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DEVELOPMENT STRATEGY AND GOVERNANCE DIVISION

January 2005

DSGD Discussion Paper No. 17

Achieving Regional Growth Dynamics in African Agriculture

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ACKNOWLEDGEMENTS

We would like to especially acknowledge Peter Hazell for providing guidance and editorial input, Liang You for sharing his DREAM analysis for East Africa, and an anonymous reviewer for sharing helpful comments and suggestions for improving the paper. Finally, we would like to thank Jeff Hill at USAID for his support and insistence that we investigate this very important subject.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURE

Tables

Figure

ABSTRACT

This study focuses on public investments and policy reforms for leveraging growth spillovers at the African regional level. A conceptual framework that is built on the endogenous growth theory and the new economic geography is presented first to gain a better understanding of the underlying theory and empirical evidence on regional integration and growth spillovers. In order to demonstrate the potential benefits from greater cross-border technology spillovers in Africa, as well as from trade liberalization and investment in infrastructure, results from ex-ante simulations using partial and general equilibrium models are then presented and discussed. Results indicate that sizeable regional spillover benefits can be obtained by permitting greater cross-border transfer and adoption of improved technologies, sometimes as large as three to four times the gain in direct benefits obtained within the innovating countries. This is especially true for commodities like mutton, groundnuts and sorghum. Moreover, reducing trade barriers between African countries in agriculture and non-agriculture can significantly increase intra-regional agricultural trade and raise economic growth rates. The simulations also demonstrate that improving transportation infrastructure generates the most encouraging results, increasing agricultural income by as much as 10%.

The findings in this study confirm that greater regional cooperation in agricultural research and development, harmonization of regulatory standards for technology adaptation, and harmonization and liberalization of trade systems within the region could play a crucial role in expanding opportunities for African farmers. Therefore, strengthening linkages among African countries through infrastructure, agricultural R&D, and expansion of intraregional trade can generate large spillovers and leverage regional growth.

ACHIEVING REGIONAL GROWTH DYNAMICS IN AFRICAN AGRICULTURE

Awudu Abdulai, Xinshen Diao and Michael Johnson [*]

I. INTRODUCTION

Although agricultural growth could yield substantial reductions in poverty and hunger in Africa, the small size and isolation of many African economies, their poor infrastructure development, fragile agro-ecologies, high dependency on rain-fed agriculture, and frequent susceptibility to droughts and tropical diseases, makes generating such growth especially challenging and resource intensive. Since the investment funds needed to overcome these challenges on a country by country basis are not likely to be nearly sufficient for the foreseeable future, we argue that more attention should be given by African policy makers and donors to investing in ways that can leverage growth dynamics at cross-country or sub-regional levels. More specifically, regional cooperation in agricultural research and development, harmonization of regulatory standards for technology release and adaptation, and harmonization and liberalization of trade systems in both input and output markets within the region, could play a crucial role in expanding opportunities for farmers and firms across the continent. Moreover, strengthening linkages between sub-Saharan African countries through infrastructure, agricultural research and development, and expansion of intraregional trade, can potentially generate large growth spillovers and enhance regional take-off.

This paper explores how coordinated policies and investment plans within sub-regions can be employed to capture positive cross-country externalities, and hence increase the impact of investments on Africa-wide trends. Particular attention is given to greater trade openness and coordinated investments in regional infrastructure and

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agricultural research. Regional spillovers are already known to arise in Africa. For example, in their study on Africa's growth tragedy, Easterly and Levine (1997) found that, *ceteris paribus*, an increase in the growth rate in one country by 1 percentage point over a decade could resulted in an increase in the growth rate in a neighboring country by 0.55 percentage points. The argument in this paper is that these spillover benefits could be strengthened through more focused and coordinated regional development strategies, and that countries generating the largest spillovers can serve as important growth poles for their surrounding regions.

Although beyond the scope of this paper, the effects of negative spillovers also deserves attention, especially in Africa where civil strife and political instability leads to negative economic consequences in neighboring countries. This occurs through the disruption of trade and input supply lines, heightened risk perceptions by potential investors, collateral damage in border areas, and diverted public resources to assist the influx of war refugees. The presence of such negative externalities only stresses the need for greater regional cooperation in dealing with, and preventing, internal political conflicts and insecurities, while also emphasizing how the occurrence of conflicts could be reduced over time as stronger political and economic ties are developed across countries through greater regional integration.

In order to gain a better understanding of the underlying theory and empirical evidence on the effects of regional integration and cross-border spillovers on economic growth, Chapters 2 and 3 first survey the literature around a conceptual framework that employs both endogenous growth theory and new geography modeling. To illustrate the potential benefits from greater cross-border spillovers in Africa, as well as from trade liberalization and investment in infrastructure, recent results from partial and general equilibrium models are presented and discussed in Chapter 4. While there is ample evidence of high economic returns, incentives associated with the provision of regional public goods remains a real challenge in Africa. Therefore, how African countries are organizing themselves to deal with these incentive problems is reviewed and discussed in Chapter 5. The last chapter presents conclusions and some policy implications.

II. A CONCEPTUAL AND THEORETICAL FRAMEWORK OF SPILLOVERS TO PROMOTE GROWTH

Spillovers are the transfers of economic benefits between firms in an industry or economy or between countries without compensating payment. In particular, knowledge spillovers—the external benefits from the creation of technological knowledge that accrue to parties other than the inventor—have a major effect on the extent of income convergence across countries.

In his description of spillovers, Griliches (1991) distinguishes between pecuniary and knowledge spillovers. According to him, when an upstream industry, through its research and development efforts, produces a higher quality good or a larger range of specialized goods which is then utilized by a downstream industry, a pecuniary externality can be said to have occurred if the upstream innovator is unable to appropriate all the surplus from this invention.

Knowledge spillovers are only said to be present when downstream users are able to reverse engineer the technology embodied in a newly developed product and use that knowledge to further their own innovative activities. Strong spillovers tend to favor convergence, while weak spillovers can result in divergence if the domestic rate of technological change varies across countries. The scope of knowledge spillovers is also important for income convergence among the developed and developing countries.

Endogenous Growth Theory and Spillovers

Knowledge spillovers are central in the growth models by Romer (1986, 1990), Barro (1990) and Lucas (1988). Their scope is also critical for the long-run distribution of incomes in the multi-country models of Grossman and Helpman (1991) and Aghion and Howitt (1992). Another area where spillovers have become important is the literature that assesses the importance of trade as a mechanism of international knowledge spillovers (Coe and Helpman 1995; Keller, 1998). Knowledge spillovers have also gained increasing significance in recent models of regional and urban

economics that seek to explain patterns of agglomeration and de-agglomeration (Krugman, 1991; Fujita et al, 1999; Keller, 2001).

The discussion that follows will consider not only trade, but also examine other channels for knowledge spillovers, as well as unidentified distance-related externalities. The model presented will be mainly descriptive in the sense that the inter-temporal consumption trade-off will not be investigated and, as such, no analysis of the determinants of resource allocation is undertaken. It is simply assumed that technology and preferences allow a maximizing agent to allocate positive amounts of resources to the dynamic sector of the economy. The analysis also focuses on the balanced growth equilibrium, which requires that the relative size of the dynamic sector and the level of consumption remain constant. These assumptions will enable us to examine the implications of regional integration and investment in regional public goods.

With these simplifying assumptions, consider the following set of equations (Bretchger, 2001):

$$\dot{K} = AZK_K^{\alpha} L_K^{1-\alpha} \tag{1}$$

$$K_K = K - K_C \tag{2}$$

$$L_K = L - L_C \tag{3}$$

$$Z = K^{\delta} \tag{4}$$

where A denotes a constant technology parameter; K is a resource that can be accumulated like physical capital, human capital, or technological knowledge; $\dot{K}$ represents the change of K in a short period of time; and L is a primary resource such as land or labor; K_K and L_K are the amount of K and L allocated to the production of K, while K_C and L_C are respectively the amounts of K and L allocated to the production of consumption goods, with α and 1-α representing the elasticities of output with respect to the inputs. Z is used to denote a public input such as research or public infrastructure as shown in equation (4), and $\delta \geq 0$ shows the intensity of the spillover effect from this public good. The equation can either be interpreted as a spillover relation or the provision of a public good that is financed through taxes.

