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Exploring Growth Linkages and Market Opportunities for Agriculture in Southern Africa

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ABSTRACT

Considering the heterogeneity of the countries of southern Africa and the presence of South Africa and other middle-income countries in the region, southern Africa has a unique opportunity to exploit agricultural potential and regional trade opportunities through regional dynamics and integration. We analyze the implications of such opportunities for the growth of the low-income countries, using a regional general equilibrium model that captures growth linkages. We find that growth in the middle-income southern African countries, such as South Africa, benefits the region's low-income countries through increased demand for their agricultural exports. Agricultural productivity growth, however, is necessary for low-income countries to take advantage of South Africa's growth. Productivity growth in the low-income countries' grain and livestock sectors generates more growth in GDP and food consumption than growth in nontraditional export crops. Unlike other regions where growth in grain production is likely to be constrained by domestic demand, expanding middle-income economies in southern Africa provide additional demand for grains and livestock, slowing the decline in grain prices in the region.

EXPLORING GROWTH LINKAGES AND MARKET OPPORTUNITIES FOR AGRICULTURE IN SOUTHERN AFRICA

Alejandro Nin Pratt and Xinshen Diao [1]

I. INTRODUCTION

Strengthening regional economic linkages that offer mutual benefits across countries is an important part of development strategies in Sub-Saharan Africa, leading to economic growth and poverty reduction. Regionalism, in fact, has received increasing attention as a result of growing fears in Africa and in the international community of African marginalization in the global economy. As a result, several regional initiatives have been developed across the continent, in particular in southern Africa. The need for the creation of institutional frameworks and programs that can improve food security in the region has been central to cooperation efforts through regional schemes such as the Common Market for Eastern and Southern Africa (COMESA), the Southern Africa Development Community (SADC), and the Southern Africa Custom Union (SACU).[2] Efforts by SADC and COMESA to establish a free trade area (FTA) and customs unions are all steps in moving toward an economic area that ultimately allows the free movement of people, goods, and services, as well as factors of production (capital and labor). Both the SADC and COMESA schemes have tried to address critical issues such as removal of tariff and nontariff barriers; development of rules of origin; cooperation in customs administration, technical standards, and sanitary and phytosanitary standards; and promotion of cross-border investment.

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[2] COMESA member countries are Angola, Burundi, Comoros, the Democratic Republic of Congo (DRC), Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, Swaziland, Uganda, Zambia, and Zimbabwe. SADC member countries are Angola, Botswana, DRC, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. SACU member countries are Botswana, Lesotho, Namibia, South Africa, and Swaziland.

Progress has also been made in improving the region's road network. Through SADC's Transport, Communication, and Meteorology Protocol, for example, member countries are harmonizing road design standards; adopting standardized road traffic signs, drivers' training manuals, and engineering specifications for road and bridge construction; and rehabilitating major transport corridors such as the Maputo Development Corridor and the Trans-Kalahari Corridor.[3] Investments in the region have also been growing, as South African service and manufacturing companies, including supermarket chains like Shoprite and Pick 'n Pay, have expanded to other countries in the region.

Despite the progress being made, the region is still a long way from taking full advantage of the opportunities to further integrate and stimulate economic development. Food deficits are still an issue in the low-income countries in the region, with productivity of cereal production still below the African average. Increased investments are needed if countries are to reap greater benefits from FTAs and to further the integration process. Foreign direct investment (FDI) inflows have lagged because individual countries have small markets, weak infrastructure, and unfavorable investment climates caused by civil wars, political unrest, and currency instability. Poorly functioning markets also lead to high transaction costs. Although southern Africa has well-established transportation corridors, transport costs remain excessively high: they have been estimated to be 30–40 percent of valued added of goods sold in the subregion (Kritzinger-van Niekerk and Moreira 2002). Several studies consistently show that high transportation costs act as a restrictive barrier to increased trade and capital flows (Yeats and Amjadi 1999; Busse 2003; Amjadi, and Yeats 1995).

In this context, the key question is what opportunities do regional integration and cooperation offer southern African countries for growth and poverty alleviation? There are at least four areas in which southern African countries can benefit from regional integration and cooperation: (1) the economic diversity of the region, (2) regional food security, (3) regional infrastructure, and (4) trade and investment. Other issues like

[3] SADC drivers' licenses have been issued in eight countries.

HIV/AIDS and armed and political strife are also areas where integration could play an important role. This study focuses on the economic linkages between middle- and low-income countries, given that southern Africa is the only region on the continent where there are a number of middle- and low-income countries in close proximity to each other.

Differences in income level often represent differences in development stages. Thus, southern Africa's economic diversity is generally viewed as a key reason for promoting greater regional integration for stimulating growth and poverty reduction. Per capita incomes in the region vary widely, and benefits from greater regional integration are expected to come from the natural role South Africa can play as an engine of growth for the region, both in terms of providing a dynamic market for regional exports and a source of investment and technology diffusion.

Many countries in southern Africa have relatively small agricultural sectors either because their economies are more advanced and diversified, or because they have a high dependency on mineral resources: Angola, Botswana, Namibia, South Africa, Swaziland. Agriculture, however, remains the primary source of employment and income in the region's low-income countries – Malawi, Mozambique, Zambia, and Zimbabwe. In these countries, poverty and hunger are still predominantly rural phenomena. Most southern African countries still have unexploited agricultural potential, especially Angola, northern Zambia, northern Mozambique, and Zimbabwe. Combining this potential with the pro-poor feature of agricultural-led growth suggests that agriculture can play a central role in reducing poverty in the region. Given that some national investments will generate positive externalities and spillovers to the neighboring countries, increased efficiency gains could be obtained from regional investment strategies, especially from investments in research and development.

Here we analyze the economic linkages in southern Africa and the implications of such linkages for the growth of low-income countries, using a regional general equilibrium model developed for this study. We find that growth in the middle-income southern African countries benefits the low-income countries in the region through increased demand for their agricultural exports. Agricultural productivity growth,

however, is necessary for low-income countries to take advantage of South Africa's being a growth pole for the region. Productivity growth in the low-income countries' grain and livestock sectors generates more growth in gross domestic product (GDP) and food consumption than growth in the nontraditional export crops. Unlike other regions where growth in grain production is likely to be constrained by limited domestic demand, growing middle-income economies in southern Africa provide additional demand for grains and livestock, slowing the decline of grain prices in the region.

The rest of this paper is organized as follows: section 2 focuses on the characteristics of southern African economies. We estimate a measure of comparative advantage in trade and use it to determine trade complementarity between countries in the region in order to assess the potential for expanding regional trade. Section 3 presents the regional computable general equilibrium (CGE) model and the model simulation results, focusing on different subsectors' potential contributions to food security, economy-wide growth, and trade expansion. Section 4 provides recommendations and conclusions of the study. Appendix A comprises a set of supplementary tables, and Appendix B presents the variables and equations that make up the CGE model.

II. AGRICULTURE IN THE SOUTHERN AFRICAN ECONOMY

The Role of Agriculture in the Economy: Low- versus Middle-Income Groups

The theoretical and empirical literature suggests that the role of agriculture in the economy is highly related to a country's stage of development (Johnston and Mellor 1961; Block and Timmer 1994; Kydd et al. 2004; Hazell 2005). Using per capita income as a proxy for development, the 11 southern African countries can be classified into two groups (Table 1): six countries belong to the middle-income group and the remaining five are in the low-income group. According to the World Bank definition, annual GDP per capita in the middle-income group was more than $735 in 2002. Of the five countries in the low-income group, two actually moved down from being middle-income countries in the early 1980s (Zambia and Zimbabwe). As middle-income countries account for more than 40 percent of southern Africa's total population, the region as a whole had average annual per capita income of $1,510 in 2002— much higher than that of other Sub-Saharan African countries (many of which have per capita income below $300). The agriculture sector accounts for only 3 percent of total GDP for the region's middle-income countries as a group, but accounts for 20 percent of total low-income countries' GDP. There is only one country – Malawi—in which agriculture's 34 percent share in GDP is above the average (31 percent) for all low-income Sub-Saharan African countries as a group.

Despite relatively small agricultural sectors, most southern African countries have large rural populations, accounting for 48 percent of population in middle-income countries and 68 percent in low-income countries. Moreover, the poverty rate is just as high as in other Sub-Saharan African countries, including in middle-income southern African countries such as Botswana, Namibia, and Swaziland. In these countries, a vast majority of the poor live in rural areas and are dependent on agricultural incomes. Although Swaziland has diversified its manufacturing sector since the mid-1980s, with sugar and wood pulp now main foreign exchange earners, subsistence agriculture still occupies more than 80 percent of its population, with farmers facing problems of

overgrazing, soil depletion, and drought. In the case of Namibia, the economy is heavily dependent on the extraction and processing of minerals for export (diamonds, uranium, lead, zinc, tin, silver, and tungsten), but the mining sector employs only about 3 percent of the national labor force. Seventy-five percent of its people depend on low-productivity, subsistence agriculture, cash transfer pensions, and wage income on commercial farms for their livelihoods (Stone and Gaomab 1994). In Botswana, unemployment officially stands at 24 percent, but unofficial estimates place it closer to 40 percent despite the country's high economic growth rates since independence in 1966 (CIA 2006). Therefore, while agriculture may not be a dominant sector in the region, it still plays an important role in reducing poverty.

Table 1. Income and Poverty for Southern African Countries

Country	GDP Per Capita[c]	Rural Population[c]	Poverty Head Count[a]		AgGDP[c]
	US$	(%)	(%)	Year	(%)
Middle-income countries [b]	2,520	48.1	24.9	-	3.4
Mauritius	4,073	58.1	10.2	1992	6.4
Botswana	3,372	50.1	30.7	1993	2.5
South Africa	3,002	41.6	10.7	2000	2.8
Namibia	1,805	68.1	34.9	1993	8.7
Swaziland	1,350	72.9	40.0	1995	9.5
Angola	803	64.5	72.0		6.4
Low-income countries [b]	310	67.9	47.8	-	19.9
Lesotho	518	70.5	36.4	1995	15.1
Zimbabwe	479	63.3	56.1	1995	15.4
Zambia	342	59.9	63.5	1998	17.6
Mozambique	243	65.6	37.9	1996	24.0
Malawi	154	84.5	41.6	1997	33.6
Southern Africa	1,510	57.1	35.4	-	4.9
Sub-Saharan Africa	509	64.0	51.0	-	17.5
Sub-Saharan Africa, not including Southern Africa	297	65.9	54.5	-	31.0

[a] Poverty headcount ratio at $1 a day (PPP) (% of population). Poverty head count for Swaziland is from FAOSTAT, Food Security Statistics.

[b] Weighted averages. Low-income countries are Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe. Middle-income countries are Angola, Botswana, Mauritius, Namibia, South Africa, and Swaziland.

c Year 2002

Source: World Bank World Development Indicators 2005.

To better understand the role of agriculture in the region, it is necessary to distinguish among countries according to a range of indicators that reflect agricultural potential and alternative sources of growth. Agricultural potential draws on a classificatory scheme developed by Dixon, Gulliver, and Gibbon (2001), which includes measures such as agro-ecological conditions and population densities. According to these indicators, all five low-income southern African countries have agricultural potential. However, even in countries where conditions are favorable, agriculture competes with other sectors for limited resources. Countries with rich mineral or oil endowments may have alternative sources of growth. And coastal countries may have advantages in export-oriented agriculture or greater opportunities in nonagriculture. Therefore, we will discuss the five low-income countries according to whether they are coastal, land-locked, or mineral-rich.

Mozambique is the only coastal country among the five low-income southern African countries. The country has relatively favorable agricultural conditions and few natural barriers to trade. While coastal countries may have better potential for export-led agricultural growth, opportunities from nonagricultural sectors may create alternative growth options. Indeed, Mozambique's GDP expanded at an annual rate of 5.7 percent between 1985 and 2002, with growth driven by both agricultural and nonagricultural sectors (Table 2). However, the country is one of the two poorest southern African countries, with annual per capita income below $250. More than 60 percent of Mozambique's population lives in rural areas, and most of the poor depend on agriculture for their living. Hence, Mozambique needs a growing agricultural sector to sustain growth. While a 5.3 percent rate of annual growth in agriculture between 1985 and 2002 is higher than most countries in the region or in Sub-Saharan Africa, agricultural growth seems to have slowed down in recent years.

Our analysis includes three land-locked, low-income countries: Lesotho, Malawi, and Zimbabwe. While being land-locked can represent a significant natural barrier to trade and undermine export opportunities, integration with neighboring countries can actually overcome such barriers. As the poorest country in the region, Malawi has the

highest agricultural GDP share (34 percent) and rural population share (85 percent). Moreover, agricultural growth is the main driver for the overall economic growth. Extremely low growth in the nonagricultural sectors during 1985–2002 resulted in an annual growth rate of GDP of only 2.36 percent and negligible growth in per capita terms (Table 2).

