The Impact of Official Development Assistance on African Agriculture

Helene Gichenje

Department of Agricultural Economics
Macdonald Campus of McGill University
Ste Anne de Bellevue, PQ, CANADA

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ABSTRACT

An aggregate agricultural production function (a pooled covariance model) based on the metaproduction approach, was estimated using cross section, time series data for 32 countries in Sub-Saharan Africa (SSA) covering the 1970-1993 period to evaluate the effect of foreign aid on agricultural production. The Almon lag structure of the foreign aid (Official Development Assistance) variable was specified to account for the effect of foreign aid over time. The results support the hypothesis that the aggregate effect of aid on agricultural production in SSA is positive. The marginal effect of foreign aid in SSA is calculated to be \$0.14 which can be interpreted to mean that a one dollar increase in aid in each of the past six years would be expected to increase the value of agricultural output by 14 cents in the current year.

There is a great variation in the effect of foreign aid on agricultural production when countries are classified according to agro-climatic region, income level and policy environment. Excluding Eastern and Southern Africa where the effect of aid is negative, the marginal effect of foreign aid ranges from \$0.40 in Sudano-Sahel to \$1.32 in Central Africa. The marginal effect of foreign aid is larger in middle income countries as compared to high income countries; it is negative in low income countries. The effect of aid is positive and significant in countries classified under a favourable policy environment but negative and insignificant in countries classified under an unfavourable policy environment. The structural adjustment dummy variable is positive and significant in most regressions indicating that structural adjustment programs have been beneficial to agriculture in most Sub-Saharan African countries.

RÉSUMÉ

Une fonction globale de la production agricole (pooled covariance model) basée sur l' approche de la metaproduction a été estimée en utilisant une coupe transversale, une série des données pour 32 pays de l' Afrique Sud Saharien (ASS) couvrant la période de 1970 à 1993 qui évaluent l'effet de l'aide étrangère sur la production agricole. La structure du décalage Almon de la variable de l' aide étrangère (Assistance du Développement Officiel) a été spécifiée pour compter la distribution des effets de l'aide étrangère au fil de temps. Les résultats de cette étude supportent l'hypothèse que l' effet global de l' aide étrangère sur la production agricole en Afrique Sud Saharien est positif. L' effet marginal de l' aide étrangère en Afrique Sud Saharien a été calculé à \$0.14 et qui peut être interpréter comme suit: pour une augmentation d' un dollar en aide dans chaque décalage de 6 ans, on peut s'y attendre à une hausse de la valeur de production agricole de 14 cents dans l' année courante.

Il y a une variation dans l'effet de l' aide étrangère sur la production agricole quand les pays sont classifiés selon leurs régions climatiques, niveau des revenus et leurs politiques environnementales. A l' exception de la partie Est et Sud de l' Afrique où l' effet de l' aide étrangère est négatif, l' effet marginal de l' aide étrangère se situe à partir de \$0.40 dans la région Soudano-Sahelien jusqu' à \$1.32 en Afrique Centrale. L' effet marginal de l' aide étrangère des pays ayant un revenu moyen est plus grand que celui des pays qui possèdent un revenu élevé; cet effet marginal est négatif pour les pays ayant un bas revenu. L' effet de l' aide étrangère est positif et significatif dans les pays qui sont classifiés parmis ceux qui ont une politique environnementale favorable. Par contre, cet effet est négatif et non significatif dans les pays qui sont classifiés parmis ceux qui ont une politique environnementale non favorable. Le factice variable de l' ajustement structurel est positif et significatif dans la plus part des régressions indiquant les programmes de l' ajustement structurel ont été bénéfique pour l' agriculture dans la plus part de pays de l' Afrique Sud Saharien.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

CHAPTER 1

INTRODUCTION

1.1 AN OVERVIEW

Africa in the 1990s is still described as being in crisis. Over the past two decades economic development has been slow in most of the countries of Sub-Saharan Africa (SSA). The economic crisis has been evident from slow or negative overall economic growth, sluggish agricultural performance coupled with rapid rates of population growth, worsening balance-of-payments and burgeoning fiscal deficits. There are divergent opinions regarding the genesis of Africa's economic crisis, but many experts believe that the poor performance of the agricultural sector is at the root of the problem (Lele, 1991). The deterioration of agricultural performance stems in part from repeated droughts and also from exogenous factors such as unfavourable terms of trade. In addition many countries in SSA are still suffering from the consequences of poor domestic policies pursued during the late 1970s and the early 1980s.

The key strategy for economic reform in SSA in the years after countries found themselves in crisis (especially aggravated by the unsustainable deficits in internal and external accounts) has been the implementation of structural adjustment programs. These programs have mainly been financed by the International Monetary Fund, the World Bank and bilateral donors. Hence donors have played an increasingly important role in trying to restore growth in SSA during the latter half of the 1980s and the early 1990s. An important accompaniment to policy-based reform has included debt cancellations and donor financing. Consequently, since the 1980s more development aid has been flowing to SSA, reflecting donors perceptions of a growing need for concessional assistance to the region.

Aid provision in the form of transactions from rich to poor, but independent countries is of recent origin. It is difficult to trace it earlier than the end of the Second World War (White, 1974). Between 1948 and 1952 over $13 billion dollars were dispensed from the United States to Europe under the Marshall Plan (Dulles, 1993). Since then billions of dollars have been transferred from developed countries to less developed countries (LDCs). Over time there have been variations in the volume of aid going to LDCs. During the 1970s up to 50 percent of net Official Development Assistance (ODA) was allocated to Asia; in the early part of the 1980s, the Middle East and North Africa were receiving up to 30 percent of ODA. Today SSA is the major recipient of ODA (OECD, 1994).

In SSA (and in many other LDCs) agricultural output is the single most important determinant of overall economic growth. This is because agriculture constitutes a major part of gross domestic product (GDP) and employment; moreover the transport, processing and trade sectors depend on the production of agricultural commodities, and incomes earned in the agricultural sector provide markets for domestically produced goods and services. The fundamental role of agriculture in the development of LDCs implies the need to accord priority to the provision of adequate investments in the development of this sector.

Foreign assistance in support of agriculture is a part of total aid. Assistance to expand agricultural production can come in the form of financial assistance, technical assistance and commodity aid. Aid to agriculture has included such diverse components as investments in land and water resource development, agricultural research, agricultural extension, land tenure reform, agricultural credit markets, rural roads, agricultural education and training, health improvement programs, integrated rural development projects and agricultural policy reform programs. Foreign assistance can play an important role in agricultural development of LDCs through the provision of vitally needed investments and technical assistance. Theoretically, agricultural assistance is given with the objective of freeing the production constraints and improving human capital through education and through nutritional gains resulting from food production and consumption.

Many of the critics of foreign aid have rejected it on ideological grounds (Krueger, 1986). However, whether aid is effective or not is an empirical question that can only be addressed with empirical evidence. Some empirical studies have attempted to assess the impact of foreign aid at the project and national levels; a brief discussion of the findings from these studies is presented below.

At the project level, aid has been evaluated in terms of the rate of return on the individual projects. The World Bank (1994d) has reported that of the 887 agricultural projects it funded during the period 1970-85, 65 percent were rated as satisfactory. This satisfactory rating is based on the achievement of benefits relative to project costs, the attainment of objectives and an economic rate of return of at least 10 percent. In 1984, the World Bank embarked on a series of studies focussed on managing agricultural development in Africa (MADIA) (Lele, 1991). The main purpose of the MADIA studies was to determine the sources of agricultural growth in selected African countries and the extent to which domestic policies, the external economic environment and donor assistance contributed to this growth. The MADIA study on aid effectiveness, "Aid to African Agriculture" (Lele, 1991), not only involved evaluations of individual projects but an in-depth analysis of the effects of aid on agricultural production, the provision of welfare services and institutional development. This study is unique in that it presents an evaluation of aid at the project sector and macro levels.

Studies that have assessed the impact of foreign aid at the national level have typically addressed three main questions: Has foreign aid alleviated poverty? Has foreign aid stimulated domestic savings? To what extent has foreign aid contributed to economic growth? Studies investigating the impact of aid on poverty have received less formal analysis and the evaluation has remained largely subjective. Critics of aid have argued that aid cannot help the poor since it provides greater political leverage to recipient governments who then hamper development by adopting inappropriate domestic policies (Krueger, 1986). However project aid can be used as a means of delivering aid more directly to the poor. Cassen and Associates (1994) state that in some situations despite an unhealthy political climate, individual aid projects have succeeded in improving the well-being of the poor. Cassen and Associates (1994) and Mosley (1983) discuss some of the evidence of aid programs and poverty and conclude that aid has been successful in alleviating poverty when properly designed with that intention.

The empirical results from studies investigating the effect of foreign assistance on domestic savings have reported that aid adds little to productive resources because its effects are largely offset by a reduction in domestic savings (Griffin and Enos, 1970, Fry, 1980, Giovannini, 1985 and Weisskopf, 1972). Mosley (1987) and Gupta and Islam (1983) examine the effect of foreign aid on growth and savings. The conclusion from the Mosley (1987) study is that there is no statistically significant correlation between foreign aid and economic growth and savings. However the results of the latter study show the effect of foreign aid to be weak and positive on growth and negative on savings. Gupta and Islam (1983) also note that the results differ when the sample is disaggregated either by income group or geographical regions.

In a review of some of the empirical work on the macroeconomic impact of aid, Michalopoulos and Sukhatme (1989) found that the results have been inconsistent and inconclusive. Cassen and Associates (1994) also provide a summary of the principal results of some empirical studies; they concluded that the relationship between foreign aid and growth is weak and that there are sizeable regional differences in the effects of aid.

A few studies have attempted to evaluate the effects of foreign aid at the agricultural sector level. Rai (1987) evaluated the effects of foreign assistance to agriculture in 59 countries during the period 1975 to 1984 and concluded that although the aggregate effect of foreign aid on agricultural production was negative, there were regional differences in the effects of aid. Norton et al. (1992) performed a multicountry analysis of the effects of development assistance on agricultural growth in 98 LDCs during the period from 1970 to 1985; the authors found a positive effect of foreign assistance on agricultural growth. More recently, Pinstrup-Andersen et al. (1995) and Kherallah et al. (1994) have examined the impact of development assistance on growth of agricultural output and imports in LDCs; both studies conclude that foreign aid had a positive influence on agricultural growth and agricultural imports. All four studies identified that significant differences in aid effectiveness existed by region and that additional analysis within regions would be needed to quantify the effects of foreign assistance to agriculture.

1.2 HYPOTHESIS AND OBJECTIVES

With over 30 years of experience with the use of foreign aid as a development tool, there has been little scrutiny of the impact of ODA on agricultural production in Africa. The main purpose of this study is to examine the relationship between ODA and agricultural production in SSA. This study will test the hypothesis that foreign aid has had a positive impact on agricultural production in SSA.

The specific objectives of this study will be to:

1. Review the nature and structure of ODA.
2. Identify and measure the determinants of agricultural production in SSA.
3. Empirically evaluate the relationship between ODA and agricultural production in SSA.
4. Evaluate the impact of ODA when countries in SSA are classified according to agro-climatic region, income level and policy environment.

1.3 ORGANIZATION OF THE THESIS

The thesis is organized as follows:

Chapter 2 provides a background discussion of the structure of ODA and a description of ODA flows to SSA. Agricultural and overall economic performance are reviewed with an attempt to justify the importance of ODA to SSA.

Chapter 3 presents a review of the literature relevant to the study and to the design of the empirical model. First, the review focuses on the economic theories of development assistance. Second, a discussion of the previous studies that have evaluated the effects of foreign aid to the agricultural sector is presented. Third, the theoretical model based on an aggregate agricultural production function is described.

Chapter 4 comprises the specification of the empirical model with a description of the variables to be used in the analysis.

Chapter 5 provides the results and discussion of the regression analysis.

Chapter 6 summarizes the main findings and outlines the limitations of the study.

CHAPTER 2

OFFICIAL DEVELOPMENT ASSISTANCE

The analysis in this study focuses on Official Development Assistance (ODA). In this chapter ODA, as compared to other types of external resource flows to less developed countries (LDCs), is defined. Following is a description of ODA flows to Sub-Saharan Africa (SSA) over the past twenty years. In the last section of this chapter an attempt is made to justify why ODA should have an impact on agricultural production in SSA.

2.1 DEFINITION OF ODA

Foreign aid, development aid and development assistance (all commonly called aid) are familiar terms used in reference to the provision of resources by developed countries to LDCs. Aid usually implies that these resources are provided at concessional terms, i.e. on terms less stringent than those available in commercial capital markets. According to the Organization of Economic Cooperation and Development (OECD, 1995b) definition, aid qualifies as ODA based on the following three criteria:

1. It is provided by official agencies, including state and local government or by their executive agencies,
2. It is administered with the promotion of the economic development and welfare of developing countries as its main objective, and

3. It is concessional in character and conveys a grant element of at least 25 percent.

ODA is clearly distinguished from three other main types of foreign resource flows to LDCs; nonconcessional official flows (NCOF), export credits and private flows (Table 2.1). Official Development Finance (ODF) includes both concessional (ODA) and nonconcessional official flows. NCOF consist mainly of lending from official sources on terms that do not qualify as ODA. The International Monetary Fund and the regional development banks are important providers of NCOF to LDCs. Since the mid 1980s a large share of NCOF has been provided by the World Bank in the form of adjustment loans.

Export credit lending is provided by donor country agencies to LDCs for the purchase of capital equipment and other investment goods. Private lending is mainly in the form of direct investment, commercial bank lending and bond lending. Private lending is an important source of external finance to LDCs; Table 2.1 indicates that private flows have accounted for more than a third of total resource flows to LDCs over the past two decades. Grants by nongovernmental organizations (NGOs) are highly concessional but nonofficial, hence are not counted as ODA.

There has been relatively little change in the amount of ODA to LDCs over the past two decades. Thus, despite the great fluctuations in the world economy and the dramatic changes in the availability of external financial resources, ODA to LDCs has remained almost constant. Total ODA flows to LDCs in billions of United States (US) dollars were 35 in 1970, 43 in 1980, 53 in 1990, at real 1990 prices and exchange rates (OECD, 1992).

Table 2.1 Total resource flows to developing countries[a] (in percent)

	1970	1975	1980	1985	1990
I. OFFICIAL DEVELOPMENT FINANCE	44.7	39.2	29.3	58.5	54.9
1. Official Development Assistance	39.7	31.9	23.3	44.5	41.4
i. Bilateral ODA	34.2	23.8	16.7	34.7	30.8
ii. Multilateral ODA	5.5	8.1	6.6	9.8	10.6
2. Non-concessional official flows	5.0	7.3	6.0	14.0	13.5
II. EXPORT CREDITS	13.6	12	14.7	4.8	3.7
III. PRIVATE FLOWS	41.7	48.8	56	36.7	41.4
1. Direct investment	18.6	24.4	9.6	7.9	21.1
2. International bank lending	15.1	18.2	41.9	18.3	14.5
3. Bond lending	1.5	0.9	0.9	5.4	-2.5
4. Other private	2	2.6	1.5	1.6	4.4
5. Grants by NGOs	4.5	2.8	2.1	3.5	3.8
Total I, II and III (1990 US billion $)	87	116	185	133	127

Note a: Developing countries, as defined by the OECD, include all countries in Africa except South Africa; in America except Canada and the United States; in Asia except Japan; in Oceania except Australia and New Zealand, and the following countries in Europe: Albania, Cyprus, Gibraltar, Greece, Malta, Turkey and Yugoslavia.
Source: OECD, 1992

A number of changes have occurred in the structure of foreign financing over the past two decades. It is necessary to consider these changes in order to appreciate the role of ODA in total foreign resource flows to LDCs. In the mid 1970s a big expansion occurred in the Organization of Petroleum Exporting Countries (OPEC) bilateral aid programs. In 1970, OPEC aid was less than five percent of ODA, but by 1980 it had grown to about 25 percent of ODA (OECD, 1992). Most of the surplus in OPEC oil revenues were deposited in US and European banks. This led to the expansion of lending from commercial banks, thus accounting for a major share of external finance to LDCs in the late 1970s. In 1970 international bank lending accounted for only about 15 percent of total resource flows to LDCs but for over 40 percent in 1980 (Table 2.1).

The debt crisis and the worldwide recession in 1982, led to a precipitous decline in private bank lending and export credits. Table 2.1 shows a fall in the share of international bank lending from 41.9 percent in 1980 to 18.3 percent in 1985. Likewise the share of export credits also fell from 14.7 percent in 1980 to 4.8 percent in 1985. As a result total foreign transfers to LDCs sharply declined; total resource flows were 185 billion in 1980, and 133 billion in 1985 - a drop in volume of almost 30 percent (Table 2.1). An important feature of private lending today is that it is primarily concentrated in only a few credit-worthy countries mainly in Asia, such as China and Indonesia (OECD, 1995a).

Important changes have also occurred in the geographical allocation of ODA. Over the past decade there has been a strong rise in the proportion going to SSA (Table 2.2). This has been accompanied by a drop in the share going to South and

Table 2.2 Regional allocation of total ODA to developing countries (in percent)

	1980	1985	1990	1991	1992
Africa, North of Sahara	7.5	7.9	12.0	11.2	8.8
Africa, South of Sahara	21.3	25.9	30.1	28.5	31.1
Latin America	7.6	11.6	8.5	9.0	9.1
Middle East	14.9	11.2	7.4	8.1	6.5
South & Central Asia	16.4	13.6	10.2	13.0	11.3
Far East Asia	10.9	13.7	14.3	11 0	14.7
Other[a]	21.5	16.3	17.6	19.1	18.5
Total in 1990 US billion $	43	55	53	54	56

Note a: Includes Europe, Oceania and geographically unallocated
Source: OECD, 1994

Central Asian countries. Aid flows to the Middle East and North Africa, which reached a peak in the early 1980s, have since declined reflecting a fall in OPEC aid. The share of ODA going to the emerging economies of Eastern Europe and the former Soviet Union have experienced a recent significant increase. In addition to the shrinking flows from private sources, many LDCs have lost credit worthiness in private capital markets. In these circumstances, ODA is of crucial importance to low income developing countries.

2.1.1 Forms of ODA

ODA is delivered to LDCs in a multitude of forms. Before an attempt is made to classify ODA, it is necessary to distinguish the three main ways in which aid is provided:

1. Financial or capital aid.

This is aid in the form of money in convertible foreign exchange (US dollars, Japanese yen, French franc, etc). Aid in money form is flexible and allows the recipient to allocate the funds to a wide range of foreign exchange requirements. Aid as money is either disbursed as a grant or a concessional loan.

2. Technical assistance.

This covers a wide variety of activities, but common to them all is the human element. Technical assistance aims at augmenting the level of knowledge, skills, technical know-how or productive aptitudes of people from LDCs. This may be achieved through local or external training, providing experts and specialists and building development related institutions.

3. Commodity aid.

This includes food aid and other commodity aid (e.g. fertilizer, farm machinery, industrial equipment).

