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IFPRI Discussion Paper 01363

July 2014

The Role of Agriculture in the Fast-Growing Rwandan Economy

Assessing Growth Alternatives

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ACKNOWLEDGMENTS

We are grateful to Mark Austin; Aparajita Goyal; Daniel Zerfu Gurara; Michael Morris; and participants at the meetings of the Ministry of Agriculture and Animal Resources (MINAGRI) of the Republic Rwanda in Kigali, of the World Bank in Washington, DC, and at the international conference "The Quest for Economic Transformation in Africa" in Nairobi for helpful comments, suggestions, and discussions. We are also grateful to the staff at MINAGRI for providing a series of data, government documents, and other unpublished materials. This study is jointly funded by the African Development Bank; the United States Agency for International Development (USAID); and the CGIAR Research Program on Policies, Institutions and Markets.

ABSTRACT

Rwanda is experiencing its best growth performance since independence, accompanied by heralded progress in reducing poverty. However, the stylized facts show that recent growth was led by nontradable services and that the public sector dominates investment, which is primarily financed by foreign grants. Foreign aid has caused the real exchange rate to appreciate, compounding difficulties faced by manufacturing and other tradable economic activities.

This study assesses the future growth prospects of Rwanda. The report first focuses on broad economic growth using a rather aggregated 18-sector dynamic general equilibrium model to display the trade-off between rapid growth and structural change. The analysis shows that with the current investment pattern, rapid growth is possible but structural transformation is slow. With an overvalued exchange rate, growth in the tradable sector slows down and its share in the economy stays small. The importance of agriculture thus should be considered in the broad development strategy, for its role not only in poverty reduction but also in economic growth.

For this reason, this study further develops a 54-sector dynamic computable general equilibrium model with more detail for the agricultural sector. The analysis shows that the agricultural and service sectors are less sensitive than other sectors to foreign inflows and their induced overvaluation of the real exchange rate, due to these two sectors' stronger linkages with the rest of the economy. This outcome indicates that the domestic market plays a crucial role in stimulating growth in Rwanda, a low-income country in its early stage of development.

Based on the analysis of future economic growth prospects, a threefold strategy is recommended for agriculture to play an active role in Rwanda's future economic growth: (1) If overall economic growth continues to be supported by foreign-financed investment similar to that in the present, meeting domestic market demand will be the dominant force to lead agricultural growth, and such growth will be driven primarily by market forces from increased domestic demand. (2) Exploring regional market demand is part of this growth strategy, because the regional market differs significantly from the international market for Rwanda's agriculture but is close to the domestic market in nature. The regional market is also less sensitive to the overvaluation of the real exchange rate that will hurt agricultural exports going to international markets. (3) When the issue of overvaluation of the real exchange rate is corrected, export agriculture will grow more rapidly and will increase its role in leading total agricultural growth. Although broadening the international trade basket and exploring nontraditional export niche markets are important, Rwanda's international trade will continue to be dominated by its two traditional export commodities, coffee and tea. Thus, increasing value addition or price premium by improving the quality of these two commodities in their production and processing is important.

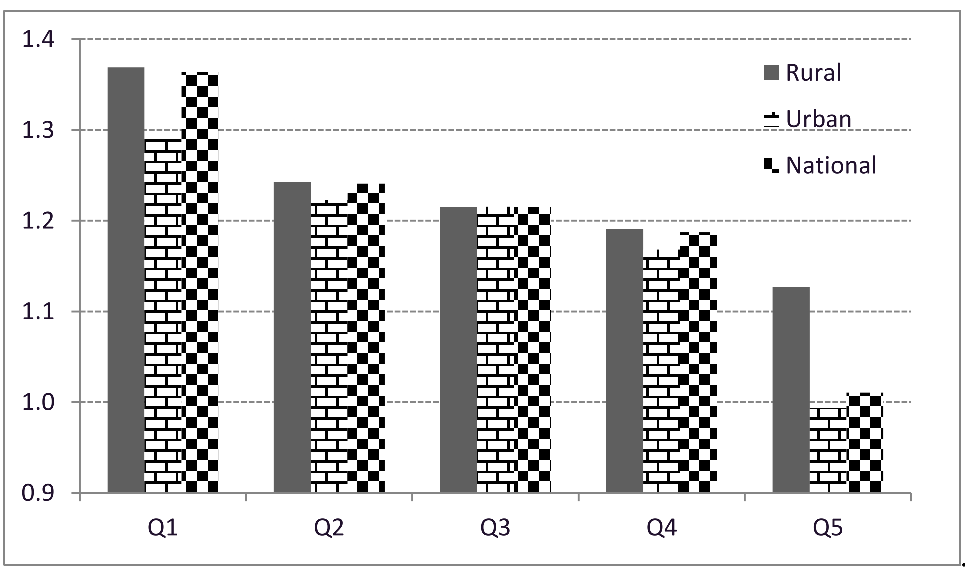
Keywords: growth and structural change, agriculture, public investment, Rwanda, general equilibrium modeling

1. INTRODUCTION

Rwanda is experiencing its best growth performance in recent years. Its average annual gross domestic product (GDP) growth rate of 8 percent from 1999 to 2012 is a historical record. A number of African countries have experienced similar growth in recent years, much of it attributed to booming world commodity prices for mineral, oil, and other natural resources. However, growth in Rwanda, a natural resource–poor country, has little to do with such commodity windfalls. Moreover, being the country with the highest population density in Africa, with 416 persons per square kilometer (2012), and being landlocked, Rwanda has more difficulty in achieving rapid growth than do many other African countries; hence, such growth is more impressive. These results reflect the persistent commitment of the government of Rwanda to reforms in health, education, general policy environment, and investment in infrastructure and education. According to the World Bank's *Doing Business* report for 2014 (World Bank 2013), Rwanda progressed from the 58th to the 32nd position in the ranking for ease of doing business worldwide from 2013 to 2014. This performance makes Rwanda the second-most-reformed economy in the world over the last five years and the third-easiest for doing business in Africa, as well as the easiest country for doing business in the East African Community.

When growth is not from commodity windfalls, it is expected to be broad based. Indeed, Rwanda's recent growth has led to rapid reductions in poverty. The national poverty rate has been lowered by 12 percentage points between 2005/2006 and 2010/2011, as reported by the Integrated Household Living Conditions Surveys (known locally as Enquêtes Intégrales sur les Conditions de Vie des Ménages, or EICVs1). The broad-based growth is depicted in Figure 1.1, in which per capita real income in 2010/2011 is compared with that in 2005/2006 according to five income groups of rural and urban households.

Figure 1.1 Change in real per–adult equivalent income by income quintile in 2010/2011 (2005/2006 = 1)



Source: Integrated Household Living Conditions Surveys 2005/2006 (EICV 2) and 2010/2011 (EICV 3).
Notes: Q1 represents the poorest 20 percent of national population according to the measure of per adult equivalent income and Q5 represents the richest 20 percent. Rural and urban stand for rural and urban households, respectively.

[1] EICV 1 covered 2000/2001, EICV 2 covered 2005/2006, and EICV 3 covered 2010/2011.