Table 2. Growth Decomposition by Sector in the Low Income Southern African Countries (Average 1985-2002)

Country	Share in GDP in 1985 (%)			Growth Rate (%)				Contribution to GDP Growth (%)		
	Agriculture	Industry	Services	Agriculture	Industry	Services	GDP	Agriculture	Industry	Services
Low-income countries [a]	31.1	25.8	43.2	2.7	1.8	2.7	2.4	34.2	18.5	47.2
Coastal										
Mozambique	47.5	13.2	39.3	5.3	8.12	5.1	5.7	44.8	19.2	36.0
Land-locked										
Lesotho	22.7	27.2	50.0	1.8	5.9	3.7	3.9	10.8	41.7	47.5
Malawi	42.9	21.9	35.2	3.6	1.1	2.1	2.4	61.3	9.1	29.5
Zimbabwe	22.7	28.0	49.3	1.0	-0.2	2.3	1.0	17.0	-3.8	86.8
Mineral-based										
Zambia	14.6	46.8	38.6	2.2	0.0	1.9	1.3	30.6	-1.8	71.2

a/ Weighted averages. Low-income countries are Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe.
Source: World Bank. World Development Indicators 2005

The other two land-locked countries, Lesotho and Zimbabwe, together with the mineral-rich country, Zambia, have evolved in different ways. Although Lesotho's economy is still primarily based on subsistence agriculture, especially livestock, it has developed a small manufacturing sector based on farm products and a rapidly expanding apparel assembly sector. The latter has grown significantly, mainly because Lesotho qualifies for trade benefits under the Africa Growth and Opportunity Act (Lesotho, Kingdom of 2006). Despite their earlier status as middle-income countries, Zimbabwe and Zambia's agricultural sectors and economies as a whole have performed the worst for various reasons, mainly political instability and conflicts. Since the agricultural GDP of

these two countries accounts for almost 20 percent of the region's total, the poor performance of their agricultural sectors has adversely affected southern Africa's total agricultural growth. The contribution of agriculture to total GDP growth in these countries has resulted in a low 2.7 percent growth of annual agricultural GDP for the low-income southern African countries as a group. However, Malawi and Mozambique had annual GDP growth rates of 3.6 and 5.3 percent, respectively, during this period.

Disappointing 20 Years for Southern Africa's Agricultural Performance

In southern Africa, food staple production is the dominant agricultural activity. More than 50 percent of agricultural land is allocated to cereals, while maize alone accounts for more than 40 percent of the total harvested area (see Appendix Table A.1). Roots and tubers currently account for 8 percent of the total crop area for the low-income countries as a group. In total, the staple crops occupy almost 66 percent of crop land in the low-income group, leaving just over 30 percent of land for other crops, mainly traditional exportables such as cotton (7 percent); tobacco, tea, coffee, spices, and sugar (5 percent); oilseeds (10 percent); and fruits and vegetables and pulses (11 percent).

The composition of the animal stock shows that more than 70 percent of the animals are beef and dairy cattle in both low-and middle-income countries. The share of poultry in total animal stock grew steadily between 1985 and 2002; chicken currently represents 10 percent of the total animal stock in the region, compared with only 2 percent in 1977–81.

Revenue from crops represents two-thirds of regional agricultural revenue, with middle-income countries producing almost 65 percent of cereals, 80 percent of fruits and vegetables, and more than 80 percent of beef and poultry meat (Appendix Table A.2). The region produced 2.6 million tons of meat and 3.6 million tons of milk in 2002, 70 percent of which was produced by South Africa. But low-income countries produce 60 percent of roots and tubers and 80 percent of traditional exportable crops (tobacco, coffee, and tea).

Although the region allocates 50 percent of agricultural land to cereal production, southern Africa as a whole has become a grain-deficit region in recent years. Cereal imports increased from 12 percent of cereal demand in 1977–81 to 22 percent in 1998–2002, with a gap between demand and production of 20 percent in low-income countries and 17 percent in middle-income countries (Appendix Tables A.3 and A.4). Moreover, 10 of the 11 southern African countries, all except South Africa, currently are maize-deficit countries, and the deficits in the five low-income countries ranged from 42 percent of domestic consumption in Lesotho to 6 percent in Zimbabwe between 1998 and 2002.

Stagnant productivity growth in agriculture is the main factor that caused the region to become dependent on food imports. Compared with 1981, the land area allocated to maize in 2002 increased by more than 30 percent in the low-income country group. Although land allocated to cereal and maize production fell in the middle-income group, the region's total area allocated to cereals still increased in this period. Despite this, total cereal as well as maize production decreased (Appendix Table A.5). With strong population growth throughout the region and increased per capita income in some middle-income countries, food demand for cereals has increased by 50 percent in the past 20 years. These two factors working together have shifted the region from a grain surplus in the early 1980s to a grain deficit in recent years.

In addition to the deficits in cereal supply, food security is under pressure from increasing populations. When government support policies for maize and other cereals were removed after the implementation of the structural adjustment programs in the late 1980s, root and tuber production in the low-income southern African countries increased. Moreover, unlike the cereal sector, productivity growth in roots and tubers seems to be quite successful in many southern African countries. While total production area of roots and tubers increased by 50 percent over the last 20 years, their output increased by more than 150 percent in the same period, which significantly contributed to the food security of many poor, rural households.

The livestock sector has performed better than the grain sector in the region. Compared with the average for 1977–81, the region's total meat production has increased

by 1.92 percent per year on average over the past 20 years. However, demand has grown more rapidly, at 2.57 percent per year in the same period. Thus, the region has shifted from a meat surplus in the early 1980s (with net exports accounting for more than 6 percent of total production in 1978–81) to a deficit (Appendix Table A.6). In the low-income group, 14 percent of the milk consumed and 6 percent of the poultry meat consumed is imported every year. For the region as a whole, 11 percent of the meat and 17 percent of the milk consumed is imported (1998–2002 average).

Opportunities to Expand Regional Trade

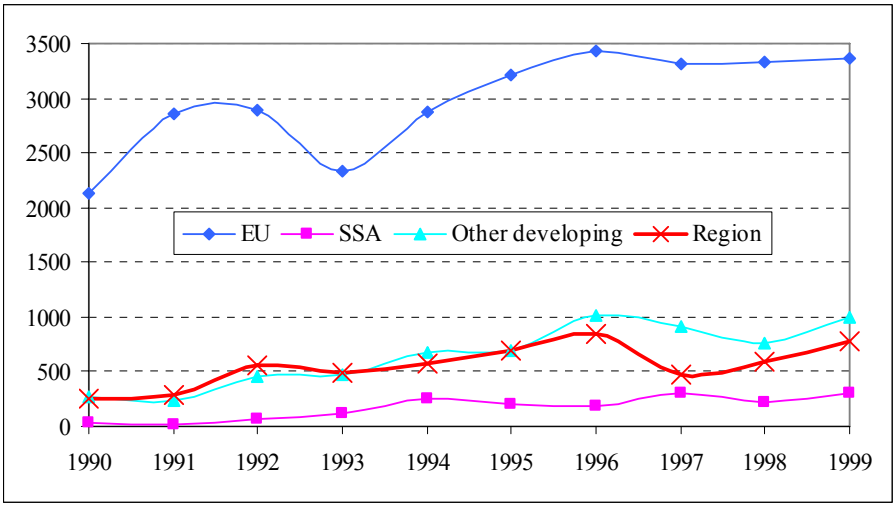
As mentioned earlier, regional schemes to foster cooperation among southern African countries, such as COMESA, SADC, and SACU, have placed great importance on integration in the region's development strategy. In this context, removal of tariffs is an important issue in the region because tariffs affect trade between middle- and low-income countries that do not belong to SACU (such as Malawi, Mozambique, Zambia, and Zimbabwe). On the one hand, South Africa imposes high tariffs on imports of dairy products, cereals, and textiles—sectors with potential for low-income countries in the region to increase exports. On the other hand, the low-income countries impose high tariffs on textiles, fruits, vegetables, and processed food products—sectors with potential for intraregional trade (Appendix Table A.7).[4] The elimination of agricultural tariffs among SADC countries would benefit the region in terms of real agricultural GDP, national income, and agricultural output (see, for example, Diao and Robinson 2003; Karingi, Siriwardana, and Ronge 2002).

However, tariffs are not the only obstacle to increased regional trade. The analysis of integration in southern Africa goes beyond trade liberalization; to explain low trade in the region, several studies have stressed the importance of transport and transaction costs and the lack of diversification in comparative advantages (see, for example, Chauvin and Gaulier 2002; Cassim 2000; Davies 1996; Geda and Kibret 2002; Goldstein 2004; Holden 1996; Jenkins, Leape, and Thomas 2000; Longo and Sekkat, 2001; Radelet

[4] Zambia is an exception, with lower tariffs on these products than other low-income countries in the region.

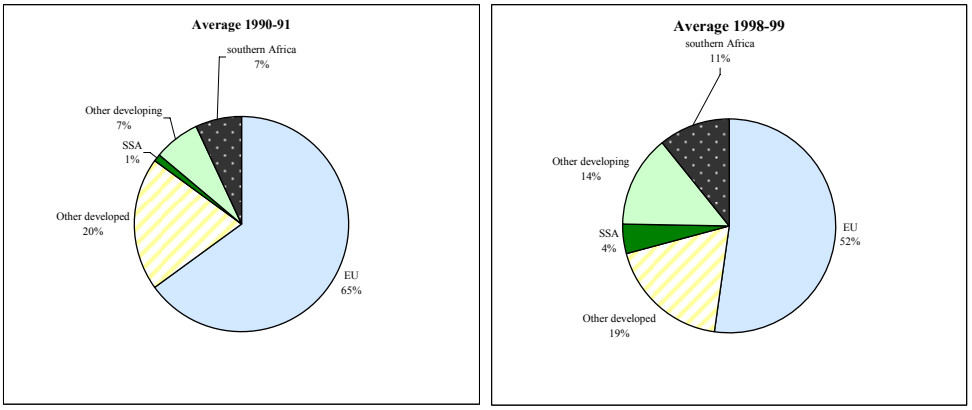
1997). This study departs from previous analysis, focusing on regional economic linkages and the implications of such linkages for the growth of low-income countries. Although we recognize the impact of trade and investment policies on productivity and economic growth, a more sophisticated intertemporal dynamic model is needed to fully take into account the endogenous linkages between these policies and economy wide growth at the individual country level (see for example, Diao 2001). The development of this model is beyond the scope of this study and will be the focus of authors' future research efforts.

Figure 1. Exports from Southern African Countries to Different Destinations, 1990–99 (US$ million, current prices)



Source: Authors' calculations from COMTRADE data.

Figure 2. Shares of Destination Regions in Southern African Agricultural Exports



Source: Authors' calculations from COMTRADE data.

In this section, we focus on the recent evolution of regional trade, using historical data to analyze comparative advantage and trade complementarity and assess the potential to expand regional trade in southern Africa. Regional trade saw a significant expansion during the 1990s (Figures 1 and 2). While total agricultural exports from the region expanded at a rate of 7.5 percent a year, intra-southern African exports grew by 13 percent annually between 1990 and 1999, resulting in increased intraregional trade shares for agricultural commodities (rising from 7 percent in 1990 to 11 percent in 1999). While Organization for Economic Cooperation and Development (OECD) countries are still the most important trade partners of southern Africa, a new trend seems to be developing whereby southern African exports are shifting to the markets in developing countries, including Asian markets and regional markets in southern Africa and in Sub-Saharan Africa in general. The share of OECD countries in the region's total exports fell to 70 percent in 1999, from 85 percent in 1990. The expansion of regional trade is associated with South Africa's increasing involvement in the region since the country was readmitted to the global economic community in 1994. Since then, South Africa has been an active investor in all SADC countries, accounting for 25 percent of total foreign direct investment (FDI) flowing into the SADC region (Rumney and Pingo 2004). South Africa has also increased its trade with its neighbors since 1994. About 75 percent of regional export expansion is explained by increased exports from South Africa,[5] while Mozambique, Zimbabwe, and Zambia together explain the remaining 30 percent (Table 3). On the import side, only 9 percent of import growth is explained by South Africa. Mozambique, Zimbabwe, Zambia, and Angola explain almost 80 percent of the increase in imports. While SACU significantly expanded net exports to the region, other exporting countries like Mozambique, Zambia, and Zimbabwe experienced a reduction in net exports to the region. In 1990, South Africa was a net importer in the region (with net imports of US$58 million). By the end of the decade, South Africa had become a net exporter to the region with US$317 millions of net exports, while all other countries saw large increases in their imports from South Africa. In particular, Zimbabwe, which was

[5] No disaggregated data of trade of SACU countries are available, but SACU trade in the region is mainly explained by South Africa

the only net exporter to the region in 1990, is still a net exporter but in a decade, its net exports were reduced to half of their 1990 value.

Table 3. Intraregional Agricultural Trade in Southern Africa (US$ million)

Country	Exports			Imports		
	1990	1999	Increase	1990	1999	Increase
Angola	0.1	0.1	0.0	9.9	87.7	77.8
Malawi	34.7	24.0	-10.7	31.5	79.5	48.1
Mauritius	1.4	1.8	0.3	33.6	77.8	44.3
Mozambique	0.1	27.6	27.5	41.5	176.3	134.9
South Africa[a]	67.9	493.2	425.3	125.7	176.2	50.5
Zambia	3.1	46.1	43.1	8.1	75.2	67.2
Zimbabwe	165.4	243.6	78.2	22.5	163.6	141.1
Total	272.8	836.5	563.7	272.8	836.5	563.7

a/ Trade of SACU countries, mainly South Africa's trade
Source: Authors' calculations using COMTRADE 2005 data

To give us a better sense of the importance of the regional market for southern African countries, we measure trade intensity in Table 4. Trade intensity measures show that there are strong trade linkages between countries in the region given that the share of trade going to the region is much larger than expected, according to the share of the region in total world trade. The exception is Angola, which shows weak linkages with southern African countries, while it appears to be overtrading with other African countries given that its trade share with these countries is larger than the share of these countries in total world trade. In contrast with their exports to the region, all countries (except Mauritius) show low export intensity to high-income countries and other regions, while most countries overtrade with the rest of Sub-Saharan Africa. The dominant role of South Africa as an exporter in the region can be seen in the bilateral trade intensity measures presented in Table 4, where South Africa's export intensity is always larger than that of any of its trade partners. For instance, the intensity of South Africa's exports to Angola is 17.0, while the intensity of Angola's exports to South Africa is only 1.2; similar results are obtained by comparing South Africa's export intensity with that of other countries.