The relation in equation (1) is considered as the dynamic sector of the economy, in which case the growth rate of the factor that can be accumulated determines the growth rate of the economy. Furthermore, a constant growth rate of the resource can be achieved by maintaining a constant share of the private resources allocated to this sector. This implies that a constant share of private inputs allocated to this sector results in a constant growth rate in output. In the endogenous growth model of Romer (1986), *K* and *Z* in equation (1), represent physical capital and knowledge, respectively, while in the model of Barro (1990), they respectively denote physical capital and infrastructure that is provided by the government.

The growth rate of *K* can easily be derived from equations (1), (2), (3) and (4) through differentiation and substitution to arrive at the following specification:

$$\theta_K = \frac{\dot{K}}{K} = A\left(\frac{L_K}{L}\right)^{1-\alpha} L^{1-\alpha}\left(\frac{K_K}{K}\right)^{\alpha} K^{\delta+\alpha-1} \tag{5}$$

where θ_K is used to denote growth rate of output. Equation (5) indicates that for values of $\delta+\alpha<1$ and constant amount of *L*, the growth rate of *K* and therefore that of output goes to zero in the long run. This is consistent with the convergence model of Solow (1956) and Koopmans (1965), where $\delta=0$ and $\alpha<0$. In the above framework, sustained growth can be achieved with $\delta+\alpha\geq 1$; with $\delta+\alpha=1$ leading to balanced growth and $\delta+\alpha>1$ implying continuous and accelerated growth in the sense of Romer (1986). For balanced growth, the case of no growth in the primary resource, $\theta_L=0$, requires that $\delta+\alpha=1$. Under this condition, the long run growth rate of the economy can be obtained from equation (5) as:

$$\theta_K = A\left(\frac{L_K}{L}\right)^{1-\alpha} L^{1-\alpha}\left(\frac{K_K}{K}\right)^{\alpha} \tag{6}$$

To examine the impact of regional integration on economic growth, the growth rates under free trade can be compared with that of growth under autarky. As demonstrated in Dixit and Norman (1980), such a comparison can be done by analyzing the equilibrium conditions of a hypothetical "integrated regional economy". In line with

models of economic integration, the free movement of goods is assumed, resulting in factor price equalization under internationally identical and homothetic preferences. As pointed out by Grossman and Helpman (1991), Z in equations (1) and (4) needs to be considered as a regional public good such as research that leads to knowledge creation or infrastructure that enhances movement of goods and services. Thus, with Z as a regional public good, growth rates will be equal in all countries involved in the economic integration. Under these conditions, the impact of trade on growth can be derived from a comparison of the growth rates under free trade in the integrated regional economy and under autarky.

Generally, three cases of Z can be considered. First, Z is just a national public good available only in a particular area or country, in which case factor prices will not be equalized. Second, Z is a regional public good as mentioned earlier, which is available within a region or integrated economy. Third is the case where Z is a global public good that is available globally without barriers. Since we are interested in regional spillovers, we will focus on the second case where Z is a regional public good.

A closer look at equation (6) will reveal that regional integration can impact the long-run growth rate either through the size of the relevant economic area as captured by L or through the inter-sectoral allocation of resources given by the shares of the inputs used in the production of the output. To show how these two determinants influence the long run growth rate, it is assumed that the economic conditions are similar, implying that the economies in the region are similar. Although this assumption is made for expositional purposes, the underlying economic structures of African countries are mostly similar. To avoid changes in relative prices and induced resource reallocations from the consumption goods sector to the dynamic sector or vice versa, it is further assumed that each country is fully specialized in the production of a country-specific consumer good.

As indicated earlier, the conditions necessary for balanced growth without any growth in the primary resource, L is that $\delta + \alpha = 1$. This condition can easily be

employed in equation (5) to illustrate that the larger the amount of the primary resource, the higher the growth rate. That is.

$$\theta_K = \frac{\dot{K}}{K} = A\left(\frac{L_K}{L}\right)^{1-\alpha} L^{1-\alpha}\left(\frac{K_K}{K}\right)^{\alpha} \tag{7}$$

The scale effect, captured by $L^{1-\alpha}$ in equation (7) indicates that larger values of L lead to higher long run growth rates. It however needs to be mentioned that for this condition to hold, the primary resource that measures the scale of the economy must be capable of being used productively in the dynamic agricultural sector. This is a condition that requires that $1-\alpha > 0$. Hence, the two conditions necessary to achieve scale effects here are $\delta + \alpha = 1$ and $1-\alpha > 0$. An economic interpretation of the scale effect is that the larger the amount of the primary resource a region accumulates, the greater the quantity of output that can be produced.[1] In addition, an increased accumulation of the resource K increases the productivity of the primary resource, either through spillover effects or private effects, again fostering long run economic growth.

To examine the growth-enhancing effect of regional integration, consisting of m countries, equation (7) can be considered as the growth rate of each country under autarky. In a regionally integrated economy, the output produced by each country j, can be represented as

$$\dot{K}_j = A\left(\frac{L_{K,j}}{L_j}\right)^{1-\alpha} L_j^{1-\alpha}\left(\frac{K_{K,j}}{K_j}\right)^{\alpha} \left(Z_j\right)^{\delta} K_j^{\alpha} \tag{8}$$

where Z which represents regional public good Z_j holds for each country. Making use of the symmetry assumption that was included earlier, and taking equation (8) into consideration, the growth rate of the each country under regional integration can be expressed as:

$$\theta_K^{reg} = m^{\delta}\theta_K^{aut} \tag{9}$$

[1] Although the condition that $\delta + \alpha > 1$ (in which case the productivity of the input K must be large) could also be included, this is avoided to focus on a balanced growth path.

where θ_K^{reg} and θ_K^{aut} denote the growth rates of output under regional integration and autarky, respectively. Equation (9) indicates that the integrated regional economy grows at a rate that is by a factor $m^{\delta} \geq 1$ greater than the growth rate under autarky. The main reason for this difference is the fact that the integrated regional economy can effectively utilize the public good $Z_j = (mK)^{\delta}$. This suggest that the greater the spillover effects δ, and the larger the number of countries joining the integration, the stronger the growth enhancing effect of regional integration. It is significant to note that in many policy papers, number of consumers—considered as a proxy for the size of the market—is often used to measure the scale effects. In the present paper, the factor that is extensively used in production in the dynamic sector is used to measure the scale of the economy. The scale effect demonstrated above tends to show the importance of regional economic integration rather than autarky.

The preceding chapters laid out the concept of positive spillovers that can be generated through economic integration. However, the significant role of distance and geography in the distribution of spillovers has not been discussed. That is, while integration that enhances the creation of spillovers might foster long run economic growth, the question that arises is whether countries nearer to each other share spillover benefits than countries further apart. In other words, are there real advantages for nearby countries to benefit from spillovers from neighboring countries, or are spillovers generally available for anyone around the globe to grab? As emphasized by Krugman (1991), acknowledging the importance of spillovers and increasing returns requires renewed attention by economists to the issues of economic geography, as there may be geographic boundaries to information flows or knowledge spillovers. Although the cost of transmitting information may be invariant to distance, presumably the cost of transmitting knowledge rises with distance, suggesting that proximity and location matter.

The motivation to investigate the role of geographical distance in the scope of knowledge spillovers is therefore to show that neighboring countries in a region tend to

benefit more from positive externalities than those located at further distances. Similarly, neighboring countries are affected by negative externalities arising from civil wars in other countries. In the next chapter, we will extend the discussion presented on spillovers to cover the spatial dimension in the benefits of positive spillovers.