Figure 1.1 shows that between 2005/2006 and 2010/2011 real per capita income increased by almost 40 percent for the poorest 20 percent of households, more than 20 percent for the second and third quintiles of households, and slightly less than 20 percent of the fourth quintile of households. Thus, growth has improved the income distribution and is favorable toward the poorest households, which is a more impressive outcome than the simple measure of national poverty rate. Change in the poverty rate is measured by the change in the fraction of total population living under a poverty line. The national poverty rate was 57 percent in 2005/2006 and fell to 45 percent by 2010/2011 in Rwanda. While this change is a big success for the country in terms of poverty reduction, the result could have been achieved without raising income for the poorest 40 percent population, represented by the first two quintiles in Figure 1.1. Put differentially, the achievement of poverty reduction in Rwanda is far more impressive than lowering the national poverty rate. Although the poorest 40 percent of the population were still living below the poverty line in 2011, their average income increased more rapidly than that of the other 60 percent of the population, who were no longer poor by 2011.

Although Rwanda's recent growth is encouraging, the country faces challenges for future growth. In the development literature, until recently, cross-country growth regressions consistently showed a negative relationship between foreign aid/capital inflows and long-term growth (Subramanian and Rajan 2011). Rodrik (2008) argued that the overvalued exchange rate resulting from foreign inflows is a fundamental explanation for the negative relationship between growth and inflows.

In the case of Rwanda, foreign inflows, measured as current account deficits, have grown at more than 15 percent annually, and this growth further accelerated after the debt relief of 2006, with the annual growth rate reaching 28 percent from 2006 to 2011. Excluding foreign grants from the current account deficit (foreign grants help to reduce the current account deficit but represent a different type of foreign inflows because they go directly through the government), the ratio of foreign inflows (measured as trade deficit) to GDP rose from 14 percent in 2006 to 22 percent in 2012 (National Account, Rwanda, MINECOFIN 2013a). Although foreign inflows help Rwanda finance its public investment, they can cause the real exchange rate to appreciate, which negatively affects growth in the tradable sectors, because the relative prices of tradables (which are more influenced by global prices than are nontradables) fall against prices in the nontradable sectors. This situation raises a concern as to whether growth can be sustained in the long term. The overvalued real exchange rate often hurts the tradable sectors more than the nontradable sectors (Rodrik 2008), which will slow structural change in the economy by slowing growth in the tradable sectors, even as the overall economy may enjoy rather rapid growth for a while (mainly led by the fast-growing nontradable sectors). Without structural change through which resources (labor and capital) move into more productive tradable sectors, particularly manufacturing, the economy lacks dynamism; that is, it lacks the new engines to drive future growth, making growth acceleration impossible and challenging growth sustainability.

Growth with Structural Change?

In order to fully recognize the challenges Rwanda faces for future growth, we conduct a growth diagnostic to better understand the drivers of recent growth, the process of the structural change (if it occurs), the financial sources available to support growth, and the channels for these supports. For these purposes, we first ask what fast-growing sectors are the leading forces for the growth of the whole economy. To answer this, we define the fast-growing sectors as those with average annual growth rates at sector level at least 50 percent higher than the 8 percent GDP growth rate. Five subsectors of the economy stand out with double-digit growth rates, ranging between 12 and 18 percent from 1999 to 2012: (1) construction, (2) hotels and restaurants, (3) transport, (4) education, and (5) other personal services. Table 1.1 displays the annual growth rates for these five sectors and their contribution to overall economic growth in the recent years.

Table 1.1 The five fastest-growing sectors in the Rwandan economy, 1999–2012

Sector	Annual growth rate (1999–2012)	Share of GDP in 1999	Share of GDP in 2012	Contribution to growth in GDP (1999–2012)
Construction	12.4	6.6	9.3	11.0
Hotels & restaurants	16.9	1.1	1.9	2.4
Transport	14.7	5.2	7.9	10.8
Education	13.4	2.8	6.4	8.1
Other personal services	18.5	0.2	0.9	1.6
Total	13.8	15.8	26.5	33.9

Source: National Account, Rwanda, MINECOFIN (2013a).
Note: GDP = gross domestic product.

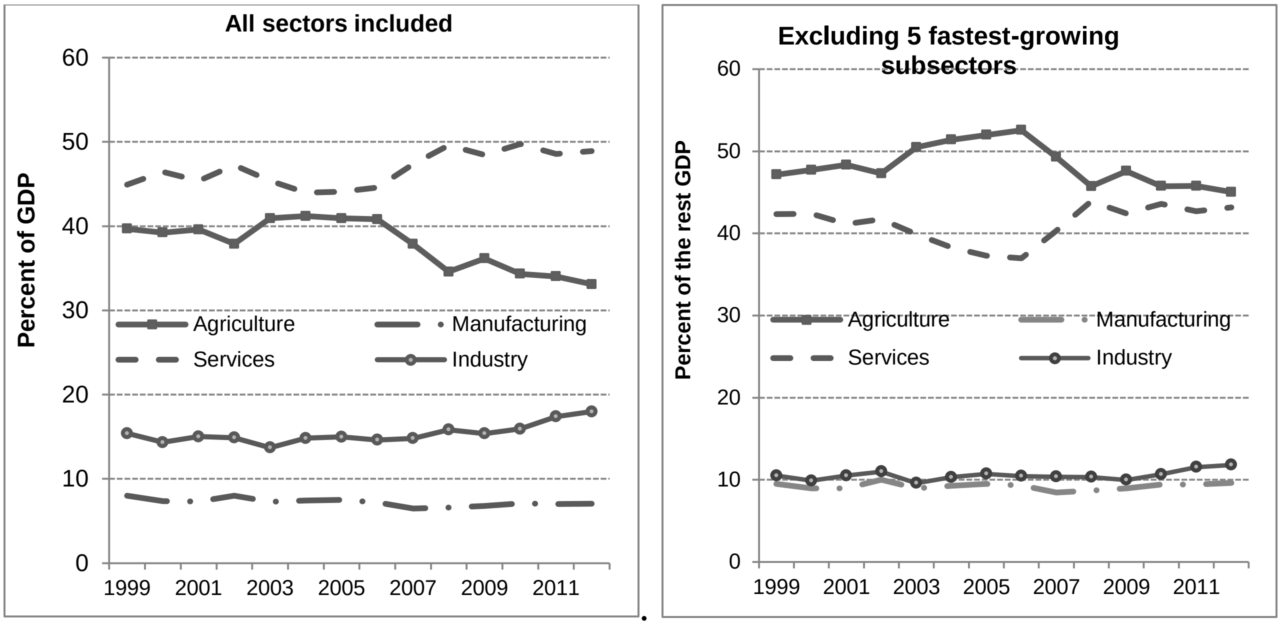
It is easy to see that all five of the fastest-growing sectors are more or less nontradable sectors. Construction as an industrial subsector is typically nontradable in most economies (particularly in developing economies), inasmuch as its activities occur locally within the national boundary. Education and other personal services are also nontradable services provided locally to the country's residents. Considering tourism as a tradable economic activity, hotels/restaurants and transportation are both, in part, exportable activities. Still, domestic demand plays a similarly important role in the growth of these two sectors, particularly in the transport sector.

These five fast-growing sectors together accounted for 16 percent of GDP in 1999, and this share increased to 27 percent in 2012. With a 14 percent average annual growth rate for the five fast-growing sectors as a whole, growth in these five sectors contributed more than one-third of the overall growth in the economy.

To further probe the role of these five sectors in the structural change of the economy, Figure 1.2 compares growth in all sectors with growth in the sectors excluding the five fastest growing ones. Including all sectors, the economic structure started to change in recent years, led by a declining share of agriculture and increasing share of services. The share of the manufacturing sector in GDP remained constant, and the share of the industrial sector, in which manufacturing is a component, rose slightly (left panel). However, when the five fastest-growing sectors are excluded from the calculation, in the right-hand panel, the structure of the economy appears stagnant. Moreover, agriculture becomes the largest sector, replacing the position originally occupied by the service sector in the left-hand panel, while the gap between the two lines for industry and manufacturing disappears, as does the rising trend in the line for industry.