Table 4. Southern African Countries' Agricultural Export Intensity in Different Markets, 1999

	Import Markets			Southern Africa							
Country	**EU**	**Other Developed Countries**	**Rest of SSA**	**Angola**	**Malawi**	**Mauritius**	**Mozambique**	**South Africa**	**Zambia**	**Zimbabwe**	**Region**
Angola	0.8	0.2	9.4	-	0.0	0.0	0.0	1.2	0.0	1.5	0.8
Malawi	0.6	0.8	0.9	0.0	-	0.7	4.9	19.8	21.0	36.1	13.2
Mauritius	1.0	0.2	2.7	0.0	17.8	-	1.3	0.8	1.0	5.3	1.2
Mozambique	0.6	0.6	0.9	0.3	43.1	2.2	-	15.5	0.8	37.7	12.9
South Africa[a]	0.6	0.5	2.7	17.0	52.1	16.6	42.2	-	44.9	45.0	12.2
Zambia	0.7	0.1	7.4	0.6	147.1	1.4	4.0	28.8	-	202.9	33.2
Zimbabwe	0.6	0.2	2.0	6.5	136.6	4.7	70.7	36.9	171.3	-	31.8

Note: Anderson and Norheim (1998) define the index of trade intensity between a specific country and a group of countries (region) as:

$$I_{ij} = \frac{x_{ij}}{m_j} = \frac{x_{ij}}{(q_j \times r_j)}$$

where x_{ij} is the share of country i's exports going to country group j; m_j is the share of group j in world imports (net of country i's); q_j is the share of country j in world GDP; and r_j is j's import-to-GDP ratio divided by the world's (net of country i's) import-to-GDP ratio. If there is no regional bias, that is, if the share of trade from country i going to region j is equal to the share of j total imports in world trade, then the index will have a value of 1.

[a]/ Trade of SACU countries, mainly South Africa's trade

Source: Authors' calculations from COMTRADE 2005 data

In order to analyze the possibilities for expanding regional trade of agricultural products, it is important to identify the commodities in which countries in the region have comparative advantages and disadvantages. Greater possibilities for regional trade expansion exist for those commodities in which some countries have comparative advantages while others have comparative disadvantages (complementarity). We use the revealed comparative advantage (RCA) indicator for such analysis. The index is measured by the ratio of exports for a specific commodity in a country's total exports, relative to the share of this commodity's trade in world total trade. We assume that if the value of the index is greater than 2 (the share of the good in the country's exports is twice the share of this good in world trade), the country has a strong revealed comparative

advantage in exporting that commodity. If the value of the index is less than –2 the country is considered to have a strong comparative disadvantage in that good.[6]

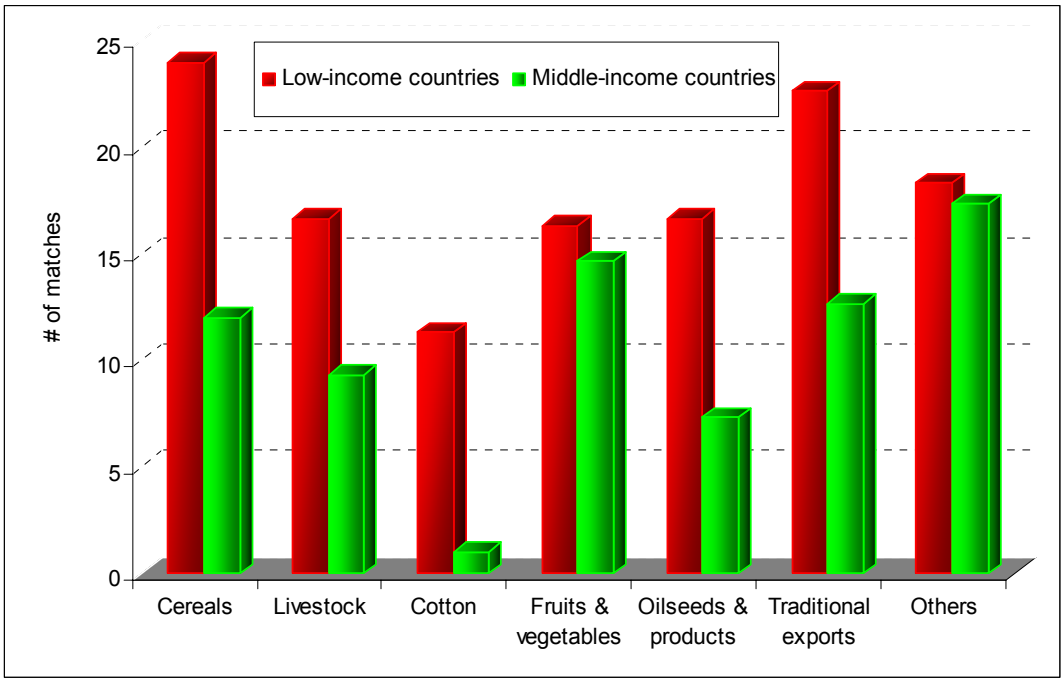
The RCA indices are used to analyze trade complementarities between countries. It is expected that countries with different comparative advantage profiles would have, in general, more opportunities to trade than countries with similar specialization patterns. We use the number of matches between commodities with RCAs in one country (exporter) and commodities with revealed comparative disadvantages (RCD) in the other countries (importers) to verify the degree of potential trade complementarity in the region. Complementarity between exporters and importers is then measured by counting the matched number of commodities bilaterally (Table 5). Comparing the total number of commodities with RCA in each country that are matched by commodities with RCD in the region, it appears that Zimbabwe and South Africa are the countries with the best opportunities to increase exports of agricultural products to the region. Conversely, Mauritius, Angola, and Mozambique in that order are the countries with the largest number of commodities with comparative disadvantages for which other countries in the region show a comparative advantage. The number of matches between commodities with RCA and RCD shows that there are regional trade opportunities for cereals, traditional exports, fruits and vegetables, livestock, oilseeds and oils, and cotton (Figure 3).

[6] Following Ferto and Hubbard (2003), we use a global measure of relative trade advantage (RTA), which accounts for imports as well as exports. This measure is calculated as the difference between relative export advantage (RXA) and an index of relative import advantage (RMA) as follows:

$$RTA_{ik} = \left[x_i^k / x_w^k\right] - \left[m_i^k / m_w^k\right],$$

where x_i^k represents the share of exports of commodity *k* from country *i* in total *i*'s exports; m_i^k is the share of imports of commodity *k* in total imports of country *i*; and m_w^k is equal to x_w^k and represents the share of world total trade of commodity *k* in total value of world trade. Positive values of this measure reveal a comparative advantage in trade of commodity *k* by country *i*, while negative values show comparative disadvantages (RCD).

Figure 3. Number of Matches Between Southern African Countries with Comparative Advantage and Disadvantage for a Similar Commodity[a] (1997–99 Average)



Note: "Other" includes beverages, leather and wood products, fish, and raw materials.
Source: Authors' calculations from COMTRADE data.

In sum, the analysis shows that there are opportunities for the low-income countries to expand and diversify agricultural trade within southern Africa. Such opportunities are conditioned by the growth of South Africa, which will generate more demand for regional agricultural exports and opportunities for FDI going to low-income countries. However, the low-income countries also face challenges from growth in South Africa, as the unbalanced expansion of intraregional trade is mainly explained by growth in South Africa's exports. As discussed by Davies (2001), regional integration could exacerbate the tendency toward polarization, calling for an approach to integration with a developmental focus (Ramsamy 2001). Rather than trade integration alone, the region needs a program that combines trade integration, sectoral cooperation, and policy coordination to address the major challenges faced by the low-income countries (Davies 2001).

Table 5. Number of Matches Between a Country with Comparative Advantage and a Country with Comparative Disadvantage for a Similar Agricultural Commodity,[a] 1997–99 average

Exporters	Importers							
	Angola	Malawi	Mauritius	Mozambique	South Africa	Zambia	Zimbabwe	Total Matches Exporters
Angola	-	0.0	1.0	0.0	0.0	0.3	0.3	1.7
Malawi	4.3	-	5.3	4.7	2.0	1.7	2.3	20.3
Mauritius	2.7	1.7	-	2.0	0.3	1.7	1.0	9.3
Mozambique	2.7	1.3	6.7	-	1.3	1.7	3.3	17.0
South Africa	8.7	6.0	22.3	10.3	-	8.3	8.0	63.7
Zambia	3.0	4.0	6.7	3.7	2.0	-	3.0	22.3
Zimbabwe	10.3	11.7	13.7	13.0	5.3	12.3	-	66.3
Total matches importers	31.7	24.7	55.7	33.7	11.0	26.0	18.0	200.7

Note: a/ Five-digit level, SITC classification
b/ Trade of SACU countries, mainly South Africa's trade
Source: Authors' calculation using COMTRADE 2005 data

Regional Agricultural Growth Opportunities

The analysis of the main economic characteristics of southern Africa and the structure and evolution of agricultural production and trade in the region resulted in the identification of several characteristics that offer southern Africa special opportunities to foster development and agricultural growth through regional linkages. Here we highlight three of these characteristics: (1) complementarities between low- and middle-income economies and hence strong trade and investment linkages across countries, (2) unexploited agricultural growth potential, and (3) unexploited agricultural trade opportunities.

Southern Africa is the only region in the African continent with a number of middle- and low-income countries in close proximity to each other. South Africa is already the region's engine of growth, with per capita income of $3,002 per year, 38 percent of the region's total population, and more than 70 percent of its GDP. Furthermore, two other middle-income countries, Botswana and Mauritius, though relatively small, are seen as the most successful examples of economic development in

Africa. Obviously, economic development among the lower-income southern African countries and the fostering of agricultural growth depends critically on how these countries can best take advantage of a unique opportunity to benefit from the regional dynamics afforded by their more advanced neighbors.

South Africa could influence growth in other countries through different channels: international trade, spillover effects, FDI, and financial linkages. This country could also affect business and consumer confidence in other African countries, given the size of its economy and its leadership role in regional economic and political initiatives. Arora and Vamvakides (2005) econometrically estimate this potential effect using data for the period 1960–99. Their results indicate that an increase of 1 percentage point in South African economic growth is correlated with a 0.5–0.75 percentage point increase in growth in the rest of southern Africa.

Although South Africa has been a high-middle-income country since the 1970s, Apartheid and the sanctions that followed it effectively isolated it from the rest of the world and prompted policies aimed at ensuring self-sufficiency. For example, past subsidies of large-scale agriculture by South Africa's government have left the country with an extremely capital-intensive agricultural sector, which none of the neighboring countries' small-scale farms can compete against. However, the lifting of the sanctions in the early 1990s and the resulting resurgence of the South African economy have allowed the country to significantly increase its foreign trade, including trade with its SADC neighbors (Thurlow 2004). Further liberalization of capital markets during the late 1990s also caused huge capital outflows from South Africa into the SADC region and the rest of Africa. Many of these investments have been in agriculture or agriculture-related sectors. For example, South African supermarkets have created demand for high-value, locally produced products and have established supply chains both within and outside of the region. There have also been South African investments in roads, ports, and other market-related infrastructure in neighboring countries, which also improve market conditions for both agricultural and nonagricultural exports in the region as a whole.

Angola is another country that has potential to generate regional growth dynamics in southern Africa. Since its postwar economic recovery began some 10 years ago, Angola has averaged almost 7 percent in annual GDP growth. As a country rich in natural resources and with annual per capita income of $803, Angola depends on imports for most agricultural products. For example, almost 60 percent of the country's cereal demand has to be met by imports: for maize alone, 30 percent of domestic supply is imported. The country also imports 30 percent of the pulses consumed domestically, and these account for 20 percent of the region's total pulse imports.[7] If Angola's economy continues to grow rapidly in the coming years, it could become an important market for agricultural exports from other countries in the region.

Regional growth opportunities also come from the region's agricultural potential. However, the poor performance of the agricultural sector, mainly a result of bad policies or politically unstable environments, has constrained the region from exploiting its agricultural potential. For example, an urban bias in economic development policies that largely emphasizes the mineral sector has significantly hurt Zambia's agricultural growth (Thurlow and Wobst 2004). In Zimbabwe, recent political instability has resulted in declining agricultural production. While five-year average yields for maize production in Zambia and Zimbabwe were only 30–40 percent below South Africa's level during the early 1980s, the yield gap has increased to 50 percent in Zambia and 80 percent in Zimbabwe in recent years (2003–05) (Table 6). These and other failures to exploit the region's agricultural potential have been largely responsible for the transformation of southern Africa into a food-deficit region. A recovery of maize productivity to its historical highest level could significantly improve low-income countries' competitiveness and result in import substitution of maize, livestock, and other commodities, providing these countries with more growth opportunities in agriculture.

[7] In terms of Angola's demand for cash crops, all sugar consumed in the country is imported, which again accounts for 30 percent of the region's sugar imports. Furthermore, 13 percent of vegetables are imported, accounting for 17 percent of the regional vegetable trade. While the country has a relatively large livestock sector, domestic production could not meet domestic demand, even back in the late 1970s. In recent years, more than 33 percent of meat demand in the country has been met by imports, including 85 percent of the poultry consumed.