ODA, either as money, technical assistance or commodity aid, can be further classified under:

i. Bilateral and Multilateral aid.

Bilateral aid involves the direct flow of resources from an individual donor country to a recipient country. The bulk of bilateral ODA is provided by the member countries of OECD. Bilateral flows have accounted for the largest share of ODA (Table 2.1). In addition to bilateral financial assistance a variety of multilateral (multi-country) institutions provide significant support to LDCs. The main multilateral organisations are the United Nations, the World Bank and the regional development banks. These organizations receive contributions from several donor countries and then dispense the funds to LDCs for specific projects.

ii. Project and Program aid.

The main ways in which ODA is delivered is in the form of project or program assistance. Project assistance implies that funds are for a specific purpose and finances are used for the establishment or expansion of identified productive activities. Program assistance is more flexible and allows the recipient country to use the aid for any purpose within the framework of the recipients overall development plan. Traditionally, much of the development assistance has been provided as project aid (Cassen and Associates, 1994). However, program assistance has been on the increase since the global recession of the 1980s that led donors to quickly disburse aid to sustain macroeconomic performance and the viability of existing projects

iii. Sector aid.

Sector aid is assistance to a particular economic subsystem whose boundaries can reasonably be drawn. Table 2.3 shows the sectoral distribution of total ODA. Development aid for social (e.g. education, health, water supply and public administration) and economic (e.g. energy, transport and communication) infrastructure accounts for about 45-50 percent of all aid. Most aid for economic purposes is allocated to energy (12 percent of all aid) followed closely by transport and communication (10 percent). The bulk of aid for production is directed to agriculture (80 percent) and 10-15 percent of total aid is allocated to the agricultural sector (OECD, 1994).

Some measurement problems arise in the calculation of ODA flows. ODA includes both grants and concessional loans. First, one cannot simply add together the dollar values of grants and loans. An outright grant of aid has a 100 percent grant element; a loan at an interest rate of 10 percent has a zero grant element; a concessional loan will lie somewhere in between (OECD, 1995b). The following general guideline is used by the OECD to calculate the grant element of a loan: a loan will not convey a grant element of over 25 percent if its maturity is less than 10 years, unless its interest rate is well below 5 percent. Thus by this convention, if the face value of a loan is multiplied by its grant element the result is referred to as the grant element of that loan (OECD, 1995b).

Table 2.3 Sectoral allocation of total ODA (in percent)

Sector	1975-76	1990-91
Social and administrative infrastructure	20.1	23.1
Economic infrastructure	10.2	24.6
Agriculture	8.1	9.5
Industry and other production	13.7	7.4
Food aid	13.1	1.9
Program assistance	5.9	1.5
Other	28.9	22.0

Source: OECD, 1994

Secondly, ODA is provided in the form of convertible foreign exchange and also in more restrictive forms such as food aid, technical assistance and tied aid (Krueger and Ruttan, 1989). Aid can be tied either by source (aid to be spent on the purchase of donor country goods and services) or by project (funds can only be used for a specific project). The value at which the donor country supplies goods and services under its loan and grant programs should be computed at prices not exceeding those prevailing in international markets (Radetzki, 1973). In practice the fair market value of donor supplies, food aid or technical assistance is usually not estimated. Cassen and Associates (1994) document how the practice of aid-tying by donors has reduced the purchasing power of aid, in some cases by over 20 percent.

Hence the value of pure aid can only be calculated once consideration is given to the different concessional terms and to the international market value of goods and services provided by the donor country. Yet the uncertainties in estimating the value of pure aid cannot be overlooked. It would be practically impossible to sort out, among the thousands of transactions, the terms applying to financial flows throughout the year. In addition, there is no regular and reliable data to calculate the excess cost in aid due to tying. It appears that if pure aid could be calculated, the result would be by far a smaller value than that reported as ODA to LDCs.

2.2 ODA FLOWS TO SUB-SAHARAN AFRICA

Sub-Saharan Africa is today the largest recipient of ODA. In 1992, 31 percent of ODA to developing countries was allocated to SSA (Table 2.2). The OECD (1994) documents that in Africa total resource flows declined in real terms after 1989, despite a growing share of ODA from donor countries. From 1986, private resource flows dwindled reflecting an unattractive environment for all categories of private finance. Export credits have also been declining since 1986. As a region Sub-Saharan African countries are heavily dependent on concessional aid for external finance.

ODA flows to SSA have been characterized by the following trends. small flows in the early 1970s, a rapid increase between the mid 1970s and the early 1980s, a stable period before the food crisis in 1984, followed by a steady increase from the mid 1980s (Lele, 1991). Table 2.4 documents the amount of ODA disbursed to Africa, south of the Sahara, in million 1990 US dollars. The annual assistance has grown from about 4 billion in the early 1970s to about 18 billion in the early 1990s (both in constant 1990 US dollars). Figure 2.1 depicts the trend in ODA flows over the period 1970-1993.

The vast change in the level of external assistance after 1973-74 was precipitated by a number of factors, beginning with the extensive drought in the Sahel region. This was a key factor that led to a sizeable increase in ODA flows to Africa. A sizeable share of the increased resources mobilized for the region during the 1970s was devoted to emergency relief and refugee settlement programs, as

Table 2.4 **ODA flows to Africa, south of the Sahara, 1970-1993, in 1990 US million dollars**

Year	$ million	Year	$ million
1970	4017	1982	11046
1971	4419	1983	10340
1972	4511	1984	10213
1973	5355	1985	10842
1974	6918	1986	12746
1975	8497	1987	14345
1976	8031	1988	15752
1977	8442	1989	16020
1978	10341	1990	17891
1979	11898	1991	16842
1980	12759	1992	17870
1981	11645	1993	15862

Source: OECD, 1995b

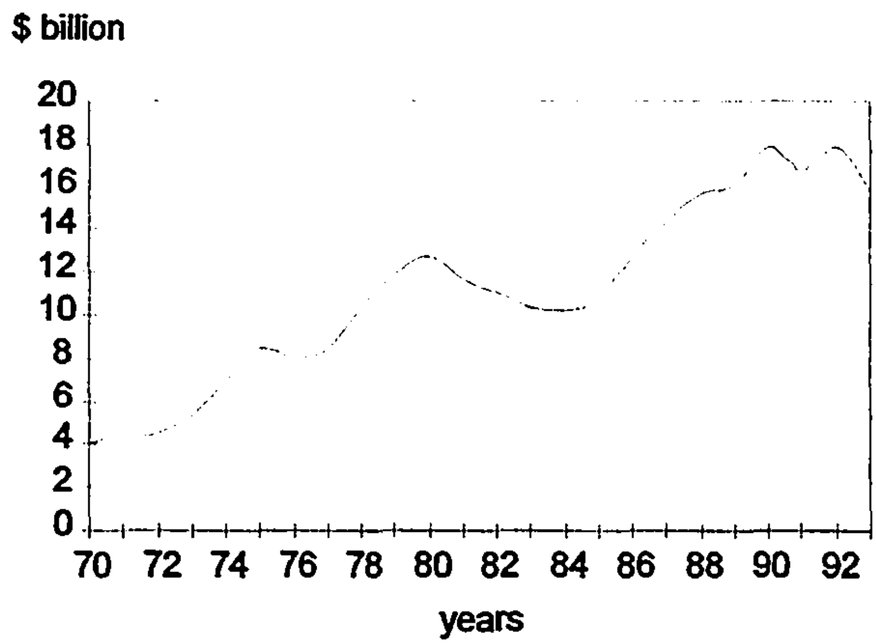

Figure 2.1 ODA flows to Africa, south of the Sahara

civil strife and drought led to growing streams of refugees. This was especially the case in the Sudan, Somalia and the Sahelian countries. Accelerated investment in agriculture, industry and infrastructure in some Sub-Saharan countries (for example in the Sudan, Tanzania, Kenya, Zaire and Zambia) led to a great increase of commitments of external assistance during the 1970s (OECD, 1987).

Much of the development assistance to SSA during the mid to late 1970s was in the form of project assistance and focused on social aspects of development namely health, nutrition, education, housing, and employment, all termed as "basic needs". Agriculture assumed a much greater role in the development programs and a number of agricultural and rural development projects were created in an attempt to increase agricultural output and rural incomes (Lele, 1991).

Total disbursements of ODA to all regions experienced a slow growth in the early 1980s. In the 1980s, many LDCs were heavily burdened by debts incurred through previous borrowing abroad - a phenomenon referred to as the "debt crisis". The African drought in 1984 further magnified the macroeconomic problems in the region and donors responded by increasing ODA commitments to SSA. Figure 2.1 shows that there was an increase in ODA flows to Africa following the 1984 drought.

The focus of development assistance shifted from "basic needs" to internal policy reform as more donors agreed that sound macroeconomic and sectoral policies were prerequisites for effective intervention in support of growth. During the 1980s structural adjustment lending became an important instrument of reform. Between 1987 and 1992, 31 countries in SSA had undertaken adjustment programs (World Bank, 1994c). The main policy reforms implemented under these programs have included the following: reduction in public expenditure, control of money supply and credit creation, reduction of subsidies, devaluation of domestic currencies, liberalization of foreign trade, decontrol of prices in all markets and increase in the role of the private sector.

Despite the emphasis on macroeconomic adjustment, two other themes were also characteristic of the 1980s: food security and sustainable development. The worldwide publicity of the 1984-85 famine in Africa caused food security issues to be analyzed from the national and household level. In 1989, the World Bank prepared a major long term perspective study of Africa's development concerns highlighting agriculture as the critical sector (World Bank, 1989).

External financing to SSA in the 1990s will continue to be dominated by credit on concessional terms from official sources. The prospects of attracting investment will be limited until the supply bottlenecks can be addressed, which entails heavy investment in both physical and human infrastructure. Because of the increase in the demand for external finance from other countries (especially from the newly independent countries in Eastern Europe), and the increasing donor scrutiny of domestic policies, the high level of ODA flows to Africa may not be maintained throughout the 1990s. One of the major challenges for SSA is to use these aid funds to create a sound and stable environment in order to attract private capital thus breaking away from aid dependency (OECD, 1994). It is imperative that the region improve its macroeconomic environment and supporting infrastructure in order to attract private investment which will facilitate growth into the next decade.

2.3 ODA AND AFRICAN AGRICULTURE

This study rests on the assumption that there is a relationship between ODA and agricultural production in SSA. In order to assess the impact of ODA to the region, it is important to note the role and performance of the agricultural sector in SSA. Following is a brief review of the agricultural and overall economic performance in SSA.

2.3.1 African agriculture

Sub-Saharan Africa consists of all countries south of the Sahara except for South Africa. It covers an area of about 2,100 million hectares and in 1993 the population was over 400 million (World Bank, 1995a). SSA is comprised of 46 countries of which 6 are island nations. Following La-Anyane (1985) the vast subcontinent can be divided into four main agro-climatic regions; Sudano-Sahel, Western Africa, Central Africa and Eastern and Southern Africa (Figure 2.2).

Much has been written on Africa's poor agricultural and overall economic performance. Notably, two World Bank reports, "Accelerated Development in Sub-Saharan Africa: An Agenda for Action" and "Sub-Saharan Africa: From Crisis to Sustainable Growth; A long term perspective study" provide a comprehensive review of Africa's economic plight (World Bank, 1982, 1989). However a few salient facts on African agriculture deserve mention here.

SSA is characterized by a high share of agriculture in economic activity and the labour force. On average agriculture accounts for over 65 percent of gross

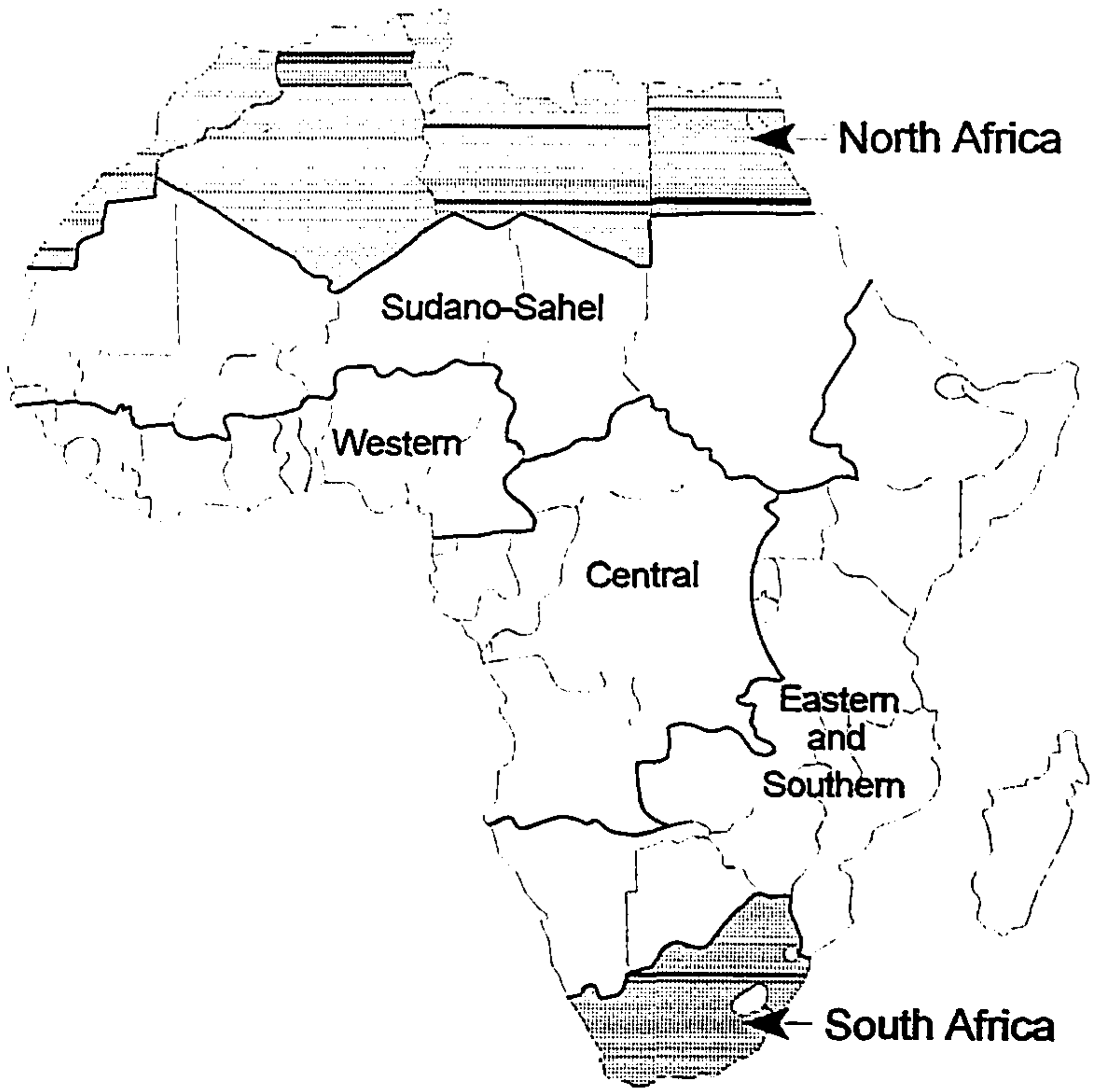

Figure 2.2 Sub-Saharan Africa

domestic product (GDP), provides employment for over 60 percent of the economically active population and contributes 50-60 percent of total exports (African Development Bank, 1990). The dominance of agriculture in the African economy implies that growth in agriculture and overall economic growth go hand-in-hand. Hence the World Bank (1989) proposes that to achieve the economic growth objective for SSA of at least 4 to 5 percent a year, it requires that agriculture grows by at least the same amount.

However past agricultural growth rates are not encouraging. Between 1960 and 1985 agricultural production in SSA rose by only two percent per year (Harrison, 1990). The author attributes the following unfavourable factors to the observed poor agricultural performance: a combination of low levels of use of modern inputs, unattractive producer prices, lack of investment in agriculture and low rainfall in parts of the continent. In addition, the Green Revolution technologies spreading in Asia had hardly been identified, let alone adopted, over most of Africa.

Moreover, agricultural production in the 1980s did not keep up with the rapid growth in population; from 1980 to 1990 the average growth of 2.1 percent in agriculture in SSA was less than the average population growth rate of 3.1 percent (Lele, 1991). Noting that more than 70 percent of the population in SSA depend on agriculture for their livelihood, this trend represents a continuing internal shock.

Other economic indicators also reveal sobering facts on the performance of the economies in SSA. In general, the economic history of the continent over the past three decades can be described as follows: the 1960s - a period when economic growth outpaced population growth; the 1970s - the decade when growth slowed and per capita income growth was often negative; and the 1980s when most economies either stagnated or declined and stabilization and adjustment programs were introduced. A number of explanations have been posited for the cause of the economic deterioration in the 1980s. For many countries the external environment continues to be hostile as reflected by adverse weather conditions, chronic deterioration in the terms of trade, increased interest rates and oil price hikes. Internal shocks have also contributed to the observed weakness in economic performance and include such factors as inappropriate domestic policies, inefficient public administration and judicial systems, ethnic conflicts, political instability, civil wars and repressive regimes.

For most African economies, one or two commodities account for more than 50 percent of exports, making the economies sensitive to changes in terms of trade. For the whole region, the decline in the world commodity prices has led to a large cumulative decline in the terms of trade for SSA, amounting to 37 percent between 1986 and 1993 (Hadjimichael et al., 1995). During 1965-73 export earnings grew at a rate of about 9 percent per annum but plunged to negative levels between 1981 and 1986 (World Bank, 1994c). In the 1990s, export earnings rose at an annual average of about 2 percent for the period 1987-91. But the decline in exports has not kept pace with that of imports; for 1986-93 the average annual growth of imports exceeded the growth in exports and real GDP (Hadjimichael et al., 1995).

Gross national savings as a percentage of GDP have fallen from 12.9 percent in 1976-85 to 11.8 in 1986-92. Investment as a percentage of GDP has remained at relatively constant levels; 18.8 in the period 1976-85 and 18.6 between 1986 and

1992 (Hadjimichael et al., 1995). These savings and investment ratios for SSA are significantly lower than for other LDCs and still too low to support a sustainable expansion in output and employment. Given the deterioration in the terms of trade, the decrease in export volumes, low investment and savings ratios, external borrowing throughout SSA have risen significantly.

Despite the heterogeneous nature (ecological zones, systems of government, languages, religions, and ethnic groups) of the group of countries in SSA, virtually all countries have gone through the same kind of economic evolution and difficulties highlighted above. In light of this common feature the World Bank (1989) (in their long term perspective study) has identified the principal policy measures that will be required to enhance agricultural development in the 1990s. These measures aim at building the capacity of African institutions, developing human resources, improving economic governance and halting environmental degradation.

Notwithstanding the difficulties over the past years, several African countries have made major progress in improving their economic performance during the early 1990s. Responding to these difficulties 31 countries have had structural adjustment programs in place at some point between 1987 and 1992 (World Bank, 1994c). Assuming that the commitments to reform among the African economies will not waver, then long run sustained growth may be achieved. Structural adjustment programs are impossible to implement and sustain without financial support from foreign sources. It is consequently necessary that future funding requirements be addressed so that the goals of structural adjustment and growth do not become impossible to achieve.

