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FOREIGN DIRECT INVESTMENT IN DEVELOPING COUNTRIES AND AGRICULTURAL PRODUCTIVITY IN THE TROPICS: WHY AFRICA RECEIVES LESS FDI AND HAS LOW AGRICULTURAL PRODUCTIVITY?

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WHY AFRICA RECEIVES LESS FDI AND HAS LOW AGRICULTURAL PRODUCTIVITY?

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF ECONOMICS

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ABSTRACT

This study examines why Africa as a region continues to attract less Foreign Direct Investment (FDI), and also has the lowest agricultural productivity among developing countries and tropical countries respectively. Attracting enough FDI will at least theoretically boost domestic investment, increase employment, enhance technology transfer and increase domestic exports (by making domestic firms competitive). The Agricultural sector employs a greatest share of Africa's labor force and also contributes most of Africa's nominal GDP. Therefore increasing agricultural productivity will go a long way in not only reducing rural unemployment but also reducing poverty. It has also been shown that growth in agricultural productivity is more poverty reducing that a similar growth in manufacturing sector.

In chapter 2, using pooled feasible generalized least squares (with individual fixed effect) on an unbalanced panel of between 55 and 77 countries, from 1984-2005, I examine the determinants of Foreign Direct Investment (FDI) in developing countries in general and sub-Saharan Africa (SSA) in particular. I find that extensive economic infrastructure is necessary for FDI flow to developing countries. With respect to institutional variables, the results also show that a stable government and conducive investment environment are associated with higher levels of FDI flow to developing countries. The results again show that while some of the regressors affect FDI inflow to sub-Saharan Africa in the same way, they do with respect to that of non sub-Saharan Africa, other regressors affect sub-Saharan Africa FDI inflow differently. For instance while infrastructural development, stable government, and conducive investment climate are associated with higher inflow of FDI to sub-

Saharan Africa and non sub-Saharan Africa regions, availability of natural resources (i.e. fuel exports) is positively associated with FDI inflow to SSA, but negatively associated with FDI to areas outside of SSA. Also the results show that below a certain threshold, larger GDP per capita and lower corruption level are positively associated with FDI flow to SSA. Other robustness checks show that the results are similar in the two datasets and various specifications.

In chapter 3, we examine the determinants of agricultural productivity in the tropics, and test whether these determinants affect tropical sub-Saharan Africa agriculture differently than in other tropical regions. We find that fertilizer usage, telephones, and rainfall have a positive and significant effect on agricultural productivity, while tractor usage and most institutional variables are insignificant. Interestingly, we find evidence that the effect of irrigation and rainfall differs inside and outside of tropical sub-Saharan Africa. Outside of Africa, irrigation positively and significantly impacts productivity. Inside it, the effect is either insignificant or highly muted. In an expanded sample of countries, we show that rainfall has a positive and significant impact on productivity in tropical SSA, but an insignificant effect outside of the region.

I discuss what needs to be done in Africa for it to increase its agricultural productivity in chapter 4. I review all the various interventions that have taken place in Africa with the goal of boosting its agricultural productivity, but failed to realize that goal. In particular I look at why the earlier Green Revolution that transformed agricultural productivity in most of the Asian and Latin American countries stalled in

Africa. I then examined the two main approaches (i.e. focused approach and comprehensive approach) that have been suggested in the literature to improve Africa's agricultural productivity. The proponents of the comprehensive approach note the complex nature of Africa's agricultural problems and hence propose that the solution should be multifaced and coordinated. Those who advocate for the focused approach argue that with scarce budgets, the solution to Africa's agricultural problems should be concise and focused on the more binding constraints to agricultural productivity. Finally, I argue that the approach that Africa adopts (be it comprehensive or focused approach) is not the key, but rather the significant role that African leaders will need to play. African leaders will have to improve rural infrastructure, make technology adoption affordable through the use of subsidies and micro-financing. Also African leaders will have to provide safety nets for farmers to reduce the risk in adopting new technology. Without African leaders providing these facilities, none of the approaches suggested stands a chance to succeed.

CHAPTER 1

GENERAL INTRODUCTION

Sub-Saharan Africa continues to be one of the slowest growing region of the world at least in the post World War II era. Foreign Direct Investment (FDI) has been argued to be very important in African countries and development partners' efforts in reducing or eradicating poverty in Africa. For instance the United Nations Millennium Declaration indicates that FDI will help Africa's Millennium Development goal of reducing poverty by half by 2015. FDI is very important to the African continent in filling the resource gap, because income levels and savings are generally low and official assistance declined in the 1990s. The official assistance to SSA declined by 41% between 1990 and 2001 (World Bank, 2003). However, while FDI flow to developing countries has seen some increase in the past decade, the increase in inflow to Africa has not kept pace with that of other parts of the world. For instance, between 2007 and 2009, on average, the proportion of world FDI flows to Latin America and the Caribbean, and South, East and Southeast Asia were 9.5% and 16.3% respectively. That of Africa for the same period was 4% (UNCTAD, 2010).

Africa's economy is mostly agrarian, with the agriculture sector employing about 65% of the labor force and contributing about 30% of GDP growth rate. Also studies have shown that increase in GDP growth rate due to increase in agricultural labor productivity is about twice more effective in improving the incomes of the poor a similar growth in GDP due to increase in non agricultural labor productivity. In particular, Bravo-Ortega and Lederman (2005) find that an increase in overall GDP

caused by an increase in agricultural labor productivity on average raises incomes of the poorest quintile 2.9 times more in developing countries and 2.5 times more in Latin America, than a similar increase in GDP caused by nonagricultural labor productivity.[1] Agricultural productivity in Africa, however, has not seen the same growth experienced in different parts of Asia and Latin America during the earlier Green Revolution. The reasons cited for this low agricultural productivity ranges from unfriendly tropical climate and its adverse effects on agricultural productivity, difficulty in transferring temperate agricultural technology to the tropics, to lack of appropriate public policies.

Chapter 2 examines the determinants of FDI flow to developing countries in general and whether investors look at different factors when investing in SSA than investing in areas outside of SSA. Using fixed effect GLS, I find that the extensive economic infrastructure attracts FDI to developing countries. The results also show that a stable government and conducive investment environment are associated with higher levels of FDI inflow to developing countries. The results again show that while infrastructural development, stable government, and conducive investment climate are associated with higher inflow of FDI to sub-Saharan Africa and non sub-Saharan Africa regions, availability of natural resources (i.e. fuel exports) is positively associated with FDI inflow to SSA, but negatively associated with FDI to areas outside of SSA. Also the results show that below a certain threshold, larger

[1] However in a recent study evaluating the impact of Milennium Village Project (MVP), Wanjala and Muradian (2011) found out that in the Sauri Millennium Village in Kenya, though agricultural productivity increased by about 70%, income levels of farmers did not change. One of the reasons cited for this break in linkage between agricultural productivity and incomes of the poor, is the small size of the farms (about 0.5 hectares per household) and hence most of the increase in productivity going to consumption.

GDP per capita and lower corruption level are positively associated with FDI flow to SSA. Other robustness checks show that the results are similar in the two datasets and various specifications.

In chapter 3, we investigate the determinants of tropical agricultural productivity in a panel of 27 tropical developing countries across several regions for the years 1984 to 2005. We examine the role that institutions, government policies, traditional inputs, and infrastructure play in explaining differences in agricultural productivity across tropical countries, and whether the effect of these variables is significantly different in Sub-Saharan African (SSA) countries. In the full sample, we find that fertilizer consumption, the number of telephone subscribers (both mainline and cell phones), rainfall, and irrigation are important to agricultural productivity. However, institutional variables, bureaucratic quality, government stability, and corruption, are all insignificant in the full sample. When we construct interaction variables to test whether the effect of these variables are different in SSA, we find some interesting results. First, fertilizer consumption, telephones, and rainfall have a positive and significant impact on agricultural productivity across regions. Second, the coefficients on tractor usage and the institutional variables are insignificant. Last, irrigation has a positive and significant effect outside of tropical SSA, but no significant effect within the region. Expanding our sample by using an alternative measure of tropicality yields very similar results. The main differences are that the effect of rainfall is now only significant in tropical SSA, and two of the institutional variables are weakly significant.

In chapter 4, I examine the two main approaches (the focused and comprehensive) suggested in the literature to help Africa transform its agricultural productivity. The proponents of the comprehensive approach note the complex nature of Africa's agricultural problems and hence propose that the solution should be multifaced and coordinated. Those who advocate for the focused approach argue that with scarce budgets, the solution to Africa's agricultural problems should be concise and focused on the more binding constraints to agricultural productivity. I also look at the prospect of South-South cooperation instead of the typical North (Consultative Group of International Agricultural Research - CGIAR) - South cooperation, in part because southern countries often have similar climates and may have faced similar agricultural challenges (e.g. bad soil, drought like in Brazil's *Cerrado*), and therefore may be able to help more effectively.[2] It should be noted that South-South cooperation can be either comprehensive or focused. I argue that no matter the kind of approach African countries adopt, the key to agricultural transformation requires a strong commitment from African leaders, with respect to the provision of needed infrastructure, improved institutions, and ensuring an enabling environment, and a coordinated effort by all partners (i.e. International Agricultural Research systems (IARs), National Agricultural Research Centers (NARCs), Sub-regional Research Organizations (SROs), both bilateral and

[2] The 15 international agricultural research centers are: International Food Policy Research Institute (IFPRI), International Center for the Improvement of Maize and Wheat (CIMMYT), International Potato Center (CIP), Biodiversity International, International Center for Tropical Agriculture (CIAT), International Center for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI), Africa Rice Center (WARDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA), International Water . Management Institute (IWMI), International Rice Research Institute (IRRI), WorldFish Center, Center for International Forestry Research (CIFOR), and World Agroforestry Center.

multilateral development partners and philanthropists). Africa's agriculture will still be underdeveloped if cooperation yields promising improved varieties and there are no efficient extension services to make the farmers aware of the new varieties and how to plant them or if other complementary inputs like fertilizer are not affordable because of poorly functioning markets for inputs and outputs. There is only so much the development partners will be able to do.

The study is organized as follows: chapter 2 examines the determinants of FDI inflow to developing countries in general and SSA countries in particular. Chapter 3 analyzes the determinants of tropical agricultural productivity. Section 4 focuses on the role that African leaders needs to play in transforming their agricultural productivity. In the last section, I present conclusions from the study.

CHAPTER 2

The Determinants of Foreign Direct Investment in Developing Countries: Why does Africa continue to underperform?

2.1 Introduction

Africa, and sub-Saharan Africa in particular, has been the slowest growing region in the post World War II period. For instance, while annual average per capita GDP growth rate for sub Saharan Africa was 0.5% between 1965-90, Latin America and the Caribbean, and East Asia and the Pacific recorded an annual per capita GDP growth rate of 1.6% and 5% respectively between the same period. Though the average annual per capita GDP growth rate recorded by sub-Saharan Africa between 2000 and 2009, 2%, is marginally more than that of Latin America and the Caribbean, 1.85%, it still lags far behind that of East Asia and the Pacific, 8%. The abysmal economic performance recorded by sub-Saharan Africa has resulted in a plethora of literature that attempts to explain the cause of this underperformance. Growth regressions have been able to uncover some of the causes. Studies have shown that low level of educational attainment, political instability, poorly developed financial systems, large black-market exchange rate premia, large government deficits and less foreign direct investment account for about half of the growth rate differential between Africa and East Asia (Easterly and Levine, 1998). In addition, it has also been documented that when a sub-Saharan Africa regional dummy variable is used in a growth regression it has a significant coefficient of -0.015 (Easterly and Levine, 1998). This means that a country's predicted growth rate

will be 1.5 percentage points lower, due to the country being geographically located in Africa.

There have been a lot of theoretical underpinnings touting the important role FDI can play in economic growth and development (with some theories pointing to possible adverse effect of FDI), the empirical results have been mostly mixed with respect to the growth potential of FDI. One theory points to the potential effects of FDI increasing domestic investment, employment, technology transfer and increased domestic exports (by making domestic firms competitive). A contrary theory also posits that FDI may crowd out domestic firms since domestic firms will not be able to compete with their foreign counterparts in terms of advertising power, improved technology, and predatory pricing. Also FDI may drive out domestic investment (especially Greenfield investment) by increasing the demand for money and hence interest rates.[3] Finally a large FDI inflow may results in appreciation of exchange rate and hence decreasing net trade. The empirical results are mixed on the FDI impacts on domestic investment, and its growth potential. For instance while Borensztein et al. (1998) shows a positive effect of FDI on domestic capital formation, Lipsey (2000) indicates past FDI inflows do not have a significant positive influence on current period's investment ratio. With respect to economic growth effect of FDI, UNCTAD (1999), and Borensztein et al. (1998) find no direct effect of FDI on economic growth, though when FDI is interacted with variables like human capital, it has positive effect on economic growth. Thus FDI may have

[3] Greenfield investment is a form of Foreign Direct Investment where a foreign company builds a new facility from the scratch, unlike Mergers and Acquisition, the other form of FDI, where a foreign company team up with domestic investor(s) or acquire a domestic company.

positive impact on economic growth when there is capacity to absorb advanced technology.

Foreign Direct Investment (FDI) has been argued to be very important in African countries and developments partners' efforts in reducing or eradicating poverty in Africa. For instance the United Nations Millennium Declaration indicates that FDI will help Africa's Millennium Development goal of reducing poverty by half by 2015. FDI is very important to the African continent in filling the resource gap, because income levels and savings are generally low and official assistance declined in the 1990s. The official assistance to SSA declined by 41% between 1990 and 2001 (World Bank, 2003). Though the Official assistance to Africa in the last decade has seen a steady increase, it still falls far below the amount needed for Africa to achieve its development goals. The need to attract FDI has been heeded by African leaders, who have fostered the necessary investment climate (trade liberalization, rule of law), macroeconomic framework (through devaluation, reduction of budget deficit and inflation), to political stability. Though the proportion of world FDI flow to developing countries has seen some increase in the past decade, the increase in inflow to sub-Saharan Africa has not kept pace with that of other parts of the world. For instance, while the proportion of world FDI flows to sub-Saharan Africa increased from 0.41% in 2000 to 2.75% in 2009, that of Latin America and Caribbean increased from 4.89% to 6.9% within the same period. For East Asia and the Pacific, the proportion of FDI inflows increased from 10.13% to 19% between

2000 and 2009.[4] The absolute value of FDI to Africa increased steadily from $10 billion in 2000 to a high of $72.2 billion in 2008, but declined to $58.6billion in 2009 (WIR, 2010).

This low inflow of FDI to sub-Saharan Africa has spurred research into the reasons behind this insufficient inflow of FDI to Africa. Asiedu (2002) examines whether the factors that have been found to attract FDI inflow affect Africa differently. She was able to show that these factors actually may be affecting Africa differently. In particular, she found that while higher return on capital and quality of infrastructure attract FDI to other non sub-Saharan developing countries, they are insignificant in the case of Africa. More importantly she also found that countries in Africa receive relatively low FDI by virtue of being located in Africa.

This chapter is similar to Asiedu (2002), in the sense that I also examine the determinants of FDI to developing countries in general, and Africa in particular but this chapter is different with respect to both the regressors used and the econometric methodology applied. For instance, while Asiedu uses GDP growth rate, I use per capita GDP as a proxy for market size. I argue that per capita GDP is a better proxy for market size since it takes into account the population growth rate. Also in Asiedu, while the average of revolution and assassination is used to measure political instability, I use three variables (the number of coups, riots, and assassinations) separately to measure political instability. In this way, I will be able to investigate how each of these three variables affects FDI inflow. While Asiedu did not use any

[4] The FDI proportions are calculated from World Development Indicators, 2010, and for only developing countries in those regions referred to.

institutional variables, I explore five institutional variables: government stability, investment profile, law and order, corruption and internal conflict. Institutional variables are very important because those are the variables that policymakers can control. I use investment profile to measure investment climate instead of trade openness which is used by Asiedu. Since investment profile measures contract viability, profit repatriation, and payment delays, I argue that it will be a better proxy for the investment environment. Also, while Asiedu used ordinary least square (OLS), here I use pooled feasible generalized least square (GLS), with country fixed effects, to account for possible bias and inconsistent estimates caused by omitted variables. The GLS is able to correct for the presence of heteroskedasticity and autocorrelation that may be present with OLS.

The results indicate that a good business climate, better economic infrastructure, and government stability are associated with higher FDI inflow to developing countries in general. Also the result shows that while natural resources (i.e. fuel exports as a percentage of total merchandized exports) are positively related to FDI inflow to Africa, they are negatively associated with FDI to non-African developing countries. Also below certain level, higher GDP per capita, and lower corruption are positively associated with FDI flow to SSA. The result is robust to an alternative sample of countries, where I include all countries with at least five years of data availability, contrary to the main sample where only countries with at least 10 years of data availability are included. The results therefore show that if SSA wants to boost its FDI inflow, then it will have to improve physical infrastructure, ensure government stability, and reduce official corruption.

For instance if government stability and investment profile increase by one index point, net FDI inflow per GDP to developing countries will increase by 5.9% and 7.3% respectively. If SSA increases its average telephone line (both fixed and mobile phones) from 16.76 (per 1000 people) to that of Honduras (30.91), the median country, SSA's FDI share of GDP will increase by about 3.8%. In the same way, if Uganda with an average telephone lines of 2.35 increases its average telephone levels to that of Honduras, Uganda's FDI share of GDP will increase by about 46.2%.

This chapter is structured as follows: in section 2.2, I review the literature on FDI to developing countries and Africa in particular. Section 2.3 discusses the data and empirical methodology, while section 2.4 presents the results and robustness checks. The last section of the chapter is devoted to conclusions, and policy recommendations.

2.2 Literature Review

The literature on FDI flow has been expanding because researchers have been trying to explain the causes of the uneven distribution of FDI flow across regions and even within the same region or continent. Since 1991, FDI inflow to developing countries accounted for only a little over a third of total flows. This proportion actually decreased by 27% during the period 2002-2003, with Asia accounting for about 60% (UNCTAD, 2002 and 2003). In 2008, FDI flows to Latin America and the Caribbean increased by 24% compared to that of 2007 with Brazil accounting for about 30% of this increase in FDI inflow, and Mexico's FDI inflow dropping by

20% in relation to its 2007 FDI inflow (Economic Commission for Latin America-ELAC, 2009). FDI to Africa has lagged behind other regions with most of FDI flowing to the primary sector. The primary sector accounted for about half the total flow to the region from 1996 to 2000 (UNCTAD, 2002). Countries with natural resources and/or huge market size (potential) like Nigeria, Angola, Egypt, and South Africa were the top receivers of FDI inflow to Africa in 2009 (WIR, 2010). For instance, Nigeria (major oil producing country), Angola (oil producing country), and South Africa, with a large market accounted for about 65% of FDI inflow to Africa between 2000 and 2002 (World Bank, 2004a). However, Asiedu (2004) was able to show that other factors like good infrastructure, an educated labor force, macroeconomic stability, and openness to FDI are important determinants of FDI to Africa.

Even though global FDI inflows and outflows declined in all the three major sectors (service, manufacturing, and primary), service and primary sectors continue to receive an increasing share of FDI. Global FDI flows started to recover in the bottom half of 2009 and have continued to recover in 2010 with developing and transitional economies serving as both key destination and source of global FDI flow (UNCTAD, 2010). For the first time, developing and transitional economies now absorb half of global FDI flow, with major players being Asian countries like China which is now second largest destination for global FDI just behind the USA in 2009. China, Hong Kong (China) and Russian Federation are among the top 20 destination for investors in the world. The proportion of global Transnational Corporations (TNCs) from developing countries have been increasing steadily from about a mere

8%, in 1990 to 28% in 2008 (UNCTAD, 2010). The South-South FDI has grown over the past 15 years with total outflows from developing countries increasing from about $4billion in 1985 to $61 billion in 2004. And most of these outflows went to other developing or transitional economies (UNCTAD, 2006).

Traditionally most of the FDI flow to Africa has come from few developed countries, but a new trend of FDI inflow to Africa has been gaining grounds recently. FDI from developing countries and cross-border Mergers and Acquisition (M&A) has been increasing recently. The United States, France, the United Kingdom, Germany, and Portugal have accounted for most of the FDI flows to Africa between 1996 and 2000 (UNCTAD, 2002). Typically FDI from developing countries has come from Asian countries like China, Taiwan, and India. These FDIs are also quite diversified ranging from manufacturing, service, information and technology, to natural resources. Investments from South Africa to other African countries have also been growing over the years.

This dominant role developing and transitional economies are playing with respect to global FDI flow may mask the uneven nature of FDI flows among developing and transitional economies. Most of the FDI flow to developing countries has gone to few countries, mostly emerging markets. And a greater share of the total FDI flows from developing and transitional economies have gone to Africa, accounting for about 21% of FDI flows to the region between 2005 and 2008.

For developing host countries, FDI from other developing countries provides some benefit in the form of technology transfer, managerial skills and a broader

source of capital (UNCTAD, 2006). FDI flowing from developing to other developing countries provides additional avenues for South-South cooperation. Also since TNCs from developing countries are likely to be using more simpler and labor-intensive technologies, developing TNCs have more employment potential than their developed counterpart. In fact in sub-Saharan Africa, it has been found that labor-intensities of developing country TNCs are larger than developed country TNCs (UNCTAD, 2006).

The theoretical determinants of FDI can be grouped into micro-determinants, macro-determinants, and strategic determinants. The empirical studies that have attempted to test these theoretical hypotheses have provided conflicting results. The micro-determinants are location specific factors and include labor cost, tariff and trade barriers, and government policies. Low labor cost and low trade barriers are argued to affect FDI inflow positively since low labor cost reduces cost of production and also low trade barriers help in importation of inputs at a relatively lower cost. Trade tariff (or "tax hopping hypothesis") stipulates that in order for foreign companies to avoid high export tariffs, foreign companies locate in the host country. Thus countries with high tariffs may attract more FDI. There is empirical evidence for both the low labor cost and "tax hopping hypothesis". Wheeler and Mody (1992), using 42 countries for the period 1982-1988 to examine the determinants of the US investment abroad found a positive relationship between labor cost and FDI inflow, and a negative relationship between FDI and taxes and tariffs. Government policies, including financial liberalization, provision of tax breaks and other incentives, and performance requirements (like the hiring and

training of local personnel, local content, and technology transfer) are touted as attracting FDI. The empirical evidence on government policies has been mixed (Helleiner, 1989; Dees, 1998).

