Leveraging regional growth dynamics in African agriculture

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Abstract

This study focuses on public investments and policy reforms for leveraging growth spillovers at the Africa regional level. It reviews first the theory and evidence of knowledge and growth spillovers generally and second the evidence in the African context. Given the limited and scattered evidence of actual past spillovers, it reviews recent ex ante simulations using partial and general equilibrium models to stress the potential for spillovers from greater cooperation in agricultural research, and from trade liberalization, policy harmonization and investments in infrastructure. The results show that permitting greater cross-border transfers and adopting improved technologies could have large spillover multiplier effects on overall economic welfare in the region. And simply reducing African countries' trade barriers and improving cross-border transport could increase agricultural incomes by as much as 10%. These two examples confirm that regional cooperation in agricultural research and harmonization and liberalization of regional trade systems are two important areas that have yet to be optimally harnessed to generate larger spillovers and enhance regional economic take-off.

Keywords: Sub-Saharan Africa; Regional cooperation; Spillovers; Agricultural development

Cette étude se concentre sur les investissements publics et les réformes politiques visant l'effet de multiplication des retombées en matière de croissance ('spillovers' en anglais), au niveau régional africain. Elle examine tout d'abord la théorie et l'existence de connaissances et de retombées en matière de croissance et en second lieu, la preuve dans le contexte africain. Étant donné l'insuffisance de preuves (éparpillées) témoignant de retombées réelles dans le passé, elle étudie de récentes simulations ex ante en se servant de modèles d'équilibre partiaux et généraux pour marquer le potentiel des retombées qui proviendraient d'une plus grande coopération au sein de la recherche agraire, d'une libéralisation du commerce, d'une harmonisation politique et d'investissements destinés à l'infrastructure. Les résultats montrent que l'autorisation d'effectuer de plus grands transferts trans-frontaliers ainsi que l'adoption de technologies améliorées pourraient augmenter la capacité des effets multiplicateurs des retombées pour l'ensemble de l'assistance économique dans la région. Le simple fait de réduire les barrières commerciales des pays africains et d'améliorer les transports trans-frontaliers pourrait entraîner une augmentation des revenus agricoles pouvant aller jusqu'à 10%. Ces deux exemples confirment que la coopération régionale au sein de la recherche agraire ainsi que l'harmonisation et la libéralisation des systèmes commerciaux régionaux représentent deux domaines importants devant être exploités de façon optimale afin de générer de plus grandes retombées et de favoriser un envol économique.

Mots clés : *Afrique sub-saharienne ; Coopération régionale ; Retombées en matière de croissance ; Développement agraire*

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1. Introduction

Although agricultural growth could substantially reduce 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 to 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 links between sub-Saharan African countries through infrastructure, agricultural research and development and expansion of intra-regional 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 agricultural research. Regional spillovers are already known to happen 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 one percentage point over a decade could result 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 deserve attention, especially in Africa where civil strife and political instability – through the disruption of trade and input supply lines, heightened risk perceptions by potential investors, collateral damage in border areas and the diversion of public resources to help war refugees – lead to negative economic consequences in neighboring countries. 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.

To offer a better understanding of the underlying theory and evidence of the growth effects of regional integration and cross-border spillovers, Section 2 surveys the literature whose conceptual framework employs the endogenous growth theory. Section 3 reviews the available evidence, more generally at first and then specifically for Africa. In the absence of sufficient data in the African context, simple simulations are also used to illustrate the size of potential spillover benefits and growth effects that can be derived from greater regional cooperation in agricultural research and development (R&D), trade liberalization and investments in infrastructure. The final section presents conclusions and some policy implications.

2. Review of theory

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. He argues that 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 used 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 said to be present only 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 ones 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.

In the economics literature, more generally, knowledge spillovers are central in the growth models of Romer (1986), Lucas (1988) and Barro (1990). 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). Knowledge spillovers have also been considered as a by-product of increased trade (Coe & Helpman 1995). They have also gained prominence in models of regional and urban economics which seek to explain patterns of agglomeration and de-agglomeration (Krugman 1991).