2.3.2 Justification for ODA

Section 2.2 highlights the large share of ODA in total external resource flows to SSA. In addition ODA is a sizeable share of GDP and gross domestic investment (GDI). The average annual shares of ODA in GDP during the periods 1975-79 and 1986-92 were 3.2 and 9 percent respectively (World Bank, 1994b). The share of ODA in GDI has also grown; the annual average of ODA as a percent of GDI for the following years 1975-1979, 1980-1985 and 1986-1992 were 26.1, 40.1 and 63.3 percent respectively (World Bank, 1994b). Many countries in SSA have a limited domestic revenue base and noting the increasing share of ODA in external financial flows implies that government investment in SSA is largely dependent on ODA (Hadjimichael et al., 1995).

The argument is not whether ODA will be of greater benefit to the economy than other forms of external finance, but whether the qualitative difference, especially to poorer LDCs, between ODA and other flows, will improve the effectiveness of aid. Poor countries have limited access to commercial funds and hence ODA is of even more value to these countries (Cassen and Associates, 1994). The authors state that there is a high opportunity cost associated with not receiving ODA, especially since ODA plays a primary role in relieving the constraints to development. They go further by emphasizing the case for ODA as an instrument to ensure the survival of a society, such as the ODA disbursements in response to the African drought in 1984. Thus, monitoring ODA to SSA is of special importance because of its significance for the economic performance of the region.

In this study it is hypothesized that total ODA is of benefit to a country as a whole and can also benefit agriculture. ODA in support of agriculture is part of total ODA. There is no consistent data on the portion of total ODA going to the agricultural sector and hence in this study, the effect of total ODA on agricultural production is examined. ODA is used for a diverse set of activities broadly grouped under social and administrative infrastructure, economic infrastructure and production. To facilitate agricultural marketing, adequate roads and communications are required. Electricity supply greatly assists in the simple processing of agricultural products. Of no less importance, but less obvious, are the benefits to the whole economy that accrue from investment in education and health. It is well known too, that the adoption of new technologies is more rapid among educated farm families (Lockheed et al., 1980). It is no accident therefore that ODA directed to a country as a whole will have benefits for the agricultural sector. In SSA, where agricultural production alone provides almost a third of GDP, about 60 percent of total employment and more than half of all export earnings, the benefits of total ODA to the agricultural sector cannot be underestimated. On these premises rest the justification of the potential effectiveness of ODA to African agriculture.

As noted in Table 2.3, ODA directed to the agricultural sector has accounted for at least 8 percent of total ODA. The most comprehensive data available on the uses of financial assistance in the agricultural sector is provided by the World Bank. Table 2.5 shows the percentage of total agricultural lending by the World Bank to Africa by sub-sectors based on a review of the performance of 887 projects undertaken between 1970 and 1985. Forty percent of World Bank agricultural

Table 2.5 Total agricultural lending to Africa by sub-sector, 1970-1985 (in percent)

Agricultural sub-sector	Percentage share of lending
Irrigation and drainage	10
Credit / finance	4
Area development	40
Perennial crops	16
Agro-industries	4
Livestock	8
Sector adjustment loans	8
Research and extension	1
Forestry	6
Fisheries	1
Other	3

Source: World Bank, 1994d

funding has been devoted to area development. Area development is the term used by the World Bank for what is commonly called "integrated rural development". Area development is aimed at eliminating rural poverty, by overcoming the common causes of rural poverty, namely - physical remoteness, poor infrastructure, and restricted and declining resources. Area development includes funding projects for physical infrastructure, education and training, health and nutrition and marketing. Sector adjustment loans were first initiated by the World Bank in 1979, and aimed at the restructuring of parastatal marketing agencies, government farms and public processing units. Lending approaches for sector adjustment loans have aimed at increasing the role of the private sector in the production, processing and marketing of agricultural produce.

The main theoretical case for postulating that aid should have an impact on African agriculture rests on the fact that in Africa, ODA is a major share of investment and that agriculture is the dominant sector. Noting the purposes for which ODA is used, ODA is perceived as a general development tool that creates an enabling environment to ensure adequate performance of the agricultural sector. More aid has been flowing to SSA precisely because of the need for external finance to stimulate and maintain economic development. It is thus evident that foreign aid may be an important influence on the performance of the agricultural sector. Hence, the task of this study is to quantify the effects of ODA on agricultural production in SSA.

CHAPTER 3

LITERATURE REVIEW

The first section of this chapter presents some of the capital-orientated growth models and economic arguments that have been used to justify foreign capital transfers to LDCs. Then a review of the previous studies on the effectiveness of aid to the agricultural sector is presented. Finally the chapter ends with a specification of the theoretical model.

3.1 DEVELOPMENT ASSISTANCE AND ECONOMIC THEORY

During the 1950s and the 1960s a number of LDCs became independent and this was accompanied by demands for large amounts of foreign assistance (Mikesell, 1983). Some economic arguments were formulated during this period based mainly on the implications of external finance for growth and capital accumulation. Following is a brief description of some of the growth models that lend support to the need for external finance in the development process of LDCs.

3.1.1 Rostow's stages of growth model

According to Rostow (1971) the transition from underdevelopment to development comprises five stages through which all countries proceed, namely (i) the traditional society, (ii) the pre-conditions for the take-off, (iii) the take off, (iv) the drive to maturity, and (v) the age of high mass-consumption. Rostow (1971) explains that the take-off stage is where modern economic activity expands and dominates society. The take-off may fail if domestic savings are not sufficient to mobilize investments in other sectors, particularly manufacturing. Rostow (1971) suggests that capital imports may be used to supplement domestic savings in order to facilitate the level of investments necessary to increase economic growth.

Development economists seized upon Rostow's (1971) suggestion of the use of foreign capital to supplement domestic savings in the take-off stage, to justify the provision of large amounts of development assistance to developing countries (Mikesell, 1983). The take-off hypothesis was applied to a number of LDCs that sought foreign assistance from industrialized countries for the promotion of economic growth. This hypothesis provided the underlying rationale for external capital requirements for LDCs and estimates were made to determine the appropriate magnitude of the external flows.

3.1.2 The two-gap planning model

The basic concept of the two-gap planning model is that economic growth is constrained by a scarce supply of productive factors (Chenery and Strout, 1966). The authors claim that when sustained growth is limited by a shortage of skills, savings or foreign exchange, there is underutilization of other factors, e.g. labour, natural resources and specific types of productive capacity. Thus, the basic argument of the two-gap analysis is that external finance can be used to fill either a savings gap or a foreign exchange gap, thereby allowing fuller utilization of all resources and a continuation of development.

Chenery and Bruno (1962) suggested that a LDC experiences one of the two gaps at a given point in time, according to whether the dominant constraint on growth is a lack of foreign exchange or capital. This approach assumes a predetermined target rate of growth with a corresponding capital-output ratio. It follows that a specific saving rate is required to achieve the targeted growth rate. Similarly, a level and rate of growth of imports is derived from the postulated fixed relationship between imports and growth of output (Chenery and Strout, 1966).

It is further claimed that a savings gap appears when the domestic savings rate is below the level necessary to permit the investment required to achieve the target rate of growth. In this situation, imports are adequate and foreign exchange is used to carry out additional investment projects. The foreign exchange gap is binding when adequate savings are available but the flow of imports is below the required level. Most LDCs are assumed to fall into this latter category.

Based on the concept of structural disequilibrium, Chenery and Strout (1968) proposed that the typical LDC moves through three distinct stages of growth, namely, a skill-limited phase, a savings-limited phase and a trade-limited phase. Each phase is characterized by a gap-filling function of aid, thus determining aid requirements when there are different sets of limiting factors. The authors have defended this model of growth regimes on the basis of inductive evidence of the data of 50 countries in a comprehensive study in 1966. Furthermore, Chenery and Strout (1968) suggest that the concept of the phases should not be analyzed as a historical sequence but rather as a planning device. In a later paper, Chenery (1969) clarified that the sequence of the phases is not central to the analytical scheme; the most important issue is to raise the savings and trade limits through optimal policies, including the use of foreign aid.

The two-gap planning model played a dominant role in US foreign assistance programmes during the 1960s (Krueger and Ruttan, 1989; Mikesell, 1983). This could not have been at a more appropriate time, as resources for bilateral and multilateral aid programmes were expanding rapidly.

Criticism of the two-gap planning model is based on the central role given to capital in the growth process. Fei and Ranis (1968) argue that more attention should be paid to the change in the learning processes that facilitate economic growth (e.g. knowledge on how to save, invest and export), rather than on how to calculate foreign aid requirements. Another criticism of the two-gap model relates to the fungibility of foreign aid. It is argued that the aid process is undermined because foreign development assistance is diverted to other categories of development expenditures or from development purposes to current expenditures. Proponents of two-gap planning models (and those advocating for external aid in general) have been troubled by this widely acknowledged possibility that aid is fungible.

According to Krueger and Ruttan (1989) the two-gap model remains to date "the most ambitious attempt - even if flawed - to integrate a theory of economic assistance and economic development" (p. 43). In some World Bank studies the long-term needs for capital inflows of LDCs continues to be estimated using the two-gap model (Krueger and Ruttan, 1989).

A shift away from the almost exclusive emphasis on increasing capital as the way to achieve economic growth, occurred as other studies revealed a more general equilibrium view of development. Schultz's (1964) work on the importance of human capital was a big advance in calling attention to the complexities of growth. His view of the sources of economic growth took into account the improvements in the quality of both human and material inputs. Schultz (1964) attributed a significant role to the quality of human resources, which included education, health and nutrition. Studies of economic growth needed to take into account improvements not only in material capital goods, but also in the skills and other capabilities of man. Schultz's (1964) work reasserted the vital role of the individual in generating economic growth.

Classic growth theory began by classifying the factors of agricultural production into three broad groups, land, labour and capital, with the state of technology held constant (Schultz, 1964). But as economic growth took place, it became clear that not only did technology change, but it also became one of the most important variables in the growth equation. A major role was assigned to technological change in accounting for growth in LDCs; the Green Revolution technologies spreading in Asia in the late 1960s provided evidence on the role of productivity and technical progress in growth.

The capital-oriented models were further undermined as a number of development programmes failed in countries that were recipients of large amounts of aid. This was part of the growing body of evidence that revealed that the policy environment is an important contributory factor to growth. The next two sub-sections review the role of technical assistance and policy in the transfer of external resources to LDCs.

3.1.3 Technical assistance

Aid intended to raise output by changing the methods of production and enhancing the productivity of factors is termed as technical assistance. During the 1950s and early 1960s there was no clear intellectual foundation on the role of technical assistance (Krueger and Ruttan, 1989). Early agricultural development programmes emphasized direct transfers of agricultural technology from high-income countries to LDCs because it was believed that LDCs would automatically increase their productivity by adopting agricultural practices and technology from industrialized countries (Staaz and Eicher, 1990). Many of the technical assistance efforts by national and international agencies failed during the 1950s and 1960s because it was not recognized that many agricultural technologies were location- specific.

By the late 1950s advances were being made in the understanding of the role of technical assistance in economic growth. Wolf (1960) clarified that technical assistance and capital assistance should not be taken as alternative activities but rather as complements in the development process. Technical assistance usually requires the introduction of new factors of production. Capital assistance on its own would raise output by only a small amount than what would be possible if it were accompanied with a change in technology. These ideas were much in line with Solow's (1957) model which embodied new technology in new capital equipment. Solow (1957) argued that the rate of productivity growth is, in part, a function of the rate of growth in capital inputs.

Johnson (1963) formulated a generalized capital accumulation approach which provided a broader concept of the sources of economic growth. This approach suggests that economic growth does not only entail investment in material capital but also investment in a set of diverse activities that add to material capital. The author suggests that investment should be made in the areas of health, skill and education of the human population, moving labour to more productive occupations and locations, and institutional arrangements that support application of existing knowledge and the discovery of new knowledge. In this perspective capital is taken as anything that yields an income stream over time. Johnson's (1963) approach shifted the attention away from the earlier technical transfer approach to a more balanced investment in complementary types of capital such as modern equipment and technology, a skilled labour force and social infrastructure. Johnson (1963) also highlighted the importance of planning for economic development, in which policy decisions would allow for the allocation of investment resources so that incentives were created for the efficient use and accumulation of all types of capital.

3.1.4 Government policy

Not until the debt crisis of the 1980s was the impact of government policies on growth given the much needed attention. It became evident that only limited growth could be realized from the simple transfer of financial resources. Until then many economists seemed to have forgotten the preconditions for the take-off as specified by Rostow (1971), the role of optimal policies in the three limiting phases of the two-gap planning model, and the broader concepts of Johnson's (1963) generalized capital accumulation approach.

In the 1950s and 1960s, development was defined in terms of growth in average per capita output and during this period development assistance agencies were concerned about macroeconomic issues. In the 1970s however, aid was directed towards sectors and projects and a policy shift occurred towards microeconomic concerns under the themes of integrated rural development and the basic needs approach. The dawn of the debt crisis in the early 1980s caused a major swing back from micro to macro concerns. Macro policy reform was the dominant development theme of the 1980s. Many LDCs embarked on structural adjustment programmes which focused on devaluing over-valued currencies to increase export competitiveness; raising agricultural producer prices to stimulate production and exports; increasing consumer prices and lowering input subsidies to reduce budget deficits; and reducing the role of public enterprises to increase market efficiency and reduce government expenditure.

A number of studies have investigated the ways in which macroeconomic policy impinges on economic growth in LDCs. These studies have included the effects of the following components: monetary and fiscal policies, exchange rate policies, price control policies, import substitution policies, tax policies, trade policies, etc. Killick (1985), in a review of the effects of macroeconomic disequilibria on agriculture, concludes that a poor macroeconomic environment will have damaging effects on agricultural performance. The author notes that without the appropriate macroeconomic environment, micro policies directed to the farmer will not bring about the intended results. Killick (1985) further observes that when a country experiences large macroeconomic imbalances as a result of policy weakness, the volume of development assistance that the country receives is likely to decline as a result of donor dissatisfaction with the recipient country's policies.

Arguments that have been used to justify development assistance to LDCs have evolved much in the past 30 years. What has clearly emerged over time is that the contribution to economic growth is to be found in an interdependent package composed broadly of capital, technical assistance, institutional building and policy reform. Even as development assistance continues to be directed to LDCs in the traditional form for poverty alleviation, human development and the building of infrastructure, aid should also be linked to improving the political and economic feasibility of implementing the reform programmes that many LDCs have adopted in recent years. Improved domestic policies in aid receiving countries will create an incentive structure for the efficient use of resources and facilitate an increase in the flow of development funds to LDCs. This will help steer many LDCs into the mainstream of the world economy thus accelerating the growth of world output.

3.2. PREVIOUS STUDIES ON THE EFFECTIVENESS OF AID

A few studies have attempted to evaluate the effects of development assistance at the level of the agricultural sector. In this section these studies are reviewed.

3.2.1 Foreign aid and agricultural imports

The studies by Pinstrup-Andersen et al. (1995) and Kherallah et al. (1994) are both aimed at investigating the link between foreign assistance to agriculture in

LDCs and export opportunities for donors. These studies attempt to counter the assertion made by farm groups in donor countries, that agricultural assistance to LDCs reduces industrialized countries farm exports.

A number of studies have looked more closely at the relationship between agricultural productivity in LDCs and the demand for imports. The results have been varied. Paarlberg (1986) found that there is no decisive evidence to determine the changing patterns of poor country farm trade from short or intermediate term farm production changes; de Janvry and Sadoulet (1986) suggested that growing agricultural imports are realized in countries experiencing strong agricultural and economic growth; Houck (1989) found that increases in agricultural productivity lead to positive income effects associated with increases in imports of cereals and other agricultural products; Anderson (1989) showed there is a positive correlation between agricultural output growth in LDCs and agricultural import growth from the developed countries; Wu and Yao (1992) found no causality in the relationship between agricultural growth and farm imports in LDCs - where there was a causal effect, there were both positive and negative results

However Vollrath (1994) documented that in 1992, 40 percent of all US agricultural exports were sold to developing market economies. As income increases in both lower and middle income countries, a food gap in production and demand in LDCs is expected to provide a powerful driving force to expand agricultural exports from the US. This argument is much in line with the argument that donor countries are motivated to provide aid because of economic self-interest concerns. The economic self-interest argument rests on the assertion that aid promotes exports from and employment in the donor country (Ruttan, 1989). The author also notes that the US economy may gain from exports of goods and services that are subsidized by development assistance programmes. Norton and Alwang (1993) agree with this line of argument and state how producers of food grains in the US might benefit from food aid programmes since less grain is placed in the domestic market hence raising local prices. Another argument that has been used to rationalize development assistance efforts, is the role of aid in strengthening commercial ties between donors and recipients of aid (Ruttan, 1989). During the period when external funds are used for the development of rural roads, irrigation projects, health improvement programmes, etc, commercial contacts are made which initiate the opening of markets for exports from the donor country.

In the study by Pinstrup-Andersen et al. (1995) calculations are made to estimate the value of additional imports created by foreign assistance to agricultural research. The authors draw upon various studies to assert that (i) agricultural research increases agricultural productivity, (ii) agricultural growth leads to economic growth, and (iii) economic growth increases imports. From these postulations the authors quantify the effect of agricultural research on imports in LDCs.

Based on data for 60 LDCs for the period 1970 to 1992, Pinstrup-Andersen et al. (1995) estimate that on average for all LDCs, a $1 increase in agricultural growth leads to an increase of $0.73 in the value of imports, of which $0.17 are agricultural imports and $0.07 are cereal imports. However this result varies across geographical regions and income groups, but in all cases agricultural growth increases overall imports. High income LDCs show the greatest increases in imports.

Since the benefits of agricultural research result in increases in agricultural production for a number of years, the authors calculate the value of imports generated over time. Assuming a 40 percent annual rate of return over 30 years for a typical agricultural project, the authors found that a $1 investment in agricultural research over this period of time generates $4.39 of additional imports, of which $1.06 are agricultural imports and $0.45 are cereal imports. Again high income countries generate the most additional imports.

The purpose of the study by Kherallah et al. (1994) was to empirically test the relationship between ODA on the one hand and agricultural growth and agricultural imports on the other. Using two-stage least squares, a system of simultaneous equation systems for agricultural growth, savings, ODA and agricultural imports were estimated for 55 LDCs over the period 1975 to 1990. The equations were specified as follows:

1. The agricultural growth equation:

$$GRA = f(\sum \beta_j ODA_{t-j}, SAV, FPI, AGTR, TOT, OVER, DEF, ARES, INF, SZ, REG1, REG2, REG3)$$

Agricultural growth was specified as a function of lagged ODA[1] ($\sum \beta_j ODA_{t-j}$), gross domestic savings (SAV), foreign private investment (FPI), net agricultural exports (AGTR), terms of trade (TOT), overvaluation of the exchange rate (OVER), budget deficit (DEF), national agricultural research expenditures (ARES), inflation (INF) and

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1/ A quadratic distributed lag of ODA was used to estimate the effect of current and past aid on agricultural growth. The ODA lag structure was specified as a 6 year second order polynomial with constrained end-points, imposing that the effect of ODA starts with current aid and ends at the sixth lag.

population size (SZ). Dummy variables were incorporated for different regions; Africa (REG1), Latin America (REG2) and West Asia/North Africa (REG3).