The macro-determinants of FDI include market size and growth, openness and exports, exchange rates, inflation rates, budget deficits, infrastructure and political stability. It is argued that firms may locate abroad to take advantage of a foreign market and hence the larger the market, the higher the FDI inflow. Chakrabarti (2001), using Extreme Bound Analysis (EBA) to examine which of the determinants of FDI used in the literature are "robust' or "fragile" to small changes in the conditioning information set, found that per capita GDP is the most robust of all the determinants used in the literature. But other papers have also found conflicting results for GDP per capita as cited by Asiedu (2002). For instance Schneider and Frey (1985), using 54 least developed countries for the years 1976, 1979, and 1980, and Tsai (1994), using a sample of countries of either 62 or 51,and covering the periods 1975-1978 and 1983-1986, found a positive relationship between FDI and real GDP per capita. Loree and Guisinger (1995), examining the effects of policy and non policy determinants of the US firms locating abroad, and Wei (2000), looking at determinants of bilateral FDI for the period 1994-1996, however found a negative relation between GDP and FDI flow. While the "tax hopping hypothesis" postulates that openness and exports will result in lower FDI inflow, international competition will result in higher productivity and hence attract higher FDI inflow. There are empirical evidences supporting the hypothesis that openness attracts FDI (Lucas, 1993; Edwards, 1990; Hausmann and Fernandez-

Arias, 2000). Wheeler and Mody (1992), however, found the openness variable to be insignificant. The inflation rate serves as an indication of the stability of the domestic macro economy. The lower and more stable the inflation, the more FDI inflow expected. Infrastructural quality and political stability are thought to attract foreign investment. The empirical evidence on political instability has been mixed. While Schneider and Frey (1985) and Edwards (1990) found a negative relationship between political instability and FDI inflow, Loree and Guisinger(1995), and Hausmann Fernandez-Arias (2000) found the political instability variable insignificant. Foreign firms may also locate abroad for strategic reasons at least in the short run. This may include protecting a foreign market or to diversify a firm's activities.

Geography and urbanization in particular have been recognized as driving forces that support FDI inflow. This is because it is argued that urbanization tends to serve as a hub for necessary inputs, like skilled labor, and amenities/infrastructure, like good roads, good banking systems, IT, etc. Naude and Krugell (2007), however, using panel data to examine the determinants of FDI from 1970 to 1990, found an urban population to be negatively related to FDI inflow. Naude and Krugell (2007) also found that geography variables like latitude, and elevation are positively related to FDI inflow.

The methodologies that have been used to analyze FDI inflow have been varying and controversial as well. These empirical studies can be broadly grouped into three: micro (firm level) econometric studies, survey data based studies, and

aggregate econometric studies. For instance, Woodward and Rolfe (1993) examined the location determinants of export oriented foreign direct investment for the Caribbean Basin using 187 new plant investments based on US Department of Commerce data, though country specific factors like per capita GNP and political instability were used as regressors. The problem with micro-data based studies is the difficulty in generalizing the results. Rolfe et al. (1993) also used a questionnaire to examine twenty specific incentives US based managers and companies with international investments believe do not restrict intercompany payments and dividends remittances. The survey based studies also have the disadvantage of having subjective responses. Most of the studies have been aggregate studies, and these forms of studies have provided the most mixed results. One reason that most researchers use the aggregate econometric method is the relative ease with which to get the data.

This study will also be based on aggregate data looking at the determinants of inbound FDI to developing countries and whether the determinants of FDI to SSA are different from those of other developing countries. However some of the regressors I use here are different from those of Asiedu (2002), and I argue that these "new" regressors are more likely to affect FDI inflow. Also the econometric methodology I use here (pooled GLS with country fixed effect) is able to account for possible omitted variables and correct for both autocorrelation and heteroskedasticity. Since OLS methodology cannot account for omitted variables, the results by Asiedu may suffer from bias and inconsistency, if there are omitted variables.

2.3. Data and Empirical Methodology

2.3.1 Data

I study an unbalanced panel of 56 developing countries for the period 1984 – 2005. Only countries with at least 10 years of data are included in the sample. But to check for robustness in the results, another sample of 77 developing countries, which includes all developing countries with at least five years of data, is used. Consistent with the literature on FDI inflow, I use net FDI inflow as a percentage of GDP as the dependent variable. The independent variables used in this study can be broadly grouped into four: macroeconomic conditions and economic infrastructure, natural resources, institutional (or policy) variables, and political conflicts. To capture macroeconomic conditions and infrastructure, I use GDP per capita (adjusted for purchasing power parity), inflation, and the number of telephones (both fixed and mobile) per 1,000 people. GDP per capita is a proxy for both economic health and market size. It is the only variable that has been shown in the literature to be consistently positively related to FDI inflow (Chakrabarti, 2001).[5] Inflation (measured here by GDP deflator) is expected to be negatively related to FDI inflow because inflation measures economic instability. Inflation is expected to be

[5] There have been a couple of papers that have found contrary results. While Edwards (1990) found a negative relationship between real GDP per capita and FDI inflow, Loree and Guisinger (1995) found real GDP per capita to be insignificantly related to FDI inflow.

negatively related to FDI flow.[6] The number of telephones is expected to be positively related to FDI inflow since it is used to proxy for economic infrastructure. Fuel exports as a percentage of merchandised exports, and non-manufactured merchandized exports as a percentage of total exports are used to proxy for natural resources. These variables are expected to be positively related to FDI inflow especially for the African sample since the majority of FDI flow to Africa is in the primary sector, with most of the FDI inflow going to the oil sector. For instance Angola, and Nigeria, with oil accounting for over 90 percent of their total exports, are among the top three destinations (with the other destination being South Africa) for FDI between 2000 and 2002 (World Bank 2004a).

As pointed out by Papaioannou (2009), it is very difficult to account for all institutional factors and norms in a country, some of which are hard to measure (e.g. traditional or religious norms, trust etc.). I use six variables (out of the 12 variables that make up the political risk rating constructed by the International Country Risk Guide) that I think are most relevant to measure institutional quality: investment profile, law and order, government stability, bureaucratic quality, internal conflict and corruption. Investment profile, which has subcomponents of contract viability, profits repatriation, and payment delays is expected to be positively related to FDI inflow (i.e. the better the investment profile, the higher the FDI inflow). Law and order is expected to be positively related to the FDI inflow as well, since an impartial legal system and strict observance of the laws are key to contract adjudication. I

[6] I use GDP deflator, instead of the consumer price index to measure inflation because it measures price changes in all aspect of the economy, including government expenditure, net trade and especially investment, which the consumer price index does not.

expect a stable government to be associated with higher FDI inflows. Bureaucratic quality, which measures how much the bureaucracy is autonomous from political pressure and has established mechanisms for recruitment and training, is also expected to be positively related to FDI inflow. Lower internal conflict, which has sub-components of civil war, terrorism, and civil disorder, is expected to be positively associated with higher FDI inflow. Corruption is also expected to be negatively related to FDI inflow (i.e. the lower the level of corruption, the higher the FDI inflow).[7]

I measure political conflict with the number of coups, number of riots, and number of assassinations. Each of those three variables is expected to be negatively related to FDI inflow because high political conflicts increases the associated with investing in a given country and hence driving away investors. Like the institutional variables, I also experimented with weighted conflict index, constructed by Cross-National Time Series Database.[8]

Tables 2.1 and 2.2 give the summary statistics of all the variables used in both samples of countries. Appendices 2.1 and 2.2 show detailed definitions of the variables used and their sources, and the list of countries in the sample and the years of data availability for each country respectively.

[7] I also use the composite index for political risk rating constructed by the ICRG, and also entered each of the 6 institutional variables, all of them simultaneously in the baseline estimation, and one at a time to check for possible multicollinearity. The results did not change, and it is available upon request.

[8] Even though both internal conflict and the political risk variables (coups, assassinations, and riots) measure conflict in some form, the political risk variables measure different aspect of conflict than what the internal conflict does.

2.3.2 Initial Testing and Empirical Methodology

I decided to go with the Least Square (country) dummy variable because of the advantage of this model being able to account for possible omitted country specific variables that may affect FDI inflow. But it is also possible that a simple Ordinary Least Square with regional dummies fits the data better. I therefore, use an F-test to determine whether a simple Ordinary Least Square with regional dummies fits the data better than either OLS with country dummies. In this way, I test whether the relative increase in the degrees of freedom in using the simpler model with fewer parameters (e.g. OLS with regional dummies) is sufficient to compensate for the relative decrease in the sum of squares residuals as a result of using fewer parameters. The F-statistic is calculated as the ratio of relative decrease in the sum of square residuals, to the relative increase in degrees of freedom as a result of using the OLS model with only regional fixed effects. Since the F-statistic (7.60) is greater than the F-critical value at the 5% level of significance (with degrees of freedom of 53 and 930, which is equal to 1.35), I conclude that using OLS with country dummies statistically improves the fit of the model.

I then use a Hausman test to decide whether to use either fixed effects or random effects. While the fixed effect model assumes that the unobserved country variables are correlated with the included regressors, the random effects assume that the unobserved country variables are random and hence not correlated with the other regressors. If the assumption that those unique individual effects are random hold, then both the random effects and fixed effects are consistent, but random effects is

more efficient. But if the omitted individual effects are correlated with the other included regressors, the random effects are inconsistent but the fixed effect is consistent. The Hausman test therefore is based on the idea that under the null that the individual effects are uncorrelated with the other regressors, the estimates from random effects should not differ systematically from that of fixed effect. With a significant P-value (0.03) in my case, the estimates from the random effects are statistically different from those of the fixed effects and therefore, the fixed effect is picked over random effects.

A modified Wald test for groupwise heteroskedasticity, and a Wooldridge test for autocorrelation in panel data indicate the presence of both heteroskedasticity and autocorrelation (Table 2.3, column 2). The modified Wald test for groupwise heteroskedasticity, which is distributed as a chi-square, tests for heteroskeadisticity across units. In this study, I test each regressor individually, and all the regressors were found to be responsible for heteroskedasticity.

The Woodridge test for autocorrelation in a linear panel is a test for first order autocorrelation. The Woodridge serial correlation test in a linear panel is done by first regressing the first difference of the dependent variable on the first difference of the regressors. The residuals obtained from this regression are regressed on its first lag. If there is no serial correlation, the correlation between the residual and its lag is expected to be -0.5, so the Woodridge serial correlation test, essentially tests whether the coefficient on the lagged residual is equal to -0.5. The initial test shows the presence of at least first order autocorrelation.

Given the results of these preliminary tests, I estimate my model with fixed effect Generalized Least squares that allows for common AR (1) process and country specific error variances.

2.4 Discussion of Results

Table 2.3 shows the results for the baseline regressions where only countries with at least ten years of data availability are included in the sample. Columns 1 and 2 report the results, when OLS with country fixed effects are used. Columns 3 and 4 however show the result when feasible GLS is used to correct for the heteroskedasticity and autocorrelation identified in the fixed effect regressions. The coefficients of the regressors from fixed effect estimation did not change much from that of the feasible GLS, though the standard errors changed. In addition, inflation is insignificant in the feasible GLS estimation but significant in the OLS (with country fixed effect) estimation. I use feasible GLS (columns 3 and 4) as the reference of my discussion because of the reasons stated above.

It can be seen from Table 2.3 (column 3) that none of the macroeconomic variables (GDP per capita and inflation) are significant in influencing FDI inflow. Inflation rate being insignificant in affecting FDI inflow to developing countries is consistent with the results of Asiedu (2002) which also found similar results concerning determinants of FDI inflow to developing countries. Perhaps GDP per capita is insignificant in affecting FDI flow to developing countries because market size is not a key determinant of FDI flow to developing countries since income levels are relatively low. FDI inflow to developing countries may come about as a result of taking advantage of cheap inputs. Edwards (1990) who examined the determinants of

FDI flow to 58 developing countries between 1971-1981, also found real per capita GDP to be insignificant in attracting FDI. GDP per capita may be significant for horizontal FDI, which is mostly market seeking. Since in this study, the dependent variable is made up of both horizontal and vertical FDI, that may explain why GDP per capita is insignificant. I find economic infrastructure like the presence of telephone lines, to be positively related to FDI inflows to developing countries. Wheeler and Moody (1992) also found that infrastructure quality is positively correlated with the US FDI flow to other countries.

With respect to the institutional (or policy) variables, the investment profile and government stability are significant in affecting FDI inflow to developing countries.[9] This is very important because the investment profile clearly signifies how receptive the recipient country is to FDI inflow. This result is consistent with Asiedu (2006), who also reports a positive impact of investment profile on FDI flow to Africa between 1984 and 2000, and Singh and Jun (1995) who show a positive relationship between business operating conditions and FDI flow to 31 developing countries between 1970 and 1993. Government stability is important since government instability may create a state of uncertainty, especially with respect to investment policies. The Law and order variable is important because it measures how the law is efficiently enforced resulting in civil order. Thus, a stable government is associated with higher FDI inflow.

[9] The institutional variables are not that highly correlated with the largest correlation of 0.68 occurring between internal conflict and law and order. The results do not change when I enter each of the institutional variables (law and order, investment profile, bureaucratic quality, corruption, and internal conflict) one at a time. Also a composite institutional variable (i.e. political risk rating index) used comes out positive and significant.

None of the political conflict variables (coups, riots and assassinations) is significant.[10] A joint significance test for the three political conflict variables as a group also shows that they are jointly insignificant (as indicated by a Chi-square of 1.77). This is also consistent with some of the results found in the literature. For instance Asiedu (2002), using the average of the number of assassinations and revolutions to measure political risk, also finds political stability to be insignificant with respect to FDI flow to developing countries. Loree and Guisinger (1995) reports similar results.

Finally, with respect to natural resources, non-manufactured exports as a percentage of overall merchandised exports are found to be significant and negatively associated with FDI inflows into developing countries. This result can be explained by the fact that it is only in Africa that it has been reported that most of the FDI inflows go to the primary sector. In fact in Asia, the service and the manufacturing sectors are the leading sectors in attracting FDI. In WIR (2010) it was noted that a new trend in FDI to Africa is emerging, where even though the primary sector, still continues to attract FDI in terms of values, manufacturing sector accounted for about 41% of the total number of Greenfield investment projects between 2003-2009. For the same period it is reported in WIR (2010) that the service sector has been the leading sector in attracting FDI in both Asia, and Latin America and the Caribbean. It is therefore not surprising that natural resources will be

[10] None of the conflict variables (coups, riots and assassinations) is significant even when I enter each of them one at a time. Also weighted average conflict index (which is weighted average of the number of Assassinations, the number of General Strikes, the number of Guerrilla Warfare, the number of Government Crises, the number of Purges, the number of Revolutions, and the number of Anti-Government Demonstrations) also comes out insignificant.

negatively associated with FDI inflow to developing countries (since two-thirds of my sample is outside of SSA). I also show below that while non-manufactured exports maintain its significant negative sign in the sample of non SSA countries, it is insignificant in the sample of SSA countries.

2.4.1 Determinants of FDI inflow to Sub-Saharan Africa

Column 4 of Table 2.3 shows the results when I include the interaction of sub-Sahara Africa dummy with other regressors. From the top panel of column 4 of Table 2.3, one can see that the results are similar to that of column 3. However unlike in column 3 where non-manufactured exports are negative and significant, in column 4, fuel exports as a percentage of exports is significant and negative. This clearly shows that non-SSA developing countries have natural resources as being negatively related to FDI inflow. In sum, physical infrastructure, natural resources, government stability and investment are significant in affecting FDI inflow to countries outside of SSA.

The bottom half of column 4 of Table 2.3 shows the results for SSA dummy interacted variables. The F-test for the joint significance of the SSA interacted variables, shows that they are significantly different from zero as a group. The only SSA interacted variables that are significant are fuel exports as percentage of total merchandised exports and number of telephone subscribers. This indicates that other than the fuel exports, and telephone subscribers, the variables that affect FDI inflow to SSA are not different from those that affect FDI flow to outside the region. Table 2.4 calculates the coefficients of the right-hand side variables for the sub-Sahara

African countries in our sample. To calculate the coefficients for the determinants of FDI inflow to sub-Saharan African countries, we sum the coefficient on the variable without the SSA dummy interaction and the coefficient of the same variable interacted with a dummy variable for SSA. Note that all calculations use coefficients from column 4 of Table 2.3. For instance, to find the coefficient on telephone subscribers, we add the first coefficient of telephone, without the dummy interaction (0.010), to its interactive term (0.028) to get 0.038. The coefficients for non-SSA tropical countries in column 2 of Table 2.4 are shown for comparison's sake.

Table 2.4 shows some of the differences and similarities in the determinants of FDI to SSA region and non-SSA regions. The results are as the following: First, though physical infrastructure is significant in affecting FDI flow to all developing regions, it has a relatively more impact on FDI inflow to SSA (due to relatively larger coefficient of 0.038 compared to 0.010 for non SSA region) For instance, while a one percent increase in the number of telephones will increase FDI to SSA by 3.8%, FDI flow to non SSA regions will increase by only one percent. If SSA increases its average telephone subscribers from 16.76 (per 1000 people) to that of Honduras (30.91), the median country, SSA's FDI share of GDP will increase by about 3.2%. In the same way, if Uganda with an average telephone of 2.35 increases its average telephone levels to that of Honduras, Uganda's FDI share of GDP will increase by about 46.2%.[11] Second, while natural resources (i.e. fuel exports) are

[11] With telephone coefficient of 0.038 (Table 3 column 1), the increase in FDI/GDP for SSA as a result of SSA increasing its telephone subscribers to that of the median country (Honduras) is calculated as: {[(30.91 -16.76)/16.76)]*100}*0.038 = 3.2%. In the same way, the increase in Uganda's FDI/GDP is calculated as: {[(30.91 – 2.35)/2.35]*100}*0.038 = 46.2%.

positively associated with FDI inflow to SSA, it is negatively associated with FDI inflow to areas outside of SSA. This clearly confirms the argument that the primary sector is key in attracting FDI to Africa. Onyeiwu and Shrestha (2004) also found that fuel export as a percentage of total exports are positively associated with FDI to Africa. Finally government stability and investment profile affect FDI flow to all developing countries with the same effect. The investment profile and government stability has the largest economic significance in attracting FDI inflow to developing countries. If government stability and investment profile in developing countries increase by one index point each, net FDI inflow per GDP to developing countries will increase by 5.9% and 7.3% respectively.[12]

The results is different from the findings of Asiedu (2002) in the sense that while she finds improved physical infrastructure to enhance FDI flow to non SSA region, and have no effect on FDI flow to SSA, I find physical infrastructure to affect FDI flow to all developing countries and even have more impact on FDI flow to SSA. The difference in results may be due to different methodology I use, pooled feasible GLS.

2.4.2 Robustness Check

The results may be sensitive to the countries selected and may not reflect the determinants of FDI in countries outside this sample of 56 countries. To find out whether the results are sensitive to the dataset, I increase the sample size from 56 to

[12] The coefficients for government stability and investment profile are 0.059 and 0.073 respectively (Table 3) The increase in FDI as a result of government stability increasing by one index point is calculated as: 0.058 * 100 = 7.8%. Likewise increase in FDI flow due to investment profile increasing by one index point is calculated as: 0.073*100 = 7.3%.

77 countries by including all countries with at least 5 years of observation, unlike the baseline dataset, which only includes countries with at least 10 years of observation.

Table 2.5 reports the results for the second sample where all developing countries with at least five years of data availability are included. The results are similar to that of the baseline sample (Table 2.3). In the main regression (column 3 of Table 2.5), like in the baseline results (Table 2.3, column 3), while telephone, government stability, and conducive investment environment are positively associated with FDI inflow to developing countries, non manufactured exports are negatively associated with FDI inflow to developing countries. In addition to these variables, now law and order is positively associated with FDI inflow. Column 4 of Table 2.5 again reports the results when the SSA dummy is interacted with the regressors. All the variables that are significant in affecting FDI inflow to non SSA countries are also significant in this second dataset. In Table 2.6 (column 1), I calculate the determinants of FDI inflow to SSA countries. Like my baseline results, fuel exports and physical infrastructure are positively associated with FDI flow to SSA. In addition GDP per capita and lower corruption are positively associated with FDI inflow to SSA. These additional variables become significant due to increase in the sample size to include eight SSA countries which have relatively lower GDP per capita and lower index of corruption (i.e. pervasive corruption).[13]In fact, the inclusion of those eight SSA countries reduced the average of GDP per capita and corruption index for SSA from 2380.15 and 2.57 to 1849 and 2.53 respectively. It seems that, below certain threshold, corruption and GDP per capita becomes

[13] The eight additional SSA countries are Republic of Congo, Cote D'Ivoire, Ethiopia, Guinea, Mali, Mozambique, Niger, and Tanzania.

significant in affecting FDI flow to SSA. In other words, when corruption index, and GDP per capita are below a certain level, investors become concerned when investing in SSA.

The results can be summarized as follows; (1) Infrastructure, government stability and good investment climate are positively correlated with FDI inflow to developing countries; (2) While natural resources proxied by fuel exports as a percentage of merchandised exports, is negatively related to FDI to non-SSA developing countries, it is positively related to FDI inflows to SSA; (3) Finally, GDP per capita and corruption become positively associated with FDI flow to SSA when their averages fall below certain level.

2.5 Conclusion and Policy Recommendations

In this study, I examine the determinants of FDI to developing countries, and test whether the traditional FDI determinants have the same effects on FDI to Africa as they have on non-African developing countries. To determine if the results are robust to different samples of countries, I also use a second larger sample, which is made up of countries with at least five years of data availability, contrary to the first sample where only countries with at least 10 years of data are included.

Using Generalized Least squares with country fixed effects, I show that infrastructural quality, good investment climate and government stability are positively correlated with FDI. Also I find that while natural resources (measured here by fuel exports) are positively associated with FDI flow to SSA, it is negatively

associated with FDI flow to non-SSA region. Finally, below certain level, GDP per capita and corruption are positively associated with FDI flow to SSA.