Table 6. Land Productivity in Low-income Southern Africa Compared to Land Productivity in South Africa (in kilograms/hectare)

	1979-81 average					2003-05 average				
	Malawi	Mozambique	Zambia	Zimbabwe	South Africa	Malawi	Mozambique	Zambia	Zimbabwe	South Africa
Maize	1,185	572	1,805	1,615	2,530	1,179	1,057	1,539	598	3,119
Wheat	1,152	1,150	3,488	4,782	1,101	675	1,088	6,429	3,925	2,211
Rice	1,153	811	510	588	2,308	1,306	1,079	1,190	2,400	2,286
Roots & tubers	6,397	4,157	6,630	3,823	12,002	14,457	5,965	5,747	4,876	27,537
Pulses	603	381	340	566	901	512	477	531	771	1,187
Oilcrops	197	167	164	193	347	202	151	120	123	473
Fruits	4,375	5,596	5,656	4,693	13,101	9,456	5,730	6,357	5,579	17,509
Vegetables	7,348	6,117	7,401	6,239	17,600	9,773	5,497	6,982	6,879	19,427
Cotton	872	406	526	1,538	1,373	871	435	1,127	681	2,021
Sugarcane	113,858	40,121	93,608	103,775	75,463	105,000	13,333	105,882	90,301	63,885
Tobacco	772	1,123	1,034	1,884	1,005	548	1,412	1,067	1,719	2,492

Source: Calculated from FAOSTAT 2006

Evidence of the potential importance of the other products for the region (such as fruits, vegetables, oilseeds, and cotton as nontraditional crops) can be derived from the expansion of trade of these products in the region and from growing regional investments in the value chains of production. South Africa's FDI to the region–mostly in mineral industries, services, and food retailing (such as supermarkets and fast food chains)–has been growing rapidly. Total South African FDI in Africa amounted to 3.33 billion dollars in 2001, 300 percent higher than in 1997. Most of this investment went to neighboring countries in southern Africa. Between 1994 and 2003, South African companies invested 2.8 billion dollars in Mozambique, while the DRC, Namibia, Zambia, and Zimbabwe also received large amounts (Rumney and Pingo 2004). Though most of the investment has gone to mining, basic steel and nonferrous industries, and utilities, a significant amount has been invested in food retail (see Weatherspoon and Reardon 2003). Although these investments are in turn helping to increase exports from South Africa, this is expected to change in the future, as the retail and agribusiness firms in each country increasingly

invest in local distribution networks and become dependent on local suppliers. Moreover, by incorporating local suppliers into regional value chains, domestic agricultural sectors could become more diversified, and even specialized, as regional trade flow increases.

As discussed by Nyirabu (2004), the major barriers to intraregional trade are not tariffs and nontariff regulatory regimes but underdeveloped production structure and inadequate infrastructure. The first of these factors is reflected in low productivity. Opportunities also exist in export agriculture. Oilseeds and textile fibers (cotton) appear to be the commodities with potential to expand exports from the region to SACU at present levels of productivity and competitiveness. More opportunities could result from increasing productivity and competitiveness of other crops. While the region exported 2.3 million tons of fruit and vegetables for a value of almost US$ 1 billion in 2002, 90 percent of these exports are from South Africa. At current technology levels, most low-income countries in the region can hardly compete with South Africa for such export markets. For example, average yields of fruit and vegetables in the region's low-income countries are only half that of South Africa and much larger gaps exist in the quality of many commodities. There also exist increased export opportunities in commodities that are traditional exportables in some countries but nontraditional in other countries. Cotton in Zambia is a good example: its cotton exports have increased sevenfold over the last two decades. Zambia now is the third largest cotton exporter in southern Africa (after Zimbabwe and Mozambique). And almost all of Zambia's cotton is produced by smallholders.

In sum, we have presented a number of distinctive characteristics of southern Africa's economy that together offer a unique opportunity to foster the region's economic development and agricultural growth through regional linkages. These characteristics include complementarities between low- and middle-income southern African economies, strong trade and investment linkages, and unexploited agricultural trade opportunities. The next section analyzes the potential impact of South Africa's economic growth for the region using a regional computable general equilibrium (CGE) model.

III. ANALYZING GROWTH LINKAGES IN SOUTHERN AFRICA

A Regional General Equilibrium Model for Southern Africa

The analysis of southern Africa's comparative advantage in agricultural trade in the previous section showed that nontraditional exports seem to offer the best opportunity to increase trade in the region. However, these results have limitations because they are obtained from historical data, during a period of low growth in South Africa and poor agricultural production and productivity growth in the low- income countries. The results are also limited because they do not allow us to compare the impact of different agricultural subsectors on economic growth in low-income countries or to identify growth linkages in the region. To evaluate fully the role of agricultural subsectors in economic growth and food security in the region, it is necessary to have an economy-wide view. Therefore, we present a regional general equilibrium model in this section and apply the model to assess how economic linkages in the region affect strategic options and priorities for agricultural development in southern Africa. A detailed description of the model can be found in Appendix B.

The Model and Data Description

The computable general equilibrium (CGE) model, as its name suggests, consists of an economy-wide, multisectoral model that solves simultaneously and endogenously for both quantities and prices. As the core of the model consists of the reconciliation of potential demand and supply imbalances in commodity and factor markets after introducing any shock (such as trade policy change and productivity growth), the CGE model is a useful tool to capture both consumption and production linkages between agriculture and the rest of the economy. In addition to these features, which are common to all CGE models, in the regional CGE model used for our study, equilibrium between commodity demand and supply in the world market is also obtained, allowing the model to capture the bilateral trade relationships between the countries included in the model. The model also solves for world commodity prices simultaneously with other endogenous variables.

The technological and behavioral functions for both producers and consumers consist of nonlinear and substitution possibilities among factors of production and among commodities in final demand. Production technology is represented by fixed input-output coefficients for intermediate goods and constant elasticity of substitution (CES) function for the following primary inputs: two types of labor (skilled and unskilled), land, other natural resources, and capital. While supply of other production factors is assumed to be fixed within each country, the model assumes the existence of unemployment in unskilled labor among low-income southern African countries. Production technology varies across sectors and countries and is calibrated to the countries' data. While production-demand linkages are mainly captured by the input-output relationships included in the model, in most low-income southern African countries, such linkages between agriculture and nonagriculture are weak, given that the level of intermediate input use is quite low in most agricultural activities. As value-added is the major component of production revenue evaluated at producer prices, consumption linkages are significantly affected by the factor intensity, which varies across sectors and countries. A capital-intensive sector may generate fewer consumption linkages among poor consumers whose incomes are mainly from wage earnings. This is one of the major reasons why growth in smallholder agriculture has relatively strong cross-sector linkages in developing countries. The empirical analysis performed in this study evaluates the magnitude of these linkages.

Consumption demand linkages are highly affected by income levels, consumption patterns, and marginal propensity to consume, each of which varies across countries. In a general equilibrium model, price responses (expressed through price elasticities of demand) are also important, as all prices in domestic markets are endogenously solved in the model. The incomes of consumers are determined in the factor markets after subtracting taxes. The demand for commodities by sector is determined from these incomes (given household savings propensities) and from the government consumption functions. Our regional CGE model solves consumer demand by maximizing a Stone-Geary utility function, which implies linear expenditure systems (LES) for individual

commodities. The income elasticities used to derive the marginal budget shares for consumption are from Reimer and Hertel 2004; for example, income elasticities for grains range from 0.4 to 0.5 for the low-income African countries. The subsistence parameters in the demand functions are calculated by assuming a Frisch parameter (together with income elasticities) for each individual country. Once we know the income elasticities and subsistence parameters, price elasticities (including own and cross price ones) can be derived by imposing the homogeneity condition on the LES functions. This procedure results in price elasticities of demand for grains, for example, of between -0.15 and -0.34.

The model assumes price-sensitive substitution (imperfect substitution) among foreign goods and domestic production and among goods produced by different trading partners. Because of this assumption, domestic goods cannot fully substitute for imports, even if productivity improves in the domestic production sector. Imperfect substitution implies that productivity improvements in the agricultural sector are not enough, and additional trading facilities and improving marketing conditions are necessary to improve substitution between domestic and foreign goods.

The model includes six individual southern African countries: Botswana, Malawi, Mozambique, South Africa, Zambia, and Zimbabwe, and two aggregate subregions: the rest of SACU and the rest of southern Africa. The model also includes three countries in East Africa: Madagascar, Tanzania, and Uganda, a "rest of Sub-Saharan Africa" region, two North African countries (Morocco and Tunisia) and a "rest of North Africa" region. Outside Africa, the model includes two big Asian countries (China and India) and a "rest of Asia" region, as well as Africa's two major trading partners (the United States and the European Union) and the other European countries as a group. The rest of the world is included as another separate region, aggregating all other countries not included above.

The focus of the study is low-income countries in southern Africa,[8] which are explicitly defined in the Global Trade Analysis Project (GTAP) database used in the study.[9]

The model focuses on agriculture and includes 21 agricultural and agriculture-related sectors and 11 nonagricultural sectors, many of which, such as transportation and textiles, directly link to the agricultural sector. Inclusion of more disaggregated agricultural subsectors is constrained by the GTAP database. In the latter, many regionally important agricultural commodities (such as tobacco for export or cassava and other root and tuber crops to meet domestic demand) are included in an aggregate sector called the "other crop" sector and cannot be distinguished as individual commodities. For the purposes of this study, we adjusted this sector according to the degree of market orientation. Specifically, we split the other crop sector included in the GTAP database into two: export other crops and domestically consumed other crops. We use export other crops to represent traditional export tree crops and tobacco, while the domestically consumed other crop sector represents roots and tubers used as staples. Similarly, we split the GTAP's aggregated vegetable and fruits sector in two: nontraditional exportables and fruits and vegetables for domestic markets.

Two transport sectors in the GTAP database, water and other transport, provide data on inputs consumed by other sectors in the production process and also affect price margins for international trade.[10] International transportation margins are calculated for African countries using bilateral data on c.i.f. and f.o.b. prices based on information from Limao and Venables (2002). While the market value of such price gaps is treated as exports of transportation services from exporting countries to importing countries,[11] the margins will be endogenously affected by the changes in the producer price for the domestic transportation sector. Improving the transportation sector's productivity lowers the unit cost of services provided by the sector, which causes exports to become more

[8] They are Malawi, Mozambique, Zambia, and Zimbabwe; in the original database, Lesotho was aggregated into a region called "rest of SACU."
[9] The GTAP database version 6.1, not the GTAP model itself, is used in this study. The GTAP is a project of Purdue University. The GTAP data version 6.1 represents the world in 2001(Dimaranan 2006).
[10] Due to data limitations, we did not consider price margins in domestic markets.
[11] Even though international transportation services can be provided by exporting or importing countries, in reality they are often provided by a third party.

profitable and imports to become cheaper at given prices, as the gap between c.i.f. and f.o.b. prices becomes smaller.

Simulation Scenarios

The study includes three groups of growth scenarios (Table 7) and growth is modeled as an exogenous increase in selected sectors' total factor productivity (TFP). The first group (Scenario 1) focuses on the role of South Africa as a possible engine of growth for the low-income southern African countries. The second group of scenarios focuses on the low-income southern African countries' own growth engines. Two types of agriculture-based growth are analyzed: TFP growth in maize and livestock (Scenario 2) examines the role of domestic and regional food markets, while TFP growth in fruits and vegetables, oilseeds, and cotton (Scenario 3) evaluates the role of nontraditional exports in regional growth. The third group of scenarios (Scenarios 4 and 5), focuses on the growth linkages between middle- and low-income southern African countries by combining the first two groups of scenarios with an expansion of nonagricultural growth of the other middle-income countries, in addition of South Africa. Specifically, in Scenario 4, TFP growth in the nonagricultural sectors in middle-income countries is combined with growth in the maize and livestock sectors in low-income countries. Scenario 5 focuses on the nontraditional export sector, combining low-income countries' productivity growth in fruits and vegetables, oilseeds, and cotton with nonagricultural growth in middle-income countries.

Table 7. CGE Model Simulation Scenarios

Scenario	South Africa	Botswana	Rest of SACU[a]	Rest of SADC[b]	Malawi	Mozambique	Zambia	Zimbabwe
	% Growth Rate in Sector's TFP							
Scenario 1: Growth in South Africa nonagriculture								
Nonagriculture	5.8	-	-	-	-	-	-	-
Scenario 2: Growth in maize & livestock in low-income countries								
Maize & other coarse grains	-	-	-	-	4.5	4.5	4.5	-
Bovine Meat	-	-	-	-	4.5	4.5	4.5	-
Pig meat and poultry	-	-	-	-	4.5	4.5	4.5	-
Milk	-	-	-	-	4.5	4.5	4.5	-
Scenario 3: Growth in nontraditional exports in low-income countries								
Fruits & vegetables	-	-	-	-	4.5	4.5	4.5	-
Oilseeds	-	-	-	-	4.5	4.5	4.5	-
Cotton	-	-	-	-	4.5	4.5	4.5	-
Scenario 4: Combination of an expansion of Scenario 1 with Scenario 2								
Nonagriculture	5.8	7.3	6.3	8.3	-	-	-	-
Maize & other coarse grains	-	-	-	-	4.5	4.5	4.5	
Bovine meat	-	-	-	-	4.5	4.5	4.5	
Pig meat and poultry	-	-	-	-	4.5	4.5	4.5	
Milk	-	-	-	-	4.5	4.5	4.5	
Scenario 5: Combination of an expansion of Scenario 1 with Scenario 3								
Nonagriculture	5.8	7.3	6.3	8.3	-	-	-	-
Fruits & vegetables	-	-	-	-	4.5	4.5	4.5	-
Oilseeds	-	-	-	-	4.5	4.5	4.5	-
Cotton	-	-	-	-	4.5	4.5	4.5	-

a/ Lesotho, Namibia, and Swaziland.
b/ Angola, Democratic Republic of Congo, Madagascar and Mauritius

Alternative Growth Scenarios for Southern Africa's Agriculture

Agriculture in Low-Income Countries Benefits from Growth in South Africa

Scenario 1 models the impact of economic growth in South Africa on the low-income southern African countries. In this simulation, South Africa's GDP is targeted to grow by 4.5 percent annually, and such growth is primarily driven by TFP growth exogenously in the nonagricultural sectors, including both manufacturing and services,

which reflects the trend of the economy in the past 25 years. This GDP growth rate is consistent with the target set by South Africa's government for the next five years in the Accelerated and Shared Growth Initiative for South Africa (see South African Government Information 2006). Our assumption regarding South Africa's growth is reasonable given that the South African economy grew by 5 percent in 2005 (Statistics South Africa 2006). There is no additional exogenous productivity growth in the agricultural sector in South Africa, nor in any other country in the region or outside the region. Thus, observed growth in South Africa's agriculture or in the other southern African countries is solely endogenously induced by the nonagricultural sector's growth in South Africa.