2. The savings equation:

SAV = g (ODA, GRA, GRNA, FPI AGTR, NAGTR, PCY, DR, TAXR)

Savings were expressed as a function of ODA, growth rate of agricultural output (GRA), growth rate of non-agricultural output (GRNA), foreign private investment (FPI), net agricultural exports (AGTR), net non-agricultural exports (NAGTR), per capita income (PCY), dependency rate (DR) and tax revenues (TAXR).

3. The ODA equation:

ODA = h (GRA, GRNA, SAV, NAGIMP, AGIMP, PCY)

ODA was expressed as a function of growth rate of agricultural output (GRA), growth rate of non-agricultural output (GRNA), savings (SAV), non-agricultural imports (NAGIMP), agricultural imports (AGIMP) and per capita income (PCY).

4. The agricultural imports equation:

AGIMP = j (ODA, GRA, PCY, FEL, INF)

Agricultural imports were specified as a function of ODA, growth rate of agricultural output (GRA), per capita income (PCY), foreign exchange holdings (FEL) and the rate of inflation (INF).

Kherallah et al. (1994) made the following conclusions from their results:

i. ODA has had a significant impact on agricultural income growth in LDCs during 1975-1990 period. Aid leads to larger food imports and supports the hypothesis that development assistance promotes agricultural growth.

ii. Aid is more likely to be directed to countries with low savings rate, for example SSA. The poorest countries receive greater amounts of aid because as per capita income increases, ODA decreases.

iii. Agricultural imports and ODA are positively related. Aid fills a trade gap and promotes trade ties between donor and recipient countries.

On the basis of the studies by Pinstrup-Andersen et al. (1995) and Kherallah et al. (1994), it can be concluded that foreign aid leads to increases in agricultural imports of LDCs by contributing to agricultural income growth and overall economic growth. These findings suggest that foreign aid is in the interest of industrialized countries and LDC farmers. Pinstrup-Andersen et al. (1995) describe their result as a win-win proposition for both donor and recipient countries.

3.2.2 Foreign aid and agricultural production

Norton et al. (1992) and Rai (1987) both used a Cobb Douglas production function model to analyze the effects of foreign assistance on agricultural productivity. Both studies also used panel (cross section over-time) data for LDCs.

In the study by Rai (1987) agricultural output was regressed on the following independent variables: livestock, labour, land, tractors, education, foreign aid and fertilizer. The foreign aid variable was specified as a 6 year second order polynomial lag to account for the effect of aid over time. Various models were estimated to incorporate regional differences, income levels, yearly factors and particular countries.

In general the results from Rai's (1987) study indicate a negative relationship between foreign aid and agricultural productivity in developing countries. Only the model that includes dummy variables that account for regional differences of aid effects, showed positive results for some regions but negative and insignificant results for other regions; foreign aid effects were positive and significant in Latin America, positive and insignificant in Europe, and negative and insignificant in the Middle East, Mexico and the Caribbean, Asia and Africa. Rai (1987) explained this inconclusive result as being due to two main reasons: one is the lack of appropriate data for all variables and that total ODA is used instead of a specific measure for agricultural aid; the second reason is the aggregation of all the countries into a single sample despite the different characteristics within the sample. What Rai (1987) does not mention are the estimation problems encountered due to heteroscedasticity resulting from the large differences in country size. The variables would need to be expressed on a per unit basis to enable some inferences on scale economies to be made across countries.

Norton et al. (1992) have attempted to correct data quality and heteroscedasticity problems encountered in the Rai (1987) study. The authors used a newly constructed data set to estimate the effects of ODA on agricultural growth in 98 less developed countries during the period 1970 to 1985. Agricultural output was the dependent variable and was defined as the real value of agricultural GDP in US dollars. The independent variables used were livestock, labour, machinery, land quality, education and foreign aid. The output and input variables were measured on per hectare basis to reduce problems of heteroscedasticity. The foreign aid variable was expressed as a 6 year second order polynomial lag. Various models were estimated incorporating regional differences, income level, debt burden, size of the agricultural sector and the level of the fiscal deficit.

The results of the study by Norton et al. (1992) indicate that foreign assistance to agriculture since 1970 has improved agricultural productivity in Asia, and to a lesser extent in SSA. Aid in the aggregate does not appear to have increased agricultural productivity in the Middle East or in Latin America. Foreign aid was positive and significant in Asia and in Africa but negative and insignificant in the Middle East and in Latin America. The results of the analysis varied by region and were at odds (for all regions apart from the Middle East) with those obtained by Rai (1987).The results also indicate that aid has been less effective in countries with high levels of debt or sizeable fiscal deficits. High levels of external debt (more than $10,000 per agricultural worker) showed a negative and significant effect of foreign aid on agricultural output. Additional results suggest that aid effectiveness did not vary by income level of the country or by the relative importance of the agricultural sector.

In both studies (Norton et al., 1992 and Rai, 1987) all the non-aid variables were positive and significant. The coefficients of the inputs from a Cobb Douglas production function are interpreted as the elasticities of output with respect to inputs. The elasticities of output from both these production studies show close similarity when compared with the results of previous studies that have estimated aggregate agricultural production functions (Appendix A: Table A-1).

The overall conclusion that can be drawn from the studies by Rai (1987) and Norton et al. (1992) is that the effect of aid varies greatly by geographical region. In order to quantify the effects of foreign assistance on agriculture it is necessary to carry out additional analysis within geographical regions.

3.3 THEORETICAL MODEL

In this study a production function approach is used to analyze the contribution of foreign aid to agricultural output in SSA. Hayami (1969) and Hayami and Ruttan (1970) introduced the concept of global agricultural production when they explored the sources of agricultural productivity differences among countries by estimating an aggregate production function based on intercountry data. Since then, a number of studies have tested this methodology by drawing upon the "meta-production" function hypothesis developed by Hayami and Ruttan.

Hayami and Ruttan (1985, p. 34) define the meta-production function as "the envelope of commonly conceived neoclassical production functions". The neoclassical production function is described as the set of all combinations of inputs that comprise a technologically feasible way to produce the maximum possible output (Varian, 1990). Hayami and Ruttan (1985) take the meta-production function to represent the envelope of the most efficient production points presently available in the world. They argue that the growth of the agricultural sector depends on the capacity to adapt to changes in productivity by adjusting to a more efficient point on the meta-production function. They also hypothesize that differences in agricultural productivity among countries can be accounted for (to a large extent) by differences in resource endowments, technical (modern) inputs and human capital. Sufficient human capital in the form of educated farmers, competent researchers and public administrators is perceived to be instrumental for exploiting new technologies. Trueblood (1989) summarizes the meta-production function hypothesis to state "that all countries have access to the same technology, that each country can produce a given level of output using different factor proportions, and that human capital is what allows countries to produce at the technologically most efficient levels at a point in time" (p. 1045).

Hayami and Ruttan (1985) following their earlier work in 1970, estimated an agricultural production function using intercountry data for 1960, 1970 and 1980. A sample of 43 countries was used in the study; 21 developed countries and 22 developing countries. Economic theory presents the traditional factors of production as land, labour and capital. Conventional inputs are those traditional choice variables in farmers' decisions while the non-conventional inputs are those factors that affect agricultural productivity which producers have no control over e.g. macroeconomic environment, weather, etc. In the Hayami-Ruttan study (1970 and 1985) the factors that were estimated (the "conventional" inputs) included land, labour, livestock, fertilizer and machinery. The "non-conventional" inputs were general education and technical education. Land and livestock served as proxy variables for resource endowments, machinery and fertilizer for technical inputs and general and technical education in agriculture for human capital.

The algebraic functional form chosen for the production function was the Cobb Douglas. The justification for the use of this functional form was based on the ease of manipulation and interpretation. Hayami and Ruttan (1970, 1985) interpret the coefficients of the variables to indicate the elasticities of production with respect to inputs. The authors continue to state that given the input variables are specified correctly, the coefficients also indicate the relative importance of each input as a source of differences in agricultural output among countries. The intercountry agricultural production function estimated by Hayami and Ruttan (1985) was expressed as:

$$\log Y = \log\delta + \alpha_L \log L + \alpha_A \log A + \alpha_S \log S + \alpha_F \log F + \alpha_M \log M + \beta_E \log E + \beta_T \log T \qquad (3.1)$$

The variables were represented as: agricultural output (Y), labour (L), land (A), livestock (S), fertilizer (F), machinery (M), and general and technical education (E and T, respectively). The α terms represented the production elasticities of the conventional inputs while the β terms represented the production elasticities of the non-conventional inputs. The intercept term was denoted by δ.

The underlying assumption in the approach used by Hayami and Ruttan is that all countries produce on the same production function. Hayami and Ruttan (1970, 1985) recognize that agricultural producers in different countries, and within different regions of the same country, may be on different micro production functions. The meta-production function is taken to encompass all the known and potentially discoverable agricultural techniques thus it describes the full range of technical alternatives available to agricultural producers across countries. A key assumption of the meta-production function is that all countries have access to the same technology. In this framework, technical change in agriculture is generated in response to changes in relative factor and product prices. The authors note that this involves (i) movement along a fixed production surface, and/or (ii) creation of a new production surface which is optimal for the new set of prices (Hayami and Ruttan, 1985).

The meta-production function is the common underlying production function that can be used to represent the input-output relationship of a given industry, eg agriculture, in all countries. Figure 3.1 shows the meta-production function and illustrates how agriculture adapts to changes in profitability. Movement towards an optimum position on the meta-production function involves the development and adoption of new techniques if the change in profitability is perceived to be sufficiently long lasting. The position of each country on the meta-production function thus reflects the factor-price ratios in that country.

3.3.1 Criticism of the meta-production function

Criticism has been raised on various aspects of the meta-production function. The most pertinent of these objections include:

1. The assumption that world agriculture can be represented by a single mode of production.

Trueblood (1989) documents how many economists reject this assumption because the aggregate production function is said to disguise many alternative micro level production functions. The theoretically attractive property of the meta-production function hypothesis is the assumption that all producers have access to the same technology, but constraints such as resource endowments, relative prices of inputs, economic environment, etc, cause each country to operate on different

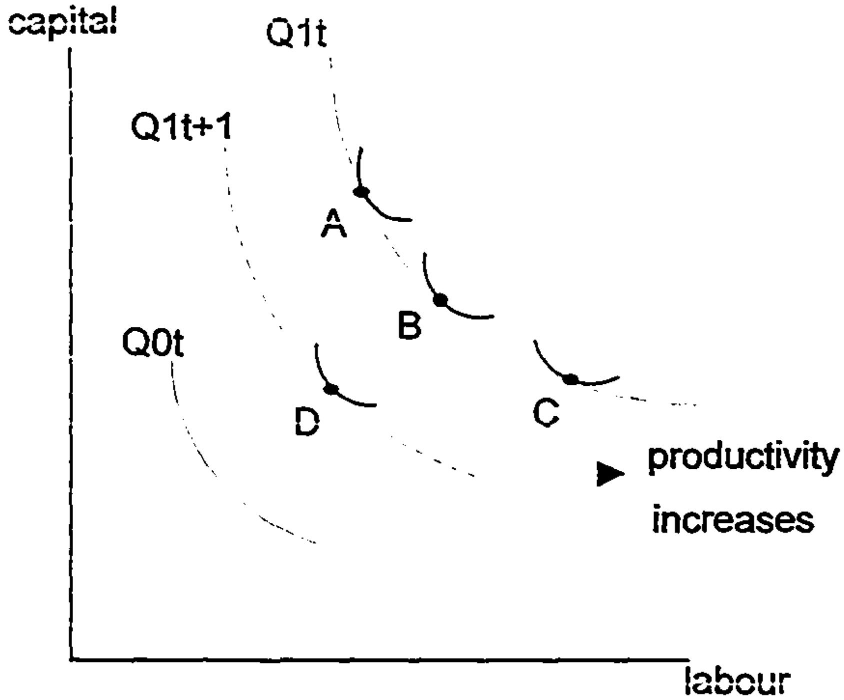

Figure 3.1 The meta-production function
For a given level of output Q1t, different countries (represented by points A, B, and C) may produce the same quantity using different factor proportions. Different output levels may be observed between countries (Q0t to Q1t), but this is only due to a size scaler. Over time, new technology increases productivity, for example by shifting the meta-production function inward (Q1t to Q1 t+1) ("input-saving" technology) (Trueblood, 1989).

parts of the meta-production function. Hence the total factor productivity level of each country is measured as a function of non-conventional inputs.

Researchers who have used the meta-production function approach defend their results by comparing aggregate level estimates with micro level estimates. Hayami and Ruttan (1970) compare national aggregate data and per farm data estimates and conclude that the production structure of world agriculture, as measured by production elasticities of conventional and non-conventional inputs, is largely the same among countries. Trueblood (1989) also compares the estimated coefficients, aggregate with per capita, per hectare and per farm, obtained by various researchers and observes that the conclusion made by Hayami and Ruttan in 1970 still appears to be appropriate.

Another important consideration for expressing the production functions either by per capita, per farm or per hectare, is to account for the large differences in country and farm size in the sample. This procedure allows for inferences to be made on scale economies and reduces problems related to heteroscedasticity.

2. The choice of the algebraic functional form for the production function.

Most of the meta-production function studies have been based on the Cobb Douglas form (Haley and Abbott, 1986, and Trueblood, 1989). Haley and Abbott (1986) note that the implications of this approach is that the Cobb Douglas production function has an elasticity of substitution between pairs of inputs of exactly one. The elasticity of substitution is a measure of the extent to which one input substitutes for another along an isoquant. This is an important economic concept that allows farmers to respond to changing relative input prices by adjusting the combination of inputs that are used. This limitation of the Cobb Douglas production function is widely known since production research both in and out of agriculture has focused on the estimation of elasticities of substitution between input pairs. An alternative production function is the translog production function. A specification for the translog production function with two inputs is:

$$y = \alpha x_1^{\beta_1} x_2^{\beta_2} e^{0.5(\delta \ln x_1 \ln x_2)} \qquad (3.2)$$

Equation 3.1 can be transformed to logarithms in base 10 or natural logarithms in base e (2.71828...) and rewritten as:

$$\ln y = \ln\alpha + \beta_1 \ln x_1 + \beta_2 \ln x_2 + 0.5(\delta \ln x_1 \ln x_2) \qquad (3.3)$$

Unlike the Cobb Douglas, the translog production function does not necessarily generate elasticities of substitution of one. This is an important advantage over the log-linear function since factors may be related either as substitutes or complements. However, Hayami and Ruttan (1985) state that when they estimated the production function in the translog form and with the use of all seven variables, the results were too complicated and could not be reasonably interpreted.

3. The procedure for measuring aggregate output.

Trueblood (1989) suggests that the Hayami-Ruttan (1970, 1985) methodology of measuring agricultural output in wheat units, may be undervaluing the output in LDC's that produce uncommon staple crops (e.g. roots and tubers). Production of staple crops is tied to agronomic limits and tradition, hence a better calculation may be obtained by using a more commonly produced commodity (eg corn). Using wheat relative prices from the US, Japan and India, quantities of individual agricultural commodities produced were converted to 3 wheat aggregate output series. A single agricultural output measure was then computed from the resulting three aggregate output series by taking their geometric means.

Hayami and Ruttan (1985) have defended the use of this approach on the grounds that prices from these countries represent the high-, middle- and low-income country price patterns. The authors continue to state that taking the geometric means of the three output series eliminates any bias arising from aggregating commodities by the prices of one of the representative countries. However Rao et al.(1991) suggests that a wider selection of countries should be considered noting that distortions arise from the peculiarities of each of the three country's relative price structure. Trueblood (1989) further states that though Japan may have been used as a representative of middle income countries in the 1960's, this is certainly not the case today.

Antle (1983) has compared three alternative procedures for measuring aggregate agricultural output for a sample of 12 countries[2]; the Hayami-Ruttan approach, the purchasing power parity (PPP) method and the exchange rate conversion. The author notes that the Hayami-Ruttan method and the exchange rate conversion produced similar values while the PPP values were uniformly greater,

2/ The selected countries were: Argentina, Colombia, Denmark, Egypt, France, West Germany, India, Japan, Mexico, Pakistan, Syria, and Turkey.

and in some cases by a factor of four or more. Based on this observation Antle (1983) used the exchange rate method in his study because the values were comparable to those of Hayami and Ruttan (1985) and also due to the ease with which these rates could be computed for a large number of countries.

The exchange rate conversion is a popular method of computing measures for intercountry comparisons of sectoral output and productivity. However, there has been increasing recognition among researchers that the official exchange rates are volatile and depend upon the socio-economic and political situations prevailing in individual countries (FAO, 1993). In recent years the PPP approach has been seen as a more robust method to derive internationally comparable value aggregates of agricultural output.

A number of studies (as reviewed by Trueblood, 1989) have examined agricultural productivity differences among countries using the meta-production function approach, as it provides a useful framework for looking at global productivity issues. Studies by Frisvold and Ingram (1995) and Haley (1991) have also used the meta-production approach to examine the sources of agricultural growth in SSA. Based on the above review the meta-production function approach will be used in this study to estimate the aggregate agricultural production function for SSA and to quantify the importance of ODA to agricultural production.

CHAPTER 4

METHODOLOGY

The empirical model used for the analysis of the impact of Official Development Assistance (ODA) on African agricultural production is presented in this chapter. First, the regression equation is specified, followed by a description of the variables to be used in the analysis. A detailed description of the foreign aid lag structure is presented in the second section of this chapter. Chapter four ends with a brief discussion of the specification tests used in choosing the most appropriate form of the econometric model based on cross section and time series data.

4.1 THE MODEL

Following the metaproduction function approach proposed by Hayami and Ruttan (1985), the agricultural production function used in this study is expressed as a function of both conventional and non-conventional inputs. The general specification of the aggregate agricultural production function for Sub Saharan Africa (SSA) used in this study can be expressed as:

$$Y = f(E, F, L, S, M, P, A) \qquad (4.1)$$

where, Y denotes agricultural output. The conventional inputs are represented by fertilizer (F), labour (L), livestock (S) and machinery (M). Non-conventional inputs are represented by education (E), foreign aid (A) and structural adjustment (P).

To reduce heteroscedasticity problems resulting from large differences in country size, all variables, except education, are measured per hectare of agricultural land. The specific output and input variables, together with the measure for agricultural land used to express the variables in per hectare basis, are defined below.