As far as policy recommendation is concerned, for SSA to increase its global share of FDI, it should strive to maintain stable government, create a conducive investment climate, with respect to profits repatriation, and payment delays, and improve its physical infrastructure. Reducing corruption level and growing their economy will also increase FDI flow to SSA.

A possible extension to this work would be to further investigate a couple of countries where one will be able to do an in depth analysis of the sources of the FDI and the determinants of FDI originating from developing countries separately from those emanating from developed countries. A study of this nature will be able to offer a tailored policy recommendation for different countries depending on whether a country's FDI is dominated by those from developing countries or those from developed countries. This is very important because a study by Cuervo-Cazurra and Genc (2008) argue and show that developing country Transnational Corporations (TNCs) thrive better, relative to their developed country counterparts, in countries with adverse institutions. Their argument is that since most of the developing country TNCs are used to weak institutions in their domestic countries, they are able to turn the "disadvantage" of adverse institutions into an "advantage", in the sense of competitive advantage over the TNCs from developed countries, which are not used to dealing with adverse institutions. If this position and findings by Cuervo-Cazurra and Genc (2008) is anything to go by, then one will expect this new trend of FDI

inflow from other developing countries to Africa to persist. The findings by Cuervo-Cazurra and Genc (2008) that South-South FDI may flourish even when the host countries' institutions are not developed, unlike the North-South FDI flow is both reassuring and worrying. It is reassuring because it gives developing countries with weak institutions some hope that they can still attract FDI inflow, especially from other developing countries. On the contrary, availability of FDI flow even in the presence of weak institutions may also not encourage host countries to develop their institutions to attract FDI inflow. Another implication of this results is that lumping all countries together, in a cross sectional studies, without knowing the source of their FDI inflow may give erroneous results especially with respect to institutional variables. This is because while strong institutions may be negatively associated with FDI from developing countries, it may be positively associated with FDI flow from developed countries.

Table 2.1: Summary Statistics for the First Sample (Countries with at least 10 years of data)

Variable	Mean	Std Deviation	Min	Max
FDI	1.871	2.279	-12.208	12.885
Fuel Exports	16.327	26.221	0.0001	99.657
Non Manufactured Exports	63.327	26.987	7.093	99.978
Telephones Lines	64.605	69.746	1.336	364.981
GDPPC	4051.861	2513.279	476.174	12890.25
Inflation	86.580	698.817	-23.479	13611.63
Political Risk Rating Index	58.821	11.240	26.417	81.667
Investment	6.523	1.963	1.167	11.5
Law and Order	3.001	1.146	0	6
Corruption	2.691	0.961	0	6
Government Stability	7.335	2.254	1	12
Internal Conflict	7.957	2.500	0	12
Bureaucratic Quality	1.789	0.849	0	4
Weighted Conflict	1356.6	2211.6	0	21250
Coups	0.008	0.089	0	1
Riots	0.534	1.684	0	26
Assassinations	0.491	1.667	0	26

Table 2.2: Summary Statistics for the Second sample (Countries with at least 5 years of data)

Variable	Mean	Std Deviation	Min	Max
FDI	2.194	3.087	-12.208	45.150
Fuel Exports	16.942	26.688	0.0001	99.657
Non Manufactured Exports	64.808	26.620	7.093	99.977
Telephones Lines	69.820	76.103	1.336	364.981
GDPPC	3933.9	2527.008	476.174	12890.25
Inflation	76.859	651.030	-29.173	13611.63
Political Risk Rating Index	59.144	10.785	26.417	81.667
Investment	6.542	1.956	1.167	11.5
Law and Order	3.098	1.147	0	6
Corruption	2.639	0.964	0	6
Government Stability	7.544	2.262	0	12
Internal Conflict	8.081	2.405	0	12
Bureaucratic Quality	1.748	0.845	0	4
Weighted Conflict	1244.3	2109.297	0	21250
Coups	0.009	0.097	0	1
Riots	0.481	1.582	0	26
Assassinations	0.450	1.567	0	26

TABLE 2.3: Fixed Effect and GLS Estimation

	1	2	3	4
Variables	**FE**	**FE**	**GLS**	**GLS**
GDPPC	-0.0001	-0.0001	-0.0001	-0.0001
	(-0.64)	(-0.52)	(-1.15)	(-0.62)
Telephone	0.009**	0.009**	0.010***	0.010***
	(2.36)	(2.24)	(5.07)	(4.84)
Inflation	-0.0002**	-0.0002*	-0.0001	-0.0001
	(-2.67)	(-1.68)	(-1.14)	(-1.13)
Fuel Exports	-0.008	-0.043**	0.0003	-0.017**
	(-0.33)	(-2.08)	(0.05)	(-2.27)
Non Manufactured	-0.007	0.005	-0.015***	-0.008
Merchandised Exports	(-0.67)	(0.40)	(3.80)	(-1.42)
Government Stability	0.109**	0.092*	0.044**	0.059**
	(2.66)	(1.82)	(2.37)	(2.57)
Law and Order	0.077	0.101	0.060	0.014
	(0.60)	(0.65)	(1.11)	(0.19)
Investment Profile	0.228***	0.266***	0.076***	0.073**
	(3.03)	(3.02)	(3.10)	(2.33)
Bureaucratic Quality	-0.004	0.044	-0.002	-0.135
	(-0.01)	(0.11)	(-0.03)	(-1.35)
Corruption	0.013	-0.085	-0.025	0.006
	(0.09)	(-0.46)	(-0.45)	(0.08)
Coups	-0.388	0.345	0.028	0.113
	(-0.85)	(0.50)	(0.12)	(0.38)
Riots	-0.038	-0.040	-0.002	-0.002
	(-0.92)	(-0.82)	(-0.15)	(-0.18)
Assassinations	-0.005	-0.001	-0.026	-0.024
	(-0.18)	(-0.05)	(-1.29)	(-1.06)
Internal Conflict	0.035	0.021	0.020	0.023
	(0.64)	(0.27)	(0.97)	(0.75)
SSA*GDPPC		0.0004		0.001
		(0.44)		(1.28)
SSA*Telephone		0.045**		0.027*
		(2.20)		(1.88)
SSA*Inflation		0.005		0.002
		(0.84)		(0.74)
SSA*Fuel Exports		0.066**		0.042***
		(2.34)		(3.65)
SSA*Non Manufactured		-0.016		-0.011
Merchandised Exports		(-1.18)		(-1.27)
SSA*Government		0.069		-0.003
Stability		(0.93)		(-0.07)
SSA*Law and Order		-0.065		0.062
		(-0.31)		(0.46)
SSA*Investment Profile		-0.132		-0.048
		(-0.85)		(-0.81)
SSA*Bureaucratic		-0.241		0.229
Quality		(-0.52)		(1.37)
SSA*Corruption		0.626*		0.163
		(1.87)		(1.03)
SSA*Coups		-1.20		-0.057
		(-1.31)		(-0.11)

SSA*Riots		0.041		-0.045
		(0.51)		(-0.96)
SSA*Assassinations		0.070		0.040
		(0.53)		(0.49)
SSA*Internal Conflict		0.020		-0.007
		(0.20)		(-0.15)
No. of Observation	996	996	996	996
No. of Countries	55	55	55	55
R-Square(Within)	0.23	0.26		
F-Test for OLS vs. Fixed effect (5%, 53, 930)	7.60			
Hausman Test (P-Value)	0.03			
Modified Wald Test for Heteroskedasticity X^2	28302.03	16285.80		
Wooldridge test for autocorrelation (F-Stat – 1, 54)	15.971	17.864		
Joint Significance test for the Political Instability Variables X^2			1.77	1.39
Joint Significance test for Africa interacted variables X^2				25.84

The values in parentheses are robust t-statistics and Z-values (for GLS regressions). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

TABLE 2.4: Sub-Saharan Africa (SSA) vs. Non Sub-Saharan Africa

	SSA	NON-SSA
GDPPC	0.001	-0.0001
	(1.34)	(-0.62)
Telephone	0.038***	0.010***
	(3.25)	(4.84)
Inflation	0.001	-0.0001
	(0.66)	(-1.13)
Fuel Exports	0.032***	-0.017**
	(3.73)	(-2.27)
Non Manuf. Exports	-0.008	-0.008
	(-1.42)	(-1.42)
Gov't Stab	0.059**	0.059**
	(2.57)	(2.57)
Law and Order	0.014	0.014
	(0.19)	(0.19)
Investment Profile	0.073**	0.073**
	(2.33)	(2.33)
Bureaucratic Quality	-0.135	-0.135
	(-1.35)	(-1.35)
Corruption	0.006	0.006
	(0.08)	(0.08)
Coups	0.113	0.113
	(0.38)	(0.38)
Riots	-0.002	-0.002
	(-0.18)	(-0.18)
Assassination	-0.024	-0.024
	(-1.06)	(-1.06)
Internal Conflict	0.023	0.023
	(0.75)	(0.75)

The values in parentheses are Z-values (for GLS regressions). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

TABLE 2.5: Fixed Effect and GLS Estimation for Alternative Dataset

	1	2	3	4
Variables	**FE**	**FE**	**GLS**	**GLS**
GDPPC	-0.0001	-0.00003	-0.0001	-0.0001
	(-0.29)	(-0.14)	(-0.82)	(-0.66)
Telephone	0.009***	0.009**	0.009***	0.009***
	(2.56)	(2.63)	(4.97)	(5.26)
Inflation	-0.0002***	-0.0002*	-0.0001	-0.0001
	(-2.69)	(-1.79)	(-1.28)	(-1.32)
Fuel Exports	-0.008	-0.045**	-0.0002	-0.018**
	(-0.35)	(-2.24)	(-0.05)	(-2.57)
Non Manufactured	-0.005	0.006	-0.014***	-0.007
Merchandised Exports	(-0.52)	(0.52)	(-3.80)	(-1.43)
Government Stability	0.092**	0.063	0.052***	0.058***
	(2.17)	(1.17)	(2.91)	(2.85)
Law and Order	0.117	0.119	0.096*	0.076
	(0.90)	(0.82)	(1.83)	(1.28)
Investment Profile	0.247***	0.242***	0.068***	0.069**
	(3.57)	(2.98)	(2.92)	(2.43)
Bureaucratic Quality	-0.074	0.038	-0.032	-0.054
	(-0.28)	(0.10)	(-0.48)	(-0.67)
Corruption	0.037	-0.036	-0.007	-0.029
	(0.29)	(-0.22)	(-0.13)	(-0.46)
Coups	-0.310	0.353	-0.036	0.056
	(-0.87)	(0.61)	(-0.18)	(0.24)
Riots	-0.036	-0.040	-0.002	-0.001
	(-0.89)	(-0.81)	(-0.20)	(-0.12)
Assassinations	-0.013	-0.007	-0.028	-0.032
	(-0.44)	(-0.23)	(-1.32)	(-1.53)
Internal Conflict	0.037	0.032	0.010	-0.007
	(0.66)	(0.44)	(0.48)	(-0.29)
SSA*GDPPC		0.0004		0.001**
		(0.45)		(2.07)
SSA*Telephone		0.049		0.056**
		(1.04)		(2.02)
SSA*Inflation		0.007		0.002
		(1.15)		(1.03)
SSA*Fuel Exports		0.067**		0.044***
		(2.48)		(3.88)
SSA*Non Manufactured		-0.0001		-0.005
Merchandised Exports		(-0.03)		(-0.55)
SSA*Government		0.045		0.028
Stability		(0.58)		(0.55)
SSA*Law and Order		0.136		-0.036
		(0.60)		(-0.25)
SSA*Investment Profile		0.099		-0.023
		(0.62)		(-0.39)
SSA*Bureaucratic		-0.379		0.188
Quality		(-0.79)		(1.11)
SSA*Corruption		0.536*		0.270*
		(1.80)		(1.79)
SSA*Coups		-1.120		-0.366
		(-1.60)		(-0.87)

SSA*Riots		0.024		-0.059
		(0.29)		(-1.09)
SSA*Assassinations		0.065		0.129
		(0.23)		(0.92)
SSA*Internal Conflict		-0.001		0.046
		(-0.01)		(0.98)
No. of Observation	1151	1151	1151	1151
No. of Countries	76	76	76	76
R-Square(Within)	0.15	0.17		
F-Test for OLS vs. Fixed effect (5%, 53, 1125)	7.60			
Hausman Test (P-Value)	0.03			
Modified Wald Test for Heteroskedasticity X^2	76885.64	66555.75		
Wooldridge test for autocorrelation (F-Stat – 1, 75)	8.72	9.23		
Joint Significance test for the Political Instability Variables X^2			0.82	2.54
Joint Significance test for Africa interacted variables X^2				41.77

The values in parentheses are robust t-statistics, and Z-values (GLS regressions). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

TABLE 2.6: Sub-Saharan Africa (SSA) vs. Non SSA for Alternative Dataset

	SSA	NON-SSA
GDPPC	0.001**	-0.0001
	(2.10)	(-0.66)
Telephone	0.062**	0.009***
	(2.52)	(5.26)
Inflation	0.003	-0.0001
	(1.16)	(-1.32)
Fuel Exports	0.031***	-0.018**
	(3.52)	(-2.57)
Non Manuf. Exports	-0.011	-0.007
	(-1.51)	(-1.43)
Gov't Stab	0.058***	0.058***
	(2.85)	(2.85)
Law and Order	0.076	0.076
	(1.28)	(1.28)
Investment Profile	0.069**	0.069**
	(2.43)	(2.43)
Bureaucratic Quality	-0.054	-0.054
	(-0.67)	(-0.67)
Corruption	0.234*	-0.029
	(1.81)	(-0.46)
Coups	-0.374	-0.366
	(-0.94)	(-0.87)
Riots	-0.051	-0.059
	(-0.90)	(-1.09)
Assassination	0.168	0.129
	(1.13)	(0.92)
Internal Conflict	0.026	0.046
	(0.71)	(0.98)

The values in parentheses are Z-values (for GLS regressions). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 2.1: Data Description and Sources

Variable	Definition	Source
FDI	Net Foreign Direct investment as a percentage of GDP	World Development Indicators, 2007
Fuel Exports	Fuel exports as a percentage of total merchandised exports	World Development Indicators, 2007
Non Manufactured Exports	This is calculated as 100 minus manufactured exports as a percentage of merchandised exports	World Development Indicators, 2010
Telephones Lines	Fixed lines and mobile phone subscribers per 1,000 people	World Development Indicators, 2007
GDPPC	Gross Domestic Product per capita, in 2000 constant international $ with PPP rates.	World Development Indicators, 2007
Inflation	GDP Deflator (annual percentage)	World Development Indicators, 2007
Weighted Policy Index	The political risk rating index which is made up of Government Stability, Socioeconomic Conditions, Investment Profile, Internal Conflict, External conflict, Corruption, Military in politics, Religious tensions, Law and order, Ethnic Tensions, Democratic Accountability, and Bureaucratic Quality.	International Country Risk Guide
Investment Profile	This has subcomponents of Contract Viability/Expropriation, Profits Repatriation, and Payment Delays. The composite score has a minimum score of 0 (More risk) and a maximum score of 12 (less risk).	International Country Risk Guide
Law and Order	This has two sub-components: Law, and Order, with a composite score ranging between 0 (Less Law and Order) and 6 (more law and order)	International Country Risk Guide
Corruption	This measures corruption in the political system (i.e. public corruption). The composite score ranges from 0(high corruption) to 6	International Country Risk Guide

	(low corruption)	
Government Stability	This index has a subcomponents of government Unity, Legislative strength, and popular support. The index ranges from 0 (less stable) to 12 (more stable).	International Country Risk Guide
Internal Conflict	This index is made up of civil war/coup threat, terrorism/political violence, and civil disorder. The index ranges from 0 (more internal conflict) and 12 (less internal conflict.	International Country Risk Guide
Bureaucratic Quality	This measures how the bureaucracy is robust to changes in government. The index is between 0 and 4.	International Country Risk Guide
Weighted Conflict	The weighted conflict index is calculated in the following manner: Multiply the value of the number of Assassinations by 24, General Strikes by 43, Guerrilla Warfare by 46, Government Crises by 48, Purges by 86, Riots by 102, Revolutions by 148, Anti-Government Demonstrations by 200. Sum the 8 weighted values and divide by 9.	Cross-National Time Series Data
Coups	The number of Coups d'état. Coup is defined as extra constitutional or forced changes in the top government elite and /or its effective control of the nation's power structure in a given year.	Cross-National Time Series Data
Riots	The number of Riots per year. Riots is defined as any violent demonstration or clash of more than 100 citizens involving the use of physical force	Cross-National Time Series Data
Assassinations	The number of assassinations per year. Assassination is defined as any politically motivated murder or attempted murder of a high government official or politician.	Cross-National Time Series Data

Appendix 2.2: List of Countries and years of Data Availability

Countries	Region	Period of Data Availability for countries with at least ten years of Data Availability	Period of Data Available for Countries with at least five years of data availability
Albania	Europe & Central Asia	1996-2004	1996-2004
Algeria	Middle East & North Africa	1984-2004	1984-2004
Argentina	Latin America & the Caribbean	1984-2005	1984-2005
Armenia	Europe & Central Asia		1999-2004
Azerbaijan	Europe & Central Asia		1999-2005
Bangladesh	South Asia	1986-1998; 2000-2004	1986-1998; 2000-2004
Belarus	Europe & Central Asia		1998-2005
Bolivia	Latin America & the Caribbean	1984-2005	1984-2005
Brazil	Latin America & the Caribbean	1984-2004	1984-2004
Bulgaria	Europe & Central Asia	1996-2005	1996-2005
Burkina Faso	Sub-Saharan Africa	1995-2004	1995-2004
Cameroon	Sub-Saharan Africa	1986-87; 1989-90; 1995-97; 2001; 2003-2004.	1986-87; 1989-90; 1995-97; 2001; 2003-2004.
Chile	Latin America & the Caribbean	1984-2005	1984-2005
China	East Asia & Pacific	1984-2005	1984 – 2005
Colombia	Latin America & the Caribbean	1984-2004	1984-2004
Congo Republic	Sub-Saharan Africa		1985-1986; 1993-1995
Costa Rica	Latin America & the Caribbean	1984-2005	1984-2005
Cote D'Ivoire	Sub-Saharan Africa		1985; 1995-2000; 2002-2003.
Dominican	Latin America &	1986-88; 1992-97;	1986-88; 1992-97;

Republic	the Caribbean	2001	2001
Ecuador	Latin America & the Caribbean	1984-2004	1984-2004
Egypt	Middle East & North Africa	1984-2004	1984-2004
El Salvador	Latin America & the Caribbean	1984-2004	1984-2004
Ethiopia	Sub-Saharan Africa		1993; 1995; 1997; 2001-2003
Gabon	Sub-Saharan Africa	1993-94; 1996-2004	1993-94; 1996-2004
Gambia	Sub-Saharan Africa		1995-2002
Ghana	Sub-Saharan Africa	1984; 1992; 1996-01; 2003-04	1984; 1992; 1996-01; 2003-04
Guatemala	Latin America & the Caribbean	1984-2005	1984-2005
Guinea	Sub-Saharan Africa		1995-2002
Guyana	Latin America & the Caribbean		1997-2005
Honduras	Latin America & the Caribbean	1984-2005	1984-2005
India	South Asia	1984-2005	1984-2005
Indonesia	East Asia & Pacific	1984-2005	1984-2005
Iran	Middle East & North Africa		1997-2005
Jamaica	Latin America & the Caribbean	1984-2002; 2004	1984-2002; 2004
Jordan	Middle East & North Africa	1984-95; 1997-2004	1984-95; 1997-2004
Kazakhstan	Europe & Central Asia		1999-2001; 2003-04
Kenya	Sub-Saharan Africa	1984-88; 1990-2004	1984-88; 1990-2004
Lebanon	Middle East & North Africa		1997-2004
Lithuania	Europe & Central Asia		1999-2004
Madagascar	Sub-Saharan Africa	1990-2004	1990-2004
Malawi	Sub-Saharan Africa	1984-88; 1990-91; 1994-2005	1984-88; 1990-91; 1994-2005
Malaysia	East Asia &	1984 - 2005	1984 - 2005

	Pacific		
Mali	Sub-Saharan Africa		1996-2001
Mexico	Latin America & the Caribbean	1984-2005	1984-2005
Moldova	Europe & Central Asia		1999-2005
Mongolia	East Asia & Pacific	1996-2005	1996-2005
Morocco	Middle East & North Africa	1984-87; 1989-2005	1984-87; 1989-2005
Mozambique	Sub-Saharan Africa		1994-1997; 1999-02
Nicaragua	Latin America & the Caribbean	1984-86; 1988-2005	1984-86; 1988-2005
Niger	Sub-Saharan Africa		1995-2003
Nigeria	Sub-Saharan Africa	1984-87; 1991; 1996-2004	1984-87; 1991; 1996-2004
Pakistan	South Asia	1984-93; 1995-2005	1984-93; 1995-2005
Panama	Latin America & the Caribbean	1984-2005	1984-2005
Papua New Guinea	East Asia & Pacific	1984-93; 1998; 2000-2003	1984-93; 1998; 2000-2003
Paraguay	Latin America & the Caribbean	1987; 1991-2002; 2004	1987; 1991-2002; 2004
Peru	Latin America & the Caribbean	1984-2005	1984-2005
Philippines	East Asia & Pacific	1984-2005	1984-2005
Romania	Europe & Central Asia	1990-2005	19909-2005
Russian Federation	Europe & Central Asia		1996-2004
Senegal	Sub-Saharan Africa	1986-87; 1989-94; 1996-2005	1986-87; 1989-94; 1996-2005
South Africa	Sub-Saharan Africa	1984; 1992-2005	1984; 1992-2005
Sri Lanka	South Asia	1984-94; 1999; 2001-2005	1984-94; 1999; 2001-2005
Sudan	Sub-Saharan Africa	1984; 1995-1997; 1999-2005	1984; 1995-1997; 1999-2005
Syria	Middle East & North Africa	1984-87; 1989-90; 1992; 1995-2004	1984-87; 1989-90; 1992; 1995-2004

Tanzania	Sub-Saharan Africa		1997-2004
Thailand	East Asia & Pacific	1984-87; 1989-2005	1984-87; 1989-2005
Togo	Sub-Saharan Africa	1986-91; 1994-2005	1986-91; 1994-2005
Tunisia	Sub-Saharan Africa	1984-2004	1984-2004
Turkey	Europe & Central Asia	1984-2005	1984-2005
Uganda	Sub-Saharan Africa	1994-2005	1994-2005
Ukraine	Europe & Central Asia		1998-2004
Uruguay	Latin America & the Caribbean	1984-2005	1984-2005
Venezuela	Latin America & the Caribbean	1984-2005	1984-2005
Vietnam	East Asia & Pacific		1997-2003
Rep. of Yemen	Middle East & North Africa	1991; 1995-2004	1991; 1995-2004
Zambia	Sub-Saharan Africa	1993; 1995-2005	1993; 1995-2005
Zimbabwe	Sub-Saharan Africa	1984-86; 1990-1997; 1999-02; 2004	1984-86; 1990-1997; 1999-02; 2004

CHAPTER 3

Tropical Agriculture: Is Africa Different?[14]

3.1 Introduction

Much of the initial optimism about development economics in the early post-war II period, and the faith in the discipline's ability to spur economic growth and eliminate poverty, has now been replaced with a greater recognition of the complexity and difficulty involved in such an undertaking. Wolfgang Sachs notes that in the 1950s, Development took on an active meaning: it turned into a project of planners and engineers who set out to systematically remodel societies to accelerate maturation–a project to be completed within several decades, if not years.[15] More than 50 years later, the literature has turned to identifying the reasons for why development is so hard. Are there intractable factors in poor countries that thwart our well-intentioned attempts to spur growth?