The Geographic Localization of Spillovers

Although there are various ways of capturing the spatial dimension in the generation of spillovers, a common approach employed in the economic geography literature to analyze the dynamics of regional growth and convergence is to model the variation of the productivity effects of research and development across countries, conditional on distance (see Keller, 2001). Productivity differences are usually measured empirically by applying the theory of total factor productivity (TFP). A first step in this direction is therefore to determine country level TFP. As suggested by Keller (2001), this can be specified as:

$$\ln P_{cit} = (\ln F_{cit} - \overline{\ln F_{it}}) - \overline{\alpha}_{cit}(\ln L_{cit} - \overline{\ln L_{it}}) - (1 - \overline{\alpha}_{cit})(\ln K_{cit} - \overline{\ln K_{it}}) \qquad (10)$$

where P_{cit} represents the total factor productivity level, F denotes value added, $\overline{\alpha}_{cit}$ is an average labor cost shares, and $c = 1, \cdots, C$ indexes a country, $i = 1, \cdots, I$ is an index for industry, and $t = 1, \cdots, T$ is the subscript for time. The variables K and L denote capital and labor, respectively. If we let $\overline{\ln F_{it}} = \frac{1}{C}\sum_C \ln F_{cit}$, then correspondingly, $\overline{\ln L_{it}} = \frac{1}{C}\sum_C \ln L_{cit}$ and $\overline{\ln K_{it}} = \frac{1}{C}\sum_C \ln K_{cit}$.

A variety of reasons can account for the impact of geographic factors on the magnitude of knowledge spillovers. For example, the trade and growth model suggested by Grossman and Helpman (1991) show that technology moves across country borders when intermediate goods embodying new knowledge are traded. Given that commodity trade entails transport costs that are increasing with geographic distance, it is acceptable to assume that it is easier to ship intermediate goods to nearby locations than to further distances. Thus, the scope of knowledge spillovers will be related to geographic distance.

As indicated earlier, cross-border spillovers in the economic geography literature is normally investigated by employing specifications that relate total factor productivity in an importing country both to domestic R&D and to foreign R&D, conditional on distance between the importing and exporting countries.[2] A commonly used empirical specification that captures this effect, as described in Keller (2001), can be expressed as:

$$\ln P_{cit} = \beta_{ci} + \beta_t + \lambda \ln\left[R_{cit} + \sum_{g \neq c} \gamma R_{git} e^{-\sigma D_{cg}} \right] + \mu_{cit} \qquad (11)$$

where $c = 1, \cdots, C$ indexes country, $i = 1, \cdots, I$ is an index for industry, and $t = 1, \cdots, T$ is the subscript for time. The variable P_{cit} is the total factor productivity level, R_{cit} is country c's research and development stock, and D_{cg} is the geographic distance between countries c and g. The role of geographic distance is captured by the parameter δ, normally referred to as the distance parameter. It is often identified from variation of the productivity effects of R&D in other countries conditional on bilateral distance, and therefore reveals whether there is a geographic dimension to international knowledge spillovers. If the term $R_{git} e^{-\sigma D_{cg}}$ is taken as country *c's* effective R&D from country *g,* positive estimates of δ will indicate that variation in productivity levels can be better explained by assuming that effective research and development from countries located more closely is larger than that of other countries located relatively far away. Thus, for positive values of γ, indicating that foreign research and development raises productivity, estimates of $\sigma > 0$ suggest that the benefits from foreign knowledge creation are declining with geographic distance. On the other hand, $\sigma < 0$ indicates that countries located further away benefit more from a given country's research and development than countries located near-by.

[2] A difficult problem confronted by the effort to test for spillover-localization is the difficulty of separating spillovers from correlations that may be due to a pre-existing pattern of geographic concentration of technologically related activities.

III. REVIEW OF EMPIRICAL EVIDENCE ON SPILLOVERS AND GROWTH

So far the conceptual framework reviewed supports the hypothesis that distance matters in the flow of positive spillovers across national borders. If that is the case, then countries that are closer together could benefit more from positive externalities arising from technological developments. The empirical evidence generally supports such a hypothesis.

Regional Integration

The empirical evidence on the role of regional integration and geographic distance, including agglomeration, on knowledge spillovers and economic growth appears to be mixed. While an impressive number of studies report positive scale effects or knowledge spillovers from economic integration, some argue that integration alone cannot promote growth without both policy and geographic factors in place. For example, in a cross-country and time series study to examine whether the openness, market size and level of development of countries in the same region foster growth in the home country, Vamvakidis (1998) found that economies of countries near large and open economies grow faster, and that the level of development of neighboring economies, especially when they are open, had significant positive spillover effects. By contrast, the size and level of development of closed neighboring economies have little or no impact on economic growth, indicating that both policy and geographical factors are significant determinants of growth.

Badinger (2001) also reported results that tend to support the significance of regional integration in economic growth. Using a growth accounting framework to examine the impact of economic integration in Europe, he finds a positive effect of regional integration on economic growth. He argues that if no integration had taken place, average per capita income of the countries in the European Union would be approximately one-fifth smaller than today. According to his findings, the bulk of the

positive effects can be traced back to increases in efficiency, while integration-induced, investment-led growth played a much smaller role.

Barro and Sala-I-Martin (1995) also found positive spillovers from high GDP per capita in neighboring countries. In a recent theoretical paper, Holod and Reed (2004) showed that the rate of growth under regional economic integration is higher than under national coordination, although the largest economic gains come from national coordination.

In exploring the evidence on growth spillovers across African economies, Richaud, Sekkat and Varoudakis (1999) examine the role of road infrastructure investments, finding that it could explain up to 25% of the resulting growth in per capita GDP among neighboring countries as markets widened and investment flows increased. The results clearly suggest that there are larger benefits to be captured from pooling resources for infrastructure investments across African countries.

The evidence on whether there is potential for widening intra-regional markets in Africa is mixed. Most studies that use aggregate data conclude that there is limited potential in the foreseeable future due to the fact that many African countries share similar natural resource endowments, and thus, usually produce and export a few primary commodities (e.g., Yeats, 1998; Foroutan and Pritchett, 1993). However, a recent study by Diao and Yanoma (2003), using data on agricultural commodities, concluded that with improvement in infrastructure and reduction in trade barriers in SSA, there is potential to increase agricultural trade across countries in the region. In particular, they find that foodstuffs are among the most dynamic products in the region and that it is possible to promote intraregional trade in these commodities. Their findings are consistent with those of Yeats (1998), who concluded from his study that foodstuffs dominate the fastest growing products in intra-regional trade, suggesting that further expansion of this exchange might be able to alleviate somewhat Africa's chronic food security problems and help improve conditions of the rural poor.

Agglomeration

The empirical work on spatial externalities and agglomeration is extensive. The most challenging task confronted by the effort to test for spillover-localization is the difficulty of separating spillovers from correlations that may be due to pre-existing patterns of geographic concentration of technologically related activities. Nevertheless, authors often employ approaches that control for these effects to ensure conservative results. The available empirical evidence on spatial spillovers to a large extent indicates that spatial externalities matter and that they can foster growth, so long as there is greater openness (as pointed out earlier).[3] For example, in the analysis of knowledge spillovers among seven major industrialized countries, Keller (2001) found that geographic distance appears to have a strong limiting effect on the scope of knowledge spillovers. Specifically, he finds that the geographic half-life of knowledge spillovers, the distance at which half of them disappeared, is only 1,200 kilometers. His results also indicate that a substantial portion of the influence of distance on the scope of knowledge spillovers, and maybe all of it, can be accounted for by differences in trade, foreign direct investment and communication links across countries.

In their study of R&D spillovers and the geography of innovation and production, Audretsch and Feldman (1996) find that even after controlling for the degree of geographic concentration in production, innovative activity tends to cluster more in industries where knowledge spillovers play a decisive role, suggesting that the propensity for innovative activity to cluster is more attributable to the role of knowledge spillovers and not merely geographic concentration of production. Thus, a key determinant of the extent to which the location of production is geographically concentrated is the relative importance of new economic knowledge in the industry.