It is common that during rapid economic growth some sectors grow more rapidly than others and fast-growing sectors often lead the structural change of the economy. Thus, it is necessary to ask whether the fast-growing sectors have the necessary growth dynamism to lead structural change and sustainable growth in the future. However, the current fast-growing sectors in the Rwandan economy are dominated by nontradables, which seem unlikely to have such dynamism as drivers of structural change. This lack of dynamism raises the question of whether recent rapid growth can be sustained.

Figure 1.2 Sector share of GDP, all sectors included versus excluding five fastest-growing subsectors, 1999–2011



Source: Authors' calculation using data from National Account, Rwanda, MINECOFIN (2013a).
Note: GDP = gross domestic product.

What Is the Driver of Growth?

Rapid growth is always associated with increased investment (if the growth does not come from commodity windfalls), and this is also the case of recent growth in Rwanda. Investment as a ratio to GDP has risen from 13 percent in 1999 to 22 percent in 2012, and investment grew more rapidly than GDP. Over 2006–2012, the annual average growth rate in investment reached 15 percent. However, most investment is in the form of construction, accounting for 77 percent in the two recent years of 2011–2012, compared with between 65 and 74 percent before 2011. Part of the construction boom, which can explain the high growth rate in the construction sector, is due to heavy investment in infrastructure such as roads, which improve the transportation condition that in turn benefits all economic sectors. However, the durable-good investment in machinery and other facility equipment is more important for the expansion of manufactures. The smaller share of such investment in total capital formation and its relatively slower growth rate seem to reflect the relatively slower growth in manufacturing, a sector crucial for structural change.

While the growth rate in investment is impressive, investment is still dominated by the public sector. The data between 2007 and 2011 show that public investment as a ratio to total capital formation was 51 percent in 2007 and rose to 64 percent in 2011. Thus we conclude that while investment has driven the recent growth in Rwanda, the public sector has played a dominant rule in the investment boom.

What Is the Financial Source of Growth?

With rapid growth in investment, it is necessary to know where the financial resources for such growth come from and through which channels. The government of Rwanda has increased its tax revenue in recent years, while the government's current (noncapital) expenditure is still more than its tax revenue. These facts imply that public investment has to be financed through external sources. Indeed, according to available data and measured in constant prices, foreign grants received by the government grew at 8 percent per year from 2000 to 2011, while growth accelerated to 20 percent per year from 2006 to 2011.

Together with the other nonprivate channels—nonprivate capital accounts and financial accounts—foreign inflows through the three nonprivate channels were equivalent to between 70 and 96 percent of total capital formation over the period 2007–2011 (Table 1.2).

Table 1.2 Ratio of different channels of foreign inflows to total capital formation, 2007–2011

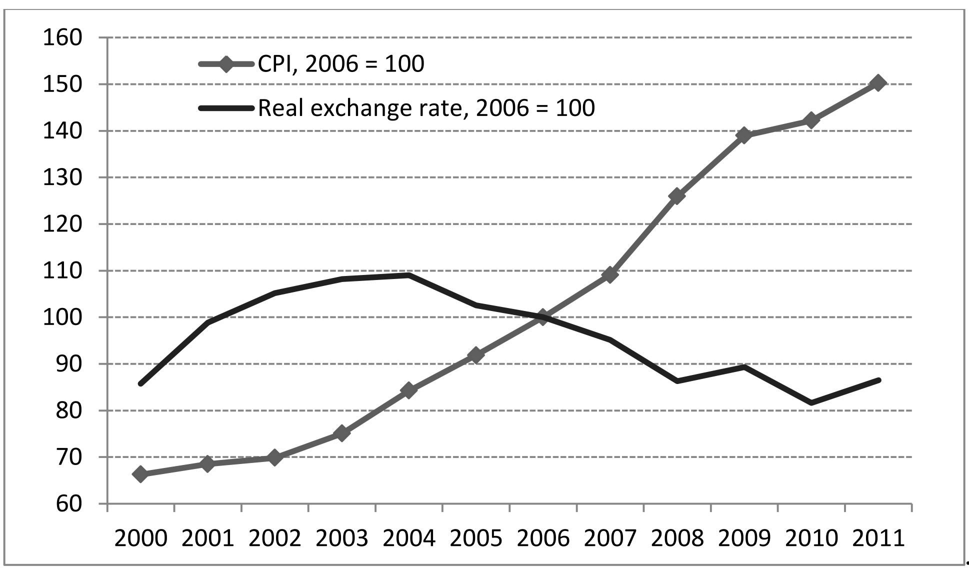
Channel	2007	2008	2009	2010	2011
Through nonprivate capital accounts	13.6	19.6	17.7	24.2	14.7
Through grants to government	53.8	41.7	46.3	48.0	55.8
Through nonprivate financial accounts	3.3	2.0	8.2	12.7	26.0
Three channels total	70.7	63.4	72.1	85.0	96.5

Source: Authors' calculation using data from current account and balance of payment, Rwanda, MINECOFIN (2013a).

Challenges to Future Growth and Structural Change

The most important challenge is the overvalued real exchange rate that results from increased foreign inflows. As discussed above, when the real exchange rate appreciates, nontradable sectors usually grow more rapidly than tradable ones, inasmuch as increased demand (as an outcome of increased inflows) for nontradables can be met only by local supply, while increased demand for tradables can be met by increased imports or reduced exports. Many nontradable sectors also have relatively low productivity. An unfavorable relative prices against tradables, of which many have higher productivity, will lead to further challenge for structural change in the growth process.

Figure 1.3 Change in real exchange rate and CPI, 2000–2010



Source: Authors' calculation using data from the current account (MIECOFIN 2013a).
Note: CPI = consumer price index.

Growth is accompanied by capital deepening, which further improves labor productivity in the economy. However, heavy dependency on nonprivate foreign inflows makes the capital deepening process less sustainable.

Rapid growth accompanied by slow structural change will make structural change—measured by the increased role of manufacturing and other sectors with high labor productivity—more difficult in the future. The reason for this difficulty is that the wage rate in the formal sectors will rise under such a growth pattern, which makes investment, including foreign direct investment (FDI), less attractive in labor-intensive manufactures.

Rapid growth in the nontradable sector is accompanied by rapid urbanization. Young people move to cities with high expectations for urban jobs, but the sectors in which they wish to work, the formal (or organized) sectors, are often tradables, where not many jobs are being created. Fewer than 7 percent of jobs created in the last 10 years have been in the manufacturing sector, and there is little sign that the growth in job creation in this sector will rise with rapid economic growth. Most migrants end up in low-productivity informal activities.