One possible factor that has gained increasing traction in the development literature is that of geography. Jared Diamond's Guns, Germs, and Steel hypothesizes that agricultural communities first began in the Fertile Crescent and that the technology created in this region spread easily East to West across Europe. It did not, however, spread well across the North-South axis. Tropical countries in Africa have significantly different climatic and soil conditions, making the adoption of temperate technology difficult. Bloom and Sachs (1998) build on this idea and detail what aspects of tropical soils make agricultural productivity difficult. Since

[14] This chapter is based on a working paper co-authored with Robin Grier. I am grateful for her guidance and support.

[15] Indeed, Sachs argues that, the South has ceased to be seen as 'young' and 'full of potential' like in Truman's time, but rather as the breeding ground of social and environmental turbulence.

almost all of the rich countries are located in temperate zones, and that is where most of the R&D takes place, most new technology will also be best suited for those climatic zones. In that way, the literature suggests that a very early geographic disadvantage has put Africa on a path-dependent trajectory of low growth and poverty.

There is reason for optimism, though, in that there are good arguments (and evidence) that tropical climates are *not* destined to be less agriculturally productive. First, the Green Revolution, which represented some of the biggest technological advances in agriculture in the post-WWII period, first took place in a tropical country (India) and with respect to a tropical crop (rice). Second, biologists have cast doubt on whether tropical soils are as disadvantaged as economists have made it seem. Third, a recent report by the U.S. based Oakland Institute shows how many developed countries and Universities like Harvard University, through hedge funds in the U.K. are buying large tracts of land in Africa for agricultural purposes. For instance the report indicates that Chinese government already owns about eight million hectares of land in the Democratic Republic of Congo, while privately owned companies like the British bioenergy giant, Crest Global Green, holding deeds to about 900,000 hectares of land in Mali, Guinea, and Senegal.[16] This clearly gives credence to the fact that tropical climate and its soils may not be that of a hindrance to agricultural productivity. Finally, good policy can negate a lot of the ill effects of bad geography. As a prime example, Brazil has made huge strides in recent years in transforming tropical soils and vastly raised their agricultural yields. In sum, it is not

[16] Accessed on 21/14/2011: http://oaklandinstitute.org/nexus-agrofuels-land-grabs-and-hunger-%E2%80%93-part-1.

clear that low agricultural productivity is the geographical destiny of tropical countries.

In this chapter, we investigate the determinants of tropical agricultural productivity in a panel of 27 tropical developing countries across several regions for the years 1984 to 2005. We examine the role that institutions, government policies, traditional inputs, and infrastructure play in explaining differences in agricultural productivity across tropical countries, and whether the effect of these variables is significantly different in Sub-Saharan African (SSA) countries.

In the full sample, we find that fertilizer consumption, the number of telephone subscribers (both mainline and cell phones), rainfall, and irrigation are important to agricultural productivity. However, institutional variables, bureaucratic quality, government stability, and corruption, are all insignificant in the full sample. When we construct interaction variables to test whether the effect of these variables are different in SSA, we find some interesting results. First, fertilizer consumption, telephones, and rainfall have a positive and significant impact on agricultural productivity across regions. Second, the coefficients on tractor usage and the institutional variables are insignificant. Last, irrigation has a positive and significant effect outside of tropical SSA, but no significant effect within the region. Expanding our sample by using an alternative measure of tropicality yields very similar results. The main differences are that the effect of rainfall is now only significant in tropical SSA, and two of the institutional variables are weakly significant.

The chapter is organized as follows: Section 3.2 discusses in more detail the argument that tropical agriculture faces significantly more obstacles than temperate

agriculture, as well as pointing to some reasons why these obstacles may not be as great as once thought. Section 3.3 examines the data and empirical methodology used in this chapter. Section 3.4 presents the results and Section 3.5 concludes.

3.2 Tropical Agricultural Productivity

Sachs (2001) and Gallup et al. (2000) argue that agriculture in tropical regions faces four main obstacles. First, farmers in tropical countries have bigger problems on average in securing adequate water for crops, an especially important point because the absence of frost in tropical climates tends to dry out topsoil. The arid tropics make agricultural production difficult without irrigation but the lack of abundant rainfall makes irrigation very expensive. In the humid tropics, however, farmers face a different problem: dry seasons combined with periodic torrential rains that leach important nutrients from the soil.

Second, the humid tropics are also characterized with a persistent cloud cover that can prevent crops from receiving enough sunlight for photosynthesis. In the summer, the temperate regions enjoy relatively longer days than the tropics, thus enhancing photosynthetic activity. Third, the tropics, with their humid climatic conditions and lack of freezing temperatures, are also conducive for pest growth, including diseases like trypanosomiasis and malaria, which negatively impact human productivity and livestock production.

Lastly, technological innovations in temperate zone agriculture may not be easily imported or adapted to tropical conditions as most agricultural R&D takes place in the developed world and is thus focused on temperate climate technology.

Arends-Kuening and Makundi (2000) argue that countries located in the tropics might not benefit much from the emergence of agricultural biotechnology from the temperate regions unless the tropical countries' priorities, as far as crops are concerned, coincide with that of the inventing (temperate) countries.

McMillan and Masters (2000) analyze tropical climate agriculture from a political economy perspective. They argue that tropical countries are more likely to have productivity-inhibiting policies, such as high taxes on agricultural products and low public agricultural R&D expenditure, than temperate ones. These policies persist even though the literature clearly shows that they lead to low agricultural productivity and lower average economic growth. McMillan and Masters explain that tropical climatic conditions are conducive for the cultivation of perennial tree crops like coffee and cocoa, and slow maturing plants, like cassava, sugar, and bananas. These crops tend to have high sunk costs and long gestation periods, making it economically efficient for policymakers to impose adverse policies when the large sunk costs have already been incurred by farmers. Since the farmers are aware of what the policymaker will do once the sunk cost is incurred, they withhold new investment. McMillan and Masters contend that the only way out of this bad equilibrium is a credible commitment from policymakers that they will pursue growth-enhancing policies (i.e. low agricultural taxes and high R&D). Temperate climates, on the other hand, support annual crops with short gestation periods and lower sunk costs. Given that, farmers in the temperate region can easily retaliate against unexpected adverse policy, giving governments an incentive to maintain low taxes and high R&D policies.

In sum, researchers have put forth an impressive array of arguments for why agricultural productivity would be expected to be lower in tropical climates. On the other hand, there are reasons for optimism. On the biological side, some researchers deny the characterization of tropical soils as being significantly disadvantaged compared to temperate ones. Sanchez (2001), for example, shows that the percentage of total land area that can be considered fertile in tropical regions is no different from that of the temperate region. Further, the proportion of fertile soils with sufficient rainfall and no permafrost are roughly equal in both regions. While temperate regions receive more solar radiation during the cropping season, the tropics have approximately twice the potential in crop production because farmers have the possibility of growing more than one crop per year.

There are other reasons to believe that tropical agricultural is not doomed to low productivity. Brazil has emerged as an innovator in tropical agricultural innovation and has successfully overcome a lot of the obstacles that seemed inherent to tropical soils. In addition, one of the biggest technological advances in agriculture involved the growing of rice, a tropical crop, in India. The Green Revolution makes it clear that there is more to differential agricultural productivity than climate. While many Asian countries were able to take advantage of the Green Revolution, African countries have been less successful in incorporating technological innovations.[17]

The success of some tropical agricultural regions suggests that perhaps tropical soils are not as big an obstacle to development as we once believed. Or

[17] See Johnson et al. (2003) for an excellent investigation into the reasons that the Green Revolution has not taken hold in Sub-Saharan Africa.

perhaps climate is not fate; that is, with the right amount of infrastructure, good policies, and research and development, tropical soils can be just as productive as temperate ones. Also, the success of some of these tropical countries also imply that there may be some applicable technology that other tropical countries in Africa can adapt to their individual agricultural circumstance.[18]

Typically, when economists argue that climate is a barrier to development, they are talking about Sub-Saharan Africa. In this chapter, we study the determinants of agricultural productivity in a sample limited to tropical, developing countries. If tropical climates really are to blame for low agricultural productivity in Sub-Saharan Africa, then agriculture in those countries should not be significantly different than that in other tropical and developing countries. If there are other factors important to productivity, then limiting the sample to tropical countries allows us to better identify what they are. Climate is no longer obscuring the issue.[19]

3.3 Data and Econometric Methodology

We study the determinants of tropical agricultural productivity in a panel of 27 tropical developing countries for the years 1984 to 2005. Appendix 3.1 provides a list of the countries in the sample as well as the years for which we have data. The data is annual but is not available for all countries for the entire period. This period was chosen because of constraints on data availability, but it is also an important

[18] Otsuka and Kijima (2010) argue, for instance, that in order for Africa to transform its agricultural sector, countries should concentrate on a crop like rice, where there is readily available technology from Asia and Latin America.

[19] Most other papers investigating agricultural productivity in Africa do so only in the context of a particular country or panel of countries in Africa. We extend the sample to other regions, but do so with the condition that the dominant climate be tropical.

period to examine. Recent papers find that SSA agricultural productivity blossomed during the mid-1980s and early 2000s after experiencing negative growth in the preceding two decades (Block, 1994 and 2010; Nin-Pratt and Yu, 2008; and Fulginiti et al., 2004).

Our baseline sample of countries was chosen using the well-known Koeppen Geiger (KG) climatic classification, which has been digitized by Strahler and Strahler (1992). In the KG climatic classification, there are three tropical zones: Equatorial rainforest (Af), Equatorial monsoon (Am), and Equatorial savannah with dry winter (Aw). In this chapter, we classify a country as tropical if at least 75% of its land area falls in the tropics.[20] This classification gives us a sample of 27 countries, consisting of 13 sub-Saharan African countries, 5 Asian, and 9 from Latin America and the Caribbean.

As a robustness test, we later experiment with using an alternative classification of tropical climate. Masters and McMillan (2001) categorize countries with an average of at least five days per month of frost in winter as temperate, and those with fewer than five days of winter frost days as tropical. Using this classification almost doubles our sample size to 53 countries, with 27 and 18 countries respectively coming from SSA, and Latin America and the Caribbean. The remaining 8 countries come from the Middle East and North Africa (3 countries) and

[20] We understand that using 75% of the land area as a cut off for classifying tropical countries may be arbitrary but using only countries with their whole land area (100%) in the tropics reduced the number of countries drastically, making it difficult to undertake any cross-country analysis.

Asia (5 countries). All of the countries in our earlier sample are also included in this alternative sample.[21]

Our dependent variable is net agricultural production (in 1,000 international dollars) divided by total arable and permanent cropland (in thousands of hectares). Both variables are taken from the Food and Agriculture Organization's statistical division (FAOSTAT).

Our independent variables include traditional agricultural inputs, infrastructure, measures of the quality of governance, the rule of law, and the general economic environment.[22] The traditional agricultural inputs include fertilizer consumption and tractor usage. We measure the former with data from the World Bank that computes the sum of nitrogenous, potash & phosphate (in metric tons) used per unit of arable land. Tractor usage is simply the number of tractors used per 100 square kilometers of arable land. This variable is included because it proxies for differences in agricultural technology across countries.

As noted by Block (2010), however, these inputs may suffer from measurement errors. For instance, the variable measuring the amount of agricultural land a country has does not account for the quality of this land, a factor that is obviously very important to agricultural productivity. Jorgenson and Griliches (1967) demonstrated that these measurement errors can be mitigated by including

[21] Jamaica is not listed in Masters et al. 2001, probably due to lack of data on frost days for Jamaica, but we decided to include it as a tropical country since Jamaica definitely will have average frost days of less than five.

[22] Tables 3.1 and 3.2 give summary statistics of the variables, and appendix 3.1gives a detailed description of the variables, and their sources.

variables that control for land quality. For that reason, we include total irrigated land as a percentage of total cropland, and annual rainfall based on the crop-weighted scheme of Ramankutty and Foley (1998), to measure agricultural land quality.[23] These traditional inputs have been widely used in the empirical literature studying agricultural productivity (see, for example, Nkamleu et al., 2003; Lusiga et al., 1997; Alene et al. 2009; and Fulginiti et al., 2004). We expect that these inputs will all have a positive impact on agricultural productivity.

It is possible that some countries are better able to take advantage of technological breakthroughs because they have invested more in rural infrastructure. The lack of infrastructure can be a large obstacle to efficient markets in poor countries. In the case of agriculture, communication and transportation systems help in the timely transportation of harvests to urban areas, which serve as secondary markets for agricultural produce. Rosegrant and Hazell (2001) argue that the Green Revolution worked so well in India at least in part due to the important increase in public investment before and during the period in question. Much of this investment was in road construction, electrification, and irrigation. Rosegrant and Perez (1997) point to a lack of irrigation as one reason that Africa has had trouble replicating the Green Revolution. They note that because medium and large-scale irrigation costs more than three times what it does in South Asia, less than 4% of agricultural areas were irrigated in the 1990s.[24] To determine the effect of infrastructure on

[23] The annual rainfall based on crop-weighted scheme involves weighting rainfall data with weights based on prevalence of cropland. The detailed description of how the rainfall data is constructed can be found on: http://acadweb.swarthmore.edu/acad/rain-econ/Framesets/CountryAggregated.htm.
[24] Johnson et al. (2003), p. 1212.

agricultural productivity, we include two measures: the number of fixed line and mobile telephone subscribers (per 1,000 people) and total irrigated land as a percentage of total cropland.[25]

Another reason that countries may be better placed to adopt new technology and raise agricultural output is because the structure and stability of their government is conducive for investment and growth. As a proxy for good governance, we use three measures from the ICRG dataset: government stability, corruption and bureaucratic quality. The first measures overall political stability, the second measures official corruption, and the third is a measure of how the bureaucracy is able to function without drastic changes in policy or interruptions in government service, especially during period of change in government. We choose these three political risk variables bearing in mind the important role well functioning stable government institutions can play, like the distribution of agricultural inputs (such as fertilizer, and seedlings), and undertaking and distributing agricultural technology, in improving agricultural productivity. We expect all of these variables to be positively and significantly related to agricultural productivity.

Some papers have shown that R&D expenditures are positively correlated with the increase in agricultural TFP in the mid-1980s in Sub-Saharan Africa (Block 1994 and 2010; Alene, 2010). In particular, Block (1994) shows that about two-thirds of the recovery of agricultural TFP in Sub-Saharan Africa can be explained by

[25] We also tried using rail lines (total km) and percentage of total roads paved to measure infrastructure, but not only did the inclusion of these variables halve our number of observations, both variables were consistently insignificant.

expenditures on agricultural R&D. We experimented with including a measure of R&D expenditures from the Agricultural Science and Technology Indicators (ASTI), but found that it was consistently insignificant. Given that its inclusion reduces our sample of countries by one-third, we decided to drop it from the model.[26]

Lastly, we also control for rainfall, which is measured as the average amount of rainfall per year weighted for the prevalence of cropland. This allows us to partially control for serious negative shocks to agriculture like droughts.

Apart from the variables from the ICRG dataset (government stability, corruption, and bureaucratic quality), all of the variables are converted into natural logs. We also include country fixed effects to control for unobserved country-specific factors.[27]

We first estimate the determinants of tropical agricultural productivity, without including annual rainfall, and total irrigated land as a percentage of total cropland. We then estimate the same regression again, but for the years 1984-2000 because the inclusion of annual rainfall and irrigation are only available for this shorter period. Finally, we estimate the same sets of regressions again, but this time we interact the regressors with a dummy variable equal to one for sub-Sahara African countries. In this way, we are able to examine whether our variables affect agricultural productivity significantly different in sub-Saharan Africa than in other regions.

[26] R&D expenditures can be downloaded from the ASTI website at http://www.asti.cgiar.org/data/.
[27] Fertilizer consumption, tractors, and the proportion of cropland that is irrigated were lagged one period to account for possible reverse causality. The results were not significantly different so we do not report them for reasons of space. They are available by request from the authors.

All of our regressions are estimated with OLS and include country dummies.[28] The standard errors are adjusted to be robust to possible heteroskedasticity, using country clustering.

3.4 Results

3.4.1 Baseline Model

Table 3.3 presents the results using the Koeppen-Geiger (KG) climatic classification of tropical countries. Column 1 of table 3.3 shows the results for the baseline regression for the period 1984-2005. We re-estimate our baseline regression in Column 2 using this shorter sample, which allows us to effectively compare the results with those in Column 3, where we add rainfall and irrigation measures. Note that the number of countries falls to 26, as there is no rainfall data available for Jamaica. The results are very similar in all the three columns of Table 3.3, except that tractor usage is not significant when the sample size is shortened.

With respect to agricultural inputs, we find that fertilizer consumption, the proportion of agricultural land that is irrigated, and rainfall are positive and significant at the .05, .05, and .10 levels, respectively. The finding that fertilizer consumption is positively related to agricultural output is consistent with Lusiga et al. (1997), who find that fertilizer usage positively affects agricultural productivity in a sample of 47 African countries from 1961-1991.

[28] We calculate joint f-tests on the country dummies and find that they are significant as a group in all of our estimations. We do not report the individual fixed effects for reasons of space, but the coefficients on them are generally relatively small, except for the case of Guyana, which has a much larger and negative coefficient.

Rainfall is also an important factor in the tropics, since irrigation systems are often not sufficiently available in developing countries. It is therefore not surprising that higher annual rainfall is positively associated with higher agricultural productivity. Also, adequate rainfall may increase the length of time in which a land is cultivated before it is allowed to go fallow; adequate rainfall will also shorten the time a fallowed land will regain its lost nutrients. Our results on rainfall are similar to Fulginiti et al. (2004), who found that the occurrence of droughts is negatively related to agricultural productivity in 41 sub-Saharan African countries. The proportion of agricultural land that is irrigated should also affect agricultural productivity in the same way as rainfall, if not more so because rainfall may be torrential and leach soil nutrients, while irrigation is more controlled.

Of these three significant agricultural inputs, the proportion of agricultural land that is irrigated has the largest quantitative effect on agricultural productivity. Specifically, a one percent increase in the proportion of irrigated agricultural land is associated with about a 0.25% increase in agricultural production per hectare.

We also find evidence that telephones and agricultural productivity are significantly related. The coefficient on telephones is positive and significant at the .01 level in all three columns in the table. Using the coefficient from column 3, we calculate that a one percent increase in the number of telephone subscribers will increase agricultural productivity by about 0.08%.

Unlike we expected, we find no evidence that tractor usage or institutional variables have a significant effect on agricultural productivity in the full sample.

Below we experiment with interacting our right-hand side variables with a dummy variable equal to one for countries located in tropical SSA.

3.4.2 Determinants of Agricultural Productivity in tropical Sub-Saharan Africa

Table 3.4 is similar to Table 3.3 except that we now interact all of our right-hand side variables with a SSA dummy. An F-test of the joint significance of the SSA interaction variables shows that they are significantly different from zero as a group.[29] This indicates that the determinants of tropical SSA agricultural productivity are different from that in tropical regions outside of SSA.

Dividing the sample into tropical SSA and tropical non-SSA causes the coefficients of fertilizer use, telephones, and rainfall to become insignificant (on the variables by themselves as well as the ones interacted with the SSA dummy). It is clear from this result that the effect of these variables on agricultural productivity is not significantly different in SSA. The one variable that does change is irrigation. We find that in countries outside of Africa, irrigation positively and significantly affects productivity at the .01 level. Inside tropical SSA, however, the variable has no significant effect. When we calculate the partial effect on the interaction term (irrigation*SSA), we find that it has a coefficient of .096 and a t-statistic of 1.08. Thus, while irrigation has a clear positive impact on agriculture in most of the tropics, it does not in Africa.

In sum, the results show fertilizer usage, telephones, and rainfall have positive and statistically significant effects throughout the tropical, developing

[29] The F-statistic (8, 25) is equal to 3.44. We experimented with estimating the model without country dummies and including a dummy variable equal to one for tropical SSA. The coefficient on the dummy was negative and significant, indicating that agricultural productivity is lower in that region.

world. Tractor usage and some common institutional variables, however, do not seem to have a significant impact on agricultural productivity. Lastly, irrigation has a mixed effect. It positively affects productivity outside of Africa, but has not significant affect inside of tropical SSA.

3.4.3 Robustness Check

In this section, we test whether our results are robust to using an alternative classification of tropical countries. Specifically, we follow Masters et al. (2001) in designating countries as tropical if they have fewer than five days of winter frost days. As noted above, this new classification increased our baseline sample from 27 to 53 countries. Tables 3.5 and 3.6 replicate the regressions reported in Tables 3.3 and 3.4 using this expanded sample.