Jaffe et al. (1993) also found evidence of the geographical localization of knowledge spillovers in their study of patent citations in the United States. To ensure that they capture true externalities, they excluded self-citations, but still obtained results

[3] Of course, in the case of negative externalities, this would lead to retarded growth.

that suggest that the localization effects are quite large and quite statistically significant. Using a production theoretic framework to analyze spatial externalities within German counties, Keilbach (2000) also obtained regression results that give evidence in favor of significant spatial knowledge spillovers. His results indicate that approximately 37% of the contribution of R&D personnel of a region will spill over to its neighbors, who benefit from this asset as an external effect.

On the other hand, Irwin and Klenow (1994) in their study of learning-by doing spillovers in the semi-conductor industry during the years of 1974-92 found that national and international knowledge spillovers are equal, suggesting that there is no localization of knowledge spillovers. Jaffe (1986) also found that a significant fraction of the total flow of spillovers affecting firms' own research productivity come from firms outside of the receiving firm's immediate technological neighborhood, suggesting that spillovers are not necessarily confined to closely related regions of technology space.

Griliches (1992) states in his review of the empirical research on spillovers that "there have been a significant number of reasonably well done studies all pointing in the same direction: R&D spillovers are present, their magnitude may be quite large, and the social rates of return remain significantly above private rates." This suggests that promoting R&D efforts in some countries could benefit other countries through cross-border externalities. This is particularly true for agriculture considering that the biological characteristics of crop technologies often cross political boundaries, and therefore the management space of national R&D systems.

Agricultural R&D and Spillovers

While the principal focus in this paper has evolved around the issue of R&D and knowledge spillovers in the economic growth literature, the interest in spillovers actually has its roots in agriculture, especially from the earlier work of Shultz (1956), Griliches (1957), Mansfield (1968) and Evenson (1968).

The importance of understanding agricultural R&D spillovers is especially relevant in the African context given that many countries are small and share similar

production systems, agro-ecology, and climate, which are all critical factors influencing the potential for spillovers. Ignoring this potential can lead to more costly and less effective resource allocations for research, ultimately resulting in a longer time lag for technology development and productivity improvement. On the other hand, taking advantage of spillovers by effectively exchanging knowledge, materials, and experience, across countries can benefit all countries more rapidly. This is because, through such joint efforts, countries can take advantage of economies of scale and scope: by achieving a critical mass for R&D that is normally beyond the capacity of individual systems; and by allowing for a greater number of research issues to be covered with minimal cost (Anderson, 1992). Measuring the potential for spillovers is therefore important for assessing the optimal size, type and location of agricultural research programs needed, from both a regional and national perspective.

Early efforts to empirically measure agricultural technology spillovers are evident in the works of Evenson (1978), White and Havlicek (1981) and Evenson (1989). In Evenson's study for example, he shows significant direct spillovers of crop and livestock technologies within similar agro-ecological regions in the United States. He also found that the relatively small research systems benefited more from spillovers than the larger ones. Other studies have attempted to measure spillovers directly by examining the research 'proximity' or the extent to which research in one institution overlaps with that of another. For example, Pardey (1986) assesses the disciplinary mix of U.S. agricultural experiment stations to come up with an index that measures 'proximity'. Thorpe and Pardey (1990) use a citation index to estimate knowledge spillovers among Latin American countries. More recently, Maredia and Byerlee (2000) use the yield performance of improved varieties to directly estimate spill-in coefficients. They show substantial spillover of CIMMYT based wheat varieties, implying that many developing countries would fare better by allocating their scarce resources to the adaptation of technology spill-ins.

All these studies show that the spillover of agricultural R&D is quite substantial, especially among those countries or regions that share similar agro-ecologies, implying

that many countries are better off capturing and adapting R&D spill-ins rather than duplicating basic research across them. Unfortunately, the empirical evidence of spillover potential in Africa has been limited to only those estimates that are derived as part of a global study (Maredia and Byerlee, 2000) or those limited to a few countries (Johnson, 2000). A principal constraint has been the lack of sufficient time-series data on technology adoption and spread. Nevertheless, various case studies have documented the region-wide success stories for cotton and rice research in West Africa, maize in East and Southern Africa, cassava in Central and West Africa (Haggblade, 2004).

Capitalizing on technology spillovers requires supporting public policies. The ability of individual firms (including farmers) or countries to perceive and take advantage of spillovers depends on their own skills and level of development. This includes having sufficient human scientific capacity to facilitate the sharing of ideas, knowledge, and materials across countries and to adapt them to local conditions. Complementary investments are therefore needed to reduce these costs to enable individuals or firms to take full advantage of potential spillovers. Such investments could include language training, advanced and specialized training of scientific manpower, building cross-border infrastructure such as roads, communication networks and exchange programs to facilitate the exchange of ideas and experience, and even co-funding of regional R&D programs and institutions.

IV. SIMULATIONS OF POTENTIAL BENEFITS FROM R&D SPILLOVERS, TRADE LIBERALIZATION AND IMPROVEMENT IN INFRASTRUCTURE IN AFRICA

The conceptual framework and empirical evidence reviewed in the last two chapters showed how regional integration can be employed to create positive spillovers that enhance economic growth amongst countries. It was demonstrated that the greater the spillover effects and the larger the number of countries joining the integration, and hence increased market power, the stronger the growth enhancing effects of regional integration. The New Economic Geography was also employed in Chapter 3 to illustrate how the scope of knowledge spillovers is related to geographic distance. Neighboring countries in a region normally tend to benefit more from positive externalities than those located at further distances. Although the empirical evidence presented appeared mixed, most of the results discussed seem to show that the positive benefits from regional integration can be substantial.

Although the theoretical and empirical framework presented consists of equations that can be estimated with econometric methods, lack of suitable data makes the estimation of these equations difficult, especially for Africa. Alternatively, ex-ante simulations using existing partial and general equilibrium models can be used to demonstrate the potential spillover benefits arising from regional investments in R&D and infrastructure development as well as trade liberalization. To the extent that the simulation exercises demonstrate the impact of regional integration and investment in infrastructure on growth in neighboring countries, it is consistent with the conceptual framework and underlying theories presented in Chapter 2.

Potential Benefits from R&D Spillovers

To illustrate the potential benefits from spillovers arising from research and development, we use IFPRI's Dynamic Research Evaluation for Management (DREAM®) model to carry out experimental simulations for some key commodities

within the East and Central African (ECA) region in Africa.[4] The DREAM® model uses the economic surplus approach as described in Alston et al. (1995). The set of commodities selected for the analysis represent a wide coverage of key commodities, including: vegetables, tree nuts, pulses, oil crops, roots and tubers, livestock, fiber crops, and cereals. Technology innovation is assumed to originate in a few innovating countries: Kenya, Uganda, and Tanzania. The analysis of potential spillovers from technology innovation (or any other cost reducing intervention) is limited to countries within the ECA region. This may lead to some under estimation of the total benefits, though spillover benefits to other countries are probably smaller because of greater differences in agroclimatic conditions.

The analysis makes other important assumptions: a technology will take five years to be fully adopted by farmers with an adoption ceiling of 100%; technology spillovers to non-innovating countries are assumed to translate into half the productivity gains initially realized in the innovating countries. This approximates for imperfect adaptation of technologies between countries. Base period production and consumption data were based on a three-year average between 1999 and 2001. Simulations were projected out to 2020 as a series of shifting supply and demand curves. For each commodity, demand is exogenous and assumed to grow at a rate equal to the population growth rate plus per capita consumption growth (which itself is determined by per capita income growth and commodity specific income elasticities). The growth rate in supply under initial conditions (i.e. without R&D induced changes) is assumed to match demand growth in every country and region to maintain real constant prices and baseline trade flows throughout the 'baseline' simulation period. This baseline growth in supply over time is assumed to come from both area expansion and yield changes that are unassociated with R&D, without any explicit constraint on the availability of suitable agricultural land over time.[5] Finally, although introducing a research-induced supply

[4] The application is based on a current working paper by You, Johnson and Wood.