In the discussion that follows, the effect of knowledge spillovers on growth is discussed within an endogenous growth theory framework. It is within such a framework that we can begin to understand the fundamental importance of knowledge spillovers in stimulating multi-country (or regional) growth dynamics. For brevity, certain important assumptions are made to enable us to examine the implications of regional integration and investment in regional public goods. First, the discussion is presented in the form of a simple mathematical growth model for descriptive purposes. Second, any inter-temporal consumption trade-offs are not investigated and thus the determinants of resource allocation are not considered either. Along the lines of Bretchger (2001), 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. Finally, the model focuses only on balanced growth equilibrium, which requires that the relative size of the dynamic sector and the level of consumption remain constant.

With these simplifying assumptions, consider the following set of equations:

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

(2) $$K_K = K - K_C$$

(3) $$L_K = L - L_C$$

(4) $$Z = K^{\delta}$$

where A denotes a constant technology parameter; K is a resource that can be accumulated, such as 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 be interpreted either 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 are 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 the growth rate of output. Equation (5) indicates that for values of $\delta + \alpha < 1$ and a 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 by 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 the 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 by comparing the growth rates under free trade in the integrated regional economy with those under autarky (Audretsch et al. 2004).

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) reveals that regional integration can affect 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 producing 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 condition 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 show 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. However, it 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, through either 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 each country under regional integration can be expressed as:

[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.

$$\theta_K^{reg} = m^{\delta}\theta_K^{aut} \quad (9)$$

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 greater than the growth rate under autarky by a factor of $m^{\delta} \geq 1$. The main reason for this difference is that the integrated regional economy can effectively use the public good $Z_j = (mK)^{\delta}$. This suggests 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 that in many policy papers the number of consumers – considered as a proxy for the size of the market – is often used to measure the scale effects.

Clearly there are strong theoretical arguments as to how regional cooperation and integration can be employed to create positive spillovers that enhance economic growth amongst countries. It has been demonstrated that the greater the spillover effects and the larger the number of countries joining the integration, and hence the increased market power, the stronger the growth enhancing effects of regional integration. We now consider whether there is sufficient evidence for such potential, first generally and then specifically in the African case.

3. The empirical evidence on spillovers and growth

A review of the empirical evidence on the role of regional integration in knowledge spillovers and economic growth generally reveals mixed results. While an impressive number of studies report positive scale effects or knowledge spillovers from economic integration in many parts of the world, some argue that integration alone cannot promote growth; policies and geographic factors need to be right too. 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 the 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 regional integration has a positive effect on economic growth. He argues that if no integration had taken place the average per capita income of the countries in the European Union would be approximately one-fifth smaller than they are 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.

For Africa, the evidence is more limited owing to insufficient and poor quality data across countries. Nevertheless, the scattered evidence is compelling. For example, in exploring the evidence on growth spillovers across African economies, Richaud et al. (1999) examined the role of road infrastructure investments, finding that this could explain up to 25% of the resulting growth in per capita GDP among neighboring countries as markets expanded 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 because many African countries share similar natural resource endowments, and thus usually produce and export only a few primary commodities (e.g. Foroutan & Pritchett 1993; Yeats 1998). However, a recent study by Diao and Yanoma (2003), using data on agricultural commodities, concludes that with improvement in infrastructure and reduction in trade barriers in sub-Saharan Africa 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 intra-regional 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 alleviate Africa's chronic food security problems somewhat and help improve conditions for the rural poor.

For knowledge spillovers generated from agricultural research and development (R&D), almost all the studies in the literature find some evidence of positive spillovers. The special nature of agriculture, depending as it does on endowments of natural resources such as agro-ecology and climatic factors, means that such spillovers would most likely occur where regions share similar characteristics in these basic factors (or have close research proximity), in addition to the usual economic factors (see Alston et al. 1995). In the general economics literature, early efforts to measure the occurrence of agricultural research spillovers empirically can be attributed to Evenson (1971), White and Havlicek (1981), Evenson (1989), and Thorpe and Pardey (1990). More recently, the work of Deininger (1995) and Maredia and Byerlee (2000) is also noteworthy. The general conclusion among all of them is that agricultural knowledge or research spillovers are quite substantial, especially among countries or regions that have similar agro-ecologies and production systems.