Table 3.5 reports the results for the overall sample. Here again our reference of discussion will be column 3, where we include annual rainfall and irrigation. Fertilizer usage, telephones, rainfall, and irrigation are all positively and significantly related to agricultural productivity at the .05, .01, .05 and .01 levels, respectively. Unlike in the earlier sample, however, we now find evidence that tractor usage and government stability affect productivity levels. Both coefficients are positive and weakly significant at the .10 level, meaning that increased tractor usage and increased government stability are related to higher agricultural productivity.

In Table 3.6, we interact our right-hand side variables with our SSA dummy. There are three main differences from Table 3.4. First, rainfall no longer has a significant effect outside of tropical SSA. It does, however, have positively impact agricultural productivity within Africa. When we calculate the partial effect of the

interaction variable, we find that the coefficient is .223 and the t-statistic is 4.13. Thus, an increase in rainfall by 1% is associated with a .22% increase in productivity.

Second, irrigation is now significantly related to agricultural productivity in SSA, but its quantitative impact is much smaller there than it is in other regions. The coefficient on irrigation for countries outside of SSA is .415, which indicates that an increase in irrigation by 1% results in increased productivity of about .42%. When we calculate the partial effect on SSA, however, the coefficient is only .142. Thus, increased irrigation positively affects productivity in that region, but by a much smaller amount.

Lastly, we find that the coefficient on corruption is negative and significant at the .10 level in tropical SSA. Since higher levels of the corruption variable actually signify lower levels of actual corruption, the finding demonstrates a negative relationship between agricultural productivity and corruption in SSA.

3.5 Conclusion

This chapter examines the determinants of agricultural productivity in the tropics and tests whether agricultural productivity is significantly different in tropical sub-Saharan Africa. We find broad and consistent support for the idea that fertilizer usage, telephones, and rainfall have a positive effect on agricultural productivity. This is true both inside and outside of Africa. We find evidence that the effect of irrigation, however, is different in tropical SSA. In our baseline sample, the coefficient on irrigation was only significant outside of Africa. In our alternative

sample, the coefficient was positive in both but the quantitative impact of irrigation was much reduced in SSA.

We do not find any evidence that our institutional measures (corruption, government stability, and bureaucratic quality) have a statistically significant impact on agricultural productivity in our baseline model. Using an alternative definition of tropicality, which increases the number of countries in our sample, we do find that government stability is positively related to agricultural productivity, and that corruption is particularly harmful to productivity in SSA.

As far as policy recommendation is concerned, government policies that encourage more fertilizer use would seemingly help raise agricultural productivity, especially in sub-Saharan Africa. Also other policies like the provision of basic infrastructure and basic amenities (proxied by telephone mainlines) will increase agricultural productivity in the tropics in general and tropical non sub-Saharan African countries. All these policy interventions will go a long way in increasing agricultural productivity.[30]

A possible avenue for future research would be to examine the determinants of agricultural productivity in those disaggregated ecological zones. This could shed more light on why the institutional variables are sensitive to the sample of countries included.

[30] The sharp increase in food prices since 2003 is both damaging to African economies as well as an opportunity for African farmers. It is damaging in that it makes food more expensive to the average consumer, which may increase malnutrition levels. If the higher food prices are positively correlated with government revenue (from export or income taxes), then the government has the opportunity to boost agricultural productivity through public investment in infrastructure, irrigation, and extension services. Ackello-Ogutu (2010) argue that whether Africa can take advantage of this recent increase in food price will depend on how integrated Africa is with the global market and whether the price of imported agricultural imports (like fertilizer) falls relative to food prices.

Appendix 3.1: Countries and Data Availability for two different definitions of tropical climates

Countries	Region	Koeppen-Geiger Classification	Masters Classification
Algeria	Middle East & North Africa		1984-2005
Angola	Sub-Saharan Africa		1985-2000; 2002-2005
Bangladesh	South Asia	1984-2005	1984-2005
Bolivia	Latin America & Caribbean		1984-2005
Brazil	Latin America & Caribbean	1984-2005	1984-2006
Burkina Faso	Sub-Saharan Africa		1985-2005
Cameroon	Sub-Saharan Africa	1984-2005	1984-2005
Colombia	Latin America & Caribbean	1984-2005	1984-2005
Congo, Rep. of	Sub-Saharan Africa	1985-2001	1985- 2001
Congo, D.R.	Sub-Saharan Africa	1984-91; 95-96; 98-2001	1984-91; 95-96; 98-2001
Costa Rica	Latin America & Caribbean	1984-2005	1984-2005
Cote D'Ivoire	Sub-Saharan Africa		1984-2005
Ecuador	Latin America & Caribbean		1984-2005
Egypt	Middle East & North Africa		1984-2005
El Salvador	Latin America & Caribbean	1984-2005	1984-2005
Ethiopia	Sub-Saharan Africa		1993-2005
Gabon	Sub-Saharan Africa	1984-2005	1984-2005
Gambia	Sub-Saharan Africa	1986-2001; 2003-2005	1986-2001; 2003-2005
Ghana	Sub-Saharan Africa	1984-2005	1984-2005
Guatemala	Latin America & Caribbean		1984-2005
Guinea	Sub-Saharan Africa	1986-2005	1986-2005
Guinea Bissau	Sub-Saharan Africa	1987-2001	1987-2001
Guyana	Latin America & Caribbean	1984-2005	1984-2005
Haiti	Latin America & Caribbean	1991-2001	1991-2001
Honduras	Latin America & Caribbean		1984-2005
India	South Asia		1984-2005
Indonesia	East Asia & Pacific	1984-2005	1984-2005
Jamaica	Latin America & Caribbean	1984-2005	1984-2005
Kenya	Sub-Saharan Africa		1984-2005
Liberia	Sub-Saharan Africa	1984-1990	1984-1990
Madagascar	Sub-Saharan Africa		1985-2005
Malawi	Sub-Saharan Africa		1984-2005
Mali	Sub-Saharan Africa		1984-2001
Morocco	Middle East & North		1984-2005

	Africa		
Mozambique	Sub-Saharan Africa		1985-2005
Nicaragua	Latin America & Caribbean		1984-2005
Niger	Sub-Saharan Africa		1985-2005
Nigeria	Sub-Saharan Africa	1984-2005	1984-2005
Panama	Latin America & Caribbean	1984-2005	1984-2005
Paraguay	Latin America & Caribbean		1984-1997
Peru	Latin America & Caribbean		1984-2005
Philippines	East Asia & Pacific	1984-2005	1984-2005
Senegal	Sub-Saharan Africa		1984-2005
Sierra Leone	Sub-Saharan Africa	1985-2001	1985-2001
Sri Lanka	South Asia	1984-2004	1984-2004
Tanzania	Sub-Saharan Africa	1990-2005	1990-2005
Thailand	East Asia & Pacific	1984-2005	1984-2005
Togo	Sub-Saharan Africa		1984-2005
Uganda	Sub-Saharan Africa	1984-2005	1984-2005
Uruguay	Latin America & Caribbean		1984-2005
Venezuela	Latin America & Caribbean	1984-2005	1984-2005
Zambia	Sub-Saharan Africa		1984-2001; 2005
Zimbabwe	Sub-Saharan Africa		1984-2005

Appendix 3.2: Data Description and Sources

Variable	Definition	Source
Agricultural Production	Aggregate volume of agricultural production relative to the base period 1999-2001, net of seeds and feed (in international dollars).	FAOSTAT: http://faostat.fao.org
Fertilizer consumption (metric tons) per hectare of arable land	Amount of fertilizer used per unit of arable land	World Development Indicators, 2010
Number of Telephone Lines Subscribers	Fixed line and mobile phone subscribers (per 1,000 people)	World Development Indicators, 2007
Irrigation	Total irrigated land as a % of total cropland	World Development Indicators, 2007
Annual Average Rainfall	Average rainfall with weights based on the prevalence of cropland.	http://acadweb.swarthmore.edu/acad/rain-econ/Framesets/CountryAggregated.htm.
Tractors Used	Number of tractors per 100 hectares of arable land	World Development Indicators, 2007
Agricultural Land	Hectares of arable and permanent crops (in 1000s)	FAOSTAT: http://faostat.fao.org
Government Stability	The subcomponents of this index are government unity, legislative strength, and popular support. Ranges from 0 to 12, with higher numbers representing more stability.	International Country Risk Guide
Corruption	A measure of corruption in the political system including excessive patronage, nepotism, job reservations etc. The composite score ranges from 0 (high corruption) to 6 (low corruption)	International Country Risk Guide
Bureaucratic Quality	This measures if the	International Country Risk Guide

	bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services, especially when there is a change in government. It ranges from 0 to 4, with higher numbers representing higher bureaucratic quality.	

Table 3.1: Summary Statistics for Sample of Countries using the Koeppen-Geiger (KG) Classification

Variable	Mean	Std. Deviation	Min	Max
Log(Agriculture Production per permanent and Arable land)	6.36	0.551	5.28	8.03
Log(Fertilizer Consumption)	-4.05	2.16	-10.55	-0.05
Log(number of Telephone subscribers)	2.56	1.54	-0.91	5.79
Log(Proportion of Cropland Irrigated)	1.29	1.74	-2.27	3.90
Log(Annual Rainfall)	7.43	0.35	6.22	8.17
Log(Number of Tractors Used)	2.90	1.82	-0.51	5.81
Corruption Index	2.45	1.14	0	5
Government Stability Index	6.25	2.35	1	11.08
Bureaucratic Quality	1.56	1.09	0	3.5

Table 3:2: Summary Statistics for the Sample using Masters' Classification of Tropical Countries

Variable	Mean	Std. Deviation	Min	Max
Log(Agriculture Production per permanent and Arable land)	6.19	0.685	4.14	8.26
Log(Fertilizer Consumption)	-4.12	1.90	-10.55	-0.05
Log(number of Telephone subscribers)	2.49	1.42	-0.91	5.99
Log(Proportion of Cropland Irrigated)	1.35	1.59	-2.35	4.61
Log(Annual Rainfall)	7.10	0.65	3.35	8.18
Log(Number of Tractors Used)	2.86	1.80	-2.39	5.81
Corruption Index	2.64	1.05	0	5
Government Stability Index	6.41	2.27	1	11.58
Bureaucratic Accountability	1.52	1.00	0	4

Table 3.3: The Determinants of Agricultural Productivity in tropical Countries

	Estimation Period 1984-2005	Estimation Period 1984 - 2000	
	1	2	3
Log (Fertilizer)	0.047**	0.039*	0.045**
	(2.26)	(1.92)	(2.31)
Log (Tractors)	0.073*	0.052	0.053
	(1.73)	(1.11)	(1.25)
Log (Telephones)	0.090***	0.115***	0.082***
	(5.22)	(3.22)	(2.88)
Log (Rainfall)			0.110*
			(1.80)
Log (Irrigation)			0.250**
			(2.25)
Corruption	0.012	0.020	0.014
	(0.57)	(0.97)	(0.69)
Government	0.005	0.003	0.004
Stability	(0.64)	(0.39)	(0.51)
Bureaucratic	-0.003	0.003	0.009
Quality	(-0.14)	(0.12)	(0.40)
R-Square (Within)	0.45	0.35	0.42
# of Observations	522	405	405
# of Countries	27	26	26

The values in parentheses are robust t-statistics. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3.4: The Determinants of Tropical Agricultural Productivity inside and Outside of SSA

	Estimation Period 1984-2005	Estimation Period 1984 - 2000	
	1	2	3
Log (Fertilizer)	0.113*	0.102	-0.008
	(1.76)	(0.87)	(-0.11)
Log (Tractors)	0.024	0.018	0.079
	(0.46)	(0.37)	(1.57)
Log (Telephones)	0.115***	0.139**	0.086**
	(3.81)	(2.46)	(2.38)
Log (Rainfall)			0.044
			(1.03)
Log (Irrigation)			0.510***
			(6.09)
Corruption	0.018	0.021	0.023
	(0.81)	(0.85)	(0.99)
Government	-0.0003	-0.005	-0.004
Stability	(-0.04)	(-0.60)	(-0.75)
Bureaucratic Quality	-0.013	0.002	0.009
	(-0.37)	(0.06)	(0.29)
Log (Fertilizer)	-0.093	-0.074	0.042
*SSA	(-1.28)	(-0.62)	(0.59)
Log (Tractors) *SSA	0.061	0.015	-0.062
	(0.56)	(0.13)	(-0.61)
Log (Tel.) *SSA	-0.053	-0.088	-0.053
	(-1.54)	(-0.98)	(-0.69)
Log (Rainfall)*SSA			0.173
			(1.27)
Log			-0.414***
(Irrigation)*SSA			(-3.43)
Corruption*SSA	-0.023	-0.025	-0.041
	(-0.61)	(-0.55)	(-0.92)
Govt. Stability*SSA	0.007	0.017	0.016
	(0.56)	(1.13)	(1.24)
Bur. Quality*SSA	0.018	0.022	0.024
	(0.34)	(0.42)	(0.46)
R-Square (Within)	0.49	0.38	0.49
# of Observations	522	405	405
# of Countries	27	26	26

The values in parentheses are (robust) t-statistics. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3.5: The determinants of agricultural productivity in tropical countries using an alternative definition of climate

	Estimation Period 1984-2005	Estimation Period 1984 - 2000	
	1	2	3
Log (Fertilizer)	0.038**	0.031*	0.036**
	(2.45)	(1.71)	(2.07)
Log (Tractor	0.086**	0.083*	0.073*
Usage)	(2.40)	(1.91)	(1.71)
Log (Telephones)	0.088***	0.105***	0.084***
	(7.57)	(4.26)	(3.95)
Log (Rainfall)			0.089**
			(2.51)
Log (Irrigation)			0.206***
			(4.44)
Corruption	-0.008	-0.010	-0.008
	(-0.60)	(-0.71)	(-0.65)
Government	0.009**	0.010*	0.008*
Stability	(2.13)	(1.90)	(1.80)
Bureaucratic	0.005	0.003	0.007
Quality	(0.28)	(0.22)	(0.43)
R-Square (Within)	0.45	0.35	0.42
# of Observations	1062	829	829
# of Countries	53	52	52

The values in parentheses are (robust) t-statistics. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3.6: The Determinants of Tropical Agricultural Productivity Inside and Outside of SSA, using an Alternative Definition of tropicality

	Estimation Period 1984-2005	Estimation Period 1984 - 2000	
	1	2	3
Log (Fertilizer)	0.071*	0.071	0.020
	(1.83)	(1.49)	(0.60)
Log (Tractors)	0.076	0.063	0.083
	(1.21)	(0.94)	(1.41)
Log (Telephones)	0.120***	0.140***	0.101***
	(5.60)	(3.82)	(4.06)
Log (Rainfall)			0.020
			(0.62)
Log (Irrigation)			0.415***
			(6.10)
Corruption	0.005	0.0001	0.004
	(0.28)	(0.01)	(0.28)
Government	0.003	0.0004	0.005
Stability	(0.68)	(0.07)	(1.06)
Bureaucratic Quality	-0.009	0.001	0.007
	(-0.34)	(0.06)	(0.30)
Log	-0.048	-0.051	0.011
(Fertilizer)*SSA	(-1.15)	(-1.01)	(0.28)
Log (Tractors)*SSA	-0.017	0.005	-0.030
	(-0.23)	(0.06)	(-0.38)
Log (Tel.)*SSA	-0.066**	-0.096	-0.084
	(-2.60)	(-1.66)	(-1.55)
Log (Rainfall)*SSA			0.203***
			(3.26)
Log			-0.257***
(Irrigation)*SSA			(-3.48)
Corruption*SSA	-0.032	-0.032	-0.042*
	(-1.21)	(-1.15)	(-1.71)
Govt. Stability*SSA	0.009	0.014	0.006
	(1.06)	(1.57)	(0.04)
Bur. Quality*SSA	0.005	0.0003	-0.001
	(0.13)	(0.01)	(-0.03)
R-Square (Within)	0.51	0.40	0.49
# of Observations	1062	829	829
# of Countries	53	52	52

The values in parentheses are (robust) t-statistics. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

CHAPTER 4

The New Agricultural Green Revolution in Africa: The Pivotal Role African Leaders need to play

4.1 Introduction

The Green Revolution that transformed much of Asia and Latin America has not materialized fully in Africa despite the efforts of the Rockefeller Foundation, the main architect of the Asian Green Revolution. There have been many reasons discussed in the literature as to why Africa has not been able to take advantage of the Green Revolution.[31] The Asian Green Revolution was technology driven package of modern improved seeds, fertilizer and irrigation. Also, much of Asia has one main farming system, irrigation farming, and also some level of infrastructural base. For instance, most Asian countries on average were spending about 15% of their national budget on agriculture by 1972 (Hazell, 2009).

Unlike in most part of Asia, agriculture in sub-Saharan Africa is characterized by small-scale farming, with diverse cropping systems which are primarily rainfed and make little use of inorganic fertilizer (World Bank, 2007, and the Rockefeller Foundation, 2006)[32]. It is therefore not surprising that when the engineers of the Asian Green Revolution, the Consultative Group on International Agricultural Research (CGIAR), tried using in Africa the same one-size-fits-all agricultural transformation method used in Asia, it did not work. In fact, the Asian Green revolution did not work in all countries in that region either, especially those

[31] Some of the previous discussions that took place in bringing Green Revolution to Africa are the Lagos Action program in the 1980s, the African Alternative in 1989 and recently the New Partnership for African Development (NEPAD) in 2002(World Bank, 2007).

[32] Though there are export crops that are cultivated under mechanized farming system, export crops account for only 8 percent of total agricultural production (Peacock, Ward, and Gambarelli, 2007).

South and East Asian countries generally classified as "less favored" (Pender, 2008). For instance, in the upland regions of the Philippines, central and Eastern China, and some parts of India where erosion is severe, the Green Revolution did not fare well there (Pender, 2008). Also, the commitment of Africa leaders in using agriculture as an engine of growth has been shaky and changing over the years since independence. The collaboration between the CGIAR and NARCs of the African countries has not been the same as it was with the Asian counterparts.

In this chapter, I examine the two main approaches (the focused, and comprehensive) suggested in the literature to help Africa transform its agricultural productivity. The proponents of the comprehensive approach note the complex nature of Africa's agricultural problems and hence propose that the solution should be multifaced and coordinated. Those who advocate for the focused approach argue that with scarce budgets, the solution to Africa's agricultural problems should be concise and focused on the more binding constraints to agricultural productivity.

I will also look at the prospect of the South-South cooperation instead of the typical North (Consultative Group of International Agricultural Research - CGIAR) - South cooperation, in part because southern countries often have similar climates and may have faced similar agricultural challenges (e.g. bad soil, drought like in Brazil's *Cerrado*), and therefore may be able to help more effectively.[33] It should be noted

[33] The 15 international agricultural research centers are: International Food Policy Research Institute (IFPRI), International Center for the Improvement of Maize and Wheat (CIMMYT), International Potato Center (CIP), Biodiversity International, International Center for Tropical Agriculture (CIAT), International Center for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI), Africa Rice Center (WARDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA), International

that South-South cooperation can be either Comprehensive or focused. I argue that no matter the approach African countries adopt, the key to agricultural transformation requires a strong commitment from African leaders, with respect to the provision of needed infrastructure, improved institutions, and ensuring an enabling environment, and a coordinated effort by all partners (i.e. International Agricultural Research systems (IARs), National Agricultural Research Centers (NARCs), Sub-regional Research Organizations (SROs), both bilateral and multilateral development partners and philanthropists. Africa's agriculture will still be underdeveloped if cooperation yields promising improved varieties and there are no efficient extension services to make the farmers aware of the new varieties and how to plant them or if other inputs like fertilizer are not affordable because of poorly functioning markets for inputs and outputs. There is only so much the development partners will be able to do.

The chapter is set up as follows; the next section discusses the evolution of agriculture research in African research over the years and the activities of the World Bank with respect to African agriculture. Section 4.3 examines why the earlier Green Revolution did not succeed in Africa. Section 4.4 discusses the pros and cons of going with a focused versus a comprehensive approach to transforming agriculture productivity in Africa and section 4.5 analyses the prospects of South-South cooperation being the panacea to Africa's agricultural problems. Section 4.6

Water Management Institute (IWMI), International Rice Research Institute (IRRI), WorldFish Center, Center for International Forestry Research (CIFOR), and World Agroforestry Center.

discusses the role Africa leaders need to play in transforming Africa's agriculture. The last section concludes.

4.2 The Evolution of Agricultural Research in Africa

Agricultural research systems in Africa has evolved from the colonial days where most of the research was undertaken in regional research centers to the current research system involving national, regional and international research centers with active roles played by philanthropical organizations, financial institutions, bilateral and multilateral donors.[34] Colonial leaders recognized both the potential of their colonies as suppliers of raw materials, as well as the diversified nature of agro-ecological conditions in Africa. They therefore opted for regional research centers strategically located in countries like Cote D'Ivoire, Kenya, Senegal, Sudan and Zimbabwe, they focused on developing technologies for a small number of export crops, and would hopefully spill over to neighboring countries (ECA, 2003). For instance, in 1921, the French established a research station in Bambey (Senegal) to undertake research on groundnuts. The mandate of this research station was expanded in 1938 to become the Federal Station for Agronomic Research in Francophone West Africa. The British also established a research station in Zimbabwe in 1909 and a cotton research center in Sudan in 1919. These regional research organizations were linked with global commodity networks, also

[34] For more detailed analysis of how agricultural research has changed over the years, the reader may refer to Beintema, and Stads (2006), Greenland (1997), Roseboom, Pardey, and Beintema (1998) and Chema, Gilbert, and Roseboom (2003).

established by the colonial leaders for the exchange of germplasm (Cooper, 1970).[35] The agricultural research under colonial rule was also fashioned out under the umbrella of 2-3 year development plans (ECA, 2003).

After World War II, the colonial leaders restructured agriculture research in Africa. The British Colonial Headquarters for regional research in East Africa was renamed the East African Agriculture and Forestry Research Organization (EAAFRO) and moved to Muguga (outside Nairobi) from Amani, to serve Kenya, Tanganyika, and Uganda. Its mandate was also broadened to cover research on both agriculture and forestry. Some of the achievements of the earlier regional research organizations, before World War II, include the development of hybrid maize in Kenya and Zimbabwe, rust-resistant wheat in Kenya, hybrid oil palms in Zaire and cotton in Uganda, Sudan, and Francophone West Africa.

