively higher rate of grain seeds retained for the next production season than other farmers who cultivate fertile lands; and (3) a decline in unconsumed surplus food-grain marketed (exchanged) for non-agricultural goods. The ban on land transfer either through lease or sale may enhance the reduction in consumption by limiting farmers’ access to more productive land. It is likely that the uniform land-use policy of the state can influence marginal farmers’ ability to fulfill normal nutritional needs thereby leading to malnutrition and rural poverty.

In addition to the land rent, a slightly differentiated agricultural income tax system is established for all farm types as follows. A lump-sum tax of 3.00 Birr is collected from farmers who produce gross annual income of not more than 600 Birr, 4.50 Birr for gross annual income between 601 - 900 Birr, and 6.00 Birr from gross income between 901-1200 Birr. Each Birr of farm income in excess of 1200 up to 33000 Birr is categorized into lower and upper bounds by a constant interval of 3000 Birr. Farmers who produce a gross income not less than 1201 Birr and are members of the socialized sector may pay a fixed tax rate of 50 percent on all net income up to ‘infinity’. On the other hand, private farmers who produce gross annual income between 1201 Birr and 33,000 Birr pay linearly graduated net income tax rates shown in table II.14. A fixed net income tax rate of 70 percent is assessed on all gross annual income not less than 33,001 Birr up to ‘infinity’.

The third factor of the agricultural tax, a rapid expansion in the state farm sector, may not be readily obvious. The state farms have been instrumental in surplus extraction from the subsistence sector. This is coordinated in two ways. First, accelerated growth in the number and size of the state farms has shifted flow of the modern technical resources away from the subsistence sector. Perhaps

**Table II.14. Agricultural Tax Structure of Socialist Ethiopia**

Taxable Gross Income (Birr)	Tax Rate (%)	Lump-Sum Tax (Birr)
<i>1. All Farms:</i>		
0 - 600		3.00
601 - 900		4.50
901 - 1200		6.00
<i>2. Private Farms:</i>		
1201 - 3000	10	
3001 - 6000	15	
6001 - 9000	20	
9001 - 12000	25	
12001 - 15000	30	
15001 - 18000	35	
18001 - 21000	40	
21001 - 27000	50	
27001 - 33000	60	
33001 → ∞	70	
<i>3. Socialized Sector:</i>		
1201 → ∞	50	

Source : Lesanework Deme, Table 1 p. 3

this was guided by an assumption that the rate of return (or food production) to investment is higher in the state farm sector than in the subsistence sector. Such a shift, however, affects productivities, relative rates of capital formation and income growth in the subsistence sector. That is, if all the modern resources such as trained human capital with advanced farm management skills, machinery power, and manufactured chemical inputs are invested in the subsistence sector at the rate that they are invested in the state sector, it is likely that collective welfare of the rural communities will be improved significantly through a multiplier effect. But given the observed experience of the high income elasticity of demand for food in rural regions, the farmers may not release the amount of food needed outside the sector. In that case, the government may have to impose a high tax on the subsistence sector. But, high taxes will not ensure political alliance, confidence and full participation of majority of the farmers in the implementation of the socialist transformations. Therefore, modernization of the state farm sector avoids direct confrontation with the farmers while meeting state objectives of food production for urban and armed forces consumption.

Second, state farms depend on two types of labor inputs, skilled and unskilled workers. The skilled labor force is "permanently" employed on jobs such as machinery operation, farm management and accounting. Naturally, the skilled workers are paid high wages relative to the unskilled and semi-skilled seasonal workers. The subsistence sector acts as a reservoir of the unskilled and semi-skilled workers on which the state farms depend for production activities that can be performed with minimum supervision and traditional wisdom. There is a feeling among some observers (Ghose and Abegaz, for example) that this class of laborers are generally paid less than their average product on the state farms. Given constant prices for labor output, the total wage bill paid to the farm labor appears to be much smaller than the surplus labor value taxed (or extracted through low wages) by the state farm sector. These two policies (low farm labor wage deliberately fixed by the state and the rapid flow of the modern inputs in favor of the state farm sector) may impose a systematic form of 'taxation' (other than direct agricultural taxes) by virtue of forgone income and technological opportunities.

The manner in which the agricultural taxation policies (as illustrated above) are implemented provides some indication of how the government goes about redistributing agricultural income within and between sectors. The overall tendency seems to be one directional. That is, between sectors, the redistribution of income flows mostly from rural to urban and, within agriculture, it flows from relatively "poor" or marginal farmers to relatively "rich" farmers, and from subsistence sector to state sector. Thus the differential tax system appears to be used to redistribute agricultural income production from politically powerless and economically poor to politically powerful and economically well-off.

In addition to their instrumental role in the transfer of agricultural surplus, the state farms are, in the long run, expected to generate positive externalities to the subsistence sector. They are to set a production norm for modern agriculture and to provide technical assistance to other farms, especially, to the producer cooperatives and settlement farms.

In the short run, the goal of the state farms is to maximize food production. This appears to be pursued without much concern for a least cost combination of resources. Table II.15 illustrates relative cost competitiveness of the private farm sector and state farm sector in the production of import substitute crops of wheat and maize. While both farm types produce the same amount of wheat per hectare and receive identical world price per ton of wheat, for example, the state farms incur relatively higher cost of production to produce a hectare of wheat than the private sector. In almost all cases of domestic cereal production, the private sector generates a social profit after all the variable and fixed inputs are paid for their services. On the other hand, allocation of the same inputs in the state sector produces a social penalty after all inputs are compensated for their services.

Relative cost competitiveness of the private and state farm sectors is compared by the ratio of domestic resource cost to the international value-added. For every Birr of the international value-added, the private sector expends 0.6 Birr worth of domestic resources on a hectare of wheat production. The state sector expends about 7.00 Birr (in absolute terms) worth of domestic

**Table II.15. Cost Competitiveness of Private and State Farms in Ethiopia (1983/84)**

	Private Sector		State Sector	
	Wheat	Maize	Wheat	Maize
1. Average yield (tons/ha)	1.13	1.79	1.35	2.63
✓ 2. World price	414	323	414	323
3. Gross income	468	578	559	850
<i>Traded Inputs at World Prices:</i>				
4. Variable Inputs	102	16	728	613
5. From farm to Addis Ababa	149	234	123	236
6. Between Borders (Assab) & Addis Ababa	176	279	211	356
<i>Non-traded Inputs at Domestic Prices:</i>				
7. Variable Inputs	62	68	0	0
8. From Farm to Addis Ababa	69	95	83	132
9. Between Borders (Assab) & Addis Ababa	87	126	106	183
<i>On Farm Factor Remuneration :</i>				
10. Fixed Cost	190	211	587	687
11. Social Profit = (3 + 6 + 9) - (4 + 5 + 7 + 8 + 10)	159	359	-645	-279
12. International Value Added = (3 + 6) - (4 + 5)	393	607	-81	356
13. Domestic Resource Cost = (7 + 8 + 10) - 9	234	248	564	636
14. Cost competitiveness (13/12)	0.6	0.41	-6.96	1.79

Note : Value is in Birr, Unit of Analysis = 1 Hectare ✓

Source : Computed from Table 63 in World Bank, *Ethiopia: Agricultural Sector Survey*

resources to produce the same hectare of wheat. No conclusive statement can be made from these results without investigating technological similarities and differences that may exist between the farms. However, tentatively it can be postulated that the private farm sector is relatively more cost competitive and socially more profitable than the state farm sector.

Despite structural differences between the farm sectors, the institutional setting with which the state farm sector is operated and production decisions are made may have some influence on the competitiveness of the state farms. For instance: (1) the overall resource allocation decisions to the state farm sector are made by planning authorities in light of the macroeconomic policies, (2) prices are exogenously determined by the planning authorities, and quite commonly, (3) management benefits (for example, job security, promotion) are granted mostly on the basis of production-quota achievements rather than producing at the lowest cost. The state farms are, therefore, more likely to incur a higher cost of production than the private sector. In fact, the relatively higher cost of production of the state farms is explicitly acknowledged by policymakers to the extent that commodities produced by the state farm sector are preferentially priced at higher domestic prices relative to the prices of the same products marketed by the private sector. Abegaz notes that despite such effort on the part of the policymakers, the state farms usually operate at a loss because the prices offered are not high enough to cover the cost of production.

Favorable agricultural output prices can be sufficient inducement for the traditional farms to produce more marketable surplus. In the short-run, this may mean a movement on the same supply function subject to the traditional technological constraints. If the farmers are to overcome this constraint and expand their production possibilities frontier, perhaps what matters is relative output prices to agricultural input prices. Favorable output prices relative to input prices can encourage the subsistence sector to implement modern technical inputs. As a result, productivity of the traditional inputs, land and labor, can be improved and technological limitations can be alleviated.

Cohen, *et al.* postulate three factors that may influence policies dealing with the use of purchased technical inputs (especially, by private farms and the producer cooperatives) and agricultural prices: (1) the ratio of factor-product prices; (2) variabilities in this ratio, crop yield and farm technology; and (3) experience, and response of the traditional producers to changes in market prices, technologies and farm policies. The higher the price of the purchased inputs (such as fertilizer) relative to the price of an output, the greater the chances that the use of the inputs will not cover the production cost, and the less incentive there will be for the private producers to employ the purchased inputs.

Favorable agricultural prices combined with a high cost of food transportation to urban centers can introduce substitution and income effects that may influence the standard of living of urban consumers. Transportation costs are often reflected in high marketing margins. Imperfectly developed road and market systems, difficult terrain and weather are some of the factors that affect marketing margins in Ethiopia. It might be necessary for the state to intervene through policies and programs that mitigate the effects of favorable agricultural prices on urban consumers.

Cohen, *et al.* suggest the following strategies. First, price effects can be mitigated through programs such as employment expansion in the industrial sector and public works, and food rationing supported by price subsidies. Second, the marketing margins can be reduced through: (1) an investment in road transport development; (2) establishing market regulations including weights and measurements; (3) developing market reporting system that will increase spatial and temporal market integration; and (4) establishing marketing cooperatives at the farmer association level. If these strategies are developed successfully, and the new growth in rural consumption of the non-agricultural products is "exploited", the improvements in rural income due to the land reform may result in more than a proportionate growth in the demand for the commodities produced outside the sector. There can be a multiplier effect on the growth process of the national economy if the demand for non-agricultural commodities is supplied through domestic production.

## ***II.5. Summary***

This chapter has reviewed current and historical changes occurring in the agricultural sector of Ethiopia. The sector has been greatly influenced by the evolution of political and economic infrastructures with which the factors of production were distributed and forces of economic development were initiated. Prior to the 1975 land reform agricultural production and distribution of farm output were influenced by the feudal land tenure system. The feudal tenure system was mainly characterized by absentee land ownership, complex tenancy relationships, and mining of the private income (or wealth) through direct or indirect tenure obligations. Agricultural policies of the feudal system were quite cautious and selective in introducing incremental improvements into the farm sector. But the feudal policies were incapable of removing both structural and institutional limitations inherent in the agricultural sector.

The socio-political, economic, and institutional changes that were introduced in 1974 attempted to remove the legacies of the feudal system. Agricultural land was nationalized and was redistributed among rural households. Many new rural institutions (such as farmer associations, service cooperatives, producer cooperatives) were established. Impressive attempts have been made to improve the rural standard of living through primary education, basic health, and other community service programs. There is, however, a concern that the agrarian reform has failed to fully activate the small-holder private sector with which the state could stimulate surplus food production.

The small-holder private farmers have not benefited much from the price policies and structural policies of the socialist state through which the government is shaping the future of the Ethiopian agriculture. Despite the changes undertaken thus far, the gap between surplus food production growth rate and population growth rate has expanded. The principle goal of the government's structural policy is to replace the small-holder private farms with the large-scale producer

cooperatives and state farms. The large-scale mechanized state farms are owned and operated by the state and the farms depend on input and output subsidies.

The overall agricultural production, marketing, and distribution systems are centrally regulated by the state. Both the producer cooperatives and state farms provide a mechanism by which rural surplus food is transferred to the non-agricultural sectors of the economy. Other mechanisms such as various forms of agricultural taxes, unfavorable terms of trade between agricultural and industrial sectors, and greater allocation of the modern technical inputs to the large-scale farms than to the small-holder private farms are currently used to transfer surplus output from agriculture. Transfer of the agricultural surplus is useful for stimulating national economic development.

Sustained surplus food production can be influenced, among other things, by technical structure of the farms and the efficient use and allocation of agricultural resources. An in-depth examination of Ethiopian agriculture would be useful, first, to gain some insight into the technical characteristics of the farms contained in the sector; and second, to ascertain Ethiopia's potential to generate surplus food to meet growing domestic demand. Analytical methods used in this dissertation are discussed in Chapter III.

# **CHAPTER THREE**

## **METHOD OF ANALYSIS**

### ***III.0. Introduction***

The objectives and hypotheses of this study were identified in Chapter I and characteristics of Ethiopian agriculture were discussed in Chapter II. It is noted throughout these two chapters that cereal production in Ethiopia varies over time, across regions and across the three modes (private, cooperative, state) of production. The variability in cereal output was also noted to be caused by many factors among which were: technical characteristics of the three modes of production, input factors they employ, regional differences in production activities, and events of nature. This chapter considers a covariance (or dummy variable) analytical method for evaluating variations in cereal output that can be explained by known set of input factors and unknown factors related to regional and temporal factors. The covariance analytical method used in this analysis and reasons for selecting this method over error components method are discussed in Section (III.1). Section (III.2.) briefly examines properties of the Cobb-Douglas (C-D) and translog (TL) functional forms. The discussion, however, is limited to the properties which are relevant to the analysis of the objectives and hypotheses specified in Chapter I. Theoretically evaluated production function properties include average and marginal productivities, technical efficiency, marginal rates of substitution, and different types of elasticities. Section (III.3) discusses a framework for selecting either of the C-D or TL functional form appropriate for analyzing production characteristics of the three farm types. Section (III.4) summarizes the chapter. ✓

### ***III.1. Variance Components Estimation Method***

The variance components estimation method consists of a covariance model (also known as dummy variable model) and error components model (also sometimes known as components of error model). These models have been used for various empirical applications and their relevant properties for empirical work have been theoretically explored in previous research.<sup>46</sup> Both methods explicitly postulate that in addition to the impact of measurable regressors on the dependent variable, random and systematic latent regional and time related factors (such as soil fertility, weather, changes in government agricultural policies, qualities of regional labor force, cross-cultural differences among regions and so on) also influence the dependent variable. The non-systematic (or random) errors are common to both regional and time dimensions. Moreover, both methods assume that the behavior of the residuals related to regional differences in a given year is independent of the behavior of the random residuals and the residuals related to years of production within a region. In other words, the behavior of the residuals of any two regions in a given year will not influence the behavior of the residuals of a given region over two different years.

Generally, as noted by Wallace and Hussain (1969), estimators obtained from the analysis of covariance method are asymptotically equivalent to estimators obtained from the error components method. Both methods implicitly assume that whatever influence the latent factors exert on the dependent variable, only the magnitude of the dependent variable will be affected without inducing a change in the form of the underlying functional relationship. But the two methods differ in the assumptions they make about the nature of the latent factors. In particular, where the two methods differ is how the impacts of the latent factors are incorporated into the regression model. The analysis of covariance treats both regional and temporal latent factors as fixed parameters, whereas, the error components model treats them as random variables. Whether

---

<sup>46</sup> See, for example, Hsiao (1986), Balestra and Nerlove (1966), Wallace and Hussain (1969), Schultz (1969), Maddala (1971), Nerlove (1971), Schultz (1973), Mukhopadhyay (1974), and Hoch (1962).

the influences of the latent variables are as treated fixed or random, estimated regression coefficients preserve the statistical properties. If the underlying functional form is specified correctly, the estimators are unbiased, consistent, efficient, and have minimum variance.<sup>47</sup> On the other hand, Wallace and Husain make an important observation about the error components method: that small sample properties of the estimators are unknown.

In this research, analysis of covariance has been applied for empirical estimation. A number of factors led to the use of this method. The first and major reason has to do with the scope of the data sets available for the analysis. Production data (see Chapter IV) were collected on (a) private farms in 77 *awrajjas* for the 1983/84 production year, (b) producer cooperatives in 67 *awrajjas* for the years 1985 to 1986, and (c) state farms in 9 *awrajjas* for the years 1980 to 1985. As can be seen from above differences in time periods covered by the study, complete data are not available for all *awrajjas* for all time periods. The imbalance of the data imposes a limitation on the application of the error components method (with a full set of information) mainly due to rigidities in the method requiring a balanced cross-sectional time-series data set. For example, 1986 data are collected for the producer cooperatives in 17 out of the 67 *awrajjas*. In the case of the state farms, 6 years data are collected for 6 *awrajjas*, 5 years data for 2 *awrajjas* and 4 years data for one *awrajjas*. Given the imbalanced nature of the data, the error components method can be employed only if the incomplete observations are deleted. Deletion of the incomplete observations could mean eliminating 17 *awrajjas* from the producer cooperatives data set and a total of three *awrajjas* in the case of the state farms. Deletion of the *awrajjas* with imbalanced observations is unacceptable, especially, in light of the small sample size. Second, as Nerlove (1971) notes, whether the regional and temporal latent factors are treated as fixed or random is a matter of judgement. The longest time period spanned by this research is six years. From a practical viewpoint, this can be considered a short time period whereby both regional and temporal effects remain fixed. Third, as indicated in the earlier discussion, the small sample properties of the error components estimators

---

<sup>47</sup> See Hsiao (1986) p.34, and Wallace and Husain, p.66

are not known. Fourth, the analysis of covariance method provides a means to adjust for (or to minimize) sources of bias in the coefficients of included regressors due to omitted variables.<sup>48</sup> Given these four points and its relative ease of application, employing the analysis of covariance method is a reasonable decision. Properties of the model specified below will be useful to study cereal production data from R regions over T years.

Let output index  $Y_{rt}$  represent the cereal output in region r in year t and  $X_{rt}^{(i)}$  represents the  $i^{\text{th}}$  input into region r's cereal production in year t. The covariance model with both region and time effects in a given mode of cereal production can be written as follows:

$$Y_{rt} = B_0 + \sum_{i=1}^n B_{ri}^{(i)} X_{rt}^{(i)} + \sum_{r=1}^R \gamma_r s_{rt} + \sum_{t=1}^T \delta_t z_{rt} + \varepsilon_{rt}, \quad (3.1)$$

where  $i = 1, \dots, n$ ,  $r = 1, \dots, R$ ,  $t = 1, \dots, T$ ,  $Y_{rt}$  = cereal output of the  $r^{\text{th}}$  region in year t,  $\varepsilon_{rt}$  = random cereal output disturbance terms due to overall region and time effects,  $\beta_i, \gamma_r, \delta_t$  = regression parameters to be estimated.

Dummy Variables:

$$s_{rt} = \begin{cases} 1 & \text{for region } r, \text{ total of } R-1 \\ 0 & \text{Otherwise} \end{cases}$$

$$z_{rt} = \begin{cases} 1 & \text{for period } t, \text{ total of } T-1 \\ 0 & \text{Otherwise} \end{cases}$$

Equation (3.1) contains RT observations in which there are  $(R - 1) + (T - 1)$  dummy variables and a total of  $[n + (R - 1) + (T - 1)]$  regression coefficients leaving  $(RT - 2) - [(R - 1) +$

<sup>48</sup> See, for example, a monograph on the *Analysis of Covariance* by Wildt and Ahtola (1978). Also, it will be instructive to note pages 419-446 in Senedecor and Cocran (1978).

( T - 1 ) ] degrees of freedom. Assuming that the disturbance terms,  $\epsilon_{rt}$ , are independent and identically distributed with zero mean and homoscedastic variance, ordinary least squares (OLS) regression of  $Y_{rt}$  on  $X$ 's,  $s$ 's (region dummies), and  $z$ 's (temporal dummies) will be unbiased and efficient (Kmenta (1971)). Historically, the main reason for constructing the covariance model has been due to the belief that regional and temporal effects on the dependent variable can be characterized by two separate intercepts: one for each region ( $= \beta_0 + \delta_r$ ) and one for each time period ( $= \beta_0 + \gamma_t$ ).<sup>49</sup> Each of the dummy variable coefficients,  $\delta$ 's and  $\gamma$ 's, is interpreted as a deviation from the overall regression intercept,  $\beta_0$ .

Equation (3.1) is an unrestricted covariance model which can be implemented empirically in many different ways depending on assumptions about the regression slopes and intercepts.<sup>50</sup> The assumptions impose certain restrictions on the unrestricted covariance model. For example, a single regression equation can be constructed by assuming that (a) slope coefficients are constant for all regions at all times but intercepts of each region are random, or (b) both slope and intercept coefficients are identical for all regions at all times. Assumption (a) leads to estimating a regression model corrected for within region mean variations whereas, assumption (b) leads towards pooling T years of R cross-sections into a single data set of TR observations and estimating a single regression equation uncorrected for the within region mean variations.

Following Hsiao, for example, the estimation procedure implied by assumption (a), an alternative expression to equation (3.1) for any given region r at time t, will be:

---

<sup>49</sup> Note that region intercept is the sum of  $\beta_0$  and  $\delta_r$ , because temporal effects are evaluated for a given region in which case  $s_{rt} = 0, z_{rt} = 1$  and the converse of this ( $s_{rt} = 1, z_{rt} = 0$ ) explains why the time intercept is given by  $(\beta_0 + \gamma_t)$ . See Pendyck and Rubinfeld (1981) p.254, Kmenta (1971) p.516 and Maddala (1971) for more detailed discussion.

<sup>50</sup> Hsiao (1986) discusses various assumptions and techniques of formulating an estimable covariance model. See pp:11-23. This portion of the discussion about the covariance model has benefited from Hsiao's discussion.

$$Y_{rt} = \beta_0 + \sum_{i=1}^n \beta_i X_{rt}^{(i)} + \gamma_r s_r + \delta_t z_t + \varepsilon_{rt}, \quad (3.1b)$$

where  $r = 1, \dots, R$ ,  $t = 1, \dots, T$ ,  $s_r, z_t, \varepsilon_{rt}$  are region, time and random effects, respectively. The error term  $s_r$  captures combined effects of the omitted variables which are unique to each region invariant over time. In other words,  $s_r$  of a particular region is fixed rather than random over time. If the regression intercept  $\beta_0$  is introduced explicitly as suggested in equation (3.1b), it measures the overall mean effect of all omitted variables for all regions at all times, in which case,  $s_r, z_t$  measures deviations of individual regional (temporal) mean effect from  $\beta_0$ . But, as Hsiao notes, both  $s_r$  and  $\beta_0$  are fixed scalars and can not be estimated simultaneously from a regression equation for a single region.

Despite its ability to generate unbiased and efficient estimates if it is specified correctly, the covariance model has some limitations which deserve mention. First, if regional and temporal variations are large, the use of the dummy variables removes a substantial portion of the variation between the dependent variable and the regressor (or known) variables. The role of the dummy variables is to capture the impact of omitted variables in the regression model. The removal of the variation may conceal presence of "ignorance" (or specification bias) in specifying cereal production activities with known input factors. Second, in some cases, the use of dummy variables results in a loss of a substantial number of degrees of freedom.

The limitations associated with the covariance model do not necessarily reduce its usefulness as a tool for empirical application. For instance, Hoch (1962), among others, applied the covariance analysis procedure to estimate CD production function parameters from pooled time-series and cross-section data of 63 Minnesota farms. The author noted that the analysis of

covariance avoids (or reduces) simultaneity bias, generates unbiased estimates of elasticity and marginal productivities, and facilitates hypotheses testing of individual and temporal fixed effects.<sup>51</sup>

### III.2. Production Functions

Assume there is a production function,  $Y = F(x_1, \dots, x_n)$ , that captures the causal relationship between cereal output  $Y$  and input factors  $x_1, \dots, x_n$ . Normally, the set of factors consists of traditional inputs, managerial abilities and agro-ecological factors of production.  $F$  is assumed to be a continuous twice differentiable strictly quasi-concave function of the inputs  $x_1, \dots, x_n \geq 0$  where  $\partial F / \partial x_i > 0$ ,  $\partial^2 F / \partial x_i^2 < 0$ . But, an appropriate algebraic functional form for Ethiopian agricultural sector is not known *a priori*. Many candidate functional forms are available in the agricultural economics literature from which a particular production function can be selected to model the physical relationship under investigation.<sup>52</sup> The selection of an appropriate functional form should

---

<sup>51</sup> For additional discussion on the covariance model, see Chang and Lee (1977), Moriarty (1975), Pindyck and Rubinfeld (1981), and Maddala (1971).

<sup>52</sup> Perhaps it needs to be noted here that the reason for considering primal rather than dual functional alternatives (cost or profit function) for this analysis is in response to inappropriateness of the traditional behavioral assumptions (cost minimization or profit maximization) under the centrally planned economic system of Ethiopia. The system imposes fundamental limitations on the process of price determination. The inappropriateness of the dual alternatives is mainly because cost and profit functions depend on the variability of input and output prices. (See Young, Mittelhammer, Rostamizadeh, and Holland (1985) for some theoretical discussion on the conditions for employing a production, cost, or profit function in empirical studies.) In order to be theoretically valid for an empirical application, the dual functions need to satisfy price-based regularity conditions: (a) continuous in prices, (b) linear homogeneity in prices, (c) monotonicity in prices (that is, non-increasing in input prices in the case of cost functions, and non-decreasing in output prices and non-increasing in input prices in the case of profit functions), and (d) the cost function must be concave in input prices and the profit function must be convex in both input and output prices. Prices are commonly assumed to come from a competitive market regime that insures price variability across regions and over time. Unlike a production function, both cost and profit functions enable one to consider multiple outputs. It would not even be necessary to know the underlying production functional form to employ cost or profit function techniques. Because of these aspects, either of the two dual techniques are useful for empirical work. Ethiopian institutional conditions and the centrally regulated market regime, however, make it necessary to use the primal (or production function) approach. Price variability is not necessary for the primal approach. It is, however, important to correctly specify a functional form that correctly summarizes a range of physical properties and techniques of the production process in the primal approach. For example, see various functional forms summarized by Griffin, Montgomery and Rister (1987).

be based on a combination of at least two factors: (a) an in-depth knowledge about the production process (for example, elasticity of substitution) under study, and (b) theoretical and empirical tractability of the functional forms for the production analysis.

The usual C-D and TL production functions are selected for the investigation. In doing so, however, no assumption is made that one functional form models Ethiopian cereal production process better than the other. For that matter, neither of the functional forms might be appropriate for the analysis. In the absence of an established theoretical and empirical research tradition that could justify hypothesizing a particular functional form appropriate for the private and socialized agricultural sectors in Ethiopia, another functional form could be as good as the ones that were selected for this analysis. However, a valid functional alternative must be the one that captures (or most closely approximates) the true relationship between a dependent variable and set of independent variables.

Both the C-D and TL functional alternatives have desirable properties such as suitability for linear statistical parameter estimation in logarithms. These properties are, however, not indicative of the appropriateness of the two functional alternatives. In terms of the C-D and TL functions, at least one thing is obvious; that is, the two functional forms are mathematically related. The C-D specification represents a specific case within the class of TL production function if the parameter estimates of the interactions terms between explanatory variables in the TL function are found to be statistically insignificant. Otherwise, employing the C-D functional alternative will introduce misspecification and the estimated coefficients will be incorrect. Appropriateness of either of these two functional forms will, therefore, be determined empirically by applying a "nested" hypothesis test since the functional forms are related (see Section III.4.).

Despite numerous functional forms available, it is interesting to note that the C-D production function is used in the majority of applied research. As indicated previously, the function is log-linear both in parameters and variables and easy to work with in applied research but it has

familiar limitations such as: (a) unitary elasticity of substitution, (b) factors of production are substitutes, and (c) the function does not allow an interaction among inputs. Cereal crops production processes usually require the interplay of two or more inputs such as labor and oxen, land and labor, or between land, labor and oxen, and so on. Considering interaction terms between inputs may have practical importance from the policy perspective.<sup>53</sup> From this viewpoint, the TL production technology can be said to represent a higher-order approximation of the input-output relationships than the C-D function. Mathematical properties of the two functional alternatives are evaluated in the next two sections.

### III.2.1. Cobb-Douglas Production Function

#### III.2.1.1. Functional Form

A Cobb-Douglas (C-D) production function takes the usual mathematical form logarithms yielding:  $Y = \alpha_0 \prod_{i=1}^n X_i^{\alpha_i} e^{\epsilon}$ , where  $\alpha_i \geq 0$ . However, it is convenient to estimate this relationship transformed into logarithmic form yielding:

$$\ln Y = \ln \alpha_0 + \sum_{i=1}^n \alpha_i \ln X_i + \epsilon, \quad (3.1)$$

where Y is output;  $\alpha_0$  is technical efficiency (or intercept) coefficient;  $X_i$  = input factors;  $\alpha_i$  = are partial output elasticities with respect to  $X_i$  inputs;  $\epsilon$  = random error independent of inputs with zero mean and constant variance in cereal output; and e is the natural logarithm base of  $\simeq 2.71828$ .

---

<sup>53</sup> For some further comments on the strengths and weaknesses of the C-D production function, see Heathfield (1971), Brown (1966), and Yotopoulos (1967).

### III.2.1.2. Technical Efficiency, Average and Marginal Productivities

Technical efficiency is represented in equation (3.1) by the constant coefficient,  $\alpha_0$ , of the C-D production function. Output will increase monotonically in response to an improvement in neutral technical progress:

$$\frac{\alpha_0}{Y} \frac{\partial Y}{\partial \alpha_0} = 1 \rightarrow \frac{\partial Y}{\partial \alpha_0} = \frac{Y}{\alpha_0} \quad (3.2)$$

Marginal productivity of the technical progress of the C-D model is identical to its average productivity, that is,  $\partial Y / \partial \alpha_0 = Y / \alpha_0$ .

A marginal increase in the technical progress of production process represents Hick's neutral upward shift in the production frontier. The change in the technical progress is Hick's neutral in the sense that no more or less of any particular input factor is used than the relative input proportions that prevailed prior to the increase in the technical progress. Thus, a neutral marginal change in technical progress may lead towards a higher level of cereal output produced with a given combination of input factors.

Both marginal product (MP<sub>*i*</sub>) and the average product (AP<sub>*i*</sub>) of input  $X_i$  of the C-D function can be derived from equation (3.1) as follows:

$$\begin{aligned} \text{MP}_i &= \frac{\partial Y}{\partial X_i} = \alpha_i \left( \frac{Y}{X_i} \right) \quad (\text{marginal product of input } i), \\ \text{AP}_i &= \frac{Y}{X_i} \quad (\text{average product of input } i). \end{aligned} \quad (3.3b)$$

The C-D production function can reflect diminishing marginal productivity with respect to  $X_i$  where  $\frac{\partial^2 Y}{\partial X_i^2} = \alpha_i(\alpha_i - 1) \frac{Y}{X_i^2} < 0$ . This result is negative because  $0 < \alpha_i < 1$  if the Stage II production function assumption is maintained.

### III.2.1.3. Marginal Rate of Substitution

The marginal rate of substitution of factor  $i$  for factor  $j$  is given by the ratio of the marginal productivities of the inputs  $X_i$  and  $X_j$  :

$$MRS_{ij} = \frac{MP_i}{MP_j} = \frac{\frac{\partial Y}{\partial X_i}}{\frac{\partial Y}{\partial X_j}} = \left( \frac{\alpha_i}{\alpha_j} \right) \frac{X_j}{X_i}, \quad i \neq j \quad (3.4)$$

The marginal rate of substitution,  $MRS_{ij}$ , of  $X_i$  for  $X_j$ , as can be seen from equation (3.4), is the ratio of input quantities weighted by the reciprocal ratio of their respective output elasticities of production. The resulting quantity indicates the amount of  $X_j$  that can be decreased in order to increase the use of  $X_i$  by one unit without a change in the level of output.<sup>54</sup>

### III.2.1.4. Elasticities

If the assumption of Stage II of production function for the C-D production function is maintained, partial cereal output elasticity with respect to each factor  $i$  falls between zero and one. Unless restricted to linear homogeneity, the sum of the partial production elasticities gives the

---

<sup>54</sup> For example, if input  $i$  is defined as labor-days and input  $j$  as extension services in terms of Ethiopian Birr, and if the government introduces a food-for-work program to build a bridge in a given region so that extension services will be delivered to that region, the measure of the marginal rate of substitution may indicate the number of average labor-days that farmers would be able to devote to bridge building to import one Birr worth of the extension services without sacrificing output.

degree of homogeneity (or a measure of returns to scale,  $\eta$ ) that can be either greater, equal to, or less than unity:

$$\frac{MP_i}{AP_i} = \left(\alpha_i \frac{Y}{X_i}\right) \frac{X_i}{Y} = 0 < \alpha_i < 1 \quad (\text{partial output elasticity of input } i)$$

$$\eta = \sum_{i=1}^n \alpha_i \begin{matrix} \geq \\ < \\ = \end{matrix} 1 \quad (\text{returns to scale}). \quad (3.5)$$

Returns to scale represent output responsiveness (on the production function surface) to an equi-proportionate increase in all controllable inputs in cereal production. Cereal output is likely to, for instance, more than double when inputs are doubled if  $\eta > 1$ , or less than double when inputs are doubled if  $\eta < 1$  or output will just double when inputs are doubled if  $\eta = 1$ . The C-D function is linearly homogeneous when  $\eta = 1$ .

The elasticity of substitution ( $\Theta_{ij}$ ) between any pair of inputs in a C-D function is unity. The C-D production function elasticity of substitution of factor  $i$  for factor  $j$  can be computed from a fixed level of output,  $\bar{Y} = \alpha_0 X_i^{\alpha_i} X_j^{\alpha_j}$ , first, by solving for slope of an isoquant with respect to  $X_i$  and  $X_j$ , second, by differentiating the slope of the isoquant with respect to  $\frac{X_j}{X_i}$ , and third, by appropriate simplification yields:

$$\Theta_{ij} = \frac{\left(-\frac{\alpha_i}{\alpha_j}\right)}{\left(-\frac{\alpha_i}{\alpha_j}\right)} = 1 \quad (3.5b)$$

Equation (3.5b) shows that the C-D elasticity of substitution does not depend on the level of the inputs neither does it depend on the level of output, but it invariably remains at the value of unity. In other words, the elasticity of substitution of the C-D production function takes the value of unity for any combination and intensity of inputs, regardless of changes in the underlying

technology over time. Many of the limitations of the C-D function can be overcome by the TL function presented in the next section.

### III.2.2. Transcendental Logarithmic production Function

#### III.2.2.1. Functional Form

The transcendental logarithmic (or otherwise known as translog) production function belongs to a class of generalized, "flexible" production functions.<sup>55</sup> Parameter estimates of the function are unrestricted in sign and they therefore may take on positive, negative or zero values (Griffin, Montgomery, Rister (1987)). An  $n$  input translog production function can be represented mathematically as  $Y = \alpha_0 \prod_{i=1}^n X_i^{\alpha_i} \prod_{i=1}^n e^{\left(\frac{1}{2} \beta_{ii} \ln^2 X_i\right)} \prod_{i \neq j} e^{(\beta_{ij} \ln X_i \ln X_j)} e^{\epsilon}$ . It is convenient to estimate this relationship transformed into logarithmic form yielding:

$$\ln Y = \ln \alpha_0 + \sum_{i=1}^n \alpha_i \ln X_i + \sum_{i=1}^n \frac{1}{2} \beta_{ii} \ln^2 X_i + \sum_{i=1}^n \sum_{j=1}^n \beta_{ij} \ln X_i \ln X_j + \epsilon, \quad i \neq j, \quad (3.6)$$

where  $Y$  is cereal output;  $\alpha_0$  is technical efficiency coefficient (or intercept);  $X_i$  and  $X_j$  are input factors;  $\alpha_i$ ,  $\beta_{ii}$ ,  $\beta_{ij}$  are parameters to be estimated; and  $\epsilon$  is random error term. Equation (3.6) can be interpreted in three different ways as: (a) an exact translog functional relationship of the underlying production process, (b) a second-order Taylor series approximation for some unknown polynomial production process, or (c) a second-order approximation to the conventional constant elasticity of substitution production process.<sup>56</sup>

<sup>55</sup> Other generalized flexible functions include generalized Leontief, generalized Cobb-Douglas, and generalized square root quadratic functions. See Berndt and Khaled (1979).

<sup>56</sup> See R.N. Boisvert (1982) for a rigorous mathematical derivation under each of the three assumptions of

Unless the order of derivatives of the Taylor series is extended to an  $n^{\text{th}}$  degree as  $n \rightarrow \infty$ , the TL function when treated as a second-order approximation to an arbitrary polynomial production function introduces an approximation induced error of unknown quantity. The approximation procedure is commonly done at some fixed point (such as arithmetic or geometric mean) on the polynomial production surface. The procedure forces influences of the explanatory variables to be centered around the point of evaluation rather than allowing the variables to vary over an “unrestricted” range of the production surface. The error is, then, equal to the difference between the polynomial function and the second-order power series evaluated at the arbitrary point of expansion. This error may or may not converge to zero as the power series approaches infinity. If the empirical information set of dependent and independent variables is marred with some built-in errors unknown to the investigator, implementing the TL function as a second-order approximating function may compound the error problem. Furthermore, Khaled (1978) notes that the approximating function does not maintain many properties of the underlying true production function.<sup>57</sup>

This study adopts the TL function as an exact production function. The TL function can be regarded as an improvement on the C-D function, because it has properties that are unavailable in the C-D functional specification. First, the TL function does not *a priori* impose constant elasticity of substitution between any pair of inputs. It requires that the elasticity of substitution,  $\Theta_{ij}$ , to be constant along an expansion path but allows them to vary along an isoquant.<sup>58</sup> Second, the TL function is quadratic in logarithms and allows interaction among inputs. Third, the TL production function, unlike the C-D function, allows testing for homogeneity rather than impose it. In other

---

the TL function. Weaknesses and usefulness of the function are also discussed in this reference. This section of the dissertation has benefited from Boisvert’s work.

<sup>57</sup> Chiang (1974) provides a good illustration of the Taylor series polynomial functions on pages 268-273. Also, see Boisvert for a critical summary of the TL function, pp:31-35.

<sup>58</sup> See Christensen, Jorgenson, and Lau (1973), Berndt and Christensen (1973), Guilkey, Lovell, and Sickles (1974), Appelbaum (1979), Lyu, White, and Lu (1984).

words, the translog technology becomes linearly homogeneous if  $\sum_{i=1}^n \beta_{ii} = \sum_{i=1}^n \beta_{ij} = 0$  and  $\sum_{i=1}^n \alpha_i = 1$  or it will be homogeneous of degree  $\sum_{i \neq j} \alpha_i \neq 1$ .