Growth in South Africa has a strong impact on the neighboring economies in the region. We used growth elasticities to measure the magnitude of this impact. Relatively large growth elasticities are observed in the region's other SACU countries (as a group): a 1 percent growth in South Africa stimulates 0.33 percent of total GDP growth in other SACU countries. Growth elasticities for the four low-income southern African countries are relatively small, but still significant, ranking from 0.10 for Zimbabwe to 0.20 for Zambia.[12] It is important to keep in mind that our analysis may significantly underestimate the potential growth linkages in the region because of the static nature of the model, which does not allow us to capture capital investment effect and spillovers from technology embodied in both investment and imports of capital goods. The captured growth linkages between South Africa and its neighboring countries in the model mainly come from commodity trade side that causes changes in relative prices or terms of trade. In brief, increased productivity growth in South Africa's nonagricultural sectors creates demand for agricultural products through increased incomes. If growth in South Africa's agriculture cannot meet with the increased domestic demand, agricultural prices will rise, which creates opportunities for its neighboring countries to increase agricultural production and exports.

[12] The estimated elasticities are Botswana, 0.19; rest of SACU, 0.33; rest of SADC (Angola), 0.02; Malawi, 0.15; Mozambique, 0.16; Zambia, 0.20; and Zimbabwe, 0.10.

The aggregate effect of South Africa's growth in the region is presented in Table 8, together with the aggregate effect of the other four scenarios. We focus here on the results for Scenario 1. Results for Zimbabwe are not included, given the particular evolution of its economy and the difficulty of deriving lessons from the present situation.[13] Growth in South Africa generates additional annual growth in real GDP in Malawi and Mozambique of 0.7 percent and almost 1 percent in Zambia. Increased agricultural production, together with higher agricultural prices, has a profound effect on real agricultural income, which increases by 0.67–1.23 percent annually in the three low-income countries, as a result of growth in South Africa's GDP of 4.5 percent a year. While raising food prices may hurt the urban poor, total food consumption in the region increases by 1.9 percent per year, with growth in the low-income countries ranging from 0.9 percent per year in Mozambique to 1.2 percent per year in Zambia.

Growth in South Africa is driven by productivity increases in the country's nonagricultural sector. Growth in its agricultural sector is either modest or negative, because capital and labor are pulled out of agriculture by a more efficient nonagricultural sector. But income generated from nonagricultural growth increases expenditure on both agricultural and nonagricultural commodities, even though demand for many agricultural goods is income inelastic in middle-income countries such as South Africa. For example, consumer demand for wheat and maize in South Africa increases by 2.2 and 2.1 percent per year respectively, while the production of these two commodities only grows 1.6 percent per year in the country. For some high-value agricultural goods with high income elasticities, such as vegetables and fruits, the growth rate on the demand side is much higher than that on the production side. As growth in production is outpaced by demand growth, South Africa's agricultural imports increase and exports fall. South Africa's net exports of maize and oilseed decline by 3.5 and 15.9 percent per year, respectively, due to increased domestic demand and slow growth in production. Already a net importer of

[13] Zimbabwe is facing its worst economic crisis since its independence in 1980, with record inflation of nearly 1,000 percent, the highest in the world. The country also faces acute shortages of food, gasoline and imports.

cotton, South Africa's cotton imports increase by 16 percent due to rising demand from growth in the country's textile industry.

Table 8. Aggregate Effect of CGE Model Simulations

Scenario	Real GDP	Real AgGDP	Agricultural trade		Food price Index	Food Consumption
			Exports	Imports		
	Additional Annual Growth Rate (%)					
Scenario 1						
Region	3.30	1.03	-0.02	1.11	0.45	1.88
Malawi	0.65	0.88	0.45	0.33	0.34	1.00
Mozambique	0.70	0.67	-0.48	0.70	0.41	0.87
Zambia	0.90	1.23	1.19	0.64	0.28	1.21
Scenario 2						
Region	0.02	0.29	0.00	-0.05	-0.04	0.29
Malawi	0.48	2.44	-0.19	-2.71	-1.33	2.59
Mozambique	0.34	1.80	1.09	-0.79	-0.76	1.58
Zambia	0.24	1.68	0.98	-1.90	-0.91	2.03
Scenario 3						
Region	0.01	0.09	0.05	0.01	0.00	0.04
Malawi	0.19	0.78	0.09	-0.36	-0.09	0.28
Mozambique	0.17	0.54	2.67	0.15	0.02	0.25
Zambia	0.18	0.65	2.29	-0.67	-0.07	0.28
Scenario 4						
Region	4.58	2.50	0.10	2.02	0.57	3.27
Malawi	1.16	3.42	0.21	-2.85	-0.99	3.63
Mozambique	1.06	2.51	0.51	-0.23	-0.34	2.46
Zambia	1.20	2.96	1.90	-1.43	-0.62	3.32
Scenario 5						
Region	4.57	2.30	0.14	2.07	0.60	3.02
Malawi	0.88	1.78	0.48	-0.54	0.26	1.31
Mozambique	0.89	1.26	2.10	0.70	0.45	1.12
Zambia	1.14	1.93	3.24	-0.21	0.23	1.56

Source: CGE model results

Changes in South Africa's agricultural exports and imports create market opportunities for neighboring countries that have a comparative advantage in exporting the commodities in which South Africa loses competitiveness. Taking oilseed trade as an example, three of the four low-income southern African countries (excluding Zambia) are net exporters of oilseeds in the base year (2001). A 16 percent decline in South Africa's oilseed exports results in increases in these three countries' net oilseed exports of

between 5 and 14 percent. A similar situation occurs in cotton trade: three of the four low-income southern African countries (excluding Malawi) increase their cotton exports, though the gains are relatively modest given that countries from outside the region are strong competitors in the South African cotton market.

Table 9. Effects on Agricultural Subsectors of CGE Model Simulations

Scenario/Country	Cereals	Livestock	Crops for Domestic Market [a]	Non-traditional Exports [b]	Traditional Exports [c]	Total
Share in agriculture value-added (%)						
Malawi	24.3	3.7	58.9	5.0	8.1	100
Mozambique	12.6	5.3	76.0	1.9	4.3	100
Zambia	29.9	13.6	25.3	11.7	19.5	100
Additional annual growth rate (%)						
Scenario 1						
Malawi	0.4	0.4	1.0	1.0	0.7	0.8
Mozambique	0.4	0.6	0.2	0.6	0.0	0.2
Zambia	0.8	0.8	0.7	1.3	1.0	0.9
Scenario 4						
Malawi	3.1	6.7	1.4	2.8	0.4	2.0
Mozambique	2.4	11.7	0.2	0.1	-0.4	1.0
Zambia	2.7	9.7	1.3	1.6	1.0	2.8
Scenario 5						
Malawi	0.7	0.6	1.3	10.6	0	1.5
Mozambique	0.5	0.8	0.2	11.6	-0.6	0.4
Zambia	0.9	1.0	1.3	8.5	0.3	1.8

a/ Roots and tubers and fruits and vegetables.
b/ Fruits and vegetables, oilseeds, and cotton.
c/ Tobacco, tea, coffee, and cocoa .

Source: CGE model results.

Increases in South African agricultural imports positively affect agricultural prices in the region, given its large market size.[14] Through price transformations (even if

[14] An increase in regional agricultural prices is also related to a model assumption that assumes an imperfect substitution between domestically produced and imported/exported goods in each country. This is a commonly used and necessary assumption for a CGE model where two-way trade in the data is observed. We try to minimize its effect on the simulation results by employing a group of substitutive elasticities with much higher value than those econometrically estimated in the literature (see, for example, McDaniel and Balistreri 2003; Gallaway, McDaniel, and Rivera 2003; Zhang and Verikios 2003; and Hertel et al. 2003).

imperfect), increased border prices further induce price increases in the domestic markets of the other southern African countries. Higher domestic prices further stimulate production, even in nonexportable agricultural sectors. Table 9 summarizes the growth effects in five aggregate agricultural subsectors and their contributions to overall economic growth in Malawi, Mozambique, and Zambia. Growth in staple crops (mainly produced for domestic markets) contributes the most to overall economic growth, due to the size of the sector and its high growth rates. For example, grain and other staple crops account for more than 10 percent of GDP in the three countries, and growth in these sectors contributes to 23–31 percent of overall GDP growth in the three countries.

Agriculture Has Strong Growth Linkages to Nonagriculture

In the second group of scenarios, we turn our attention to the low-income southern African countries' own growth engines. Scenario 2 focuses on the maize and livestock sectors, while Scenario 3 analyzes the impact of growth in the nontraditional export sector. In these scenarios, we exogenously increase sector's TFP growth by 4.5 percent (the same growth rate of South Africa's GDP as in the previous experiment) in the respective sectors of the three low-income countries, while there is no additional growth in the other sectors in these three countries and no additional growth in any sector of other southern African countries. The cumulative effect is equivalent to doubling the countries' yields for maize and livestock production per head of animal stock in 15 years. The same TFP growth is also assumed for the three export-oriented agricultural subsectors in Scenario 3. By applying the same TFP growth rate at the sectoral level for the three countries, we are able to capture differences in response across countries, indicating differences in the linkage effects of those sectors in each country's economy.

Numerous earlier studies have concluded that agriculture, especially food crops, have strong growth linkages and multiplier effects; that is, increased agricultural (or food crop) production in a country would generate a disproportionately large increase in the country's total GDP, through increased demand for inputs and, more importantly, through

increased consumption demand as a result of higher agricultural incomes.[15] In these two scenarios, we focus on such linkage effects by calculating GDP growth multipliers, derived from TFP shocks in corresponding agricultural subsectors. We define the multipliers as the increase in total GDP, divided by the increase in the shocked sector's total value-added, both measured at the initial (base-year) level of prices. The resulting multipliers derived using CGE models are in general relatively smaller than the standard fixed-price multipliers.[16] Our model simulation results show strong multiplier effects of growth in both staple food (maize and livestock) and exportable agriculture (fruits and vegetables, oilseeds, and cotton): 1.00 unit of increase in maize and livestock's value-added generates 1.23–1.36 units of increase in total GDP, and 1.00unit of increase in fruits and vegetables, oilseeds, and cotton generates 1.26–1.66 units of increase in total GDP in the three countries.

Multiplier analysis cannot reveal the scale effect, as a larger sector can have a stronger impact on overall growth, even though the multiplier may not be big. For this reason we also look at the aggregate effect of growth in an agricultural subsector on total GDP, agricultural GDP, agricultural exports and imports, and other macroeconomic indicators under the two scenarios (Scenarios 2 and 3 in Table 8). Maize and livestock combined account for 32–55 percent of agricultural GDP in the three countries, while nontraditional exports account for a much smaller share (3–9 percent of agricultural GDP). Growth in maize and livestock together results in 0.24–0.48 percent and 1.68–2.44 percent annual growth in total GDP and agricultural GDP, respectively, in the three countries.

Moreover, a productivity shock of the same magnitude applied to nontraditional export crops generates a much smaller effect on both total GDP and agricultural GDP. As

[15] See Bell and Hazell (1980) for an early methodological discussion of alternative multiplier models used in growth linkage analysis, and the discussion of Haggblade, Hammer, and Hazell (1991) on the improvement in the multiplier models with limited price endogeneity.

[16] See Dorosh and Haggblade (2003 for a comparison of CGE and fixed-price multipliers for several Sub-Saharan African countries. In general, the impact of endogenizing prices on multipliers depends on economic structure and varies by sector. CGE multipliers for the agricultural sector are lower than fixed price multipliers, while multipliers for the manufacturing sector are significantly higher. These differences are explained mainly by the importance of backward linkages and demand and supply elasticities.

expected, maize and livestock growth has a larger impact on domestic production and import substitution, with maize imports falling by 12.2–38.7 percent and livestock imports falling by 8.6–10.8 percent in the three countries, resulting in a decline in total agricultural imports of 0.8–2.7 percent. However, the major impact of increased productivity in nontraditional export crops is on exports, which increase by 2.3–2.7 percent per year in Mozambique and Zambia.

The expansion of grain and livestock output reduces domestic food prices at an annual rate of −0.76 percent in Mozambique and −1.33 and −0.91 percent in Malawi and Zambia respectively. This not only explains the significant increases in food consumption but also shows the existence of demand constraints to the expansion of grain production. With no simultaneous growth in income generated outside the grain sector and significant substitution for imports through improved import channels, productivity growth in the grain sector can cause a shift in domestic terms of trade against agriculture, negating the income benefit of productivity improvement (Adelman 1984). Simultaneous growth in maize and livestock, as simulated in Scenario 2, can help improve the terms of trade in the grain sector, such that with increased grain production, domestic prices will fall while agricultural income increases in all three countries.