Unfortunately, the empirical evidence of agricultural research spillovers in the African context has so far been limited to those derived as part of a global study (Maredia & Byerlee, 2000), those limited to a few countries (Johnson et al. 2006), or studies intended to document individual crop success stories, e.g. cotton and rice research in West Africa, maize in East and southern Africa, cassava in West and central Africa (Gabre-Madhin & Haggblade 2004). One principal constraint has been the lack of sufficient time series data on technology adoption and spread in Africa. The lack of consistent data across countries has also limited the extent to which regional growth dynamics and spillovers can be examined more closely at the multi-country level in Africa.

In these circumstances, therefore, measuring the extent to which positive growth spillovers can occur more broadly from agricultural research, and greater regional integration from trade liberalization and infrastructure investments, is only possible through the application of ex ante simulation models. More specifically, simulations that employ partial and general equilibrium economic models are especially useful for this purpose: they can help provide empirical estimates of the potential income and growth spillovers to be derived from R&D investments, trade liberalization and infrastructure investments. Moreover, the sectors which enjoy the largest share of regional economies and markets (either within or outside agriculture) are most likely to generate greater growth dynamics and spillovers, consistent with the endogenous growth theory arguments presented in the previous section.

We now present some illustrative evidence to show this potential, using examples of R&D investments and of greater economic integration through transport infrastructure improvements in Africa. The first example uses a commodity-specific partial equilibrium model specifically designed to illustrate the research spillover question and the second a regional computable general equilibrium (CGE) model that is more suitable for illustrating the potential economy-wide spillover benefits from reduced transport costs among neighboring countries.

3.1 Benefits from research spillovers[2]

The potential for spillovers arising from R&D in Africa is assessed by using IFPRI's Dynamic Research Evaluation for Management (DREAM®) model to carry out experimental simulations for some key commodities in the East and Central African (ECA) region. The DREAM® model is a single commodity and multi-market partial equilibrium model. It uses the economic surplus approach as described in Alston et al. (1995) to measure benefits from shifts in technology and market conditions over time. It is applied to a number of key commodities in the ECA region, selected to represent those widely grown in the region: vegetables, tree nuts, pulses, oil crops, roots and tubers, livestock, fiber crops and cereals. For this experiment, technology innovation is assumed to originate in a few innovating countries, Kenya, Uganda and Tanzania, and only to be transferable within the ECA region because of geographic proximity.[3]

In the absence of sufficient data across all the commodities analyzed, and as a preliminary experiment, certain simplifying assumptions were imposed on the model. First, gains in productivity due to research for each commodity were maintained artificially low and equal across commodities, simulated as a 1% shock. The actual variation in productivity gaps across different commodities and countries is not considered. Instead, the experiment focuses more attention on measuring the potential marginal benefits of research spillovers within each commodity sub-sector on region-wide economic benefits, measured as spillover multipliers. Second, technologies are assumed to take five years to be fully adopted by farmers, with a target adoption ceiling of 80%. While this may be overly optimistic in the African context, it turns out not to be very important since the experiment simulates an arbitrarily small 1% shock to productivity. Third, technology spillovers to non-innovating countries are assumed to translate into half the productivity gains initially realized in the innovating countries. This is intended to approximate the imperfect adaptation of technologies and transfer costs between countries. Actual production and consumption data were based on a three-year average between 1999 and 2001.

Simulations were projected out to 2015 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 based on 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 overtime 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.[4] Finally, although introducing a research-induced supply 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.[5]

Whether a commodity is traded in regional, international, or domestic markets can only 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

[2] The model and application used here is taken from You & Johnson (forthcoming) where the model assumptions and scenarios are described in more detail. A similar analysis and approach has also been presented in the ASARECA/IFPRI Report (2006).

[3] The choice of these three countries was based on the initial study done at IFPRI by You and Johnson (forthcoming) for the United States' Initiative to End Hunger in Africa (IEHA). The three countries were considered as target countries for increased funding under the IEHA program, which was also intended to benefit the entire region.