Inputs are limitational in the translog function (as they are in the C-D function) in the sense that crop output will vanish if any of the inputs takes a zero value. Thus, empirical application of the TL function amounts to the assumption that it is necessary to employ some positive quantity of all inputs in order to produce some positive quantity of output. Other properties of the TL function are derived next.<sup>59</sup>

### III.2.2.2. *Technical Efficiency, Average and Marginal Productivities*

Output grows proportionately in response to a proportionate increase in neutral technical progress as shown in equation (3.7):

$$\frac{\alpha_0}{Y} \frac{\partial Y}{\partial \alpha_0} = 1 \quad \rightarrow \quad \frac{\partial Y}{\partial \alpha_0} = \frac{Y}{\alpha_0} \quad (3.7)$$

The last expression of equation (3.7) shows that the marginal product of a small increase in neutral technical progress is the same as its average product.

Marginal product (MP<sub>i</sub>) and the average product (AP<sub>i</sub>) of input X<sub>i</sub> can be derived from equation (3.6) as follows:

---

<sup>59</sup> Additional properties (restrictions) such as additivity and separability pertaining to the translog production function will not be considered in this study but they are discussed in Christensen, Jorgenson and Lau (1973), and Denny and Fuss (1977).

$$\begin{aligned} MP_i &= \frac{\partial Y}{\partial X_i} = \left( \alpha_i + \sum_{j=1}^n \beta_{ij} \ln X_j \right) \frac{Y}{X_i}, \\ AP_i &= \frac{Y}{X_i}, \end{aligned} \quad (3.7b)$$

where  $i = 1, \dots, n$ . If  $B_{ij} = 0$ , marginal product of  $X_i$  will be its average product weighted by  $\alpha_i$ . The TL allows increasing, decreasing and negative marginal productivity of inputs. This property will be useful for examining, for instance, if the marginal product of labor in traditional farms is close to zero or negative. If the marginal product of labor is negative, it indicates more than “optimal” labor services are combined with the services of another input such as capital. Cautious interpretation of the negative marginal product of labor would, however, be necessary because it could be the result of a specification error rather than due to an “unlimited” use of labor on a fixed supply of resources such as land.

As shown in equation (3.7c), the underlying TL production function meets the strict quasi-concavity assumption if the partial differential of  $MP_i$  with respect to  $X_i$  is negative:

$$\frac{\partial^2 Y}{\partial X_i^2} = \frac{Y}{X_i^2} \left[ \beta_{ii} + (\alpha_i + \sum_{j=1}^n \beta_{ij} \ln X_j)(\alpha_i + \sum_{j=1}^n \beta_{ij} \ln X_j - 1) \right] < 0, \quad i = 1, \dots, n \quad (3.7c)$$

The influence of a change in the use of  $X_j$  on the marginal product of  $X_i$  is:<sup>60</sup>

$$\frac{\partial^2 Y}{\partial X_i \partial X_j} = \frac{\partial^2 Y}{\partial X_j \partial X_i} = \frac{Y}{X_i X_j} \psi \geq 0, \quad (3.7d)$$

where:

---

<sup>60</sup> Also, note that the reverse of this result holds for the cross effect of  $X_i$  on  $X_j$

$$\psi = \left[ \beta_{ij} + (\alpha_i + \sum_{j=1}^n \beta_{ij} \ln X_j)(\alpha_j + \sum_{i=1}^n \beta_{ij} \ln X_i) \right]$$

If equation (3.7d) is positive, negative or zero, it indicates that the two inputs are complements, substitutes or neutral, respectively.

### III.2.2.3. Marginal Rate of Substitution

The marginal rate of substitution of factor i for factor j, as was computed for the C-D case, is  $MRS_{ij} = MP_i/MP_j$ . Substituting the appropriate components from equation (3.7b), the marginal rate of substitution for the translog function takes the form:

$$MRS_{ij} = \frac{MP_i}{MP_j} = \left[ \frac{\alpha_i + \sum_{j=1}^n \beta_{ij} \ln X_j}{\alpha_j + \sum_{i=1}^n \beta_{ij} \ln X_i} \right] \frac{X_j}{X_i} \quad (3.8)$$

The translog marginal rate of substitution will collapse to the C-D marginal rate of substitution if  $\beta_{ii} = \beta_{jj} = 0$ . Otherwise, the translog marginal rate of substitution is generally influenced by the parameter values of  $\alpha_i$ ,  $\beta_{ii}$ ,  $\beta_{ij}$  and by the quantities of the input factors  $X_i$  and  $X_j$ .

### III.2.2.4. Elasticities

Partial cereal output elasticity ( $\eta_i$ ) of each input can be computed as  $\eta_i = \frac{\partial \ln Y}{\partial \ln X_i} = \frac{\partial Y}{\partial X_i} \frac{X_i}{Y}$ . In a log transformed econometric model analysis,  $\eta_i$  will represent the partial output elasticity with respect to factor i if the underlying technology is of a Cobb-Douglas type. But, in the case of the

translog technology,  $\eta_i$  is the sum of relevant  $\alpha_i$  and weighted logarithms of the input quantities where the weights are appropriately associated  $\beta$ 's. This is shown in equation (3.9):

$$\eta_i = \frac{\partial \ln Y}{\partial \ln X_i} = \alpha_i + \beta_{ii} \ln X_i + \sum_{j \neq i}^n \beta_{ij} \ln X_j \quad (3.9)$$

where  $\eta_i$  is partial output elasticity with respect to  $X_i$ . The sum of the partial output elasticities indicates the degree of homogeneity (or returns to scale) computed as:

$$H = \sum \eta_i = \sum \alpha_i + \sum \beta_{ii} \ln X_i + \sum \beta_{ij} \ln X_{i,j} \quad i \neq j \quad (3.9b)$$

As discussed previously,  $\sum \eta_i = \sum \alpha_i$  only if  $\beta_{ii} = \beta_{ij} = 0$  for  $i \neq j$ . If these restrictions hold globally, then the underlying translog technology is homogeneous.<sup>61</sup> Equation (3.9) indicates that once the partial output elasticity is computed, it is a straight forward exercise to compute the associated marginal products, marginal rates of substitution, and the second order partial differentials with respect to  $X_i$ ,  $i = 1, \dots, n$  as:  $MP_i = \eta_i \frac{Y}{X_i}$ ,  $MRS_{ij} = \left( \frac{\eta_i}{\eta_j} \right) \frac{X_j}{X_i}$  and  $\frac{\partial^2 Y}{\partial X_i^2} = \frac{Y}{X_i^2} [\beta_{ii} + \eta_i(\eta_i - 1)] < 0$ , where  $X_i, Y$  are evaluated at their geometric means. The TL function meets conditions of the law of diminishing returns and concavity if  $\eta_i > 0$  and  $\beta_{ii} < -\eta_i(\eta_i - 1)$ .

Both TL marginal productivity and returns to scale vary with the levels of inputs.<sup>62</sup> This also holds for other translog production properties such as marginal rate of substitution and elasticity of substitution. The rate of substitutability between any pair of inputs is often indicated by the

<sup>61</sup> On the other hand, if the restrictions do not hold, then the underlying technology is non-homogeneous. The non-homogeneous translog production technology would exhibit variable marginal rates of substitution ( $MP_i/MP_j$ ) and elasticity of substitution ( $\Theta_{ij}$ ) along an expansion path.

<sup>62</sup> These properties imply that it is possible to depict more than one stage of production with the TL function.

value of the elasticity of substitution,  $\Theta_{ij}$ . The translog elasticity of substitution is discussed below by using a general formula suggested by Allen (1939).

$$\Theta_{ij} = - \left\{ \frac{f_{ij}f(X_i f_i + X_j f_j)}{X_i X_j (\Phi)} \right\}, \quad (3.9c)$$

where the marginal productivity,  $\Phi$ , direct and cross partial effects terms are defined in terms of partial elasticities of the two factors  $X_i$  and  $X_j$ :

$$\begin{aligned} \Phi &= (f_j^2 f_{ii} - 2f_{ij} f_{ij} + f_i^2 f_{jj}), \\ f_i &= \frac{\partial Y}{\partial X_i} = \eta_i \frac{Y}{X_i}, \\ f_j &= \frac{\partial Y}{\partial X_j} = \eta_j \frac{Y}{X_j}, \\ f_{ii} &= \frac{\partial}{\partial X_i} \frac{\partial Y}{\partial X_i} = [\beta_{ii} + \eta_i(\eta_i - 1)] \frac{Y}{X_i^2}, \\ f_{jj} &= \frac{\partial}{\partial X_j} \frac{\partial Y}{\partial X_j} = [\beta_{jj} + \eta_j(\eta_j - 1)] \frac{Y}{X_j^2}, \\ f_{ij} &= f_{ji} = \frac{\partial}{\partial X_j} \frac{\partial Y}{\partial X_i} = \frac{Y}{X_i X_j} (\beta_{ij} + \eta_i \eta_j). \end{aligned}$$

Combining these terms yields:

$$\Theta_{ij} = - \left[ \frac{\eta_i \eta_j (\eta_i + \eta_j)}{\eta_i^2 \beta_{jj} + \eta_j^2 \beta_{ii} - \eta_i \eta_j (2\beta_{ij} + \eta_i + \eta_j)} \right] \quad (3.9d)$$

Normally, since the elasticity of substitution is bounded between zero and infinity, either the denominator or the numerator should be negative. However, by the strict quasi-concavity assumption of the TL function,  $\Phi \geq 0$ .<sup>63</sup> Then, the numerator would have to be negative in order to maintain the neo-classical production properties of the TL function.

<sup>63</sup> See Henderson and Quandt (1980), p.73.

The expression  $\Phi = (f_i^2 f_{ii} - 2f_i f_{ij} f_{ji} + f_j^2 f_{jj})$  provides useful information about the shape of an isoquant. A large value of  $\Phi$ , for example, indicates that the isoquant is highly curved and  $\Theta_{ij}$  will take on a relatively small value. If the value of  $\Phi$  is zero or close to zero, the value of  $\Theta_{ij}$  approaches infinity thereby indicating that the isoquant has a very little curvature. The rate of substitution between two inputs declines as the value of  $\Theta_{ij}$  declines with increasing value of  $\Phi$  and the inverse is true for declining values of  $\Phi$ . The important point of these observations is that the magnitude of  $\Theta_{ij}$  indicates the ease or difficulty of substituting one input for another given the limitations of the underlying technology. As indicated previously, the TL function will be regular strictly quasi-concave if  $\Theta_{ij}$  takes non-negative values. In other words, the function may not be globally quasi-concave if  $\Theta_{ij}$  is negative.

### ***III.2.2.5. Limitations in Empirical Application***

The TL production function has some limitations. First, direct estimation of the translog production function is difficult to accomplish because it involves many parameters. For any number of explanatory variables, estimating an unrestricted translog function involves a total of  $N^2 + 3N + 1$  parameters where  $N$  is the number of explanatory variables and 1 is for an intercept. Degrees of freedom considerations may therefore limit the number of estimable parameters to  $.5(N^2 + 3N) + 1$  if symmetry conditions are imposed on the function.

Second, empirical TL functions have been estimated which violated concavity assumption. Guilkey, Lovell and Sickles (1974) reported that the translog cost function share equation estimates resulted in a number of negative elasticities of substitution, despite the fact that the translog function fit the data very well. The negative elasticity of substitution violates regularity conditions of isoquant curvature and quasi-concavity of the underlying production properties.

Third, collinearity is likely to be a serious problem in empirical applications because of the extra explanatory variables generated from the same data set by the translog construct. The collinearity problem can raise at least two concerns: (a) the assumption of linear independence among the explanatory variables will be violated and it may not be possible to conduct a comparative static evaluation, (b) estimated regression coefficients will be imprecise due to large variances of the coefficients. With large estimated standard errors, the coefficients are more likely to be judged statistically insignificant thereby increasing possibilities of incorrectly failing to reject (Type I error) the null hypothesis that the coefficients are not significantly different from zero. But, despite the presence of collinearity, the least-squares coefficients still retain the usual statistical properties and are best linear unbiased estimators.<sup>64</sup>

64

It is often said that collinearity is a characteristic of the production data set under investigation. Existing econometric estimation techniques have commonly used such "rules of thumb" as high  $R^2$ , signs of regression coefficients different from hypothesized signs, variance inflation factor (VIF), and condition indices (CI) together with variance proportions (VP) of two or more regression coefficients to diagnose the presence of the collinearity. According to these rules of thumb, collinearity will be detected, for example, if all of the following are diagnosed: VIF exceeds 10%, the value of CI ( $= (\mu_{\max}/\mu_k)^{0.5}$ ,  $k = 1, \dots, p$ ) exceeds 30 and VP is greater than 0.50. VIF is determined by the level of a multiple correlation coefficient,  $R_i^2$ , of an auxiliary regression of the variable  $X_i$  on the other  $n-1$  explanatory variables. The inverse of  $1 - R_i^2$  gives the value of VIF:  $(VIF = (1 - R_i^2)^{-1})$ . The variance of  $X_i$  coefficient,  $\sigma_{\beta_i}^2$ , is inflated by VIF percent. If  $R_i^2 = .9$ , for example,  $\sigma_{\beta_i}^2$  will be inflated by 10 percent, but if  $R_i^2 = .95$ ,  $\sigma_{\beta_i}^2$  would be inflated by 20 percent, which would be unacceptable according to the rules of thumb. It is clear from this example that other than indicating the general nature of the collinearity, the VIF measure does not isolate which subset of variables are more collinear with  $X_i$  than others. Because of this apparent weakness of the VIF measure, Belsley, Kuh and Welsch (1980) suggest, based on experiments with real data, the use of the CI along with associated VP's to evaluate the nature of collinearity between independent variables.

Both the CI and VP are computed from the sample variance-covariance matrix of the data under investigation and are related as follows:  $VP_k = \frac{\phi_{kj}}{\phi_k}$ ,  $k, j = 1, \dots, p$ , where  $VP_k$  = variance proportion of the least-squares estimator,  $\beta_k$ ,  $\phi_{kj} = v_{kj}^2/\mu_j^2$ ,  $\phi_k = \sum \phi_{kj}$ , where  $v_{kj}$  = element of an eigenvector  $k$  of a  $V$  matrix that diagonalizes the variance-covariance matrix, and  $\mu_j$  = eigenvalue (diagonal element) of the variance-covariance matrix associated with  $v_{kj}$ . "Small" values of  $\mu_j$  associated with the collinear columns of the variance-covariance matrix will indicate high variance proportions. Unlike the VIF, the VP will point towards a group of the explanatory variables in the collinear dependency. If the variance-covariance matrix is orthogonal, the variance proportion of the least-squares estimators associated with the corresponding eigenvalues will be zero. On the other hand, if the variables are perfectly collinear, (where  $\mu_j \rightarrow 0$ ) the variance proportions will be unity. Thus, for example, the value of  $VP = 0.50$  indicates that

Apart from limiting the partial analysis of individual impacts of the collinear variables, the fact that a collinear relationship exists between two or more input variables might contain useful information. Hardly any variable of economic interest is likely to be independent of all other variables. Although a collinear variable plays a statistically insignificant role in explaining variations in output, its removal will influence the role of the remaining variables. But, that influence is likely to be small relative to the gain in precision of the estimated coefficients. On the other hand, if the collinear variable plays a statistically significant role, its removal will not only affect the influence of the collinear variables, it will also bias the least-squares estimators remaining in the model. This certainly creates a dilemma: either to generate biased least-squares estimators in an attempt to “correct” for the collinear relationship or to settle for unbiased but imprecise coefficients.

The collinearity problem is traditionally addressed by employing *ad hoc* methods such as ridge regression and principal components. Other methods such as pooling cross-sectional and time series data, or aggregation of variables are also used. The usual ridge regression (RR) estimation procedure works, for example, by augmenting the diagonal components of the variance-covariance matrix by some arbitrarily selected constant factor,  $b$ , yielding the RR estimator  $B^{RR} = (X'X + bI)^{-1}X'Y$ . The process of determining the correct level of  $b$  often requires several experiments with the same data set and the process can not guarantee that the presence of the collinearity will be mitigated. Furthermore, as Burt, Frank and Beattie (1987) note, the process of searching for the “correct” level of the  $b$ -value will shrink the least-squares estimators “toward an untenable prior, namely, the null vector” (p.135). These authors make two additional observations about RR: (a) the process of selecting the  $b$ -value introduces “too much” bias, and (b) standard

---

50 percent of the variance of  $\beta_k$  is accounted by the corresponding eigenvalue  $\mu_j$ . The 0.50 variance proportion level does not necessarily indicate the absence of the collinear dependency among the explanatory variables, but it represents a level of “tolerance” or a rule of thumb with which the least-squares estimators are interpreted as precise and efficient. Or put differently, the level of VP and associated CI approximate the extent of distortion of the variance of the collinear variables. The level of impreciseness of the TL function estimators will, therefore, depend on the linear correlations between the columns of two or more factors of production.

errors generated under the biased RR estimation procedure have limited application for hypothesis testing because the magnitude of the bias part of mean square error is unknown.

In a "small" sample situation, researchers often use behavioral assumptions of profit maximization or cost minimization to mitigate the TL collinearity problem by estimating a system of share equations instead of directly estimating the translog production function. In this way, the parameter estimates of the translog production function are obtained in an indirect fashion.<sup>65</sup> Assuming perfect competition in both factor and output markets in Ethiopia's centrally planned economic system is not justifiable. In other words, a system of competitive equilibrium conditions for Ethiopian farm operators can not be derived in an attempt to correct for a collinearity problem.

### ***III.3. Functional Form Selection Criterion***

If the TL production function can be hypothesized to be homogenous in the set of coefficients of the interaction terms, a restricted form of the function with the homogeneity and symmetry conditions can be derived. Testing this hypothesis will indicate whether the C-D or TL functional specification is appropriate for analyzing the private and socialized crop production processes in Ethiopian agriculture. If the homogeneity conditions hold uniformly, the results may lead towards the C-D functional specification. Consider the following unrestricted log-transformed translog function with one dependent variable and four inputs (it is more convenient to illustrate this point with four input variables than with  $X_i$  and  $X_j$  as in the previous sections):

---

<sup>65</sup> For example, a system of share equations is generated from a (normalized) profit and/or cost function as a ratio of expenditures (on variable factors of production) relative to total profit or total cost of production. If the underlying production technology does not possess the translog production process, however, estimation of the share equations may lead to erroneous results and erroneous conclusions.

$$\begin{aligned}
\ln y_i = & \ln \alpha_0 + \sum_{k=1}^4 \alpha_k \ln x_k \\
& + \frac{1}{2} \beta_{11} \ln^2 x_{11} + \beta_{12} \ln x_1 \ln x_2 + \beta_{13} \ln x_1 \ln x_3 + \beta_{14} \ln x_1 \ln x_4 \\
& + \frac{1}{2} \beta_{22} \ln^2 x_{22} + \beta_{23} \ln x_2 \ln x_3 + \beta_{24} \ln x_2 \ln x_4 \\
& + \frac{1}{2} \beta_{33} \ln^2 x_{33} + \beta_{34} \ln x_3 \ln x_4 \\
& + \frac{1}{2} \beta_{44} \ln^2 x_{44} + u_i
\end{aligned} \tag{3.10}$$

The homogeneity hypothesis requires that the coefficients on the quadratic portion of the unrestricted translog function are set to zero:  $\beta_{ii} = \beta_{ij} = 0$ . In this case the degree of homogeneity is given by the sum of the  $\alpha$ 's:  $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = C$ . The degree of homogeneity  $C$  can take any value unless constrained to unity.

The restrictions implied by the homogeneity hypothesis can be tested statistically by computing an F-statistic from unexplained errors by both restricted (C-D) and unrestricted (TL) models:

$$F_{(r, n-K)} = \frac{(RESS - UESS)/r}{UESS/(n - K)}, \tag{3.11}$$

where RESS = error sum of squares generated by estimating restricted TL; UESS = error sum of squares generated by estimating unrestricted TL;  $r$  = number of homogeneity restrictions, (= 10 in this example),  $n$  = number of observations, and  $K$  = number of independent variables (= 15 including the intercept term in this example) in the unrestricted TL model. If the computed F-value exceeds the critical F-value with  $(r, n-K)$  degrees of freedom, then the homogeneity conditions will be rejected. The failure to accept the homogeneity conditions provides sufficient evidence against the C-D functional specification for the productivity analysis of the private and socialized farms in Ethiopia. In other words, empirically estimated coefficients of the TL

production function explain the underlying production properties of the farms more accurately than the coefficients of the C-D function.

Provided that the underlying functional form is correctly identified, it will be useful to examine the function for specification error. Whether or not the specification error exists can be evaluated by constructing an auxiliary regression model as suggested by Ramsey (1969). The test is commonly known as 'regression specification error test' (RESET) and it involves procedures similar to the following:

1. Regress the dependent variable,  $Q$ , on the subset of the selected regressors;
2. Get predicted values,  $\hat{Q}$ , of the dependent variable,
3. Transform the  $\hat{Q}$ 's into polynomials such as  $\hat{Q}^2, \hat{Q}^4, \hat{Q}^6$ ,<sup>66</sup>
4. Regress  $Q$  on the independent variables (from step 1) and the polynomial  $\hat{Q}$ 's,
5. Compute an F-test using residual sum of squares from the restricted (RRSS, step 1) and unrestricted (URSS, step 4) models.

The RESET test is generally summarized in terms of an F-ratio as follows:

$$F_{(m, n-k)} = \frac{(RRSS - URSS)/m}{URSS/(n - k)}, \quad (3.12)$$

where  $m$  = number of restrictions (or the number of regression coefficients postulated not to be significantly different from zero),  $n$  = number of observations, and  $k$  = number of coefficients in the auxiliary regression with polynomial  $\hat{Q}$ 's.

<sup>66</sup>

Note that  $\hat{Q}^3, \hat{Q}^5$  are omitted intentionally because their presence leads toward a singular regressor matrix. There is no predetermined limit as to the number of the polynomial  $\hat{Q}$ 's. But Ramsey notes that three  $\hat{Q}$ 's will be sufficient.

The null hypothesis of no specification error will be rejected if the F-test indicates that  $F_{obs.} > F_{critical}$  with degrees of freedom (m, n-k) at the probability level of 5 percent. The converse will be accepted if the value of observed (computed) F-test is no more than a critical F-value with appropriate degrees of freedom thereby concluding that there is no statistically significant evidence of specification error. In this way, the F-test evaluates the combined effect of the omitted variables rather than significance of the individual polynomial  $\hat{Q}$  coefficients.<sup>67</sup>

Moreover, some of the estimated coefficients may not be efficient estimators (that is, may not have minimum variance) due to collinearity (already discussed in Section III.2.2.5), heteroskedasticity and serial correlation. Heteroskedasticity and serial correlation are statistical problems arising from non-spherical properties of the regression residuals (Kennedy (1986)). As it is commonly known, heteroskedasticity (non-constant variance) occurs if the mathematical expectation of squared residuals is not constant along the main diagonal of the variance-covariance matrix of the residuals. On the other hand, the problem of serial correlation between residuals occurs if the expectation of the off-diagonal elements (or covariance between pairs of residuals) is different from zero. Likely effects of these two problems, if not corrected, on the statistical properties of the estimated coefficients can be found in the econometrics literature (for example, see Kennedy (1986), Johnson, Johnson and Buse (1987), Spanos (1987) among others). It is sufficient to briefly note here that in the presence of heteroskedasticity and/or serial correlation, (a) ordinary least squares estimators will not have minimum variance, (hence, they will be inefficient) but the estimators still preserve other desirable properties such as unbiasedness and consistency, (b) variance estimators ( $\hat{\sigma}_i^2$ ) will be biased up (overestimation) or down (underestimation) depending on the relationship between each variance and each regressor in the case of heteroskedasticity (Gujarati (1988)) and they will be biased up (or down) if residuals are positively (or negatively) correlated in the case of serial correlation, consequently, (c) t and F statistics are likely to be

---

<sup>67</sup> The RESET test also checks for non-linearity of the statistical models. The test procedure is concisely summarized by Maddala, page 408. Spanos discusses the RESET test procedure in the context of testing for non-linearity (see pages 460 and 461).

inappropriate for hypothesis testing and they can lead towards inaccurate conclusions if the test statistics are used.

Several methods of detecting heteroskedasticity exist in the literature<sup>68</sup> including the one suggested by White (1980). Unlike the traditional tests (see preceding footnote), Kennedy notes that, significance of the White test is that "it tests specifically for whether or not any heteroskedasticity present causes the variance-covariance matrix of the OLS estimator to differ from its usual formula" (p.98). In fact, the White test does more than that: (a) it tests whether or not the underlying model is specified correctly and (b) it checks if errors are correlated with regressors. The test progresses in three steps. First, residuals are generated from the underlying regression equation. Second, residuals are squared and are regressed on an intercept, quadratic and interaction terms of the original regressors (  $\hat{e}_i^2 = \hat{\beta}_0 + \sum_{i=1}^k \sum_{j \geq i}^k \hat{\beta}_{ij} \omega_i \omega_j$  ). Finally, a joint hypothesis of  $\hat{\beta}_{1j} = \dots = \hat{\beta}_{kk} = 0$  is tested with an asymptotically distributed chi-squared statistic. White goes on to indicate that the chi-squared statistic can be approximated by  $NR_k^2$ , where N is sample size,  $R^2$  is the multiple coefficient of determination of the auxiliary regression and k is degrees of freedom equal to the number of regressors without the intercept of the auxiliary regression. The test will be insignificant (that is, probability of finding test statistic greater than the computed approaches unity  $\chi^2 \rightarrow 1$  ) if the model in question is homoskedastic, correctly specified and the residuals are independent of the regressors. Significant  $\chi^2$  will indicate violation of any of these three properties of the model.<sup>69</sup>

The Durbin-Watson (d) test will be applied to test for the presence of serial correlation. Normally, the test criterion indicates that d will be approximately equal to 2 if the residuals are

---

<sup>68</sup> For example, text book type of diagnostic methods include (a) inspection of residual plots for structural pattern other than random scatter, (b) Goldfeld-Quandt test which suggests (i) dichotomizing ordered observations by some criterion (for example, values of the dependent variable) into two non-overlapping balanced groups by deleting a certain number of central observations, (ii) estimating variance of residuals in each group, (iii) computing an F-ratio from the estimated variances which indicates constant variance if the ratio is unity and otherwise if it is different from unity, (c) Breush-Pagan test which is more general than the Goldfeld-Quandt test (see, for example, Johnson, Johnson and Buse (1987), and so on. Other traditional tests for heteroskedasticity can be found in Judge, Griffiths, Hill, and Lee (1980):145-152.

<sup>69</sup> Additional discussion on the White test can be found in Spanos (1987) pp. 466-7.

independent. That is,  $d = 2(1 - \hat{\rho}) \cong 2$  as  $\hat{\rho} \rightarrow 0$ , where  $\hat{\rho}$  is coefficient of correlation between residuals in time  $t$  and  $t-1$ .<sup>70</sup> As can be seen from the above relationship, the  $d$ -statistic is influenced by the values that  $\hat{\rho}$  takes. If  $|\hat{\rho}|$  is significantly different from 0, it will indicate the presence of either negative serial correlation where the  $d$ -value will be larger than 2 or positive correlation where the  $d$ -value will be smaller than 2. As Kmenta (1971) suggests, the null hypothesis of no serial correlation can be tested against its alternative:

$$\begin{aligned} H_0: & \quad \rho = 0 \\ H_A: & \quad \rho \neq 0 \end{aligned}$$

Kmenta goes on to indicate that, in a large sample case, maximum likelihood estimator  $\hat{\rho}$  will be distributed normally and the student's  $t$ -statistic can be computed as:

$$t = \frac{\hat{\rho}}{s_{\hat{\rho}}} = \frac{\hat{\rho}}{\sqrt{n^{-1}(1 - \hat{\rho}^2)}} \quad (5.14)$$

where  $n$  = number of sample observations. The null hypothesis of no serial correlation will not be rejected if the computed  $t$ -statistic is smaller than the critical  $t$ -statistic at a probability level of not more than 5 percent. Otherwise the decision will be in favor of the alternative hypothesis.

---

<sup>70</sup> Note that  $\hat{\rho}$  is commonly computed as

$$\hat{\rho} = \frac{\text{cov}(\hat{e}_t, \hat{e}_{t-1})}{s_{\hat{e}_t} s_{\hat{e}_{t-1}}}$$

### ***III.4. A Procedure for Hypothesis Testing***

The major hypothesis that was postulated in Chapter I is concerned with returns to scale (RTS) within each farm type. The RTS hypothesis allows to examine if the partial income elasticities with respect to inputs in the empirical production model of each farm type sum to one or to a value more or less than one. Specifically, it is postulated in Chapter I that the RTS are (a) increasing (if greater than one) in the private farm (PF) sector and in the producer cooperative (PC) sector but (b) decreasing (if less than one) in the state farm (SF) sector.

It is convenient to evaluate the RTS hypotheses if they are stated formally as follows:

$$\begin{aligned} H_0^{\text{PF,PC}} : \sum \eta_i = 1 & \quad H_A^{\text{PF,PC}} : \sum \eta_i > 1, \\ H_0^{\text{SF}} : \sum \eta_i = 1 & \quad H_A^{\text{SF}} : \sum \eta_i < 1, \end{aligned} \tag{3.13}$$

where  $\eta_i$  = partial income elasticity (PIE) with respect to the  $i^{\text{th}}$  input; PF, PC SF = private, cooperative, and state farms, respectively. Note that a one-tailed test is implied in the above hypotheses and test statistics will be computed from equation (3.5) if the C-D functional form is accepted for the analysis or from equation (3.9b) if the TL production function is adopted.

### ***III.5 Summary***

The two types of production functions (Cobb-Douglas, translog) and the variance components model presented in the previous sections will be useful to explain variations in Ethiopian cereal production. The variations can be explained by two major factors. First, by a set of known inputs

that are included in the production function estimation process. Second, the variations that are not explained by the set of known inputs will be captured by spatial and temporal dummy variables and the remaining overall variation will be attributed to a random effect of both regional and temporal factors.

The next chapter describes an empirically feasible set of economic variables and production regions included in this study. Agro-ecological regions for which sample research data are collected are identified and their physical characteristics are briefly described. The sample data will be used as a guide to select either of the functional forms with the covariance statistical method discussed in the first part of this chapter.

## **CHAPTER FOUR**

### ***REGIONS, VARIABLES AND SOURCES OF DATA***

#### ***IV.0. Introduction***

The analytical methods summarized in Chapter III will be useful to examine technical characteristics of the three farm types. The type of information generated with estimated production functions will, however, depend on the type and quality of data. This chapter briefly discusses characteristics of cereal producing agro-ecological regions in Section IV.1. This is followed by discussion of the output and input variables in Section IV.2. The input variables consist of traditional and modern inputs in cereal production. These are land sown to cereals, labor, oxen, fertilizer, traditional farm implements, tractors, weather, and modern yield-increasing inputs (such as improved seeds, fertilizer, herbicides, and pesticides), productive livestock (cattle, sheep, goats, chickens), animal power (horses, mules, donkeys, camels), and per capita rural school enrollment ratio in grades 1-12. A descriptive summary of the data is presented in Section IV.3. Section IV.4 identifies sources of research data. The last section of the chapter presents a concise summary of the data and the variables.

#### ***IV.1. Characteristics of Agro-ecological Regions***

Agro-ecological conditions vary from region to region, influence agricultural practices, and tend to determine distribution and productivity of the cereal crops. Classifying agro-ecological regions

that produce the cereal crops is, however, a complex matter and a complete characterization of the ecological factors is beyond the scope of this research. This section briefly sketches some physical characteristics that tend to provide homogeneity and heterogeneity within and among the cereal producing regions under consideration.

Aggregation or disaggregation of social information in Ethiopia usually follows the pattern that the country is divided into for political administration. As discussed in Chapter II, the country is divided into 14 provinces (or administrative regions as they are called since 1974), 102 *awrajjas* (districts), 471 *weredas* (sub districts), and numerous small units of villages. Several of the *awrajjas* will be considered in the productivity analysis of the private and socialized agriculture in Ethiopia. The number of the *awrajjas* will be limited to cereal producing ones contained in twelve out of fourteen provinces, namely, Arsi, Bale-Goba, Gemu-Goffa, Gojjam, Gonder, Harrarge, Illubabor, Keffa, Shewa, Sidamo, Wellega, and Wello.<sup>71</sup>

The most common breakdown of the agro-ecological regions of Ethiopia consists of four major classifications: central highlands (an average elevation range of 1800-3000 meters above sea level (m.a.s.l.), eastern highlands (above 1800 m.a.s.l.), southwestern highlands (at 1400-2400 m.a.s.l.), and southeastern highlands (at above 1400 m.a.s.l.). *Awrajjas* located in each of the agro-ecological zones vary in many respects including population, land size, production habits, weather, and types of soil. Diverse characteristics of the central highlands are shared largely by Shoa, Gojam, Gonder, and Wello provinces. Arsi, Balie-Goba and Hararghie provinces make up the eastern highlands. The southwestern highlands span Illubabor, Keffa and Wellega provinces. Sidamo and Gemu-Goffa provinces are in the southeastern highlands.<sup>72</sup>

---

<sup>71</sup> The two excluded provinces are Eritrea and Tigray. They are excluded because no reliable information is available due to persistent political unrest in the two provinces. Unfortunately, the provinces are also the ones severely affected by drought.

<sup>72</sup> A more detailed discussion of the agro-ecological regions can be found in the *Ten-Year Development Plan, 1984-1994* of Ethiopia and in Bellete's Ph.D. dissertation completed in 1978 at Oregon State University.

The agro-ecological regions are represented in the empirical models by dummy (or proxy) variables defined as follows:  $D_1$  = Eastern highlands,  $D_2$  = Southwestern highlands, and  $D_3$  = Southeastern highlands. The central highlands are used as a benchmark to which technical efficiency of the other regions are compared.

The agro-ecological zones tend to define average environmental conditions suitable for best growth of cereal grains: *teff*, wheat, barley, maize, and sorghum. For example, *teff* is commonly grown at an altitude range of 1700-2400 m.a.s.l. where it receives an average annual rainfall of 200-400 millimeters (mm). Wheat grows between 1700-2800 m.a.s.l. with average rainfall of above 300mm. Barley appears to be prevalent between 1800-2200 m.a.s.l. where it receives at least 240 mm of average rainfall. Regions that are situated below or at 2200 m.a.s.l. and which get more than 400 mm of rainfall are suitable mainly for maize production, whereas, other regions situated at slightly lower altitude of not-more-than 2000 m.a.s.l. where they receive 400-600 mm of rainfall tend to be best suited for sorghum cultivation.

National agricultural surveys show that farmers in Arsi, Gojam, Gonder, Shewa, and Wello allocate most of the cultivable land area to *teff*, whereas, farmers in Gemu-Goffa, Illubabor, Keffa, Sidamo, and Wellega plant most of the cropland to maize. Farmers in Balie and Hararghie provinces plant the majority of the cultivated land area to wheat and sorghum, respectively. All the provinces produce barley, but the crop does not appear dominant relative to other food grains.<sup>73</sup>

The national Atlas of Ethiopia, published in 1981 by the Ethiopian Mapping Agency, identifies 13 major types of soils. Three soil types, *cambisols*, *nitosols*, and *regosols*., out of the 13 are most prevalent in the cereal producing *awrajjas* and cover about 64 percent of Ethiopia's land mass. For instance, *cambisols* cover 20.44 percent, *nitosols* 13.87 percent, *regosols* 29.93 percent. *Cambisols* and *nitrous* are dominant in the western plateau (otherwise known as the Central Lava Highlands

---

<sup>73</sup> See National Atlas of Ethiopia (1981), pp:64-64.

and Massifs). *Regosols* are arid and dominant largely in the southeastern and northeastern regions of Ethiopia.

Among other factors, productivity characteristics of these soils tend to dictate regional differences in vegetation and agricultural crop-mix. *Cambisols*, for example, are characterized as having a relatively productive A-horizon with little salinity problem. *Nitosols* are often identified as having a B-horizon dominated mainly by a high clay content. Both *cambisols* and *nitols* are high in soil moisture retention capacity and are generally suitable for hoe and plough cultivation and pasture production. On the other hand, *regosols* tend to be arid and suitable mainly for animal (horses, asses, camels, mules, and other livestock) production and slightly suitable for rain-fed cereal production. ✓

The economic, social and historical influence of the agro-ecological regions on the production habits of the Ethiopian farmers is quite complex. As a result of repeated application of the production practices over long periods of time, Ethiopian farmers have developed reasonably stable agrarian traditions and common production norms that tend to prevail cross-sectionally. Over time, the farmers have developed an optimizing behavior subject to the agro-ecological, cultural and political circumstances facing them. Resource allocative skills and the optimizing behavior of the farmers are latent inputs which can not be measured accurately. Regardless in which agro-ecological zone the farmers are settled, their dominant preoccupation appears to be security of subsistence living. The past and present tradition of subsistence living has, therefore, taught them a conservative approach to factors which they perceive to be inducing potential risk and uncertainty in their production habits. The signs and magnitudes of estimated coefficients of the conventional inputs (oxen, land, traditional farm labor and implements) will indicate how cereal output responded to these inputs. Allocation of the inputs is invariably influenced by farmers' traditional wisdom, agro-ecological conditions, and historical production experience. Other dependent and independent variables are discussed next.

## ***IV.2. Production Variables***

Economic variables included in this study and methods of specifying the variables and normalization of the variables are discussed in sections (IV.2.1.) through (IV.2.11). Production data for the variables are limited to the main cereal production season between June and December.

### **IV.2.1. Aggregate Cereal Output**

Yearly data on cereal output for each district was gathered for five cereal crops: *teff*, maize, barley, sorghum, and wheat. In order to evaluate the impact of changes in input factors on cereal production by each of the three farm types, these cereal crops would have to be aggregated into a single quantity. Quantities of each crop were converted into gross value of output (that is, gross income from which cost of production is not deducted) by multiplying the output quantities by corresponding annual prices received by producers. For reasons discussed below, the cereal crops produced by the socialized farm sector (cooperatives and state farms) are weighted by centrally determined prices and those of the private sector are weighted by parallel market prices. Employing price weights is useful for converting heterogeneous (in terms of kind and quality or nutritional value) cereal output quantities to a single monetary value.