4.2 SPECIFICATION AND DERIVATION OF VARIABLES

4.2.1 Agricultural output

Two different conversion procedures are used to compute aggregate agricultural output; the official exchange rate and the purchasing power parity (PPP). National aggregates of agricultural output valued in domestic currency are first deflated to 1985 domestic prices using country specific domestic price deflators for agricultural and then converted to i) constant United States (US) dollars using official exchange rates for 1985 and ii) constant international dollars using a set of PPP indices for 1985 developed by Summers and Heston (1988). Summers and Heston (1988) have estimated each country's PPP as the product of the price level of GDP and the official exchange rate. They have derived the price levels from the real income and price data obtained from a country's national accounts. Summers and Heston (1988) have computed PPP (and other variables) for the period 1950-1985 but published 1985 tables in the above publication. Since the PPP data was not readily available and did not cover the entire observation period for this study, only the 1985 data was used to compute agricultural output. Norton et al. (1992) also used the 1980 PPP indices from the Summers and Heston (1988) study for the measurement of agricultural output.

Data for agricultural output valued in domestic currency and agricultural domestic price deflators are obtained from the World Tables (World Bank, 1995). Official exchange rates are obtained from the International Financial Statistics Yearbook (International Monetary Fund (IMF), 1995).

4.2.2 Land

To express the input and output variables in per hectare basis, the total quantity of agricultural land (arable land, land under permanent crops and permanent pastures) is used. Data for agricultural land are collected from the Food and Agricultural Organization (FAO) Production Yearbook (FAO, 1995).

4.2.3 Labour

The labour variable is defined as the economically active population in agriculture. Over the years LDC's have experienced increases in their agricultural labour because of rapid population growth and insufficient employment by the non-agricultural sector. Surplus labour and the uneven access to various agricultural inputs in many SSA countries suggests that labour is not fully or uniformly utilized across countries. Haley (1991) interprets agricultural labour not as a measure of direct input but as an available input whose degree of productivity depends on the levels of other production inputs. Interpretations of labour productivity will be considered in this context. Data for the economically active population in agriculture are collected from the FAO Production Yearbook (FAO, 1995).

4.2.4 Livestock

Livestock represents a form of internal capital accumulation. The livestock variable is specified in animal units and represents the total livestock capital available for agricultural production. Hayami and Ruttan (1985) have assigned the following weights to different animals: camels, 1.1; buffaloes, horses and mules, 1.0; cattle and asses, 0.8; pigs, 0.2; sheep and goats, 0.1; poultry, 0.01. These weights are used to aggregate the different types of animals existing on farms. Data for the number of livestock are collected from the FAO Production Yearbook (FAO, 1995).

4.2.5 Fertilizer

Advances in agricultural technology are usually associated with the increased use of commercial fertilizers and machinery. The use of new high yielding crop varieties requires higher levels of fertilizer use. In this study, the fertilizer variable is specified as the total quantity of nitrogen, potassium and phosphorous. The data are collected from the FAO Fertilizer Yearbook (FAO, 1994).

4.2.6 Machinery

A machinery variable, measured as the total number of wheel and crawler tractors in a country, is used in this study to represent the whole range of inputs in which modern mechanical technologies are embodied. Data for the number of tractors are collected from the FAO Production Yearbook (FAO, 1995).

4.2.7 Education

It is well recognized that modern agricultural technologies are intensive in various forms of human capital which include education, research and extension. Education is used in this study to encompass the quality and improvements of the agricultural labour. This variable is measured as the literacy rate and is defined by the United Nations as the proportion of population over the age of fifteen that can read and write a short simple statement of their everyday life. Data are collected from the United Nations Educational, Scientific and Cultural Organization (UNESCO) Statistical Yearbook (UNESCO, 1994), World Development Reports (World Bank, 1993) and African Socio-Economic Indicators (United Nations Economic Commission for Africa, 1994). As the complete data were not available for all the years, the available data were used to create a trend line and the values computed were used to complete the data set.

4.2.8 Structural adjustment

As noted in chapter three, an improved domestic policy environment in aid receiving countries facilitates for the efficient use of resources. Many African countries adopted reform programmes in the 1980's. A dummy variable accounting for the presence of structural adjustment programs in each country is incorporated into the agricultural production function. The value 0 is assigned for those years without structural adjustment programs and the value 1 is assigned for those years when structural adjustment programs were in place. Information on the years in which structural adjustment programs were in place in each country is obtained from the Trends in Developing Economies (World Bank, 1995).

4.2.9 Foreign aid

The flow of Official Development Assistance (ODA) to aid recipient countries is used as a measure of foreign aid. Its effect on agricultural production is justified earlier in chapter two. Data for the foreign aid variable are collected from the Geographical Distribution of Financial Flows to Aid Recipients (Organization of Economic Cooperation and Development (OECD), 1995) and deflated using GNP deflators obtained from the International Financial Statistics Yearbook (IMF, 1995).

4.2.9.1 Foreign aid lag specification

In estimating the effects of foreign aid on agricultural output, it is important to consider that the levels of ODA in earlier periods as well as in the current period may have some influence on agricultural output. Foreign assistance to agriculture includes extensive development efforts in research, extension, education, health, and various infrastructure. Development efforts bear fruit over a period of time hence current agricultural production is influenced by past levels of foreign aid. This type of relationship can be captured by a distributed lag. A general formulation of a distributed lag relationship is expressed as:

$$Y_t = \alpha + \delta_0 A_t + \delta_1 A_{t-1} + \delta_2 A_{t-2} \ldots\ldots \delta_k A_{t-k} + \mu_t \qquad (4.2)$$

where Y = dependent variable (measured in log values in this study),

α = constant,

δ_i = coefficient measuring the impact of A in various time periods on Y,

A = explanatory variable and in this case foreign aid measured in log values; A_{t-k} are lagged (past) values of foreign aid, the length of the lag (k) going from 1 to k, and

μ = disturbance term.

The Almon approach to distributed lag models assumes that the shape of the lag distribution can be approximated with a polynomial. In accordance to a theorem in mathematics known as Weierstrass's theorem, the rule for determining the degree of the polynomial is that the degree should be at least one more than the number of turning points in the curve (Gujarati, 1988). Hence by examining the pattern of the δ_i's over the lag length the degree of the polynomial can be approximated.

Before equation 4.2 can be formulated it is necessary to specify the appropriate length of the lag (k) and degree of the polynomial. Previous studies have used a six year second order polynomial distributed lag to measure the effect of aid on agricultural output (Rai, 1987; Norton et al., 1992 and Kherallah et al., 1994). In this study the foreign aid lag structure is also specified as a six year second order polynomial. The six year lag is proposed based on results from World Bank evaluation reports that the average benefits from projects it funded were distributed across time as shown in Table 4.1 (Mosley, 1987). This distribution (as illustrated by

Figure 4.1) also shows that the benefits were small in the early years, then rose and eventually tapered off. Using Table 4.1 it is shown that 96 percent of project benefits are felt in the next 6 years from when aid is first distributed (i.e. sum of benefits in year 1 to 7). Hence in this study it is proposed that in any given year not only current aid but also aid received from 6 previous years, has an effect on agricultural production.

Based on the Almon approach to distributed lag models, the degree of the polynomial is determined by the number of turning points over the lag length. One turning point is observed in Figure 4.1 and hence a second order polynomial is used as an appropriate approximation to describe the lagged values of ODA. The second degree polynomial is expressed as:

$$\delta_i = a_0 + a_1 i + a_2 i^2 \qquad (4.3)$$

This is the simplest possible polynomial structure.

With the lag length specified as six years and a second degree polynomial, equation 4.2 may be written as:

$$Y_t = \alpha + \sum_{i=0}^{6} \delta_i A_{t-i} + \mu_t \qquad (4.4)$$

Substituting the second degree polynomial (equation 4.3) into equation 4.4 we get:

$$Y_t = \alpha + \sum_{i=0}^{6} (a_0 + a_1 i + a_2 i^2)\, A_{t-i} + \mu_t \qquad (4.5)$$

Table 4.1 **Distribution of project benefits across time**

Year since aid was first distributed	Percentage of total project benefits accruing in year stated
0	3
1	18
2	24
3	18
4	13
5	9
6	8
7	6

Source: Mosley, 1987

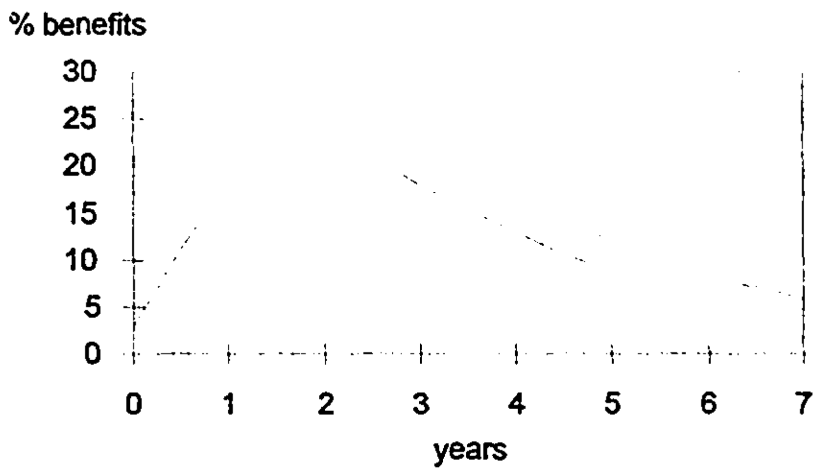

Figure 4.1 Polynomial approximation to the distribution of project benefits across time

Expanding the terms:

$$Y_t = \alpha + a_0 \sum_{i=0}^{6} A_{t-i} + a_1 \sum_{i=0}^{6} iA_{t-i} + a_2 \sum_{i=0}^{6} i^2 A_{t-i} + \mu_t \qquad (4.6)$$

Defining

$$Z_{0t} = \sum_{i=0}^{6} A_{t-i}$$

$$Z_{1t} = \sum_{i=1}^{6} iA_{t-i}$$

$$Z_{2t} = \sum_{i=1}^{6} i^2 A_{t-i} \qquad (4.7)$$

and substituting the terms in equation 4.7 into equation 4.6 we get,

$$Y_t = \alpha + a_0 Z_{0t} + a_1 Z_{1t} + a_2 Z_{2t} + \mu_t \qquad (4.8)$$

Rai (1987), Norton et al. (1992) and Kherallah et al. (1994) have constrained the end points of the lag distribution by imposing that $\delta_{-1} = 0$ and $\delta_6 = 0$. In this study the lag distribution will be restricted by imposing $\delta_{-1} = 0$ and $\delta_7 = 0$. These restrictions lie outside the lag interval of 0 to 6 years and constrain all the coefficients in the model.

By imposing $\delta_{-1} = 0$ and $\delta_7 = 0$ two linear relationships are given between the a's in equation 4.3 as:

$$\delta_{-1} = a_0 - a_1 + a_2 = 0$$

$$\delta_7 = a_0 + 7a_1 + 49a_2 = 0 \qquad (4.9)$$

This simplifies to:

$$a_0 = -7a_2$$

$$a_1 = -6a_2 \qquad (4.10)$$

Hence equation 4.8 may be written as:

$$Y_t = \alpha - 7a_2 Z_{0t} - 6a_2 Z_{1t} + a_2 Z_{2t} + \mu_t$$

$$Y_t = \alpha + a_2 (Z_{2t} - 7Z_{0t} - 6Z_{1t}) \qquad (4.11)$$

If:

$$Z_t = Z_{2t} - 7Z_{0t} - 6Z_{1t} \qquad (4.12)$$

then:

$$Y_t = \alpha + a_2 Z_t \qquad (4.13)$$

Equation 4.13 is a simple regression model relating Y_t to Z_t. Once a_2 is estimated from the regression model we can solve for a_0 and a_1 because of the relationship expressed in equation 4.10. By substituting these values of a_0, a_1 and a_2 into equation 4.3 we may compute the δ_i coefficients as:

$$\delta_0 = a_0$$

$$\delta_1 = a_0 + a_1 + a_2$$

$$\delta_2 = a_0 + 2a_1 + 4a_2 \qquad \textit{so on upto}$$

$$\delta_6 = a_0 + 6a_1 + 36a_2 \qquad (4.14)$$

The total impact of aid on the output variable is given as the sum of the δ_i coefficients.

It is important to consider what the substitution has achieved. Equation 4.8 requires estimation of 4 parameters (a_0, a_1, a_2 plus an intercept term). By imposing end point restrictions on the lag of the foreign aid variable, the number of parameters to be estimated is reduced to 2 (a_2 and an intercept term: equation 4.13). Due to the way Z_{0t}, Z_{1t} and Z_{2t} are constructed, a multicollinearity problem arises when OLS is applied to equation 4.8. By compressing Z_{0t}, Z_{1t} and Z_{2t} into one variable Z_t, it is expected that the precision of the regression is increased (Norton, 1996).

An F test is used to test the validity of the end point restrictions (equation 4.9) imposed on the lag of the foreign aid variable. To test the hypothesis:

H_0: valid end point restrictions

H_A: end point restrictions are not valid

the F test (following Griffiths et al., 1993) is given by:

$$F_1 = \frac{S_Z - S_{3Z} / J}{S_{3Z} / (NT - N - K)}$$

where S_z = residual sum of squares from the equation estimated with end point restrictions on the lag of the foreign aid variable,

S_{3z} = residual sum of squares from the equation estimated without end point restrictions on the lag of the foreign aid variable,

J = degrees of freedom in the numerator which is equal to the difference between the degrees of freedom associated with the equation with and without end point restrictions on the lag of the foreign aid variable, and

(NT - N - K) = degrees of freedom in the denominator; where N is the number of cross sections, T is the number of time periods and K is the number of explanatory variables.

If F_1 with J and (NT - N - K) degrees of freedom is significant we cannot reject the null hypothesis hence it is valid to impose end point restrictions on the lag of the foreign aid variable. If the calculated value of F (i.e. F_1) is less than the table value of F with J and (NT - N - K) degrees of freedom, then we reject the null hypothesis and the lag of the foreign aid variable can be estimated without end point restrictions.

4.3 PANEL DATA

The combination of cross section and time series data is known as panel data. In this study, data is used for 32 countries (cross sections) that are observed during the period 1970-1993 (time series). When using panel data it is important to specify a statistical model that will take into account unobserved individual differences so that the data may be combined for estimation and inference purposes.

The general panel data model can be expressed as:

$$Y_{it} = \alpha_i + \beta_i X_{it} + \mu_{it} \qquad (4.15)$$

with i=1 to N (cross sections) and t=1 to T (time series).

Hsiao (1986) suggests that three types of restrictions can be imposed on equation 4.15. The following models illustrate these restrictions:

1. Both slope and intercept coefficients are the same:

$$Y_{it} = \alpha + \beta X_{it} + \mu_{it} \qquad (4.16)$$

2. Regression slope coefficients are identical but intercepts are not:

$$Y_{it} = \alpha_i + \beta X_{it} + \mu_{it} \qquad (4.17)$$

3. Regression intercepts are the same but slope coefficients are not:

$$Y_{it} = \alpha + \beta_i X_{it} + \mu_{it} \qquad (4.18)$$

The restriction imposed by equation 4.18 is not a model often used in practice, because the hypothesis of a common intercept but different slopes is seldom a meaningful question to ask (Hsiao, 1986). Hence in this study, only the restrictions imposed by equation 4.16 and 4.17 will be considered.

Equation 4.16 is commonly referred to as a pooled[3] model. It can be estimated by applying ordinary least squares (OLS) to the whole sample. This will provide common parameter estimates for the slopes and the intercept across countries and over time. In equation 4.17 it is assumed that the intercept term varies across cross sections but remains constant over time. This variable intercept equation is called the covariance model. It is estimated by applying OLS to the pooled data with N cross section dummy variables and no overall intercept term.

When pooling cross section and time series observations, it is important to incorporate assumptions that recognize cross section specific effects. Kmenta (1986) points out that the behaviour of the disturbances over cross sections is most probably different from the behaviour of the disturbances of a given cross section over time. Hence, prior specifications with respect to the disturbances term apply in a given situation depending on the data. Kmenta's (1986) approach to pooling methods involves combining the assumptions often made when using cross section data with those made when using time series data. This study involves a cross country comparison. In such a setting Kmenta (1986) proposes the following assumptions: for cross section data it is assumed that the disturbances are mutually independent but heteroskedastic, and for time series data it is assumed that the disturbances are autoregressive. Combining these assumptions leads to a model that is cross sectionally heteroskedastic and timewise autocorrelated. Cross

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3/ Combining cross section and time series data is known as pooling. In this study the term "pooled model" will refer to the panel data model with homogeneous intercept and slope (equation 4.16).

sectional independence is achieved by allowing the disturbance term to vary over countries. The assumptions of the Kmenta (1986) model (cross sectional heteroskedasticity and timewise autoregressive) are used in the estimation of both equation 4.16 and 4.17.

To determine if the pooled model or the covariance model, best represents the data, an F test, as specified by Griffiths et al. (1993), is performed. To test the hypothesis:

H_0: $\alpha_1 = \alpha_2 = ... = \alpha_N$

H_A: α_i varies across countries

the F test is given as:

$$F_2 = \frac{S_P - S_C / J}{S_C / (NT\text{-}N\text{-}K)}$$

where S_P = residual sum of squares from the pooled equation,

S_C = residual sum of squares from the covariance equation,

J = degrees of freedom in the numerator which is equal to the difference between the degrees of freedom associated with the pooled equation and the covariance equation, and

(NT - N - K) = degrees of freedom in the denominator.

If F_2 with J and (NT - N - K) degrees of freedom is significant we cannot reject the null hypothesis and therfore estimate the aggregate agricultural production function in the form of the pooled model. If the calculated value of F (i.e F_2) is less than the table value of F with J and (NT - N - K) degrees of freedom then we reject the null hypothesis and estimate the aggregate agricultural production function using the covariance model.

4.4 THE FINAL MODEL

Based on the above discussion of the specification of the foreign aid variable and the pooling methods involved in the use of panel data, the exact functional form of the aggregate agricultural production function for SSA is presented below. This production function will be estimated from cross section, time series data for 32 countries in Sub-Saharan African for the period 1970-1993. The functional form of the equation to be used is the Cobb Douglas which may be expressed in the following form:

$$\begin{aligned} logY_{it} = \sum_{i=0}^{32} \alpha_i + \beta_1 \log E_{it} + \beta_2 \log F_{it} + \beta_3 log L_{it} + \beta_4 \log S_{it} \\ + \beta_5 \log M_{it} + \beta_6 P_{it} + \beta_7 Z_{it} + \mu_{it} \qquad (4.19) \end{aligned}$$

The variables are expressed as:

Y = per hectare value of agricultural output in millions of 1985 i) United States (US) dollars as computed from official exchange rates ii) international dollars as computed from PPP derived from Summers and Heston (1988),

E = percentage literacy rate,

F = tonnes of nitrogen, potassium and phosphorous used per hectare,

L = economically active population in agriculture per hectare,

S = aggregated livestock units per hectare,

M = number of tractors per hectare,

P = dummy variable for the presence of structural adjustment programs,

Z = represents a complex measure of ODA per hectare (in log terms) as computed from equation 4.12, and

B_7 = coefficient on the Z variable (similar to coefficient a_2 in equation 4.13); it is used to calculate the total impact of aid on agricultural output as shown in equation 4.14.