[4] 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.

[5] See, for example, Abdulai and Huffman (2005) for empirical evidence on an S-shaped adoption curve in the African context.

within the region, and plantains, sweet potatoes, sorghum, millet, cow milk and mutton within domestic markets only.

For each commodity, the productivity shock of 1% is initially simulated 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 2015. A second simulation then permits technologies to be adapted elsewhere (the 'with spillovers' scenario) among so-called 'non-innovating' countries in the region: Burundi, the DRC, Eritrea, Ethiopia, Madagascar, Rwanda, Sudan, Somalia and the rest of East Africa (areas such as Zanzibar and Djibouti). The results are reported in Table 1 and Figure 1 below.

Table 1: Degree and scope for capturing R&D spillovers in East Africa

Commodity	Total regional benefits *without* spillovers ($,000/yr)[a]	Additional benefits *with* spillovers ($,000/yr)[a]	Spillover benefits as a share of total regional benefits *with* spillovers (%)[b]	Spillover multiplier[c]	Cross country spillover variation index[d]
	a	*b*	*b/(a+b)*	*(a + b)/a*	
1. Plantain	$6,575	$659	9.2	1.1	2.49
2. Maize	$5,659	$1,477	20.7	1.3	1.99
3. Cassava	$5,200	$2,581	33.4	1.5	2.29
4. Cow milk (dairy)	$4,456	$2,984	40.8	1.7	1.71
5. Beef	$3,741	$2,409	39.2	1.6	1.44
6. Coffee	$2,566	$1,461	37.7	1.6	2.22
7. Vegetables	$1,742	$956	35.4	1.5	1.09
8. Dry beans	$1,701	$626	27.0	1.4	1.09
9. Sorghum	$1,064	$2,059	66.3	2.9	1.83
10. Potatoes	$982	$490	33.7	1.5	1.32
11. Rice	$854	$1,355	61.3	2.6	2.51
12. Groundnuts	$553	$1,254	69.5	3.3	2.07
13. Mutton/Lamb	$467	$1,399	75.6	4.0	1.75
14. Cotton	$427	$251	37.1	1.6	1.64
15. Cashew nuts	$396	$5	1.6	1.0	3.00

[a] 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.
[b] Total regional benefits include initial benefits accruing to the innovating countries and the spillover.
[c] Ratio of total benefit to initial benefit without spillovers
[d] Measured as the coefficient of variation of spillover benefits accruing across countries (standard deviation/mean).