As indicated in Chapter II, there are two types of agricultural output prices in Ethiopia: official prices and parallel market prices. The official prices are determined by a central planning committee (CPC) and the prices are generally invariant over time and space. The CPC plays the role of a competitive market and determines prices on a *cost-plus* basis. Presumably, the CPC prices are supposed to: (a) represent the competitive behavior of buyers and sellers over which they have no direct influence and (b) guide production decisions of the cooperative and state farms. Producers

in the private farm sector also adhere to the CPC prices to deliver output quotas which are a proportion of their total output of each cereal crop.

The parallel market prices are observed in the private sector. These prices are usually higher than the CPC determined prices. Hence, producers in the private sector respond largely to these prices. Central authorities tolerate the parallel market prices mainly because the parallel market prices transfer cereal grains from surplus regions to deficit regions and, perhaps most importantly, they indirectly promote the quota system (see Chapter II).

At least, two limitations inherent in constructing the aggregate output variable need to be noted. First, the use of parallel market price weights is likely to generate upward biased productivity estimators of the private farm sector. On the other hand, the use of the CPC price weights is likely to generate downward biased productivity estimators of the cooperative and state farms. Each category of the price weights, however, closely approximates the actual price policy environment under which production plans of each farm type are implemented. In reality, the CPC prices may have limited relationship to the actual payments to the factors of production employed by cereal producing farms in the cooperative and state sectors. For the most part, the centrally determined CPC cereal prices are based on insufficient knowledge about resource scarcity, production capacities and productivity of the resources. As a result, cereal grains of the socialized farm sector are likely to be valued below their marginal cost of production per unit of output. Second, even though the price weights provide a method to convert the cereal grains into a "common" unit, the cereal crops are not complements nor are they perfect substitutes. A direct summation of the cereal crops weighted by prices may, therefore, result in an aggregation error for obvious reasons: the method fails to recognize cross-sectional and temporal changes especially in in output of the state farms (but, official agricultural prices are invariant over time and space). These limitations can raise some doubts about the plausibility of the results reported in Chapter VI. A better method of constructing output variable (for example, in terms of wheat equivalents as in Hayami and Ruttan) may generate more plausible results. However, as discussed previously, the prices employed in this research are

price signals to which producers have been reacting and thus it can be argued that these prices do influence the production decisions of the producers.

#### IV.2.2. Farm Labor

In the estimation of an agricultural production function, farm labor is sometimes dichotomized either into skilled and unskilled, full time and part-time, family labor and hired-in labor, male and female, or “young” and “old” workers. The main purpose of such dichotomization is to correct the labor input for differences in quality. If labor quality is ignored, technical properties such as marginal productivity and elasticity of output with respect to labor may be biased. But, if the labor variable is not correlated with the omitted labor quality variable, the estimated labor coefficient will not be biased. Otherwise, direction of the bias will depend on whether the correlation is negative or positive.

Agricultural production of both private and socialized sectors depends heavily on labor supplied by the farm households. For purposes of this study, the labor variable includes male and female workers in a working age population group between ages 15 and 59 years.<sup>74</sup> Under the prevailing cultural norms of the traditional farming practices managerial and operational labor is provided mainly by the head of a household (usually male). The farmer receives additional labor input supplied by his wife and other members of the household. A female becomes the head of the household in the absence of a male head.

---

<sup>74</sup> Other categories of rural population include persons between ages 0 -14 years which accounts for 46 percent and persons of age 60 and over which account for the remaining 4 percent. The population between ages 0 - 14 and 60 and over may not have sufficient physical ability to undertake substantial crop production activities. But, it is fair to recognize their participation in field operations such as weeding, occasionally transporting farm implements to work places, herding cattle, carrying sheaves during harvest and so on. Especially, persons of ages 60 and over indirectly participate in agricultural production activities through functions such as imparting traditional wisdom to the younger generation, “managing” children between ages 0 - 14, and making sure that law and order are maintained both at household level and community level. See *Ethiopia: Statistical Abstract* 1980. p. 38.

State farms hire unskilled labor, often identified as temporary relative to permanent labor. The permanent labor consists of salaried persons who possess modern education and technical skills of planning, research, finance, secretarial services, machinery operation (for example, tractor driving, raking, maintenance), and so on. Temporary workers are hired seasonally from the traditional sector at a constant wage rate of 1.92 Birr per day. The workers are hired for field operations such as seedbed preparation, weeding, irrigation, harvest, and crop protection from birds and theft. Most of these are identical jobs that the temporary workers normally do if they are self employed on their own farms.

The labor input for the state farms is limited (for reasons discussed next) to the temporary labor in the main season. The variable is measured in terms of temporary labor-days by dividing total wage bill paid to the temporary workers on cereal farms by the daily wage rate, 1.92 Birr. It would be more accurate to include separate measures for both permanent and temporary labor components of the state farms than focusing only on the temporary labor. This could not be done because data were not available for the permanent labor component. The estimated coefficient of the temporary labor might therefore be biased upward because of a positive correlation between the two components of labor. Awareness of this limitation is necessary when interpreting the labor coefficient of the state farms.

Hired-in labor is almost non-existent in the private farms and the producer cooperatives. In fact, current farm laws, introduced following the 1975 land reform, prevent farmers (except the state farms) from using hired labor. An exact definition of the labor input for the private farms and the producer cooperatives is not as straight forward as it is for the state farms. The following brief discussion explains procedures employed to identify the labor variable for the private farms and producer cooperatives.

As indicated in Chapter II, the producer cooperatives are a new institution created over the last decade. They coexist with the private farms from which they are developed. In this regard, the

producer cooperatives possess many of the underlying characteristics of their parent institution. It would, however, be a mistake to treat them as an identical institution to the private farms. To begin with, the producer cooperatives are guided by cooperative legislation which gives them a legal status different from the private farms. They operate under a detailed and strict set of regulations that establish standard procedures for resource ownership, labor supply, output distribution, and other legal and political aspects of the cooperatives. As discussed in Chapter II, they enjoy benefits of preferential treatment by the government in terms of a relatively lower land use tax than the private farmers.

Some modern technical inputs such as fertilizer are supplied at relatively lower prices than the prices normally charged to the private farmers. Depending upon the stages of collectivization, most traditional resources such as land and labor are owned communally (see Chapter II). Labor, in this context is to be understood in terms of a person's physical and mental ability to supply the necessary farm power (energy) to produce an output. At the close of each production period, labor is remunerated its share of output in-kind proportional to its quantity of work points (hours) but not necessarily according to the needs of the person who supplies the labor. Such incentive-driven remuneration, based on an achieved points system, is therefore expected to extract the maximum amount of cooperative labor to produce increased levels of output.

The Ethiopian producer cooperative sector is relatively less understood than the private farms and state farms and it deserves a separate research agenda. For the purposes of this study, however, note that cereal crop production activities of the cooperatives rely on the collectively owned labor input provided by male and female members. Among other requirements, an individual "seeking" a membership with a given producer cooperative (PC), is required to attain a minimum age of 18 years before the applicant is registered as a member. The 18 years of age criterion appears to stand at variance with the 15 years of age as the starting point of "working age" population defined by both the Central Statistical Office (CSO) and the Ministry of Agriculture (MOA). The 1980 census compiled by CSO, for instance, identifies the working age population between 15 and 65 years of

age. The MOA, on the other hand, defines the working age population between ages 15 and 59. Obviously, the CSO definition (of working age between 15 - 65) includes more people than the MOA's definition (of working age between 15 - 59). The differences are small in terms of numbers, but may significantly influence the estimated marginal productivity of labor: compared to the MOA's working age definition, the labor input coefficient might be underestimated if CSO's working age population is used. The CSO's definition is in-line with the international convention about an average working age population. However, in view of the (a) availability of the essential data for the labor input between ages 15 and 59, and (b) given largely substandard nutritional and low life expectancy conditions that prevail in the country, the MOA definition of the working age population is used in this research.<sup>75</sup>

The CSO undertook a nationwide rural labor force (RLF) study between April 1981 and April 1982 and results were published in 1985. The RLF study is used to extract two relevant pieces of information for this research: (a) the percentage of rural households employed in cereal production and (b) the seasonally adjusted mean number of days worked per week by employed persons.<sup>76</sup> First, eight major rural industrial groups were identified in the RLF report and agriculture is one of them.<sup>77</sup> Agriculture was found to employ over 97 percent of all employed persons in various rural industries. Because of the revealed importance of agriculture, the sector was disaggregated into ten different occupational subsectors. At the national level, over 96 percent of all employed persons in

---

<sup>75</sup> Since both CSO and MOA are public institutions whose actions are often translated into some type of national policy, it would be advisable to establish a uniform definition of the working age population. In the absence of a uniform definition, erroneous labor related policies, programs and plans can emerge on the basis of conflicting information.

<sup>76</sup> A person must be engaged in some type of productive work during various rounds of the survey in order to be considered as employed. Any form of work that produces goods or services for market or home consumption was defined as productive work. For example, according the RLF survey, typical productive work includes such activities as planting, pre-harvest and harvest operations, pottery, weaving, black smithing, and so on. However, ordinary household production activities such as food preparation, fencing, fetching fire wood, and so on, were not considered as part of the productive work.

<sup>77</sup> Other rural industrial groups include manufacturing, mining and quarrying, electricity, construction, wholesale and retail trade, transport and communications, and services.

agriculture are reported to be involved in various activities of cereal production.<sup>78</sup> These results of the RLF study clearly indicate that production of cereals is the most dominant profession for the majority of Ethiopian rural households.

Second, the study also contains the seasonally adjusted mean number of work days for each province of Ethiopia. As a whole, the study indicates that rural Ethiopians work an average of 3.9 days in any given week.<sup>79</sup> Male workers employed in productive work spend 4.2 mean days and female workers spend 3.3 mean days per week. The mean work days of productive activities are influenced largely by the seasonality of agricultural activities,<sup>80</sup> religious holidays, age, sex, and cultural practices such as wedding and visitation traditions following the Easter holidays.<sup>81</sup>

As indicated previously, the two principal seasons of cereal production are *meher* between June and December and *belg* between February and May. *Meher* is traditionally the main season for agricultural production. Due to lack of reliable data for the *belg* season production, this study considers only the main season cereal production.

The mean days worked vary from one province to another thereby, among other factors, indicating regional variations in (a) rural households' attitudes towards leisure and labor (work) preferences, (b) cropping patterns, demographic factors, and (c) environmental factors such as weather. As noted previously, the mean work days vary between genders in each province. The

---

<sup>78</sup> Other agricultural subsectors include pulses, fruit trees, cash crops (see Chapter II), hunting, livestock, agricultural services, forestry, fishing, and others.

<sup>79</sup> The length of the mean work days is not included in the study.

<sup>80</sup> Calendar year seasons include *Tebi* or Autumn (September, October, November), *Bega* or Summer (December, January, February), *Belg* or Spring (March, April, May), and *Kremt* or Winter (June, July, August).

<sup>81</sup> A thorough account of the number of holidays in Ethiopia would be quite a complicated task due to religious (mainly Orthodox and Muslim) traditions associated with patron saints. Celebrations of the saint's holidays in some cases vary from one village to another depending on population distribution that adheres to a particular type of religion. The preference of such holidays is perhaps "local" compared to the Ethiopian societies' collective choice between work and leisure which is revealed in the number of official calendar holidays.

province of Gojjam, for instance, allocates 99 percent of its employed labor input (male = 99.4 percent, female = 98.5 percent) to cereal production but its population works 3.2 mean days (male = 3.4, female = 2.7) per week, whereas, Shoa province allocates 96.4 percent (male = 98.4 percent, female = 92.2 percent) of its employed labor input to cereal production and its residents work about 3.9 mean days (male = 4.1, female = 3.4) per week. These results of the RLF study seem to suggest that, since, cereal production is dominant agricultural subsector, it claims a large portion of the mean days worked.

Both the PC and the private farms sector labor must be transformed into homogeneous units of labor-days as is done for the state farms. The transformation process is illustrated below in two stages. A transformation factor is computed first, then a measure of total labor-days is computed for each *awrajjja* with this information. The process is summarized with the following notation:

$i$  = cohort groups 1, ... , 9 (i.e., ages 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59),

$j$  = male, female gender,

$N'_{ijr}$  = number of persons in cohort  $i$  of gender  $j$  in *awrajjja*  $r$ ,  $f$  = private or cooperative farm,

$D_{jp}$  = seasonally adjusted mean number of days worked per week by gender  $j$  in province  $p$ ,

$k$  = weeks (as explained below) required by one person to complete main season cereal production activities,

$R_{jp}$  = proportion of gender  $j$  employed in cereal producing activities in province  $p$ ,

$w_{ij}$  = adjustment factor to transform  $N'_{ijr}$  into labor-days,

$L_{rf}$  = total labor-days employed either on  $f$  = private or cooperative farm type in the main season cereal production period in *awrajjja*  $r$ .

The conversion factor,  $w$ , is computed as:

$$w_{ij} = kR_{jp}D_{jp} \quad (4.1)$$

where the arguments are as defined previously. The value of  $w$  indicates total number of days that one person of gender  $j$  in the working age population group  $i$  would require to complete the main season cereal production activities starting from seedbed preparation in June to harvest in December. It ( $w$ ) is a proxy adjustment factor for some qualitative variables which might influence slope of the labor variable. For instance, it roughly adjusts for differences in sex and age and other associated elements such as physical ability to do productive work. These qualitative characteristics are implicit in the adjustment process.

The exact value of  $k$  may arguably vary with type of a cereal crop and/or with *awrajja* under consideration. In this research, however, it is assigned a value of 28 weeks, the duration of time needed to complete the main season cereal production.<sup>82</sup> Note that similar adjustment of the state farm labor input is not necessary because the temporary labor data are already adjusted by the seasonality of cereal production.

Since R and D components of  $w$  are given only at provincial level, *awrajjas* represented by a province receive the same  $w$ . But the total labor-days,  $L$ , between any two *awrajjas* will not be identical, because  $N'_{ijr}$  is available for each farm type on an *awrajja* basis.

Finally, the results of Equation (4.1) can be used to compute total labor supply of private and cooperative farms in a given *awrajja*:

$$L_{rf} = \sum_{j=1}^2 \sum_i^9 w_{ij} N'_{ijr} \quad (4.1b)$$

---

<sup>82</sup> This assumption agrees with the cereals production time schedule recorded by Pankhurst (1968), p. 191.

where  $L$  is total labor-days in the main season cereal production period either in the private farm sector or in the cooperative farms in *awrajja*  $r$ . As indicated in the earlier discussion, the number of cohort groups begins with 1 for the private sector and with 2 for the cooperative sector. This (or  $i = 2 \dots 9$ ) is because the labor data of the producer cooperatives consist of the number of members who are at least 18 years of age. Thus, the labor variable for the cooperative sector is adjusted starting from the second cohort.

The above adjustments implicitly reduce effects of some factors such as idle labor that would otherwise induce a bias in labor productivity estimates.<sup>83</sup> Reasons for idle labor can be numerous including an interaction between bad weather and labor, death of a relative or community member, sickness, or politically induced organizational meetings. Most of these potential limitations are, however, already accounted for in the determination of the seasonally adjusted mean days,  $D_{ijp}$ , worked by employed persons. Based on these adjustments, it would be reasonable to expect positively significant but different regression coefficients of the labor variable for each farm type.

### IV.2.3. Work Oxen

Oxen are the main source of power for plowing farm land in the private farms and producer cooperatives, but not in the state farms. The current cultivation practices combine one plow with a pair of oxen. Yearly data on total number of oxen employed by each farm type (private farms and producer cooperatives) are used for each *awrajja*. The number of oxen is converted to oxen-days by a constant factor of work-days. The conversion procedures are discussed next.

First, studies by the International Livestock Center for Africa (ILCA) (1984) indicate that crop production activities such as land preparation, planting and threshing require an annual average of

---

<sup>83</sup> Cross-sectional variations that persist over time due to labor quality differences will be relegated to regression residuals; although, some of the variations will be captured by regional dummy variables.

350 hours per oxen pair (H). ILCA's estimate of oxen hours includes oxen employed in cereal production during both *meher* (main) and *belg* (short) seasons. The total hours of oxen use, therefore, need to be adjusted to the *meher* season. Traditionally, oxen are used intensively for planting operations during June, July and August, for threshing harvested cereal grains in November and December, and again for the short rainfall season planting and threshing activities in the months of February and May, respectively. These dates constitute a total of 152 and 60.8 possible work days that a pair of oxen could be at work in the main and short rainfall seasons, respectively. Thus, the 350 hours of oxen-use need to be adjusted roughly by a proportion of the 152 days (m) out of the total of 212.8 ( = 152 + 60.8) possible days of work for a pair of oxen. ILCA notes that a pair of oxen commonly operates for 4 to 9 hours (or for a geometric mean of 6 hours) a day (h). Based on these pieces of information, oxen-use over the 152-day period can be converted into oxen days:

$$X_{fr} = \left[ .5N_{fr} \left( \frac{H}{h} \right) \right] \frac{m}{212.8} = 20.83333N_{fr} \quad (4.2)$$

where:  $X_{fr}$  = total oxen-days worked in farm type f (f = private farms, producer cooperatives) in *awraja* r in a given production year,  $N_{fr}$  = total number of single oxen of farm type f in *awraja* r, 0.5 = factor used to convert  $N_{fr}$  to a pair of oxen in compliance with the traditional farming practices, H = total hours (350) worked by a pair of oxen in a production year, h = geometric mean (6) hours worked per oxen pair per day.

The above adjustment process is based on incomplete information and it may lead towards an underestimation of the contribution of oxen. This is especially the case with the threshing activity which does not require use of paired oxen alone. The threshing activity is often shared with other livestock animals such as cows and workstock animals, but it is difficult to isolate exact number of oxen-days used for the threshing activity. There are additional complications which limit an accurate definition of the oxen variable and they are noted next.

The foregoing discussion indicates that the traditional agriculture of Ethiopia is dependent largely on a two-oxen technology. Needless to say, every farmer does not have two oxen: some farmers own two or more oxen, some own only one, and some own none. It would be instructive to highlight some socially preferred strategies that the traditional communities employ to manage seasonal oxen scarcity. For instance, farmers who own none-to-one ox often enter into an oxen-rental system. The rental process is not standardized. It varies among different regions. Rental values are more often paid in-kind than in-cash. The terms of the contractual agreement are unwritten. The terms are usually established bilaterally within regionally received norms of rental practices. An equitable distribution of the benefits from the rental arrangements could become complicated when one considers such factors as the possibility of uneven land ownership that requires extended use of oxen by one of the contracting farmers who happens to own more land, and variation in the integrity of the renters with respect to the maintenance of normal working conditions of one's own ox during the period the ox is employed by the other contracting farmer.

Among other factors, the length of oxen work days, the amount of work and the speed with which a pair of oxen works is influenced by weight, nutrition and training of each work ox (ILCA (1984)). These responsibilities vary with the type of rental agreement, but generally feeding, training and maintaining the normal working conditions of an ox are the responsibility of the individual owners.

Those farmers who have no oxen of their own rent an ox (with which they can pair up another ox owned by a farmer in the neighborhood): (a) for a year at the rental-value of up to 300 kilograms of grain (type of grain is implicitly value-driven and gets determined in the bargaining process) to be paid at the next harvest, or (b) pay the cost of the rent in terms of their own labor supply, to the ox owner usually at a 2-to-1 ratio: 2 days of labor supply for every day of oxen use, or (c) rent a young ox to train while getting field work done with the ox and return the ox to the original owner at the end of the production season, or (d) some farmers who are incapable of bearing rental costs enter into a share-cropping arrangement with another farmer who would supply

his own labor and oxen to cultivate the land of the “incapable” farmer for a return of 50 percent of the total production.<sup>84</sup>

The oxen-pair dependent agricultural system of Ethiopia appears to induce production risk because, due to oxen scarcity and techniques used to manage the scarcity, a good number of the farmers are usually unable to complete critical field operations in a timely fashion. Collective output value of the lost time in the oxen rotation process (or transaction costs) may create a deadweight loss to the society unless recovered by gains somewhere else in the economy. The risk of lost income opportunities may be reduced if the use of single oxen for crop production is widely accepted by a majority of the farmers. The technology is being developed by ILCA but it is still at its embryonic stage.

Finally, Ethiopian oxen studies by Gryseels, Astatke, Anderson, and Assamenew (1984) indicate a negative relationship between land area planted to non-cereal crops and the number of draft oxen owned by private producers. Producers who own non-to-one ox tend to shift their production preferences towards relatively less power intensive cash grains such as flax and peas planted to smaller pieces of land than those farmers who own two or more oxen and who shift cropping patterns to cereals planted to much larger land area. But, as documented in series of oxen-loan studies by the Agricultural and Industrial Development (AID) Bank (1987) of Ethiopia, changes in crop yield per hectare are influenced by a number of cultural and environmental factors including oxen power.

---

<sup>84</sup> See *Draft Oxen Evaluation Study* by the Agricultural and Industrial Development (AID) Bank of Ethiopia (1987).

#### IV.2.4. Traditional Farm Implements

Three categories of traditional implements are commonly used in the subsistence agriculture of Ethiopia: land preparation and planting, harvesting winnowing. The land preparation and planting operations are performed with a plow head (*maresha*), plow beam (*mofer*), wedges (or wings), yoke (*kenber*), handle, and adjustable leather strap. These implements are used along with oxen. Other land preparation implements (or hand tools) include a flat tip hoe (*domma*), forked hoe (*mekotkotcha*) and (*dengora*). These are relatively less sophisticated implements than the previous ones.

Weeding and harvest operations are performed with a sickle (*mechid*), whereas winnowing operations are performed with either wooden fork (*yenchet mensh*) or metal fork (*yebret mensh*) and large spade-like wooden spoon (*layda*).

The non-wooden implements are usually produced and sold in open markets by private entrepreneurs. Price is determined by supply and demand forces that prevail in local markets, but varies with size, type and quality of the implements. In some cases, the implements can either be produced at home or purchased at local markets. Both wooden and non-wooden implements become fixed capital stock once farmers invest in them. The implements age, depreciate and deteriorate overtime until they must be replaced despite regular maintenance and/or repair.

In this research, the traditional farm implements are defined in terms of two variables: an (O) for land preparation and planting implements (*maresha*, *mofer*, *kenber*, *mekotkotcha*, *domma*) and a (H) for harvest and winnowing operations (*machid*, *layda*, *yenchet mensh*, *yebret mensh*). Components of each category are aggregated in terms of Birr valued at prices paid by farmers within each *awrajja*. Due to data limitations, the implements are measured in terms of stock (their total value) rather than service flow. No attempt is made (since it would be impossible) to adjust the

implements for differences in quality. Managerial ability of farmers which might be correlated with the use of the implements is also omitted from the estimation process. The marginal productivities and elasticities of the implements would be biased either upward or downward depending on the nature of correlation of the omitted variables.

The traditional farm implements are defined only for the private farm sector due to the unavailability of the essential data especially for the producer cooperatives sector. The implements are, however, not relevant for the state farms because these farms use modern farm technology.

#### **IV.2.5. Education**

Education improves the quality of farm labor and plays an important role in labor productivity in cereal production. Average years of farmers' education would indicate the general level of formal education in rural communities and would be one important measure of human capital. Most of the farm labor force in Ethiopia is, however, "uneducated" in terms of modern schooling but data on education of adults are not available. Due to the lack of such information, the education variable is defined in this research in terms of annual school enrollment ratios of male and female pupils in primary (grades 1-6) and secondary (grades 7-12) levels of education to rural population in each cereal producing *awraja*. This measure was chosen on the assumption that the ratio of enrolled children is positively correlated with the level of education of the adults of the *awrajas*.<sup>85</sup> The number of pupils as a percent of school age population may be a better indicator of the general level of education in rural Ethiopia because it reflects the proportion of enrolled children relative to the school age population. However, data were not available for the school age population.

---

<sup>85</sup> School enrollment ratio approach was used by Hayami and Rutan (1985) to define the education variable in their international comparison of agricultural production and factor productivities.

The education variable can reflect the impacts of various factors including (a) human capital development in rural areas, (b) willingness and ability of rural households to educate their children and (c) availability of social infrastructure such as access roads, schools and other services that promote education. Even though it is outside the realm of this study, it is useful to understand the implications of the last two (willingness and ability on the one hand and social infrastructure on the other) factors for the level of general education in rural Ethiopia. A separate research agenda seems appropriate to address these factors. In Ethiopia, where child education is not compulsory, parents' willingness to send their children generally tends to be inversely related to farm households' demand for family labor. Moreover, their ability to pay for the child's books, transportation, food, clothing, and housing away from the home environment also influences the willingness of farm households to educate their children.

The preceding discussion briefly illustrates that the education variable represents a complex set of issues and it will be difficult to clearly interpret implications of the estimated coefficient of the variable. For this reason, interpretation of the education coefficient will be limited to its impact as an approximate measure of human capital. The definition of the education variable as a measure of the contributions of human capital seems reasonable, especially if children's education level is assumed to directly relate to "parents' education" or *vice-versa*. Generally, farmers who are aware of the value of education are more inclined to send their children to school than those farmers who are unaware of the value of education. Moreover, school children influence quality of farm labor in many different ways. They often engage in explaining agricultural policies to farmers, transfer new information about farming to their parents and communities, inform parents (who do not understand the Amharic language) about weather conditions from the national radio, and interpret instructions on fertilizer packages to farmers who can not read or write either Amharic or English. Some high school graduates who live in rural areas assist local communities with teaching, bookkeeping for village institutions, meetings of community organizations, political consciousness, and community health and hygiene (Sjostrom (1987)). These are certainly positive contributions from which rural communities can benefit.

As indicated in Chapter II, despite the Ethiopian government's policy against out-migration from rural communities, it is not uncommon to see a good number of unemployed high school graduates who leave rural communities in search of employment in major cities such as Addis Ababa and Jimma. The majority of the students, however, return to their communities for occasional visits during which time they (a) inject new information into the communities about urban life style; (b) assist families with farm and household production activities; and (c) consume their share of family income. On the other hand, the students withdraw some resources such as labor, human capital, food, and cash from the rural communities when they return to the urban centers in search of non-farm employment. In this regard, it can be postulated that out-migration of the majority of high school graduates away from the rural communities is likely to reduce direct benefits to the home community of secondary education of children.

#### **IV.2.6. Modern Yield-Increasing Inputs**

As defined in this research, the modern yield-increasing (MYI) inputs consist of fertilizer, improved seeds, herbicides and pesticides. The most widely used types of fertilizer in Ethiopia are diammonium phosphate otherwise know as DAP and urea. DAP is more widely used than urea. Experts in the AID Bank estimate that urea accounts for only about 3 percent of total fertilizer consumption.

Information on fertilizer input on the cereal producing private and cooperative farms comes in physical units of total quintals (1 quintal = 100 kilograms). The physical quantities of each fertilizer component (DAP and urea) are converted to total Birr value by domestic prices paid by farmers. Then, these monetary values are aggregated to construct a single fertilizer variable (F). In the case where only total combined quantities of fertilizer data are reported for any farm time, the quantities are converted to Birr by a weighted price computed as follows:

$$P_w = \left[ \frac{d}{d+u} \right] p_d + \left[ \frac{u}{d+u} \right] p_u \quad (4.3)$$

where  $P_w$  is weighted fertilizer price,  $p_d$  and  $p_u$  are per quintal prices of DAP (d) and urea (u), respectively. National price and quantities are used to compute the weighted price.

These fertilizer inputs (DAP and urea) are purchased by the government of Ethiopia at world prices. Farm level consumption could be influenced indirectly by market conditions that prevail in international trade flows. Ethiopian farmers are, however, insulated by subsidized prices from the direct impacts of world price fluctuations by the government of Ethiopia which manages variabilities in domestic prices.

As indicated previously, fertilizer data are collected only for the private farms and the producer cooperatives. The other category of MYI inputs includes aggregate expenses on improved seeds, herbicides and pesticides for the producer cooperative sector and total expenses on improved seeds, herbicides, pesticides, and fertilizer for the state farm sector. A separate definition of fertilizer input on the state farms would be preferable but disaggregate fertilizer cost data with adequate detail were not available. Finally, note that the use of chemical ingredients such as kilograms of nitrogen and phosphorus may be more appropriate than price weights. However, information on the specific chemical composition of the fertilizer components used in Ethiopia was not available. Also, since urea makes up such a small component (3 percent) of total fertilizer use, lack of this adjustment may not be that serious.

#### **IV.2.7. Mechanical Power**

The mechanical power variable is relevant only to the two farm types in the socialized sector as mechanical power information is not available for the private farm sector. This variable is defined

in terms of number of tractors, as capital stock, in the cooperative sector. But, the variables is defined in terms of flow of machinery services on the state farms. The machinery services are measured in terms of operating costs such as maintenance, repair, lubrication, and fuel. Depreciation was not included in the machinery services due data limitations.

The use of farm machinery such as tractors is not as common in the private sector as in the socialized sector. The private sector depends more on oxen power than on tractors. Naturally, traditional farmers, either individually or collectively, are limited by capital constraints in their acquisition of modern machinery. A good number of the traditional farmers are increasingly becoming aware of the benefits that can be derived from this technology. Such a transformation in the behavior of the traditional farmers towards modern technology is the result of a combination of endogenous and exogenous forces on the sector. Some of the notable events include rapid changes in the general political and social environment that have elevated farmers' levels of consciousness, lack of rain that has exacerbated production risk, government price policies that have paid them artificially low prices relative to the parallel market prices, increased mobility of community members to new frontiers from depleted areas to areas with abundant natural resources, and so on. Policy makers seem to be aware of these changes in farmers' behavior towards modern technology.<sup>86</sup> But the low prices received for their cereal grains may discourage farmers from adopting modern technology.

Machinery operating costs of (fuel, lubrication, repair and maintenance) production are used for the state farms. Since this type of information on operating costs is not available for the producer cooperatives, total number of tractors is used. As measured in this study, the number of tractors of the producer cooperatives indicates at least two factors. First, it measures tractors as a stock of

---

<sup>86</sup> For example, the government established an Agricultural Mechanization Service Corporation in 1985 which delivers machinery services mainly to a small group of resettled communities. The Corporation provides plowing, discing, and harvest services at centrally determined rental rates. It charges 30.57 Birr per hour for plowing, 31.66 Birr per hour for discing, and 35.19 Birr per hour for transporting inputs to and products from the farms. The corporation hopes to expand its services to other farmers through the country.

mechanical power (or energy), and second, it reflects differences between the techniques of production on various producer cooperatives with respect to the adoption of machine power as an alternative to the farm labor or work oxen power.

This approach of measuring contributions of tractors to cereal crop production on producer cooperatives is not strongly defensible; because, first, all tractors are not homogeneous inputs and they may not have identical marginal productivity; second, tractors differ in their performance and purpose of use due to such differences as horse-power and size; third, heterogeneous conditions (for example, the degree of soil water retention, stoniness, slope, farm size, etc.) of field operations can differ from one *awrajja* to another (although this is somewhat captured in the statistical analysis by regional dummies); and fourth, some tractors might be fairly old while others might be new thereby influencing relative performance of the tractors. In this sense, adjusting tractors for size and quality differences can minimize specification error. It will not be surprising, therefore, if the tractor coefficient carries a negative sign or is statistically insignificant largely because of the obvious specification error.

#### **IV.2.8. Livestock**

The livestock variable in this study represents cattle, sheep, goats, donkeys, mules, horses, camels and, chickens. The interest of this research is not to evaluate contributions of each type of animal, but the interest is to evaluate the role that the animals play collectively in the productivity of cereal crops. Animals, other than farm oxen that are discussed previously, play an important role in the agrarian economy of rural Ethiopia. Their role ranges from providing transportation services to rural communities thereby reducing opportunity cost of travel time and to being important source of meat and dairy products. Traditional farm communities are direct beneficiaries of “non-interest bearing banking” and ceremonial services provided by the animals. Animals are also used in cereal production activities such as threshing and they provide manure input for the

croplands. So livestock and cereals are integral components of the traditional agriculture in Ethiopia.<sup>87</sup>

The livestock variable is relevant only to the private sector. Livestock data were not available for the producer cooperatives. Incorporating the variable in the state farms production model is, however, not appropriate because there is no direct relationship (perhaps except feed) with cereal crop production and livestock production on the state farms. The state farms produce livestock for market but not for household consumption as is mostly true in the case of the private farms.

The livestock variable is analyzed in this research as a proxy measure of the contributions of capital stock accumulated within agriculture. Although the animals differ in many ways such as type, size, productivity, and consumption of forages and land related resources, it is necessary to aggregate them into a composite variable by being careful about introducing aggregation bias. A method used by Hayami and Ruttan (1985) is applied in this research.<sup>88</sup> According to this method, the animals are weighted in livestock units before they are aggregated to a livestock variable. Each animal type is therefore weighted in terms of livestock units as follows:

$$\begin{aligned}
 K &= P + W, \\
 W &= 1.1E + 1.0(M + H) + 0.8D \\
 P &= 0.8C + 0.1(S + G) + 0.01N
 \end{aligned}
 \tag{4.4}$$

where K = aggregate livestock; W = aggregate of workstock (camels, mules, horses, donkeys) livestock; P = aggregate of productive (cattle, sheep, goats, chicken) livestock; E, M, H, D, C, S, G, N = number of camels, mules, horses, donkeys, cattle, sheep, goats, and chicken, respectively. The coefficients in the above relationships are livestock units.

---

<sup>87</sup> Animals are so essential in Ethiopian agriculture that approximately 51 percent (63,725,700 hectares) of the total land area is used for livestock (except chicken) production. This is a large proportion of land relative to the 13.1 percent of land allocated to annual crop production. See the 1985-94 Ten-Year Development Plan of Ethiopia, p.154.

<sup>88</sup> Also, see FAO Production Yearbook (1972), p: 419.

The cattle (C) component in the P equation consists of cows, heifers, male and female calves, and bulls. Quantities of these animals were converted to animal units with the following weights: cows and heifers with 1, male and female calves with 0.7, and bulls with 1.3. Then, the results are added up to form the cattle component of equation (4.4).<sup>89</sup> The weights may not be suitable for cattle conditions (such as average live weight, quantity and quality of feed consumption) that prevail in Ethiopia. But they are adopted out of necessity to reduce possible aggregation bias if the animals are combined without some adjustment.

As shown in equation (4.4), the aggregate livestock variable, K, is dichotomized into productive livestock, P, and workstock livestock, W. P consists of cattle, sheep, goats, and chicken. W part consists of donkeys, horses, mules, and camels. If the livestock variable is estimated as K, it may mask individual effects of P and W. Dichotomization of the livestock variable will help to capture separate contributions of each category. But, it should be noted that both P and W animals are not factors used directly in cereal production like conventional factors such as land and labor. Productivity effects of other input variables are, therefore, likely to be underestimated by including both P and W livestock components as independent variables.

Regression estimates are expected to produce a negative sign on the P coefficient and a positive sign on the W coefficient. The principal reason for expecting a negative P coefficient is based mainly on the researcher's knowledge about the traditional livestock management system and the growing population pressure of the productive livestock on land and land dependent resources. Traditionally, the animals roam freely without being confined to a fenced area often watched by fairly young "cow boys". The animals feed largely on vegetation, mulch and plant residues after harvest thereby making croplands prone to soil moisture loss. They also exacerbate soil compaction problems by treading on soft soil surfaces following harvest. The process continues without restriction until available food on the fields is almost completely depleted. Subsequent to this

---

<sup>89</sup> The weights are taken from *Feeds and Nutrition* by Ensminger and Olentine (1978).

grazing, it is quite common to see cropland from which most of the soil surface cover is removed, and the soil configuration is disturbed (broken) thereby making it susceptible to wind and water erosion. In this regard, the livestock population (especially, the productive livestock) implicitly competes with grains for resources that have a potential to enhance cereal production. On the basis of these observed relationships between grains and productive livestock, perhaps it will not be unreasonable to expect a negative impact of the productive livestock on cereal output.

The above observations, however, are not intended to minimize the role of livestock resources in the national economy. For instance, as Gryeels and Anderson (1983) note, livestock and livestock products contribute about 35 percent of total value of agricultural production. Ceremonial contributions and the role that the livestock play as a status symbol are quite important in the social fabric of traditional Ethiopia. Furthermore, the work stock animals are the major means for human and material transportation.

#### **IV.2.9. Rainfall**

The usual tendency of aggregate production function studies such as this (that are not crop specific) is to define an aggregate rainfall variable and attempt to evaluate its impact on aggregate output. Such definition of the rainfall variable may not generate meaningful information from the viewpoint of timely field operations. Studies that have applied this approach have estimated either negative and/or insignificant coefficients for rainfall.<sup>90</sup> Perhaps this is mainly because (a) effects of rain water vary with type of crops aggregated over regions, (b) usefulness of rainfall for field crops may depend on the time of its inception either at the beginning, during or at the end of planting season, and (c) individual crops might be more susceptible to rainfall deviations from a norm ( or average rainfall) than to total annual rainfall. The use of rainfall deviations from the norm is an

---

<sup>90</sup> See, for example, Nadkarni, M.V. and P.K. Ghosh (1978), Sampath, R.K. (1979), Singh, Ram D. (1979), and Mukherjee, Chandan and A. Vaidyanathan (1980).

often recommended approach. But, the approach requires a long time-series of rainfall data. The specific approach one chooses to specify the rainfall variable may, therefore, depend on data availability, the length of time-period under consideration, and/or empirical objectives of the estimation. In the case of this study, monthly rainfall of planting months, June to September, is deemed important for reasons discussed next.

Cereal farmers of Ethiopia invariably depend on rainfed cultivation practices. Rainfall, therefore, plays a crucial role in the productivity of Ethiopian cereal production. Generally, two periods of rainfall season - *belg* of small rains and *kremt* of main rains - are sources of water for cereal production. The small rains of the *belg* season come between February and May. The rains are quite unreliable: sometimes they come in abundance for the whole period and sometimes they may not come at all. These rains are not equally distributed throughout various regions but are mostly confined to the escarpment of the Rift Valley in northeastern parts of the country.<sup>91</sup>

*Kremt* is the major rainfall period for the *meher* cereal production season. It spans the months of June, July, August, and some parts of September. Farmers' production decisions and expectations about crop yields at harvest are often influenced by the conditions of rainfall they observe early in this season. Generally, in normal years of rainfall, the country receives not-less-than 80 percent of the total annual rainfall during these four months. Also, ILCA (1985) notes that it would not be uncommon to receive monthly rainfall of between 150 mm and 350 mm either in July or August. Intensive seedbed preparation activities occur concurrently with the heavy rains beginning in June. Unfortunately, these practices have historically (and still do) contributed to substantial soil loss by rill-erosion and thereby a subsequent reduction in soil depth.