2. ECONOMYWIDE ASSESSMENT OF GROWTH TRANSITION AND STRUCTURAL CHANGE

In order to quantitatively assess the challenges faced by Rwanda's future growth, we developed a dynamic computable general equilibrium (CGE) model with 18 sectors and used the model for a set of scenario analyses.[2] Among the 18 sectors we considered 12 tradable and 6 nontradable sectors in order to measure the differential effects between tradable and nontradable sectors (if any) of an overvalued exchange rate. Both tradable and nontradable sectors can be categorized as agriculture, industry, or services; we further distinguish tradables as importable and exportable. The import-substitutable sectors are as follows: (sector number 2) cereals, a subsector in which the country heavily depends on imports; (9) processed food, of which 22 percent of domestic demand is imported; (11) other manufactured consumption goods, for which 38 percent of domestic demand is met by imports; (12) intermediate goods and (13) investment goods, both with import dependency; and (17) services dependent on imports, such as finance. Among six exportable sectors, three are in agriculture: (3) crops exported directly as raw materials (such as pyrethrum and other horticulture crops); (5) food crops that are exportable, such as dry beans; and (6) livestock. The two major export sectors of Rwanda are (7) mining and (10) processed export crops, such as washed coffee beans and processed tea. The last export sector is in services, and we call it (16) export services, in which tourist-related service activities dominate. Among the six nontradable sectors, two are in agriculture: (1) cereals such as sorghum and (4) root crops such as cassava, both of which are not traded much outside the country and hence their domestic prices are unlikely to be directly affected by world prices. In the industrial sector, construction is the dominant nontradable, which we call (14) nontradable industry. There is a (16) nontradable food processing sector that summarizes all domestically oriented manufacturing activities. In the service sector, most activities are nontradable, such as trade, transport, education, other government services, and other personal services, and we aggregate them into two sectors (15) nontradable private services and (18) nontradable public services (see Table 2.1 for a list of the 18 sectors).

Table 2.1 The 18 sectors in the aggregated dynamic computable general equilibrium model for Rwanda

	Sector	Position in trade
1	Cereals, nontradable	Nontradable
2	Cereals, importable	Import substitutable
3	Export crops	Exportable
4	Other crops, nontradable	Nontradable
5	Other crops, exportable	Exportable
6	Livestock, exportable	Exportable
7	Mining, exportable	Exportable
8	Food processing, nontradable	Nontradable
9	Food processing, importable	Import substitutable
10	Coffee and team processing, exportable	Exportable
11	Manufacturing, consumption goods	Import substitutable
12	Manufacturing, intermediate goods	Import substitutable
13	Manufacturing, investment goods	Import substitutable
14	Construction and other nontradable industry	Nontradable
15	Services, nontradable	Nontradable
16	Services, exportable	Exportable
17	Services, importable	Import substitutable
18	Public services, nontradable	Nontradable

Source: Authors.

[2] The social account matrix (SAM) used for the 18-sector model is the SAM of the Rwandan economy created in 2011. The next section gives a detailed discussion of this SAM.

With certain modifications, the endogenous growth model developed by Rodrik (2008) is applied for structuring the dynamic CGE model of Rwanda. According to Rodrik (2008), change in the real exchange rate affects long-term growth as measured by productivity. Moreover, substantial studies in the literature show a positive linkage between productivity growth and public investment. For these reasons, we link the productivity coefficient in the model to increases in public investment and changes in the real exchange rate. For the effect of public investment on productivity, we use an elasticity of 0.25; that is, 1 percent growth in public capital investment spending is associated with 0.25 percent growth in productivity. This elasticity is comparable with the relationship between the growth in public investment in capital formation and change in total factor productivity (TFP) of the Rwandan economy as a whole over the period 1999–2011; such a comparison will be further discussed in Section 4.

We first conducted a simple growth accounting exercise in order to measure the TFP growth rate in recent years. A more detailed description of this growth accounting exercise will be covered in Section 4. The analysis shows that the average annual TFP growth rate over the years 1999–2011 was 3.14 percent. The initial TFP growth rate in the first period of the model scenario is chosen according to this result.

We further created a productivity-augmenting parameter for measuring the longer-term impact of the real exchange rate over time. The real exchange rate is defined as the ratio of an index for world prices over the index for domestic prices for the 18 commodities of the model. Given that world prices are exogenous, we can normalize the index for world prices to equal 1. Thus, the real exchange rate is simply a reverse of the domestic price index.

Using panel data for 188 countries and 11 five-year periods, Rodrik (2008) estimated the growth impact of the real exchange rate from changes within countries. He found that for developing countries, a 10 percent undervaluation is associated with a boost in annual growth of real income per capita during the same five-year period of 0.26 percentage points. This finding is robust, many different methods having been applied in the same paper to validate the tests, with similar results found each time. Furthermore, the growth impact of undervaluation depends heavily on a country's level of development. For poor countries, for example, Ethiopia, the growth impact of undervaluation can be three times as large as that for a middle-income developing country, for example, Brazil (Rodrik 2008, 374). The explanation for this finding is that tradable sectors are more sensitive to valuation of the real exchange rate than are nontradable sectors, and undervaluation can help tradable sectors improve the competitiveness of an economy on the world market. This benefit will not only be a one-time gain in exports or import substitution but also create certain longer-term effects measured by per capita income growth in a certain period.

We applied this result in the current model. Specifically, we allowed the change in undervaluation to augment the growth rate of TFP that is determined by the public investment through a productivity-augmenting parameter for which the initial value is 1. A positive change in this parameter is associated with depreciation of the real exchange rate and a negative change with its appreciation. We then chose an elasticity of 0.95 on the change in real exchange rate for this parameter in order to get a growth impact of undervaluation similar to the one in Rodrik (2008). The initial real exchange rate is normalized to 1 and, without changing over time, it has no impact on growth. When the undervaluation occurs, the value of the growth-augmenting parameter starts to increase, which augments the TFP growth rate. For example, if the real exchange rate depreciates (appreciates) by 2 percent in a year, the TFP growth rate in this year becomes 3.058 percent (2.944 percent) instead of 3 percent when the real exchange rate effect is not considered. Changes in both the real exchange rate and the growth rate of public investment are endogenous in the model.[3] The initial TFP growth rate in the first year of the entire period is arbitrarily chosen such that the initial GDP growth rate in year one is able to reproduce the actual GDP growth rate of 8 percent averaged over the years 2006–2012.

[3] This is because domestic prices as well as government savings to finance public investment are both endogenous.

The growth dynamics of an economy also include capital accumulation, which captures investment-led economic growth. In the model, the stock of capital is augmented over time through investment, and investment is financed by three sources of savings: household savings, which are endogenously determined by household income at a given saving rate; government savings, which are the difference between government revenue (endogenous in the model) and government current expenditure (exogenous in its quantity measure but endogenous in its value terms given that prices are endogenous); and foreign inflows to finance investment directly (exogenous). Given that the public investment will form public goods, which have already been considered as a source of productivity growth, we did not include it in the accumulation of capital employed in the private production process.

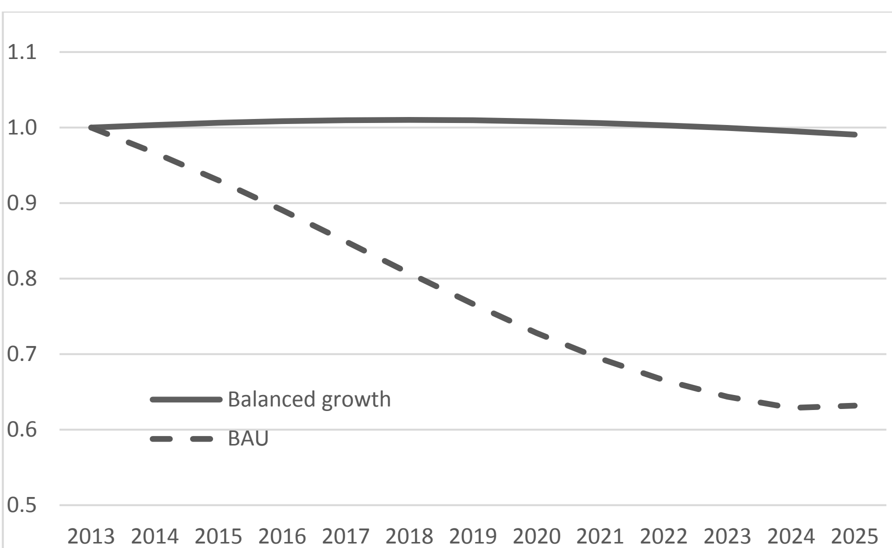
Other exogenous variables that also affect growth include supply of labor, expansion of crop areas, and increases in the stock of livestock. We assume that the agricultural labor supply grows at 2.8 percent and other labor at 4.4 percent annually, while total crop area and stock of livestock both grow at 1.9 percent annually.