[5] With adequate information on both base yield and area expansion growth rates, more reasonable growth estimates can be incorporated to account for future land area constraints.

shift implies a one time increase in productivity or production per unit area, technology diffusion is assumed to occur gradually over time following an S-shaped adoption curve.

Whether a commodity is traded in regional, international, or domestic markets only can affect the extent to which there are price effects from a research induced supply shift in domestic or regional markets. Among the commodities analyzed, cashew nuts, coffee, cotton, dry beans, maize, rice, vegetables, and beef, are all considered as internationally traded, while cassava, groundnuts and potatoes are assumed to be traded within the region, and plantains, sweet potato, sorghum, millet, cow milk, and mutton, within domestic markets only.

For each commodity, productivity is initially simulated by 1% in each of the three innovating countries to measure both the technology and price effects on economic welfare 'without spillovers'. Total economic welfare is measured as a stream of annual net benefits in consumer and producer surplus that accrues to each country and the entire region by 2020. A second simulation permits technologies to be adapted elsewhere, as a 'with spillovers' scenario, among 'non-innovating' countries: Burundi, Congo DR, Eritrea, Ethiopia, Madagascar, Rwanda, Sudan, Somalia and the rest of East Africa (areas like Zanzibar and Djibouti). Results are reported in Table 1 and Figure 1 below.

Based on the simulation results, annual net gains from spillovers are estimated to range between $5,000 for cashew nuts to almost $3 million for dairy, with almost all of it derived from technology spillovers because of negligible price effects in both regional and international markets (Table 1, 2nd column, and Figure 1).[6] Proportionate spillover gains that accrue to non-innovating countries, as a proportion of total regional benefits, range from 1.6% for cashew nuts to 75.6 % for mutton (fourth column), or translated as spillover multipliers of 1.01 and 4.00 respectively (third column). Groundnuts, sorghum and rice technologies also demonstrate high spillover multipliers.

[6] In absolute value terms, the stream of annual net gains does not only reflect a commodity's spillover potential, but is also a reflection of its initial unit value and scale of production (or total value of production). So, for widely grown commodities like cassava, maize, sorghum, and dry beans, the absolute gains can be quite large, and so are those for high value commodities like dairy, beef, coffee and vegetables (i.e. a 1%productivity shock would translate into a higher value shock in dollar terms).

Table 1. Degree and Scope for Capturing R&D Spillovers in East Africa.

Commodity	Total annual regional gains *without* spillovers ($,000/yr)[1]	Additional annual gains *with* spillovers ($,000/yr)[1]	Spillover multiplier[2]	Spillover gains as a share of total regional gains *with* spillovers (%) [3]	Degree of cross country variation in spillover gains (index)[4]
	a	*b*	(a + b)/a	*b/(a+b)*	
1. Plantain	$6,575	$659	1.10	9.2%	2.49
2. Maize	$5,659	$1,477	1.26	20.7%	1.99
3. Cassava	$5,200	$2,581	1.50	33.4%	2.29
4. Cow milk (dairy)	$4,456	$2,984	1.67	40.8%	1.71
5. Beef	$3,741	$2,409	1.64	39.2%	1.44
6. Coffee	$2,566	$1,461	1.57	37.7%	2.22
7. Vegetable	$1,742	$956	1.55	35.4%	1.09
8. Dry beans	$1,701	$626	1.37	27.0%	1.09
9. Sorghum	$1,064	$2,059	2.94	66.3%	1.83
10. Potato	$982	$490	1.50	33.7%	1.32
11. Rice	$854	$1,355	2.59	61.3%	2.51
12. Groundnuts	$553	$1,254	3.27	69.5%	2.07
13. Mutton/Lamb	$467	$1,399	4.00	75.6%	1.75
14. Cotton	$427	$251	1.59	37.1%	1.64
15. Cashew nut	$396	$5	1.01	1.6%	3.00

[1] Initial R&D investments occur in three countries: Kenya, Tanzania and Uganda. Technology spillovers are assumed to occur when regional collective arrangements are in place to aid in the transfer and adaptation of R&D elsewhere in the region.

2. Ratio of total benefit to initial benefit without spillovers.

[3] Total regional gains include initial gains accruing to the innovating countries and the spillover.

[4] Measured as the coefficient of variation across countries (standard deviation/mean)

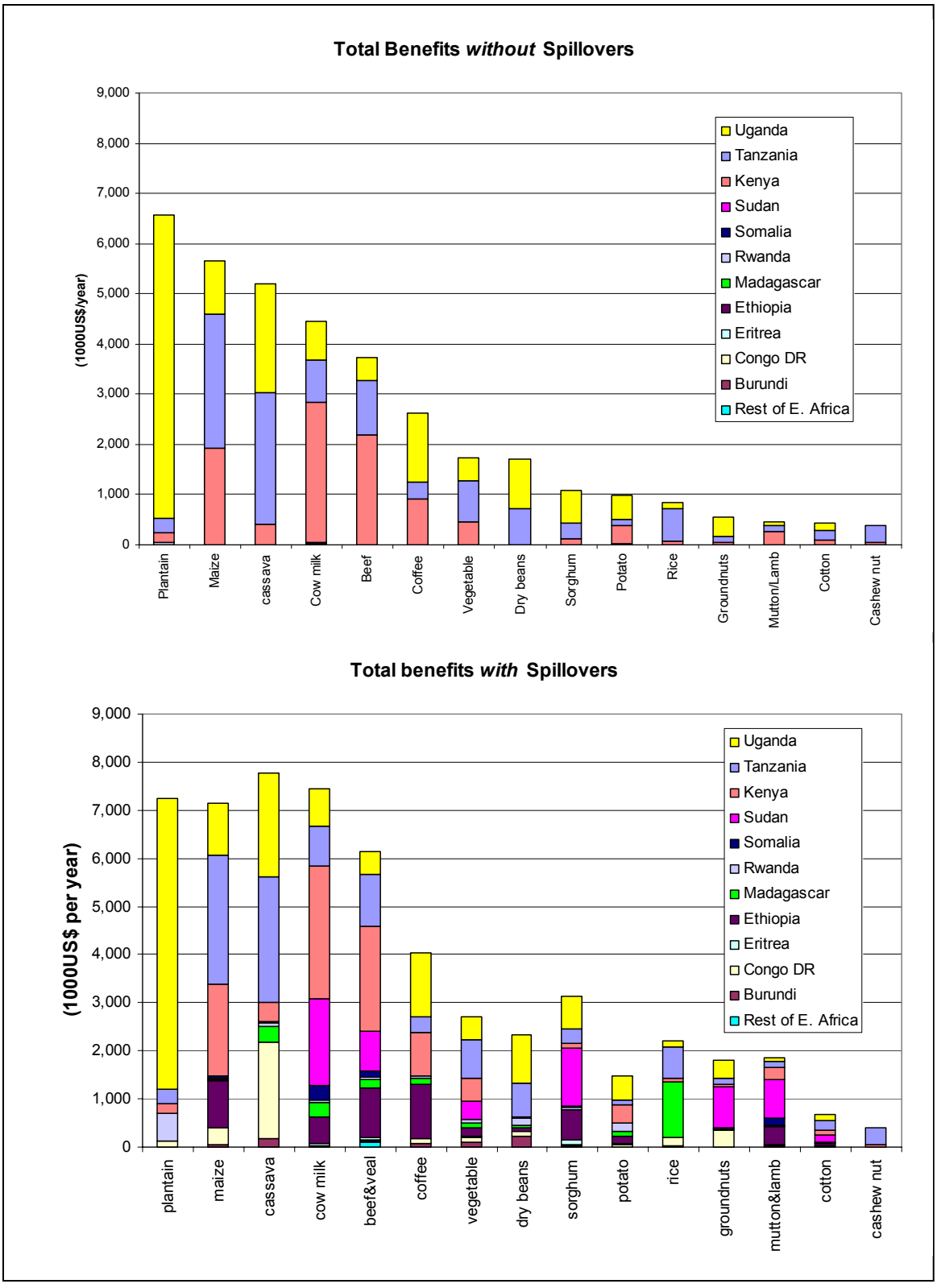

Figure 1. Total Annual Benefits *Without* and *With* Technology Spillovers

Given the free rider nature of these spillover benefits, there is a clear incentive for the region to under invest in these commodities from an aggregate welfare perspective.