Most cereal crops (except sorghum) are planted sometime in June. Sorghum is usually planted in April since it takes a relatively longer time to mature than other cereals. If the rains stop

---

<sup>91</sup> See Bethke, S. in Hussein, ed. (1976), PP:97-103.

sometime in September (as they usually do in the second week of the month), cereals and other crops such as pulses must rely on soil moisture retained from previous months of rainfall. Soil water retention may not be possible for eroded and shallow soils of the northern regions thereby leading toward crop failure. The northern regions and some segments of the northcentral region have historically and recently suffered severe drought and famine.

The risk of crop failure due to a short supply of rain water in September may be reduced if farmers can strike the balance between timely (early) planting and rainfall inception in June. This is easier said than done, however, because quite often farmers' ability to take advantage of the early rains by completing field operations in a timely fashion is constrained by insufficient supply of work oxen. Furthermore, difficulty of traditional farm tools in breaking soils hardened by several months of hot and dry climate induces farmers to wait until the land is adequately softened by rain water. Even after the rains come, farmers do not plant seeds right away. Instead, they make several passes over the cropland with oxen and plow before they actually plant the seeds. The rationale is partly to reduce weed infestation, partly to increase water mobility in the soil by breaking the dry and compacted land surface, and generally, to prepare an optimum environment for seed germination. In the process, however, planting is delayed and productive soils are gradually removed from the fields by rain water erosion. Water erosion is quite evident on steep slopes of the central highlands where most of the agricultural activities are concentrated. Also, farmers assume a potential risk of seed damage if sufficient rainfall is unavailable during/before the seed germination.

This approach of defining the rainfall variable in terms of monthly rainfall will help to implicitly study timeliness of planting operations and interaction effects between monthly rains. The rainfall variable is measured in millimeters for all farm types. Furthermore, based on the (subjective) observations outlined in the previous discussions, it may not be surprising if June rainfall is estimated to be statistically insignificant and/or negatively contributing to cereal output.

#### **IV.2.10. Land Planted to Cereal Crops**

The land input variable is measured in physical units of hectares. Annual cereal crop area sown by each farm type is used for each *awraja*. Quality of agricultural land in Ethiopia is a very heterogeneous factor of production. In some cases, the quality of land is a major source of output variation between districts. One rich hectare of land in Arsi province, for example, is not the same factor of production as an arid hectare of land in the eastern part of Wello province. Strictly speaking, one hectare of land planted to wheat, for example, may not be a perfect substitute for one hectare of land planted to *teff*. It would be more instructive to adjust land input for quality differences than just using annual crop area of land.

A reliable classification of farm land into productivity grades is, however, not available in Ethiopia. Alternatively, the unit price of land could be used as an approximate measure of land quality differences in various districts. This will not be possible, however, because a land market does not exist in Ethiopia. The 1975 land reform prohibits exchange of farm land either through sale, lease, rent, or mortgage. Thus the only reasonable option is to measure land in physical units: in hectares planted to the cereal crops.

#### **IV.2.11. Normalization of the Variables**

Except rainfall and education variables, all other variables are normalized (converted to a per hectare basis) by the total number of hectares planted to the cereal crops (barley, corn, sorghum, *teff*, and wheat) under each mode of production in each cereal producing *awraja*. School enrollment in grades 1-12 is normalized by total rural population to develop an education index of each *awraja*. The rain variable is, however, not normalized since it is already normalized by convention in the process of data generation.

Normalization of the variables by land is one of many methods of constructing "partial" productivity measures. Other methods, for example, include normalizing by labor and number of farms to construct partial and "total" productivity measures, respectively. Techniques of cereal production and introduction of farm technology to Ethiopia's agricultural sector seem to be influenced to a large extent by the average size of farms. As discussed previously in this chapter and in Chapters I and II, state farms are the largest and most mechanized relative to the private and cooperative farms, whereas the cooperative farms are larger and more mechanized than the private farms. Given these observations, the method of normalization is likely to influence productivity estimates and interpretation of several economic factors such as average product and returns to scale. The choice of a particular normalization method, however, depends on the objectives of a given study and availability of appropriate information. Normalizing by number of farms, for example, would indicate hectares per farm, output per farm, or labor-days per farm as a measure of the average scale of each farm type. As far this study was concerned, normalizing by number of farms would have been a better approach than normalizing by land but data (on the number of farms) were not available, especially for the private and cooperative farms. It is, however, hoped that normalization by land (a) adjusts for differences in land quality and (b) provides useful insights into the role of other input factors per hectare in cereal production by each farm type.<sup>92</sup>

<sup>92</sup> Since the land variable disappears in the normalization process, its slope or elasticity coefficient can not be estimated directly. But, land would receive a residual as illustrated below. Suppose an estimated regression equation takes a deterministic (non-stochastic) Cobb-Douglas functional form in terms of per hectare (z) units of output (q), labor (l), oxen (x), and fertilizer (f). The elasticity coefficient for land can be computed as follows:

$$\begin{aligned}\log\left(\frac{q}{z}\right) &= \log \beta_0 + \beta_1 \log\left(\frac{l}{z}\right) + \beta_2 \log\left(\frac{x}{z}\right) + \beta_3 \log\left(\frac{f}{z}\right) \\ \log q - \log z &= \log \beta_0 + \beta_1 \log l - \beta_1 \log z + \beta_2 \log x - \beta_2 \log z + \beta_3 \log f - \beta_3 \log z \\ \log q &= \log z + \log \beta_0 + \beta_1 \log l - \beta_1 \log z + \beta_2 \log x - \beta_2 \log z + \beta_3 \log f - \beta_3 \log z \\ \log q &= \log \beta_0 + \beta_1 \log l + \beta_2 \log x + \beta_3 \log f + (1 - \beta_1 - \beta_2 - \beta_3) \log z\end{aligned}$$

The derivation could be quite complicated if the estimated function is non-linear in the logarithms of the variables such as the translog function. Also, note that the last equation shows that the coefficient of the log-transformed land variable is  $1 - \beta_1 - \beta_2 - \beta_3$ . It can be statistically tested to examine if the coefficient is not significantly different from zero:

$$\begin{aligned}H_0: & 1 - \beta_1 - \beta_2 - \beta_3 = 0 \\ H_A: & 1 - \beta_1 - \beta_2 - \beta_3 \neq 0\end{aligned}$$

Then, the usual t-statistic can be calculated by noting that:

### IV.3. Descriptive Summary of Data

Sample means, coefficients of variation (C.V.), minimum, and maximum value of various variables are summarized in table IV.1. Except for education and rainfall variables, all other variables in the table are defined in terms of per hectare of land planted to cereal crops.<sup>93</sup> Mean values of the private farms are averages of a single production year (1983/84) quantities over 77 observations. Two years (1985, 1986) quantities are averaged over 117 observations for the producer cooperatives and six years (1980 - 1985) quantities are averaged over 50 observations for the state farms. The mean and C.V. statistics describe some basic features of the three farm types. The C.V. is unit-free statistic and it measures relative dispersion of the mean statistic.<sup>94</sup>

$$t_{\text{observed}} = \frac{(1 - \beta_1 - \beta_2 - \beta_3) - 0}{\sqrt{S_{\beta_1}^2 + S_{\beta_2}^2 + S_{\beta_3}^2 + 2[\text{Cov}(\beta_1, \beta_2) + \text{Cov}(\beta_1, \beta_3) + \text{Cov}(\beta_2, \beta_3)]}}$$

If the observed t-value exceeds the critical t-value with (n - 4) degrees of freedom, then we fail to accept the  $H_0$  in favor of the alternative hypothesis,  $H_A$ , which states that the land variable plays a significantly important role in influencing output level.

<sup>93</sup> Land is measured in terms of hectares planted to the cereal (barley, corn, sorghum, *teff*, wheat) crops.

<sup>94</sup>

The C.V. statistic is computed as follows:  $C.V. = \frac{\text{standard error of the mean}}{\text{mean}}$ . It is appropriate to examine if the means of common variables (such as gross farm revenue and labor) among the three farm types are statistically different from each other. The differences can be checked by computing t-statistics for the following pairs of means:  $(\bar{X}_{pf}, \bar{X}_{pc})$ ,  $(\bar{X}_{pf}, \bar{X}_{st})$ ,  $(\bar{X}_{pc}, \bar{X}_{st})$ . The t-statistics are, for example, computed for pairs of gross farm income means and variances of the three farm types by using a formula suggested in Walpole and Myers (1978) on p. 276:

$$t = \frac{(\bar{X}_i - \bar{X}_j) - 0}{S_p \sqrt{\frac{1}{n_i} + \frac{1}{n_j}}}$$

where :

$$S_p = \sqrt{\frac{(n_i - 1)S_i^2 + (n_j - 1)S_j^2}{n_i + n_j - 2}}$$

where  $S_p$  is pooled standard error of the samples,  $S_i^2, S_j^2$  are sample variances = 278525.34, 66740.07, 43741.21, associated with the mean gross revenue product of the private farms, producer cooperatives and state farms, and  $\bar{X}_{i,j}$  = 876.997, 294.064 and 700.713, mean gross revenue product of the private farms,

**TABLE IV.1. Descriptive Summary of Data for Private Farms, Producer Cooperatives and State Farms (Per Awrajjia)**

Variables	Unit	PRIVATE FARMS (77)*					COOPERATIVE FARMS(117)*					STATE FARMS (50)*		
		Average	Minimum	Maximum	C.V.*	Average	Minimum	Maximum	C.V.	Average	Minimum	Maximum	C.V.	
Gross Income	Birr/ha	878.00	346.90	4376.14	60.11	294.06	25.55	1521.12	87.85	700.71	227.02	1303.08	87.85	
Labor	Days/ha	534.41	106.13	6317.53	154.22	439.31	8.10	8299.29	200.88	46.20	2.95	359.70	200.88	
Oxen	Days/ha	35.99	3.53	357.14	121.08	73.44	1.16	927.37	187.25	-	-	-	187.25	
TLP Tools	Birr/ha	36.46	0.43	314.41	109.35	-	-	-	-	-	-	-	-	
TH Tools	Birr/ha	24.94	0.46	216.88	121.19	-	-	-	-	-	-	-	-	
Fertilizer	Birr/ha	596.63	1.00	9582.78	254.39	46.21	0.00	2034.08	425.37	-	-	-	-	
Enrlmnt 1-6	Ratio	0.06	0.00	0.15	50.89	0.06	0.01	0.19	57.60	-	-	-	-	
Enrlmnt 7-12	Ratio	0.01	0.0	0.44	77.76	0.01	0.00	0.05	70.51	-	-	-	-	
MYI Inputs	Birr/ha	-	-	-	-	46.68	0.00	4183.08	829.86	196.98	0.11	1005.29	829.86	
Tractors	Nmbr/ha	-	-	-	-	0.00	0.00	0.03	370.67	-	-	-	370.67	
Machinery	Birr/ha	-	-	-	-	-	-	-	-	251.63	9.21	978.90	-	
P.Livestock	LU/ha*	8.35	0.66	262.64	368.18	-	-	-	-	-	-	-	-	
W.Livestock	LU/ha*	1.53	0.04	22.19	221.69	-	-	-	-	-	-	-	-	
June Rain	mm	143.82	1.00	776.00	121.78	115.99	0.00	1126.00	161.81	293.64	1.00	978.90	161.81	
July Rain	mm	240.41	1.00	910.10	101.33	178.91	0.00	1176.00	154.10	480.71	48.80	1628.10	154.10	
August Rain	mm	321.97	1.00	1112.60	85.73	206.48	0.00	1901.00	167.77	497.76	127.70	1666.10	167.77	
Spimbr Rain	mm	228.00	1.00	1039.50	98.33	124.79	0.00	1134.00	151.70	447.38	40.20	3002.00	151.70	

\* Figures in parentheses are number of observations, LU = Livestock Unit, P = productive, W = workstock, C.V. = coefficient of variation, TLP = pre-harvest traditional tools, TH = post-plant traditional hand tools, MYI = modern yield-increasing, Nmbr = number, ha = hectare, mm = millimeters

Source: Generated from production data sets provided by Ethiopian Ministry of Agriculture, Ministry of State Farms, Meteorological Services of Ethiopia, and Ministry of Education

Interpretation of the preliminary results in this section and econometric estimates in the next chapters, however, need to be somewhat cautious because (a) the information collected from each farm type does not cover all years for all farms which makes it impossible to directly compare the results and (b) the gathered information might be "contaminated" by errors in data. Errors in data could occur, for example, due to inaccurate recording/reporting of inputs and output values, incorrect sampling procedures and systematic adjustment of the data (more will be said later about the data problem).<sup>95</sup> But assuming that the data at hand are reasonably accurate, a few preliminary observations can be made about the production characteristics of the farm types.

### IV.3.1. Output-to-Land Ratio

Table IV.1 tends to indicate that one hectare of cereal land generates much more gross farm income under private ownership than under socialized ownership. The private farm sector, for instance, appears to generate approximately 3 times more gross farm income per hectare than the producer cooperatives and about 1.3 times more gross income than the state farms sector. However, it can not be stated with certainty that the small-holder farms in the private sector are collectively more technically efficient than the farms in the socialized sector given insufficient information regarding 1983/84 production year. The 1983/84 production year could be a special year for the private sector relative to the 1980 - 1985 and 1985-86 production periods for the state and cooperative farms, respectively. For example, over the 1985-86 production period covered by this study, the producer cooperatives experienced about twice as much variation in mean gross farm income relative to the private farms and 3 times as much variation relative to the state farms.

---

producer cooperatives and state farms, respectively. The t-statistics = 10.25, 2.30, 9.83 with degrees of freedom = 192, 125, and 165, respectively, are computed for each of the three pairs of the means of the gross revenue products. The computed t-statistics therefore provide convincing evidence that the gross revenue means are significantly different from each other at a probability level of 5 percent. Appropriate t-values can be computed in a similar fashion for other means shown in table IV.1.

<sup>95</sup> See Zvi Griliches (1986) for a general discussion on economic data issues.

### **IV.3.2. Labor-to-Land Ratio**

If the three farm types are arranged by land size, individual farms in the state farms are likely to be the largest and individual farms in the private farms are likely to be the smallest. The producer cooperatives would fall somewhere in the middle. The size of the farms, however, does not appear to be positively correlated with rural labor employment given the observation that labor employment per hectare is the highest on the smallest of all farms. For example, table IV.1 shows that the private farms tend to employ about 1.2 and 11.6 times more labor per hectare than the producer cooperatives and the state farms, respectively. Both the private farms and the producer cooperatives are therefore more labor intensive than to the state farms. Also, note that as indicated by the C.V. associated with the labor-to-land ratio, average labor input per hectare is more variable in the producer cooperatives sector than it is on the other two farm types.

### **IV.3.3. Oxen-to-Land Ratio**

Unlike the state farms, both the private farms and the producer cooperatives mostly rely on oxen power for crop production related field operations. It appears that the producer cooperatives, by pooling oxen together under a collective ownership, have much more oxen power input per hectare at their disposal than the private farms. Also, given previous observations about the relative size of the farms, the data suggest that the producer cooperatives employ more oxen days per hectare than the private farms.

Finally, the above three observations are not intended to be exhaustive but they illustrate some basic differences among the farm types under investigation. The information summarized in table IV.1, however, gives a general impression that the producer cooperatives are relatively less productive per hectare and a more heterogeneous group than others as judged by the relevant C.V.

statistics. As noted previously, the observed low land productivity of the producer cooperatives relative to the other two farm types needs to be examined carefully. It may indicate some problems in the 1985-86 production period and/or problems in the data set, especially, in terms of measurement error that would occur in the process of preparing annual reports required by the Ministry of Agriculture. Because of their recent establishment, the cooperatives have little experience in record keeping and reporting production data to higher offices. Perhaps it would be worth illustrating here how production data are usually generated in the state and cooperative sectors.

Production practices of the producer cooperatives and state farms often mix input-output decisions with pre-planned production targets and realized quantities. Quantity targets of inputs and outputs are set prior to a planting period. The practice of setting quantity targets and the requirements to closely adhere to the planned targets is, however, more prominent in the state farms sector than it is in the producer cooperatives sector. Target quantities of inputs and outputs vary simultaneously on the basis of social, economic and political objectives perceived by the managers of the state farms. Reasonableness or achievability of the targets is often revised through a series of "negotiations" at various levels of the state farms organizational structure. The revision process involves a complex set of personal and corporate factors in the sense that managers at each decision node behave as economic agents on the one hand and political agents on the other. At an individual level, however, it can be said that the immediate goal of the planners is to ensure that implicit and/or explicit rewards to their efforts exceed the potential cost of making an erroneous decision. For example, they seek to formulate decisions that are politically innocuous. They strive to strike a "balance" between what seems to be an economically achievable level of production given resource limitations and a politically acceptable production plan given the overall objectives of the institution. In the process, over-optimistic targets are revised downward whereas over-conservative targets are revised upward. In doing so, the planners try to minimize the gap (or deviation) between planned quantities and quantities that can be realized after the production season. This process shows the likelihood that the realized output quantities in a given production

year will not only be a function of factors of production but also a function of errors (deviations) in previous planned targets. In other words, the amount of inputs allocated and used to produce planned level of output in the current production period will be influenced by the scope of errors between the realized and planned quantities of the previous production period(s). Given such systematic practices of data generation (and possible distortions in the realized quantities), it will not be unreasonable for the data of the socialized agricultural sector to exhibit, among other problems, the usual problem of serial correlation.

#### *IV.4. Sources of Data*

As initially planned, efforts were made to collect *awraja* level cross-sectional and time-series (1975 - 1985) agricultural data for private farms (PF), producer cooperatives (PC) and state farms (SF). Most of the data that were available were not complete for all years nor were the data disaggregated at the *awraja* level of economic planning. Traditionally, both the Central Statistical Office (CSO) and the Ministry of Agriculture (MOA) have generated aggregate *estimates* of agricultural production information either at the national and/or provincial level but not at the *awrajj* level. Recently, however, compelled by the importance of disaggregated data in dealing with complex problems of rural Ethiopia, the government has established the institutional framework to generate and to maintain various types of disaggregated agricultural and agro-ecological data at the *awraja* level.

Cross-sectional data for the private farm sector were collected for 77 *awrajjas* for the 1983/84 production year. The data were taken from the General Agricultural Survey records of the MOA. The Ministry compiled the data from a house-to-house interview of 19,602 private households organized under farmer associations. The survey covered almost all the *awrajjas* contained in 12

out of the 14 provinces. Eritrea and Tigray provinces were not included in the survey process due to political unrest in the two provinces.

Two-years (1985, 1986) of *awraja* level data were collected for the producer cooperatives in 67 *awrajjas*. When pooled, the data set included a total of 117 observations. The data were obtained from annual report records of the cooperatives maintained in the Cooperatives Development Department of the MOA. Since the PCs are newly established institutions, they do not have a historical production data base accumulated over a number of years.

Physical production information for cereal producing state farms in 9 *awrajjas* comes from the records of the Ministry of State Farms Development (MSFD). Various inputs and cereal crops output data were collected both by crop-type and farm-type for the 1980 - 1985 production period. Since the data were obtained in terms of cost of production, the Finance and Audit Department along with its branch offices of Northwestern and Southeastern Corporations of the MSFD supplied the data. The data were, however, valued at prices that remained constant throughout the six-year production period. There are a total of 50 observations in this data set.

Weather data for 1975 to 1986 were provided by the Ethiopian Meteorological Services. Enrollment data in grades 1-12 in rural schools were taken from the records of the Ministry of Education for years 1975 - 1980 at provincial level and for 1981 -1986 at *awraja* level.

Various other government institutions were consulted for miscellaneous supplementary information. CSO supplied "parallel" market price information and results of a rural labor force survey, the Agricultural and Industrial (AID) Bank of Ethiopia provided price data for fertilizer and results of oxen credit studies, Agricultural Inputs Supply Corporation (AISCO) gave data on modern yield-increasing inputs distributed to the private and cooperative farms in different *awrajjas*. These inputs are distributed to the two farm types through Service Cooperatives which function as an intermediary institution between the government and the traditional farm sector.

## ***IV.5. Summary***

The preceding discussion has identified a number of variables and briefly presented a descriptive summary of the research data with which production characteristics of the private, cooperative and state farms will be studied in the next two chapters. Table IV.2 brings together all the variables containing abbreviated variable codes, description of the codes, units of measurement, and hypothesized signs for coefficients of the variables. In addition, the table isolates variables for which research data were available within each mode of production. Note again that the variables (except land) are expressed in terms of natural logarithms. Codes of the variables will be used repeatedly throughout the next chapters.

**Table IV.2. Summary of Variables, Units and Hypothesized Signs.**

Code	Description	Unit	Hypothesized Signs		
			PF	PC	SF
Q	= ln(aggregate output/hectare)	Birr			
L	= ln(labor/hectare)	lday	+	+	+
X	= ln(work oxen/hectare)	xday	+	+	
O	= ln(hectare prep tools/hectare)	Birr	+		
H	= ln(hand tools/hectare)	Birr	+		
F	= ln(fertilizer/hectare)	Birr	+	+	
A	= ln(enrl. grds.1-6/rop)	ratio	+	+	
B	= ln(enrl. grds.7-12/rop)	ratio	-	+/-	
I	= ln(MYI inputs/hectare)	Birr		+	+
T	= ln(tractors/hectare)	num		+	
M	= Machinery services	Birr			-
P	= ln(pdtv. livestock/hectare)	lu	-		
W	= ln(work. livestock/hectare)	lu	+		
J	= ln(Jun rain)	mm	-	-	+
Y	= ln(July rain)	mm	+	+	+
U	= ln(August rain)	mm	+	+	+
S	= ln(September rain)	mm	+	+	+
D	= 0 - 1 dummies for region and time factors				

Note:

lday = labor-days  
xday = oxen-days  
num = number of tractors  
lu = number in livestock units  
mm = millimeters  
rop = rural population  
PF = Private farms  
PC = Producer cooperatives  
SF = State farms

Source : See Section IV.1 through VI.4.

## **CHAPTER FIVE**

### ***ECONOMETRIC PROBLEMS OF ESTIMATED MODELS***

#### ***V.0. Introduction***

This chapter discusses issues that became important in the estimation process of the empirical models. As will be shown, the estimation issues are essential to the understanding and interpretation of the empirical results summarized in Chapter VI. The discussion is organized in the following order. The conceptual Cobb-Douglas (C-D) and translog (TL) models presented in Chapter III are translated into empirical models in Section V.1 with the set of variables discussed in Chapter IV. Collinearity was found to be a severe problem in estimating the TL model for each farm type without reducing the number of parameters to be estimated. Section V.2 discusses procedures implemented for building statistically estimable restricted TL models with a subset of regressors. The restricted TL models were used to conduct functional form misspecification tests and to generate structural coefficients for each farm type. Also, this section evaluates efficiency of the structural coefficients in terms of diagnostics and remedies for the problems of heteroskedasticity and serial correlation. SAS (Statistical Analysis System) Version 5.16 on Virginia Polytechnic Institute and State University main farm was used for the analysis. Discussion of the chapter is briefly summarized in Section V.3.

## *V.1. Towards Specification of Empirical Models*

Chapter IV described research data without any explicit reference to an algebraic form of the underlying production function. In this section, however, empirical models are postulated for each farm type in terms of both the C-D and TL functional forms. Gross income per hectare of each farm type constitutes a dependent variable determined endogenously as a function of labor, machinery, farm oxen (not the same as work animals), fertilizer, two sets of traditional farm tools (one set consists of inputs combined with labor and oxen and the other set consists of tools that are commonly combined only with labor), livestock (productive and work-stock), ratio of rural school enrollment in grades 1-6 and 7-12, improved seeds, herbicides, pesticides, and monthly rainfall for June, July, August, and September.<sup>96</sup> Both the C-D and TL production functions are studied in terms of log-transformed variables with the following notations.<sup>97</sup>

$$Q = \ln(\text{total revenue/hectare}),$$

$$L = \ln(\text{labor-days/hectare}),$$

$$X = \ln(\text{oxen-days/hectare}),$$

$$O = \ln(\text{Birr value/hectare of traditional land preparation (TLP) tools}),$$

$$H = \ln(\text{Birr value/hectare of post-plant traditional hand (TH) tools}),$$

$$F = \ln(\text{Birr value of fertilizer/hectare}),$$

$$A = \ln(\text{rural school enrollment in grades 1-6/rural population of an } awrajja),$$

$$B = \ln(\text{rural school enrollment in grades 7-12/rural population of an } awrajja),$$

---

<sup>96</sup> See Chapter IV for a detailed discussion on the definition of each variable. This list of the inputs does not pretend to include all possible set of inputs that influence cereal production. For instance, variables such as producers' managerial abilities, latent regional and temporal factors are not included explicitly because they are not easily measurable. On the other hand, it may not be economically practical nor theoretically justifiable to include all possible variables if the included sample inputs adequately describe properties of the underlying "population" from which the inputs are sampled. As will be seen later in Chapter VI, the sample inputs considered for the empirical analysis of the farm types explain a reasonable proportion of the variation in total revenue.

<sup>97</sup> Unless indicated otherwise, all the variables are normalized by hectares of land planted to five cereal crops which consist of barley, corn, sorghum, *teff*, and wheat.

$I = \ln(\text{Birr value of modern yield-increasing inputs/hectare}),$   
 $T = \ln(\text{number of tractors/hectare}),$   
 $M = \ln(\text{Birr value of machinery services/hectare}),$   
 $P = \ln(\text{productive livestock/hectare}),$   
 $W = \ln(\text{work-stock (or work animals) livestock/hectare}),$   
 $J = \ln(\text{June rain}),$   
 $Y = \ln(\text{July rain}),$   
 $U = \ln(\text{August rain}),$   
 $S = \ln(\text{September rain}),$   
 $D_1 = \text{dummy for } \textit{awrajjas} \text{ in eastern highlands agro-ecological zone,}$   
 $D_2 = \text{dummy for } \textit{awrajjas} \text{ in sw. highlands agro-ecological zone,}$   
 $D_3 = \text{dummy for } \textit{awrajjas} \text{ in se. highlands agro-ecological zone,}$   
 $D_4 = \text{dummy for 1986 production year of producer cooperatives,}$   
 $D_5 = \text{dummy for 1984 production year of state farms,}$   
 $D_6 = \text{dummy for 1983 production year of state farms,}$   
 $D_7 = \text{dummy for 1982 production year of state farms,}$   
 $D_8 = \text{dummy for 1981 production year of state farms,}$   
 $D_9 = \text{dummy for 1980 production year of state farms,}$   
 $Z = \text{regression residuals,}$

where natural logarithm ( $\ln$ ) of a variable is defined with base  $e = 2.718281$  and central highlands (CH, not shown) = agro-ecological region to which estimated values of other regional dummies are compared. The remaining agro-ecological regions include eastern highlands  $\leftarrow D_1 \rightarrow$  (Arsi, Bale, Hararre), southwestern highlands  $\leftarrow D_2 \rightarrow$  (Illubabor, Keffa, Wellega), and southeastern highlands  $\leftarrow D_3 \rightarrow$  (Sidamo, Gemu Goffa). The analysis of the temporal effects is relevant only to the two farm types in the socialized sector. The dummy,  $D_4$ , for the 1986 production year captures impacts of the temporal factors on the per hectare productivity of the producer cooperatives. The Dummies  $D_5$  through  $D_9$  for the 1980-1984 production period capture influences of the temporal factors on

the per hectare productivity of the state farms. The 1985 production year (not shown) is used in both farm types as a benchmark to which per hectare productivity impacts of temporal factors of other years are compared. Dummies for both CH and 1985 are set to zero. The following equations (5.1) through (5.6) are “unrestricted” models for each farm type. The models indicate data limitations for each mode of production but not different functional forms other than the C-D and TL functional forms.

PRIVATE FARM SECTOR:

$$Q_{pf}^{CD} = \alpha_0 + \alpha_l L + \alpha_x X + \alpha_f F + \alpha_o O + \alpha_h H + \alpha_p P + \alpha_w W + \alpha_a A + \alpha_b B \\ + \alpha_j J + \alpha_y Y + \alpha_u U + \alpha_u U + \alpha_s S + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + Z_{pf}^{CD}$$

$$Q_{pf}^{TL} = Q_{pf}^{CD} \text{ [without } Z_{pf}^{CD}] \\ + \phi_{ll} L^2 + \alpha_{lx} LX + \alpha_{lf} LF + \alpha_{lo} LO + \alpha_{lh} LH + \alpha_{lp} LP + \alpha_{lw} LW \\ + \alpha_{la} LA + \alpha_{lb} LB + \alpha_{lj} LJ + \alpha_{ly} LY + \alpha_{lu} LU + \alpha_{ls} LS + \phi_{xx} X^2 \\ + \alpha_{xf} XF + \alpha_{xo} XO + \alpha_{xh} XH + \alpha_{xp} XP + \alpha_{xw} XW + \alpha_{xa} XA + \alpha_{xb} XB \\ + \alpha_{xf} XF + \alpha_{xy} XY + \alpha_{xu} XU + \alpha_{xs} XS + \phi_{ff} F^2 + \alpha_{fo} FO + \alpha_{fh} FH \\ + \alpha_{fp} FP + \alpha_{fw} FW + \alpha_{fa} FA + \alpha_{fb} FB + \alpha_{ff} FJ + \alpha_{fy} FY + \alpha_{fu} FU \\ + \alpha_{fs} FS + \phi_{oo} O^2 + \alpha_{oh} OH + \alpha_{op} OP + \alpha_{ow} OW + \alpha_{oa} OA + \alpha_{ob} OB \\ + \alpha_{oj} OJ + \alpha_{oy} OY + \alpha_{ou} OU + \alpha_{os} OS + \phi_{hh} H^2 + \alpha_{hp} HP + \alpha_{hw} HW \\ + \alpha_{ha} HA + \alpha_{hb} HB + \alpha_{hj} HJ + \alpha_{hy} HY + \alpha_{hu} HU + \alpha_{hs} HS + \phi_{pp} P^2 \\ + \alpha_{pw} PW + \alpha_{pa} PA + \alpha_{pb} PB + \alpha_{pj} PJ + \alpha_{py} PY + \alpha_{pu} PU + \alpha_{ps} PS \\ + \phi_{ww} W^2 + \alpha_{wa} WA + \alpha_{wb} WB + \alpha_{wj} WJ + \alpha_{wy} WY + \alpha_{wu} WU + \alpha_{ws} WS \\ + \phi_{aa} A^2 + \alpha_{ab} AB + \alpha_{aj} AJ + \alpha_{ay} AY + \alpha_{au} AU + \alpha_{as} AS + \phi_{bb} B^2 \\ + \alpha_{bj} BJ + \alpha_{by} BY + \alpha_{bu} BU + \alpha_{bs} BS + \phi_{jj} J^2 + \alpha_{jy} JY + \alpha_{ju} JU \\ + \alpha_{js} JS + \phi_{yy} Y^2 + \alpha_{yu} YU + \alpha_{ys} YS + \phi_{uu} U^2 + \alpha_{us} US + \phi_{ss} S^2 \\ + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + Z_{pf}^{TL} . \tag{5.1}$$

PRODUCER COOPERATIVE SECTOR:

$$Q_{pc}^{CD} = \theta_0 + \theta_L L + \theta_X X + \theta_F F + \theta_T T + \theta_I I + \theta_A A + \theta_B B + \theta_J J \\ + \theta_Y Y + \theta_U U + \theta_S S + \theta_1 D_1 + \theta_2 D_2 + \theta_3 D_3 + \theta_4 D_4 + Z_{pc}^{CD}$$

$$Q_{pc}^{TL} = Q_{pc}^{CD} \text{ [without } Z_{pc}^{CD}]$$

$$\begin{aligned} & + \phi_{ll} L^2 + \phi_{lx} LX + \phi_{lf} LF + \phi_{lt} LT + \phi_{li} LI + \phi_{la} LA + \phi_{lb} LB \\ & + \phi_{lj} LJ + \phi_{ly} LY + \phi_{lu} LU + \phi_{ls} LS + \phi_{xx} X^2 + \theta_{xf} XF + \theta_{xt} XT \\ & + \theta_{xi} XI + \theta_{xa} XA + \theta_{xb} XB + \theta_{xj} XJ + \theta_{xy} XY + \theta_{xu} XU + \theta_{xs} XS \\ & + \phi_{ff} F^2 + \theta_{ft} FT + \theta_{fi} FI + \theta_{fa} FA + \theta_{fb} FB + \theta_{ff} FJ + \theta_{fy} FY \\ & + \theta_{fu} FU + \theta_{fs} FS + \phi_{tt} T^2 + \theta_{ti} TI + \theta_{ta} TA + \theta_{tb} TB + \theta_{tj} TJ \\ & + \theta_{ty} TY + \theta_{tu} TU + \theta_{ts} TS + \phi_{ii} I^2 + \theta_{ia} IA + \theta_{ib} IB + \theta_{ij} IJ \\ & + \theta_{iy} IY + \theta_{iu} IU + \theta_{is} IS + \phi_{aa} A^2 + \theta_{ab} AB + \theta_{aj} AJ + \theta_{ay} AY \\ & + \theta_{au} AU + \theta_{as} AS + \phi_{bb} B^2 + \theta_{bj} BJ + \theta_{by} BY + \theta_{bu} BU + \theta_{bs} BS \\ & + \phi_{jj} J^2 + \theta_{jy} JY + \theta_{ju} JU + \theta_{js} JS + \phi_{yy} Y^2 + \theta_{yu} YU + \theta_{ys} YS \\ & + \phi_{uu} U^2 + \theta_{us} US + \phi_{ss} S^2 + \theta_1 D_1 + \theta_2 D_2 + \theta_3 D_3 + \theta_4 D_4 \\ & + Z_{pc}^{TL} \end{aligned} \tag{5.2}$$

## STATE FARMS SECTOR

$$Q_{sf}^{CD} = \delta_0 + \delta_l L + \delta_i I + \delta_m M + \delta_j J + \delta_y Y + \delta_u U + \delta_s S + \delta_1 D_1 \\ + \delta_2 D_2 + \delta_3 D_3 + \delta_5 D_5 + \delta_6 D_6 + \delta_7 D_7 + \delta_8 D_8 + \delta_9 D_9 + Z_{sf}^{CD}$$

$$Q_{sf}^{TL} = Q_{sf}^{CD} \text{ [without } Z_{sf}^{CD}] \quad (5.3) \\ + \phi_{ll} L^2 + \delta_{li} LI + \delta_{lm} LM + \delta_{lj} LJ + \delta_{ly} LY + \delta_{lu} LU + \delta_{ls} LS \\ + \phi_{ii} I^2 + \delta_{im} IM + \delta_{ij} IJ + \delta_{iy} IY + \delta_{iu} IU + \delta_{is} IS + \phi_{mm} M^2 \\ + \delta_{mj} MJ + \delta_{my} MY + \delta_{\mu} M + \delta_{ms} MS + \phi_{jj} J^2 + \delta_{jy} JY + \delta_{ju} JU \\ + \delta_{js} JS + \phi_{yy} Y^2 + \delta_{yu} YU + \delta_{ys} YS + \phi_{uu} U^2 + \delta_{us} US + \phi_{ss} S^2 \\ + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \delta_5 D_5 + \delta_6 D_6 + \delta_7 D_7 + \delta_8 D_8 \\ + \delta_9 D_9 + Z_{sf}^{TL} .$$

where the regression coefficient  $\phi$  is a proxy estimator of the coefficients of the log-quadratic regressors in the translog function. Otherwise, it will not be possible to directly estimate coefficients of the log-quadratic regressors with 0.5 in front of the coefficients.<sup>98</sup> The proxy coefficient,  $\phi$ , is therefore defined as  $\phi_{nn} = .5(\alpha_{nn}^{pf}, \theta_{nn}^{pc}, \delta_{nn}^{st})$  where the subscript nn stands for the relevant log-quadratic terms in the equations of each farm sector. Both the C-D and TL functions are linear in parameters and this is usually a desirable property for empirical work. The linearity-in-parameters makes the ordinary least squares analytic method appropriate for statistical estimation of the coefficients  $\phi$ 's,  $\alpha$ 's,  $\theta$ 's,  $\delta$ 's.

The production properties with which this research is concerned are discussed in Chapter III and it is not necessary to repeat the discussion here. However, since the interpretation of elasticities is not obvious in the translog model (as in the case of the C-D function), it is be appropriate to explicitly state the framework for computing empirically estimated translog elasticities. First, note that partial output elasticity,  $\eta_i$ , with respect to a one percentage change in a given input is generally

<sup>98</sup> See equation (3.5) in Chapter III.

defined as  $\eta_i = \partial \ln Q^j / \partial \ln \omega_i$ , where  $Q^j$  is the dependent variable for farm type  $j$ , and  $\omega_i$  is a proxy for a regressor  $i$ . This expression illustrates how the partial production elasticities (shown next) are computed for each farm type. The elasticities are evaluated at the logarithmic means of the variables.