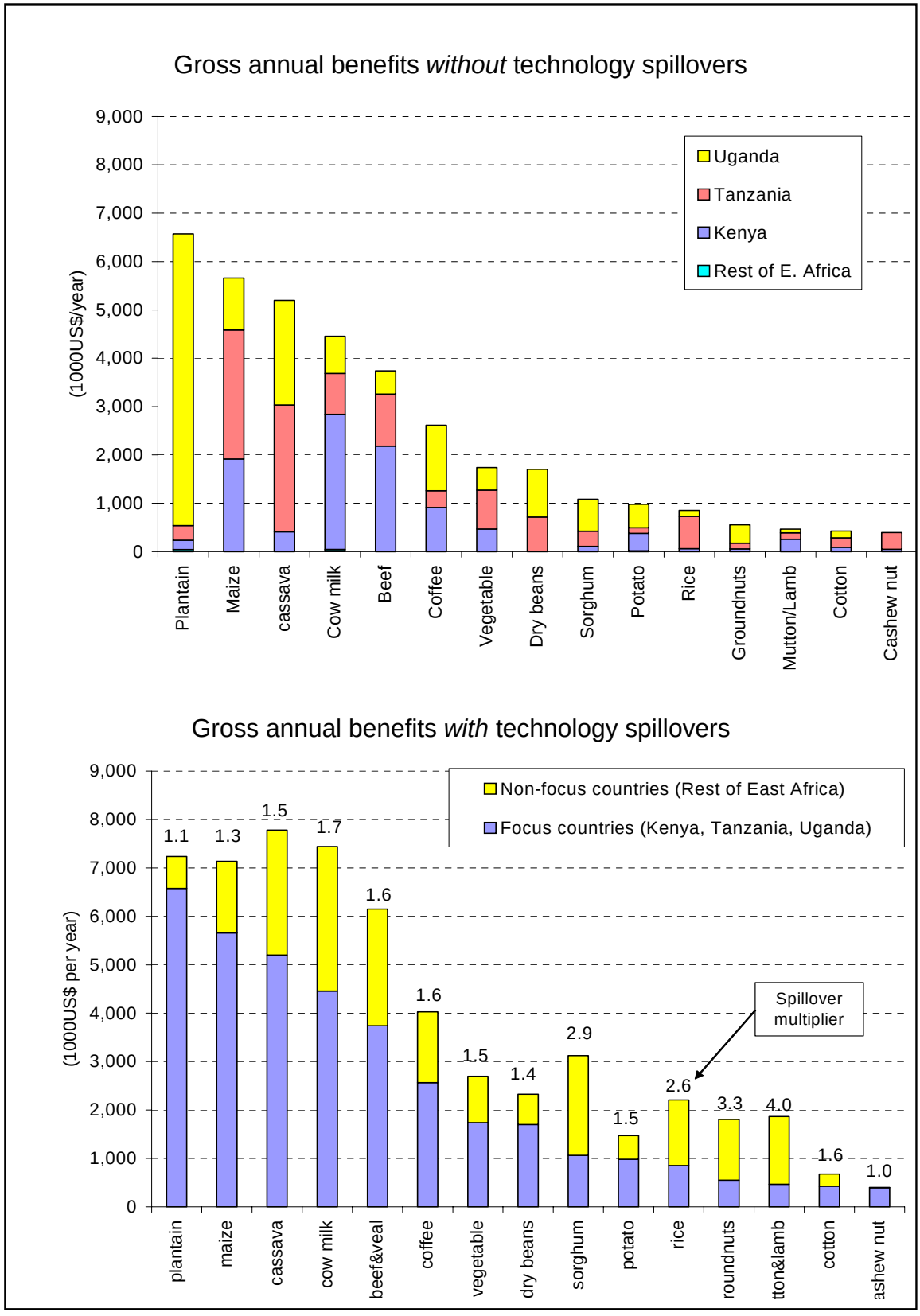

Figure 1: Gross annual benefits from spillovers following a productivity shock of one percent in three focus countries (Kenya, Tanzania and Uganda)

Based on the simulation results, annual net gains from spillovers can potentially be quite large, ranging from an estimated $5000 for cashew nuts to almost $3 million for dairy products, with almost all of it derived from technology spillovers because of negligible price effects in both regional and international markets (Table 1, second column, and Figure 1).[6] Proportionate spillover gains that accrue to non-innovating countries, as a proportion of total regional benefits, are shown potentially to range from 1.6% for cashew nuts to 75.6% for mutton (third column), translated as spillover multipliers of 1.0 and 4.0, respectively (fourth column). In addition to mutton, technologies for producing groundnuts, sorghum and rice also demonstrate high spillover multipliers. This simply reflects the fact that these crops are either more widely grown outside the countries from which the technologies originate or are grown in fairly large quantities in the region as a whole.

Given the free rider nature of these spillover benefits, from an aggregate welfare perspective there is a clear incentive for the region to under-invest in these commodities. In other words, what incentives would countries have to invest in a regional research program if there are significant spillovers to be captured from those few member countries with strong research programs? On the other hand, the significant scope for spillover benefits to accrue to a large number of countries should also provide an incentive at the regional level to collectively invest in R&D activities so as to take advantage of economies of scale. This may be the case for commodities such as plantain, cassava, coffee, rice, groundnuts and cashew nuts. As can be seen in Table 1 and the bar charts in Figure 1, the simulated cross-country variation in potential spillover benefits is quite high for these commodities (greater than 2.0). Moreover, if a region's welfare objective is to maximize both the absolute levels and distribution of spillover benefits across member countries, then commodities with both a potentially high spillover multiplier and a lower cross-country spillover variation (implying a more equitable distribution in spillover benefits) are the most ideal. For example, combining a threshold of not less than 1.5 for the spillover multiplier with that of a cross-country variation index of not more than 2.0 results in a list of commodities that have a potentially higher geographic scope and scale for generating spillover benefits in the East African region: namely, mutton, sorghum, dairy products and beef. Cooperation in research will require some political bargaining among member countries, but in the long run should lead to substantial welfare gains for all member countries.