We apply the model for constructing two scenarios to assess the alternative growth and structural change patterns under different assumptions on foreign inflows. In scenario one, we assume that foreign aid and other nonprivate foreign inflows grow at a much lower rate such that the economy becomes less dependent on foreign aid over time, a scenario called "balanced growth." In scenario two, foreign aid and other nonprivate foreign inflows grow initially at the current trend of 20 percent annually and eventually fall to a one-digit growth rate toward the end of the period; we call this the "business-as-usual" (BAU) growth scenario. Besides the different assumptions on foreign inflows, all assumptions for other exogenous variables and the structure of the model (including the coefficients to link TFP with public investment and real exchange rate) are the same in both scenarios. Both scenarios consider a period of 13 years, that is, future growth from 2013 to 2025, where 2012 is the base.

Different Patterns of the Two Growth Drivers

Given that the major concern in the analysis for future growth in Rwanda is the role of foreign inflows, that is, the impact on real exchange rate and support to investment, we first evaluate the different outcomes of real exchange rate movement and growth in investment under different assumptions on foreign inflows.

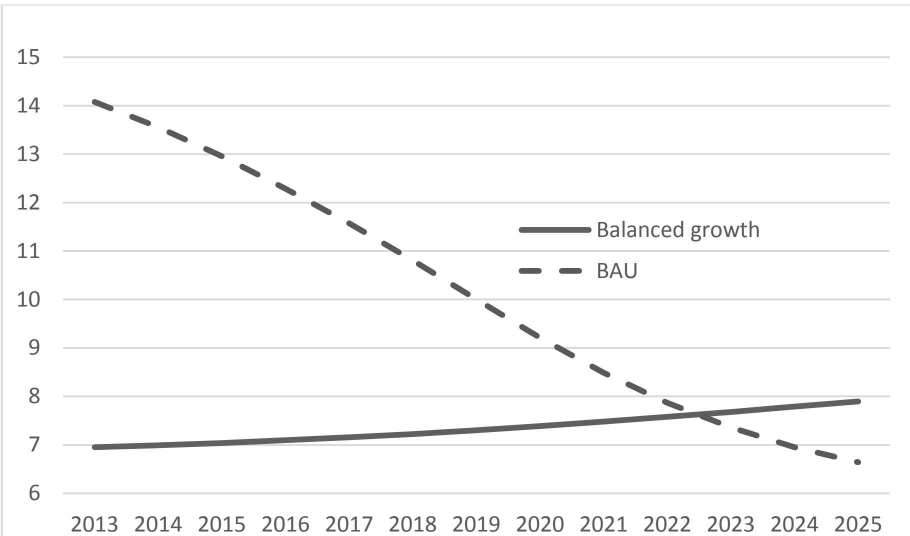
Figure 2.1 Change in real exchange rate (2013 = 1.0), 2013–2025



Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

Figure 2.1 shows the movement of real exchange rate under two different foreign inflow assumptions. When inflows grow slowly and their ratio to the level of GDP falls, under the balanced growth scenario, the value of the real exchange rate is very stable; that is, domestic prices (the denominator in the measure of the real exchange rate) are stable against world prices (the numerator of the real exchange rate). In contrast, when foreign inflows grow too rapidly, as has happened until recently, the real exchange rate appreciates significantly.

Figure 2.2 Annual growth rate of total investment (percent), 2013–2025



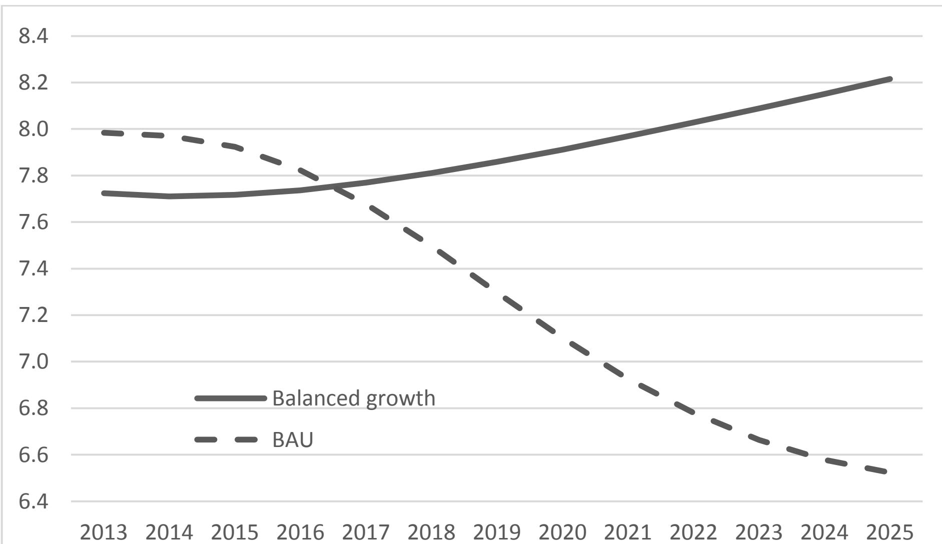
Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

Figure 2.2 displays the growth rate of investment under the two different foreign inflow scenarios. As expected, more foreign inflows stimulate growth in investment. At the high growth rate of foreign inflows, the growth rate for investment is 14 percent per year initially, a rate similar that of recent years. However, the growth rate in investment slows down over time and falls to 6.6 percent by 2025. The reason for the slowdown in investment is the diminishing returns on scale with the accumulation of capital as well as increased labor cost. This slowdown in investment occurs as an outcome of the slowdown in productivity growth shown in Figure 2.4 later. When returns on capital fall and the cost of labor rises, the unit cost of capital investment increases. Thus, at the same level of investment measured in value terms, there is less formation of actual capital measured in volume terms, which causes a slowdown in the growth rate of real investment. On the other hand, under the balanced growth scenario, the growth rate in investment is much lower (at 7 percent initially) with much a lower level of foreign inflow growth (5 percent annually). However, the growth rate in investment is much more stable, rising slightly with increases in productivity and reaching almost 8 percent by 2025. This implies that economic growth is much more balanced; hence the cost of investment is relatively stable and even falls slightly over time, which leads to slight increases in the growth rate of actual capital formation.