The β coefficients represent the regression parameters and since the equation is expressed in the Cobb Douglas form, these parameters are interpreted as the elasticities of the various production inputs. Also α_i is an unobserved country effect, specific to each country's agricultural production function. The disturbance term μ_{it} is assumed to be normally distributed with mean zero and constant variance over time and across countries.

CHAPTER 5

RESULTS

In this chapter the regression results of the aggregate agricultural production function for Sub Saharan Africa (SSA) are presented. Statistical tests are performed to determine: i) whether to estimate a pooled regression equation with a common intercept term for all countries (pooled equation) or estimate a separate intercept for each country (covariance equation); ii) if end-point restrictions imposed on the lag of the foreign aid variable are valid. Additional models are also estimated when countries are classified according to agro-climatic regions, income level and policy environment.

5.1 SPECIFICATION TESTS

The production function can either be specified as a pooled equation or as a covariance equation. In each of these equations the lag of the foreign aid variable can be measured either with no end point restrictions (the aid variable is represented by Z_{0t}, Z_{1t} and Z_{2t}; equation 4.8) or with end point restrictions in which the lag of the foreign aid variable is compressed into a single measure, Z_t (equation 4.13). Table 5.1 presents the summary of the specification tests performed to determine which panel data model to use and if the end-point restrictions imposed on the lag of the foreign aid variable are valid.

Table 5.1 Summary of the specification tests

Model specification	F value	df[a]	H_0	Selected model
A. PPP used to compute agricultural output				
i. Pooled vs Covariance				
- no end-point restrictions	9.64	(31, 536)	reject[b]	covariance equation
- end-point restrictions	7.75	(31, 538)	reject[b]	covariance equation
ii. Validity of end-point restrictions	0.32	(2, 536)	accept[c]	end-point restrictions
B. Official exchange rates used to compute agricultural output				
i. Pooled vs Covariance				
- no end-point restrictions	9.63	(31, 536)	reject[b]	covariance equation
- end-point restrictions	7.74	(31, 538)	reject[b]	covariance equation
ii. Validity of end-point restrictions	0.32	(2, 536)	accept[c]	end-point restrictions

Note: a. degrees of freedom of the numerator and denominator respectively
b. H_0: common intercepts for all countries. The critical value for rejection at the 1% level is 1.7
c. H_0: valid end-point restrictions. The critical value for rejection at the 1% level is 4.61

From these results it can be concluded that for both equations estimated with alternative measures of agricultural output (either computed from purchasing power parity (PPP) or official exchange rates) the model that best represents the panel data for aggregate agricultural production in SSA is the covariance equation in which the lag structure of the foreign aid variable is measured with end-point restrictions.

5.2 REGRESSION RESULTS

Equation 4.19 represents the agricultural production function for 32 countries in SSA for the period 1970-1993. The equation is expressed as a Cobb Douglas function. The linear model was also estimated as an alternative mathematical form of the agricultural production function, and the results are presented in Appendix B, Table B-1. In the linear model not all the inputs are significant. However it is worthwhile to mention here that the elasticities for labour, education and foreign aid are all highly significant and similar to those obtained in the Cobb Douglas model. In particular the elasticity of output obtained in the linear model is the same as that obtained in the log model. It is also noted that the country specific intercept terms show great variability in magnitude and significance which indicates there are important country specific factors that are being picked up by the intercept terms.

In section 5.1 the chosen model is the covariance equation and agricultural output is either computed from PPP or from official exchange rates. The regression results obtained from these two equations are the same; only the coefficients for the country intercepts differ. Similar results are obtained despite using two different measures for agricultural output because the PPP derived by Summers and Heston (1988) are computed from individual country price levels and official exchange rates. The varying intercept term for each country absorbs whatever variation there may be due to the different methods of computing agricultural output. However if different PPP were computed for every year under observation then different regression parameters may have been obtained. As a comparison, the regression results for the pooled model (homogeneous slope and intercept: equation 4.16) are presented in Table 5.2. The regression coefficients for the equation in which foreign aid is computed from PPP appear to be superior to the equation in which output is computed from official exchange rates. As the two measures of agricultural output do not produce different regression results when the covariance equation is estimated, the discussion that follows is based on the production function in which agricultural output is computed from PPP.

Table 5.2 presents the regression results of the aggregate agricultural production function. Overall, the regression fits the data very well; the Buse Raw-Moment R-square[4] indicates that the explanatory variables are able to explain 99 percent of the variation of the aggregate agricultural production function. All the regression coefficients (except foreign aid) are significant at the 1 percent level of significance. Foreign aid is significant at the 5 percent level.

4/ The Buse Raw-Moment R-square (proposed by Buse 1973) is generally used as a goodness of fit measure in models in which the intercept term is suppressed in the pooled regression: it displays properties usually associated with R-square and when the intercept term is dropped it is also bound by zero and one.

Table 5.2 **Estimated regression coefficients of the pooled agricultural production function for SSA**

Variable[a]	Homogeneous slope and intercept Equation 1[b]	Equation 2[c]	Covariance Model[c]
Fertilizer	0.001	0.028***	0.019***
Labour	0.655***	0.727***	0.175***
Livestock	0.072***	0.107***	0.091***
Machinery	0.126***	0.096***	0.067***
Education	0.014	-0.050*	0.046***
Foreign Aid	0.143[d]**	0.250[d]**	0.043[d]**
Structural Adjustment	-0.005	-0.015	0.045***
Intercept	-6.662***	-5.063***	
Country Intercepts:			
Benin			-6.868***
Botswana			-9.838***
Burkina Faso			-7.554***
Burundi			-6.591***
Cameroon			-7.533***
Central African Republic			-7.372***
Chad			-8.932***
Congo			-8.995***
Côte d'Ivoire			-7.210***
Ethiopia			-7.196***
Gabon			-8.482***
Gambia			-6.417***
Ghana			-6.702***
Guinea			-7.499***
Kenya			-8.004***
Lesotho			-7.709***
Madagascar			-8.262***
Malawi			-7.319***
Mali			-8.637***
Mauritania			-9.965***
Mauritius			-5.609***
Mozambique			-8.107***
Niger			-8.004***
Nigeria			-6.631***
Rwanda			-6.493***
Senegal			-7.373***
Swaziland			-7.718***
Tanzania			-7.437***
Togo			-7.200***
Uganda			-10.564***
Zambia			-9.320***
Zimbabwe			-7.873***
Number of observations	576	576	576
Buse Raw Moment R-square	0.99	0.99	0.99

Note: a. All variables except structural adjustment are in logarithmic form. The dependent variable is the value of agricultural output.
b. Agricultural output measured on the basis of official exchange rates.
c. Agricultural output measured on the basis of purchasing power parities (PPP).
d. Calculation based on the sum of the distributed lag coefficients.
*,**,*** Denotes significance at the 10, 5 and 1 percent level, respectively.

The output elasticities for fertilizer, livestock and machinery are 0.019, 0.91 and 0.067 respectively and are comparable to those obtained by Norton et al. (1992), Fisvold and Ingram (1995) for SSA and also to those reported in studies for less developed countries (LDCs) (Table A-1, Appendix A). However the output elasticity for labour of 0.175 obtained in this study, is lower than obtained in other studies. The estimated elasticity for education of 0.046. This is probably because this variable is measured as the literacy rate pertaining to the entire population rather than to the agricultural labour force. Trueblood (1989) in his review of studies that estimate agricultural production functions, reports that despite numerous measures for education, the production elasticity associated with this variable has displayed great variability. It is reasonable to assume that if data was available for the educational level of the rural population, a better estimate for education would be obtained. The coefficient for the structural adjustment dummy variable is 0.045 and significant. To compute the increase in agricultural output due to structural adjustment programs we take the antilog of 0.045, which is equal to 1.11. The interpretation from this procedure is that the value of agricultural output per hectare has increased by $1.11 due to the presence of structural adjustment programs.

The coefficient of foreign aid is calculated based on equation 4.14. Once the individual δ_i coefficients are computed they are summed to give the total impact of aid on agricultural production (δ). In the aggregate model the coefficient of foreign aid is 0.04. Following Norton et al. (1992) the marginal product (MP) of foreign aid to agriculture is calculated as:

$$MP = \delta \frac{\overline{Y}}{\overline{A}} \qquad (5.1)$$

where $\overline{Y}$ and $\overline{A}$ are the average per hectare values of agricultural output and foreign aid, respectively. The coefficient δ is the calculated value of the distributed lag of foreign aid. The MP of foreign aid in this study is found to be $0.14. This is interpreted to mean that a one dollar increase in foreign aid in each of the past six years is expected to result in an increase in agricultural output of 14 cents in the current year. The impact of aid on the agricultural sector in SSA appears to be low but it is important to bear in mind that the foreign aid variable includes total aid and not only agricultural aid. Hence the impact of aid on the agricultural sector is most likely underestimated.

The coefficients for the varying intercept for each country are highly statistically significant indicating that the country effect is important in explaining the variation of agricultural production in SSA. The country effect includes important behavioral differences excluded in the production function (e.g. agro-climatic potential, soil quality and management skills).

Based on the equation in which agricultural output is computed from PPP, alternative models are estimated to discover other factors that may influence the structure of agricultural production in SSA and the effectiveness of foreign aid and structural adjustment programs. Countries are grouped according to agro-climatic regions, income level and policy environment. In each of these three classifications separate equations are estimated for each group within the country classification. By the use of the Chow test it is established that it is valid to estimate separate equations. The results of the Chow test are presented in Appendix C.

As a guide to the interpretation of the regression results, Table D-1 (Appendix D) reports the average amounts of agricultural output and input variables used during the period of analysis. Average values of all variables are summarized for the whole sample and for the various samples within the classification groups.

5.2.1 Agro-climatic regions

First, countries are classified according to agro-climatic regions. Following La-Anyane (1985) and Elmi (1994), the four main agro-climatic regions in SSA are Sudano-Sahel, Western Africa, Central Africa and Eastern and Southern Africa. Groupings of the countries in SSA are illustrated in Figure 2.2.

The regression results for countries classified according to agro-climatic regions are presented in Table 5.3. Fertilizer is positive and significant in the Sudano-Sahel, Western Africa and Central Africa but insignificant in Eastern and Southern Africa. Yet more fertilizer per hectare is used in Eastern and Southern Africa as compared to other regions (Appendix D, Table D-1). High fertilizer use goes hand in hand with increased water requirements of the high yielding varieties. The extensive drought in Eastern and Southern Africa could possibly be a reason why the higher use of fertilizer in the region has not contributed significantly to agricultural production.

Table 5.3 Pooled results for different agro-climatic regions of SSA

Variable[a]	Sudano-Sahel	Western	Central	Eastern & Southern
Fertilizer	0.025*	0.021*	0.034**	0.014
Labour	0.096**	0.375***	0.071*	0.351***
Livestock	-0.070	0.227***	-0.024	0.058*
Machinery	0.137***	0.086	0.193***	0.040***
Education	0.010	-0.024	-0.263	0.037
Foreign Aid	0.268[b]***	0.124[b]**	0.377[b]**	-0.044[b]*
Structural Adjustment	0.077***	0.026	0.074***	0.025*
<u>Country Intercepts</u>:				
Burkina Faso	-7.059***			
Chad	-8.469***			
Gambia	-5.936***			
Mali	-7.750***			
Mauritania	-9.062***			
Niger	-7.089***			
Senegal	-6.726***			
Benin		-6.834***		
Côte d'Ivoire		-6.187***		
Ghana		-5.638***		
Guinea		-6.589***		
Nigeria		-5.192***		
Togo		-6.985***		
Cameroon			-4.065***	
Central Af. Republic			-4.820***	
Congo			-5.843***	
Gabon			-5.215***	
Botswana				-9.596***
Burundi				-7.882***
Ethiopia				-8.883***
Kenya				-9.281***
Lesotho				-10.190***
Madagascar				-9.621***
Malawi				-8.899***
Mauritius				-6.723***
Mozambique				-9.576***
Rwanda				-7.734***
Swaziland				-9.298***
Tanzania				-8.535***
Uganda				-8.360***
Zambia				-10.237***
Zimbabwe				-8.916***
No. of observations	126	108	72	270
Buse Raw-M. R-square	0.99	0.99	0.99	0.99

Note: a. All variables except structural adjustment are in logarithmic form. The dependent variable is the value of agricultural output measured on the basis of purchasing power parities (PPP).
b. Calculation based on the sum of the distributed lag coefficients.
*,**,*** Denotes significance at the 10, 5 and 1 percent level, respectively.

Labour is positive and significant in all four agro-climatic regions. In Western Africa and Eastern and Southern Africa the coefficient for labour is notably larger and highly significant (1 percent level); this result could be due to the larger agricultural populations in the two regions. Livestock is positive and significant in Western Africa and Eastern and Southern Africa but negative and insignificant in the Sudano Sahel and Central Africa. In the Sudano Sahel region the major economic activity is nomadic pastoralism (La-Anyane, 1985). These nomadic communities regard the livestock herd more as a symbol of wealth than a productive asset in agricultural production. This may explain that despite livestock production being a major industry in the Sudano Sahel, the coefficient for livestock is negative and insignificant.

Machinery is positive and highly significant in the Sudano Sahel and Central Africa. In Western Africa machinery is insignificant and in Eastern and Southern Africa machinery is positive and significant but lower in magnitude than in other regions. Binswanger and Pingali (1988) report that tractor adoption in SSA is done mainly to save labour and extend land. This explains the larger machinery coefficient in the Sudano-Sahel and Central Africa; in these regions the coefficient for labour is low indicating that labour saving technologies have been adopted.

The output elasticity for foreign aid is positive and significant in the Sudano Sahel (0.268), Western Africa (0.124) and Central Africa (0.377). The marginal products of foreign aid in these regions are $1.32 in Central Africa, $0.91 in Western Africa and $0.40 in the Sudano-Sahel, in order of magnitude of returns from one dollar invested in each of the 6 previous years. Note that the marginal products obtained in these regions are larger than the marginal product calculated for the aggregate model. It is clear that the effects of foreign aid are masked when all countries are pooled together. In Eastern and Southern Africa foreign aid has a negative and significant (10 percent level) effect on agricultural production; the output elasticity is -0.044. However during the period of analysis, the Eastern and Southern African region has received the highest amount of aid per hectare of agricultural land. It is important to note that over the past two decades SSA has experienced a number of droughts which have been particularly extensive in Eastern and Southern Africa. Hence these countries have received large volumes of food aid. As mentioned in Chapter 2 food aid is a form of ODA. The negative impact of aid in Eastern and Southern Africa could perhaps be explained as being due to more of total aid being allocated for food aid. Hence more foreign aid funds were allocated for consumption rather than more direct productive investment during the drought years.

The presence of structural adjustment programs affects agricultural production positively and significantly in the Sudano Sahel, Central Africa and Eastern and Southern Africa; however in Western Africa the impact of structural adjustment programs is insignificant. In 1994 the World Bank published its findings on the performance of adjustment programs in SSA (World Bank, 1994a). In this World Bank study, of the countries in the Western Africa classification group, only Ghana was reported to have made large improvements in macroeconomic policies; Benin, Côte d'Ivoire, Nigeria and Togo were classified among countries with a deterioration in macroeconomic policies. Hence despite structural adjustment programs having been in place longest in Western Africa, the impact on agriculture is insignificant because of the poor policies adopted. However, all countries in Central Africa are reported by the World Bank to have worsened their macroeconomic policies yet the coefficient of the structural adjustment variable is positive and significant. To explain this result the following example is drawn from the World Bank study: Nigeria is classified as having worsened its policies while Ghana has made large improvements in macroeconomic policies. Yet agriculture is growing faster in Nigeria than in Ghana. A number of factors have been posited to account for this difference: Ghana, continues to exert a major influence on producer prices; Nigeria has made investments in research and extension services; Ghana has been slow to make reforms within agriculture (World Bank, 1994a). According to Jaeger's (1992) classification of countries in SSA by agricultural policy environment (proxied by real producer prices, agricultural taxation and exchange rate distortion) the Central African Republic, Cameroon and Congo are classified as having a favourable policy environment (Gabon is unclassified due to lack of sufficient data). Hence despite the countries in the Central Africa group being classified as having worsened their overall adjustment policies, the structural adjustment variable exhibits a positive and significant coefficient because these countries have adopted policies that are more favourable to agricultural growth.

In all four agro-climatic regions the coefficient of the education variable is insignificant. The coefficients for the country intercepts for all regions are highly significant.

In general, the classification of countries in SSA by agro-climatic regions has not clearly indicated a pattern in the structure and performance of agricultural production in the various regions. The classification of countries by agro-climatic region is used as a common point of reference, but these groupings do not serve to reflect the agricultural patterns in SSA. Agricultural practices in SSA have evolved over the years due to a host of factors such as technological practices, climate, and economic, social and political factors. Not all these factors are incorporated into the production function and hence their influence can only be picked up by the country specific intercept term. However the results have confirmed observations made by Binswanger and Pingali (1988) that in general modern inputs are unlikely to be widely adopted by farmers in SSA. In many areas of Africa land is still abundant and market access is poor, hence farmers are reluctant to use more advanced techniques unless they are perceived to be cost effective. Thus the coefficient for fertilizer and machinery are low in the regression results.

5.2.2 Income level

The second classification is according to average level of income, expressed as Gross National Product (GNP) per capita in United States (US) dollars. In this study the 1986-1993 annual averages of GNP per capita, obtained from the African Development Indicators (World Bank, 1995) are used to classify countries by income level. There are 6 countries with 1986-1993 annual average GNP per capita of less than \$US 200 (low income), 16 countries with GNP per capita between \$US 200-500 (middle income) and 10 countries with GNP per capita above \$US 500 (high income).

Table 5.4 presents the results of countries classified according to income groups. The coefficients for fertilizer are positive and significant in low and middle income countries. However fertilizer is insignificant in high income countries, yet these countries have used more fertilizer per hectare of agricultural land as compared to other income groups. As noted earlier, the increased use of fertilizer is not an important contributor to agricultural production in many parts of SSA - hence the insignificant coefficient for the fertilizer variable for high income countries.

Labour is positive and significant (1 percent level) in all income groups. The coefficient for labour is large in low income countries as compared to other income groups, indicating that agricultural practices are more labour intensive in low income countries.

The coefficient for livestock is positive and significant (1 percent level) in low and middle income countries. In high income countries this coefficient is negative and insignificant. The large livestock coefficient (0.386) displayed in low income countries indicates that livestock production plays an important role in this group of countries. Machinery is negative and insignificant in low income countries and positive and significant in middle and high income countries. The large number of tractors in use in high income countries (Appendix D, Table D-1) explains the large coefficient for machinery for this group of countries.