In considering commodity areas to collectively invest in agricultural R&D, the region will also have little incentive to invest in those areas that will benefit only one or two countries, unless the affected countries can bear the bulk of the cost. This is especially true for commodities like plantain, cassava, coffee, rice, groundnuts and cashew nuts. As can be seen in Table 1 and the bar charts in Figure 1, the degree of cross country variation in spillover gains is quite high for these commodities (greater than 2.0). Considering both a spillover multiplier of greater than 1.6 and a cross-country variation index of less than 2 (implying a more equitable distribution of spillover gains across countries), identifies those type commodities that have a potentially wider geographic scope and scale for generating spillover benefits: namely, mutton, sorghum, dairy, and beef.

Based on these preliminary findings, there is certainly some scope for cooperation among African countries with respect to establishing regionally focused R&D programs that can help promote and facilitate technology spillovers. The size and diffusion of returns will likely be larger if the investments are targeted at those types of commodities (or production systems) that offer tangible opportunities for scaling up and translating into huge impacts on rural income growth. However, even if cooperation makes sense and is optimal from a regional perspective, careful consideration should also be given to organizational capacity, administrative and transaction costs, and commitment among member countries, to ensure high marginal returns (Alston et al. 2000). And just as important, because income gains from technology spillovers could easily be lost if producers fail to market any surplus output, problems of poor physical infrastructure and weak transportation networks will also need to be confronted.

Potential Spillover Effects from Regional Integration and Infrastructure Improvement

Growth in African agriculture and increased intra-regional agricultural trade are critically constrained by high marketing costs in the region (Diao et al., 2003). Investments in public goods such as road and transport infrastructure could help reduce such marketing costs. As the conceptual framework in Chapter 2 demonstrated, the role of such public goods in fostering greater economic integration plays a critical role in stimulating growth in member countries. To explore the potential benefits from integration and infrastructure provision to agricultural and overall economic growth, we employ a regional CGE model to simulate how African economies would grow under alternative policy scenarios involving liberalization and reduced marketing costs.

In particular, we focus on how total and agricultural GDP in Sub-Saharan African, as well as imports and exports would change in three scenarios: (i) trade liberalization across Sub-Saharan Africa;[7] (ii) Increased transport sector productivity in Mozambique that contributes to a reduction in transportation costs in its neighbor, Malawi;[8] and (iii) Increased transport productivity to reduce marketing costs in Africa as a whole.

The simulation results for scenario 1 are presented in Table 2. The findings indicate that through regional trade liberalization, total GDP and agricultural real income would increase by 2.82 and 1.52%, respectively, for African countries as a whole. While agricultural production rises slightly (0.16%), agricultural exports would increase by 19%. More importantly, intra-regional agricultural trade would increase by more than 50%, reflecting the current high barriers to commodity exchange across African countries, and hence, a strong potential for future growth in such exchange.

[7] Due to the data limitations, we have to use only tariff data to represent such distortions.

[8] Mozambique and Malawi are chosen as an example to illustrate how reducing transport costs in a country can benefit other countries in the region.

Table 2. Reducing Transaction Costs Scenarios: Sub-Saharan Africa Macro Results

Scenario	Real GDP	Real Agr GDP	Total agr Produc-tion	Food Consump-tion	Total agr Exports	Exports to EU&US	Total agr Imports	Intra-SSA imports	Food Prices
			Percent change over the base						
1. Full trade liberalization in SSA	2.82	1.52	0.16	-0.37	18.8	18.0	24.3	53.2	-0.71
2. 50% increase in SSA transport TFP	5.26	9.63	7.63	5.14	27.7	27.9	11.7	22.4	0.34

Source: Diao and Yanoma (2003)

To explore the significance of improving infrastructure to reduce marketing and transaction costs within countries and subsequent positive spillover effects on neighboring countries, we choose Malawi and Mozambique as examples for the analysis. As a land-locked country, all Malawian exports and imports have to transit through neighboring countries, mainly South Africa and Mozambique (a coastal country). Improving the efficiency of the Mozambique transportation sector not only reduces Mozambique marketing costs, but also benefits Malawi. We simulate such effects by increasing total factor productivity (TFP) in the Mozambique transportation sector by 50%, which causes unit transport costs in trade (including both goods imported and exported by Mozambique and transiting to other countries) to fall. This benefits all production sectors in Mozambique for which transportation services are an intermediate input. The benefits for traded commodities are much larger, as the transportation margins that lower the prices received by producers and inflate the prices paid by consumes are reduced. The direct benefits to the Mozambique economy from the 50% increase in transport TFP are 7% increases in the country's GDP and agricultural real income (Table 3). Both producers and consumers directly benefit from these positive impacts. Measured by total agricultural production and food consumption, the benefits accruing to agricultural producers and consumers are comparable, both increasing by six percent.

Simultaneously, reducing Mozambique's transportation costs indirectly benefits the Malawian economy by lowering the cost on transit trade. That is, import prices faced by Malawian importers fall and export prices rise. Agricultural exports increase by seven percent, while imports increase by 18% in Malawi due to the improvement in infrastructure. Malawi's real GDP increases by two percent and farm incomes, agricultural output and food consumption also rise because of the reduced marketing costs.

Table 3. Reducing Mozambique Transaction Costs Scenarios: Macro Results for Mozambique and Malawi (Scenario 2)

	GDP	Real Agr GDP	Total agr Production	Food Consumption	Total agr Exports	Total agr Imports
	---- Percent change over the base -----					
Mozambique	6.6	6.9	5.9	5.9	15.7	15.4
Malawi	1.8	3.0	2.6	1.4	7.1	17.7

Source: Diao and Yanoma (2003), p.xx.

In the third scenario, we further explore the significance of improving infrastructure to reduce marketing and transaction costs for all of Sub-Saharan Africa. Specifically, we increase TFP in the transportation sector for all African countries by 50%, except for South Africa. Given its relatively more advanced technological status, we assume that the transport sector in South Africa is initially more efficient than in the other countries. Thus, a smaller increase (30%) in the transportation sector is assumed for South Africa.

Improving the transportation sector's productivity significantly and positively affects African countries by lowering marketing costs in domestic markets and trade margins for both regional and international trade. Africa's agricultural trade increases significantly; exports by 28% and imports by 12%. There is also a 22% increase in intra-regional trade within Africa (Table 2, second row). This has a sizeable impact on the region's welfare. The region's total GDP increases by 5.3%, and agricultural real income increases by 9.6%. For the region as a whole, both producers and consumers benefit:

total food consumption increases by 5.1%, though the food prices rise slightly. Total agricultural production increases by 7.6% and such increases do not cause producer prices to decline because of lowered marketing costs.

While it is hard to separate direct benefits of a country's own marketing cost reduction and indirect benefits through reduced trade margins in neighboring countries in a general equilibrium model, these results confirm the significant cross-country benefits to be gained from regional cooperation to reduce marketing costs. Investments in road networks, as well as harmonization of regional agricultural commodity and input market policies and regulations, can all help to reduce marketing costs at both the country and sub-regional level.