Growth Rates Differ in Short and Longer Runs

We now evaluate the effect of different patterns of foreign inflows on the short and medium run of growth, measured by GDP growth rate until 2025 in a period of 13 years, and longer-term growth, measured by TFP. The magnitude of the impact of foreign inflows on growth depends not only on which of the two opposite forces dominates but also on the initial structure of the economy. The positive role of foreign inflows in growth comes directly from its stimulus role on investment as well on productivity growth as an outcome of public investment, while the negative role of foreign inflows in growth comes from the appreciation of the real exchange rate. The initial condition of the economic structure also matters. An economy that is less dependent on international trade may be less sensitive to the negative effect of real exchange appreciation on growth than an economy with large tradable sectors. On the other hand, foreign inflows to finance investment and thereby improve productivity may benefit an economy with large tradable sectors more than a relatively closed economy, because such investment and productivity growth can help the country improve its international competitiveness. Moreover, the magnitude of the growth impact of foreign inflows may change over time depending on which of the two opposite forces dominates. Thus, whether the growth rate is higher or lower with more or fewer foreign inflows, particularly over time, is an empirical question.4

Figure 2.3 Annual growth rate of gross domestic product (percent), 2013–2025



Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

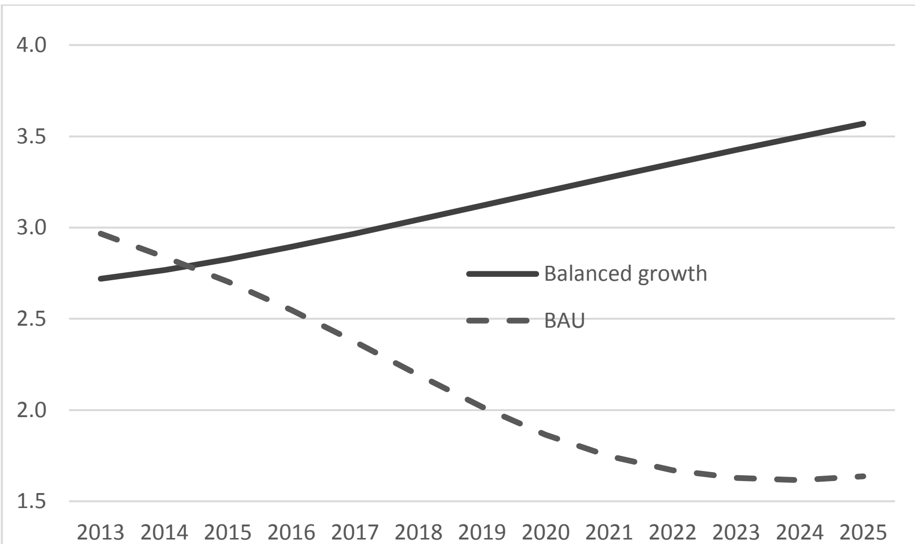
Figure 2.3 displays the growth rate of GDP between 2013 and 2025 under the two different foreign inflow scenarios. The model shows that with more rapid growth in investment under the BAU scenario, GDP growth is driven by investment and is relatively more rapid in the early years. However, when the investment growth rate slows down due to increased investment cost and the appreciation in real exchange rate, growth starts to slow down. The initial annual growth rate of GDP is 8 percent, similar to the average growth rate during 2000–2012. However, the growth rate falls to below 7 percent after 2020 and eventually falls to 6.5 percent in the simulated final year, 2025. On the other hand, under the balanced growth scenario, GDP growth starts at 7.7 percent per year and stays below 8 percent until 2021. The pace of growth steadily picks up and eventually reaches 8.2 percent in the final simulation year, indicating a much more sustainable growth pattern.

The long-run effect of foreign inflows can be better measured by the growth in productivity (TFP) shown in Figure 2.4. The sustainable growth in the long run has to come from productivity gain instead of growth in capital accumulation. Without productivity growth, diminishing returns on scale kick in with capital accumulation. As shown in Figure 2.4, the annual growth rate in TFP is about 3.0 percent

[4] The magnitude of the growth impact of foreign inflows is also affected by the assumption of elasticity of the two drivers to TFP growth, that is, growth in public investment and change in real exchange rate. Given the elasticity of the real exchange rate in the productivity coefficient discussed above, the higher the elasticity of TFP growth with respect to the growth in public investment, the more positive the effect of inflows on growth. Similarly, given the elasticity of TFP with respect to the growth in public investment, the higher the elasticity of change in the real exchange rate, the more negative the effect of inflows on growth.

initially in BAU, led by high level of public investment, which contribute to the improvement in TFP, in addition to the direct contribution to investment-led growth. However, the TFP growth rate slows down quickly over time, when the adverse effect of the appreciated real exchange rate starts to dominate. Toward the end of the period, the TFP growth rate falls to between 1.62 percent and 1.64 percent in the years 2023–2025 under this scenario. In contrast, under the balanced growth scenario, the initial growth rate of TFP is lower, at 2.7 percent per year, but it steadily rises over time and reaches 3.5 percent and more toward the end of the simulation.

Figure 2.4 Annual growth rate of total factor productivity (percent), 2013–2025



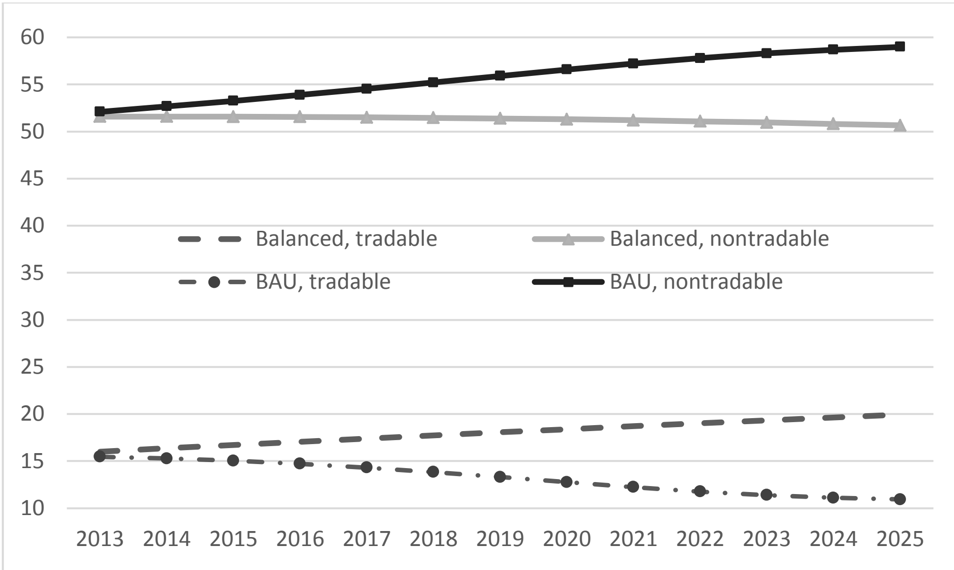
Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

Given that the economy can grow more rapidly with more foreign inflows to finance investment in the early years than under balanced growth, the government often prefers the current effect of foreign inflows instead of the long-run effect, that is, faster present growth supported by more foreign inflows and high investment. Indeed, with the elasticity used in the model on the linkages between TFP and public investment and real exchange rate, the more foreign inflows under BAU provide a higher level of per capita GDP than that under the balanced growth scenario until 2018, and only after 2018 is the level of per capita GDP eventually higher under balanced growth. Should we worry about anything after 2018 or later? Indeed, five or more years of rapid growth in the future will help Rwanda achieve its middle-income goal earlier. However, even with this goal being achieved, the country would still be poor, and growth would still be necessary. The model results show that there is a challenge for such growth to be sustained if we consider only rapid growth in the near future.

Structural Change in Growth Transition

Growth sustainability comes from structural change during growth transition; that is, labor and other resources move to more productive and profitable tradable sectors, which compete internationally with other countries in a much bigger market. Development of tradable sectors allows the country to overcome the constraint or limit of market size for a small country. For this reason, we further assess the effect of different patterns of foreign inflows on the structural change in growth.