The coefficient for foreign aid is -0.083 and significant (5 percent level) in low income countries, 0.196 and significant (1 percent level) in middle income countries and 0.055 and significant (10 percent level) in high income countries. Low income

Table 5.4 Pooled results for countries classified according to income level

Variable[a]	Low income[b]	Middle income	High income
Fertilizer	0.050***	0.015**	0.003
Labour	0.297***	0.143***	0.161***
Livestock	0.386***	0.071***	-0.012
Machinery	-0.022	0.032**	0.213***
Education	-0.073*	0.079***	-0.049
Foreign Aid	-0.083[c]**	0.196[c]***	0.055[c]*
Structural Adjustment	0.068**	0.056***	0.014
Country Intercepts:			
Chad	-10.146***		
Ethiopia	-8.953***		
Malawi	-8.604***		
Mozambique	-8.652***		
Tanzania	-8.273***		
Uganda	-8.130***		
Benin		-7.740***	
Burkina Faso		-8.641***	
Burundi		-7.107***	
Central African Republic		-8.470***	
Gambia		-7.386***	
Ghana		-6.720***	
Guinea		-7.740***	
Kenya		-8.708***	
Madagascar		-9.083***	
Mali		-9.145***	
Mauritania		-10.410***	
Niger		-8.635***	
Nigeria		-6.207***	
Rwanda		-6.909***	
Togo		-8.073***	
Zambia		-9.875***	
Botswana			-8.296***
Cameroon			-6.268***
Congo			-8.022***
Côte d'Ivoire			-6.461***
Gabon			-7.392***
Lesotho			-8.480***
Mauritius			-5.080***
Senegal			-6.711***
Swaziland			-7.922***
Zimbabwe			-7.352***
Number of observations	108	288	180
Buse Raw Moment R-square	0.99	0.99	0.99

Note: a. All variables except structural adjustment are in logarithmic form. The dependent variable is the value of agricultural output measured on the basis of purchasing power parities (PPP).
b. Low income = GNP/capita ($US 200, middle income = GNP/capita $US 200-500, high income = GNP/capita) $US 500.
c. Calculation based on the sum of the distributed lag coefficients.
*,**,*** Denotes significance at the 10, 5 and 1 percent level, respectively.

countries have received the least amount of foreign aid per hectare of agricultural land. and low income per capita could also be an indicator of the lack of investment in supporting infrastructure that facilitates for the efficient use of foreign aid. Also, a large part of aid may be in the form of food aid hence aid is allocated to consumption rather than investment activities. This may explain the negative impact of foreign aid in low income countries. It is precisely in low income countries where more foreign aid needs to be directed in order to finance basic infrastructure projects (e.g. roads, railways and power installation) because these projects are prerequisites for further development. The marginal product of foreign aid in middle income countries is $0.74 while in high income countries it is $0.16. The returns to foreign aid in high income countries is lower than in middle income countries yet high income countries have received more foreign aid. A high proportion of aid going to the high income countries may not have been directed to agricultural programs. In all of the high income countries agriculture is not necessarily the dominant sector. In Botswana, Cameroon, Congo and Gabon mining is a major industry; in Lesotho, Senegal and Swaziland the service sector accounts for up to 50 percent of GDP; in Zimbabwe the manufacturing sector accounts for up to 30 percent of GDP (World Bank, 1994b). Hence it is most likely that foreign aid in these countries has been directed to non-agricultural sectors, thus explaining the smaller impact of aid on agricultural production in high income countries in SSA.

Structural adjustment is positive and significant in low and middle income countries but insignificant in high income countries. Since agriculture is not the dominant sector in the economy of high income countries, the policies adopted in the reform programs may be directed to other more productive sectors, hence explaining the insignificant coefficient obtained for the structural adjustment dummy variable.

In the three income groups all the coefficients for the country intercepts are significant at the 1 percent level.

As with the classification of countries by agro-climatic regions, grouping countries by income level (GNP per capita) is used as another criterion to classify countries. In the sample used in this study as per capita income increases, aid per hectare also increases, yet the general observation made by Kherallah et al. (1994) was that poor countries receive greater amounts of aid. SSA is today the largest recipient of Official Development Assistance and is classified amongst the poorest regions in the world. Hence it is interesting to note that within SSA more aid is directed to higher income countries. Agricultural production per hectare is highest in the high income group but unlike the middle income group (where all independent variables are significant at least at the 5 percent level) two conventional inputs, fertilizer and livestock display insignificant coefficients. As mentioned with the classification of countries by agro-climatic region, agricultural practices have evolved due to a number of factors and hence farming systems are not likely to be uniform in each income group. The classification of countries by income level has served well to illustrate the effect of foreign aid and structural adjustment. However, a uniform pattern does not emerge with respect to the more traditional agricultural inputs.

5.2.3 Policy environment

Third, countries are classified according to policy environment. Jaeger (1992) groups countries in SSA into two based on the policy environment that existed in the mid- to late- 1980s. The principal criteria used by Jaeger (1992) for classification were the direct policies that affect agricultural incentives (the real producer prices and levels of agricultural taxation) and indirect policies that affect the competitiveness of the agricultural sector (extent of exchange rate distortion). Using these key policy variables, countries in SSA were classified as having a favourable policy environment (FPE) or as having an unfavourable policy environment (UPE).

It is important to consider that the agricultural production function used in the regression estimation includes a structural adjustment dummy variable indicating the presence or absence of adjustment programs in each country. The structural adjustment dummy variable differs from the policy environment classification proposed by Jaeger (1992). The policy performance measures (producer prices, level of agricultural taxation and real exchange rate) used by Jaeger (1992) are expected to have a short-run impact on overall economic performance and agricultural production in particular. Structural adjustment programs differ among countries, and many of the policy changes undertaken (reforms in the public sector and government revenue collection) have longer-term objectives.

Jaeger (1992) also points out that some countries in the FPE category (e.g. Benin, Burkina Faso and Cameroon) had not yet undertaken structural adjustment programs, while other countries (Mauritania and Tanzania) after having implemented structural adjustment programs, still exhibited exchange rate distortions, hence were classified as having UPE. Thus the structural adjustment dummy variable is not omitted from the analysis when the regression is performed on countries classified according to policy environment.

Table 5.5 presents the regression results for countries classified by policy environment. In the FPE group all regression coefficients are significant except for education. In the UPE group all coefficients are significant except machinery and foreign aid.

It is interesting to note that foreign aid is positive and significant at the 1 percent level only in countries classified as having favourable policies, implying that a sound economic policy environment is necessary for positive returns on investment. The marginal product of foreign aid in countries with a FPE is $0.65. The coefficient for the foreign aid variable is negative but insignificant in countries classified under the UPE group. This indicates that a poor agricultural policy environment does not allow for foreign aid to enhance agricultural production.

The coefficient for structural adjustment dummy variable is positive and significant (1 percent level) in both the FPE and UPE groups. However structural adjustment has a high coefficient in countries with UPE indicating that in these countries more benefits have been realised to agricultural production by implementing and maintaining structural adjustment programs.

The results obtained when countries are grouped according to policy environment confirm some observations made in Chapter 3. Countries grouped under FPE have received more aid than those grouped under UPE - confirming the

Table 5.5 Pooled results for countries classified according to policy environment

Variable[a]	Favourable	Unfavourable
Fertilizer	0.021***	0.022*
Labour	0.243***	0.151**
Livestock	0.094***	0.252***
Machinery	0.065***	0.043
Education	-0.015	0.074*
Foreign Aid	0.193[b]***	-0.024[b]
Structural adjustment	0.034***	0.067***
Country Intercepts:		
Benin	-6.972***	
Burkina Faso	-7.780***	
Burundi	-6.346***	
Cameroon	-6.840***	
Central African Republic	-7.547***	
Chad	-8.835***	
Congo	-7.948***	
Côte d'Ivoire	-6.646***	
Gambia	-6.786***	
Ghana	-5.901***	
Guinea	-6.868***	
Kenya	-7.784***	
Madagascar	-8.060***	
Malawi	-7.452***	
Mauritius	-5.535***	
Niger	-7.762***	
Nigeria	-5.376***	
Senegal	-7.398***	
Togo	-7.259***	
Botswana		-9.979***
Ethiopia		-9.005***
Mali		-9.757***
Mauritania		-10.850***
Mozambique		-9.313***
Rwanda		-7.449***
Tanzania		-8.627***
Uganda		-8.305***
Zambia		-10.321***
Zimbabwe		-9.116***
Number of observations[c]	342	180
Buse Raw Moment R-square	0.99	0.99

Note: a. All variables except structural adjustment are in logarithmic form. The dependent variable is the value of agricultural output measured on the basis of purchasing power parities (PPP).
b. Calculation based on the sum of the distributed lag coefficients.
c. Data for only 29 countries was available from the study by Jaeger (1992)
*,**,*** Denotes significance at the 10, 5 and 1 percent level, respectively.

observation made by Killick (1985) that aid donors are not willing to give aid to a country with a poor policy environment. He also notes that a poor policy environment has damaging effects on agricultural performance: Table D-1 (Appendix D) shows that despite a larger endowment of land and almost similar amounts for other production inputs (except foreign aid and fertilizer) countries grouped under UPE have low agricultural output per hectare, confirming Killick's (1985) observation.

The results obtained from this sub-sample further emphasize for the continued need for structural adjustment programs in Africa. Countries with poor agricultural policy (classified as UPE by Jaeger, 1992) have experienced benefits from reform programs. Hence it can be concluded that favourable domestic policies create an incentive structure for the efficient use of foreign aid which in turn impacts agricultural production positively and significantly.

CHAPTER 6

CONCLUSION

6.1 SUMMARY

In this study, an aggregate agricultural production function was estimated from cross section, time series data (panel data) for 32 countries in Sub-Saharan Africa (SSA) during the period 1970-1993. The functional form of the equation used was the modified Cobb Douglas and aggregate agricultural output was expressed as a function of fertilizer, labour, livestock, machinery, education, foreign aid and structural adjustment (incorporated into the equation as a dummy variable).

The main objective of the study was to quantify the effects of foreign aid to agricultural production in Africa. It was hypothesized that Official Development Assistance (ODA) has a positive impact on agricultural production in SSA. ODA was used as the measure of foreign aid and was first defined and differentiated from other external resource flows received by developing countries. It was also shown that in recent years more ODA has been allocated to SSA and constitutes for a major share of gross domestic product and gross domestic investment. Noting that the agricultural sector is the dominant sector in SSA, an attempt was made to justify why ODA should have an impact on agricultural production.

An important element of this study was the specification of the foreign aid variable. Previous studies by Kherallah et al. (1995), Norton et al. (1992) and Rai (1987) have not provided any basis for estimating foreign aid as a quadratic distributed lag. In this study the length and the order of the foreign aid lag variable was chosen as a 6 year second order polynomial on the basis of the distribution of benefits from World Bank projects as reported by Mosley (1987). In addition, specification tests were also performed to test the validity of the end point restrictions imposed on the lag of the foreign aid variable.

This study involved the use of cross section, time series data. Previous studies that have estimated aggregate agricultural production functions from international data (Appendix A, Table A-1), have commonly chosen a model in which both the slope and intercept term are the same across countries. In this study an important step was to specify a statistical model that would account for unobserved country differences so that the panel data could be combined for estimation and inference purposes. Through specification tests it was established that the covariance model in which the regression slope coefficients were identical but the intercept term varied across countries, best represented the data.

The results of the study support the hypothesis that the aggregate effect of ODA on agricultural production in SSA is positive. The output elasticity for foreign aid was 0.04. From this coefficient the marginal product was calculated to be $0.14 (Table 6.1); the marginal product is interpreted to mean that a one dollar increase in ODA in each of the past six years would be expected to increase the value of agricultural output by 14 cents in the current year. Over the past 5 years (1989-1993) ODA to Africa has been approximately 17 billion dollars (1990 US $) per annum (Table 2.4). It would be expected that the impact due to a continuous flow of aid of this magnitude, would be an increase of agricultural GDP by 2.4 (0.14*17)

Table 6.1 Summary results of the marginal product of foreign aid to agricultural production in SSA

Region	Marginal product[a] (in dollars)
SSA	0.14
Agro-climatic regions:	
Sudano-Sahel	0.40
Western Africa	0.91
Central Africa	1.32
Eastern and Southern Africa	-0.15
Income level:	
Low	-0.34
Middle	0.74
High	0.16
Policy environment:	
Favourable	0.65
Unfavourable	ns[b]

Note: a. The marginal product is interpreted to be the increase in the value of agricultural production in the current year due to a one dollar investment in each of the 6 previous years.
b. ns indicates that the coefficient is non-significant at the 10 percent or lower level

billion dollars annually in aggregate to the economy of the whole region.

There were significant differences when countries were grouped according to agro-climatic region, income level and policy environment. When countries were classified according to agro-climatic regions aid was positive and significant in all regions except Eastern and Southern Africa. Due to the incidence of drought in Eastern and Southern Africa, a large component of total aid may have been used for famine relief (i.e. food aid) in this region hence explaining the negative impact of aid on agricultural production. The impact of aid differed in magnitude in each region; the marginal products of foreign aid obtained in each region revealed that foreign aid had the greatest impact in Central Africa ($1.32), followed by Western Africa ($0.91) and then the Sudano-Sahel ($0.40) (Table 6.1). Additional analysis would be needed to interpret why these differences occurred.

The results obtained when countries were classified according to income level showed that the impact of aid was positive and significant in middle and high income countries but negative and significant in low income countries. The marginal product of foreign aid to agricultural production was calculated to be $0.74 in middle income countries and $0.16 in high income countries (Table 6.1). Middle income countries have a dominant agricultural sector (as compared to high income countries), thus explaining the larger impact of foreign aid on agricultural production. This result also indicates that low income countries lack the absorptive capacity to put foreign aid to productive use. Thus foreign aid needs to be directed to low income countries in order for investments to be made in supporting infrastructure (both physical and human) that enhances the effectiveness of aid.

The effect of aid was positive and significant in countries classified under a favourable policy environment but negative and insignificant in countries classified under an unfavourable policy environment. As agriculture is the dominant sector in SSA, it is vital that countries pursue policies that are favourable to agriculture. Not only are countries with favourable agricultural policies more productive (Appendix D, Table D-1) but foreign aid also affects agricultural production positively and significantly. The marginal product of foreign aid to agricultural production in countries with a favourable policy environment was $0.65 (Table 6.1).

The structural adjustment dummy variable was positive and significant in most regressions indicating that the presence of structural adjustment programs has been beneficial to agriculture in SSA. Many countries in SSA have undertaken reform programs and it is now in the mid-1990s that the effects of these programs are being felt. The World Bank study (World Bank, 1994a) on the effectiveness of reforms in SSA, reports that countries with large improvements in macroeconomic policy are experiencing a turn around from the decline in the economic performance of the previous years. For structural adjustment to have a strong impact on agricultural production it is not only important that countries pursue favourable overall economic policies but also that policies that stimulate the growth of the agricultural sector are adopted.

The elasticities of output for the other production inputs compare well with those obtained in previous studies (Appendix A, Table A-1). The coefficient for labour is smaller in magnitude in this study. But as compared to other inputs used in this study it is still relatively large and hence still indicates that labour plays a dominant role in agricultural production in SSA. In general, the traditional inputs (labour and livestock) were the major determinants of agricultural production in SSA. The elasticities of output for the modern inputs (machinery and fertilizer) were small indicating that these inputs are important determinants but make a relatively smaller contribution to agricultural production in SSA. The coefficient for education has shown great variability in magnitude, significance and sign in the different regression equations. As mentioned in the explanation for the aggregate model, a better measure for this variable is the education level of the rural population. However this data is not available.

These results are largely consistent with the results of Binswanger and Pingali (1988) who have observed that in SSA, the use of advanced agricultural technologies has not produced much success because the wrong technologies have been followed in many countries. Viable agricultural research in SSA needs to take proper account of the heterogenous nature of the continent which has resulted in a variety of farming systems. Binswanger and Pingali (1988) suggest that since in many parts of Africa land is still abundant and market access is poor, research and extension should focus on stress avoiding technologies, new crops and high quality varieties. In addition, investment in infrastructure is vital to provide access to markets thus making farming more profitable. Advanced agricultural technologies are likely to be adopted when farming is profitable; hence agricultural research and infrastructure investment should be made in areas with good land and suitable climate to ensure the quickest returns.

6.2 CONCLUSIONS

It can be concluded from this study that foreign aid has had a positive effect on agricultural production in SSA. It is important to note that there is a great variation in the effect of foreign aid on agricultural production when countries are classified according to agro-climatic region, income level and policy environment. The marginal product of foreign aid ranges from the small negative effect in Eastern and Southern Africa to the very large positive effect in Central Africa. When countries were grouped according to income level, the marginal product of foreign aid was larger in middle income countries as compared to high income countries, and negative in low income countries. The effect of aid was positive and significant in countries classified under a favourable policy environment but negative and insignificant in countries classified under an unfavourable policy environment. The negative relationship between foreign aid and agricultural production in some countries in SSA (as indicated by the regression results for Eastern and Southern Africa, low income countries, and countries with unfavourable policy environment) dampens the overall effect of aid in the aggregate model. Thus the impact of aid may appear small when all countries are aggregated but the magnitude is fairly high when those few countries with a negative effect are not included.

Moreover the marginal products obtained indicate that the returns to agriculture from foreign aid investment are low partly because total aid and not agricultural aid is used in the analysis. Total aid is directed towards investment in human (e.g. education, health, nutrition) and physical infrastructure (e.g. roads, ports, power stations) in which the full returns can only be captured in the very long run. Since commercial capital to finance these development projects may not be available to the countries of SSA, international financial assistance can be of particular importance for facilitating and sustaining development in poor countries. Given the low interest rate and attractive terms of ODA, it can be concluded that foreign aid has made a net positive contribution to agricultural production in SSA. Noting the large share of agriculture in the African economy, the broader conclusion from this study is that, with the exception of a few countries, foreign aid has succeeded in its development objectives in SSA.

The findings from this thesis also indicate that the policy environment is an important determinant to aid effectiveness. Policy reform in SSA has been the key development strategy since the late 1980s. This study confirms that there is continued need to improve the domestic policies in Africa. As mentioned by Killick (1985), countries pursuing favourable domestic policies are likely to receive more foreign aid. More importantly, favourable domestic policies encourage the mobilization of domestic savings thus creating productive investment. The effect of aid is shown to be positive in the high and middle countries of SSA. Greater wealth could be an indicator of the availability of public infrastructure (better roads, reliable power supplies, efficient telephones, etc.) which has created an enabling environment for the efficient use of both domestic and foreign resources. Hence the reform programs implemented by African countries need to be diligently pursued; foreign aid would then assume its proper role of supplementing domestic investment. The high level of ODA flows to Africa may not be maintained throughout the 1990s and one of the major challenges of the region is to use these resources efficiently to create a sound and stable environment that will attract domestic and private investment thus facilitating growth into the next decade.

6.3 LIMITATIONS

There were a number of limitations encountered in this study. These shortcomings relate mainly to data problems which have an effect on the quality of the regression results.