After most African countries gained their independence in the late 1950s and 1960s, the regional research centers established by the colonial authorities were typically merged into the National Agricultural Research centers (NARCs) or closed. For instance, three years after Nigeria's independence in 1963, West Africa Institute for Oil Palm Research (WAIFOR), based in Nigeria, which had helped Nigeria to become the largest exporter of oil palm at the time of its independence, was nationalized. After WAIFOR was nationalized, it was renamed the Nigeria Institute for Oil Palm Research (NIFOR). The number of staff of NIFOR was also increased

[35] Germplasm is genetic material used to breed crops/plants that are more productive (e.g. through being more responsive to other inputs such as fertilizer, and having short maturity period) and resistance to constraints like pest and diseases.

from 15 to 283 within a span of five years (Eicher, 1989). Likewise, the West Africa cocoa research in Ghana was nationalized and renamed the Cocoa Research Institute of Ghana. One major problem almost all African countries faced with respect to agricultural research was that, with the exception of Nigeria and Kenya, most countries did not have the qualified staff to effectively run their agricultural extension services. Fortunately, the world market price for cash crops like cocoa, coffee, and tea were favorable in the 1960s and 1970s. Most revenue derived from the exports of these cash crops were used to train manpower, with the main agricultural strategies articulated in national development plans (ECA, 2003). In the 1970s, most African countries, using national food policy plans, tried to increase the production of foodstuff to ensure food sufficiency, with varying degrees of success. For instance, Tanzania, Nigeria, Senegal, Kenya and Ghana all adopted a national food sufficiency policy in the 1970s.[36]

While these regional research centers were being "Africanized", the national agricultural research centers (NARCs) were being expanded in terms of the number of staff, commodities, and research projects, with readily available donor funding from institutions like USAID. Another phenomenon that took place in the wake of this unprecedented expansion is the disproportionate distribution of agricultural scientists across African countries. For instance, while about 80 percent of agricultural scientists were located in 13 countries, the remaining 20 percent of the

[36] Nigeria had operation *Feed the Nation* as a pilot project in 1976, and later adopted *Accelerated Food Production Program* in 1978. Ghana also adopted *operation Feed Yourself* in 1973. While Nigeria achieved surpluses in some crops, Ghana only achieved an annual agricultural growth rate of 2.6% against a targeted growth rate of 6% (Girdner et al., 1980; Lawani and Babaleye, 1992).

scientists were located in the remaining 35 countries (CGIAR, 2003). This skewed distribution of scientists likely results in some areas (countries) being neglected since there are not many regional research centers to rely on.

The problems in the expansion of the NARCs between 1960 and 1980 resulted in the rebirth of regional research in the 1980s as a way of addressing this disproportional distribution of expertise. A group of western donors established the Special Program for African Agricultural Research (SPAAR) in 1985. The SPAAR was mandated to coordinate donor aid to agricultural research in Africa and to strengthen the capacity of NARCs to utilize new technology from the Consultative Group on International Agricultural Research (CGIAR) system (SPAAR, 1997). In the 1990s, the SPAAR, launched an initiative to promote regional research by noting that it has considerable potential to strengthen the NARCs (SPAAR, 1995:42). SPAAR played a key role in establishing three sub-regional Research Organizations (SROs) in the 1980s and 1990s. The West and Central African Council for Agricultural Research and Development (CORAF/WECARD), founded in 1987, has 22 member countries located across three agroecological zones.[37] The Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training (SACCAR) was the most active and well-organized SRO during the early 1990s, but most of its activities were discontinued in recent years due to a major reorganization of the Southern African Development Community (SADC), its parent

[37] The member countries for CORAF/WECARD are Benin, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Cote D'Ivoire, Democratic Republic of Congo, Gabon, The Gambia, Ghana, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

organization, in 2001.[38] The Food, Agriculture and Natural Resources (FANR) Directorate was launched in December 2001, as part of a SADC restructuring exercise. The last SRO that SPAAR helped in establishing is the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the most influential SRO currently, which was established in 1993, with 10 members, with the goal of promoting regional cooperation in agricultural research in Eastern and Central Africa.[39]

While these SROs were being rebuilt and the NARCs were being restructured, the CGIAR, with its 15 International Agricultural Research System (IARS), was also making inroads and laying the foundation for the launching of a new Green Revolution for Africa. After the International Rice Research Institute (IRRI) was established in 1962 in the Philippines by the Rockefeller and Ford Foundations, the International Institute of Tropical Agriculture (IITA) was established in 1967 in Nigeria to improve the yield and quality of tropical food crops other than rice. The IITA was perhaps overambitious in the number of crops it conducted research on in the initial stages. In particular by 1974, IITA researchers were researching over 10 crops, including cassava, sweet potatoes, cocoyam, maize, and rice. On the other hand, the IRRI and the International Center for the Improvement of Maize and Wheat (CIMMYT) only concentrated on wheat and maize, sorghum and millet respectively. Despite IITA being overambitious with the

[38] The founding member states of SADC are Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.
[39] The members of ASARECA are Burundi, D.R. Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, and Uganda.

initial large number of crops it conducted research on, it chalked up early success in releasing high yielding cassava varieties in 1976, which increased yield by about 40% without fertilizer (Nweke, Spencer, and Lynam, 2002). The IITA has also made important contributions in developing soybean, cowpeas, and maize variety, which is resistant to streak virus and downy mildew.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established in 1972 by CGIAR and given the mandate to conduct research in 5 crops: sorghum, pear millet, groundnuts, pigeonpeas, and chick peas (legumes). The West Africa Rice Development Association (WARDA), now called Africa Rice Association, was also established in Monrovia as an autonomous intergovernmental research association of 11 countries in West Africa. WARDA joined the CGIAR in 1974. The major achievement of WARDA is the development of NERICA which is a rice crossbreed that has the robustness of African rice and the high yielding properties of Asian rice. Though there have been some technological improvements in agricultural production in Africa, especially in the area of the development and release of improved seeds like sorghum, rice, wheat, and maize, the increase in productivity has been modest and has generally not been able to keep pace with population growth (Nweke et al., 2002). For instance, even though Sub-Saharan Africa has seen a steady increase in the adoption of improved cereal varieties, only 22 percent of its land area was devoted to improved cereal variety cultivation in 2000 (World Bank, 2008). While most of the increase in agricultural production in sub-Saharan African has been due to increased land area cultivated, with crop yield stagnating, that of Asia and Latin America has been due to crop yield

(World Bank, 2007 and Toenniessen et al., 2008). Also the modest agricultural productivity experienced in Africa has been varying and dramatic across countries. For instance, while a country like Gabon moved from poor performance in 1990–2000 to better performance in 2000–04, Malawi moved in the opposite direction. Only about 25% of African countries, among them Benin, Burkina Faso, Gabon, Nigeria, Tanzania and Ghana, exhibited consistently better performance between 1990 and 2000 (World Bank, 2007). Chapter 1 of this thesis shows how important fertilizer usage, infrastructure, and rainfall are to agricultural productivity in sub-Saharan Africa. With low levels of physical infrastructure, low fertilizer usage, and erratic rainfall levels, it is not surprising to see lower agricultural productivity in Africa.

It is clear that the focus of agricultural research has moved from relying on more regional research organizations to national one and then later to collaboration between regional, national and international research organizations. This evolution has been dictated by the role agriculture is perceived to play by various policymakers at different point in time. During the colonial era, agriculture was seen mostly as a source of raw materials for industries in the West. Immediately after independence, agriculture was considered, by African leaders, as a source of foreign exchange and hence the emphasis being on the production of cash crops like cocoa, coffee and rubber. It was only in the 1980s that efforts were made to make agriculture the engine of growth and the main source of poverty reduction in Africa, perhaps because of the earlier success of the Green Revolution in Asia and Latin America.

This resulted in collaboration between international agricultural research institutions and some national agricultural research centers in Africa.

The World Bank has not had a formal strategy for the agricultural sector in Africa, but rather the Bank's goal for agricultural development is articulated under the broader rural development strategies. The importance given to agriculture under the rural development strategy has been changing over the years. In the 1970s, agriculture development was very prominent but become less so in later years. This change in prominence of agricultural development is because in the 1970s, the Bank's activities in the rural areas were mainly in the agricultural sector. But in the 1980s and 1990s, the Bank's role expanded into human development, and sustainable development respectively. The Bank's rural development strategy continued to become broader in subsequent years and agriculture became a smaller percentage of the total rural portfolio (World Bank, 2007).

The World Bank's lending to agricultural sector in Africa increased through the 1960s and 1970s. For instance, while Bank's lending to the agricultural sector in Eastern African countries increased from 1964-1968 annual average of $5.3 million to an annual lending of $124.2 million in 1975, that of Western African countries increased from $3.6 million to $323 million within the same period (World Bank, 1975). Some of the notable projects undertaken by the Bank in Africa within this period are lending to boost exports of cocoa in Cameroon and Ivory Coast, cocoa/coffee project in Togo, a rubber project in Cameroun and pineapple project in Guinea in 1974.

The Bank supported about 262 projects in Africa with agricultural components between 1991 and 2006, valued at $14.31 billion, out of which only $4.5 billion was devoted solely to agricultural projects (World Bank, 2007). Further examination of the Bank's lending to Africa's agriculture shows that investment lending was even smaller. For instance, out of $ 4.5 billion dollars devoted to pure agricultural lending projects, $2.8 billion was investment lending while the remaining $1.72 billion was structural adjustment or development policy lending (World Bank, 2007). These figures illustrate how agriculture has become less prominent in the Bank's general rural development strategy in the 1990s, since the $2.8 billion investment lending for Africa's agriculture constitutes only 8 percent of the Bank's total investment lending to the region. The percentage of the Bank's lending for agricultural projects for Africa has increased considerably since the late 1990s. For instance, while investment lending for agriculture in Africa decreased from $419 million in 1991 to $123 million in 2000, it increased to $685 million in 2006 (World Bank, 2007 p. 26).

A review by the World Bank's activities in Africa with respect to agricultural productivity by the Bank's Internal Evaluation Group (2007) concluded that the Bank has had limited success in addressing the constraints confronting Africa's agricultural productivity. Some of the reasons cited are that the analytical work which is supposed to diagnose the constraints has been limited, not readily available, the Bank's lending support has lacked coordination, and has not taking multifaceted approach.

In sum, while various interventions have taken place in African agriculture, the results have been subpar. The CGIAR attempted to implement Africa's version of Green Revolution but it also fell short of expected results. I discuss various reasons for this lack of success.

4.3 Why the Original Green Revolution Stalled in Africa

The general consensus is that the earlier Green Revolution started in the mid 1960s and continued into the 1990s. But the idea of Green Revolution was nursed in 1941 with a casual conversation between the then Vice-President of the United States, Henry Wallace, and the Rockefeller president then, Raymond B. Fosdick. The conversation was about the US Vice-President, telling the Rockefeller foundation president to increase the yield of beans and corn in Mexico and that will be the greatest thing happening to that country. That conversation resulted in a research center being established outside Mexico City. The success achieved in Mexico convinced the Rockefeller Foundation to start a similar country program in India in 1957, and three years later the Rockefeller and Ford Foundation created the International Rice Research Institute (IRRI) at Los Banos, Philippines. The breeding and adoption of modern high yielding varieties of crops spread from Mexico to Colombia, India, and Philippines and farther into other parts of Asia and Latin America (Rockefeller Foundation, 2006). It should be noted that though the first generation high yielding modern varieties (MVs) were released in the mid 1960s, the second and third generation MVs were also released in the 1970s. The first generation MVs, which was originally developed by IARC (e.g. rice developed by

IRRI, and wheat and maize developed by CIMMYT) are high yielding varieties that responded well to the use of inorganic fertilizer, but susceptible to pest and diseases. The second generation MVs were both high yielding and resistant to pests and diseases. While both the first and second generation MVs were bred for cross country adoption, the third generation MVs were more ecological specific (Otsuka and Kalirajan, 2005).

The success of this earlier Green Revolution did not reach all part of Asia and Africa. In particular the less favored areas of South and East Asia did not reap the full benefit of this earlier Green revolution (Pender, 2008).[40] This has prompted the proposition of a different agricultural technology approach for these less favored regions in Asia. This new proposed technology approaches include low external input and sustainable agriculture, organic agriculture and biotechnology (Pender, 2008).

The Ford and Rockefeller Foundations which spearheaded the earlier Green Revolution in Asia and Latin America attempted to implemented similar policies in Africa, but like less favored areas in Asia, Africa did not achieve the same success as in earlier Green Revolution. The International Institute of Tropical Agriculture (IITA) was opened in 1967 in Ibadan, Nigeria, After 7 years of its establishment, the IITA was carrying out research on cassava, yam, sweet potato, cocoyams, maize, rice, cowpea, soybean, lima bean, pigeonpea, winged bean, African yam bean and velvet bean (IITA, 1992). The IITA released a high yielding cassava variety in the

[40] The less favored region of East and South Asia is defined as those areas located in uplands and mountains, marginal coastal areas and drylands. The main agricultural practices in these areas rely on rainfall, with poor market and infrastructure.

1970s and 1980s which was widely adopted in Nigeria, Ghana and Uganda, which was even productive without fertilizer. In 1979, IITA, CIAT and other national and international organizations cooperated to find a solution for cassava mealybug, resulting in a release of the wasp, the predator of the mealybug, in 1990. The IITA also contributed to the development of soybean, cowpeas, and steak virus and downy mildew resistance in maize, the adoption of which was hampered by unavailability of fertilizer, at least in Nigeria.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established in 1972 in India with its West African program launched in mid-1975 by posting scientists to Burkina Faso, Senegal, Nigeria, Niger and Mali. The ICRISAT had little success in importing improved sorghum varieties from India. It is clear that ICRISAT realized that one cannot just import an improved variety and expect it to work in an agro-diversified African environment.

The West African Rice Development Association (WARDA), now AfricaRice, was established in 1971, and became a member of CGIAR in 1974. The WARDA also did not do well with the importation of rice variety from IRRI initially until it launched Special Research Projects in Liberia, Sierra Leone, Mali, Senegal, and Cote D'Ivoire with the aim of developing a rice variety that will perform well under West African conditions. The main success of WARDA is the introduction of the New Rice for Africa (NERICA).

The International Livestock Center in Africa (ILCA) was established in 1974 in Ethiopia. The ICLA also had little success because of the complexities of African agriculture. The CIMMYT also has some partnership with other national research

centers in developing national wheat and maize varieties. It can be seen that the earlier international research centers in Africa did not achieve the same success as in Asia and Latin America.

The reasons for Africa's inability to take advantage of the earlier Green Revolution can be traced in part to the difficulty of the IARs to develop an adaptable improved variety for Africa. Compounding the problem was the lack of physical infrastructure and the institutional framework to enable the smooth transfer and adoption of the improved technologies introduced by the IARs in working with the various National Agricultural Research Centers (NARCs). The early success in the breeding of rice and wheat varieties was due to access to rich stocks of genetic resources already developed by advanced countries (Evenson and Gollin, 2003). For other crops like tropical cassava and beans, however, there was no prior work on them done by the developed countries to rely on and the lack of research of elite germplasm in the 1960s (Dalrymple, 1986 and Johnson et al., 2003). The development of modern varieties for these crops therefore took longer.

Thus researchers on African crops had to start from scratch unlike in Asia and Latin America, where there were abundant body of knowledge on modern varieties of the two main crops, rice and wheat to rely on. Also, unlike in Asia and Latin America, where researchers only had to breed two main crops, rice and wheat, which are predominantly cultivated by most of the farmers, in Africa, crop breeders had to breed many crops which face different agroecological constraints.

There were also impediments to the growth yield of the developed modern varieties in Africa. The complementary inputs that were needed to make farmers

realize the full potential of the MVs were either unavailable or unaffordable. Africa as a region uses less fertilizer than Asia and Latin America on average. For instance, in 1995 to 2005, while the average intensity of fertilizer use throughout Africa was roughly 9 kilograms per hectare, it was 86 and 104 kilograms in Latin America and South Asia, respectively (World Bank, 2007). The reasons cited for this lack of fertilizer usage is the high cost of fertilizer. It is estimated that free on board (f.o.b.) prices and landing costs make fertilizer twice as expensive on average in Africa as it is in Asia (Shepherd and Coster, 1987). This high cost of fertilizer in Africa is due to the small volumes of fertilizer bought by many African countries, which reduces their bargaining power, as well as the high transportation costs caused by bad roads (Vlek, 1990).

Another important input/infrastructure that was readily available in the earlier Green Revolution but was lacking in Africa is irrigation. While rice and wheat were grown on irrigated farms in Asia, Africa's farming system mostly depended on rainfall, which is very erratic, with little control of the amount of water available. The proportion of arable and permanent crop land irrigated in 2002 was only 4% in Africa but 39% in South Asia (World Bank, 2008). The unavailability of irrigation and fertilizer also reduced the adoption of modern varieties because the high risk of crop loss or not realizing the full yield of the Modern Varieties. Thus the three main factors that propelled the earlier Green Revolution in Asia and Latin, modern varieties, irrigation, and fertilizer were not available in Africa in sufficient quantities. In Asia, the main genetic factors hindering crop productivity before the Green Revolution was that the local crops did not respond to inorganic fertilizer. The first

generation Modern Varieties (MV1) released was a high yielding variety which responded very well to the application of inorganic fertilizer. Africa on the other, rainfed agriculture with little use of either organic or inorganic fertilizer, has to develop a crop variety that will be able to withstand droughts, insufficient soil nutrients, pests, and diseases (Toenniessen et al., 2008).

Government commitment has also been lacking in Africa, with respect to devoting the necessary resources for the development of the agricultural sector. As already indicated, though there had been some discussions of bringing the Green Revolution to Africa, there have not been much concrete steps taken by African leaders to make this happen (World Bank, 2007). An effective government is needed to provide the necessary infrastructure like roads, and an enabling environment for the development of market for both inputs and outputs. Toenniessen et al. (2008), found a positive correlation between the rate of technology agricultural technology adoption and the state of market institutional development. The provision of this infrastructure will go a long way in reducing the price of fertilizers, and also entice farmers to adopt the MVs since there will be likely market where there can sell their harvest as a result of growing the MVs. Also national governments will be required to institute educational reforms to train manpower to form efficient local crop breeders and extension officers for the development and dissemination of local MVs. This is very important because local crop breeders are more familiar with local crop constraints like diseases and pests, and thus will be in a better position to help develop an MV which will be resistant to those local constraints. Even if the IARs take a leading role in the breeding of the crops, local inputs will be needed and

government could play a major role in developing that local manpower. Rosegrant and Hazell (2001) argue that the Green Revolution worked so well in India at least in part due to the important increase in public investment before and during the period in question. Much of this investment was in road construction, electrification, and irrigation, underscoring the important role played by national government.

It will also be helpful if African leaders can provide the necessary environment to ensure the functioning of a sound financial market to enable farmers access credit to buy the needed improved seeds and complementary inputs like inorganic fertilizer. Additionally maintaining law and order and reducing corruption should be undertaken by African leaders. Reducing corruption is very important so that farmers are not exploited in terms of getting the seeds from various mandated government agencies.

Another problem faced by African agriculture is the sometimes uncoordinated effort by various development partners. An Independent Evaluation Group (IEG) study commissioned by the World Bank in 2007 to assess its funding for the development of African agriculture found, among other things, that though the Bank has funded many aspect of agricultural activities like research, extension, credit, seeds, and policy reforms, the Bank has failed to recognize the potential synergy among them to effectively contribute to agricultural development. The report also found that though there has been some comparative success in some areas, like research, progress in other areas have stalled as a result of a weak linkages with extension and limited availability of such complementary and critical inputs as fertilizers and water. The report further indicates that of the top ten borrowers

(including Cote D'Ivoire, Ethiopia, Tanzania, and Uganda), none had received a consistent and simultaneous support across all critical subsectors of agricultural production.

There have been policy strategies, proposed by African leaders, development partners, and philanthropy organizations, aimed at addressing some of the various problems of African agricultural productivity discussed above. In 2003, African leaders endorsed the Comprehensive African Agriculture Development Program (CAADP) under the auspices of the New Partnership for Africa's Development (NEPAD). The CAADP is a policy framework which encourages African leaders to make conscious efforts at restoring agricultural growth, food and nutritional security, and rural development. The CAADP has four pillars under which various strategies are articulated in achieving the stated goal of agricultural productivity, food security and rural development. The pillar IV of the CAADP discusses what needs to be done, among other things including devoting at least 10% of national budgets to agriculture, to increase productivity. The agricultural productivity of sub-Saharan Africa is also expected to reach 6% per annum by 2015, if most African countries are to meet their Millennium Development Goal of halving poverty level by 2015.The Forum for Agricultural Research in Africa (FARA) was set up in 2002, to bring together and coordinate efforts of all stakeholders in agricultural research and development in Africa, thus essentially replacing the Special Program for African Agricultural Research (SPAAR). Since the inception of FARA, it has organized various conferences and training programs for staff from various national agricultural research organizations and regional agricultural research organizations.

In 2006, there was also an African Fertilizer Summit, organized in Abuja, Nigeria and sponsored by development partners like the International Fund for Agricultural Development. The summit, which was attended by most of the African leaders sought to inform the leaders how important affordable fertilizer would be to the smooth rollout of Africa's Green Revolution. In the end African leaders agreed to remove tariffs on fertilizer. It is believed that this will go a long way in reducing the price of fertilizer and encouraging its use by farmers, which ultimately will lead to agricultural productivity.