This simple experiment helps to illustrate and support the argument that there is certainly some scope for greater cooperation among African countries in regionally focused R&D programs, especially ones that help to promote and facilitate technology spillovers. The size and diffusion of benefits may be higher if the investments are targeted at those types of commodities (or production systems) that offer tangible opportunities for scaling up, potentially translating into huge impacts on rural income growth. While not explicitly illustrated in this example, they are also likely to be greater where countries share similar agro-ecologies and farming systems (see You & Johnson, forthcoming; and the ASARECA/IFPRI Report 2006).

Given that research costs are not included, and some of the parameters are estimated under simplifying assumptions, the results presented cannot and should not be considered as absolute predictions of the potential impact of cooperation in R&D programs. Rather, they should be viewed only as indicative of this potential. Moreover, even if cooperation in research makes sense and is optimal from a regional perspective, to ensure high marginal returns careful consideration would still need to be given to organizational capacity, administrative and transaction costs, and commitment among member countries (Alston et al. 1995). Finally, and not least importantly, 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 transport networks will still need to be confronted. Moreover, as the conceptual framework in Section 2 demonstrated, the role of public goods (such as transport infrastructure and R&D) in fostering

[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 such as dairy products, beef, coffee and vegetables (i.e. a 1% productivity shock would translate into a higher value shock in dollar terms).

greater economic integration is critical for stimulating growth in member countries. The next example illustrates this potential in more detail.

3.2 Benefits 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 & Yanoma 2003). Investments in public goods such as road and transport infrastructure could help reduce such marketing costs while fostering greater economic integration and growth spillovers across member countries. To explore the potential economy-wide benefits from integration and infrastructure provision, a general equilibrium approach that captures a domestic economy's interactions with regional and world commodity and input markets is more appropriate.

First, productivity growth in one country's agricultural or non-agricultural sector not only increases the country's competitiveness in regional markets, it also positively or negatively affects other countries in the region as well. The effects are positive when investments in one country benefit other countries through improvement in either agricultural productivity (as discussed above) or conditions outside the agricultural sector, such as in the transport sector. They are negative, for example, if the two countries compete in the same export commodity markets.

Second, agricultural growth does not only depend on direct investments in agriculture, such as R&D investments, it also depends on investments that help lower marketing costs, such as transport and road infrastructure. These are important products and services provided by other economic sectors outside of agriculture. Thus, the linkage effect between the agriculture and non-agriculture sectors is just as important and is the primary focus in this second simulation example.

To simulate how African economies would grow under alternative policies involving liberalization and reduced marketing costs, a regional CGE model is employed.[7] The simulations focus on three scenarios. The first scenario is trade liberalization and its effect on the countries of sub-Saharan Africa.[8] The second is the growth spillover effects of investments in roads or the transport sector, using the example of the neighboring countries of Mozambique and Malawi, in particular the effects of improvements in Mozambique's road and transport infrastructure on Malawi's transport costs and hence agricultural growth. In the third and final scenario, the effect of continent-wide productivity improvements in the transport sector on agriculture and economic growth is further analyzed.

The simulation results of Scenario 1, focusing on how the total and agricultural GDP in sub-Saharan Africa, as well as imports and exports, would change are presented in Table 2. The findings indicate that through regional trade liberalization the total GDP and agricultural real income would increase by 2.8 and 1.5%, respectively, for African countries as a whole. While agricultural production rises slightly (0.2%), 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. The results also stress that even under existing infrastructure conditions gains from regional trade liberalization can be quite large. Together with infrastructure improvements (Scenario 2), however, the gains could be much higher (Table 2, second column). These results are considered in the discussion of Scenario 3, below.