#### PARTIAL TRANSLOG ELASTICITIES OF PRIVATE FARMS SECTOR:

$$\begin{aligned}
 \text{Labor: } \eta_l^{\text{pf}} &= \alpha_l + 2\phi_{ll}L + \alpha_{lx}X + \alpha_{ly}F + \alpha_{lo}O + \alpha_{lh}H + \alpha_{lp}P \\
 &\quad + \alpha_{lw}W + \alpha_{la}A + \alpha_{lb}B + \alpha_{lj}J + \alpha_{ly}Y + \alpha_{lu}U + \alpha_{ls}S \\
 \text{Oxen: } \eta_x^{\text{pf}} &= \alpha_x + \alpha_{lx}L + 2\phi_{xx}X + \alpha_{xy}F + \alpha_{xo}O + \alpha_{xh}H + \alpha_{xp}P \\
 &\quad + \alpha_{xw}W + \alpha_{xa}A + \alpha_{xb}B + \alpha_{xj}J + \alpha_{xu}U + \alpha_{xs}S \\
 \text{Fertilizer: } \eta_f^{\text{pf}} &= \alpha_f + \alpha_{fy}L + \alpha_{fx}X + 2\phi_{ff}F + \alpha_{fo}O + \alpha_{fh}H + \alpha_{fp}P \\
 &\quad + \alpha_{fw}W + \alpha_{fa}A + \alpha_{fb}B + \alpha_{fj}J + \alpha_{fy}Y + \alpha_{fu}U + \alpha_{fs}S \\
 \text{TLP.Tools: } \eta_o^{\text{pf}} &= \alpha_o + \alpha_{lo}L + \alpha_{xo}X + \alpha_{fo}F + 2\phi_{oo}O + \alpha_{oh}H + \alpha_{op}P \\
 &\quad + \alpha_{ow}W + \alpha_{oa}A + \alpha_{ob}B + \alpha_{oj}J + \alpha_{oy}Y + \alpha_{ou}U + \alpha_{os}S \\
 \text{TH.Tools: } \eta_h^{\text{pf}} &= \alpha_h + \alpha_{hl}L + \alpha_{hx}X + \alpha_{hf}F + \alpha_{ho}O + 2\phi_{hh}H + \alpha_{hp}P \\
 &\quad + \alpha_{hw}W + \alpha_{ha}A + \alpha_{hb}B + \alpha_{hj}J + \alpha_{hy}Y + \alpha_{hu}U + \alpha_{hs}S \\
 \text{P.Lvstk: } \eta_p^{\text{pf}} &= \alpha_p + \alpha_{pl}L + \alpha_{px}X + \alpha_{pf}F + \alpha_{po}O + \alpha_{ph}H + 2\phi_{pp}P \\
 &\quad + \alpha_{pw}W + \alpha_{pa}A + \alpha_{pb}B + \alpha_{pj}J + \alpha_{py}Y + \alpha_{pu}U + \alpha_{ps}S \\
 \text{W.Lvstk: } \eta_w^{\text{pf}} &= \alpha_w + \alpha_{wl}L + \alpha_{wx}X + \alpha_{wf}F + \alpha_{wo}O + \alpha_{wh}H + \alpha_{wp}P \\
 &\quad + 2\phi_{ww}W + \alpha_{wa}A + \alpha_{wb}B + \alpha_{wj}J + \alpha_{wy}Y + \alpha_{wu}U + \alpha_{ws}S \\
 \text{Enrl.1 - 6: } \eta_a^{\text{pf}} &= \alpha_a + \alpha_{al}L + \alpha_{ax}X + \alpha_{af}F + \alpha_{ao}O + \alpha_{ah}H + \alpha_{ap}P \\
 &\quad + \alpha_{aw}W + 2\phi_{aa}A + \alpha_{ab}B + \alpha_{aj}J + \alpha_{ay}Y + \alpha_{au}U + \alpha_{as}S \\
 \text{Enrl.7 - 12: } \eta_b^{\text{pf}} &= \alpha_b + \alpha_{bl}L + \alpha_{bx}X + \alpha_{bf}F + \alpha_{bo}O + \alpha_{bh}H + \alpha_{bp}P \\
 &\quad + \alpha_{bw}W + \alpha_{ba}A + 2\phi_{bb}B + \alpha_{bj}J + \alpha_{by}Y + \alpha_{bu}U + \alpha_{bs}S \\
 \text{June: } \eta_j^{\text{pf}} &= \alpha_j + \alpha_{jl}L + \alpha_{jx}X + \alpha_{jf}F + \alpha_{jo}O + \alpha_{jh}H + \alpha_{jp}P \\
 &\quad + \alpha_{jw}W + \alpha_{ja}A + \alpha_{jb}B + 2\phi_{jj}J + \alpha_{jy}Y + \alpha_{ju}U + \alpha_{js}S \\
 \text{July: } \eta_y^{\text{pf}} &= \alpha_y + \alpha_{yl}L + \alpha_{yx}X + \alpha_{yf}F + \alpha_{yo}O + \alpha_{yh}H + \alpha_{yp}P \\
 &\quad + \alpha_{yw}W + \alpha_{ya}A + \alpha_{yb}B + \alpha_{yj}J + 2\phi_{yy}Y + \alpha_{yu}U + \alpha_{ys}S \\
 \text{August: } \eta_u^{\text{pf}} &= \alpha_u + \alpha_{ul}L + \alpha_{ux}X + \alpha_{uf}F + \alpha_{uo}O + \alpha_{uh}H + \alpha_{up}P \\
 &\quad + \alpha_{uw}W + \alpha_{ua}A + \alpha_{ub}B + \alpha_{uj}J + \alpha_{uy}Y + 2\phi_{uu}U + \alpha_{us}S \\
 \text{September: } \eta_s^{\text{pf}} &= \alpha_s + \alpha_{sl}L + \alpha_{sx}X + \alpha_{sf}F + \alpha_{so}O + \alpha_{sh}H + \alpha_{sp}P \\
 &\quad + \alpha_{sw}W + \alpha_{sa}A + \alpha_{sb}B + \alpha_{sj}J + \alpha_{sy}Y + \alpha_{su}U + 2\phi_{ss}S.
 \end{aligned} \tag{5.4}$$

PARTIAL TRANSLOG ELASTICITIES OF COOPERATIVE SECTOR:

$$\begin{aligned}
 \text{Labor: } \eta_l^{\text{PC}} &= \theta_l + 2\phi_{ll}L + \theta_{lx}X + \theta_{ly}Y + \theta_{lt}T + \theta_{lu}U + \theta_{la}A + \theta_{lb}B \\
 &\quad + \theta_{lj}J + \theta_{ly}Y + \theta_{lu}U + \theta_{ls}S \\
 \text{Oxen: } \eta_x^{\text{PC}} &= \theta_x + \theta_{lx}L + 2\phi_{xx}X + \theta_{xy}Y + \theta_{xt}T + \theta_{xi}XI + \theta_{xa}A \\
 &\quad + \theta_{xb}B + \theta_{xj}J + \theta_{xy}Y + \theta_{xu}U + \theta_{xs}S \\
 \text{Fertilizer: } \eta_f^{\text{PC}} &= \theta_f + \theta_{fl}L + \theta_{fx}X + 2\phi_{ff}F + \theta_{ft}T + \theta_{fi}I + \theta_{fa}A \\
 &\quad + \theta_{fb}B + \theta_{fj}J + \theta_{fy}Y + \theta_{fu}U + \theta_{fs}S \\
 \text{Tractors: } \eta_t^{\text{PC}} &= \theta_t + \theta_{tl}L + \theta_{tx}X + \theta_{tf}F + 2\phi_{tt}T + \theta_{ti}I + \theta_{ta}A \\
 &\quad + \theta_{tb}B + \theta_{tj}J + \theta_{ty}Y + \theta_{tu}U + \theta_{ts}S \\
 \text{MMT Inputs: } \eta_i^{\text{PC}} &= \theta_i + \theta_{il}L + \theta_{ix}X + \theta_{if}F + \theta_{it}T + 2\phi_{ii}I + \theta_{ia}A \\
 &\quad + \theta_{ib}B + \theta_{ij}J + \theta_{iy}Y + \theta_{iu}U + \theta_{is}S \\
 \text{Enrl.1 - 6: } \eta_a^{\text{PC}} &= \theta_a + \theta_{la}L + \theta_{xa}X + \theta_{fa}F + \theta_{ta}T + \theta_{ia}I + 2\phi_{aa}A \\
 &\quad + \theta_{ab}B + \theta_{aj}J + \theta_{ay}Y + \theta_{au}U + \theta_{as}S \\
 \text{Enrl.7 - 12: } \eta_b^{\text{PC}} &= \theta_b + \theta_{lb}L + \theta_{xb}X + \theta_{fb}F + \theta_{tb}T + \theta_{ib}I + \theta_{ab}A \\
 &\quad + 2\phi_{bb}B + \theta_{bj}J + \theta_{by}Y + \theta_{bu}U + \theta_{bs}S \\
 \text{June: } \eta_j^{\text{PC}} &= \theta_j + \theta_{jl}L + \theta_{xj}X + \theta_{fj}F + \phi_{ij}T + \theta_{ij}I + \theta_{aj}A \\
 &\quad + \theta_{bj}B + 2\phi_{jj}J + \theta_{jy}Y + \theta_{ju}U + \theta_{js}S \\
 \text{July: } \eta_y^{\text{PC}} &= \theta_y + \theta_{ly}L + \theta_{xy}X + \theta_{fy}F + \phi_{iy}T + \theta_{iy}I + \theta_{ay}A \\
 &\quad + \theta_{by}B + \theta_{jy}J + 2\phi_{yy}Y + \theta_{yu}U + \theta_{ys}S \\
 \text{August: } \eta_u^{\text{PC}} &= \theta_u + \theta_{lu}L + \theta_{xu}X + \theta_{fu}F + \theta_{tu}T + \theta_{iu}I + \theta_{au}A \\
 &\quad + \theta_{bu}B + \theta_{ju}J + \theta_{yu}Y + 2\phi_{uu}U + \theta_{us}S \\
 \text{September: } \eta_s^{\text{PC}} &= \theta_s + \theta_{ls}L + \theta_{xs}X + \theta_{fs}F + \theta_{ts}T + \theta_{is}I + \theta_{as}A \\
 &\quad + \theta_{bs}B + \theta_{js}J + \theta_{ys}Y + \theta_{us}U + 2\phi_{ss}S.
 \end{aligned} \tag{5.5}$$

PARTIAL TRANSLOG ELASTICITIES OF STATE FARMS SECTOR:

$$\begin{aligned}
 \text{Labor: } \eta_l^{\text{sf}} &= \delta_l + 2\phi_{ll}L + \delta_{ll}l + \delta_{lm}M + \delta_{lj}J + \delta_{ly}Y + \delta_{lu}U + \delta_{ls}S \\
 \text{MYI Inputs: } \eta_i^{\text{sf}} &= \delta_i + \delta_{il}L + 2\phi_{ii}l + \delta_{im}M + \delta_{ij}J + \delta_{iy}Y + \delta_{iu}U + \delta_{is}S \\
 \text{Machinery: } \eta_m^{\text{sf}} &= \delta_m + \delta_{ml}L + \delta_{ml}l + 2\phi_{mm}M + \delta_{mj}J + \delta_{my}Y + \delta_{mu}U + \delta_{ms}S \\
 \text{June: } \eta_j^{\text{sf}} &= \delta_j + \delta_{jl}L + \delta_{jl}l + \delta_{mj}M + 2\phi_{jj}J + \delta_{jy}Y + \delta_{ju}U + \delta_{js}S \\
 \text{July: } \eta_y^{\text{sf}} &= \delta_y + \delta_{yl}L + \delta_{yl}l + \delta_{my}M + \delta_{jy}J + 2\phi_{yy}Y + \delta_{yu}U + \delta_{ys}S \\
 \text{August: } \eta_u^{\text{sf}} &= \delta_u + \delta_{ul}L + \delta_{ul}l + \delta_{mu}M + \delta_{ju}J + \delta_{yu}Y + 2\phi_{uu}U + \delta_{us}S \\
 \text{September: } \eta_s^{\text{sf}} &= \delta_s + \delta_{sl}L + \delta_{sl}l + \delta_{ms}M + \delta_{js}J + \delta_{ys}Y + \delta_{us}U + 2\phi_{ss}S.
 \end{aligned} \tag{5.6}$$

The computed partial output elasticity,  $\eta_i$ , of a regressor takes either a positive, negative or zero value following statistical estimation. The magnitude and the sign that  $\eta_i$  takes will be determined by the sum of the relevant regression coefficients. Furthermore, the sign of  $\eta_i$  will be influenced by the sign that a regressor will take in the process of logarithmic transformation prior to statistical estimation. If, for example, normalized  $\omega_i$  takes a value between zero and one, its logarithmic mean will be negative.<sup>99</sup> Both the magnitude and the sign  $\eta_i$  takes are important in determining marginal rate of technical substitution, elasticity of substitution and marginal revenue products of  $\omega_i$  and  $\omega_j$ . As will be shown in Chapter VI,  $\eta_i$  and average product of  $\omega_i$  jointly determine marginal product of  $\omega_i$ . What this implies is that both the sign and the magnitude of the marginal product of  $\omega_i$  would be influenced by the two components.

It can be seen from equations (5.1), (5.2) and (5.3) that the C-D functional form implicitly states the null-hypothesis that the joint effect of interaction terms of the translog functional form are not significantly different from zero. If, indeed, the hypothesis can not be rejected on the basis of statistical evidence, then imposing the translog functional form on the production data would induce misspecification. On the other hand, if the converse is statistically verified, then the translog

---

<sup>99</sup> Or mathematically, if  $0 < \omega_i < 1$  its logarithmic mean will be  $\bar{\omega}_i = \frac{1}{n} \sum_{i=1}^n \omega_i \leq 0$ .

functional form will be appropriate to study production properties of the three farm types under investigation. First, however, it is necessary to construct statistically estimable TL model from the unrestricted models defined in equations (5.1) through (5.3). Procedures implemented to select subset of regressors for building TL models suitable for statistical estimation are discussed next.

## ***V.2. Statistically Estimable Models***

The TL production model of the PF, PC, and SF expressed in equations (5.1) through (5.3) involves a total of 107, 81, and 43 regressors, respectively. Empirical relevance of the model, if estimated as defined, to generate useful information is found to be severely limited, first, by lack of enough degrees of freedom, especially, in the case of the PF and SF since the number of observations for PF is 77 and that of the SF is 50 and, second, by collinearity among the regressors. The collinear relationship was a problem under both functional specifications, but it was much more severe with the translog specification. Also, as detected by examining condition indexes and variance proportions of the unrestricted models, the problem was quite severe in the data sets of the state farms and producer cooperatives relative to the private farms sector.

Existing econometric literature (see Judge, Griffiths, Hill, and Lee pp.471-486, among others) suggests several *ad hoc* ways of addressing the collinearity problem but no theoretically defensible solution is offered. Researchers who work with the TL function have applied various strategies to mitigate effects of collinearity. Vinod (1972), for example, purposely avoided log-quadratic regressors before estimating production properties of the Bell System. Others such as Shih, Hushak and Rask (1977) used small t-ratios as a condition to drop a regressor when they examined validity of the C-D production function against the translog function to study properties of Taiwanese agriculture. This research also omits statistically insignificant and collinear (or extraneous)

regressors but the strategies applied to omit the insignificant regressors are more systematic and restrained than the methods used in the studies cited above.

First, a constrained stepwise regression procedure was applied to the unrestricted TL equations (5.1) through (5.3) with and without log-quadratic terms.<sup>100</sup> The stepwise regression was constrained to start the search for a parsimonious-in-regressors TL model with non-interaction terms of the C-D function. Selected interaction terms (one at a time) were added to this set if they played a significant role in reducing mean square error of the regression at each step. Mallow's  $C_p$  statistic criterion was used to evaluate the validity of a series of the restricted models established at each stage of the stepwise regression. In order to be selected, a model with the subset of the regressors must meet the  $C_p$  criterion defined as follows:

$$C_p = \frac{(K - p)\hat{\sigma}_p^2}{\hat{\sigma}^2} + (2p - K) \cong p \quad (5.7)$$

where  $\hat{\sigma}_p^2$  = variance of the restricted model with p regressors at any stage of the stepwise regression,  $\hat{\sigma}^2$  = sample variance of the unrestricted full model with K regressors, and p = number of regressors included in a restricted model. If the selected (or restricted) model is unbiased, then  $\hat{\sigma}_p^2 \cong \hat{\sigma}^2$  and the  $C_p$  value will be approximately (or exactly) equal to p.<sup>101</sup>

The stepwise regression procedure with the  $C_p$  criterion made it possible to obtain a statistical model for the state farms with some of the log-quadratic terms included which met the selection

---

<sup>100</sup> Apparently, stepwise selection of a subset of regressors is an old problem which has led previous researchers toward the development of several criteria for choosing a "correct" model. See, for example, Maddala (1988), Hoking (1976), Judge, Griffiths, Hill, and Lee (1980) and Amemiya (1980) among others. The criteria are summarized by Maddala on page 426 and they include (a) Theil's corrected  $R^2$ , (b) Hocking's  $S_p$ , (c) Amemiya's PC, and (d) Akaike's AIC. Weaknesses and strengths of each criterion are discussed in Judge, *et. al.*

<sup>101</sup> As Maddala notes, the  $C_p$  criterion is based on minimizing mean square error (MSE--commonly defined as a sum of variance and square of a bias) of prediction. The principal goal of the  $C_p$  criterion is not necessarily finding a "true" model, but its goal is to construct a statistical model with a limited number of regressors that improves the MSE of prediction.

criterion. On the other hand, the  $C_p$  criterion of the stepwise regression with the log-quadratic terms indicated that statistically estimable TL models could not be constructed for the private and cooperative farms because of severe collinearity. This was shown by extremely high  $C_p$  values relative to the number of regressors included in each model. The stepwise regression was run again without the log-quadratic terms which resulted in statistically estimable TL models with a subset of regressors for the private and cooperative farms. The selected models had the  $C_p$  values close to  $p$ . The usefulness of this procedure (that is, omitting log-quadratic terms) is that it reduces structurally induced collinearity among regressors. But the strategy does not completely disentangle the collinear relationship. Further experimentation was necessary to eliminate collinearly-extraneous-regressors.

The second strategy involved deletion of a single collinearly extraneous regressor at a time over series of linear regressions with the restricted TL models. At each step, the Student's  $t$ -statistic ( $< .10$ ) and the nature of collinearity as indicated by variance proportions ( $> 0.50$ ) corresponding to a large condition index ( $> 30$ ) were used as a set of criteria for deleting a regressor. For example, if the estimated coefficient is not significantly different from zero at the probability level of not more than 10 percent and more than 50 percent of its variance is associated with a large condition index, the regressor was deleted. The fact that the deleted regressor is collinear indicates that it carries some properties that can be captured by other regressors in the relationship. Although, its influence on the dependent variable is statistically insignificant, deleting the regressor will induce a bias on the coefficients of the collinear regressors. But, the bias is expected to be small relative to the gain in efficiency.

Statistically estimable restricted TL regression models with the subset of regressors are summarized below for each mode of production in equations (5.8) through (5.10). Note that the C-D model in each case represents a TL model in which all the interaction terms are postulated to be not significantly different from zero. This hypothesis is statistically examined for a functional

form misspecification test in Section V.2.1. with appropriate residuals generated from the following restricted models.

**PRIVATE FARM SECTOR:**

$$\hat{Q}_{pf}^{CD} = \hat{\alpha}_0 + \hat{\alpha}_x X + \hat{\alpha}_f F + \hat{\alpha}_p P + \hat{\alpha}_a A + \hat{\alpha}_y Y + \hat{\alpha}_s S \\ + \hat{\alpha}_1 D_1 + \hat{\alpha}_2 D_2 + \hat{\alpha}_3 D_3 + \hat{Z}_{pf}^{CD}$$

$$\hat{Q}_{pf}^{TL} = \hat{\alpha}_0 + \hat{\alpha}_x X + \hat{\alpha}_f F + \hat{\alpha}_p P + \hat{\alpha}_a A + \hat{\alpha}_y Y + \hat{\alpha}_s S \\ + \hat{\alpha}_{lf} LF + \hat{\alpha}_{lh} LH + \hat{\alpha}_{ly} LY + \hat{\alpha}_{xf} XF + \hat{\alpha}_{xb} XB + \hat{\alpha}_{xy} XY \\ + \hat{\alpha}_{fh} FH + \hat{\alpha}_{fu} FU + \hat{\alpha}_{oh} OH + \hat{\alpha}_{oj} OJ + \hat{\alpha}_{oy} OY + \hat{\alpha}_{hw} HW \\ + \hat{\alpha}_{ha} HA + \hat{\alpha}_{hb} HB + \hat{\alpha}_{hj} HJ + \hat{\alpha}_{hy} HY + \hat{\alpha}_{hs} HS + \hat{\alpha}_{pa} PA \\ + \hat{\alpha}_{pb} PB + \hat{\alpha}_{pj} PJ + \hat{\alpha}_{py} PY + \hat{\alpha}_{ps} PS + \hat{\alpha}_{wb} WB + \hat{\alpha}_{wu} WU \\ + \hat{\alpha}_{ws} WS + \hat{\alpha}_1 D_1 + \hat{\alpha}_2 D_2 + \hat{\alpha}_3 D_3 + \hat{Z}_{pf}^{TL} . \quad (5.8)$$

**PRODUCER COOPERATIVE SECTOR:**

$$\hat{Q}_{pc}^{CD} = \hat{\theta}_0 + \hat{\theta}_f F + \hat{\theta}_l L + \hat{\theta}_j J + \hat{\theta}_s S \\ + \hat{\theta}_1 D_1 + \hat{\theta}_2 D_2 + \hat{\theta}_3 D_3 + \hat{\theta}_4 D_4 + \hat{Z}_{pc}^{CD}$$

$$\hat{Q}_{pc}^{TL} = \hat{\theta}_0 + \hat{\theta}_f F + \hat{\theta}_l L + \hat{\theta}_j J + \hat{\theta}_s S + \hat{\theta}_{lj} LJ + \hat{\theta}_{ly} LY + \hat{\theta}_{lu} LU \\ + \hat{\theta}_{xl} XL + \hat{\theta}_{xy} XY + \hat{\theta}_{xs} XS + \hat{\theta}_{ff} FJ + \hat{\theta}_{fu} FU + \hat{\theta}_{fs} FS \\ + \hat{\theta}_{yl} YJ + \hat{\theta}_{yt} TY + \hat{\theta}_{lu} TU + \hat{\theta}_{ly} IY + \hat{\theta}_{lu} IU + \hat{\theta}_{ls} IS \\ + \hat{\theta}_1 D_1 + \hat{\theta}_2 D_2 + \hat{\theta}_3 D_3 + \hat{\theta}_4 D_4 + \hat{Z}_{pc}^{TL} . \quad (5.9)$$

STATE FARM SECTOR:

$$\begin{aligned}\hat{Q}_{sf}^{CD} = & \hat{\delta}_0 + \hat{\delta}_l L + \hat{\delta}_i I + \hat{\delta}_m M + \hat{\delta}_j J + \hat{\delta}_y Y + \hat{\delta}_u U + \hat{\delta}_s S + \hat{\delta}_1 D_1 \\ & + \hat{\delta}_2 D_2 + \hat{\delta}_3 D_3 + \hat{\delta}_5 D_5 + \hat{\delta}_6 D_6 + \hat{\delta}_7 D_7 + \hat{\delta}_8 D_8 + \hat{\delta}_9 D_9 + \hat{Z}_{sf}^{CD}\end{aligned}\tag{5.10}$$

$$\begin{aligned}\hat{Q}_{sf}^{TL} = & \hat{\delta}_0 + \hat{\delta}_l L + \hat{\delta}_i I + \hat{\delta}_m M + \hat{\delta}_j J + \hat{\delta}_y Y + \hat{\delta}_u U + \hat{\delta}_s S \\ & + \hat{\theta}_{lm} LM + \hat{\theta}_{ly} LY + \hat{\theta}_{lu} LU + \hat{\theta}_{ls} LS + \hat{\phi}_{ll} l^2 + \hat{\theta}_{ij} IJ \\ & + \hat{\theta}_{iu} IU + \hat{\theta}_{is} IS + \hat{\theta}_{yu} YU + \hat{\phi}_{mm} M^2 + \hat{\delta}_1 D_1 + \hat{\delta}_2 D_2 \\ & + \hat{\delta}_3 D_3 + \hat{\delta}_5 D_5 + \hat{\delta}_6 D_6 + \hat{\delta}_7 D_7 + \hat{\delta}_8 D_8 + \hat{\delta}_9 D_9 + \hat{Z}_{sf}^{TL}.\end{aligned}$$

where  $\hat{Z}$  = estimated residuals and the hat notation indicates estimated values.

It is not necessary to work out homogeneity restrictions from the above equations (5.8) through (5.10) because proper procedures to construct such conditions follow the same procedures that are developed in Chapter III. But it will be sufficient to indicate that the number of the homogeneity conditions that can be imposed on the TL function in equations (5.8) through (5.10) includes 25, 15 and 10 for each model of the private farms, producer cooperatives and state farms, respectively. These numbers are used in hypothesis testing for misspecification of functional form in the next section.

### V.2.1. Functional Form Selected

It needs to be stated at the outset that appropriateness of the C-D functional specification to study production properties of both private and socialized farms of Ethiopia is rejected. This finding is based on carefully established statistical evidence. Procedures that led to this finding include the following. A subset of regressors selected according to the procedures discussed in Section V.2. were used to construct two regression models for each farm type: one with the C-D production

function and the other with the TL production function. The C-D functional form represents a restricted case of the TL functional form. In other words, given the set of homogeneity conditions discussed in Chapter III, the C-D model represents the null hypothesis and the TL model represents an alternative hypothesis illustrated in terms of the following general notation:

$$\begin{aligned}
 H_0^{\text{CD}}: \quad Q^j &= \hat{\mu}_0 + \sum_{i=1}^k \hat{\mu}_i \omega_i \\
 H_A^{\text{TL}}: \quad Q^j &= \hat{\mu}_0 + \sum_{i=1}^k \hat{\mu}_i \omega_i + \sum_{i=1}^k \frac{1}{2} \lambda_{ii} \omega_i^2 + \sum_{i=1}^k \sum_{j \geq i}^k \hat{\lambda}_{ij} \omega_i \omega_j
 \end{aligned}
 \tag{5.11}$$

where, as before, all the variables are log-transformed variables,  $\omega_i$  is a proxy for regressors in equations (5.8) through (5.10).

If there is sufficient statistical evidence against the alternative hypothesis at a probability level of 5 percent, it will imply that  $\hat{\lambda}_{1j} = \dots = \hat{\lambda}_{i1} = \dots = \hat{\lambda}_{kk} = 0$ . That is, all the log-quadratic and interaction terms included in the TL function will not be jointly statistically different from zero.<sup>102</sup> Otherwise, the TL functional form would be selected for the analysis. This can be checked by computing an F-type test for functional form misspecification.<sup>103</sup> The F-values computed from the restricted regression models given in equations (5.8), (5.9) and (5.10) are summarized below in the order of PF, PC and SF models with the following statistics: homogeneity restrictions = 25, 15,

<sup>102</sup> For a good scholarly discussion on nested and non-nested hypothesis testing procedures, see unpublished Ph.D. dissertation by L. Bauer (1987).

<sup>103</sup> Recall that the test is defined as:

$$F_{(r, N-k)}^{\text{obs.}} = \frac{(RRSS_{\text{CD}} - URSS_{\text{TL}})/r}{URSS_{\text{TL}}/(N-k)}$$

where RRSS = residual sum of squares from the C-D model, URSS = residual sum of squares from the TL model  $r$  = number of restrictions imposed by the homogeneity conditions.

10; residual sum squares in  $(C - D, TL)^{PF} = (6.89, 2.04)$ ,  $(C - D, TL)^{PC} = (43.68, 15.12)$ , and  $(C - D, TL)^{SF} = (2.28, 0.59)$ :

$$\begin{aligned}
 PF: F^{\text{obs.}} &= \frac{(6.89 - 2.04)/25}{2.04/42} = 3.99 > F^{\text{critical}} \cong 1.77 \\
 PC: F^{\text{obs.}} &= \frac{(43.68 - 15.12)/15}{15.12/93} = 11.71 > F^{\text{critical}} \cong 1.79 \\
 SF: F^{\text{obs.}} &= \frac{(2.28 - 0.59)/10}{0.59/24} = 6.87 > F^{\text{critical}} = 2.26
 \end{aligned} \tag{5.12}$$

where PF = private farms, PC = producer cooperatives, SF = state farms,  $F^{\text{obs.}}$  = F-value computed from the restricted regression results and,  $F^{\text{critical}}$  = critical values obtained from statistical tables in Kmenta (1971).<sup>104</sup>

As can be seen from the above results, the observed F-test statistics are significantly different from the corresponding critical F-values at a probability level of 5 percent. This suggests that the null hypothesis of the homogeneity conditions (see equation (5.11)) instrumental in defining the C-D functional form are rejected in all cases. The failure to implement the homogeneity conditions, therefore, provides sufficient evidence that the C-D functional specification is not appropriate to analyze the underlying production properties of the private and socialized farms in Ethiopia.<sup>105</sup> The

<sup>104</sup> Critical F-values which can not be obtained from Kmenta (1971) with appropriate degrees of freedom at the probability level of 5 percent are interpolated as follows:

$$c = \left( \frac{y - x}{z - x} \right) b + \left( 1 - \frac{y - x}{z - x} \right) a$$

where  $y$  = degree of freedom that falls somewhere between  $x$  and  $z$  digress of freedom,  $a$  and  $b$  are F-values corresponding to  $x$  and  $z$  degrees of freedom, respectively, and  $c$  = interpolated critical F-value corresponding to  $y$  degree of freedom. Note that  $x < y < z$ . See Senedecor and Cochran (1978) p.541 for the interpolation procedure.

<sup>105</sup> These findings raise doubts about the validity of Cornia's results that were estimated by the C-D functional specification. As discussed in Chapter 1, Cornia used the C-D functional specification to generate statistically estimated production elasticities for a number of international regions among which Ethiopia was one. Given the data sets, results and the scope of this dissertation, it can be said that the elasticity coefficients generated for Ethiopian agriculture by Cornia are biased and the author incorrectly (at least, implicitly) assumed that additional information generated by the TL specification was not significantly different from zero.

A brief review of the previous production function studies of the developing regions other than

remainder of this chapter and the next chapter will, therefore, focus on the regression results generated with the TL functional specification given in equations (5.8) through (5.10). So, the TL function is checked below for (a) omitted variables, (b) efficiency of the estimated coefficients (in terms of heteroskedasticity and serial correlation) and (c) regularity conditions of the underlying TL production.

### V.2.2. Translog Regression Specification Error Test

As discussed in Chapter III, regression specification error test (RESET) is applied to the statistically estimated TL regression equations (5.8) through (5.10) and the relevant F-tests are computed for each farm model with the following statistics. Homogeneity restrictions = 3 for all three TL farm models (or 3 is the number of polynomial  $\hat{Q}$ 's added back into the TL model), residual sum of squares in  $(rTL, uTL)^{PF} = (2.04, 1.92)$ ,  $(rTL, uTL)^{PC} = (15.12, 13.99)$ , and  $(rTL, uTL)^{SF} = (0.59, 0.47)$ :

$$\begin{aligned}
 PF: F^{obs.} &= \frac{(2.04 - 1.92)/3}{1.92/38} = 0.79 < F^{critical} = 2.85 \\
 PC: F^{obs.} &= \frac{(15.12 - 13.99)/3}{28.58/90} = 1.85 < F^{critical} = 2.72 \\
 SF: F^{obs.} &= \frac{(0.59 - 0.47)/3}{0.47/21} = 1.79 < F^{critical} = 3.07
 \end{aligned} \tag{5.13}$$

where  $rTL$  and  $uTL$  = restricted and "unrestricted" TL models where the  $uTL$  contains polynomial  $\hat{Q}$ 's, PF = private farms, PC = producer cooperatives, SF = state farms, and  $F^{obs}$  = observed

---

Ethiopia also shows that the use of the C-D function is quite prevalent. For example, Yotopoulos (1967) used the C-D function to study production properties of Cyprus. Boyd (1988) also used the C-D function to study effects of policy and institutional organization on the performance of private and socialized agriculture in Poland. On the other hand, the validity of the C-D functional specification was rejected in some cases. For instance, after conducting regression experiments with farm level production data from Taiwan, Shih (1975) and Shih, Hushak and Rask (1977) showed that the C-D function was not appropriate for modeling farms in Taiwan.

F-values computed from the *rTL* and *uTL* regression results. As can be seen from the above results, the observed F-test statistics are not significantly more than the corresponding critical F-values at the probability level of 5 percent. This suggests that the null hypothesis of no specification error can not be rejected.

### V.2.3. Efficiency of the Translog Coefficients

As indicated in Chapter III, the White test is applied in this research to detect the presence of heteroskedasticity in the restricted TL regression models of equations (5.8) through (5.10). Results of the test generated the following statistics:

Private sector's TL model: Chi-Squared = -4.72E + 11, df = 78, P-value = 1.000

Cooperative sector's TL model: Chi-Squared = 76.66, df = 81, P-value = 0.6158

State sector's TL model: Chi-Squared = -6.30E + 15, df = 50, P-value = 1.000

Except in the case of the cooperative sector's TL model, the above results of White test indicate the presence of homoskedastic variance for the private and state sectors' TL models. Correcting for the heteroskedasticity of the cooperative sector's TL model is necessary but the method of correction is a matter of trial and error with various assumptions about the structure of heteroskedasticity. The trial and error approach seems unscientific, however, it is the method often applied in empirical research (Johnson, Johnson and Buse (1987)). Thus, the heteroskedastic nature of the residuals of the cooperative sector's data set was changed to a constant variance by assuming that the variance is proportional to the predicted values of the dependent variable. That is,  $E(\varepsilon_i^2) = \text{ABS}(\hat{Q}_i)^{-0.5}$ . Equation (5.9) was weighted by  $\text{ABS}(\hat{Q}_i)^{-0.5}$  by using 'Weight' option of the SAS (Statistical Analysis System) procedure. The transformation exercise resulted in a constant variance as shown by the following statistics of the White test: Chi-Squared = 38.98, df = 81 and P-value = 1.00. The transformation reported above is only the one that has successfully transformed

heteroskedasticity to a constant variance. Many other structural forms were tried and failed to correct for it. Note that the White test provides further evidence that the restricted TL models of all the farm types are correctly specified and the residuals are independent of the regressors.

Finally, the Durbin-Watson statistics of the regression models of the private, cooperative and state farms were found to be 2.106, 2.163 and 2.222, respectively. Implementation of the theoretical tools suggested in Chapter III indicated no serial correlation between residuals.

## *V.2. Summary*

This chapter has provided detailed discussion of econometric problems and solutions of the estimated models specified for each farm type. Especially, the chapter has indicated statistical evidence for adapting the translog specification as an appropriate functional form for studying production properties of the three farm types. Methods employed in this research to address such problems as multicollinearity, heteroskedasticity (hence, non-normality) and serial correlation were briefly clarified. The next chapter presents interpretation of the results.

# **CHAPTER SIX**

## **INTERPRETATION OF RESULTS**

### ***VI.0. Introduction***

The following discussion of the empirical results is based on the research data gathered from the private and socialized farms of Ethiopian agriculture. Separate econometric estimates of the translog production function are generated for each farm type. Production relationships unique to each farm type are evaluated as they are revealed in the estimation process. A set of observable factors of production that would help to explain changes in gross farm income per hectare of each sector are identified. Agro-ecological and temporal latent omitted (or simply spatial and temporal) factors are captured by dummy variables  $D_1, \dots, D_9$ .

The discussion of the results is organized into four sections. An overview of the results is discussed in Section VI.1. This section summarizes goodness-of-fit of the empirical models and examines technical efficiencies of the three farms types. Productivity impacts of the input variables (that were defined in Chapter IV) are discussed in Section VI.1. The hypotheses postulated in Chapter I are examined in Section VI.3. Also, this section evaluates regularity conditions of the underlying TL production function (in Subsection VI.3.2) in terms of signs on elasticity of substitution between several input pairs. Finally, some important policy implications are discussed in the last section.

## *VI.1. Overview of the Results*

The regression results of the translog functional form are summarized for each farm type in tables VI.1, VI.2 and VI.3. Each table contains regressors included in the estimation, corresponding regression coefficients, t-ratios, and p-values.<sup>106</sup> The t-ratios associated with the regression coefficients indicate whether or not the coefficients are statistically different from zero at the probability levels indicated by the associated p-values. The “-” notation in tables VI.1 and VI.2 indicates that the corresponding variables were deleted because they were statistically insignificant and collinear with other variables. Procedures for dropping variables were fully discussed in Chapter V. The variables are, however, reported only because of the associated symbols used in the interaction parts of the tables. At this point, however, not much can be said about the importance of the individual coefficients, because, in most cases, each coefficient plays only a partial role in determining production properties of the farm types. The TL coefficients would have a collective importance only in terms of partial elasticities as illustrated in equations (5.4), (5.5) and (5.6) and related statistics such as marginal productivities of the factors under investigation.

Two important features of the estimated production models are summarized below. These include: (a) the overall performance of the statistical models that were selected in Section V.2 (equations (5.8) through (5.10)); and (b) the nature of the technical efficiency and the regional and temporal latent variables.

---

<sup>106</sup> Note again that, unless expressed otherwise, all the variables (dependent and independent) are defined in terms of natural logarithms.

**TABLE VI.1. Translog Function Estimates for Cereal Production  
on Private Farms with Output Measured in Birr per Hectare**

Variable	Coefficient	T-Ratio	Probability
Intercept	11.624	7.374	0.0001
Labor-Days (L)	-	-	-
Oxen-Days (X)	-2.602	-4.002	0.0002
Fertilizer (F)	-0.232	-1.653	0.1059
LPT Tools (O)	-	-	-
TH Tools (H)	-	-	-
P. Livestock (P)	1.451	3.227	0.0024
W. Livestock (W)	-	-	-
Enrollm. 1-6 (A)	1.159	2.687	0.0103
Enrollm. 7-12 (B)	-	-	-
June Rain (J)	-	-	-
July Rain (Y)	-0.487	-2.488	0.0169
August Rain (U)	-	-	-
September Rain (S)	0.614	3.493	0.0011
<u>Interaction Variables</u>			
LF	-0.048	-1.565	0.1250
LH	0.224	3.854	0.0004
LY	-0.075	-1.725	0.0919
XF	0.119	3.866	0.0004
XY	0.130	2.642	0.0115
XB	-0.381	-3.521	0.0011
FH	0.062	2.198	0.0335
FU	-0.013	-2.428	0.0196
OH	-0.152	-4.118	0.0002
OJ	-0.264	-3.500	0.0011
OY	0.288	3.884	0.0004
HW	-0.137	-2.281	0.0277
HJ	0.248	3.074	0.0037
HY	-0.263	-2.888	0.0061
HA	-0.438	-2.873	0.0064
HB	0.346	3.221	0.0025
PJ	0.061	2.107	0.0411
PY	0.297	3.750	0.0005
PS	-0.338	-3.978	0.0003
PA	0.223	2.005	0.0154
PB	0.185	2.243	0.0302
WU	-0.346	-3.434	0.0014
WS	0.313	2.095	0.0035
WB	-0.163	-3.701	0.0006
<u>Intercept Shifting Dummies</u>			
Eastern Highlands (D1)	-0.006	-0.058	0.9542
S.W. Highlands (D2)	0.270	2.211	0.0325
S.E. Highlands (D3)	-0.223	-1.350	0.1842
<u>Other Statistics (OLS)</u>			
R <sup>2</sup> /Adjusted R <sup>2</sup>		0.8192/0.673	
F-Value/P-Value of the model		5.596/0.0001	
Durbin-Watson (d)		2.106	
White Test : Chi-Squared = -4.72E11, df = 78, P-value = 1.000			
Sample Size		77	

LPT = pre-harvest traditional tools, TH = post-plant traditional hand tools, P = productive, W = workstock, "-" indicates that variable was dropped/insignificant

Source: Generated from 1983/84 production year data

**TABLE VI.2. Translog Function Estimates for Cereal Production on  
Producer Cooperatives with Output Measured in Birr Per Hectare**

Variable	Coefficient	T-Ratio	Probability
Intercept	5.699	33.974	0.0001
Labor-Days (L)	-	-	-
Oxen-Days (X)	-	-	-
Fertilizer (F)	0.107	1.907	0.0596
Tractors (T)	-	-	-
MYI Inputs (I)	0.146	2.116	0.0370
June Rain (J)	-1.411	-2.281	0.0248
July Rain (Y)	-	-	-
August Rain (U)	-	-	-
September Rain (S)	1.237	2.104	0.0381
<b>Interaction Variables</b>			
LJ	0.260	2.210	0.0296
LY	-0.171	-1.546	0.1256
LU	-0.054	-1.732	0.0865
XJ	-0.095	-1.122	0.2648
XY	0.288	1.677	0.0969
XS	-0.207	-1.580	0.1175
FJ	0.058	0.900	0.3706
FU	0.091	1.266	0.2085
FS	-0.158	-1.724	0.0880
TJ	-0.062	-2.168	0.0327
TY	-0.070	-1.392	0.1672
TU	0.110	1.990	0.0495
IY	-0.101	-1.452	0.1498
IU	0.044	0.539	0.5911
IS	0.016	0.175	0.8612
<b>Intercept Shifting Dummies</b>			
Eastern Highlands (D1)	-1.003	-2.802	0.0062
SW Highlands (D2)	-0.964	-5.082	0.0001
SE Highlands (D3)	-0.511	-1.913	0.0588
1986 Production Year (D4)	-0.479	-2.750	0.0072
<b>Other Statistics (OLS)</b>			
R <sup>2</sup> /Adjusted R <sup>2</sup>		0.4496/0.3135	
F-Value/P-value of the model		3.3030/0.0001	
Durbin-Watson (d)		2.163	
White Test: Chi-Square = 38.98, df = 81, P-value = 1.000			
Pooled Sample Size [1985,1986]			117

\* - \* indicates that variable was dropped/insignificant

Source: Generated from 1985-86 production period data.