The Rockefeller Foundation and Bill & Melinda Gates Foundations established the Alliance for a Green Revolution in Africa in 2007 and the United Kingdom's Department for International Development (DFID) became a funding partner in 2008. The strategy for Africa's Green Revolution share some basic principles of the earlier Green Revolution, like improved seed variety, with an integrated soil management which encompasses the use of both organic and inorganic fertilizer, alternative farming system that disturb the soil less, like no tillage, mulching, water harvesting, and growth of cover crops like legumes. It also has a semblance of both the comprehensive approach and the focused approach, in that while it targets all the various aspect of agricultural productivity, like developing improved variety, developing local man power, developing market for agricultural inputs and outputs, lobbying government to provide the enabling environment, it also

focuses first on a few countries it deems the "breadbasket". [41]Since its establishment in 2007, AGRA has launched programs ranging from human capital development to soil management. For instance in 2010, AGRA launched a PhD program in soil science for West Africa at Kwame Nkrumah University of Science and Technology (KNUST) located in Kumasi, Ghana.[42] In 2009, AGRA launched the Program for Integrated Soil Management in Maputo, Mozambique, with the aim of increasing production among farmers in the Nampula and Zambezia provinces.[43]

There has been general understanding among African leaders as to what needs to be done in order for Africa to increase its agricultural productivity. Some inroads have been made, with respect to African leaders committed to provide the necessary public investment in agriculture and reducing tariff on fertilizer. More work is still needed to be done for Africa's experience any appreciable growth in its agricultural productivity.

[41] The "breadbasket" refers to four countries, Ghana, Mali, Mozambique and Tanzania, that are deemed to have large concentration of smallholder farmers, have relatively good soils and basic infrastructure are already in place.
[42] Accessed on 09/27/2011: http://www.agra-alliance.org/content/news/detail/1250.
[43] Accessed on 09/27/2011: http://www.agra-alliance.org/content/news/detail/1043.

4.4 Approaches to Transform Africa's Agricultural Productivity

As mentioned above, there are two main approaches that have been proposed that Africa can adopt to increase its agricultural productivity: the Comprehensive approach, and the focused approach. The comprehensive approach, argues that Africa and development partners should take a broader approach in developing agricultural productivity. It is believed that Africa can make meaningful headway in increasing agricultural productivity only when African leaders develop sufficient manpower for agricultural research, breed different crop varieties that do well in different agroecological zones, improve extension services, engage in integrated soil management, provide physical infrastructure (e.g. roads, irrigation, goods and financial market), and strengthen institutions (e.g. efficient seed and output markets, and policies to address land tenure problems). The proponents of the focused approach argue that since Africa may not have the resources to engage in the comprehensive approach to develop its agricultural sector, it should instead focus on a few crops, like rice, that it has the potential of growing on a large scale. For the proponents of this second strategy, when African countries are successful in doing this, their central governments will have the incentive to provide the necessary infrastructure and improved institutions.

The new Green Revolution for Africa launched by the Rockefeller and Bill and Millender Gate Foundations has characteristics of both the comprehensive and focused approaches. This is because the new Green Revolution for Africa embodies both the comprehensive and focused approaches.

The Millennium Village Project (MVP) which was launched in 2005/6 with the aim of helping rural African communities to achieve the Millennium development goals, among them halving the poverty level by 2015, also has features of both comprehensive and focused approach. The MVP has five priority areas - agriculture, health, education, infrastructure, and business development- which are executed simultaneously and hence being comprehensive in that sense. However the MVP only was launched in a dozen of villages with the possibility of being scaled up and so being focused. While there have been some level of consensus on the growth in agricultural productivity (though the rate of the increase in agricultural productivity has been varying from study to study), the income levels of the participating villages have not increased that much (see e.g. Wanjala and Muradian, 2011).

4.4.1 Comprehensive Approach

The first strategy that has been proposed by many agricultural researchers (e.g. the proponents of AGRA; ECA, 2003; Sachs, 2005; and World Bank, 2008) as to the way agricultural productivity can be transformed in Africa is what I term the "Comprehensive Approach". The proponents of this approach argue that any strategy to transform Africa's agricultural productivity should be multifaceted, and should include the breeding of several crops, a well trained extension service staff, integrated soil management, good institutions (e.g. land reforms, corruption free), and the necessary physical and financial infrastructure. Toenniessen et al. (2008) proposed a "rainbow" Green Revolution which encompasses productivity growth for

many different crops, with an emphasis on farmer participation, local adaptation, a strengthening national and local institutions, and the building of agricultural value chains (especially with involvement of agribusiness) that enables farmers to generate profits from surplus production.

It is argued that the only way Africa can increase its productivity is the breeding of modern varieties of crops that are not only high yielding but also resistant to various crop diseases and pests. But unlike in the earlier Green revolution where mostly two crops, Rice and Wheat and to a lesser extent, corn, were the main crops, in Africa, because of the different agroecological zones, more crops will be needed since one or two crops may not do well in different agroecological zones. For instance, Gordon Conway's "Doubly Green Revolution" (1997) calls for the breeding of improved varieties, with less use of inorganic fertilizer to avoid the environmental problems caused by the earlier Green Revolution in Asia and Latin America. There should also be a well trained extension service staff to inform the farmers about the new improved varieties and how to plant them. This is very important because to get the most out the improved variety, most of the improved varieties are given in a package (i.e. the number of seeds, the amount of fertilizer to apply, and the space between the plants).

With respect to integrated soil management, both organic and inorganic fertilizer should be used to reduce the possible harmful effect excessive use of inorganic fertilizer may have on the biodiversity. Also other practices such as no-tillage, water harvesting, growing of cover crops like legumes, and mulching should

be encouraged. Then there should be a well functioning market for both agricultural inputs and products, and good roads. Well functioning markets would allow farmers to get access to the various seeds on time and to sell the produce in the market, which also encourages farmers to adopt the improved varieties. To reduce over reliance on the rainfall, there should be some type of irrigation systems. The provision of irrigation will also go a long way to reduce the risks associated with crop loss as a result of varying and uncertain rainfall levels. Finally, there should be a well functioning financial system to enable the farmers access credit to the needed inputs.

The main argument for the comprehensive approach is that all of these aspects of agricultural production should occur simultaneously or at least in a coordinated fashion because the absence of any can ruin the effort put in other aspects. For instance, if agronomists are able to breed the improved varieties and the farmers are unable to afford complementary inputs like fertilizer, due to high cost caused by bad roads or no market for inputs, the yield from the improved variety will be lower and that will adversely affect the adoption of that technology. In the same vein, if the soil is poor in nutrients, it will affect crop yields and the adoption of new technologies. Most of the cooperation between International agricultural research centers, national agricultural research centers, donor agencies, and philanthropists has generally been fashioned in a comprehensive approach. For instance, the Rockefeller foundation has awarded some scholarships to African students to pursue Masters and PhD degrees in Agricultural science in various Universities. Also International Agricultural research systems under CGIAR have worked closely with

national agricultural research centers in breeding improved crop varieties. But all the facets of this comprehensive approach (e.g. improved variety, soil fertility, adequate rainfall or irrigation, and well functioning institutions) have not been present at all time.

A report by Internal Evaluation Group of the World Bank (2007) indicated that the Bank have not had the desired results with respect to agricultural development in Africa because the Banks strategies and policies have not been comprehensive and coordinated enough. In particular, the report noted that because of the complex nature of the problems faced in agricultural productivity in Africa, the solutions will require coordinated interventions across a range of activities both in the agricultural sector and other relevant related sectors like the service sector. The report in particular states that if improved seeds, water, infrastructure, and credit extension, among other measures are made available simultaneously or in optimal sequence, rapid growth in agricultural income is achievable in Africa (World Bank, 2007).

The World Bank report (World Bank, 2008) also indicated that the new approach to agricultural development should meet some preconditions and the strategies being comprehensive and environmentally sustainable. The preconditions are political and macroeconomic stability, without which any agricultural agenda will be difficult to implement.

4.4.2 Focused Approach

The proponents of focused approach to transforming Africa's agriculture argue that Africa may not have the necessary resources to pursue the comprehensive approach and also because of the complementary nature of the various constraints to agricultural productivity in Africa, it is not necessary solving all the constraints simultaneously. They propose that, contrary to the comprehensive approach, Africa should concentrate on breeding a couple of crops. Also they argue that because of the interrelated nature of the constraints, Africa should concentrate on eliminating the constraints that are more binding.

It is also argued that since the earlier Green Revolution was technology led and institutionally supported, Africa can use similar method, and when they are successful in improving yields, institutional reforms will follow as a result. For instance, Otsuka and Kijima (2010) note that the development of high yielding rice and wheat by International Rice Research Institute (IRRI), and the International Center for the Improvement of Maize and Wheat (CIMMYT) subsequently induced public expenditure on irrigation, credit programs, national research and extension services because of the increased return on those investments caused by the high yields of the MVs. They also note that markets for both inputs and outputs subsequently emerged because of the profitable opportunities created by the modern varieties.

Otsuka and Kijima (2010) propose that Africa should concentrate on human capacity building, research and irrigation. They also propose that Africa should use

rice as the main crop that spur in the Green revolution in Africa because the body of knowledge is already available.

It is a bit difficult to assume that as soon as there is increase in crop yield, public investment in other complimentary areas like irrigation, markets and infrastructure will increase subsequently. In fact in the 1970s, the international prices for most of the African cash crops were favorable, but one did not see any massive increase investments in infrastructure. If African leaders are committed to improving agricultural productivity but lack resources for a comprehensive approach, then one will expect that an increase in crop yield may subsequent result in increase public spending in other areas.

Clearly the comprehensive approach would be the ideal solution to Africa's agriculture difficulties, but due to lack of adequate resources to implement the comprehensive approach, African countries may have no option other than going with the focused approach. The proponents of the New Green Revolution for Africa may have anticipated the difficulty of implementing the comprehensive approach in all countries in Africa. Rather the new Green Revolution will be implemented in phases starting with countries having basic rural infrastructure, and then spreading to other African countries. This is in some sense having features of both the focused and comprehensive approaches to agriculture.

4.4.3 Case Study: The New Green Revolution for Africa

As president of the Rockefeller Foundation for six years (1998-2004), Gordon Conway had the institutional and financial power of one of the world's largest philanthropic organizations behind him. The result was that the New Green Revolution in Africa finally got off the ground in 1999. After its official launch, the Alliance for a Green Revolution in Africa (AGRA) was established by the Rockefeller Foundation and Bill and Melinda Gates Foundation in 2006. AGRA was established as a public charity with the aim of using agriculture to reduce hunger and poverty in Africa. AGRA intends to do so by increasing the productivity and profitability of small-scale farmers through technological, policy and institutional innovations that are environmentally and economically sustainable. The Program for a Green Revolution in Africa (ProGRA), a supporting organization for AGRA was also established to implement the initiatives under the auspices of AGRA.

The real question is whether this new Green Revolution for Africa will be different from the earlier one. In other words, how will this new Green revolution be able to increase the small scale African peasant farmers yield and income, and at the same time be gentle on fresh water supplies, crop diversity and soil health, that all suffered during earlier Green Revolution? Conway indicated that the success of this new revolution will depend on four sub-revolutions: 1) Agroeconomists working closely with farmers to identify obstacles and opportunities; 2) the use of existing resources; 3) integrating the African farmer into the global market and ensuring that the farmers receives the necessary benefit; 4) management of continuous revolution of science and technology (Conway, 1997). These strategies have generally been

adopted by AGRA in its strategies. This is quite different from the one-size-fits all policy adopted by the earlier researchers in modernizing African agriculture. AGRA envisages a new strategy that will involve "disseminating many crop varieties that will thrive in diverse conditions; improving soil health through integrated soil fertility management; and developing technologies that maximize the use of rainwater and deliver small-scale irrigation" (AGRA, 2008). The new strategy encompasses both the focused approach and the comprehensive approach in the sense that it will concentrate on only the 4 countries at first but the four programs are comprehensive in nature and will be pursued concurrently.

AGRA's integrated strategy is made up of three portfolios and four programs. The first portfolio will concentrate on four countries – Ghana, Mali, Mozambique and Tanzania- with high potential "breadbasket", in terms of large concentration of small-scale farmers, relatively good soil and basic infrastructure. It is believed that increased access to improved seeds, soil and water management has the potential to significantly and sustainably increase farmers' production of key staple food crops. AGRA expects to devote about 40 percent of its resources to this portfolio and evaluate it for a possible scale up in 2012. In portfolio two, AGRA will be preparing the grounds for agricultural transformations in nine additional countries. This will involve the strengthening of smallholder productivity, develop staple crop markets and improve market access. The number of countries is expected to increase to 13 in 2013. The third and last portfolio will coordinate regional initiatives and advocacy to establish a supportive environment either through developing policies or raising

funds for rural roads and power lines. AGRA will allocate 13% of its resources to this portfolio.

The four programs of AGRA-seeds, soil health, market access, and policy and partnerships-are integrated in all three portfolios of AGRA. In addition to these four programs, AGRA's resource mobilization strategy involves both activating the traditional sources of bilateral and multilateral funding and tapping into previously untapped resources within Africa. The seeds program will involve funding agro-ecology based breeding by national and local research programs, coordination with the Consultative Group on International Agricultural Research (CGIAR) system to disseminate existing improved seed varieties through supporting the development of seed retailers, and partnering with African Universities to train more African agricultural scientists. The seed program will also call for AGRA to advocate for the seeds regulatory framework to make the seeds affordable to smallholder farmers.

The Soil Health Program will focus on the dissemination of locally adapted and environmentally friendly soil fertility practices including the use of farm manure, grain legumes, water harvest, conservation agriculture and agro-forestry, and water management. It will also involve the use of some inorganic fertilizer but the focus is on other locally adaptable environmentally friendly soil management systems. The African Soil Information system, which is a joint initiative of AGRA, the CGIAR's International center for Tropical Agriculture, and Columbia University, use data collected on African soils to improve the way the soils are evaluated, monitored and managed.

For the Market Access Program, AGRA will engage in activities like creation of rural market places and commodity exchange which reduce transaction cost. AGRA will also support programs that will add value to farmers' crops like small milling or food processing operations. With regard to Policy and Partnerships Program, AGRA will engage national governments and donors to establish an enabling environment to pave the way for a Green Revolution in Africa. Some of the policies will include advocating or lobbying for seeds, fertilizers and market policies at national and regional levels, and building national policy hubs to develop policies paving the way for Green Revolution.

Thus the new Green revolution in Africa recognizes the difference in challenges faced in African Agriculture (like diverse agro-ecological conditions and small-scale nature of the farms), and tries to fashion a program that will thrive in the African case, and at the same time trying to minimize the adverse effect the earlier revolution had on the environment in Asia and Latin America. Many researchers have had doubts as to whether this new green revolution for Africa will work. Their pessimism stem from the fact that since this new Green Revolution is being pushed by the same players like the Rockefeller Foundation, who initiated the earlier Revolution, this is more or else like an old wine in a new bottle. And since the earlier Green revolution did not work for Africa, this new Green Revolution is also likely to fail. It is also argued in some quarters that this New Green revolution is another form of neocolonialism (Dano, 2007). Whether this new revolution will work or not will depend on how committed the NARCs, IARs, financial institutions and donors are and whether African farmers will be actively involved in the development of the

appropriate crop varieties. The African farmer will only adopt the new technology if she believes that the new technology package will reduce the risk of crop of crop failure. So not only it is important to make the technology package available to the farmers, but the farmers should be involved in putting together the package and also making them affordable. For instance, farmers are supposed to work closely with researchers in breeding improved crop varieties and also offering inputs in breeding newer versions of already available improved varieties. Also it is important that all the four programs of AGRA (seeds, soil health, market access, and policy and partnerships) are provided in a coordinated fashion. For instance, it would not do much good to the farmer if she is supplied with a high yielding variety when there is no available market to sell the surplus or no means of processing the surplus created by the adoption of the new yield. It will only result in high post harvest losses.

Because tropical developing countries like Brazil has encountered and been able to overcome similar agricultural challenges faced by most African countries, it has been suggested that African countries can learn a lot from them, in developing its agricultural productivity. The prospect of south-south cooperation in agricultural productivity is examined below.

4.5 South-South Cooperation as a possible boost to Africa's Agricultural Productivity

As mentioned above, there are new ideas of how Africa should proceed in order to increase its agricultural productivity. It has been argued that South-South cooperation has a better prospect of transforming Africa's agriculture than the current relationship between various International agricultural research institutions and national agricultural research centers.

South-South cooperation has to do with the fact that other developing countries that have been able to transform their agricultural productivity should take a central role in transforming Africa's agricultural. This proposition is based on the premise that since developing countries may have similar climatic conditions (e.g. tropical climate) and also some have been able to get around most obstacles to agricultural productivity (e.g. low nutrient soil, varying rainfall pattern) that has plagued African agriculture, they will be in the better position to help Africa improve its agricultural productivity. In this section, I study how Brazil was able to transform its agricultural productivity and how they can play a key role in transforming agricultural productivity of Africa.

South-South cooperation can be an important means by which African countries can adapt some of the best agricultural technology and practices that have worked in countries with similar agroecological conditions. This cooperation can range from working together on common challenges in agricultural productivity, adaptation to climatic change, water conservation, to rural development and poverty reduction. Even though the earlier Green Revolution of one size fits all technological package may not have worked for Africa, there are a lot that Africa may learn from the earlier Green Revolution in Asia and Latin America, especially the roles played by agro-industries and marketing sectors. One benefit from South-South cooperation is that all of the programs that AGRA intends to rollout in Africa have been applied in one form or another in tropical developing countries. For instance, Brazil has been able to transform its agricultural sector through the development of high yielding crops using soil conservation practices like less to no tillage. The cooperation

between Africa and other developing countries have been ongoing and some successes have been chalked up as a result.

For instance Bangladesh's innovation in micro credit has been applied with some degree of success in many African countries. The Hunger Project's Microfinance program established in 1999 has since grown its loan portfolio to approximately US$2.4 million across Benin, Burkina Faso, Ethiopia, Ghana, Malawi, Mozambique, Senegal and Uganda.[44] With respect to agricultural cooperation between African countries on one hand and other developing countries on the other, a clear success has been the introduction of robust high yielding rice called the New Rice for Africa (NERICA). The introduction of NERICA is a manifestation of a remarkable cooperation between Africa and Asia. As already indicated, the NERICA is a hybrid that combines the robust nature of African rice and high yielding Asian rice traits. The NERICA is reported to yield up to 50% more grain than the traditional African varieties, and even quadruple its yield when fertilizer is used. The development of NERICA shows, among other things, two main things: First it exemplifies the importance of involving farmers in identifying the problem and then participating in developing the necessary technology. The successful development of the NERICA, is due in part to farmers providing valuable feedback to the scientist, after the farmers have grew several varieties. The scientists were able to learn the traits valued by the farmers and then incorporate them into the development of NERICA. Second, it shows the potential success of South-South

[44] Accessed on 09/27/2011: http://www.thp.org/what_we_do/key_initiatives/microfinance/overview?gclid=CO-pkOvIxKsCFSE95QodYCUO4w).

cooperation.[45] Viet Nam also has some cooperation with some African countries, including an agricultural cooperation with Mozambique.

Despite these successes, there is no developing country like Brazil that has the means and commitment to transfer and share agricultural technology with African countries. The Brazilian Agricultural Research Corporation (EMBRAPA), which is linked to the Brazilian Ministry of Agriculture, is in charge of the agricultural research cooperation between Brazil and African countries. EMBRAPA opened an African regional office in Accra, Ghana, in 2006 to oversee its activities in Africa. As of 2007, EMBRAPA had agreements with over 23 African countries, which represent about 60 percent of total international collaboration that EMBRAPA have with other countries (Galerani and Bragantini, 2007). Brazil's technical cooperation in Africa has focused on the transfer of skills, capacity building, empowerment of local workers, and projects adapted to the reality of the countries in question. What makes this collaboration promising is that EMBRAPA has the means to transform ones agricultural system, like it did in Brazil, and also the commitment to do it, by establishing a regional office in Africa.

4.5.1 Case Study: The Agricultural Transformation of Brazil

Before the1970s, Brazil's predominant agricultural commodities were coffee and sugarcane. The First World War and the Brazilian Revolution in 1930 led to intense cultivation of other crops other than coffee and sugarcane, though

[45] The FAO awarded the World Food Prize in 2004 to Dr Monty Jones (popularly called the father of NERICA) for the role he played in developing NERICA at AfricaRice (formerly called West Africa Rice Development Association, WARDA), which is a member of CGIAR.

agricultural holdings were mostly organized on small scale basis. Products like oranges, corn and other foodstuffs got support from the federal government, under the policy of import substitution (Lopes, 2010). It was only in the 1960s that attempts were first made to modernize agriculture with the establishment of the National Rural Credit Program in 1965, this organization was given the responsibility of providing finance to famers to buy modern inputs and equipment.

Agricultural production before the 1970s was also concentrated in the temperate South/Southeast part of Brazil, and crop yields were low. This resulted in food supply crisis and high rural poverty levels. There was also no specific knowledge about tropical agriculture since agricultural production mostly took place in the southern temperate part of the country. Another problem with Brazil's agricultural sector before the 1970s was an institutional void (with respect to agricultural research, education, and governmental agencies) and lack of improved infrastructure (Ministry of Agriculture, Livestock and Food Supply, 2010).

In the 1970s, the federal government created a Rural Insurance Program (PROAGRO), Embrapa, and the Enterprise for Technical Assistance and Rural Extension (Embrater). In addition many state governments created their own agricultural research organizations during this period. These actions undertaken by both the federal and the state governments, and their continual support for the agricultural sector since, have resulted in a major evolution of Brazilian agricultural production after the 1970s. As already indicated, agricultural production used to take

place mostly in a small southern part of the country. Now total land area cultivated has expanded throughout the Southeast portion of the country.

Within three decades, Brazil was able to transform itself from a food importer to one of the world's great breadbaskets. It is also the first country, and only tropical country, to catch up with the traditional "big five" grain exporters (the USA, Canada, Australia, Argentina, and the European Union). Between 1996 and 2006, the value of Brazil's crops increased by about 365%, from 23 billion reais ($23 billion) to 108 billion reais (The Economist, 08/26/2010). Its beef exports also increased tenfold in a decade. In 1994, Brazil's soybean production accounted for a third of the world exports, second only to the USA. In 2008, Brazil exported more than 1500 types of agricultural products to foreign markets. It is now the world largest exporter of poultry, sugar cane, orange juice, coffee, beef, and soybeans (SPA/MAPA-Agricultura Brasileira em Numeros). Table 4.1 lists some of the products that Brazil is a major producer of and exporter. Figure 4.1 also shows that the real price index of staple food has been declining steadily from a 1974 high of 1 to about 0.024 in 2000. This indicates how agricultural production of staple food has increased steadily.