The results of the last two scenarios suggest strong cross-sectoral linkages between African agriculture and non-agriculture, especially transportation and marketing services. With poor market and transport conditions and high transaction costs, it is too expensive to market many African produced agricultural commodities domestically, let alone in regional or world markets. Without improvements in the efficiency of these non-agricultural sectors that provide critical inputs or services to agricultural production and trade, it is virtually impossible for African countries to increase their competitiveness in international markets, and the region would gain little from trade liberalization. Moreover, given many African countries are land-locked and small, cooperative efforts to improve marketing and road infrastructure at the sub-regional level is not only necessary but also makes good economic sense.

V. THE ROLE OF INSTITUTIONS IN THE PROVISION OF PUBLIC GOODS

Both the theory and empirical evidence clearly suggests that regional cooperation and knowledge spillovers across borders have an impact on the economic welfare and growth rates of neighboring countries. However, problems can arise in the provision of such public goods if countries fail to cooperate, resulting in either non-provision or provision at the sub-optimal level. In this chapter we discuss potential problems associated with the provision of public goods and then proceed to discuss how African countries are organizing to deal with them.

Regional cooperation and harmonization activities to generate cross-border spillovers generally fall under collective action, which stipulates that a group of people with common interests will naturally get together and collaborate for the common goal (Olsen, 1969). However, Olsen states that unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interest. In particular, if some members perceive the expected benefits as public goods, there is the potential for users failing to reveal their true preferences and therefore waiting for the good to be provided and then free-ride. As argued by Sandler (2001), free-riding behavior is expected to be the norm in the absence of an exclusion mechanism. Why should a nation spend scarce resources on something that it can get for free? Olsen (1969) suggests that to overcome the free-rider problem, separate and selective incentives need to be put in place such that incentives accrue to group members.

Technology Aggregation in the Provision of Public Goods

Sandler (2001) uses Hirshleifer's (1983) approach of technology aggregation (i.e., the relationship between contributions and the overall supply of the public good concerned) to discuss how best different cross border public goods can be supplied and

what kind of international action is required. He considers four alternative technologies for producing cross border public goods, which we discuss below.

First is the summation technology. In this technology, each nation's contribution adds to the overall level of the public good. Examples include basic research and environmental management. In each case, the total level of the regional public good depends on the contributions of all member states. Under this condition, potential participants may not contribute if the perceived own benefit is lower than the own cost. To escape this prisoner's dilemma for regional public goods, one or more nations must gain sufficient benefits, beyond those of the average nation, to provide the public good. Another escape can come from an organized effort on behalf of a multilateral organization to collect the necessary funds to provide the public good.

A second technology is the weakest link. For this technology, the level of the public good equals the smallest individual provision. Partnerships to foster the financing of these weakest link regional public goods can be either bilateral or multilateral. Examples include efforts to curb the spread of infectious diseases, protection of tropical rain forests and fire controls. Recognition of weakest-link regional public good provides a whole new rationale for foreign assistance.

Third is the weighted-sum technology, in which the amount of the public good received by a country depends on the contributions made by other nations and the benefits received by the country in question. Sandler (2001) uses pest control as an example and argues that efforts to control a pest may adhere to weighted sum if the distribution of the pest is unequal, so that eradication efforts in its stronghold yield greater results than where the pest is less prevalent. With this technology, some nations receive disproportionately greater benefits and thus possess a large incentive to support the regional public good. Efforts should therefore be channeled to where provision has the greatest marginal impact.

A final technology is the best shot, which represents the aggregation technology for which the largest contribution of a nation sets the aggregate level of the regional

public good available for consumption. An example here is where the research team that expends the largest effort acquires success that benefits everyone. Scientific and health breakthroughs generally abide by a best-shot aggregation technology. Supply efforts should be concentrated where the prospects and existing resources are greatest for success.

The preceding discussions show that managing cross border externality requires at least three types of interrelated inputs (Kanbur, 2001). First, is bringing the countries together to discuss and agree upon the problem and the coordinated actions. Second, monitoring the coordinated actions; and third, compensation for the short run costs that result from the coordinated actions, relative to the option of breaking ranks. Given that the institutional setting for discussing and arriving at an agreement, and then monitoring and enforcing it is not costless, foreign aid could be quite significant here.

Recent estimates by the World Bank (2001) indicate that providing public goods through foreign aid has assumed increasing significance. The estimates show that for 1994-98, the annual averages of development assistance for the production of international public goods amounted to about US$5 billion annually and another US$11 billion annually for complementary activities. This is quite significant when compared to aid flows of US$40 billion, excluding technical assistance. The percentage of total ODA allocated to core activities of international public goods increased from about one percent in the 1970s to about eight by 1999. In terms of sectors, most of the resources were spent on health and research, particularly in the agricultural sector. The recent literature on the provision of international public goods however indicate that institutions for international public goods provision need to be designed on the basis of the various principles of economies of scale, economies of scope, specialization and subsidiarity (Sander, 1998; Sandler, 2001).

Institutions for Regional Collaboration in Africa

In response to the challenges and opportunities arising from globalization, and recognizing the potential benefits from regional cooperation, a growing number of

African countries have begun to explore and participate in regional arrangements that provide social and economic benefits to member countries. Several regional cooperation schemes have therefore been designed and implemented over the past three decades. While earlier approaches of regional cooperation were developed along the lines of free trade and customs unions, recent efforts have given more emphasis to the common market formula, providing for the movement of resources and factors of production so as to enable a more efficient exploitation of existing resource complementarities, regional economies of scale in the provision of public goods infrastructure (like communications, roads and energy), facilitating technology spillovers across national boundaries, and the harmonization of economic policies in support of regional production and market integration. In some cases, these regional institutions have been used to deal with negative spillovers from civil wars.

Several regional economic cooperation schemes (RECs) are therefore in place across Africa. Overall, there are 14 RECs of varying design, scope, and objectives, with seven of them dominating the integration landscape. These include: the Arab Maghreb Union (AMU), with 5 members; the Common Market for Eastern and Southern Africa (COMESA), with 20 members; IGAD, with 7 members; the Economic Community of Central African States (ECCAS), with 10 members; the Economic Community of West African States (ECOWAS), with 15 members; the Southern African Development Community (SADC), with 14 members; the Inter-Governmental Authority on Development (IGAD), with 7 members; the Community of Sahel-Saharan States (CEN-SAD), with 18 members.

In addition to these seven major RECs, six others are geographically limited or subsets of larger RECs: the West African Economic and Monetary Union (UEMOA), with eight members, all also belonging to ECOWAS; the Mano River Union (MRU), with three members, also belonging to ECOWAS; the Central African Economic and Monetary Community (CEMAC), with six members, also belonging to ECCAS; the Economic Community of Great Lake Countries (CEPGL), with three countries, also belonging to ECCAS; the East African Community (EAC), with three members, two

belonging to COMESA and one to SADC; the Indian Ocean Commission (IOC), with five members, four belonging to COMESA and one to SADC; the Southern African Customs Union (SACU), with five members, all of which belong to SADC and two to COMESA.

These regional integration efforts have brought some improvements in the provision of public infrastructure like telecommunications and energy in some parts of the continent. Part of this is most likely due to the global revolution in telecommunication technologies and the growing commercialization and privatization of national services. In the energy sector, positive changes have also been occurring. With the aim of minimizing energy costs, many RECs are exploiting economies of scale through larger supply systems and developing benign power sources. In particular, some member countries in ECOWAS, SADC and EAC have made significant progress (ECA, 2004).

In the area of agricultural R&D, sub-regional organizations (SROs) have been established to promote and facilitate technology spillovers across national boundaries. Examples of such arrangements include the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the Conference of the agricultural research leaders in West and Central Africa (CORAF). The organizations generally support the interests of National Agricultural Research Systems (NARSs) and Institutes (NARIs) of member countries, with the objectives of increasing the efficiency and effectiveness of agricultural research in each region so as to facilitate economic growth, food security and export competitiveness. The SROs carry out their activities through regional research networks, programs and projects, to strengthen the research capacities of NARSs and NARIs through co-operation between its members, international agricultural research centers (IARCs), and other development partners (e.g. non-governmental organizations, private sector, and donors). Both ASARECA and CORAF have established competitive research grant systems to encourage innovative research in member countries.