**TABLE VI.3. Translog Function Estimates for Cereal Production on State Farms with Output Measured in Birr Per Hectare**

Variable	Coefficient	T-Ratio	Probability
Intercept	-13.077	-3.117	0.0041
Labor Days (L)	-0.134	-0.158	0.8758
MYI Inputs (I)	1.203	3.832	0.0008
Machinery (M)	1.497	2.633	0.0146
June Rain (J)	0.886	4.603	0.0001
July Rain (Y)	2.492	4.685	0.0001
August Rain (U)	4.718	3.370	0.0026
September Rain (S)	-3.532	-2.657	0.0138
<b>Interaction Variables</b>			
LM	0.315	3.472	0.0020
LY	-0.439	-3.614	0.0014
LU	-0.183	-1.485	0.1506
LS	0.333	2.500	0.0196
I <sup>2</sup>	0.032	1.710	0.1001
IJ	-0.149	-3.544	0.0017
IU	-0.535	-2.912	0.0076
IS	0.440	2.443	0.0223
M <sup>2</sup>	-0.229	-2.864	0.0086
YU	-0.210	-2.301	0.0304
<b>Intercept Shifting Dummies</b>			
Eastern Highlands (D1)	-0.230	-0.978	0.3379
SW Highlands (D2)	0.151	1.405	0.1730
SE Highlands (D3)	0.027	0.191	0.8499
1984 Production Year (D5)	-0.286	-2.290	0.0311
1983 Production Year (D6)	-0.378	-2.825	0.0094
1982 Production Year (D7)	-0.311	-3.020	0.0059
1981 Production Year (D8)	-0.374	-3.017	0.0060
1980 Production Year (D9)	-0.252	-2.141	0.0427
<b>Other Statistics (OLS)</b>			
R <sup>2</sup> /Adjusted R <sup>2</sup>		0.9138/0.8240	
F-Value/P-value of the model		10.174/0.0001	
Durbin-Watson (d)		2.222	
White Test : Chi-Squared = -7.36E16, df = 52, P-Value = 1.0000			
Pooled Sample Size			50

Source: Generated from 1980-1985 production period data

### VI.1.1. Goodness-of-Fit

Overall goodness-of-fit of the three models is reasonable. The goodness-of-fit of each model is judged by the magnitudes of adjusted  $\bar{R}^2$  and F-ratios. The set of independent variables employed in the private sector explains 67 percent of the variation in gross farm income per hectare from cereal production in that sector. The producer cooperative model explains 31 percent whereas the state farm model explains about 82 percent. Furthermore, statistical significance of the production models is indicated by the overall observed F-ratios of 5.596, 3.303 and 10.174 for the private farms, producer cooperatives and the state farms, respectively. In addition to the above F-ratios, stability of the statistical production functions is shown by the respective p-values of 0.0001, 0.0001 and 0.0001.<sup>107</sup>

The relatively low  $\bar{R}^2$  associated with the producer cooperatives' model relative to the other two farm types is indicative of the presence of large variation in the production practices of the cooperatives across individual *awrajjas*. This is consistent with the overall heterogeneous nature of the sector. That is, unlike the other two farm types, the process of cereal production in the producer cooperatives does not seem to be organized around a common procedure across regions partly because the cooperatives have not been around for a long time (relative to the other two farm types) and partly because each producer cooperative is still going through a rapid transition. As discussed in Chapter II, the process of cooperativization is not completed yet and the rate at which new members enter into the institutional framework varies across regions. In short, it may not be unreasonable to state that the producer cooperatives are heterogeneous as far as production norms are concerned which, in turn, provides a partial explanation for the low observed  $\bar{R}^2$ . The presence of these forces is also reflected in the fact that their regional and temporal dummy variables are significantly different from the base measures. But, it should be noted that the proportion of

---

<sup>107</sup> The p-value indicates probability that collective impact of the variables included in each TL model is zero.

variation in the producer cooperatives gross farm income per hectare explained by the statistically estimated production model is high enough to accept the results with confidence.

### VI.1.2. Technical Efficiency

As measured by the estimated coefficients of the dummy variables, the assumption of the non-zero regional and time related latent factors has produced mixed results. From the statistical viewpoint, inclusion of the dummy variables implicitly postulates that the overall intercept of each model is non-constant across regions and time. The intercept would increase or decrease depending on the nature of the latent factors represented by the dummy variables. In this case, regional dummy variables are likely to measure whether or not the impacts of time-invariant agro-ecological factors are significantly different from the base measure. Also, temporal dummy variables indicate whether or not the impacts induced by the latent factors that remain constant across regions but that vary over time are significantly different from the base measure of the 1985 production year.

From a technical efficiency viewpoint, coefficients of regional and temporal dummy variables indicate differences in land productivity of a group of farms in the cereal producing *awrajjas*. A technically more (less) efficient group of farms are likely to generate a larger (smaller) level of gross farm income per hectare from a given set of inputs relative to the reference group of farms. Examination of the impacts of both regional and temporal latent factors on the per hectare productivity of each farm type leads to some useful observations.

*Private farms:* The influence of omitted regional latent factors of the southwestern (SW) highlands on the per hectare productivity of the private farms is 0.270 (antilog = 1.31) and significantly different from the overall influence of the regional latent factors on the per hectare productivity of the private farms in the central highlands of Ethiopia. This result indicates that overall intercept locus shifts up away from the origin by 0.31 due to the latent regional factors of the SW highlands.

In other words, the group of private farms in *awrajjas* in the SW highlands collectively appear to be technically more efficient than the group of private farms in *awrajjas* represented by the central highlands. They appear to have generated 31 percent more gross farm income per hectare from the same level of inputs.<sup>108</sup> It is possible that the observed differences in technical efficiency per hectare are likely to be due to omitted variable problem. Even though it is outside the scope of this research, it will be instructive to find out why the group of private farms in the SW highlands collectively enjoy higher technical efficiency per hectare in cereal production relative to the group of the private farms in the other regions.

The productivity influence of the regional latent factors on a group of the private farms in eastern and southeastern (SE) highlands are not significantly different from those of the central highlands. This means that the group of the private farms contained in the eastern and SE agro-ecological regions are technically as efficient per hectare as the group of the private farms contained in the central highlands.

**Producer Cooperatives:** Impacts of the spatial latent factors on the per hectare productivity of the producer cooperatives in eastern, SE and SW highlands are -1.003, -0.964, and -0.511, respectively. The coefficients are significantly different from that of the central highlands. The antilogs of the coefficients are 0.37, 0.38 and 0.60, respectively. If interpreted in terms of technical efficiency per hectare, these results indicate that the group of producer cooperatives in the the eastern, SE and SW highlands generate less gross farm income per hectare than the group of producer cooperatives in the central highlands. That is, if the producer cooperatives in these three agro-ecological regions were given the same level of inputs per hectare, the group of cooperatives in the eastern region appear to have generated less gross income by 0.37 Birr per hectare, the group of cooperatives in the SE region appear to have generated less gross income by 0.38 Birr per hectare and the group

---

<sup>108</sup> Since the shift in the regression intercept is parallel, production habits indicated by slope coefficients are not affected.

of cooperatives in the SW region appear to have produced less gross income by 0.60 Birr per hectare than the group of cooperatives in the central highlands.

It was postulated that some omitted temporal factors that vary over time would significantly influence the 1986 production in a different fashion than the 1985 production. Empirical results do not indicate otherwise. Relative to the 1985 production year, the cooperatives appear to have produced less gross income by 0.62 Birr per hectare (antilog of -0.479) in the 1986 production year. In terms of the effects of policy and related temporal factors on the productivity growth of cereal production on the cooperative farms, the estimated temporal dummy coefficient, -0.479, suggests the producer cooperatives experienced a negative rate of productivity growth during the 1986 production year. Thus, the estimated result implies that had input levels per hectare remained constant at the 1985 production level, gross income per hectare of the cooperative farms in 1986 would have fallen below that of the 1985.

*State Farms:* Regional differences among the cereal producing state farms are statistically insignificant. That is, if the state farms in each agro-ecological region are supplied with the same set of factors of production per hectare, it seems that they would produce approximately an identical level of gross income per hectare. This result is reasonable given the fact that the state farms produce under centrally standardized norms of operation. The result, also, seems to suggest that soils planted to cereal crops under the state mode of production are not significantly different across regions. Furthermore, scientific research, modern technology, skilled human capital applied to various aspects of farm management, and the ability of the institution as a whole to process new and old information appear to “wash-out” or to effectively control sources of regional variation in gross farm income per hectare generated by the state farm sector.

On the other hand, production on the state farms appears to be susceptible to temporal factors. As shown in table VI.3, impacts of the temporal factors on the growth of the state farms’ gross income per hectare over the 1980-1984 period are reflected by the signs and magnitudes of the

temporal dummy coefficients of -0.374, -0.311, -0.378, -0.286, and -0.252, respectively. If interpreted as rates of productivity growth in cereal production on the state farms, the estimated coefficients indicate significant impacts of policy and temporal factors on the performance of the state farms. The results imply that the state farms experienced negative rates of productivity growth over the entire period of analysis. The rate of decline in productivity growth appears to be most pronounced in 1980 and 1982. The rate of decline in 1984 was slightly below the rate of decline in 1981. The lowest rate of decline was in the 1984 production year relative to the rate of productivity growth in 1985. The reasons for the decline in productivity growth are not obvious. But, the above estimates of the rates of decline in productivity growth seem to imply that the state farms would have experienced a significant decline in gross income per hectare had the level of inputs remained constant at the per hectare input levels of 1985 production year. Finally, although it is outside the realm of this study, an in-depth investigation of the policy reasons would be useful to understand the observed decline in gross income per hectare due to temporal factors.

## *VI.2. Impacts of Input Resources*

Several input variables were identified and their possible effects on gross farm income per hectare for each farm type were suggested in Chapter IV. In this section, the impact of each variable is discussed in terms of production elasticities and marginal productivities. As discussed previously, both production elasticities and marginal revenue products are evaluated at the geometric means of the dependent and independent variables. See tables VI.4, VI.5 and VI.6. All the tables VI.1 through VI.6 contain t-ratios and p-values associated with each coefficient and the p-value indicates a probability that true value of the coefficient is zero. The t-ratios and p-values used for evaluating statistical significance of the elasticities and marginal productivities of the regressors under investigation are generated by SAS procedure using appropriate formulae derived from the translog production function in Chapter III. For purposes of the following discussion the elasticities and

marginal productivities, unless specified otherwise, are significantly different from zero at a probability level of  $\leq 5$  percent.

As discussed previously note that productivity impacts of the variables under investigation can not be compared statistically among the farm types because different models (but same functional form) were estimated and the same factors were not held constant across the farms when evaluating partial productivity impacts of the variables. Moreover, the resources employed within each farm type are not identical across the three farm types. The traditional labor employed by the state farms is, for example, exposed to modern technology, new farming methods and leadership provided by educated farm managers. The cooperative sector operates with a different outlook and expectations that are perhaps more critically influenced by the socialist ideology (due to more direct political pressure) than the private sector. These are implicit differences which need to be kept in mind when studying productivity estimates of the resources employed in each farm type.

### **VI.2.1. Impact of the Traditional Labor**

As shown in tables VI.4, 5 and 6, productivity parameters of labor include (a) partial income elasticities (PIE) of 0.15 in the private farms (PF), 0.04 in the producer cooperatives (PC), and 0.81 in the state farms (SF) and (b) marginal revenue products (MRP) of 0.34 Birr, 0.04 Birr and 17.82 Birr per hectare in the private farms, producer cooperatives and state farms, respectively. The above PIE and MRP parameters of the private and state farm sectors are significant at 5 percent and those of the cooperative sector are not.

The above labor productivity measures are summaries of labor's interaction with other variables as shown in tables VI.1, 2, and 3. The labor input on the private farms interacts positively with H-implements used for post planting field operations which is partially offset by labor's negative interaction with fertilizer and July rain. The Cooperative labor input interacts positively with June

**TABLE VI.4. Translog Production Elasticity and Related Statistics for Private Farms Cereal Production**

Variable	Unit	PARTIAL INCOME ELASTICITY			MARGINAL REVENUE PRODUCT			
		AR. Product* (Birr)	Parameter (%)	T-Ratio	P-Value*	Parameter (Birr)	T-Ratio	P-Value
Labor	Days/ha	2.26	0.15	2.084	0.0217	0.34	2.084	0.0217
Oxen	Days/ha	28.99	0.07	0.760	0.2257	2.029	0.760	0.2257
Fertilizer	Birr	35.74	0.26	1.632	0.0550	9.29	1.632	0.0551
LPT Tools	Birr/ha	30.75	-0.15	-1.786	0.0407	-4.613	-1.786	0.0407
TH Tools	Birr/ha	46.25	0.52	2.546	0.0074	24.05	0.0074	0.0074
Combined	Birr/ha	37.71	0.37	0.937	0.1772	13.95	1.820	0.0380
P. Livestock	LU/ha	268.20	-0.10	-1.511	0.0691	-26.82	-1.805	0.0391
W. Livestock	LU/ha	1215.0	0.09	1.853	0.0355	109.35	1.853	0.0355
Combined	LU/ha	570.84	-0.01	-0.743	0.2307	-5.71	2.502	0.0082
Enrlmnt. 1-6	Ratio	16038.0	0.15	1.433	0.0796	2405.70	0.462	0.3231
Enrlmnt. 7-12	Ratio	80190.0	0.01	0.101	0.4603	801.90	0.101	0.4603
Combined	Ratio	35862.05	0.16	1.832	0.037	5737.93	0.362	0.3594
June Rain	mm	29.58	-0.07	-3.116	0.0165	-2.07	-3.116	0.0017
July Rain	mm	14.94	0.004	0.435	0.3331	0.06	0.434	0.3333
August Rain	mm	10.11	0.12	2.362	0.0115	1.213	2.362	0.0115
Sp/mb Rain	mm	13.52	0.11	1.457	0.0763	1.487	1.457	0.0763
Combined	mm	15.68	0.16	2.199	0.0167	2.509	3.850	0.0002
Total Output Elasticity (RTS)			1.16	1.618	0.0566			

\* LU = livestock unit, AR = average revenue

P-value indicates probability that true value of the coefficient is zero

AR.Product, Partial Income Elasticity and Marginal Revenue Product are evaluated at the geometric means

Source: Generated from 1983/84 production year data

**TABLE VI.5. Translog Production Elasticities and Related Statistics for Producer Cooperatives Cereal Production**

Variable	Unit	PARTIAL INCOME ELASTICITY			MARGINAL REVENUE PRODUCT			
		AR. Product* (Birr)	Parameter (%)	T-Ratio	P-Value*	Parameter (Birr)	T-Ratio	P-Value
Labor	Days/ha	1.04	0.04	0.423	0.3370	0.04	0.423	0.3370
Oxen	Days/ha	7.22	0.02	0.189	0.4250	0.14	0.187	0.4260
Tractor	Nmbr/ha	1131.65	-0.03	-2.344	0.0110	-33.95	-2.344	0.0110
Fertilizer	Birr/ha	32.75	0.09	2.186	0.0160	2.95	2.185	0.0160
MY1 Inputs	Birr/ha	66.18	0.05	0.679	0.2490	3.31	0.679	0.2490
Combined	Birr/ha	46.55	0.14	2.560	0.0060	6.52	1.777	0.0390
June Rain	mm	18.66	-0.11	-1.724	0.0440	-2.05	-1.724	0.0440
July Rain	mm	14.51	0.08	0.424	0.3360	1.16	0.424	0.3360
August Rain	mm	13.73	-0.22	-1.825	0.0360	-3.02	-1.825	0.0360
September Rain	mm	16.41	0.23	1.721	0.0440	3.77	1.721	0.0440
Combined	mm	15.72	-0.02	-1.679	0.0480	-0.31	-1.679	0.0480
Total Output Elasticity(RTS)			0.15	-2.273	0.0130			

\* AR = Average Revenue, P-value indicates probability that the true value of the coefficient is zero  
AR.Product, Partial Income Elasticity and Marginal Revenue Product are evaluated at the geometric means

Source: Generated from 1985-1986 production period data

**TABLE VI.6. Translog Production Elasticity and Related Statistics for State Farms Cereal Production**

Variable	Unit	PARTIAL INCOME ELASTICITY			MARGINAL REVENUE PRODUCT			
		AR. Product* (Birr)	Parameter (%)	T-Ratio	P-Value*	Parameter (Birr)	T-Ratio	P-Value*
Labor	Days/ha	22.0	0.81	2.135	0.0216	17.82	2.135	0.0216
MYI Inputs	Birr/ha	5.32	-0.02	-3.162	0.0021	-0.11	-3.161	0.0021
Machinery	Birr/ha	3.24	0.11	3.173	0.0021	0.36	3.173	0.0021
June Rain	mm	2.93	0.17	4.384	0.0001	0.50	4.385	0.0001
July Rain	mm	1.61	-0.29	-2.647	0.0071	-0.47	-3.790	0.0005
August Rain	mm	1.50	0.85	2.467	0.0106	1.28	2.465	0.0106
September Rain	mm	1.85	-0.29	-2.573	0.0084	-0.54	-2.573	0.0084
Combined	mm	1.90	0.44	1.802	0.0421	0.84	3.680	0.0006
Total Output Elasticity (RTS)			1.34	0.457	0.3258			

\* AR = Average Revenue, P-value indicates probability that the true value of the coefficient is zero.  
AR.Product, Partial Income Elasticity and Marginal Value Product are evaluated at the geometric means

Source: Generated from 1980-1985 period production data.

rain which is partly offset by the labor's negative interaction with July and August rain. State farms' labor input interacts positively with machinery services and September rain but negatively with July rain. Partial income elasticity with respect to the labor input on the state farms is partly offset by the negative value of  $\hat{\delta}_l$  (non-interaction coefficient of labor). The t-ratios associated with the coefficients of the above variables indicate that all the coefficients, except  $\hat{\alpha}_{Hr}$ ,  $\hat{\theta}_{ly}$ ,  $\hat{\delta}_l$ , are significantly different from zero at the 10 percent level.

The insignificance of labor-fertilizer interaction under the private mode of production might be due to two factors. First, the insignificant relationship is a likely outcome of the incompatibility of the traditional farmers' human capital and procedures necessary for a proper application of the fertilizer input. That is, the traditional farmers may not have adequate training to read labels, to comprehend, and to interpret information required for a correct mix of the fertilizer input with the labor input. Second, as discussed in Chapters I and II, it could be due to structural limitations caused by lack of labor mobility outside of the agricultural sector. Labor immobility engenders an intensive use of labor per hectare to the extent that the range of variability in the proportions of the private labor per hectare that can be combined with the fertilizer input per hectare is unimportant.

The significantly positive interaction of the private labor input with traditional hand tools, H, is reasonable, given farmers' familiarity and many years of experience with a proper implementation of the tools. The negative interaction between labor days and rainfall in the month of July suggests that timely completion of field operations, such as land preparation and planting, can be adversely influenced by environmental conditions that are beyond farmers' control.

In summary, with the exception of the state farms, which, during the study period, tended to employ labor where its marginal and average returns per hectare were approximately equal, both the private farms and the producer cooperatives appear to have employed labor intensively to the extent that the marginal contribution of labor input to gross farm income per hectare fell below its average contribution. The estimated production elasticity of 0.15 with respect to labor-days

indicates a 0.15 percent increase in the gross farm income per hectare with a one percent increase in the use of the private sector labor-days. A one percent increase in labor-days used in each of the two farms in the socialized sector would, however, not change gross farm income of the producer cooperatives but it would result in a 0.81 percent increase in the gross income per hectare of the state farms. More will be said later in Section VI.6 about the implication of these estimates.

### VI.2.2. Impact of Draft Oxen

Partial income elasticity and marginal revenue product of oxen input per hectare under the private mode of production are 0.07 and 2.029 Birr per hectare. But, both parameters are not significantly different from zero. Productivity estimates of the oxen input in the producer cooperatives have a PIE of 0.02 and marginal return of 0.14 Birr per hectare. As in the case of the private sector, PIE and MRP parameters of the oxen input on the cooperative farms are insignificant.

The gross farm income elasticities of each mode of production with respect to oxen-days are computed from several relations that are summarized in tables VI.1, 2 and 3. The oxen input on the private farms interacts positively with fertilizer and July rain but negatively with school enrollment ratio in grades 7-12. Also, its PIE is partially offset by the negative value of  $\hat{\alpha}_x$ . On the other hand, oxen input on the producer cooperative farms interacts significantly with July rain but insignificantly with June and September rain. Despite traditional characteristics of the underlying production processes commonly shared by both the private sector and the cooperative sector, it is interesting to note that the oxen input does not appear to interact with the same set of variables (except July rain) in the producer cooperative sector as it does in the private farm sector. This is likely due to differences in the underlying production technology.

Oxen utilization is generally believed to impact farm income growth in at least three ways. First, it would enable farmers to increase land area planted to cereal crops. Second, total income would increase (even despite constant prices) as a result of a greater total output coming from an expansion in land area. Third, total income per hectare (yield) may improve due to the completion of field operations in a timely fashion.

### VI.2.3. Impacts of Modern Yield-Increasing Inputs

Marginal revenue products of fertilizer,  $F^{PF}$ ,  $F^{PC}$ , both in the private and cooperative sectors, and the other modern yield-increasing inputs in the producer cooperatives and the state farms,  $I^{PC}$ ,  $I^{SF}$  are 9.29, 2.95, 3.31, and -0.11 Birr per hectare, respectively. The MRP's, except  $MRP = 3.31$ , are significant at 5 percent. The private farm sector appears to be moderately responsive to MYI inputs (fertilizer) relative to other inputs in that sector. This is indicated by the private farms' PIE of 0.26 with respect to the fertilizer input. The producer cooperatives' PIE with respect to the fertilizer input is 0.09. The producer cooperatives' and state farms' PIEs with respect to the  $I^{PC}$ ,  $I^{SF}$  MYI input variables per hectare are 0.05 and -0.02, respectively. Note, however, that an increased application of the  $I^{PC}$  modern yield-increasing inputs per hectare does not appear to have a significant impact on the gross farm income per hectare of the cooperative sector.

As shown in tables VI.1, 2 and 3, there are some noticeable differences in the interaction pattern of the F and I inputs with other input variables in each of the three farm types. Examining t-ratios associated with the relevant coefficients in the the three tables indicates that: (a) all coefficients except  $\hat{\delta}_{ii}$  in the state farms (SF) production model, are significantly different from zero at a probability level of less than 5 percent; and (b) except for  $\hat{\alpha}_{xf}$ ,  $\hat{\alpha}_m$ ,  $\hat{\alpha}_{fo}$ ,  $\hat{\theta}_{fs}$ , all the coefficients of interaction regressors with the appropriate modern yield-increasing inputs per hectare on the private farms and producer cooperatives are not significantly different from zero.

In summary, the estimates of the partial income elasticities of the producer cooperatives sector with respect to  $F^{PC}$  and  $I^{PC}$  per hectare sum to a significant value of 0.14. This result suggests that with a one percent increase in the use of the modern yield-increasing inputs ( $F^{PC} + I^{PC}$ ) per hectare, the gross farm income per hectare of the producer cooperatives is likely to increase by 0.16 percent. Similarly, with one percent increase in the use of the modern yield-increasing inputs per hectare in the state farm sector, the gross farm income growth per hectare is likely to fall by 0.02 percent. But, the gross farm income per hectare is likely to increase by 0.26 percent with a one percent increase in the use of fertilizer, allocated to the private farm sector.<sup>109</sup> Both PIE parameters of 0.02 and 0.26 are significant at 5 percent.

#### VI.2.4. Impacts of Traditional Farm Implements

Recall that the two types of traditional farm implements included in this study are (1) land preparation and planting implements (O) which are aggregated in terms of Birr, and (2) post planting hand implements for harvest and winnowing operations (H) which are also aggregated in terms of Birr. Each of the two classes of traditional implements appear to impact the gross farm income per hectare of the private sector quite differently. Per hectare marginal revenue products are -4.613 Birr for the O-implements and 24.05 Birr for the H-implements. The PIEs with respect to the O-implements and H-implements are -0.15 and 0.52, respectively. Both MRP and PIE with respect to the O and H-implements are significantly different from zero.

The O-implements interact significantly and negatively with the H-implements and June rain (J) but positively and significantly with July rain (Y). Among the many interactions of the H-implements with other variables in the relation, it is interesting to note that the implements

---

<sup>109</sup> Note that these results give only a broad picture about the role of the MYI inputs in the production of gross farm income per hectare with each farm type. Thus, the results seem to be limited in guiding policies to allocate the MYI inputs among the three farm types. Disaggregate information is necessary for specific policy prescription.

interact negatively with the ratio of enrollment in rural schools in grades 1-6 (A) but positively with the school enrollment ratio in grades 7-12 (B). The negative interaction between the H-implements and the A-level education and the positive interaction with the B-level education suggest that farmers educated at the B-level are likely to make better use of the H-implements. Also note the positive interaction of the H-implements with labor (L), fertilizer (F) and June rain (J) (see table VI.2).<sup>110</sup> All the interaction terms with the H and O-implements are significant at 5 percent.

The negative PIE with respect to the O-implements was unexpected, especially, since many observers following the recent famines, feel that most Ethiopian traditional farmers' output is constrained by lack of adequate farm implements. Contrary to these subjective assessments, however, the estimated results reflect the nature of physical relationship between the gross farm income per hectare and the ratio of the O-implements-to-land. It is very likely that the negative response is indicative of a concentration of the O-implements on small parcels of land per farm household following the redistribution of cropland after the 1974 revolution. As discussed in Chapter II, many farmer associations have parcelled cultivable lands into pieces smaller than the members were allocated right after the land reform. Periodic land redistributions are occurring especially in farmer associations which "own" small land size relative to their membership.

Finally, it is instructive to note that the combined productivity impact of the traditional implements is positive. Gross farm income of the private sector appears to have increased significantly by 1.82 Birr per hectare for every Birr invested on an additional unit of the traditional implements. But, the gross farm income elasticities with respect to the H and O-implements sum to 0.37 and this value is not significant at 5 percent. The elasticity coefficient suggests that the gross farm income per hectare of the private farms is not likely to respond to a one percent increase in the ratio of the traditional implements-to-land planted to the cereal crops.

---

<sup>110</sup> The interaction of the H-implements with some variables during land preparation and planting season is not amenable to interpretation. Some components of the H-implements such as sickles are, however, often used for preparing animal feed during the planting months and for cutting materials from which farmers make rope to assemble parts of plow, wedges and yokes. So the observed relationships may indicate such inter-seasonal interactions.

### **VI.2.5. Impact of Education**

Recall that the education variable, discussed in Chapter IV, is defined in terms of school enrollment ratio of A -level education = ratio of pupils in grades 1-6 and B-level education = ratio of pupils in grades 7-12. Both A and B ratios are intended to measure contributions of human capital development in rural Ethiopia to cereal production. In the statistical estimation process, however, several alternative definitions were experimented with, including: (a) A + B, (b) A, aggregate of grades 7-8, 9-12, and (c) A + 7-8, 9-12. Except A and B, none of the alternative definitions generated significant results. Neither the A and B definition nor the alternatives were statistically significant at 5 percent in the cooperative and state farms' production models which, led to the deletion of the education variable. The reason for incorporating education information especially into the state farms production model is based on the view that the state farms benefit from the development of human capital which is "stored" in the traditional agricultural sector. The insignificant impact of the enrollment ratio, however, suggests that the state farms may rely more on labor with technical education than on labor with general education. Labor with technical education is, however, not included in this study.

MRPs of A and B ratios of the private farm sector are 2405.7 Birr and 801.90 Birr per hectare, respectively, and are not significant. The PIEs with respect to the A and B ratios of the private sector are 0.15 and 0.01, respectively. The PIE = 0.01 with respect to B-level enrollment is not significant at 5 percent. These results suggest that the school enrollment ratio in grades 1-6 is associated with gross farm income per hectare of the private sector in a significantly positive way whereas the enrollment ratio in grades 7-12 seems to have no effect.

Production variables with which the A and B school enrollment ratios are found to interact and which are instrumental in the computation of the above partial income elasticities with respect to A and B are summarized in tables VI.1 and 2. The A-level enrollment ratio interacts negatively

with the traditional hand tools and positively with the productive livestock. The B-level enrollment ratio interacts negatively with oxen and the workstock livestock but positively with the traditional hand implements and the productive livestock variables. It can be noted in the tables that all interaction components of the PIEs with respect to A and B are significantly different from zero at 5 percent. While the data do not directly reflect the following relationship, one plausible interpretation consistent with the negative interaction between oxen and B-level education is that the private mode of production in cereal producing regions is likely to experience a decline in gross farm income per hectare if the sector insists on combining high quality human capital with draft oxen as the main source of farm power in cereal production.

The above observations of gross income per hectare response with respect to the enrollment ratio must be interpreted with some care as there are limitations in the definition of the education variable. The study does not consider temporal contributions of education which usually begin to accrue after a gestation period. That is, the benefits from "human capital" are not exhausted within the same year of investment, as implicitly assumed in this research, but are distributed over time. Better data are necessary to properly assess human capital's impact on gross farm income from cereal production. On the other hand, the insights gained thus far suggest that human capital at the level of primary schooling (grades 1-6) is more likely to benefit the private sector than the human capital at the level of secondary schooling (grades 7-12).

#### **VI.2.6. Impact of Mechanical Technology**

Marginal revenue product of tractors in the producer cooperatives is -33.95 Birr per hectare and marginal revenue product of the machinery services in the state farms is 0.36 Birr per hectare. The producer cooperatives and state farms PIEs with respect to tractors and machinery services are -0.03 and 0.11, respectively. Both values of MRP and PIE are significant at less than 5 percent.

As shown in table VI.2, the interaction of tractors with August rain (U) has a significantly positive effect on the producer cooperatives' productivity with respect to tractors but that effect is more than offset by a negative interaction of tractors with June (J) and July (Y) rain. Also, note from table VI.3 that the machinery input (M) through its interaction with traditional labor input (L) has a significantly positive influence on the state farms' income response with respect to the machinery services, which is partially offset by a significantly negative interaction with itself (M).

The computed PIE and MRP parameters of tractor technology appear to have significantly negative implications for the growth of the producer cooperatives' gross farm income per hectare from cereal crop production. It is not possible to evaluate exact ramifications of the tractors' negative productivity without an accurate specification (in terms of flow of tractor services) of the variable and an in-depth understanding of the producer cooperatives' policy and structural environment. The significantly negative productivity of tractor use is, however, a likely indication of two problems: lack of data for a proper specification and operational problems. First, the negative productivity of tractors could be the result of aggregating non-homogeneous tractor assets which differ in their performance, size and age. Due to data limitations discussed in Chapter IV, the tractor variable is not adjusted for differences in size and quality. Second, as Pausenaug (1988) notes, machinery operational problems are prevalent in the cooperative sector. Tractors are introduced to the cooperative sector with assistance from the central leadership with the goal of developing a "strong" collective agriculture and to improve productivity of the traditional farming techniques. The cooperatives, however, often find it difficult to generate enough gross farm income per hectare to cover payments to such factors of production as fuel, spare parts and repair costs, and to meet increasing internal demand for food by their growing membership. Thus, the negative tractor productivity may indicate a failure of the cooperative sector to exploit useful attributes of the tractor input factors mainly due to lack of collaborative materials, management and advanced knowledge embodied in the cooperative members.

The marginal contribution of machinery services to the growth of the state farms' gross income per hectare is positive. Note that the tractor parameter is measuring the productive impact of the tractor capital asset which is not exhausted in a given production period. The machinery coefficient of the state farm sector, on the other hand, is measuring the productivity impact of the machinery services flow consumed within a given production period. Thus, the estimated coefficients of the machinery services are not directly comparable to the estimated coefficients of the tractor capital asset.

Finally, as the results show, for every additional Birr invested on machinery services per hectare, the state farms' gross income appears to have increased by 0.36 Birr per hectare. Such a low level of marginal return relative to average return is to be expected, given the current investment practice of approximately 204 Birr of machinery services per hectare, which on the average generates about 3 Birr of gross income per hectare. On the whole, the marginal productivity of the machinery services would probably be increased if the state farms either cut back on current and future investment on the machinery services or expand farm size while maintaining expenses on the machinery services at current levels.

### **VI.2.7. Impact of Livestock**

Livestock (dichotomized into P = productive livestock and W = workstock livestock) represent capital assets accumulated within the private farm sector. The marginal value products of the P and W livestock components are -26.82 and 109.35 Birr per hectare. The signs of the marginal value products are consistent with the postulates of Chapter IV. Also, the PIE's with respect to P and W livestock components are -0.10 and 0.09, respectively. The PIEs and MRPs are significant at less than 10 percent.

Note in table VI.1 that coefficients of the variables with which P and W variables interact are significantly different from zero at the probability level of less than 5 percent. P-livestock variable has a positive influence on the productivity of all other variables in the relation, except September rain. This is, however, more than offset by a combination of its negative interaction with September rain and school enrollment ratios, A and B. Also, the W-livestock interaction with September rain has a significantly positive influence on its output response, but the influence is partly offset by its negative interaction with the other variables in the relation.

Finally, with livestock assets (P and W) not directly related (for example, like land or labor) to the process of cereal grain production, the magnitudes of the marginal revenue products and the partial income elasticities with respect to P and W are difficult to interpret. It is, however, interesting to note that the gross farm income per hectare of the private sector appears to have declined as the ratio of the productive livestock population to cereal land increases and it appears to have increased as the ratio of the workstock livestock population to cereal land increases at the margin. Looking at the foregoing results from the viewpoint of cereal grains production, the evidence of this research implies that in the absence of major changes in traditional range management and the prevailing livestock-to-land ratio, competition of the productive livestock component with cereal crops for land and land based resources is likely to have a significantly negative impact on the growth of the gross farm income per hectare from cereal production. In reality, however, positive effects of livestock such as milk, meat, transportation and other benefits may outweigh what appears to be negative effect on cereal production.

### **VI.2.8. Impact of Monthly Rainfall**

The impacts of rainfall on gross farm income with the three modes of production are evaluated in terms of millimeters of rain-water input in four critical months of June, July, August, and September. Results of the analysis are summarized below for each month.

Marginal revenue products and partial income elasticities with respect to June rain are respectively, (a) -2.05 Birr per hectare and -0.11 in the private sector, (b) 4.67 Birr per hectare and 0.25 in the cooperative sector, and (c) 0.50 Birr per hectare and 0.17 in the state farm sector. Both PIEs and MRPs of June rain on the private, cooperative and state farms are significant at less than 5 percent. For reasons discussed in Chapter IV, a negative productivity impact of June rain was postulated in the private and cooperative farm sectors, but a positive impact in the state farm sector. Signs of the estimated partial income elasticities with respect to June rain are therefore consistent with *a priori* expectations.

As noted in table VI.1, the private farm sector's productivity with respect to June rain is influenced by its significantly negative interaction with the pre-harvest traditional tools (O). Similar influences are also observed in table VI.2 for June rain interaction with the number of tractors (T) in the producer cooperatives sector. Furthermore, the negative interaction of June rain with modern yield-increasing inputs (I) in the state farm sector significantly affects its impact on the productivity of the state farms (see table VI.3).

Productivity parameters of July rain on the private farms, producer cooperatives and state farms sector include values of MRP of 0.06, 1.16 and -0.47 Birr per hectare, respectively, and its PIEs are 0.004, 0.08 and -0.29, respectively. Only the values of MRP and PIE with respect July rain on the state farms are significant at 5 percent.

The above results indicate the manner in which rainfall in July impacts gross farm income per hectare. Two interesting points to note from the relations summarized in tables VI.1, 2 and 3 are that July rain appears to have a significantly (a) negative interaction with labor input on all farm types and (b) positive interaction with oxen input on both the private farms and the producer cooperatives.

Signs of the PIE with respect to July rain on the private farms and producer cooperative farms are consistent with *a priori* expectations. The state farms' negative PIE with respect to the July rain input is, however, unexpected. Given technological capabilities of the state farms to complete field operations in a timely fashion and to take advantage of the rain-water input in the month of July, it seems reasonable to expect a positive impact of July rain on the state farms' gross income per hectare from cereal crop production. The negative PIE of the state farms may, however, indicate excessive moisture content in the soils of cereal croplands retained from the rain water in the months of June and July.

As in the case of the previous two components of the rainfall variable, mixed results are obtained on the per hectare productivity impacts of August rain. The results show that August rain impacts both the private farms' and the state farms' gross income per hectare positively while it impacts that of the producer cooperatives negatively. These influences of August rain are measured by its MRP's and PIE's. The MRP's are 1.21, -3.02 and 1.28 Birr per hectare in the private farms, producer cooperatives and state farm sector, respectively. Also the PIE's with respect to August rain are 0.12, -0.22 and 0.85, in the private farms, producer cooperatives and state farm sector, respectively. All the PIE and MRP values are significant at 5 percent.