Growth in Middle-Income Countries Can Help Low-Income Countries Overcome their Domestic Demand Constraints for Grains

In the third group of scenarios, agricultural productivity growth in selected sectors of low-income southern African countries is combined with growth in South Africa and other middle-income countries in the region. In the other middle-income southern African countries, we include Botswana, the rest of SACU, and the rest of the southern African region (representing Mauritius and Angola). This group of scenarios can help us further understand the strong linkages and interdependency between these two groups of countries in the region.

Two scenarios combine nonagricultural TFP growth in middle-income countries with agricultural TFP growth in the three low-income countries. In both scenarios, South

Africa's GDP is targeted to grow at the same rate as in Scenario 1 (4.5 percent annually), while growth in Botswana is targeted to be 7 percent and that in the rest of SACU is 6 percent, close to the average historical growth rates of these countries. The rest of the SADC region, which represents Angola, is targeted to grow at 7 percent too, based on the economic recovery process in Angola. In all these countries, growth is driven by TFP increases in the nonagricultural sectors, while for the three low-income countries, growth is driven by TFP increases in maize and livestock (in Scenario 4) or in nontraditional export crops (in Scenario 5). Similar to Scenarios 2 and 3, an annual growth rate of 4.5 percent is assumed for the selected agricultural subsectors' TFP.

When stimulated by the growth in the middle-income countries, productivity shocks, similar to those used in Scenario 2, for the three low-income countries result in much higher growth rates in their maize and livestock sectors. Compared with Scenario 2, in which maize grows at 1.9–2.6 percent and livestock at 9.7–11.2 percent in Malawi, Mozambique, and Zambia, the growth rate of maize rises to 2.8 – 3.1 percent and that of livestock increases to 10.6–12.0 percent in the three countries. This indicates fewer demand- side constraints from income growth in the middle-income countries. This, along with other general equilibrium linkage effects, results in much higher annual growth in per capita GDP in Scenario 4 (1.1–1.2 percent in the three countries), compared with Scenario 2 (below 0.5 percent), in which growth is generated solely from the countries' own agricultural productivity increase (Table 8).

Increased economic growth in middle-income countries also enhances the impact of productivity growth on farm income. Real agricultural GDP per capita grows at 2.5, 3.0, and 3.4 percent in Mozambique, Zambia, and Malawi, respectively, much higher than the corresponding growth rates obtained in Scenario 2. Economic growth in the middle-income countries also boosts the impact of productivity growth in nontraditional exports in the low-income countries (Scenario 5). GDP growth in Malawi, Mozambique, and Zambia is 7 to 10 times larger in this scenario than in scenario 3 in which agricultural export growth is stimulated by improving productivity in these countries alone (Table 8). Given the strong linkage effects between low- and middle-income countries in the region,

growth in the grain and livestock sectors has larger effects on low-income countries' GDP, agricultural output, and food consumption than a similar growth in agricultural exports.

The contribution of different agricultural subsectors' growth to overall economic growth varies across the three low-income countries, even though the productivity shock is the same in these countries (scenarios 4 and 5 in Table 9). For example, at the agricultural subsector level, maize and livestock are equally important to GDP growth in Malawi, while, in Mozambique and Zambia, the contribution of livestock to GDP growth is more than twice as large as the contribution of growth in the maize sector. The relative sizes of the sectors and resulting real growth in the shocked sector both matter in explaining such differences across countries. In terms of sectoral size, maize accounts for more than one-third of agricultural GDP in Malawi, while it is a much smaller subsector in Mozambique and Zambia. With 4.5 percent productivity growth in Scenario 4, production of maize grows by 3.1 percent in Malawi and only 2.4 percent in Mozambique and 2.7 percent in Zambia because resources (land and labor) are released from maize production and transferred to other agricultural sectors.

As expected, growth in nontraditional export sectors has a larger impact on agricultural exports than growth in the staple sector. In Mozambique, for example, total agricultural exports grow at an annual rate of 2 percent in Scenario 5, compared with only 0.5 percent in Scenario 4, where productivity growth in the maize and livestock sector is assumed to be similar. Fruits and vegetables show the highest export growth rate in Mozambique, while oilseed exports increase more rapidly in Zambia. However, the major contribution to agricultural export growth in both countries does not come from growth in fruits and vegetables or oilseeds, given their small share in total exports, but from cotton (Table 10). This crop could offer export opportunities for Zambia, as cotton is still considered a nontraditional export crop there. Cotton's share of agricultural exports is 11 percent in Zambia, compared with more than 22 percent in Mozambique. These results confirm the potential that these countries have to diversify their exports by expanding

nontraditional crops, but they also show the limitations of these crops as growth engines in the agricultural sector, due to their small share of agriculture.

Table 10. Growth in Nontraditional Exports in Scenario 5

Country	Fruits & vegetables	Oilseeds	Cotton
Malawi			
Share in total exports (%)	1.9	0.4	1.2
Additional annual growth in exports (%)	22.3	35.1	24.5
Contribution to agricultural export growth (%)	89.1	29.6	57.9
Mozambique			
Share in total exports (%)	10.2	5.7	22.2
Additional annual growth in exports (%)	20.7	12.7	14.9
Contribution to agricultural export growth (%)	39.5	13.7	62.2
Zambia			
Share in total exports (%)	9.3	0.7	10.6
Additional annual growth in exports (%)	16.8	38.0	21.6
Contribution to agricultural. export growth (%)	43.6	7.7	63.7

Note: Sum of the contributions is greater than 100 because of declines in the other sectors' exports.
Source: CGE model results.

IV. CONCLUSION

This study has identified several characteristics of southern Africa that provide opportunity for agricultural growth through exploitation of regional linkages. The first characteristic is the complementarity between the low- and middle-income southern African economies. Southern Africa is the only region in the continent where there are a number of middle- and low-income countries in close proximity to each other. Six countries in the region are middle-income countries. Among these, South Africa is already the region's engine of growth, while Botswana and Mauritius, though relatively small, are often considered the most successful examples of development in Africa. Economic development and agricultural growth among the lower-income southern African countries depend critically on how these countries can benefit from the regional dynamics afforded by their more advanced neighboring countries.

Second, potentially strong trade and investment linkages in the region can contribute to agricultural growth in the low-income countries. Regional trade expanded significantly during the 1990s, largely as a result of South Africa's increasing involvement in the region. Regional demand could expand further in the coming years if South Africa could sustain its economic growth rates of recent years. This would offer new opportunities to low-income countries to expand and diversify exports. The analysis of comparative advantages in this study shows that there are regional complementarities in agriculture of which the low-income countries can take advantage, especially as far as nontraditional export crops are concerned.

Third, regional growth opportunities based on the region's agricultural potential also exist. Given the high proportion of the population that still lives in rural areas and depends on agriculture for income and sustenance, southern Africa faces a growing food deficit, exacerbated by stagnant or even declining levels of agricultural productivity. This is despite the fact that all low-income southern African countries have relatively favorable agricultural potential and conditions. A recovery of maize productivity to its historical highs would significantly improve low-income countries' competitiveness and

result in import substitution of maize, livestock, and other commodities, thus providing these countries with more growth opportunities in agriculture. Agricultural growth opportunities can also come from nontraditional export crops, such as vegetables, oilseeds, and cotton. Such growth could be based on an expansion of trade of these products in the region, on growing regional investment in their value chains, and, perhaps most importantly, on increased productivity and competitiveness of these crops.

By applying a regional general equilibrium model to southern Africa, we were able to analyze the effects of the region's unique characteristics on the growth choices of low-income southern African countries. We found that growth of the middle-income countries, such as South Africa, benefits the low-income countries in the region through increased demand for their agricultural exports. Agricultural productivity growth, however, is the key for low-income countries to take advantage of South Africa's growth. Productivity growth in the low-income countries' grain and livestock sectors generates more growth in GDP and food consumption than growth in the nontraditional export crops. Unlike other regions where growth in grain production is likely to be constrained by domestic demand, growing middle-income economies in southern Africa provide additional demand for grains and livestock, slowing down the decline in grain prices in the region.

A significant productivity gap currently exists in maize and livestock production between low- and middle-income countries in the region, implying that low-income countries have potential to increase productivity and accelerate growth of agricultural production by promoting sustainable growth in their maize and livestock sectors. Whether the low-income southern African countries can take advantage of the economic growth of their richer neighbors depends on both increases in investment and continued policy reforms. A regional initiative to define these investments and policy reforms appears to be important if low-income southern African countries are to take advantage of the unique growth opportunities offered by the region.

Regional integration policies and investment are preconditions for strengthening regional linkages and exploiting regional dynamics. To analyze the linkages between

such policies and investments and increases in low-income Southern African countries' productivity and economic growth requires a more sophisticated intertemporal dynamic model that fully takes into account the endogenous linkages between regional integration policies and investment and economy wide growth at individual country level. This will be the focus of authors' future research efforts.

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APPENDIX A. SUPPLEMENTARY TABLES

Table A.1. Land Use and Animal Stock Composition in Southern Africa

Commodity	1977-1981 average			1998-2002 average		
	Region	Low income[a]	Middle income[b]	Region	Low income	Middle income
% of total land by crop						
Maize	40.7	41.6	40.2	43.6	48.5	40.5
Wheat	8.8	1.0	13.9	5.2	1.2	7.8
Other cereals	9.2	13.6	6.4	8.3	8.9	7.9
Roots and tubers	6.9	12	3.6	7.2	7.6	6.9
Pulses	3.9	6.5	2.2	5.2	8.3	3.2
Fruits	2.2	2.1	2.3	3	2.2	3.5
Vegetables	1.2	1.3	1.1	1.6	1.3	1.7
Oilseeds	9.3	14.2	6.1	9.3	10.1	8.7
Cotton	2.2	3.8	1.2	3.2	6.7	1.0
Tobacco, coffee, tea, spices	2.0	2.1	1.9	2.3	4.0	1.2
Sugarcane	2.0	1.2	2.6	2.9	1.1	4.1
Forage and others	11.5	0.6	18.6	8.1	0	13.4
Total	100	100	100	100	100	100
% of total cow equivalent by animal group						
Cattle	66.7	76.6	62.5	60.9	67.5	58.0
Milking cows	10.5	8.4	11.3	9.5	7.7	10.3
Chickens	2.1	4.1	1.3	10.1	12.4	9.1
Goats	5.9	6.1	5.8	6.4	7.2	6.1
Pigs	2.4	2.6	2.3	2.6	3.4	2.3
Sheep	12.4	2.1	16.7	10.4	1.9	14.2
Total	100	100	100	100	100	100

a/ Low-income countries: Lesotho, Malawi, Mozambique, Zambia and Zimbabwe.
b/ Middle-income countries: Angola, Botswana, Mauritius, Namibia, South Africa and Swaziland

Source: FAOSTAT 2005..

Table A.2. Composition of Agricultural Revenue by Crop and Livestock Group in the Southern African Region (%)

Commodity	1977-1981 average			1998-2002 average		
	Region	Low-Income Countries[a]	Middle-Income Countries[b]	Region	Low-Income Countries	Middle-Income Countries
Crops						
Maize	15.3	4.5	10.8	10.8	3.9	6.9
Wheat	3.0	0.3	2.6	2.7	0.4	2.3
Other cereals	1.6	0.8	0.8	1.3	0.8	0.5
Roots and tubers	5.9	3.5	2.4	11.6	7.0	4.7
Pulses	1.4	0.7	0.6	1.4	0.9	0.5
Fruits	9.5	1.9	7.6	10.8	1.9	8.9
Vegetables	5.6	1.6	3.9	6.5	1.5	5.1
Oilseeds	4.5	2.7	1.8	3.5	1.8	1.7
Cotton	1.5	0.9	0.6	1.5	1.2	0.3
Tobacco, coffee, tea, spices	4.5	3.5	1.0	5.6	4.9	0.6
Sugarcane	5.2	1.1	4.1	4.8	1.0	3.8
Forage and others	9.4	0.1	9.3	4.5	0.0	4.5
Total crops	67.3	21.6	45.7	65.1	25.3	39.8
Livestock						
Beef and buffalo Meat	12.5	2.5	10.0	10.0	2.1	7.9
Milk, total	8.5	1.5	7.0	6.8	0.9	5.9
Eggs, primary	2.3	0.6	1.7	3.5	0.8	2.7
Poultry meat	3.9	0.8	3.1	9.7	1.2	8.5
Pig meat	2.0	0.5	1.5	2.2	0.7	1.5
Sheep and goat meat	3.6	0.3	3.3	2.7	0.4	2.3
Total Livestock	32.7	6.2	26.5	34.9	6.1	28.8
Total	100.0	27.7	72.3	100.0	31.4	68.6

a/ Low-income countries: Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe.
b/ Middle-income countries: Angola, Botswana, Mauritius, Namibia, South Africa, and Swaziland.

Source: FAOSTAT 2005.