[7] The model and application reported here are discussed in more detail in Diao & Yanoma (2003).
[8] Owing to the data limitations, we have to use only tariff data to represent such distortions.

Table 2: Reducing transaction costs scenarios: Sub-Saharan Africa macro results

	Full trade liberalization in SSA	50% increase in SSA transport TFP
	------ percent change over the base ------	
Real GDP	2.82	5.26
Real agricultural GDP	1.52	9.63
Total agricultural production	0.16	7.63
Food consumption	-0.37	5.14
Total agricultural exports	18.8	27.7
Exports to EU and US	18.0	27.9
Total agricultural imports	24.3	11.7
Intra-SSA imports	53.2	22.4
Food prices	-0.71	0.34

In Scenario 2, to explore the significance of improving infrastructure to reduce marketing and transaction costs within countries and the subsequent positive spillover effects on neighboring countries, we chose Mozambique and Malawi as examples for the analysis. As a landlocked country, all Malawian exports and imports have to transit through neighboring countries, mainly South Africa and Mozambique (coastal countries). Improving the efficiency of the Mozambique transport sector not only reduces Mozambique marketing costs but also benefits Malawi. We simulate such effects by increasing total factor productivity (TFP) in the Mozambique transport sector by 50%, which causes per unit of transport service cost in trade (including goods both imported and exported by Mozambique and transiting to other countries) to fall. This benefits all production sectors in Mozambique for which transport services are an intermediate input. The benefits for traded commodities are much larger, as the transport margins that lower the prices received by producers and inflate the prices paid by consumers are reduced. The direct benefit to the Mozambican economy from the 50% increase in transport TFP is a 7% increase 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 for agricultural producers and consumers are comparable, both increasing by 6%.

Table 3: Reducing Mozambique transaction costs scenarios: Macro results for Mozambique and Malawi

	Mozambique	Malawi
	------ percent change over the base ------	
Real GDP	6.6	1.8
Real agricultural GDP	6.9	3.0
Total agricultural production	5.9	2.6
Food consumption	5.9	1.4
Total agricultural exports	15.7	7.1
Total agricultural imports	15.4	17.7

Simultaneously, reducing Mozambique's transport costs indirectly benefits the Malawian economy through the channel of lowered cost on transit trade. That is, import prices faced by Malawian importers will fall and export prices will rise. Agricultural exports increase by 7%, while imports increase by 18% in Malawi owing to the improvement in infrastructure. Malawi's real GDP increases by 2%, and farm incomes, agricultural output and food consumption also rise because of the reduced marketing costs.

In Scenario 3 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 transport sector for all African countries by 50%, except for South Africa. Given South Africa's relatively more advanced technological status, we assume that its transport sector is initially more efficient than that of the other countries. Thus, a smaller increase (30%) in the transport sector is assumed for South Africa.

Improving the transport 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. The region's total GDP increases by 5.3%, and agricultural real income increases by 9.6% (Table 2, second column). For the region as a whole, both producers and consumers benefit: total food consumption increases by 5.1%, though 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 the direct benefits of a country's own marketing cost reduction from the indirect benefits through reduced trade margins in neighboring countries in a general equilibrium model, more than 20% of the increase in intra-regional agricultural trade and 30% of the increase in agricultural exports for all of sub-Saharan Africa stresses the significant cross-country benefits to be gained from regional cooperation to reduce marketing costs. Investments in road networks and harmonization of regional agricultural commodity and input market policies and regulations can both help to reduce marketing costs at both the country and sub-regional level.

The results of the second and third scenarios suggest strong cross-sectoral links between African agriculture and non-agriculture, especially transport 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.

4. Conclusions and policy implications

Both the theory and empirical evidence clearly suggest that regional cooperation and knowledge spillovers across borders have an impact on the economic welfare and growth rates of neighboring countries. Countries can take advantage of economies of scale and scope: by achieving a critical mass of R&D investments 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).