First, as discussed in Chapter 2, aid directed to agriculture is only part of total aid. Data on agricultural aid is not available and hence total ODA was used as the measure for agricultural aid. It is expected that the use of total aid underestimated the impact of aid on agricultural production.

Second, the total number of tractors in a country was used to represent modern mechanical technologies. A more suitable measure would have been tractor horsepower available in a country, as tractors differ widely in their power output. However data for average horsepower available in SSA does not exist.

Third, the complete data set for the education variable, measured as the literacy rate, was not available. Missing values were estimated from the existing data and this source of error could perhaps account for the weak explanatory power of the education variable in the regression results. Moreover the literacy rate pertains to the entire population of a country; if data were available, a more suitable measure would be the literacy rate of the agricultural population.

It is expected that improving the data base for this study would produce better regression results.

REFERENCES

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

Anderson, K. (1989). "Does agricultural growth in poor countries harm agricultural-exporting rich countries?" Agricultural Economics 3: 309-321.

Antle, J.M. (1983). "Infrastructure and aggregate agricultural productivity: international evidence." Economic Development and Cultural Change 31: 609-619.

Binswanger, H. and P. Pingali. (1988). "Technological priorities for farming in Sub-Saharan Africa." World Bank Research Observer 3: 81-98.

Buse, A. (1973). "Goodness of fit in generalized least squares estimation." The American Statistician 27: 106-108.

Cassen, R. and Associates. (1994). Does Aid Work? Oxford: Clarendon Press.

Chenery, H.B. (1969). "The two gap approach to aid and development: a reply to Bruton." American Economic Review 59: 446-449.

Chenery, H.B. and A. Strout. (1968). "Foreign assistance and economic development: reply." American Economic Review 58: 912-916.

Chenery, H.B. and A. Strout. (1966). "Foreign assistance and economic development." American Economic Review 56: 679-733.

Chenery, H.B. and M. Bruno. (1962). "Development alternatives in an open economy: the case of Israel." Economic Journal 72: 79-103.

de Janvry, A. and E. Sadoulet. (1986). "The conditions for harmony between third world agricultural development and U.S. farm exports." American Journal Of Agricultural Economics 68: 1340-1346.

Dulles, A.W. (1993). The Marshall Plan. Oxford: Berg Publishers, Inc.

Elmi, O.S. (1994). Agricultural prices and supply response in tropical Africa. M. S. Thesis, McGill University.

Fei, J.C.H. and G. Ranis. (1968). "Foreign assistance and economic development: comment." American Economic Review 58: 897-910.

Food and Agricultural Organization of the United Nations (FAO). (1995). FAO Production Yearbook 1994. Rome. (and previous issues)

FAO. (1994). FAO Fertilizer Yearbook 1993. Rome. (and previous issues)

FAO. (1993). "Intercountry comparisons of agricultural output and productivity." FAO Economic and Social Development Paper no. 112. Rome.

Fry, M.J. (1980). "Savings, investment, growth and the cost of financial repression." World Development 8: 317-327.

Giovanni, A. (1985). "Saving and the real interest rate in LDCs." Journal of Development Economics 18: 197-217.

Griffin, K.B. and J.L. Enos. (1970). "Foreign assistance: objectives and consequences." Economic Development and Cultural Change 18 (3): 313-327.

Griffiths, W.E., R.C. Hill and G.C. Judge. (1993). Learning and practicing econometrics. New York: John Wiley and Sons, Inc.

Gujarati, D.N. (1988). Basic econometrics. New York: Mc-Graw Hill, Inc.

Gupta, K and M.A. Islam. (1983). Foreign capital, savings and growth: an international cross-section study. Dordrecht: D. Reidel Pub. Co.

Hadjimichael, M.T., D. Ghura, M. Muhleisen, R. Nord and E.M. Uger. (1995). Sub-Saharan Africa: growth, savings, and investment, 1986-93. Washington, D. C.: IMF Occasional Paper 118.

Haley, S.L. (1991). "Capital accumulation and the growth of aggregate agricultural production." Agricultural Economics 6: 129-157.

Haley, S.L. and P.C. Abbott. (1986). "Estimation of agricultural production functions on a world-wide basis." Canadian Journal of Agricultural Economics 34: 433-454.

Harrison, P. (1990). Sustainable growth in African agriculture. Background Papers: The Long Term Perspective Study of Sub-Saharan Africa. Vol. 2. Economic and Sectoral Policy Issues. Washington, D. C.: World Bank.

Hayami, Y. (1969). "Sources of agricultural productivity gap among selected countries." American Journal of Agricultural Economics 51: 564-575.

Hayami, Y and V.W. Ruttan. (1985). Agricultural development: an international perspective. Baltimore: The John Hopkins University Press.

Hayami, Y and V.W. Ruttan. (1970). "Agricultural productivity differences among countries." American Economic Review 60: 895-911.

Houck, J.P. (1988). "Link between agricultural assistance and international trade." Agricultural Economics 2: 159-166.

Hsiao, C. (1986). Analysis of panel data. New York: Cambridge University Press.

International Monetary Fund. (1995). International Financial Statistics Yearbook 1995. Washington, D.C.

Jaeger, W.K. (1992). "The effects of economic policies on African agriculture." World Bank Discussion Paper no. 147. Washington, D.C.: World Bank.

Johnson, H.G. (1963). "Towards a generalized capital accumulation approach to economic development" in The Canadian Quandary: Economic Problems and Policies. Toronto: McGraw-Hill Inc.

Kawagoe, T., Y. Hayami and V.W. Ruttan. (1985). "The intercountry agricultural production function and productivity differences among countries." Journal of Development Economics 19: 113-132.

Kherallah, M.W., J.C. Beghin, E.W.F. Peterson and F.J. Ruppel. (1994). "Impacts of official development assistance on agricultural growth, savings and agricultural imports." Agricultural Economics 11: 99-110.

Killick, T. (1985). "Economic environment and agricultural development: the importance of macroeconomic policy." Food Policy 10: 29-40.

Kmenta, J. (1986). Elements of econometrics. New York: Macmillan Pub. Co.

Krueger, A.O. (1986). "Aid in the development process". World Bank Research Observer 1: 57-78.

Krueger, A.O. and V.W. Ruttan (1989). "Toward a theory of development assistance." In Aid and Development. Edited by A.O. Krueger, C. Michalopoulos and V.W. Ruttan. Baltimore: The Johns Hopkins University Press.

La-Anyane, S. (1985). Economics of agricultural development in tropical Africa. New York: John Wiley and Sons.

Lau, L.J. and P.A. Yotopoulos. (1989). "The meta-production function approach to technical change in world agriculture." Journal of Development Economics 31: 241-269.

Lele, U. (1991). "The MADIA countries: aid inflows, endowments, policies, and performance." In Aid to African agriculture: lessons from two decades of donors' experience. Edited by U. Lele. Washington, D. C.: World Bank.

Lokheed, M.E., D.T. Jamison and L.J. Lau. (1980). "Farmer education and farm effeciency: a survey." Economic Development and Cultural Change 29: 37-76.

Michalopoulos, C. and V. Sukhatme. (1989). "The impact of development assistance: a review of the quantitative evidence". In "Aid and development." Edited by A.O. Krueger, C. Michalopoulos and V.W. Ruttan. Baltimore: The Johns Hopkins University Press.

Mikesell, R.F. (1983). The economics of foreign aid and self-sustaining development. Boulder: West View Press.

Mosley, P. (1987). Foreign aid: its defence and reform. Lexington: The University Press of Kentucky.

Norton, G.W. (1996). Personal communication.

Norton, G.W. and J. Alwang. (1993). Introduction to economics of agricultural development. New York: McGraw-Hill Inc.

Norton, G.W., J. Ortiz and P.G. Pardey. (1992). "The impact of foreign assistance on agricultural growth." Economic Development and Cultural Change 40: 775-786.

Organisation for Economic Cooperation and Development (OECD). (1995a). Development Cooperation: 1994 Report. Paris: OECD.

OECD. (1995b). Geographical Distribution of Financial Flows to Aid Recipients: 1989-1993. Paris. OECD. (and previous issues)

OECD. (1994). Development Cooperation: 1993 Report. Paris. OECD.

OECD. (1992). Development Cooperation: 1992 Report. Paris. OECD.

OECD. (1987). Development Cooperation: 1986 Report. Paris. OECD.

Paarlberg, R.L. (1986). "Farm development in poor countries: the disputed consequences for U.S. farm trade." American Journal of Agricultural Economics 68: 1353-1357.

Pinstrup-Andersen, P., M. Lundberg and J.L. Garrett. (1995). Foreign assistance to agriculture: a win-win proposition. Washington, D.C.: Food Policy Report, The International Food Policy Research Institute.

Radetski, M. (1973). Aid and development: a handbook for small donors. New York: Praegar Publishers.

Rai, K. (1987). Impact of foreign assistance on less developed countries. M. S. Thesis, Virginia Polytechnic Institute and State University.

Rao, D.S.P., K.C. Sharma and W.F. Shepherd. (1991). "On the aggregation problem in international comparisons of agricultural production aggregates." Journal of Development Economics 35: 197-204.

Rostow, W.W. (1971). The stages of economic growth. New York: Cambridge University Press.

Ruttan, V.W. (1989). "Why foreign economic assistance?" Economic Development and Cultural Change 37: 411-424.

Schultz, T.W. (1964). Transforming traditional agriculture. New Haven: Yale University Press.

Solow, R.M. (1957). "Technical change and the aggregate production function." The Review of Economics and Statistics 39: 312 - 320.

Staaz, J.M. and C.K. Eicher. (1990). "Agricultural development ideas in historical perspective" in: Agricultural development in the third world edited by C.K. Eicher and J.M. Staatz. Baltimore: The Johns Hopkins University Press.

Summers, R. and A. Heston. (1988). "A new set of international comparisons of real product and price levels estimates for 130 countries, 1950-1985." Review of Income and Wealth Series 34: 1-25.

Trueblood, M.A. (1989). "Agricultural production function estimates from aggregate intercountry observations: a selected survey." Canadian Journal Of Agricultural Economics 37: 1045-1060.

United Nations Economic Commission for Africa. (1994). African Socio-Economic Indicators 1993. Addis Ababa. (and previous issues)

United Nations Educational and Scientific Organisation (UNESCO). (1994). UNESCO Statistical Yearbook 1994. Paris. (and previous issues)

Varian, H.R. (1990). Intermediate microeconomics: a modern approach. New York: W.W. Norton and Co.

Vollrath, T.L. (1994). "The role of agriculture and its prerequisites in economic development: a vision for development assistance." Food Policy 19 (5): 469-478.

Weisskopf, T.E. (1972). "The impact of foreign capital inflow on domestic savings in underdeveloped countires." Journal of International Economics 2: 25-38.

White, J. (1974). The politics of foreign aid. London: The Bodley Head Ltd.

Wolf, C.Jr. (1960). Foreign aid: theory and practice in Southern Asia. Princeton: Princeton University Press.

World Bank. (1995a). Trends in Developing Economies. Washington, D. C.: World Bank. (and previous issues)

World Bank. (1995b). World Tables 1995. Washington, D. C.: World Bank. (and previous issues)

World Bank. (1994a). Adjustment in Africa: reforms, results and the road ahead. New York: Oxford University Press.

World Bank. (1994b). African Development Indicators. Washington, D. C.: World Bank.

World Bank. (1994c). Global Economic Prospects and the Developing Countries: 1994. Washington, D. C.: World Bank.

World Bank. (1994d). 1992 Evaluation Results. Washington D. C. World Bank Operations Evaluation Department.

World Bank. (1993). World Development Report 1993. Washington, D. C.: World Bank. (and previous issues)

World Bank. (1989). Sub-Saharan Africa: from crisis to sustainable growth. Washington, D. C.: World Bank.

World Bank. (1982). Accelarated development in Sub-Saharan Africa: an agenda for action. Washington, D.C.: World Bank.

Wu, X. and X. Yao. (1992). "Relationship between agricultural growth and farm imports in LDCs: a Sims' causality test based on 35 countries." Agricultural Economics 7: 341-349.

APPENDIX A: AGRICULTURAL PRODUCTION FUNCTION ESTIMATES FROM SELECTED STUDIES

Table A-1 Comparison of OLS estimates obtained from different studies for aggregate agricultural production functions in Less Developed Countries and Sub Saharan Africa

Sample	Less Developed Countries				Sub Saharan Africa[a]		
Source	Antle (1983)	Kawagoe, Hayami and Ruttan (1985)	Rai (1987)	Lau and Yotopoulos (1989)	Norton, Ortiz and Pardey (1992)	Frisvold and Ingram (1995)	Gichenje[b] (1996)
Observation period	1965	1960, 1970, 1980	1975-1984	1960, 1970, 1980	1970-1985	1973-1985	1970-1993
Conventional Inputs							
Fertilizer	0.136	0.084	0.093	0.042	-	0.026	0.019
Labour	0.400	0.608	0.264	0.268	0.518	0.600	0.175
Land	0.085	-0.052	0.230	0.891	0.673[c]	0.914[c]	-
Livestock	0.252	0.274	0.041	0.053	0.213	0.186	0.091
Machinery	-	0.133	0.056	0.044	0.087	0.047	0.067
Non-conventional inputs							
Education[d]	-0.010	-	0.289	-	0.069	-	-
Education[e]	-	0.287	-	0.282	-	-	0.046
Foreign aid	-	-	-0.036	-	0.030	-	0.043

Note: a conventional inputs and foreign aid measured per hectare of agricultural land
b summary results of the aggregate model used in this study
c land variable measured as a land quality index
d education variable measured as primary and secondary enrollment ratios
e education variable measured as the literacy rate
-. indicates variable not included in the study

APPENDIX B: LINEAR REGRESSION MODEL

Table B-1 Pooled results for the linear agricultural production function for SSA

Variable[a]	Linear model
Fertilizer	0.003
Labour	0.211***
Livestock	-0.111
Machinery	0.008
Education	0.052***
Foreign Aid	0.044[b]**
Structural Adjustment	0.001*
<u>Country Intercepts</u>:	
Benin	0.925E-04***
Botswana	-0.019E-04
Burkina Faso	0.132E-04***
Burundi	1.835E-04***
Cameroon	0.805E-04***
Central African Republic	0.280E-04***
Chad	-0.005E-04
Congo	0.008E-04
Côte d'Ivoire	0.989E-04***
Ethiopia	0.465E-04***
Gabon	0.260E-04***
Gambia	1.585E-04***
Ghana	3.323E-04***
Guinea	0.763E-04***
Kenya	0.176E-04***
Lesotho	-0.191E-04**
Madagascar	0.046E-04
Malawi	0.265E-04***
Mali	0.085E-04***
Mauritania	-0.025E-04
Mauritius	10.262E-04***
Mozambique	0.073E-04*
Niger	0.164E-04**
Nigeria	4.394E-04***
Rwanda	2.467E-04***
Senegal	0.487E-04***
Swaziland	0.125E-04*
Tanzania	0.685E-04***
Togo	0.546E-04***
Uganda	1.130E-04***
Zambia	-0.077E-04***
Zimbabwe	0.448E-04***
Number of observations	576
Buse Raw Moment R-square	0.99

Note: a. The dependent variable is the value of agricultural output.
b. Calculation based on the sum of the distributed lag coefficients.
*,**,*** Denotes significance at the 10, 5 and 1 percent level, respectively.

APPENDIX C: THE CHOW TEST

The Chow test is used to test for structural difference when a sample is broken down into two or more structures resulting in the estimation of separate equations. Equation 4.1 including all 32 countries, is broken down into sub-samples when additional models are estimated when countries are classified according agro-climatic zones, income level and policy environment. The results from these additional models are presented in chapter 5. By means of the Chow Test, it is intended to establish if separate structures exist for the different classifications.

To test the hypothesis:

H_0: no structural difference

H_A: structural difference exists

the Chow Test is given by the following general specification of the F test:

$$F = \frac{(S_R - S_U) / k}{S_U / (n - 2k)}$$

where S_R = residual sum of squares from the restricted equation: the restricted equation in the Chow test is the single equation estimated by pooling the entire set of observations,

S_U = sum of the residual sum of squares from the unrestricted equations,

k = degrees of freedom of the numerator; it is obtained by subtracting the degrees of freedom associated with the unrestricted equations from the degrees of freedom associated with the restricted equation, and

(n - k) = degrees of freedom of the numerator which equals the sum of the separate degrees of freedom of the unrestricted equations; where n is the number of observations and k is the number of parameters estimated.

Table C-1 Results from the Chow test

Country classification	F value	df[a]	H_0	Conclusion
Agro-climatic regions	15.065	(22, 515)	reject[b]	separate equations
Income level	28.648	(14, 523)	reject[c]	separate equations
Policy environment	38.871	(6, 481)	reject[d]	separate equations

Note: a. degrees of freedom of the numerator and denominator respectively
b. H_0: no structural difference exists. The critical value at the 1% level is 1.88
c. H_0: no structural difference exists. The critical value at the 1% level is 2.04
d. H_0: no structural difference exists. The critical value at the 1% level is 2.80

As reported in Table C-1, the results from the Chow test indicate that it is valid to estimate separate equations for each classification group. Hence a different production function equation exists when countries are classified according to agro-climatic regions, income level and policy environment.

Appendix D: SUMMARY OF VARIABLES USED IN THE AGRICULTURAL PRODUCTION FUNCTION FOR SSA

Table D-1 Average values for output and input variables

	Ag. GDP[a]	Fertilizer[b]	Labour[b]	Livestock[b]	Machinery[c]	Education[b]	Aid[d]	SAP[e]	Land[f]
1) SSA	145.41	0.01	0.337	0.313	3.9	45.3	42.768	7.0	19
<u>Agro-climatic</u>:									
2) Sudano-Sahel	70.249	0.002	0.286	0.398	0.5	21.9	46.965	7.6	21.6
3) Western	216.550	0.002	0.310	0.242	1.7	37.2	29.382	8.5	17.6
4) Central	56.197	0.001	0.118	0.156	1.0	51.3	16.100	7.5	8.8
5) East & South	175.810	0.019	0.429	0.344	7.1	57.9	53.276	6.5	21.2
<u>Income level</u>:									
6) Low	80.807	0.003	0.332	0.312	2.2	42.9	19.988	5.8	33.9
7) Middle	150.590	0.002	0.400	0.317	1.0	37.7	40.144	8.4	19.2
8) High	175.870	0.028	0.238	0.307	9.5	59.0	60.635	6.1	9.8
<u>Policy Env.</u>:									
9) Favourable	189.910	0.015	0.368	0.326	2.7	40.0	56.461	8.3	15.7
10) Unfavourable	93.142	0.003	0.331	0.296	3.8	50.0	21.663	6.0	30.2

Note: a. per hectare value of agricultural output in 1985 international dollars computed from purchasing power parities
b. more detailed definitions are given in Chapter 4
c. number of tractors per 10,000 hectares
d. per hectare value of ODA in 1985 international dollars computed from purchasing power parities
e. average duration of structural adjustment programs in each country
f. million hectares of agricultural land