Table A.3. Production, Demand, and Trade by Crop in Southern Africa in Low- and Middle-income Countries

Commodity	1977-1981 Average				1998-2002 Average			
	Production	Demand	Exports/ Production	Imports/ Demand	Production	Demand	Exports/ Production	Imports/ Demand
	(1000 Mt)	(1000 Mt)	(%)	(%)	(1000 Mt)	(1000 Mt)	(%)	(%)
Low-income countries[a]								
Cereals	5,710	5,132	6.1	15.5	6,587	7,892	3.7	19.6
Roots and tubers[b]	1,332	1,267	0.3	0.1	3,025	3,027	0.1	0.2
Pulses	306	206	4.6	2.1	519	520	2.6	2.8
Fruits	881	783	2.7	1.3	1,164	1,147	6.9	5.5
Vegetables	750	687	0.1	1.8	824	841	2.1	4.0
Oil crops	1,117	877	17.1	0.7	1,153	1,064	11.0	3.6
Cotton lint	85	23	73.3	0.4	167	49	72.3	6.0
Sugar (raw equivalent)	731	455	43.3	5.8	1,065	895	35.8	23.6
Tea	60	4	94.2	31.8	70	14	81.7	9.6
Tobacco	156	24	86.9	13.9	315	36	92.2	32.0
Middle–income countries[c]								
Cereals	14,125	10,182	23.3	9.9	12,428	14,483	9.9	22.7
Roots and tubers	643	590	1.0	0.9	1,826	1,861	0.8	2.7
Pulses	192	213	5.2	27.3	208	308	5.0	35.8
Fruits	3,380	2,107	33.6	2.5	5,377	3,521	39.2	7.1
Vegetables	1,926	1,743	1.6	2.4	2,594	2,702	2.9	6.8
Oil crops	843	791	9.3	7.6	1,267	1,329	6.4	10.8
Cotton lint	63	64	17.8	18.9	44	95	13.5	59.7
Sugar[b]	3,008	1,409	56.6	11.1	3,731	1,704	64.7	22.6
Tea	11	24	43.0	74.5	14	24	59.8	76.5
Tobacco	43	46	20.0	24.5	35	18	129.4	157.9

a/ Low-income countries: Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe.
b/ Quantities of roots and tubers are expressed as dry equivalent; sugar is raw equivalent.
c/ Middle-income countries: Angola, Botswana, Mauritius, Namibia, South Africa and Swaziland

Source: FAOSTAT 2005

Table A.4. Production, Demand, and Trade by Crop in Southern Africa as a Whole.

Commodity	1977-1981 average				1998-2002 average			
	Production	Demand	Exports/ Production	Imports/ Demand	Production	Demand	Exports/ Production	Imports/ Demand
	(1000 Mt)	(1000 Mt)	(%)	(%)	(1000 Mt)	(1000 Mt)	(%)	(%)
Cereals	19,834	15,315	18.3	11.8	19,014	22,375	7.7	21.6
Roots and tubers (dry equivalent)	1,975	1,857	0.5	0.3	4,851	4,888	0.4	1.1
Pulses	498	419	4.8	14.9	727	828	3.3	15.0
Fruits	4,261	2,890	27.2	2.2	6,541	4,668	33.4	6.7
Vegetables	2,677	2,430	1.2	2.3	3,418	3,543	2.7	6.2
Oil crops	1,960	1,668	13.7	4.0	2,420	2,393	8.6	7.6
Cotton lint	148	87	49.7	14.0	211	144	60.0	41.4
Sugar (raw equivalent)	3,739	1,864	54.0	9.8	4,796	2,599	58.3	23.0
Tea	71	28	86.2	68.1	84	38	78.0	51.8
Tobacco	199	69	72.4	20.8	350	54	95.9	73.5

Source: FAOSTAT 2005

Table A.5. Growth Rate of Production, Demand, and Trade by Crop and Livestock Product, 1977 – 2002

	Demand			Production			Imports			Exports		
	Region	Low-income[a]	Middle income[b]	Region	Low-income	Middle income	Region	Low-income	Middle income	Region	Low-income	Middle income
Crops												
Maize	1.7	2	1.5	-0.4	0.6	-0.8	5.4	4.8	6	-5.3	-3.1	-5.6
Wheat	2.3	2.2	2.3	0.8	2.1	0.6	4.7	2.3	6.2	4.5	11.5	3.8
Cereals	1.8	2.1	1.7	-0.2	0.7	-0.6	4.8	3.2	5.8	-4.2	-1.7	-4.6
Roots & Tuber[c]	4.7	4.2	5.6	4.4	4	5.1	10.8	9	11	2.7	-0.8	4.1
Pulses	3.3	4.5	1.8	1.8	2.6	0.4	3.3	6	3.1	0	-0.1	0.2
Fruits	2.3	1.8	2.5	2.1	1.3	2.2	7.9	9.1	7.7	3.1	6	3
Vegetables	1.8	1	2.1	1.2	0.5	1.4	6.8	4.8	7.2	5.2	15.7	4.3
Oilcrops	1.7	0.9	2.5	1	0.2	2	4.9	9	4.2	-1.2	-1.9	0.2
Cotton Lint	2.4	3.7	1.9	1.7	3.2	-1.7	7.9	17.4	7.6	2.6	3.2	-3
Sugar[c]	1.6	3.3	0.9	1.2	1.8	1	5.8	10.4	4.4	1.6	0.9	1.7
Tea	1.4	5.8	0	0.8	0.8	1.2	0.1	0	0.1	0.4	0.1	2.8
Tobacco	-1.2	2	-4.4	2.7	3.4	-1	4.9	6.1	4.4	4.1	3.7	8.2
Livestock												
Milk	0.2	-1.7	0.5	0.3	-1.1	0.5	1.2	-2.5	2	7.1	13.3	6.4
Meat	2.6	2.4	2.6	1.9	1.8	2	8.4	5	8.7	-1.6	-5	-0.7
Bovine Meat	0.5	1.5	0.3	0.2	0.6	0.1	0.7	-3	1	-2.5	-6.1	-1.3
Pig meat	2.7	3	2.2	1.8	3	1.4	9.8	2.4	10.2	2.7	3.7	2.4
Poultry meat	6.5	3.8	7	5.7	3.5	6.1	20.2	32.3	19.9	-0.3	11.4	-0.9

a/ Low-income countries: Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe.
b/ Middle-income countries: Angola, Botswana, Mauritius, Namibia, South Africa, and Swaziland.
c/ Quantities of roots and tubers are expressed as dry equivalent; sugar is raw equivalent

Source: FAOSTAT

Table A.6. Production, Demand and Trade of Different Livestock Products in Southern Africa (%)

Commodity	1977-1981 Average				1998-2002 Average			
	Production	Demand	Exports/ Production	Imports/ Demand	Production	Demand	Exports/ Production	Imports/ Demand
	(1000 Mt)	(1000 Mt)	(%)	(%)	(1000 Mt)	(1000 Mt)	(%)	(%)
Low-income countries[a]								
Milk	621	741	0.6	16.7	488	513	9.8	14.2
Meat total	326	290	12.7	1.6	478	477	3	2.7
Bovine Meat	176	140	22.7	2.6	199	190	5.4	1
Pig meat	36	36	2.2	1.4	67	66	2.5	1.2
Poultry meat	57	57	0.2	0	118	124	1.1	6.4
Middle-income countries[b]								
Milk	2,825	3,163	2	12.5	3,152	3,542	6.7	16.9
Meat total	1,274	1,216	8.2	3.8	1,909	2,087	4.7	12.8
Bovine meat	719	673	11.5	5.5	733	715	8.5	6.3
Pig meat	109	111	2.7	3.9	146	174	3.4	19
Poultry meat	236	228	4.9	1.4	816	949	1.2	15
Region								
Milk	3,445	3,904	1.8	13.3	3,640	4,055	7.1	16.6
Meat total	1,600	1,505	9.1	3.4	2,387	2,564	4.4	11
Bovine meat	895	813	13.8	5	932	906	7.9	5.2
Pig meat	145	146	2.6	3.3	212	239	3.1	14.1
Poultry meat	294	285	4	1.1	933	1,073	1.2	14.1

a/ Low-income countries: Lesotho, Malawi, Mozambique, Zambia, and Zimbabwe.
b/ Middle-income countries: Angola, Botswana, Mauritius, Namibia, South Africa, and Swaziland

Source: FAOSTAT 2005

Table A.7. Applied Tariff Rates for Selected Southern African Countries (%)

Commodity	Botswana	South Africa	Malawi	Mozambique	Zambia	Zimbabwe
Cereals	2.2	27.6	0.1	2.1	2.9	8.3
Fruits & Vegetables	0.2	5.8	15.0	23.0	9.0	23.0
Oilseeds	0.0	1.0	0.0	9.9	3.0	5.0
Fiber crops	0.0	8.4	9.4	0.0	1.0	2.9
Traditional crops	5.4	6.7	14.0	5.2	6.9	37.2
Beef	5.3	6.4	2.7	11.5	9.9	16.3
Poultry and pigs	0.5	5.9	2.8	17.4	6.9	10.9
Dairy	8.6	42.8	8.6	17.7	12.3	30.0
Food industries	5.8	7.4	11.4	13.3	9.3	17.6
Minerals	0.4	4.2	7.6	8.6	8.4	11.2
Textiles	6.6	22.4	20.2	21.8	18.6	21.3
Other manufactures	2.4	5.8	11.7	10.0	7.7	16.8
Average	2.2	5.6	9.1	7.6	7.1	9.6

Source: GTAP 2006

APPENDIX B. Mathematic Presentation of the Regional CGE Model

Notation

The *i* and *i'* indices refer to sectors, *r* and *s* refer to countries. The notation *otp* is a specific sector (transport) included in *i*:

Variables

Production side	
$PX_{i,r}$	Output price of good ***i*** in country ***r***
$PVA_{i,r}$	Value added price of good ***i*** in country ***r***
$X_{i,r}$	Output of sector ***i*** produced in country ***r***
$FD_{f,i,r}$	Factor demand of ***f*** by sector ***i*** in country ***r***
$FS_{f,r}$	Supply of factor ***f*** in country ***r***
$INTD_{i,r}$	Intermediate demand of good ***i*** in country ***r***
$WF_{f,r}$	Price of factor ***f***
Demand side	
YH_r	Household income in country ***r***
$GOVREV_r$	Government revenue in country ***r***
$ZTOT_r$	Total investment in country ***r***
$GOVTRAN_r$	Government transfers to household in country ***r***
$CD_{i,r}$	Household demand of good ***i*** in country ***r***
$GD_{i,r}$	Government demand of good ***i*** in country ***r***
$INVD_{i,r}$	Investment demand of good ***i*** in country ***r***
Trade	
$PWM_{i,r,s}$	c.i.f. price of good ***i*** for country ***s*** imported from ***r***
$PWE_{i,r,s}$	f.o.b. price of good ***i*** for country ***r*** exporting to country ***s***
$PM_{i,r,s}$	Import price of good ***i*** in country ***s***'domestic market and imported from country ***r***
$PE_{i,r,s}$	Export price of good ***i*** at the border of country ***r*** and exporting to country ***s***
$PMM_{i,r}$	Armington price of import-composite good ***i*** for country ***r***
$PEE_{i,r}$	CET price of export-composite good ***i*** in country ***r***
$PD_{i,r}$	Price for output ***i*** domestically produced and consumed in country ***r***
$PC_{i,r}$	Armington price of composite good ***i*** in country ***r***
$E_{i,r,s}$	Good ***i*** exporting from country ***r*** to country ***s***
$M_{i,r,s}$	Good ***i*** imported by country ***s*** from country ***r***
$EE_{i,r}$	Export-composite good ***i*** for country ***r***

$MM_{i,r}$	Import-composite good ***i*** for country ***r***
$DC_{i,r}$	Output ***i*** domestically produced abd consumed in country ***r***
$CC_{i,r}$	Composite good ***i*** for country ***r***
$TRANSPR_{i,r,s}$	International transport cost for good ***i*** shiping from country ***r*** to ***s***
$TSPRM_{i,r,s}$	Transport cost for good ***i*** imported by country ***s*** from country ***r*** occurred in country ***s***' domestic markets
$TSPRE_{i,r,s}$	Transport cost for good ***i*** exporting from country ***r*** to ***s*** and occurred in country ***r***'s domestic markets

Macro closures

$\overline{FSAVE}_r$	Fixed net foreign savings (trade deficits) of country ***r***
$\overline{GOVEXPS}_r$	Fixed government total expenditure in country ***r***

Parameters

Defined parameters

$\sigma^c_{i,r}$	Armington elasticity of substitution between domestic and import-composite good ***i*** in country ***r***
$\sigma^m_{i,r}$	Armington elasticity of substitution between imports of good ***i*** by country ***r*** from different exporting countries
$\sigma^t_{i,r}$	CET elasticity of substitution between domestic and export-composite good ***i*** in country ***r***
$\sigma^e_{i,r}$	CET elasticity of substitution between exports of good ***i*** from country ***r*** to different importing countries
$\sigma^x_{i,r}$	Elasticity of substitution in CES value-added production function for sector ***i*** in country ***r***

Computed parameters

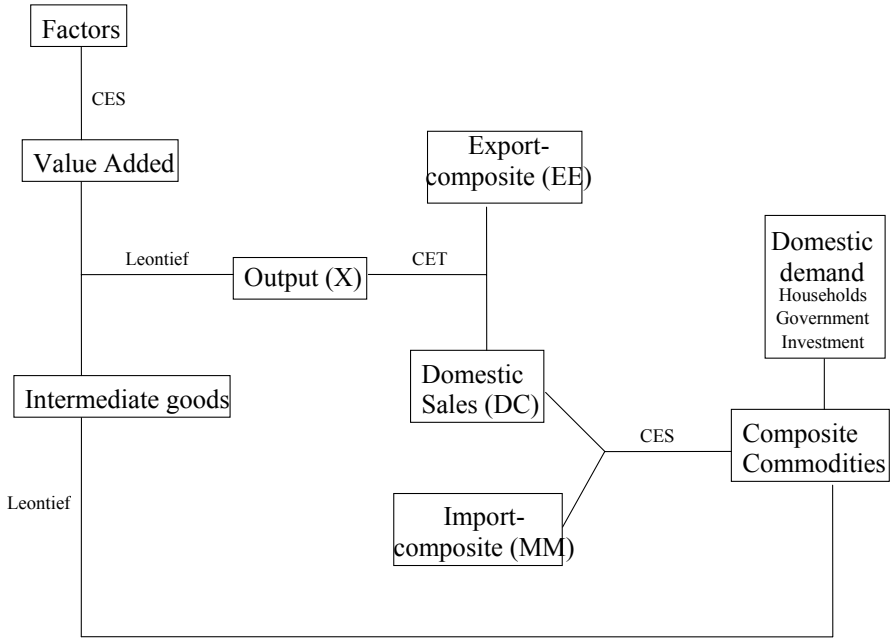
$\beta^c_{i,r}$	Share parameter in household's demand function for good ***i*** in country ***r***
$\beta^g_{i,r}$	Share parameter in government's demand function for good ***i*** in country ***r***
$\beta^z_{i,r}$	Share parameter in investment demand function for good ***i*** in country ***r***
$\alpha_{f,i,r}$	Share parameter in value-added production function of sector ***i*** for factor ***f*** in country ***r***
$\delta^m_{i,r,s}$	Share parameters in Armington import function for good ***i*** imported by country ***s*** from ***r***