Note again from tables VI.1, 2 and 3 that the interaction between August rain and modern-yield increasing inputs (F, I) per hectare in the private farm sector and the state farm sector, respectively, is significantly negative; whereas its interaction with tractor (T) use per hectare on the cooperative farms is significantly positive at 5 percent.

The marginal revenue productivity rates of September rain in the private farms, producer cooperatives and state farm sector are 1.49, 3.77 and -0.54 Birr per hectare, respectively. Also, the partial income elasticities with respect to September rain input on each farm type are estimated at 0.11, 0.23 -0.29, respectively. The above PIE and MRP parameters are significant at less than 10 percent.

Finally, as indicated in tables VI.1, 2 and 3, August rain interacts (a) negatively with the H-implements and W-livestock which is partially offset by the positive values of  $\hat{\alpha}$ , and the coefficient of the W-livestock interaction on the private farm sector, (b) negatively with oxen and modern yield-increasing inputs (I) which is partially offset by positive  $\hat{\theta}$ , and the coefficient of fertilizer input interaction on the producer cooperative farms, and (c) positively with labor and modern yield-increasing inputs which is more than offset by the negative value of  $\hat{\delta}$ , of the state farms.

It is interesting to note that positive and negative impacts of the rain on the cooperative and state farms alternate over the four critical months under consideration. That is, the output response with respect to the rain input on the state farms is positive, negative, positive, and negative in the months of June, July, August, and September, respectively. The response of the cooperatives' gross income per hectare with respect to June, July, August, and September rain is negative, positive, negative, and positive, respectively. But, neither of the two patterns seems to hold for the private farm sector. The observed differences in rainfall productivity pattern are perhaps likely outcome of, as discussed in Chapter II, the fundamental disparities in farm management, soil characteristics and topographic differences between the croplands under the private and cooperative "ownership" and croplands under the ownership of the state farms.

In summary, the above gross farm income elasticities with respect to each of the four months (June, July, August, September) in each farm type sum to 0.16, -0.02, 0.44 for the private farms, producer cooperatives and state farms, respectively. These values are significant at the probability of less than 5 percent and they indicate the percentages by which the levels of gross farm income per hectare appear to have increased with a one percentage increase in total rainfall over a period of the four critical months. These elasticity parameters with respect to rainfall are perhaps indicative of important differences in the types of land, labor and capital resources under the command of each farm type and with which the farms can take advantage of the rainfall during the critical months. Also, the parameters are as much a function of environmental factors, such as

temperature, soil depth and soil type in which the cereal crops are planted, as they are a function of the level of technological disparity among the three farm types.

### *VI.3. Hypothesis Testing*

As discussed in chapters I and III, the major hypothesis of this study is concerned with returns to scale (RTS) to an equiproportionate increase in all inputs (except land) within each farm type. Increasing RTS were hypothesized for the private and cooperative sectors whereas decreasing RTS were hypothesized for the state farms sector. The RTS are constant, increasing, or decreasing if the partial income elasticities with respect to inputs in the empirical production model of each farm type sum to one or to a value more or less than one, respectively.

The RTS parameter of the private farm sector is 1.164 and this value is not significantly greater than one at a probability level of approximately 5 percent. The producer cooperative sector's RTS parameter is found to be 0.15 and it is significantly less than one at about a 1 percent probability level. Also, the RTS parameter of the state farms' production function is 1.340, but this value is not significantly greater than one at a probability level of 5 percent. If it is assumed that the estimated translog production functions include all relevant input factors, these results suggest that the RTS are likely to (a) decrease in the producer cooperative sector and (b) to remain constant in the private and state farm sectors for an equiproportionate increase in "all" input factors under investigation.

The decreasing RTS in the producer cooperative (PC) sector indicate a technical input-output relationship within which the gross farm income per hectare would increase at a decreasing rate for an equiproportionate increase in a set of inputs (except land) employed in cereal crop production. The constant RTS in the private and state farm sectors, on the other hand, suggest that resources

are applied where MRP and maximum average revenue product (ARP) of a set of inputs per hectare are approximately identical. The observed input-output relationship, therefore, suggests a technical relationship within which the private and state farms can increase or decrease current levels of input use per hectare with the same technology by a constant proportion and expect no more or less proportionate change in the gross farm income from cereal production.

The observed RTS parameters can indicate whether or not the three farm types are allocatively efficient. If the ratio of MRP and ARP of the set of inputs (except land) is equal to one, it indicates that factors of production are being used at socially optimum levels. If the ratio is greater (less) than one, it suggests that resources are being used extensively (intensively) under the existing techniques of production. As shown previously, the ration of MRP to ARP (or RTS index) is less than one for the cooperative sector but it is equal to one for both the private and state farm sectors. Thus, from society's viewpoint, the observed RTS parameters imply that the cooperative sector is allocatively inefficient and both the private and state farms are allocatively efficient. Nevertheless, as Yotopoulos notes, social efficiency in the use of agricultural resources can only be attained if marginal resource costs and marginal revenue products are equated in all sectors of the economy.

Perhaps a critical question to be raised is "How reasonable are the above results?" Reasonableness of the estimated returns to inputs is conditional on how completely specified and measurement error-free the empirical production models of the three farm types are. Specification of the econometric production model for each farm type, especially that of the producer cooperative sector, has not been free of specification and measurement errors in such variables as tractors and education because of data limitations. If the data were available, it would be appropriate to include, for example, traditional farm implements and livestock capital inputs in the empirical production model of the producer cooperatives. Also, as should be remembered from the discussion in Chapter IV, permanent labor employed in the state farm sector was not included in the empirical production model of the sector. The fact that influences of such variables were not evaluated explicitly may have biased the returns to scale. Thus, it can be argued that the returns to scale and other estimated

coefficients are biased and the results provide only preliminary approximations from which firm conclusions cannot be drawn about the technical input-output relationships in the three modes of production. Whether the returns to scale are overestimated, underestimated or unbiased, however, depends on a positive, negative or no correlation between omitted variables and those variables included in the empirical models.

On the other hand, it can be argued that the returns to scale reflect unbiased technical input-output characteristics that are internal to each mode of production within the range of inputs and outputs considered in the empirical models. Theoretically consistent econometric procedures applied to the estimation of the empirical models would help to maintain confidence in the RTS estimates and other results of this research. It should be remembered, for example, that the application of the covariance estimation method by including region-effect and time-effect dummy variables would be likely to generate "bias free" coefficients of the included variables. Furthermore, the hypothesis of no-specification error was tested and results of the test did not provide evidence against the hypothesis. So, it seems reasonable to claim that the equi-proportionate returns to the factors of production are unbiased and are increasing in the private farm sector, decreasing in the cooperative farm sector and constant in the state farm sector.

#### ***VI.4. Elasticity of Substitution***

AS discussed in Chapter I, one of the objectives of this study is to evaluate substitutability of inputs in each farm sector. Table VI.7 contains elasticity of substitution values for a number of factors of production. The following discussion on the substitutability between mechanical power and labor power briefly illustrates interpretation of the parameters.

**TABLE VI.7. Substitutability of Inputs In Translog Production Function  
for Cereal Production on Private, Cooperative and State Farms**

		<b>ELASTICITY OF SUBSTITUTION</b>		
		<b>Private Farms</b>	<b>Cooperative Farms</b>	<b>State Farms</b>
<b>Substitute</b>	<b>For</b>	<b>Value</b>	<b>Value</b>	<b>Value</b>
<b>Labor-Days</b>	Oxen-Days	1	1	-
	Fertilizer	1.31	1	-
	Tractors	-	1	-
	MYI Inputs	-	1	0.27
	LP Tools	0	-	-
	TH Tools	0.60	-	-
	Machinery	-	-	0.19
	P. Livestock	1	-	-
	W. Livestock	1	-	-
	Enrlmnt. 1-6	1	-	-
	Enrlmnt. 7-12	1	-	-
	June Rain	1	-0.16	1.0
	July Rain	0	-0.55	1.45
	August Rain	1	0.62	1.28
Sept. Rain	1	1	0.44	
<b>Oxen-Days</b>	Fertilizer	0.58	1	-
	Tractors	-	1	-
	MYI Inputs	-	1	-
	LP Tools	1	-	-
	TH Tools	1	-	-
	Machinery	-	-	-
	P. Livestock	1	-	-
	W. Livestock	1	-	-
	Enrlmnt. 1-6	1	-	-
	Enrlmnt. 7-12	-0.12	-	-
	June Rain	0	0.32	-
	July Rain	0.21	0.15	-
	August Rain	1	1	-
	Sept. Rain	1	-1.52	-
<b>Fertilizer</b>	Tractors	-	1	-
	MYI Inputs	-	1	-
	LP Tools	1	-	-
	TH Tools	0.86	-	-
	Machinery	-	-	-
	P. Livestock	1	-	-
	W. Livestock	1	-	-
	Enrlmnt. 1-6	1	-	-
	Enrlmnt. 7-12	1	-	-
	June Rain	1	0.02	-
	July Rain	1	1	-
	August Rain	1.07	2.55	-
	Sept. Rain	1	-80.00	-

TABLE VI.7. Continued

		ELASTICITY OF SUBSTITUTION		
		Private Farms	Cooperative Farms	State Farms
Substitute	For	Value	Value	Value
Tractors	MYI Inputs	-	1	-
	LP Tools	-	-	-
	TH Tools	-	-	-
	Machinery	-	-	-
	P. Livestock	-	-	-
	W. Livestock	-	-	-
	Enrlmnt. 1-6	-	-	-
	Enrlmnt. 7-12	-	-	-
	June Rain	-	0.98	-
	July Rain	-	0.95	-
	August Rain	-	1.03	-
	Sept. Rain	-	1	-
MYI Inputs	LP Tools	-	-	-
	LH Tools	-	-	-
	Machinery	-	-	0.28
	P. Livestock	-	-	-
	W. Livestock	-	-	-
	Enrlmnt. 1-6	-	-	-
	Enrlmnt. 7-12	-	-	-
	June Rain	-	1	0.30
	July Rain	-	-1.81	0.38
	August Rain	-	2.07	0.40
Sept. Rain	-	0.90	-5.34	
LP Tools	LH Tools	5.61	-	-
	Machinery	-	-	-
	P. Livestock	1	-	-
	W. Livestock	1	-	-
	Enrlmnt. 1-6	0	-	-
	Enrlmnt. 7-12	1	-	-
	June Rain	0.29	-	-
	July Rain	-0.35	-	-
	August Rain	1	-	-
Sept. Rain	1	-	-	
TH Tools	Machinery	-	-	-
	P. Livestock	1	-	-
	W. Livestock	1.19	-	-
	Enrlmnt. 1-6	-0.56	-	-
	Enrlmnt. 7-12	0.43	-	-
	June Rain	0.48	-	-
	July Rain	-86.67	-	-
	August Rain	1	-	-
Sept. Rain	1	-	-	

TABLE VI.7. Continued

		ELASTICITY OF SUBSTITUTION		
		Private Farms	Cooperative Farms	State Farms
Substitute	For	Value	Value	Value
Machinery	P. Livestock	-	-	-
	W. Livestock	-	-	-
	Enrlmnt. 1-6	-	-	-
	Enrlmnt. 7-12	-	-	-
	June Rain	-	-	0.29
	July Rain	-	-	0.13
	August Rain	-	-	0.36
	Sept. Rain	-	-	0.13
P. Livestock	W. Livestock	1	-	-
	Enrlmnt. 1-6	0.10	-	-
	Enrlmnt. 7-12	-0.32	-	-
	June Rain	12.96	-	-
	July Rain	0	-	-
	August Rain	1	-	-
	Sept. Rain	-0.02	-	-
W. Livestock	Enrol. 1-6	1	-	-
	Enrlmnt. 7-12	-0.44	-	-
	June Rain	1	-	-
	July Rain	0	-	-
	August Rain	-0.44	-	-
	Sept. Rain	-0.47	-	-
Enrlmnt. 1-6	Enrlmnt. 7-12	1	-	-
	June Rain	1	-	-
	July Rain	1	-	-
	August Rain	1	-	-
	Sept. Rain	1	-	-
Enrlmnt. 7-12	June Rain	1	-	-
	July Rain	0	-	-
	August Rain	1	-	-
	Sept. Rain	1	-	-
June Rain	July Rain	0	1	1
	August Rain	1	1	1
	Sept. Rain	1	1	1
July Rain	August Rain	0	1	4.0
	Sept. Rain	0	1	1
August Rain	Sept. Rain	1	1	1.0

" - " = not applicable

Source : Computed from tables VI.1 - VI.6.

The elasticity of substitution value of tractors for labor is unity in the producer cooperative sector. Also, the elasticity of substitution of machinery for labor equals 0.19 in the state farm sector. Thus, the elasticity of substitution ( $\Theta_{ij}$ ) of machinery for labor is unity in the cooperative farm sector but less than unity and inelastic in the state farm sector. On economic grounds, the unitary elasticity of substitution implies, for example, that a ten percent increase in the transfer of tractors into the cooperative farm sector will replace labor by a ten percent. A ten percent increase in machinery operating costs in the state farm sector will, on the other hand, replace flow of the temporary labor services by less than ten percent.

The inelastic relationship between machinery and labor in the state farm sector may suggest that the state farms start off cereal production with large quantities of machinery and other modern inputs relative to low level of labor input. Perhaps incorporating the permanent skilled labor component might have generated a different estimate of the elasticity of substitution of machinery for labor. The permanent labor component is not included in this study due to data limitations. But, the inelastic relationship is also likely indication that the state farms are operating with a close to fixed proportions type of technology.

As indicated previously, a close examination of each  $\Theta_{ij}$  value in table VI.7 would reflect not only the underlying technical relationship between pairs of input factors, but it would also reflect policy and structural influences on substitutability between input factors. In other words, some of the  $\Theta_{ij}$  values seem to suggest that the range of substitutability between input factors tends towards complementary relationship as the institutional transformation and management techniques of the cereal producing farms shift from the private mode of production to a more advanced and centrally managed state mode of production. For example, a one percent increase in the introduction of the modern yield-increasing inputs into the cereal producing farms is likely to replace traditional labor-days by 1.31, 1.00 and 0.27 percent on the private, cooperative and state farm sector, respectively. But, it is not clear if these and the other  $\Theta_{ij}$  values are significantly more than zero or different from unity.

Regardless of the policy and structural influences, factors of production should either be (a) perfect substitutes ( $\Theta_{ij} = \infty$ ), (b) imperfect substitutes ( $0 < \Theta_{ij} < \infty$ ), or (c) perfect complements ( $\Theta_{ij} = 0$ ). The negative values of  $\Theta_{ij}$  in table VI.7, therefore, contradict the above possibilities and are likely indication that the regularity property of the empirical TL production function is violated. Within the context of the neo-classical theory of production, the regularity property of the TL production technology would be maintained if the function, among other factors, meets a quasi-concavity assumption with respect to the input factors under consideration. As discussed in Chapter III, signs that  $\Theta_{ij}$  take on are often employed by previous researchers such as Wales to check whether or not the function satisfies the regular strict quasi-concavity assumption. The strictly concave TL function implies convex isoquants. The function maintains quasi-concavity property if  $\Theta_{ij}$  takes non-negative values.

As usual,  $\Theta_{ij}$  between any given pair of inputs is computed by holding output and other inputs at constant levels. The  $\Theta_{ij}$  values are evaluated at the geometric means, but not for a range, of the input factors involved in the substitution relation. So, each value of the  $\Theta_{ij}$  reported in table VI.7 is a measure of ease of the substitutability of the input pairs at a particular sample point on a locus of an isoquant.

As the empirical results of this research indicate, the regular strictly convex property of the TL function isoquants is maintained in 118 out of a total of 133 input substitutions. The 15 cases for which the  $\Theta_{ij}$  is negative appear to indicate that the TL function isoquants may not be strictly convex to the origin with respect to a combination of the inputs in the substitution relation. Out of the 15 non-convex cases, 9 of them are in the private farm sector, 5 in the producer cooperative sector and one in the state farm sector. Without exception, all the cases for which concavity of the TL function appears to be violated are connected with education and rain variables.

The negative elasticity of substitution occurred despite reasonably high  $\bar{R}^2$  estimates which indicate that the TL functional form fits the overall data sets well. But, both the sign and

magnitudes of the  $\Theta_{ij}$  need to be interpreted with reservation for, at least, four reasons. First, the input factors for which the estimated elasticity of substitution is negative may indicate problems in the data for the variables rather than inappropriateness of the TL functional form to describe production characteristics of the three farm types under consideration. Second, the estimated negative elasticity of substitution was computed under special restrictions (see Chapter V) of some or all  $\beta_{ii} = 0$  that were imposed in the process of constructing the parsimonious-in-regressors TL model for each mode of production. Although the restrictions were necessary for identifying a statistically estimable TL models, it is likely that the fundamental property of flexibility of the TL function is compromised for a few cases. On the other hand, researchers such as Boisvert note that omission of collinear log-quadratic regressors does not reduce flexibility of the translog production function. Third, the fact that the elasticity of substitution is unity for most input substitutions may not be an accurate characterization of the production technologies of the three modes of production, but it is the likely outcome of the structural restrictions mentioned earlier. Finally, and most importantly, there are no probability measures provided (due to limitations in SAS estimation procedure) with which to establish statistical significance/insignificance of the computed parameters of the  $\Theta_{ij}$ .

## ***VI.5. Policy Implications***

This section brings together important insights gained from analyzing technical aspects of the private farms, producer cooperatives and state farms. Two limitations need to be clarified, however, before discussing implications of the results. First, as discussed in Chapter IV, the scope of the study is restricted to the per hectare productivity analysis of the private and socialized modes of production without a comparison of the results across the three farm types. The comparison would have helped to determine, for example, one farm type which is relatively more technically efficient than others and would have generated useful information for allocating resources according to the

relative technical efficiencies of the three farm types. Nevertheless, appropriate data were not available for comparing technical characteristics of the farm types. Second, as discussed previously, some of the PIE and MRP parameters are inconsistent with *a priori* expectations. The inconsistencies (assuming that the *a priori* expectations are consistent with theory and observations) are likely due to limitations inherent in the research data themselves and subsequent econometric problems resulting from the analysis of the data. However, despite cautioning that some of the parameters need to be interpreted within these limitations, the overall results still point to important policy implications with which intra-farm resource allocation priorities can be influenced.

There appears to be an important relationship between yield per hectare and employment of farm labor per hectare within the three modes of production. The MRP of labor input in the state farm sector (computed at the geometric means) is 17.82 Birr per hectare and it is significantly different from zero at less than 5 percent. The MRP of the labor input might be measuring two components: (a) the true marginal revenue productivity of unskilled (temporary) labor per hectare and (b) a proportion of an upward bias due to a positive correlation between the unskilled labor and skilled (permanent) labor that is not included (due to data limitations) in the analysis. It is difficult to estimate the exact level of the bias in the MRP. The MRP per hectare is, however, about nine times the daily minimum wage rate of 1.92 Birr paid by the state farms and is about 81 percent of the average revenue product of labor.<sup>111</sup> Given government's policy intervention in the farm labor market with minimum daily wage fixed at 1.92 Birr, it may not be reasonable to compare the MRP of labor to the daily minimum wage. But, if it is assumed that 1.92 Birr is a measure of marginal resource cost (MRC) for employing additional unit of labor services in the state farms, the MRP of labor appears to indicate a disequilibrium between the minimum wage rate offered by the state

---

<sup>111</sup> The daily wage rate of 1.92 Birr that the state farms pay to temporary farm labor is a monthly minimum wage of 50 Birr divided by 26 days. Minimum wage legislation was introduced at the early stages of the 1974 revolution. The law enacted 50 Birr per month as a minimum wage and it has remained fixed ever since. Consequently, purchasing power of the minimum wage has not kept up pace with inflation that has been at an average annual rate of 12 percent (World Bank (1987)). The inflation rate would have been much higher had the government not controlled domestic prices, avoided wage increases and maintained an exchange rate at a fixed level of 2.05 Birr per one U.S. Dollar.

farms to hire additional unit of labor services and the wage rate with which the unskilled workers are unwilling (discussed later) to offer their services.

The gap between the MRP of labor and the MRC can be reduced (or eliminated) by employing more labor per hectare in the state farms sector. For example, as illustrated in table VI.8, increasing labor employment per hectare by 10 percent while holding other inputs constant, appears to reduce the MRP of labor only by 1.7 percent.<sup>112</sup> A 10 percent increase in labor employment per hectare will not be enough to bring its MRP in line with the MRC. Hence, a substantial number of unskilled workers per hectare would have to be employed.

Two likely changes are inevitable if the state farms increase labor per hectare. First, more labor will be substituted for some cereal production activities that are unlikely to be capital intensive thereby causing the MRP of labor to decline. Second, gross farm income per hectare may increase due to an increase in the complementary factors (such as worker training and management) with which increased labor services are combined. The importance of the latter effect for increased labor employment per hectare will be influenced by the cereal output prices, assuming that the prices are flexible. That is, depending on the price elasticity of demand for cereal grains as a group whose production is affected by the unskilled labor services, high output prices are likely to induce high agricultural employment and low output prices may discourage it. The price elasticity of demand for cereal foodgrains in Ethiopia is generally low; but, it varies with an individual cereal crop type. The low level of price elasticity and its implications for induced labor demand for the agricultural employment of factors of production at low levels, especially in the traditional sector, are often

---

<sup>112</sup> The use of a give input at 10 percent above or below its average level influences its mrginal revenue productivity through the partial income elasticity with respect to that input and yields:

$$\text{MRP}_{\pm 10\%} = \overline{\text{MRP}}_i \left[ \frac{1 \pm 0.10\eta_i}{1 \pm 0.10} \right]$$

where  $\overline{\text{MRP}}_i = \eta_i(\overline{Q}/\overline{\omega}_i)$ ,  $\omega_i$  is any given input factor, Q is gross farm income per hectare of each sector, and the bar notation indicates that both Q and  $\omega_i$  are evaluated at their geometric means. For additional discussion, see Yotopoulos page 199.

**TABLE VI.8 Marginal Revenue Product at 10% Above and Below the Mean**

Inputs	Unit	MARGINAL REVENUE PRODUCT					
		10% ABOVE THE MEAN			10% BELOW THE MEAN		
		PF	PC	SF	PF	PC	SF
Labor	Days/ha	0.31	0.04	17.51	0.37	0.04	18.20
Oxen	Days/ha	1.86	0.13	-	2.24	0.15	-
TLP Tools	Birr/ha	-4.13	-	-	-5.20	-	-
TH Tools	Birr/ha	23.00	-	-	25.33	-	-
Fertilizer	Birr/ha	8.67	2.71	-	10.05	3.25	-
MY1 Inputs	Birr/ha	-	3.02	-0.10	-	3.66	-0.12
Tractors	Nmbr/ha	-	-30.77	-	-	-37.84	-
Machinery	Birr/ha	-	-	0.33	-	-	0.40
P. Livestock	LU/ha*	-24.14	-	-	-30.10	-	-
W. Livestock	LU/ha*	100.30	-	-	120.41	-	-
Enrlmnt. 1-6	Ratio	2219.81	-	-	2633.91	-	-
Enrlmnt. 7-12	Ratio	729.73	-	-	890.11	-	-
June Rain	mm	-1.87	-1.84	0.46	-2.32	-2.30	0.55
July Rain	mm	0.05	1.06	-0.41	0.07	1.28	-0.54
August Rain	mm	1.12	-2.69	1.26	1.33	-3.43	1.30
September Rain	mm	1.37	3.51	-0.48	1.60	4.09	0.62

\* LU = livestock Unit, PF = private farms, PC = producer cooperatives, SF = state farms, . . . = variable is insignificant/dropped

Source : Computed from tables VI.4, VI.5, VI.6

attributed to the lack of grain storage facilities which play a major role in transferring foodgrains over time, lack of integrated regional markets, logistic and communication problems.<sup>113</sup>

Economic logic suggests that the state farms should be faced with a perfectly elastic supply of labor until a point of equilibrium is reached between the daily minimum wage fixed at 1.92 Birr and its marginal revenue product at the origin of the labor input. It is, however, interesting to note that the state farms are unable to attract as many seasonal rural workers as needed with the minimum daily wage. In most cases, seasonal farm workers are unwilling to offer their services at the minimum wage rate. An alternative strategy to raising the minimum wage rate has been to allocate a seasonal labor-quantity-quota to farmers' associations in order to ensure an adequate supply of seasonal labor. This strategy undermines the economic rationale of individual farmer's choice of employment. Although the MRP of labor does not prove the existence of the disequilibrium in the farm labor market, the farm labor's reservation to offer its services at the prevailing wage rate suggest that (a) labor is paid less than its marginal revenue product and (b) the 1.92 Birr wage rate per day is not high enough to compensate for the disutility of work and simultaneously compensate for the psychic cost of being separated from family members, relatives, familiar environment, and unappealing physical conditions (due to factors such as disease) where some of the the state farms are established.

A statistically insignificant relationship is observed between gross farm income per hectare of the producer cooperatives and a marginal increase in labor employment per hectare. Specifically, the producer cooperatives' gross farm income per hectare appears to have remained unaffected by the use of additional labor-days per hectare. The insignificance of the MRP of cooperative labor is perhaps the consequence of the rapid institutional development of the producer cooperatives which appears to have created intensive labor employment. As a result, the cooperative sector appears to

---

<sup>113</sup> See Shire (1986) and World Bank (1987) for an additional discussion on some of these constraining factors. Shire's study provides very interesting findings on the behavior of the Ethiopian traditional farmers with respect to price responsiveness and demand for factors of production.

have been populated at a faster rate than the internal capital infrastructure has been formulated. The process of capital formation and accumulation, among other factors, takes time, experience, investment in land-saving capital, and improvement in the quality of the cooperative labor.

As was discussed in Chapter II, one of the notable features of the 1975 land reform was the abolition of the rural market for traditional labor. The principal reason for prohibiting rural labor wage employment was to avoid exploitation of “man by man” and to make every farmer his own employer so that any surplus value will accrue to his own account.<sup>114</sup> In the case of the cooperative sector, however, this form of exploitation appears to have been replaced by an intensive use of labor characterized by near zero marginal productivity in cereal production. If all other inputs are kept constant at current levels (computed at the geometric means) and if labor were the only variable factor of production, it is unlikely that additional subsistence income from cereal crops would be generated as labor use per hectare increases at the margin. The marginal revenue product of labor appears to be less than the (implicit) marginal cost of using additional labor per hectare and the share of gross farm income that goes to each working member appears to be declining.

Also, oxen and modern yield-increasing inputs (except fertilizer) appear to have been employed where their marginal revenue productivities per hectare are insignificant. An attempt is made in table VI.8 to illustrate the potential impact of reducing labor employment per hectare (and other inputs) by 10 percent in the producer cooperatives. However, such small reduction does not appear to improve marginal revenue productivities. Quite a large reduction is necessary in conjunction with other changes. Or put differently, a substantial increase in capital investment would be necessary to achieve full rural employment of labor and draft oxen.

Recall that the producer cooperatives appear to be faced with decreasing returns to the factors of production. The cost of the decreasing returns to the factors (or increasing cost per quintal of

---

<sup>114</sup> Implications of the law for social and private costs and/or benefits remain as issues for future research. But according to the traditional Marxian labor theory of value, exploitation is regarded as the main source of surplus value that accrues to the owners of capital.

cereal output) is subsidized with interest-free credits from service cooperatives and with a relatively easy access to loans from the Agricultural and Industrial Development Bank of Ethiopia. The subsidy appears to promote production at a stage where gross farm income per unit of the inputs is declining. In the long run, however, the producer cooperatives may stand a chance of becoming a viable agricultural subsector not by subsidizing the decreasing returns to factors of production nor by reducing labor employment alone, but, as the findings of this research seem to suggest, by introducing major changes in the system of production. A viable strategy to improve the overall returns to the factors of production, marginal revenue productivity of some controllable inputs and to mitigate the chance of a potential economic crisis in the producer cooperatives seems to be a reduction in the allocation and intensive use of seemingly surplus inputs per hectare and simultaneously to modify membership size of the producer cooperatives.

Marginal revenue product of private sector labor is 0.34 Birr per hectare. This value is 15 percent of the average revenue product of labor of 2.26 Birr per labor-day and, as shown in table VI.8, it is significantly different from zero at 5 percent. The result is inconsistent with the observed labor shortages that would normally prevail during critical seasons of field operation. In a 1975 survey of rural household labor conducted by the Central Statistical Office, for example, about 17 percent of the interviewed households indicated lack of sufficient labor power as one of the reasons for not completing field operations in a timely fashion and for not expanding cultivated land area. Even as recently as 1984, research conducted by Demeke noted that on an average about 74 percent of *teff* farmers interviewed in three different regions of Shoa province reported labor shortages.<sup>115</sup>

---

<sup>115</sup> See Woldemariam p. 73 for the first example and Merid (1988) p.53 for the second example. At least, five reasons can be postulated to explain why the private farm sector is faced with labor shortages since the 1974 revolution: land reform, cooperativization, famine, conscription, and labor demand by state farms. First, in addition to prohibiting rural labor employment for wages, the 1975 land reform provided provisions for distributing rural land among farmers who could cultivate it with their own labor. Distribution of the rural land has expanded rural self employment of numerous private farmers who owned nonè-to-small pieces of land prior to the reform. In this way, the national land reform appears to have reduced possibilities of the so called "surplus" labor, especially, during critical periods of seasonal field operations. Second, the traditional private farm sector has experienced another structural change when the cooperative system of farming was introduced. The establishment of the producer cooperatives has shifted labor away from the private farming. Third, labor is continuously withdrawn from both the private and the cooperative sectors to defend national borders and to fight civil wars. The withdrawal tends to be permanent as most of the farmers do not return to their homestead either due to death in battle field or extended military service. Fourth, although more concentrated in the northern administrative regions

In this study, the private farm sector is found to exhibit constant returns to factors of production. Most of the traditional and modern technical inputs per hectare appear to have contributed positively and significantly to the gross farm income per hectare. The constant returns to inputs imply constant cost of production per unit of output. But the sector is faced with low marginal revenue productivity of some inputs such as labor and work oxen relative to other inputs such as fertilizer and traditional hand tools. The low marginal productivity of labor and work oxen implies high marginal cost of production per unit of output. The ability of the private farm sector to produce more gross farm income per hectare, therefore, appears to have been limited by quantity and quality of the set of productive resources under its command.

Improving MRP of the traditional inputs on the private farms seems to be conditional on changes in the qualitative and quantitative characteristics of the factors of production. Changing the qualitative attributes of the factors of production is easier said than done, especially, in the Ethiopian traditional agriculture in which only 10 percent of its farmers are said to use chemical fertilizer, and only 2 percent of the farmers use improved seeds. Why not expand introduction of these and other types of modern yield-increasing inputs (MYI) into the private farm sector? There are economic and infrastructural impediments such as high price of fertilizer which many small farmers can not afford partly because of a continued rise in fertilizer price and partly because the farmers do not receive high enough prices for their cereal crops (due to fixed prices) to cover the cost of the purchased inputs. Also, distribution of the inputs is hampered by logistic, organizational and managerial limitations.<sup>116</sup>

---

than others, a series of famines that have occurred in the recent past have claimed lives of many rural people. Finally, state farms employ a number of temporary (some for wages who voluntarily seek employment and others who are forced) workers in cereal fields, cotton plantation, vegetable farms and so on. It seems that these factors, among others, have contributed to the decline of labor supply in the private farm sector to the extent that the remaining labor contributes non-zero marginal revenue product to the gross farm income per hectare of the sector.

<sup>116</sup> The World Bank (1987), in its review of the prospects for Ethiopian economic development, also regards these as major limiting factors for fertilizer distribution and consumption in the private farm sector.

The findings of this study indicate that the marginal revenue product of the modern yield-increasing inputs per hectare is significantly positive on both the private and cooperative farms but significantly negative on the state farms. It might be difficult to justify the negative marginal revenue productivity of the MYI inputs on the state farms, which may indicate econometric problems in the statistical model. On the other hand, given the fact that the state farms control about 4 percent of the cultivable land and claim 12-15 percent of the government's budgeted capital allocation to the agricultural sector, it may not be surprising that the state farms appear to have applied the modern yield-increasing inputs more intensively than the other two farm types in the traditional sector. Also, there are additional reasons which might lead towards the observed negative technical relationship: economic issues of cereal production are secondary to agronomic aspects of it. This is evident mostly in the fact that the state farms incur high costs of production relative to the gross revenue they usually generate at preferred output prices. Policymakers seem to be aware of these high costs and they intervene to minimize the losses by (a) allowing the state farms to delay payment of loans and interest on the loans to local banks, (b) granting them a preferential access to bank loans at low and/or fixed interest rates and (c) giving them exclusive right to market cereal grains at prices that are higher than centrally fixed producer prices. Thus, assuming that the estimated results are reasonable, it can be said that they reflect policies of the Ethiopian government which appear to have distributed inequitable proportions of the MYI inputs to the state farms and the producer cooperatives at relatively lower prices than prices charged to the private farms.

Finally, the relatively low marginal revenue productivities of the MYI inputs on the cooperative and state farms seem to suggest that the MYI inputs are used more intensively on the two farms in the socialized sector than on the private farms. As discussed in Chapters I and II, the MYI inputs are imported by the government and are distributed among the three farm types. Thus, ramifications of the resource allocation policies, as evidenced by the results of this study, lead to a general observation that the policies are likely to induce a social cost at least comparable to the differences in the marginal resource cost of the MYIs per quintal of output. This cost can be

recovered totally or partially by gains in other parts of the national economy. Given the results of this study, however, one likely alternative for mitigating the losses is to revise the input allocation policies of the government in favor of the private farm sector. In other words, the findings of this research suggest that seemingly more potential exists to motivate growth in the gross farm income from a hectare of land planted to cereal crops with the private mode of production if the sector is allocated more quantities of the MYI inputs (especially, fertilizer) per hectare than either of the farms in the socialized sector.

## *CHAPTER SEVEN*

### *SUMMARY AND CONCLUSIONS*

Main points of the dissertation are summarized in the following order. Section VII.1 summarizes the dissertation, Section VII.2 offers some concluding remarks and policy implications and Section VII.3 notes limitations of the study and offers some suggestions for further research.

#### *VII.1 Summary*

The agricultural growth rate in Ethiopia in the post-1974 revolution period has declined by about 50 percent relative to the agricultural growth rate during the 1965-73 period. The bulk of the decline in the agricultural growth rate has been attributed to environmental and policy factors. Environmentally, lack of rain over an extended period of time limited farmers' ability to grow cereal crops. Policywise, the government introduced fundamental changes in (a) agricultural price policy; (b) distribution of resources; (c) rural surplus extraction; and (d) rural institutions. Furthermore, these changes appear to have contributed to the decline in the production of cereal grains in two ways. First, as discussed in Chapter II, aggregate cereal output declined in the process of transferring croplands from the private sector to the cooperative and state sectors. Second, a good proportion of labor and management resources was shifted away from cereal production activities to organizing many private and cooperative farmers to implement (a) socialist modes of production; (b) land redistribution; (c) rural institutional development; and (d) settlement of disputes over social, economic and political matters.

Despite the decline in the growth rate, however, agriculture continued to contribute 50 to 60 percent to the gross domestic product of Ethiopia. The substantial share of agriculture, as a percent

of the gross domestic product, shows that Ethiopia's economic growth will be determined to a large degree by the development of the agricultural sector. Agriculture plays an important role in the national economy; first, by providing food and fiber to the population of 42 million that is growing at an annual rate of 2.8 percent; second, by generating both human and material capital needed to support industrial development; third, by being a large market base for goods and services produced in non-agricultural sector; and finally, by employing about 90 percent of the nation's 42 million people. Thus, increasing farm output and factor productivity to enhance agriculture's contribution to overall economic development presents a challenge to Ethiopia's agricultural policymakers. The agricultural policy, however, needs to be consistent with the technical characteristics of the modes of production.

Both conceptual and empirical focuses of this study were, therefore, concerned with the goal of determining production characteristics of the three cereal producing farm types so that such characteristics as technical efficiency, impacts of regional and temporal factors, marginal productivity, output elasticities, returns to scale, and elasticities of substitution could be evaluated. It was hypothesized that returns to scale are increasing in the private and cooperative sector but decreasing in the state farm sector.

The economic setting of Ethiopian agriculture was examined in Chapter II. Agricultural characteristics of the country, traditional and modern modes of production, traditional land management practices, and pervasiveness of resource extraction were briefly reviewed in this chapter. Moreover, the discussion focused on the most dominant types of land tenure and agrarian conditions under the feudal system prior to the 1975 land reform. The land tenure types summarized include kinship, village, private, church, and government tenure. Each tenure type was noted to have had important political and socio-economic implications for the well-being of the agrarian communities in rural Ethiopia. In particular, land availability to many rural farm households and their ability to produce and consume agricultural income were conditioned, among other factors, on the tenure system in a given region.

The traditional land tenure system has been replaced by usufructuary-rights system since the 1975 land reform in which the state owns the land and everybody else has the right to use the land without being able to transfer it either through mortgage, sale, lease, or inheritance. The reform was augmented by such major changes as stratification of the modes of production into the private, cooperative and state farms and by establishment of various rural institutions including private farmer associations and service cooperatives. The agrarian reform has, however, failed to fully activate the small-holder private farm sector to produce a marketable surplus of food grains. At least three factors appear to be responsible for the failure: (a) a bias toward the socialized farm sector in the distribution of modern technical inputs; (b) centrally fixed prices that are low enough to depress farm income and to limit purchasing power of the private producers; and (c) agricultural surplus extraction policies enforced through compulsory deliveries of grain quotas, unfavorable terms of trade, and regulation of income generating activities such as abolition of rural markets for land and labor.

A number of theoretical and empirical techniques are available in the field of agricultural production economics with which to undertake the objectives of this study. The strengths and weaknesses for empirical application of the Cobb-Douglas (C-D) and translog (TL) production functions and a covariance model were conceptually discussed in Chapter III. The production function approach used in the study, however, was based on the assumption that technical efficiency is independent of price efficiency. This assumption is necessary because, unlike the price efficiency, technical efficiency does not require the use of competitive market prices that vary across regions and over time. Official prices in Ethiopia lack such variability because they are fixed across regions and over time. Empirically generated coefficients in this research, therefore, indicate technical characteristics of crop production activities with the three farm types.