Figure 2.5 Structural change of the economy—share of nonagricultural tradables and nontradables in gross domestic product (percent), 2013–2025



Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

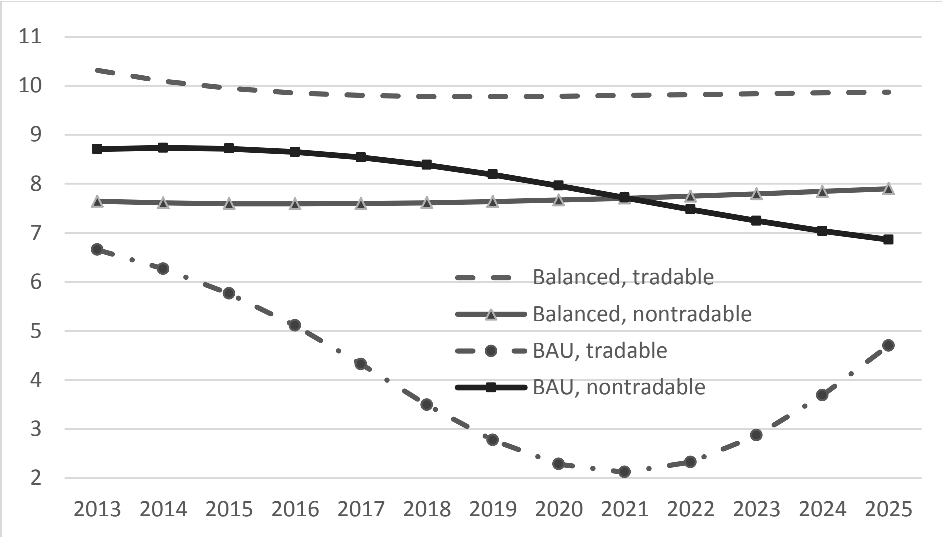
As we discussed before, the model includes 12 tradable sectors and 6 nontradable sectors. For comparison purposes, we consider the nonagricultural sectors only and aggregate the 12 nonagricultural sectors into tradables and nontradables according to their shares in GDP under the two alternative scenarios (Figure 2.5). Measured by the share in GDP, the Rwandan economy has a rather smaller tradable nonagricultural sector, about 16 percent of total GDP initially.[5] Under the BAU growth scenario, the share of tradable nonagriculture falls to 11 percent by 2025 as the outcome of an overvalued real exchange rate, which slows down the growth in the tradable part of the nonagricultural economy (Figure 2.6), an indication that the economy becomes less competitive internationally.[6] Growth in the nontradable nonagricultural sectors is similar to the growth of GDP (Figure 2.6), which implies that the share of nontradable nonagriculture in GDP is constant, as shown in Figure 2.5.

Along the balanced growth path, the tradable nonagricultural sector grows more rapidly, and its growth rate is higher than the growth in the nontradable part of the nonagricultural economy (Figure 2.6), leading the share of tradables in GDP to rise from 16 percent in 2012 to 20 percent by 2025 (Figure 2.5).

[5] The other 10 percent of GDP is tradable agriculture.

[6] The growth rate for tradable nonagricultural GDP starts to recover from its lowest level when the pace of foreign inflows slows down after 2021 (Figure 2.6).

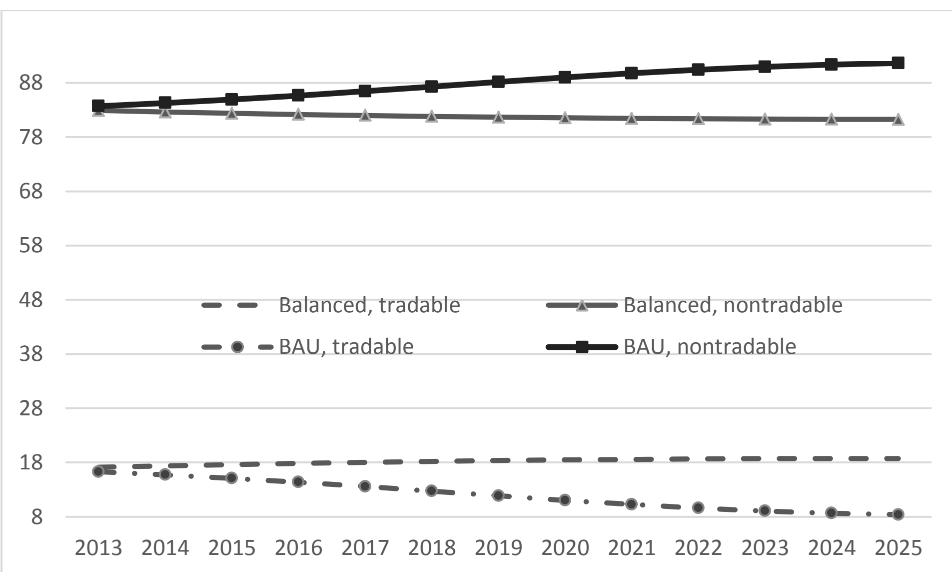
Figure 2.6 Growth rate of tradable and nontradable nonagricultural gross domestic product (percent), 2013–2025



Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

We further measure the labor mobility between tradable and nontradable sectors under the two alternative scenarios. Again, we consider nonagricultural labor only in this case. About 17 percent of nonagricultural labor is employed in the tradable sectors and the rest, 83 percent, in the nontradable sectors. Under the BAU scenario with a high growth rate in foreign inflows, most jobs are created in the nontradable sectors, causing the employment share for tradable nonagriculture to fall by half, to 8.4 percent, by 2025 (Figure 2.7).

Figure 2.7 Nonagricultural labor share of tradable and nontradable sectors (percent), 2013–2025

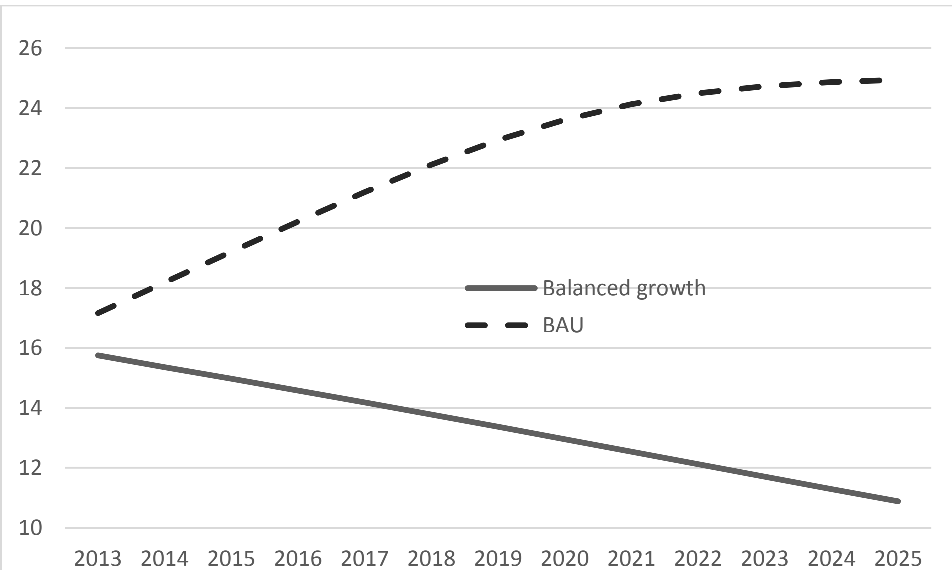


Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

On the other hand, under the balanced growth scenario, the employment share of tradable nonagriculture rises by almost 2 percentage points by 2025. Indeed, the tradable sector is still a small part of the economy even with much-slowed-down growth in foreign inflows in the future. This indicates that correcting the damage of an overvalued exchange rate on the incentives to develop the tradable economy is only a necessary condition for a boom in the tradable sectors, which are dominated by manufactures. As shown by Rodrik (2013), expansion of manufactures is the most powerful driving force of structural change in the early stage of transformation for developing countries. This is exactly what East Asian countries have done in the process of structural transformation of their economies. Expanding manufactures and hence having more labor to move from low-productivity nontradable sectors to tradable ones requires investment directly into the manufacturing sector, and most such investments often are from foreign countries (that is, FDI). However, the model does not have a capacity to measure such structural change led by FDI, which may significantly underestimate the potential for developing competitive tradable sectors in the Rwandan economy.