$\delta^{e}_{i,r,s}$	Share parameters in CET export function for good ***i*** exported by country ***r*** to ***s***
$\delta^{t}_{i,r}$	Share parameters in CET function for export-composite good ***i*** in country ***r***
$\delta_{i,r}$	Share parameters in Armington function for import-composite good ***i*** imported in country ***r***
$\gamma_{i,r}$	Subsistence parameter in Stone-Geary utility function
$\Lambda^{m}_{i,r}$	Shift parameter in Armington import function
$\Lambda^{c}_{i,r}$	Shift parameter in Armington import-composite function
$\Lambda^{e}_{i,r}$	Shift parameter in CET export function
$\Lambda^{t}_{i,r}$	Shift parameter in CET export-composite function
$\Lambda^{x}_{i,r}$	Shift parameter in CES value-added production function

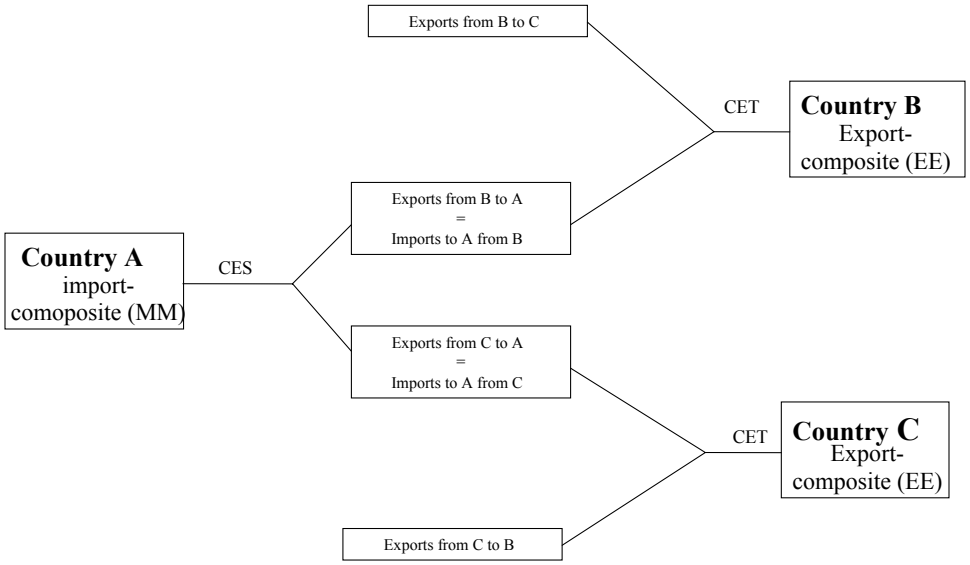
Other computed parameters

$\phi_{i,,r,s}$	International transport margin
$\phi^{m}_{i,r,s}$	Transport margin for imports of ***i*** paid to importing country ***s***' domestic transport firm and imported from country ***r***
$\phi^{e}_{i,r,s}$	Transport margin for exports of ***i*** paid to exporting country ***s***' domestic transport firm and imported from country ***r***
$io_{i,j,r}$	Input-output coefficient for good ***i*** used in sector ***j*** in country ***r***
$xtaxr_{i,r,s}$	Export tax rate on good ***i*** for exporting from country ***r*** to ***s***
$mtaxr_{i,r,s}$	Import tax rate on good ***i*** for imported by country ***s*** from ***r***
$ptaxr_{i,r}$	Producer tax
$ctaxr_{i,r}$	Commodity sales tax rate
$hsaver_{r}$	Household saving rates in country ***r***
exr_{r}	Nominal exchange rate in country ***r***

A. Illustration of the regional CGE model: within countries



B. Illustration of the regional CGE model: trade flows between countries



Equations

Relationship between CIF and FOB prices

(1) $$PWM_{i,s,r} = TRANSPR_{i,s,r} \times PWE_{i,s,r}$$

(1a) $$TRANSPR_{i,s,r} = \phi_{i,s,r} \times PWE_{otp,s,r}$$

Production and input demand

CES value-added function

(2) $$PVA_{i,r} = \left(\Lambda^{x}_{i,r}\right)^{-1} \times \left[\sum_{f} \left(\alpha^{\sigma^{x}_{i,r}}_{f,i,r} \times WF^{1-\sigma^{x}_{i,r}}_{f,r}\right)\right]^{\frac{1}{\left(1-\sigma^{x}_{i,r}\right)}}$$

Factor demand

(3) $$FD_{f,i,r} = \left(\Lambda^{d}_{i,r}\right)^{\sigma^{x}_{i,r}-1} \times \left(\frac{PVA_{i,r} \times \alpha_{f,i,r}}{WF_{f,r}}\right)^{\sigma^{x}_{i,r}} \times X_{i,r}$$

Intermediate demand

(4) $$INTD_{i,r} = \sum_{i'} \left(io_{i,i',r} \times X_{i,r}\right)$$

Relationship between value-added and output prices

(5) $$\frac{PX_{i,r}}{\left(1+ptaxr_{i,r}\right)} = PVA_{i,r} + \sum_{i'} \left[io_{i,i',r} \times PC_{i',r} \times \left(1+ctaxr_{i',r}\right)\right]$$

Imports and exports

Armington import function for composite goods

(6) $$PC_{i,r} = \left(\Lambda^{c}_{i,r}\right)^{-1} \times \left(\delta^{\sigma^{c}_{i,r}}_{i,r} \times PMM^{1-\sigma^{c}_{i,r}}_{i,r} + \left(1-\delta_{i,r}\right)^{\sigma^{c}_{i,r}} PD^{1-\sigma^{c}_{i,r}}_{i,r}\right)^{\frac{1}{\left(1-\sigma^{c}_{i,r}\right)}}$$

Demand for import-composite goods

(7) $$MM_{i,r} = \left(\Lambda^{c}_{i,r}\right)^{\sigma^{c}_{i,r}-1} \times \left(\frac{\delta_{i,r} \times PC_{i,r}}{PMM_{i,r}}\right)^{\sigma^{c}_{i,r}} \times CC_{i,r}$$

Demand for domestically produced goods

$$(8) \qquad DC_{i,r} = \left(\Lambda^{c}_{i,r}\right)^{\sigma^{c}_{i,r}-1} \times \left(\frac{\left(1-\delta_{i,r}\right)\times PC_{i,r}}{PD_{i,r}} \right)^{\sigma^{c}_{i,r}} \times CC_{i,r}$$

Armington function for import-composite goods

$$(9) \qquad PMM_{i,r} = \left(\Lambda^{m}_{i,r}\right)^{-1} \times \left[\sum_{s} \left(\left(\delta^{m}_{i,s,r}\right)^{\sigma^{m}_{i,r}} \times PM^{1-\sigma^{m}_{i,r}}_{i,s,r} \right) \right]^{\frac{1}{1-\sigma^{m}_{i,r}}}$$

Import price in domestic markets

$$(10) \qquad PM_{i,s,r} = \left(1+mtaxr_{i,s,r}\right)\times EXR_{r} \times TSPRM_{i,s,r,s} \times PWM_{i,s,r}$$

$$(10a) \qquad TSPRM_{i,s,r} = \phi_{i,s,r} \times PX_{'otp',r}$$

Imports demand

$$(11) \qquad M_{i,s,r} = \left(\Lambda^{m}_{i,r}\right)^{\sigma^{m}_{i,s}-1} \times \left(\frac{PMM_{i,r} \times \delta^{m}_{i,s,r}}{PM_{i,s,r}} \right)^{\sigma^{m}_{i,s}} \times MM_{i,r}$$

CET function for export-composite goods

$$(12) \quad PX_{i,r} = \left(\Lambda^{t}_{i,r}\right)^{-1} \times \left(\left(\delta^{t}_{i,r}\right)^{-\sigma^{t}_{i,r}} \times PEE^{1+\sigma^{t}_{i,r}}_{i,r} + \left(1-\delta^{t}_{i,r}\right)^{-\sigma^{t}_{i,r}} PD^{1+\sigma^{t}_{i,r}}_{i,r} \right)^{-\frac{1}{1+\sigma^{t}_{i,r}}}$$

Supply of export-composite goods

$$(13) \qquad EE_{i,r} = \left(\Lambda^{t}_{i,r}\right)^{-\left(1+\sigma^{t}_{i,r}\right)} \times \left(\frac{\delta^{t}_{i,r} \times PX_{i,r}}{PEE_{i,r}} \right)^{-\sigma^{t}_{i,r}} \times X_{i,r}$$

Supply to domestic markets

$$(14) \qquad DC_{i,r} = \left(\Lambda^{t}_{i,r}\right)^{-\left(1+\sigma^{t}_{i,r}\right)} \times \left(\frac{\left(1-\delta^{t}_{i,r}\right)\times PX_{i,r}}{PD_{i,r}} \right)^{-\sigma^{t}_{i,r}} \times X_{i,r}$$

CET function of export-composite goods

$$(15) \qquad PEE_{i,r} = \Lambda^{e}_{i,r} \times \left(\left(\delta^{e}_{i,r} \right)^{-\sigma^{e}_{i,r}} \times PE^{1+\sigma^{e}_{i,r}}_{i,r,s} \right)^{-\frac{1}{1+\sigma^{e}_{i,r}}}$$

Export price in domestic markets

$$(16) \qquad PE_{i,r,s} = \frac{\left(1 - xtaxr_{i,r,s}\right) \times EXR_{r}}{TSPRE_{i,r,s}} \times PWE_{i,r,s}$$

$$(16a) \quad TSPRE_{i,r,s} = \phi^{e}_{i,r,s} \times PX_{'otp',r}$$

Export supply

$$(17) \qquad E_{i,r,s} = \left(\Lambda^{e}_{i,r} \right)^{-\left(1+\sigma^{e}_{i,r}\right)} \times \left(\frac{PEE_{i,r} \times \delta^{e}_{i,r,s}}{PE_{i,r,s}} \right)^{-\sigma^{e}_{i,r}} \times EE_{i,r}$$

Idenatication between imports by country ***r*** from ***s*** and exports from country ***s*** to ***r***

$$(18) \qquad M_{i,s,r} = E_{i,s,r}$$

Final demand and income

Household income

$$(19) \qquad YH_{r} = \sum_{f} \sum_{i} WF_{f,r} \times FD_{f,i,r} \times GOVTRAN_{r}$$

Household consumption demand

$$(20) \qquad CD_{i,r} = \frac{\beta^{c}_{i,r} \times \left(YH_{r} \times \left(1 - hsaver_{r}\right) - \sum_{i'} PCT_{i',r} \times \gamma_{i,r} \right)}{PC_{i,r} \times \left(1 + ctaxr_{i,r}\right)} + \gamma_{i,r}$$

Government revenue

$$
\begin{aligned}
GOVREV_r = & \sum_i \sum_s \left[xtaxr_{i,r,s} \times exr_r \times PWE_{i,r,s} \times E_{i,r,s} \right] + \\
& \sum_i \sum_s \left[mtaxr_{i,s,r} \times exr_r \times PWM_{i,s,r} \times M_{i,s,r} \right] + \\
& \sum_i \left[PC_{i,r} \times \left(1 + ctaxr_{i,r}\right) \times CC_{i,r} \right] + \\
& \sum_i \left\{ \left[ptaxr_{i,r} / \left(1 + ptaxr_{i,r}\right) \right] \times PX_{i,r} \times X_{i,r} \right\}
\end{aligned} \tag{21}
$$

Government final demand

$$
GD_{i,r} = \frac{\beta_{i,r}^{g} \times \overline{GOVEXPS}_r}{\left(PC_{i,r} \times \left(1 + ctaxr_{i,r}\right)\right)} \tag{22}
$$

Government transfers

$$
GOVTRAN_r = GOVREV_r - \overline{GOVEXPS}_r \tag{23}
$$

Investment demand

$$
INVD_{i,r} = \frac{\beta_{i,r}^{z} \times ZTOT_r}{\left(PC_{i,r} \times \left(1 + ctaxr_{i,r}\right)\right)} \tag{24}
$$

Equilibrium conditions

Commodity markets

$$
CC_{i,r} = CD_{i,r} + GD_{i,r} + INVD_{i,r} + INTD_{i,r} \tag{25}
$$

Factor market

$$
\sum_i FD_{f,i,r} = FS_{f,r} \tag{26}
$$

Foreign savings

$$
\overline{FSAVE}_r = \sum_i \sum_s \left(PWM_{i,s,r} \times M_{i,s,r}\right) - \sum_i \sum_s \left(PWE_{i,r,s} \times E_{i,r,s}\right) \tag{27}
$$

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