An economically feasible set (in terms of time and money) of input-output variables and characteristics of agro-ecological regions in which cereal crops are produced were identified in Chapter IV. Sample data were collected from various Ethiopian government institutions on

variables including five cereal crops, namely, barley, corn, sorghum, *teff*, and wheat and several input factors, namely, labor, land, oxen, traditional farm implements, tractors, machinery services, modern yield-increasing inputs, livestock, education and rainfall over a total of 77 *awrajjas* for the 1980-1986 production period. However, data were not available for all input variables, years and farm types. For example, only 1983/84 production data were collected for all variables except machinery services and tractor inputs in the private farm sector; 1985-1986 production data were collected for all variables except livestock, traditional farm implements and machinery services in the cooperative farms; and, finally, 1980-1985 production data were collected for variables including only labor, machinery services, modern yield-increasing inputs and rain-water input in the state farms.

Various econometric problems encountered in the statistical models estimated with the above sample variables were summarized in Chapter V. The chapter begins by specifying C-D and TL econometric models in general terms in which the TL model involves a total of 107, 81 and 43, regressors of cereal output with the private, cooperative and state farms, respectively. Diagnostics and remedies for the problems of degeneracy, heteroskedasticity and serial correlation were discussed in Chapter V. Furthermore, it was established that the C-D functional form was not appropriate to study production properties of either private or socialized farms in Ethiopia. This finding is based on carefully established statistical evidence. First, it was necessary to construct a parsimonious-in-regressors TL econometric model because of insufficient degrees of freedom and lack of linear independence among the regressors in the general model. This called for omitting some regressors which did not have a significant role in explaining variations in gross farm income and constructing a "good" statistical model with a subset of the regressors. Mallow's  $C_p$  criterion was used in a stepwise regression to select regressors that were important in explaining the variations in gross farm income per hectare with each mode of production. This was followed by elimination of a single collinearly-insignificant-regressor, one-at-a-time, over a series of regression steps. At each step, a t-statistic less than 0.10 and the nature of collinearity indicated by variance proportions

greater than 0.50 corresponding to a large condition index greater than 30 were used as a set of criteria for deleting a regressor.

Second, two regression models, one with the C-D function and the other with the TL function, were constructed for each farm type with the subset of the selected regressors. Resulting residual sums of squares were used to construct an F-type misspecification test for an appropriate functional form between the C-D and TL functions. Given homogeneity conditions, the Cobb-Douglas function represented a restricted case of the translog functional form. The F-values computed from the statistical models with the set of the selected regressors were found to be significantly more than the corresponding critical F-values at a probability level of 5 percent, leading to the conclusion that the underlying technical characteristics of the three modes of production can best be explained by the non-homogeneous translog functional form. Finally, a regression specification error test was applied to the TL model after the functional form selection to check if important regressors were overlooked in the process of regressor selection. Results of the test indicated that the hypothesis of no specification error due to the omission of the insignificant regressors could not be rejected at the 5 percent level of significance.

Results of the empirical translog production function were interpreted in Chapter VI. By and large, overall goodness-of-fit of the three models, judged by the magnitudes of the adjusted coefficient of multiple determination,  $\bar{R}^2$ , and F-statistic, was reasonable. The proportion of variation in gross farm income per hectare ( $\bar{R}^2$ ), explained by the set of regional and temporal dummies and other independent variables were 67, 31 and 82 percent for the private, cooperative and state farm sectors, respectively. The impact of regional latent factors appears noticeable on the private and cooperative farms but not on the state farms. The private farms in the eastern and southeastern highlands and the cooperative farms in the southeastern highlands, for example, collectively appear technically as efficient as the farms within each farm type in the central highlands. The group of private farms in southwestern highlands appear more technically efficient whereas the group of the cooperative farms in the eastern, SW and SE highlands appear less

technically efficient than the farms within each farm type in the central highlands. The state farms, on the other hand, did not appear as responsive to regional latent factors as they were to the temporal latent factors. Compared to average region-specific conditions of the central highlands, the group of state farms in the southwestern, eastern and southeastern highlands invariably appeared to have produced approximately the same level of cereal output per hectare. This is reasonable observation given the fact that the state farms are equipped with institutional and technological abilities to centrally process technical information and to minimize managerial variations across cereal producing regions. But, the temporal factors appear to have had significant influence on the production of cereal crops. For example, the state farms appear to have generated less gross income per hectare from cereal production during the 1980 through 1984 production periods relative to the 1985 base year. The cooperative farms also appeared to have produced less gross income per hectare in 1986 than in the 1985 production year.

Productivity impacts of the measurable input factors per hectare also appear to be different across the three farm types. Results were evaluated in terms of marginal revenue products (MRP) and partial income elasticities (PIE) with respect to each input factor. The values of both MRP and PIE with respect to labor input per hectare were quite high in the state farm sector in which traditional labor employment is the least. During the study period, the state farms appeared to have employed labor where its marginal and average returns per hectare were approximately equal. The private and cooperative farms, on the other hand, employed labor in a range wherein marginal revenue product of labor input per hectare fell below its average revenue product. As the results suggest, labor input was responsible for a PIE of 0.15 and 0.81 percent significant increases in gross farm income per hectare of the private and state farms, respectively. The cooperative labor input per hectare, however, played an insignificant role in cereal production.

The overall impact of the modern technical inputs on gross farm income per hectare seems somewhat modest, especially in the socialized farms. The modern yield-increasing inputs, for example, appear to have significantly contributed at the PIE of 0.26, 0.14 and -0.02 percent to gross

farm income per hectare of the private, cooperative and state farms, respectively. Although the negative contribution of the inputs must be evaluated with caution (for reasons discussed in Chapter VI), the results suggest that the modern yield-increasing inputs were applied per hectare quite intensively in the state farms.

Machinery services played a positively significant role in inducing growth of the state farms' gross income per hectare at the PIE rate of 0.11. Gross farm income per hectare of the producer cooperatives responded in a negatively significant way to tractor use. The PIE with respect to the tractor capital was -0.03 percent and the sign of the parameter is not unreasonable. The negative productivity of tractor use is a likely indication of data problems and/or machinery operational problems. First, the negative productivity of tractors could be the result of aggregating non-homogeneous tractor assets which differ in their performance, size and age. Due to data limitations, the tractor variable was not adjusted for differences in size and quality. Second, machinery operational problems are prevalent in the cooperative sector. Tractors were introduced to the cooperative sector with assistance from the central leadership with the goal of developing a "strong" collective agriculture and to improve productivity of the traditional farming techniques. The cooperatives, however, often find it difficult to generate enough gross farm income per hectare to cover payments to such factors of production as fuel, spare parts and repair costs, and to meet increasing internal demand for food by their growing membership. Thus, the negative tractor productivity may indicate a failure of the cooperative sector to exploit useful attributes of tractors mainly due to lack of collaborative materials, management and advanced knowledge embodied in the cooperative members.

Despite the observed sluggishness in the productivity of the modern technical inputs per hectare on the state farms, the state farms seem to hold a technological edge to take advantage of such environmental factors as rain-water input. With a one percent increase in rainfall in the critical months of June, July, August, and September, gross farm income per hectare of the state farms increased at the PIE rate of 0.44. On the other hand, the gross farm income per hectare of the

private and cooperative farms responded at the PIE rate of 0.16 and -0.02, respectively, with respect to a one percent increase in rain-water input in the four critical months. The observed rainfall productivity parameters are perhaps an important reflections of the type of labor, capital and management resources under the command of each farm type and with which the farms can take advantage of the rainfall during the critical months of cereal production. Also, the rainfall productivity parameters of each farm type are as much a function of factors such as timeliness of field operations, temperature, soil depth and soil type in which cereal crops are planted as they are a function of the level of institutional development and technological concentration.

Land productivity impacts of draft oxen, rural education in grades 1-12, livestock, and traditional farm implements were determined for the private and cooperative farms. Apart from the draft oxen, each of the above input factors is broken down into two separate variables: the livestock asset variable is dichotomized into productive and workstock livestock; traditional farm implements into harvest and pre-harvest tools; and rural education into primary (grades 1-6) and secondary (grades 7-12) education. As discussed in Chapter IV, the education variable was expected to approximate contributions of human capital. Except in the private farm sector, productivity impacts of the education input factor on gross income per hectare of the cooperative and state farm sectors were found to be insignificant. The livestock asset variable was postulated to measure approximate impacts of the capital on cereal production of the private farm sector. With the exception of the significantly negative impacts of the pre-harvest traditional tools and productive livestock asset, the private farms have benefited from significantly positive contributions of the primary education of rural children and the traditional farm implements employed for harvest operations. Specifically, the pre-harvest traditional tools, harvest tools, productive livestock, workstock livestock, and primary education were responsible for the private sector's PIE rates of -0.15, 0.52, and -0.10, 0.09, and 0.15, respectively. Although the PIEs with respect to the traditional tools, livestock assets and education capital must be interpreted with caution because contributions of the input factors do not diminish completely within a given production year as implicitly assumed in this research, the computed PIEs may roughly indicate a proportion of a multi-period

impacts of the capital input factors on gross farm income per hectare of the private sector. The draft oxen input factor is likely to have played an insignificant role in the determination of variations in the private and cooperative sectors' gross farm income per hectare. That is, as the results indicate, a one percent increase in the use of draft oxen, would have no impact on the variability of gross income per hectare of the private and cooperative farms.

Finally, returns to scale parameters of the private and state farm sectors are 1.16 and 1.34 percent, respectively. These two parameters of returns to scale are not significantly more than one, reflecting that returns to scale are constant in the private and state farm sectors. The returns to scale parameter of the cooperative farm sector is 0.15. This value is significantly less than one, suggesting that gross farm income per hectare increases at a decreasing rate in the cooperative mode of production, despite relatively favorable policy in the distribution of modern factors of production. In other words, if all inputs (except land) in cereal production under the cooperative sector are increased by one percent, gross farm income per hectare of the sector is likely to increase only by 0.15 percent.

## ***VII.2 Conclusions and Policy Implications***

Insights gained about Ethiopian agriculture from this research lead to some conclusions and policy implications summarized next.

First, structural relationships embedded in Ethiopian cereal production per hectare appear to exhibit returns to input factors that are constant in the private and state farm sectors, and decreasing in the cooperative sector. These findings are important in light of Ethiopia's current agricultural policy (discussed in Chapters I and II) to substitute cooperative and state modes of production for privately operated traditional mode of production. The shift to the cooperative mode of production

appears to result in decreasing returns to scale to an equi-proportionate increase in all inputs under investigation except land. The technical characteristics of the private and state farm sectors, however, suggest that duplication of current cereal production technologies is likely to generate gross farm income per hectare at the same proportion as an equi-proportionate increase in all factors (except land) under investigation. Moreover, as can be seen from the results discussed in Chapter VI, implicit in the technical characteristics of the three farm types and their stages of production are therefore policy measures that are likely to influence gross farm income per hectare within each sector by increasing: (a) labor employment per hectare in the state farm sector and (b) quantities of the modern yield-increasing inputs per hectare in the private farm sector; but (c) by reducing some inputs (for example, labor, oxen) that are used intensively in the cooperative sector.

Second, the findings of this research show that marginal returns to labor and draft oxen inputs on the cooperative farms are not significantly different from zero. An important implication of this result is that the more intensive is the use of labor and oxen per hectare, the lower the incentive will be to increase active participation of the two factors in cereal producing activities of the cooperative organization. Following this reasoning, results of this study seem to point out a conflict between the cooperative policy objectives of full employment and maximum gross income per hectare. The policy seems unlikely to generate maximum gross income per hectare with seemingly redundant traditional input factors such as labor and draft oxen without a major change in the current production techniques and structural policies of the cooperative sector. In the long run, the cooperative sector may become a viable partner in Ethiopian agricultural development not by promoting current production processes that rely largely on an intensive use of surplus input factors, neither by prolonging the decreasing returns through subsidies (as is done currently), but by reducing seemingly redundant employment of such input factors as draft oxen and labor and also by simultaneously modifying the institutional structure of the cooperatives. The “right” structural unit of the cooperative organizations is an issue that needs to be determined by an in-depth study of the institution.

Third, it is quite interesting to note that partial income elasticities with respect to individual input factors are generally small across the three modes of production. The small size of the coefficients is evident particularly in the cooperative mode of production. These results indicate that an "easy" land productivity gain from a steady use of predominantly traditional factors of production in the private sector has probably been exhausted. On the other hand, the national agricultural policy emphasis on the producer cooperatives and state farms might have induced an over supply of modern and traditional inputs to the extent that land productivity of cereal output is "penalized" with respect to the individual inputs within the two farm types.

Finally, the relative magnitudes of the elasticities computed in Chapter VI for each farm type suggest that: (a) the private sector's gross farm income per hectare is most responsive to traditional hand tools, fertilizer, labor, human capital at the primary level of education, and rain in August and September; (b) the cooperative sector's gross farm income is positively most responsive to fertilizer and to rain in September; whereas (c) that of the state sector is most responsive to labor and machinery services and to rain in June and August. Thus, these results lead to the observation that factor productivity in the private sector is likely to be revitalized by qualitative changes in traditional inputs and water management, and by introduction of modern technical inputs such as fertilizer and farmer education. Factor productivity in the socialized sector is, however, likely to improve by increased labor employment on the state farms, water management, and restrained supply of input factors that are currently under intensive use.

### ***VII.3. Limitations and Suggestions for Future Research***

First of all, the analysis of this research is based on an assumption that technical efficiency is independent of allocative efficiency. This assumption was instrumental in evaluating technical characteristics of the modes of production with respect to the set of resources under the command

of each farm type over the study period covered by this research. Because of the production function approach, the study does not incorporate such policy instruments as output prices, wages and interest rates as independent variables. For the most part, regional and inter-temporal variations in these instruments are centrally managed at fixed levels and their influence on the resource allocation behavior of the producers is unknown. Although it was outside the scope of this study, the analysis could employ shadow prices to evaluate resource allocation behavior of the three farm types. The shadow prices would have reflected the opportunity cost or benefit that a resource could have earned if had been employed in its next best alternative use. But, shadow prices are imputed marginal social values of inputs and outputs which may or may not be the same as the centrally determined prices that prevail in Ethiopia. The shadow prices would be closely approximated by market prices if the prices were uninfluenced by government interventions.<sup>117</sup> Farmers are required to deliver a grain quota to the Agricultural Marketing Corporation at fixed output prices. In the long run, it is likely that marketable cereal output will decline and quota targets adjust downward if output prices are fixed below an "optimum" price. Thus, a research agenda that will evaluate resource allocation decisions of the private and cooperative producers under the system of quantity quota and fixed prices may reveal useful insights about the ability of the policy to generate surplus food and to guide an efficient allocation of agricultural resources.

Second, The government of Ethiopia has recently named about 50 surplus producing *awrajjas*. Its goal is to channel more technical assistance and modern inputs to these regions in order to increase domestic food production. This policy has the potential to enhance productivity of some regions with a high regional effect while exacerbating regional differences in resource use and level of food production. Given observed differences in the levels of gross farm income per hectare among cereal producing agro-ecological regions, it is not obvious if the policy will achieve its objectives simply by channeling inputs without identifying and addressing critical elements that enhance the regional differences that already exist. Research that evaluates determinants of variation in gross

---

<sup>117</sup> See Gittinger (1982) and Heal (1973) for a discussion on shadow prices.

farm income due to factors that are region specific will be a useful contribution to developing regional resource allocation policies consistent with the characteristics of cereal producing regions.

Third, an important question that could not be fully addressed in this research due to limitations in the data and method of study is “Will agricultural income from cereal crops increase if the state farms stop producing cereal crops?” There is a perception among Ethiopian agricultural policy makers and some donor agencies that cereal producing state farms are inefficient and too costly to the country and are competing with the traditional small farmer for modern technical inputs. If the state farms get out of cereal production and the modern technical inputs are reallocated to the traditional private sector, total farm income may increase and the level of marketable surplus food may improve in Ethiopia. The traditional labor employed by the state farms will be released and the total wage bill “transferred” to the traditional sector will be foregone if the state farms terminate cereal production. On the other hand, it is doubtful that the government will adopt this policy because the state farms are “guaranteed” source of food grains to armed forces and urban consumers. A normative (or mathematical programming) approach to the question may generate useful information.

## REFERENCES

- Abate, Alula and Fassil G. Kiros. "Agricultural Reform, Structural Changes and Rural Development in Ethiopia." *Agrarian Reform in Contemporary Developing Countries*, ed. Ajit Kumar Ghose, pp. 141-184. New York: St. Martins Press, 1983.
- ✓ Abramov, V. *The Basic Principles of the Organization of Soviet Agriculture*. Moscow: Progress Publishers, 1971.
- ✓ Abegaz, Haile Yesus. *The Organization of State Farms in Ethiopia After the Land Reform: Plannig, Relations, Potential and Problems*. Fort Lauderdale, USA: Verlag breitenbach. Publishers, 1982.
- Admassie, Yeraswork, Mulugeta Abebe, Markos Ezra, and J. Gay. *Ethiopian Highlands Reclamation Study: Report on the Sociological Survey and Sociological Considerations in Preparing a Development Strategy*. Addis Abeba, Ethiopia: The Institute of Development Research for Land Use Planning and Regulatory Department of Ministry of Agriculture and Food and Agriculture Organization of the United Nations, Working Paper No. 4, December 1983.
- Agricultural and Industrial Development Bank. *Draft Oxen Evaluation Study*. Addis Abeba, Ethiopia, 1987.
- Allen, Roy G. D. *Mathematical Analysis for Economists*. New York: Macmillan Company, 1939.
- Amemiya, T. "Selection of Regressors." *International Economic Review*, 21(June 1980):331-354.
- Applebaum, Elie. "On the Choice of Functional Forms." *International Economic Review*, 20(June 1979):449-458.
- Balestra, Pietro and Marc Nerlove. "Pooling Cross Section and Time Series Data in the Estimation of Dynamic Model: The Demand for Natural Gas." *Econometrica*, 34(July 1966):583-612.
- Bauer, Laura. "Hypothesis Testing Procedures for Non-Nested Regression Models." Ph.D. Thesis, Virginia Polytechnic Institute and State University, 1987.
- ✓ Belete, Solomon. "An Economic Analysis of Small-Holder Agriculture in the Central Highlands of Ethiopia: A System Simulation Approach." Ph.D. thesis, Oregon State University, 1978.
- Belsley, Daniel A., Edwin Khu and Roy E. Wesch. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*. New York: John Wiley & Sons, 1980.
- Berndt, E.R. and L.R. Christensen. "The Translog Function and the Substitution of Equipment." *Journal of Econometrics*, 1(March 1973):81-114.
- Berndt, E.R. and M.S. Khaled. "Parametric Productivity Measurement and Choice Among Flexible Functional Forms" *Journal of Political Economy*, 87(December 1979):1120-1146.
- Berry, R. Albert and Ronald Solingo. "Rural-Urban Migration, Agricultural Output, and the Supply Price of Labor in a Loabor-Surplus Economy." *Oxford Economic Papers* 20(July 1968):230-249.
- Bethke, S. "Basic Zonal Rainfall Patterns in Ethiopia." *Rehab: Drought and Famine in Ethiopia*, ed. Abdul Mejid Hussein, pp. 97 - 103. London: International African Institute, 1976.

Bezzabeh, Mulgeta, Eshetu Debabu and Tekelehaimanot Dersso. "Agrarian Reform and Rural Development in Ethiopia." Unpublished paper for World Conference on Agrarian Reform and Rural Development, Food and Agricultural Organization of the United Nations, Rome, June 12-20, 1979.

Boisvert, Richard N. *The Translog Production Function: Its Properties, Its Several Interpretation and Estimation Problems*. A.E.Res. 82-28, Cornell University, September 1982.

✓ Bondestan, Lars. "People and Capitalism in the Northeastern Lowlands of Ethiopia". *Modern African Studies*, 12(September 1974):423-439.

Boyd, Michael L. "The Performance of Private and Socialist Agriculture in Poland: The Effects of Policy and Organization." *Journal of Comparative Economics*, 12(1988):61 - 73.

Brietzke, Paul. "Land Reform in Revolutionary Ethiopia" *The Journal of Modern African Studies* 14(1976):637-660.

Brown, Murray. *On the Theory and Measurement of Technological Change*, Cambridge: The University Press, 1966.

Bunce, Arthur C. *Economics of Soil Conservation*. Ames Iowa: The Iowa State College Press, 1950.

Burt, Oscar R., Michael D. Frank and Bruce R. Beattie. "Prior Information and Heuristic Ridge Regression for Production Function." *Western Journal of Agricultural Economics*, 12(December 1987):135-143.

Central Statistical Office. *Statistical Abstract* Addis Abeba, Ethiopia, 1980.

----- *Rural Labor Force Survey April 1981 - April 1982*. Statistical bulletin No. 51, Addis Abeba, Ethiopia, 1985.

Chang, Alpha. *Fundamental Methods of Mathematical Economics*. New York: McGraw-Hill Book Company, 1974.

Chang, Hui-Shyong and Cheng F. Lee. "Using Pooled Time-Series and Cross-Section Data to Test the Firm and Time Effects in Financial Analysis" *Journal of Financial and Quantitative Analysis*, 12(September 1977):457-72.

Chayanov, Aleksandr Vasilevich. *The Theory of Peasant Economy*. eds. Daniel Thorner, Boris Kerblay and R. E. F. Smith. Homewood, Illinois: The American Economic Association, 1966.

Christensen, Laurits R., Dale W. Jorgenson and Laurence J. Lau. "Transcendental Logarithmic Production Frontiers" *The Review of Economics and Statistics*, LVI(February 1973):28-45.

✓ Cohen, John M., Arthur A. Goldsmith and John W. Mellor. "Rural Development Issues Following Ethiopian Land Reform" *Africa Today* 22(1976):7-27.

Cohen, John M. and Dov Weintraub. *Land and Peasants in Imperial Ethiopia: The Social Background to Revolution*. Assen, Netherlands: Koninklijke Van Gorcum & Comp. B.V., 1975.

Cornia, Giovanni Andrea, "Farm Size, Land Yields and the Agricultural Production Function." *World Development*, 13(April 1985):513-534.

- Dasgupta, P. S. and G. M. Heal. *Economic Theory and Exhaustible Resources*. Digswell Place, Welwyn: Cambridge University Press, 1979.
- Dejene, Alemneh. *Peasants, Agrarian Socialism, and Rural Development in Ethiopia*. Boulder, Colorado: Westview Press, Inc., 1987.
- ✓ Deme, Lesane Work. "The Agricultral Tax in Socialist Ethiopia: A Preliminary Evaluation of the Tax System." *Ethiopian Journal of Development Research* 3(1979):1-13.
- Denny, Michael and Melvyn Fuss. "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates". *The American Economic Review*, 67(June 1977):404-418.
- Dixit, Avinash. "Models of Dual Economies" in *Models of Economic Growth* INCOMPLETE
- ✓ Donahue, Roy L. *Ethiopia: Taxonomy, Cartography, and Ecology of Soils*. Occassional Paper Series Monograph No. 1, East Lansing: African Studies Center, 1972.
- Dunning, Harrison, C. "Land Reform in Ethiopia: A Case Study in Non-Development." *UCLA Law Review* 18(December 1970):271-307.
- Ellis, Gene. "Agricultural Development Strategy in Ethiopia: on Reaching the Peasant Sector" *Proceedings of the First United States Conference on Ethiopian Studies*, ed. Harol G. Marcus, pp. 385-398. Occassional Paper Series Monograph No. 3, East Lansing: African Studies Center, 1973.
- El-Swaify, S. A. and E. W. Dnagler. "Rainfall Erosion in the Tropics: A State-of-the-Art." *Soil Erosion and Conservation in the Tropics*. American Society of Agronomy (ASA) Special Publication no. 45, pp.45-51. Madison, Wisconsin: ASA and Soil Science Society of America, 1982.
- Ensminger, M.E. and C.G. Olentine,Jr. *Feeds and Nutrition-Abridged*. Cloris, California: The Ensminger Publishing Company, 1978:1400.
- Ethiopian Deligation. *Ways of Solving Agrarian Problems in Light of the Ethiopian Experience*. Paper presented at the Soviet-African Conference for Peace and Social Progress, Africa Institute fo the Ussr Academy of Science, October 14-16, 1981.
- Food and Agriculture Organization (FAO) of the United Nations. *Keeping the Land Alive: Soil Erosion--Its Causes and Cures*. Soil Bulletin 50, Rome, 1983.
- . *Production YearBook*, Vol. 26, Rome, 1972:419.
- Fuss, Melvyn and Daniel McFadden, eds. *Production Economics: A Dual Approach to Theory and Applications*, Vol. 1, New York: North-Holland Publishing company, 1978.
- Getahun, Amare. "Agroclimates and Agricultural Systems in Ethiopia." *Agricultural Systems* (January-March 1980):39-50.
- ✓ Ghose, Ajit Kumar; "Transforming Feudal Agriculture: Agrarian Change in Ethiopia Since 1974." *The Journal of Developing Studies* 22(October 1985):127-149.
- Green, David A. *Ethiopia: An Economic Analysis of Technological Change in Four Agricultural Production Systems*.Occassional Paper Series Monograph No. 2, East Lansing: African Studies Center, 1974.

- ✓ Griffin, Keith and Roger Hay, "Problems of Agricultural Development in Socialist Ethiopia: An Overview and a Suggested Strategy." *The Journal of Peasant Studies*, 13(October 1985):37-66.
- Griffin, Ronald C. John M. Montgomery and M. Edward Rister. "Selecting Functional form in Production Function Analysis." *Western Journal of Agricultural Economics*, 12(December 1987):216-227.
- Griliches, Zvi. "Economic Data Issues" *Handbook of Econometrics*, Vol III, ed. Zvi Griliches and Michael D. Intriligator, pp. 1465 - 1514. New York: North-Holland, 1986.
- Gittinger, J. Price. *Economic Analysis of Agricultural Projects* Baltimore: The Johns Hopkins University Press, 1982.
- Gryseels, G., Abiye Astatke, F.M. Anderson, and Getachew Assemenew. *The use of Oxen for Crop Cultivation in Ethiopia*. Addis Abeba, Ethiopia: International Livestock Center for Africa (ILCA) Bulletin No. 18, 1984: 20 - 25.
- Gryseels, Guido and Frank M. Anderson. *Research on Farm and Livestock Productivity in the Central Ethiopian Highlands: Initial Results, 1977 - 1980*. Addis Abeba, Ethiopia: ILCA Research Report No. 4, December 1983.
- Guilkey, David K., C.A. Knox Lovell and Robin Sickles. "A comparison of the Performance of Three Flexible Functional Forms" Memo, 1974.
- Gujarati, Damodar N. *Basic Econometrics*. 2d ed., New York: McGraw-Hill Book Company, 1988.
- Heal, G.M. *The Theory of Economic Planning*. New York: American Elsevier Publishing Co., Inc., 1973.
- Heathfield, David F. *Production Economics*, New York: The Macmillan Press Ltd., 1971.
- , "Planning, Prices and Increasing Returns" *Review of Economic Studies*, 28(July, 1971).
- Henderson, James A, and Richard E. Quandt. *Microeconomic Theory: A Mathematical Approach*. 2d ed., New York: McGraw-Hill Book Company, 1980.
- Henricksen, B.L. and J.W. Dirkin. "Moisture Availability, Cropping Period and the Prospects for Early Warning of Famine in Ethiopia." Addis Abeba, Ethiopia: ILCA Bulletin No. 21, January 1985:2-9.
- Hoben, Allan. *Land Tenure Among the Amhara of Ethiopia: The Dynamics of Cognitive Descent*. Chicago: University of Chicago Press, 1973.
- Hoch, I. "Estimation of Production Parameters Combining Time-Series and Cross-Section Data." *Econometrica*, 30(January, 1962):34-53.
- Hocking, R.R. "The Analysis and Selection of Variables in Linear Regression." *Biometrika*, 32(March 1976):1-49.
- Howe, Charles W. *Natural Resource Economics: Issues, Analysis, and Policy*. New York: John Wiley & Sons, Inc., 1979.
- Hsiao, Cheng. *Analysis of Panel Data*. Cambridge: Cambridge University Press, 1986.

- Hyams, Edward. *Soil and Civilization* New York: Harper & Row, Publishers, Inc., 1952.
- Johnson, Aaron C., Jr., M. B. Johnson and R.C. Buse. *Econometrics: Basic and Applied*. New York: Macmillan Publishing Company, 1987.
- Judge, George G., W.E. Griffiths, R.C. Hill and T.C. Lee. *The Theory and Practice of Econometrics*. New York: John Wiley & Sons, 1980.
- Kanel, Don. "Size of Farm and Economic Development" *Indian Journal of Agricultural Economics* 22(April-June 1967):26-44.
- Khaled, M.S. "Productivity Analysis and Functional Specification: A Parametric Approach." Ph.D. Thesis, University of British Columbia, 1978.
- Kenedy, Peter. *A Guide to Econometrics*. Cambridge, Massachusetts: The MIT Press, 1985.
- Kmenta, Jan. *Elements of Econometrics* New York: Macmillan Publishing Co., Inc., 1971.
- Kramer, Randall. "An International Overview of Soil Conservation Policy." Paper Presented at the XIX International Conference of Agricultural Economists, Malaga, Spain, August 26-September 4, 1985.
- Kuznets, Simon. "Modern Economic Growth: Findings and Reflections." *American Economic Review* 63(June 1973):247-258.
- Langdale, W. G. and W. D. Shrader. "Soil Erosion Effects on Soil Productivity of Cultivated Croplands." *Soil Erosion and Conservation in the Tropics*. American Society of Agronomy (ASA) Special Publication no. 45, pp.45-51. Madison, Wisconsin: ASA and Soil Science Society of America, 1982.
- Lewis, A.W. "Economic Development With Unlimited Supplies of Labor" *Manchester School of Economics and Social Studies*, 22(May, 1954):139-91.
- Lyu, Syu-Jyun Larry, Fred C. White and Yao-Chi Lu. "Estimating Effects of Agricultural Research and Extension Expenditures on Productivity: A Translog Production Function Approach" *Southern Journal of Agricultural Economics*, ?(December 1984):1-8.
- Maddala, G.S.. "The Use of Variance Components Models in Pooling Cross-Section and Time-Series Data". *Econometrica*, 39(March 1971):341-58.
- "Diagnostic Checking, Model Selection and Specification Testing." *Introduction to Econometrics*. New York: Macmillan Publishing Company, 1988:405-451.
- Markakis, John. *Ethiopia: Anatomy of a Traditional Polity*. Oxford: Clarendon Press, 1974.
- Markakis, John and Nega Ayele. *Class and Revolution in Ethiopia*. Nottingham: Spokesman Press, 1977. (check year)
- ✓ Merid, Lema. "Agricultural and Macroeconomic Behavior in Ethiopia's Constrained Economy: An Econometric Policy Simulation." Ph.D. Thesis Boston University, 1988.
- Millar, James R. "Soviet Rapid Development and the Agricultural Surplus Hypothesis." *Soviet Studies* 22(July 1970):77-93.
- Moriarty, Mark. "Cross-Sectional, Time-Series Issues in the Analysis of Marketing Decision Variables" *Journal of Marketing Research*, 12 (May 1975):142-50.

- Mukherjee, Chandan and A. Vaidyanathan. "Growth and Fluctuations in Food Grains Yields Per Hectare: A Statewise Analysis." *Indian Journal of Agricultural Economics*, XXXV(April-June 1980).
- Mukhopadhyay, Sudhin Kumar. "Sources of Variation in Agricultural Productivity: A Cross-Section-Time-Series Study of India." Ph.D. Thesis, University of Minnesota, 1974.
- Nelson, Harold, MORE. *Ethiopia: A Country Study*. Washington D.C.: U.S. Government Printing, 1980.
- Nerlove, Marc. "A note on Error Components Models." *Econometrica*, 39(March 1971):383-396.
- Pankhurst, Richard. *Economic History of Ethiopia, 1800 - 1935*. Addis Abeba, Ethiopia: Haile Sellassie I University Press, 1968.
- Pausewang, Siegfried, "Participation in Social Research in Rural Ethiopia." *The Journal of Modern African Studies*, 26(1988):253-276.
- Pevsner, Ya. *State Monopoly Capitalism and the Labor Theory of Value* Moscow: Progress Publishers, 1978.
- Pindyck, Robert S. and Daniel L Rubinfeld. *Econometric Models and economic Forecasts*. New York: McGraw-Hill Book Company, 1981.
- Provisional Military Government of Ethiopia. *Ten-Year Plan 1985-1994*. Addis Abeba, Ethiopia, September 1985.
- Rahmato, Dessalegn. *Agrarian Reform in Ethiopia*. Trenton, New Jersey: The Red Sea Press, 1985.
- Ramsey, J. B. "Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis." *Journal of Royal Statistical Society*, 31(1969):350-371.
- Ranis, Gustavo and J. Fei. "A Theory of Economic Development." *American Economic Review* 51(September):534-565.
- Relief and Rehabilitation Commission. *Combatting the Effects of Cyclical Drought in Ethiopia*. Addis Abeba: Berhanena Selam Printing Press, 1985.
- Reynolds, Lloyd G. *Image and Reality in Economic Development*, New Haven: Yale University Press, 1977.
- Sampath, R.K. "Nature and Measurement of Economic Efficiency in Indian Agriculture." *Indian Journal of Agricultural Economics*, XXXIV(April-June 1979):17-34.
- ✓ Saith, Ashwani; "The Distribution Dimensions of Revolutionary Transition: Ethiopia" *The Journal of Development Studies*, 22(October, 1985):150-179.
- Scholler, Heinrich and Paul Brietzke. *Ethiopia: Revolution, Law and Politics*. Munchen: Weltforum Verlag, 1976.
- Schuh, G. Edward. "Out-Migration, Rural Productivity and Distribution of ncome." Paper presented at the World Bank Research Workshop on Rural-Urban Labor Market Interactions, Washington, D.C., 1976.

- Schultz, Theodore W. *Transforming Traditional Agriculture*. Chicago: The University of Chicago Press, 1964.
- Schultz, T. Paul. "An Economic Model of Family Planning and Fertility." *Journal of Political Economy*, 77(November/December 1969):153-180.
- "Expalanation of Birth Rate Changes Over Space and Time: A Study of Taiwan." *Journal of Political Economy*, Part II, 81(March/April):S238-S278.
- Shih, Jhi-Tzeng. "Specification and Estimation of Farm Level Production Function From Combined Cross-Section Time Series Data in Taiwan." Abridged Ph.D. Thesis, The Ohio State University, 1975.
- Shih, J.T., L.J. Hishak and N. Rask. " The Validity of the Cobb-Douglas Specification in Taiwan's Developing Agriculture." *American Journal of Agricultural Economics*, 59(August 1977):554-558.
- ✓ Shire, Saad Ali. "The Role of Prices in Agricultural Supply: A Household Production Systems Approach for Smallholders in Ethiopia." Ph.D. Thesis, Pennsylvania State University, 1986.
- Singh, Ram D. "Shifts in Pulses Acreage: An Interregional Analysis of Dynamics of Farmers' Response." *Indian Journal of Agricultural Economics*, XXXIV(April-June 1979):1-18.
- ✓ Sisaye, Selashe and Eileen Stommes. "Agricultural Development in Ethiopia: Government Budgeting and Development Assistance in the Pre and Post 1975 Period." *The Journal of Developing Areas* 14(October 1979):157-185.
- Sjostrom, Rolf. "A pilot Study of Effects of Primary Schooling in a Rural Community of Ethiopia: The Case of Saya Debir." Addis Abeba, Ethiopia: Ministry of Eduation, February 1986.
- Snedecor, George W. and William G. Cochran. *Statistical Methods*. Ames: Iowa State University Press, 1978.
- Spanos, Aris. *Statistical Foundation of Econometric Modeling*. Cambridge: Cambridge University printing Press, 1987.
- Spencere, Milton H. *Contemporary Economics*. 3rd ed. New York: Worth Publishers, In., 1977.
- Stanis, Vladimir. *The Socialist Transformation of Agriculture* Moscow: Progress Publishers, 1976.
- Tang, Anthony M. "Comment: Subjective Equilibrium of the Subsistence Farmer." *Subsistence Agriculture and Economic Development*, ed. Clifton R. Wharton Jr., pp.190-196. Chicago: Aldine Publishing Company, 1969.
- ✓ Teclé, Tesfai. "The Evolution of Alternative Rural Development Strategies in Ethiopia: Implications for Employment and Income Distribution." African Rural Employment Papers Series, East Lansing, Michigan: Michigan State University, 1975.
- Todaro, Michael P. "A Model Labor Migration and Urban Unemployment in Less Developed Countries" *The American Economic Review* LIX(March, 1969):138-148.
- *Internal Migration in Developing Countries*. Geneva: International Labor Office, 1976.

- Vinod, H.D. "Nonhomogeneous Production Functions and Applications to Telecommunications." *The Bell Journal of Economics and Management Science*, 3(1972):531-543.
- Wallace, T.D. and Ashiq Hussain. "The Issue of Error Components Models in Combining Cross Section with Time Series Data." *Econometrica*, 37(January 1966):55-72.
- Wales, Terence J. "On the Flexibility of Flexible Functional Forms" *Journal of Econometrics*, 5(1977):183-93.
- Walpole, Ronald E. and Raymond H. Myers. *Probability and Statistics for Engineers and Scientists*. 3d ed., New York: Macmillan Publishing Company, 1985.
- Wharton, Jr., Clifton R. "Subsistence Agriculture: Concepts and Scope." *Subsistence Agriculture and Economic Development*, ed. Clifton R. Wharton Jr., pp.190-196. Chicago: Aldine Publishing Company, 1969.
- White, H. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica*, 48(May, 1980):817-838.
- Wildt, Albert and Olli Ahtola. *Analysis of Covariance*. Beverly Hills: SAGE Publications Ltd., 1978.
- ✓ Woldesemait, Bekure. "Prospects for Rural Industrialization in Ethiopia." *Ethiopian Journal of Development Research* 3(1979):15-29.
- WoldeMariam, Mesfin. *Rural Vulnerability to Famine in Ethiopia: 1958-1977*. New Delhi, India: Vikas Publishing House PVT LTD, 1984.
- World Bank. *Ethiopia: Agricultural Sector Survey*. Unpublished data, 1986.
- *Ethiopia: Recent Economic Developments and Prospects for Recovery and Growth*. Report No.5929ET., Washington, D.C. 1987.
- Yotopoulos, Pan A. *Allocative Efficiency in Economic Development*. Athens, Greece: F. Constantinidis and C. Mihalas, 1967.
- Young, Douglas L., Ron C. Mittelhammer, Ahmad Rostamizadeh, and David W. Holland. *Duality Theory and Applied Production Economics Research: A Pedagogical Treatise*. College of Agriculture and Home Economics Research Bulletin 0962, Wahsington State University, 1985.

**The vita has been removed from  
the scanned document**