Some institutions in the region have also been employed to control negative externalities from civil wars. For example, the ECOMOG, which is a military force formed by member states of ECOWAS from units of their national armed forces was set up to deal with the security problem that followed the collapse of the formal state structure in the Republic of Liberia in 1990. The force successfully restored an atmosphere that permitted the reinstatement of a functional state structure in Liberia. It is currently engaged in the process of re-establishing the authority of the democratic order and ending a nine-year savage civil war in the Republic of Sierra Leone.

Many countries in the region have also joined the Global Forum on Agricultural Research (GFAR) to benefit from its services. The GFAR is a multi-stakeholder initiative that serves as a neutral forum for the discussion in agricultural research for development. It facilitates and promotes cost-effective and strategic alliances among the stakeholders in their efforts to alleviate poverty, achieve food security, and promote the sustainable use of natural resources. It strives to enhance national capacities to generate, adapt, and transfer knowledge.

The preceding discussion indicates that African countries generally chose to create and belong to several RECs to pursue their integration and facilitation of technology spillovers across national boundaries on several tracks. Some members of a larger bloc thought they could proceed at a faster rate in separate smaller grouping. A number of countries also sought to maximize the benefits of integration and minimize losses by spreading risks. In particular, economically weaker countries perceived this as a strong incentive to join several blocs. Although these RECs have had some successes, they have generally not met their objectives of greater production and internal trade partly because of the lack of strong commitment by member states, as well as the downdrafts of Africa's shrinking economies and shares in global trade (ECA, 2002).

Part of the problem is that regional cooperation requires good leadership, as well as a convergence in political and economic principals, which remains a real challenge in Africa today. Mills (2002), for example, stresses this point by noting that while European integration developed through a process of convergence in political and

economic values, the push for regional integration in Africa has precipitated this process. The historical divergence in political and economic systems, as well as the persistence of insecurity and civil conflict in each of the major sub-regions of Africa, continues to challenge any wel-intentioned efforts at cross-border cooperation and economic integration. This especially problematic among those larger states that have the potential to lead the process and serve as a source for regional growth and stability, such as Nigeria, Congo and Sudan, and yet have done just the opposite due to internal civil strife (Mills, 2002). The economic consequences of internal conflicts on neighboring countries can be quite significant, according to a study by Murdoch and Sandler (2002). In observing the negative effects of civil wars in neighboring countries in the short-run, they find that uncertainty and direct disruption of economic activity contributes the most to these effects, rather than the more direct dilution of a population's human capital or enhanced population growth rate due to migration.

Despite the enormous challenges, a majority of Africa's leaders are committed to regional cooperation as a means of penetrating global markets and attracting foreign direct investment. They have therefore advanced towards regional integration with the recent moves closer to the African Union and the New Partnership for Africa's Development (NEPAD). African leaders have decided to work and ensure that many of the regional economic communities will turn into building blocks for integration, to ultimately create larger and more attractive market and investment opportunities in the region. However, the extent to which the individual RECs can be used as building blocks will depend on the political commitment collectively displayed by the member states in moving towards integration. It will also mean coming to grips with the existence of a multitude of existing REC arrangements, which have sometimes only succeeded in adding more to the complexities in harmonizing policies and investment flows across countries.

To deal with these challenges, the Treaty aiming for African Economic Cooperation provides for implementation in six phases. The initial phase focuses on strengthening the RECs to make them effective building blocks for the cooperation. The

later phases are designed to ensure that the RECs evolve into free trade areas, customs unions, and through coordination and harmonization, will eventually merge into a common market embracing the entire region (ECA, 2002).

VI. CONCLUSIONS AND IMPLICATIONS

Since agriculture still dominates the economies of most sub-Saharan African countries, strategies aimed at reducing hunger and poverty need to increase the productivity of this sector. Promoting agricultural growth across sub-Saharan African will, however, also require investments that strengthen linkages between individual countries in the region. This study has argued that regional cooperation in agricultural research and development, harmonization of regulatory standards for technology release and diffusion, and harmonization and liberalization of trade systems in both input and output markets within the region, could play a crucial role in expanding opportunities for farmers and firms.

It has been emphasized that strengthening linkages between sub-Saharan African countries through infrastructure or expansion of intraregional trade can play a significant role in generating growth spillovers and enhancing regional economic growth. The endogenous growth theory was employed to show that the pursuance of regional integration and provision of regional public goods would enable SSA countries to reap the benefits of economies of scale through the enlargement of markets. As an extension, the new economic geography modeling framework was used to illustrate the significance of spatial dimensions in promoting local spillovers.

To illustrate the potential benefits from spillovers arising from research and development, IFPRI's DREAM model was used to carry out some ex ante simulations for some key commodities within the East and Central African region in Africa. Results indicate that the spillover multiplier on economic welfare can be as high as 3.0 to 4.0 from permitting cross-border technology transfer and adoption. This is especially true for mutton, groundnuts and sorghum. Not only do the benefits to the region increase substantially because of spillovers, the benefits accruing to non-innovating countries is about 70 to 80%of total regional benefits for these commodities. Among commodities like mutton, sorghum, dairy, and beef, there is significant potential for a wider geographic scope in spillover gains outside the three innovating countries. On the other

hand, spillover gains from technology improvements in cassava and coffee production are more likely to benefit fewer, but large, neighboring countries.

These results indicate that regionally focused technology programs could take advantage of existing R&D investments in focus countries, especially when they have a high potential for adaptation in neighboring countries, and therefore likely to generate larger benefits from spillovers. It is, however, worth mentioning that the ability of individual countries to take advantage of spillovers depends on their own skills and level of development. Countries therefore need to be actively engaged in the process of acquiring the benefits associated with spillovers. That is, there are costs associated with the exploitation of spillovers. It should therefore be part of policy to reduce these costs to enable individual countries take full advantage of these spillovers. Such measures could include language training, communication networks, specialized training for technology adaptation and extension.

Given that poor infrastructure and institutional barriers have constrained African countries to further exploit their comparative advantage and strengthen their economic linkages, a series of Computable General Equilibrium model simulations were carried out to show how Sub-Saharan African countries could benefit from trade liberalization and infrastructure improvement in the region. The simulation results show that reducing African countries own trade barriers, both in agriculture and non-agriculture, can significantly increase intra-regional agricultural trade (by more than 50%), although increased agricultural income is rather low (1.5%). Improving the transportation sector's TFP generates the most encouraging results, increasing agricultural income by 9.6%, and total food consumption by 5.1%. The above findings indicate removing trade barriers could help expand intra-regional trade in sub-Saharan Africa. In addition, it is clear from the analysis that investment in infrastructure can generate positive spillovers on neighbors. If individual countries do not consider such spillovers, they are likely to underestimate the return to investment in infrastructure and therefore choose suboptimal levels of investment in infrastructure. A coordinated regional program could help in

ensuring that cross-border externalities are considered when making investment decisions.

While there is ample evidence of high economic returns to be gained from regional cooperation in the provision of regional public goods, a real challenge for African countries is how to better organize themselves to not only pool resources, but to deal with incentive problems related to their own political imperatives and local constituents. Ultimately, regional cooperation will require good leadership, and overtime, a convergence in political and economic principals. The persistence today of insecurity and civil conflict is a clear sign of this need, especially as it continues to also undermine any well-intentioned efforts at cross-border cooperation and economic integration. Therefore, in order to leverage growth spillovers and achieve regional growth dynamics in Africa, countries will need to ensure regional cooperation in the provision of public investments in infrastructure and R&D, coordinated responses to conflicts, as well as concerted efforts to converge political and economic principals over time, including improved governance and accountability.

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