What is even more astonishing about Brazil's agricultural production is how it has been able to achieve this success. Brazil was able to transform its agricultural sector, not through subsidies and protection of farmers, but through advanced technology and open trade. Even though Brazil has the largest spare farmland in the world, sustainability in agricultural production has been its focus. Since 1996, the area under cultivation in Brazil has increased by about a third, and this has not

happened in the Amazon rainforest but in the savanna lands of *cerrado*. The *cerrado* consists of 200 million hectares of tropical savanna which, prior to the 1970s, was thinly populated and only used for extensive cattle grazing. The transformation of the *cerrado* into a vibrant agricultural region is one of the major achievements of Embrapa. Today, the *cerrado* accounts for about 70 percent of Brazil's total farm output (The Economist, 08/26/2010). The *Cerrado* region was transformed by Embrapa by first reducing the levels of acidity in the soils through liming.[46] Also Embrapa bred varieties of rhizobium, a bacterium that helps fix nitrogen in legumes and hence reduces the need for chemical fertilizer. Second, through cross breeding, Embrapa used a grass called *brachiaria*, from Africa, to create a variety called *braquiarinha*, which produces about 20-25 tonnes of grass feed per hectare, far more than what the local grass could have produced. The third and most important thing Embrapa did was to turn soybean into a tropical crop through cross breeding. Soybeans originated from north-east China, a temperate region. Brazil also has been importing a genetically modified soya seeds, and is now the world's second largest grower of genetically modified soya after the USA. Embrapa also created a new variety of soya, which is more resistant to acidic soils.

Finally Embrapa pioneered and encouraged new operational farm techniques. These techniques include "no-tillage" agriculture, where the soil is not ploughed and crops are harvested not at the ground level, but rather cut high on the stalk. This puts less stress on the soil. Also monoculture was replaced with what is called forest,

[46] Liming to improve soil quality is a process of applying liming materials, like calcium, magnesium carbonates, oxides, and hydroxides to the soil to reduce its acidity. In the Brazilian case, pulverized limestone was applied to the soil.

agriculture and livestock integration, where the fields are used alternatively for crops and livestock but threads of trees are also planted in between the fields for cattle foraging. Thus the *cerrado* region was transformed by Embrapa through various cutting-edge technology ranging from liming of the soil to lessen its acidity, nitrogen fixation, creation of acid resistant soybeans, to cross breeding.

4.5.2 The Role Played by EMBRAPA in Transforming Brazil's Agricultural Productivity

The Brazilian Agricultural Research Corporation (Embrapa), a semiautonomous federal agency was established in 1973 and administered by the Ministry of Agriculture, Livestock and Supply. Embrapa is the largest component of the National System for Agricultural Research and Innovation (SNPA), and the largest agricultural R&D agency in Latin America, based on both the number of employees and expenditure.[47] For instance, in 2007, the agency had 8,695 employees, with 2,020 scientists and 1,580 of them with doctoral degrees. The Embrapa working budget was US$1 billion for 2009. Embrapa has been able to build its research capacity in the past four decades. For instance, while the number of scientist with PhDs and Master of Science (MSc) degrees increased from 15 and 133 in 1974 to 1580 and 596, respectively, in 2007, the number of employees with only Bachelor of Science (BSc) degrees, however, decreased from 724 to 31 over the same period (Brazilian Ministry of Agriculture, Livestock and Supply Report, 2010). Embrapa operates forty-two research centers in Brazil, three virtual laboratories

[47] The SNPA is a two tier system of federal-and state based agencies responsible for organizing, coordinating and implementing research, with the objective of improving agricultural productivity and development, sustainable use and preservation of natural resources. The components of SNPA are State Research Institutes, universities and Embrapa.

abroad (in the USA, South Korea, and the Netherlands), and three technology transfer centers in Ghana, Venezuela, and Panama. The purpose of the virtual laboratories (Labex) abroad is for cooperation in cutting-edge agricultural R&D.

4.5.3 How Can Brazil Help Africa?

There has always been the concern as to whether Brazil's agricultural technology can be transferred to Africa. This is a very legitimate concern because the pioneers of the earlier Green Revolution attempted to implement similar technologies that have worked well in Asia, but not in Africa. As already indicated, technology in general, and agricultural technology in particular can be ecologically specific and hence be difficult to transfer across different ecological zones. But Brazil has some similarities with most African countries with respect to climate, soils, Biomes, and farming systems.[48]

Most of Brazil is in the tropics and Brazilian researchers are familiar with the challenges that come with tropical agriculture, like poor soil nutrients. Brazil has been able to overcome these challenges, which makes it a good candidate to succeed in Africa with respect to transferring and adapting agricultural technology. The soils of the *cerrado* region which now account for about 70 percent of the agricultural production in Brazil, is very similar to most of the grasslands in Africa. In fact, as Sanchez (2001) indicated, many of the soils of subhumid tropical Africa, especially in East Africa, is similar to that of c*errado*, but while in the case of *cerrado*, lime was needed to reduce the soil acidity, in the case of East Africa, the soil is not

[48] Biomes is basically similar climatic conditions, such as communities of plants, animals, and soil organisms. It is often referred to as ecosystems.

aluminum toxic and therefore liming is not necessary. The other difference is that the *cerrado* receives relatively more rainfall than most of the African grasslands. It is clear that the challenges with respect to *cerrado* soils will be similar, if not worse, to that of most of the grasslands in Africa, so one will anticipate that the technology that was used to transform this grassland into a breadbasket can be applied in Africa, with the necessary institutional framework.

As discussed above, the *Brachiaria*, used to create a variety called *braquiarinha*, which produces about 20-25 tonnes of grass feed per hectare, far more than what the local grass can produce originated from Africa, and the *nelore* cattle herd came from India. It is quite possible that the technology that was used to transform this grass, *Brachiaria*, can easily be applied in Africa since the grass originated from there.

Embrapa also has expertise and research centers for most of the tropical staple crops. One of the reasons cited as to why some of the agricultural technology from the temperate regions may not work in the tropical region is that they have different staple crops and hence the focus of their research is different. This is even more important with respect to agricultural biotechnology. As Cammandeur (1997) indicated, with the exception of corn, there was no temperate country research on most of the tropical African crops like banana, cassava, sweet potatoes, millet, and sorghum. There has however been some research on crops like sorghum and cassava,

undertaken by CGIAR under its network of international agricultural research.[49] This indicates that the research focus of most of the temperate agriculture is on crops other than these tropical staple crops. Brazil however provides some hope in this regard. Brazil has research centers for cassava and sorghum and has made some huge strides in these tropical staples.

Brazil already had diplomatic relations with many African countries, especially the Portuguese speaking African countries like Angola and Cape Verde, but a major step was taken in transferring agricultural technology in Africa when the Embrapa African regional office was opened in 2006 in Accra, Ghana.

What one can see from the Brazilian experience was a multifaceted approach involving the training of manpower, the breeding of improved crop varieties, soil management and active participation of both the federal and states governors in the provision of the required institutions, safety nets (through insurance programs) and infrastructure. As an article published in *The Economist* (Accessed August 26th, 2010) emphasized, Embrapa's methodology is a "system approach", with all the interventions working together. This means that whether the technology transfer in Africa will work or not will be due in part to institutional framework that will be put in place by the various African governments. These institutional frameworks may include the development of the rural sector, with the provision of roads, and market. Also the National agricultural institutions of various African countries will have to

[49] For instance the International Institute of Tropical Agriculture, IITA, and the International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, have conducted research on cassava and sorghum respectively.

be strengthened to sustain and manage any technology that may be imported from other southern countries.

4.6 Government Led Approach

The general consensus has been that the earlier Green Revolution was technology driven, but there were important public interventions in the area of development of rural infrastructure (like building of feeder roads, electricity supply and irrigation), institutional intervention – subsidies for inputs, provision of credit facilities, and in some cases the practice of price support system. I argue that Africa's main obstacle in developing its agricultural productivity is not so much about the approach (i.e. either comprehensive approach or focused approach). What Africa needs are strong leaders who will see agriculture productivity as the key sector that will reduce poverty that has engulfed the continent and devote the necessary resources and commitment to its development. Whichever approach Africa decides to pursue to develop its agricultural sector, without its leaders taking the central role in providing the necessary infrastructure, and enabling institutional framework, that approach is bound to fail.

The main trend of the Green Revolution in Asia (in particular in India, Philippines and Indonesia) were driven by technology (i.e. high yielding seeds, fertilizer, and irrigation). But the national leaders played a key role in making sure this package was affordable to the farmers, and created the environment to reduce the risk of adopting this new technology package by the farmers. As Djurfeldt et al. (2005), reports, the governments of these three countries, India, Philippines and

Indonesia, in their effort to make this new technology package affordable, subsidized the main agricultural inputs (i.e. fertilizer and the improved seeds) and also provided credit facilities to farmers through rural banks and cooperative associations, especially in India. There was also huge investment in human capital in the form of offering scholarship to the indigenes to obtain advanced degrees in agricultural agronomy and economics in developed countries like the USA. Also more importantly there was huge public investment in the provision of physical infrastructure in at least the rural regions better potential in agricultural productivity. African leaders will have to play a similar role in developing its agricultural productivity, albeit with some variations.

With respect to public spending on agriculture, road construction is very important in the transportation of both inputs and outputs. As already indicated, sub-Saharan Africa is the region with the lowest consumption of fertilizer in part because of the high cost of fertilizer caused by high transportation cost. Insufficient use of fertilizer has been given as one reason why the earlier Green Revolution did not reach Africa as expected. In a survey among traders in Benin, Madagascar, and Malawi, it was found that transport cost accounts for about 50 - 60 percent of the total marketing cost of agricultural products (Fafchamps et al., 2005). Therefore improving road networks in rural areas in Africa in particular, will reduce both the cost of agricultural inputs and outputs, and hence their prices. As in cases like Punjab in India, African leaders can concentrate in providing at least feeder roads in areas having high agricultural productivity potential. Another important public expenditure on agriculture in Africa should be irrigation. Most African smallholder farmers

depend on rainfall as the main source of water for their crops. The problem with rainfall is that the amount is erratic and is not a reliable source of water. Rainfall variability in Africa is about twice that of the temperate regions (World Bank, 2004). Droughts in the region are also more frequent than any other region in the world (World Bank, 2007). Lack of access to water reduces the incentive to use fertilizer since the use of fertilizer without sufficient water results in crop loss. Governments providing irrigation will go a long way in reducing water variability, reducing the risk of crop loss, and hence increase the adoption of new modern varieties.

Another essential public investment in the agricultural sector is the development of human capital and R&D expenditure. Training of agricultural scientists and extension officers is very important in the development of improved modern varieties of crops and the dissemination of those crops to farmers. The development of human capital in the area of agriculture is even more important than it was during the earlier Green Revolution where some work had already been done for the main crops like Rice. Also because of the similar farming system (e.g. irrigation farming system), these bred improved varieties were easily exported to other countries. For instance, the International Rice Research Institute (IRRI) developed the semi dwarf variety, borrowing from rice breeding work done in China, Japan, and Taiwan. India jumpstarted its Green Revolution by importing improved varieties from the IRRI. In the case of Africa, most of the main food stuff like cassava, maize, have not benefited much already existing breeding work on them. And even if these improved varieties for the main African food crops exist, it would not be easily adapted in different African countries because of the diverse agro-

ecological zones and different farming systems. This makes it more necessary for African leaders to develop their national agricultural research centers in order for them to undertake meaningful research. Local researchers will be better informed on the constraints that local crops face, which will form the basis for the development of new modern varieties. If African countries are to take a leading role in their agricultural development agenda, then they should take a key role in both the breeding and dissemination of improved modern crop varieties. Embrapa in Brazil played a key role in transforming agricultural productivity there. Also Indonesia, academic scholars in economics and agricultural science mostly trained in developed countries (popularly called the 'Berkeley Mafias') and politicians worked hand in hand in developing the country's agricultural productivity (Djurfeldt et al., 2005).

African leaders should also create the enabling investment climate for private sector to invest in the agricultural sector through developments of finance and dissemination of agricultural inputs. Sub-Saharan Africa is one of the regions where farmers have a high unmet demand for credit (World Bank, 2005). Before structural adjustment program, some of these credits were met by the government through provision of subsidies, and distribution of inputs, like seeds and fertilizer, on credit. This resulted in huge government budget deficit because of large number of defaulters. The advent of structural adjustment programs in the 1980s curtailed those facilities, and hence worsening the credit plight of the farmers. Unlike in Bangladesh, where the private sector was ready to perform the various functions, like the provision of credit to the farmers, which were undertaking by the government, the private banks in most of the African countries are unwilling to offer credit to

farmers because of the high risk of default. African leaders can help by creating the enabling environment for the establishment of microfinance institutions like rural banks, where they can lend to cooperative farmers. Lending to cooperative farmers associations spread the liability and hence members encouraging each other to repay the loans. This will reduce the number of defaulters.

Finally one important problem confronting African farmers that have not been discussed much in the literature is the post harvest losses. This normally occurs because of lack of available closer markets for perishable crops like tomatoes, which go bad often few days after they are harvested. So during bumper harvest, in order to reduce this post harvest losses, farmers are forced to sell their products at lower prices. In earlier Green revolution, countries like India instated price support system to reduce this variability in the prices of farm products (Djurfeldt et al., 2005). African leaders can also help by the provision storage facilities in the main agricultural producing towns.

Toenniessen et al., 2008, discuss the important role policy makers and donors played in the earlier Green Revolution in Asia and Latin America with respect to the provision of physical infrastructure and provision of financial support. In particular, they indicated that, the governments in Asia and donor agencies manipulated markets (for both inputs and outputs) to promote the adoption of high yielding technologies in the 1960s and 1970s. These interventions undertaken by various governments in Asia went a long way in reducing the risk of adopting the new technology (like new high yielding crops and fertilizer), and hence increasing the rate of the technology adoption.

I believe that any of the strategies discussed above, focus approach, or comprehensive approach, has the potential to be successful, but that African leaders need to take a central role in any strategy. It is very clear the important role the federal and states governments of Brazil played, in providing insurance policies and infrastructure, to spur the transformation of their agricultural productivity.

It looks like the African leaders may be have finally realized the important role they play individually and collectively to improve Africa's agricultural productivity as seen by the New Partnership for Africa's Development (NEPAD) initiative. What remains to be seen is whether all the boardroom talk will translate into action.

The Brazilian experience shows how important role state and public institutions played transforming its agricultural sector. The state was instrumental in training its human capita (specifically agricultural scientist), provision of rural infrastructure, provision of safety nets, in the area of micro finance and subsidies, to reduce the risk of adopting a new technology. African leaders will also have to provide similar services even in a South-South cooperation.

It is also important to point out that whether African leaders will have the incentive to put in place the necessary measures and policies that will ensure increase in agricultural productivity will in some part depend on the political economy of agricultural investment. As already indicated, McMillan and Masters (2000), argue that because of the average long gestation period of crops grown in the tropics, compared to that of the temperate region, tropical farmers incur higher sunk cost. McMillan and Masters argue further that once this large sunk cost is incurred,

leaders in the tropical impose high tax on farm income and products. Tropical farmers also knowing this will withhold investment in the first place. According to McMillan and Masters, the only way out of this low investment from tropical farmers for fear of higher taxes is for tropical leaders to be credible to the farmers that they will put in place measures for the farmers to maximize the return on their investment.

In a recent study by Bates and Block (2011), they argue and show that political competition actually gives African leaders incentive to put in place policies that will increase agricultural productivity. They suggest that in an era of lack of political competition, policies will be "urban biased", because the urban population constitute more organized interest group than their counterpart in the rural areas. The rural farmers are dispersed geographically and hence organizing cost is high. However, with electoral competition, politicians will have the incentive to bear the cost of political organization. With farmers constituting a greater proportion of the population in most African countries, political leaders will have no choice than to put in place policies that will not be detrimental to farmers, if they have any intention of retaining their political power. Bates and Block (2011) were able to show that electoral competition has actually resulted in policies that are favorable to farmers, which in turn resulted in modest increase in agricultural productivity in Africa. The good news is that political competition has been increasing steadily in Africa since early 1990's and hopefully African leaders will continue to have the incentive to put in place the necessary policies to increase agricultural productivity.

4.7 Conclusion

In this chapter, I set out to examine why the Green Revolution did not reach Africa in the same way it did for Asia and Latin America. I also looked at the various strategies that have been proposed to help Africa transform its agricultural productivity. I then conclude by proposing that the success of any strategy hinges on the central role Africa leaders will have to take, and the commitment they will have to exhibit in transforming their agricultural productivity.

The strategies propose are the focused approach and comprehensive approach. It is believed that since tropical developing countries may have encountered similar problems in their effort to transform their agricultural sector, African countries can learn a lot from them in improving their agricultural productivity. While the comprehensive approach believe that any agricultural strategy should involve the simultaneous pursuance of all aspects of agricultural productivity (crop breeding, soil management, provision of infrastructure, and enabling policies), the proponents of focus approach believe that inadequate resources may not allow for comprehensive form of strategy. Therefore, proponents of focus group propose that African countries should just concentrate on a crop, for instance rice, where a body of knowledge is already available, and when yield improves, public investment infrastructure will subsequently follow.

While I agree some aspects of all the strategies proposed, I argue that the success of any or a combination of them will depend on the important role played by African leaders. African leaders are supposed to maintain some level of

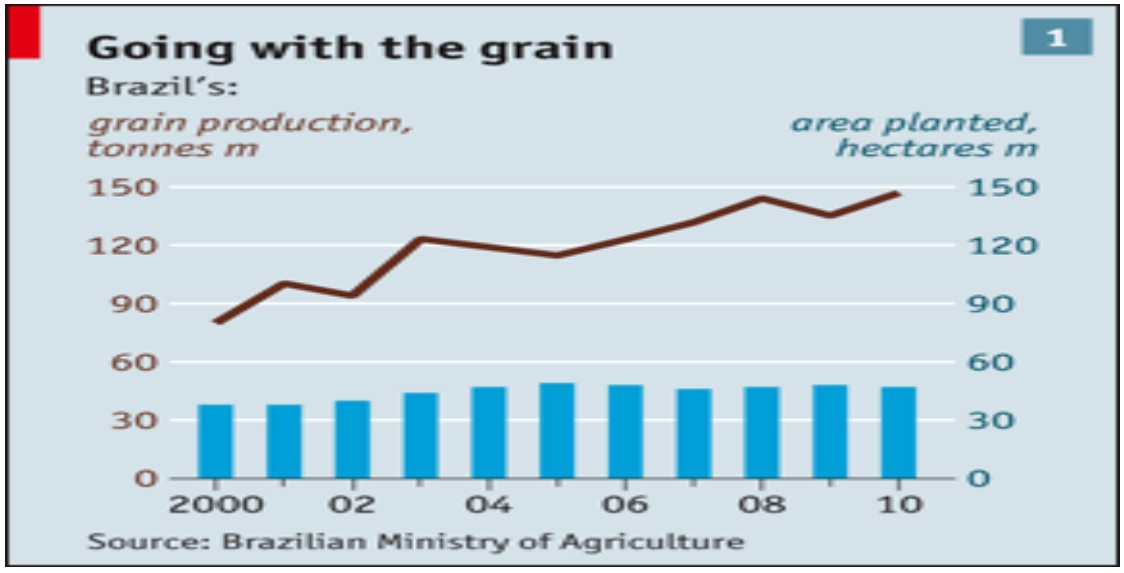
macroeconomic and political stability before any agricultural approach will have any chance of succeeding. Also any approach (i.e. focused or comprehensive) will need availability of physical infrastructure like roads and irrigation systems. Also Africa is supposed to sustain any growth in agricultural productivity, there should be home grown scientists who will always be available to bread improved crop varieties for farmers. African leaders will also be needed to create the necessary environment enable private investors to invest in the agricultural sector. I believe that a good strategy may encompass a dose of comprehensive approach, focused approach, in a coordinated fashion with good leadership from African leaders.

Table 4.1: Brazil's World Food Ranking

Product	Production	Exports
Sugar	1st	1st
Orange Juice	1st	1st
Coffee	1st	1st
Beef	2nd	1st
Soybean	2nd	1st
Tobacco	3rd	1st
Broiler	3rd	2nd
Corn	3rd	4th

Source: SPA/MAPA (Agricultura Brasileira em Numeros)

Figure 4.1: Grain Production and area planted



CHAPTER 5

Summary of Findings and Conclusions

This study sets out to examine why African countries attract less FDI, and also why they have not been able experience the agricultural transformation experienced by its Asian and Latin America counterparts. Finally the study highlights the pivotal role African leaders will have to play in any solution to Africa's abysmal agricultural productivity.

I find that that infrastructural quality, good investment climate and government stability are positively correlated with FDI. Also I find that while natural resources (measured here by fuel exports) are positively associated with FDI flow to SSA, it is negatively associated with FDI flow to non-SSA region. Finally, below certain level, GDP per capita and corruption are positively associated with FDI flow to SSA.

In chapter 3, we find broad and consistent support for the idea that fertilizer usage, telephones, and rainfall have a positive effect on agricultural productivity. This is true both inside and outside of Africa. We find evidence that the effect of irrigation, however, is different in tropical SSA. In our baseline sample, the coefficient on irrigation was only significant outside of Africa. In our alternative sample, the coefficient was positive in both but the quantitative impact of irrigation was much reduced in SSA. Using an alternative definition of tropicality, which increases the number of countries in our sample, we do find that government stability

is positively related to agricultural productivity, and that corruption is particularly harmful to productivity in SSA.

Chapter 4 shows that African leaders have a lot to learn from their counterparts in Asia and Latin America, if they want to boost their agricultural productivity. In particular they will have to play similar roles played by Asian leaders, during the earlier Green Revolution. They will have to improve rural infrastructure, make complementary inputs like fertilizer affordable, and provide some safety nets to reduce the risk of adoption of new technology. The good thing is that the political climate currently existing in most African countries, give the African leaders added incentive to put in place the necessary policies that will increase agricultural productivity.

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