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 Africa will, however, also require investments that strengthen links 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 links between sub-Saharan African countries through infrastructure development or expansion of intra-regional trade can generate significant growth spillovers and enhance regional take-off. The endogenous growth theory was employed to show that pursuing regional integration and providing regional public goods would enable sub-Saharan African countries to reap the benefits of economies of scale through the enlargement of markets.

To illustrate the potential benefits from spillovers arising from research and development, a simulation model was used to show that, for some key commodities within the ECA, spillover multiplier effects on economic welfare under certain conditions can be quite high from permitting cross-border technology transfer and adoption. This is shown to be potentially the case for mutton, groundnuts and sorghum. Not only do the benefits to the region increase by more than half because of spillovers, the benefits accruing to non-innovating countries can be quite large, accounting for about 80% of the total regional benefits for these commodities. On the other hand, spillover gains from technology improvements in cassava and coffee production may only benefit fewer, but large, neighboring countries. Overall, there is potentially wider geographic scope and scale in spillover gains outside the three innovating countries for commodities such as mutton, sorghum, dairy products and beef.

The results illustrated in this example help to highlight the potential for large gains from regionally focused technology programs that take advantage of existing R&D investments in a few focus countries, especially when they have a high potential for adaptation in many more countries. In other words, any regional policy designed to maximize the size of technology spillover gains to the region should also consider the variation of spillover gains across countries.

The ability of individual countries to take advantage of spillovers will depend on other factors, such as the degree of research adaptation, extension and/or farmer-to-farmer information sharing. Countries therefore need to be actively engaged in acquiring the benefits associated with spillovers. As there are costs associated with the exploitation of spillovers, it should be part of policy to reduce these costs to enable individual countries take full advantage of spillovers. Such measures could include language training, communication networks and specialized training for technology adaptation and extension.

Given that poor infrastructure and institutional barriers have obliged African countries to further exploit their comparative advantage and strengthen their economic links, a series of CGE model simulations were carried out to show how sub-Saharan African countries could benefit from trade liberalization and infrastructure improvement in the region. The 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 transport sector's TFP generates the most encouraging results, increasing agricultural income by 9.6% and total food consumption by 5.1%. These findings indicate that 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 on investment in infrastructure and therefore choose sub-optimal levels of investment in it. A coordinated regional program could help ensure 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 also deal with incentive problems related to their own political imperatives and local constituents. Ultimately, regional cooperation will require good leadership and, over time, a convergence in political and economic principles. The persistence today of insecurity and civil conflict is a clear sign of this need, especially as it also continues to 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 cooperate regionally in public investments in infrastructure and R&D and coordinated responses to conflicts, and make concerted efforts

to converge political and economic principals over time, including improved governance and accountability.

Fortunately, some of this has already begun with the formation of regional organizations (RECs) that increasingly give more emphasis to the common market formula. These organizations provide for the movement of resources and factors of production so as to more efficiently exploit existing resource complementarities and regional economies of scale in public goods infrastructure (such as communications, roads and energy), to facilitate technology spillovers across national boundaries, and to harmonize economic policies in support of regional production and market integration.[9] In some cases, the RECS have been used to deal with negative spillovers from civil wars.

The primary challenge for these efforts at regional cooperation and harmonization is to create sufficient incentives for member countries to strive for the common goal of economic growth and development. So long as members perceive the expected benefits as public goods, there is the potential for users to conceal their true preferences, wait for the benefits 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 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. What the current incentives are is not very clear and is beyond the scope of the current study. However, it is certainly an important topic that deserves further research.

Despite these 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 to ensure that many of the regional economic communities will become building blocks for integration, to ultimately create larger and more attractive market and investment opportunities in the region.

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[9] Overall, there are 14 RECs of varying design, scope and objectives, with seven of them dominating the integration landscape. These are the Arab Maghreb Union (AMU), with five members; the Common Market for Eastern and Southern Africa (COMESA), with 20 members; the Economic Community of Central African States (ECCAS), with ten 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 seven members; and the Community of Sahel-Saharan States (CEN-SAD), with 18 members.

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