The BAU scenario is based on an assumption that most foreign inflows are grants that are free of interest to the government. Even without a consideration of debt accumulation, if the inflows are foreign borrowing instead of foreign grants, the ratio of trade deficit to GDP will rise to a level that is worrying to the health of the macroeconomy in the future. Figure 2.8 displays this ratio.

Figure 2.8 Ratio of trade deficit to gross domestic product, 2013–2025



Source: Result of authors' 18-sector dynamic computable general equilibrium model simulation.
Note: BAU = business-as-usual.

Currently, the trade deficit is about 16 percent of GDP in Rwanda. The ratio can rise to 25 percent if the country continues to receive a huge amount of foreign inflows as grants (Figure 2.8). If foreign grants are replaced by foreign borrowing, the ratio can further increase, with the amount of foreign loans similar to that of grants because of the payment of interest. Under the balanced growth scenario, the ratio of trade deficit to GDP will fall steadily to between 10 and 11 percent in the future, toward the end of the simulation. Considering that the country is poor in natural resources and its export base is currently small, the high dependency on foreign aid could put the country in a rather risky situation for its macroeconomic stability in the long run, and such stability is a condition necessary for sustainable economic growth.

Summary of Section 2

Rwanda is experiencing its best growth performance since independence. This growth success is also accompanied by heralded progress in reducing poverty. However, the challenge is the weakness of Rwanda's economic structural transformation. The stylized facts show that recent growth was led by nontradable services, in particular construction, transport, hotels and restaurants, and expansion of public services (education, for example). The public sector dominates investment, and the bulk of public investment is financed by foreign grants. Foreign aid has caused the real exchange rate to appreciate, compounding difficulties faced by manufactures and other tradables.

The simulation analysis using a dynamic general equilibrium model displays the trade-off between rapid growth and structural change. When the public sector dominates investment, primarily financed by foreign aid, rapid growth is possible but structural transformation is slow. This pattern of growth can make structural change more difficult in the future, which leads to the question of whether this growth performance can be sustained.

Almost two decades of economic growth in Rwanda have also raised a young population's expectations of good jobs in urban areas and nonfarm sectors while the country has yet to create the capacity to deliver them. Without giving up the growth opportunities created by foreign inflows, the government, in its strategy and planning, needs to pay more attention to creating a set of conditions necessary for accelerating structural transformation. One necessary condition is to keep the real exchange rate undervalued instead of overvalued (Rodrik 2008). The model results of this report show that with an overvalued exchange rate, growth in the tradable sector slows down, few job opportunities are created in manufactures and tradable services, and the share of tradable nonagriculture in the economy remains small and becomes even smaller in the future.

The model results also show that correcting the damage of an overvalued exchange rate is a necessary condition, and the tradable sectors—often led by the manufacturing sector—are still a small component of the economy. While the model is limited in its consideration of the role of FDI, East Asian experiences show that expansion of manufactures is a short cut to structural transformation in the early stage of development (Rodrik 2013). More foreign investment must be attracted to the tradable economy in order to speed up this process. With a reality of relatively limited growth opportunities in tradable nonagriculture in the near future, the important role of agriculture should be considered in the broad development strategy for its role not only in poverty reduction but also in economic growth and transformation. For this reason, Section 3 turns to agriculture.

3. AGRICULTURAL GROWTH OPTIONS WITH BALANCED FOREIGN INFLOWS

In the period discussed in the introduction section, that is, the rapid economic growth period of 1999–2012, Rwanda has also experienced the most rapid agricultural growth in its history. Agricultural GDP grew at 5.2 percent annually during 1999–2012, and growth accelerated in 2006–2012 to 5.7 percent per year. With dependence on rainfall for a majority of agricultural crop production, crop growth is affected by weather conditions and fluctuation is unavoidable. However, in the 13 years between 2000 and 2012, there were only 2 years in which per capita agricultural growth fell (2003 and 2004). Recent public investment in agriculture seems to have started to show its impact in that the country has significantly improved its resilience to the adverse effects of unfavorable weather conditions. The performance of the food crop sector is particularly impressive, and in the recent period of 2006–2012, the food crop value-added growth rate of 6.2 percent per year was higher than the growth rate for agricultural GDP in total. Rwanda is known for its high population density and small holding size. Although the land frontier was reached long ago, recent investment in marshland development and terracing has made more land available for cultivation. According to the crop assessment data for 2005–2013, about 280,000 ha of new land has been reported available for crop production since 2004, with a total increase of 17 percent since 2004 (MINAGRI 2014). This is equivalent to about 2 percent of the annual growth rate from 2005 to 2012. Considering that food crop value-added grew at 5.7 percent per year in the same period, productivity growth, including yield improvement and crop diversification, has been the main driving force behind growth in agriculture.

The 54-Sector Dynamic CGE Model for Rwanda

Agriculture continues to be one of the most important growth pillars for Rwanda, and a much higher growth target is set for agriculture under the new development strategy (Rwanda, MINECOFIN 2013b) and investment plan for the next five years. For Rwanda to achieve a double-digit annual growth rate and become a lower-middle-income country by 2020, the goal set in the strategy document (Rwanda, MINECOFIN 2013c), an annual growth rate for agriculture is set at 8.5 percent per year from 2014 to 2018. In this section, we first address what achieving this growth goal will imply for the different agricultural subsectors and how these subsectors will contribute to total agricultural and overall economic growth and poverty reduction. With the forward-looking nature of these questions, a simulation tool for analysis is an appropriate tool to apply, and thus, we have developed a highly disaggregated dynamic CGE model for Rwanda. This model is consistent with the 18-sector model used in the analysis of Section 2, with agricultural and nonagricultural sectors further broken down according to the actual economic structure of Rwanda in 2011. Specifically, the disaggregated dynamic CGE model for Rwanda includes 26 agricultural sectors, 8 agroprocessing sectors, 8 other industrial or manufacturing sectors, and 12 service sectors. The model further disaggregates 24 agricultural sectors other than forestry and fisheries into four provinces. A social account matrix (SAM), the dataset for a CGE analysis, is constructed for the model and represents the economy in 2011. The 2011 SAM is based on the 2006 SAM developed by Emini (2007) and modified and documented by Diao et al. (2010). Data used for SAM updating include data from a recent agricultural survey, EICV 3, and crop assessment at the provincial level for major crops, and a set of other statistics for trade, nonagriculture, and macroeconomic variables. Detailed information about the sectors and the SAM structure can be found in Table A.1 in the appendix.

It is necessary to have a set of assumptions up front for the CGE model before we use the simulation tool for any scenario analysis. Based on the analysis of Section 2, we chose a macroeconomic assumption consistent with the balanced growth scenario in the previous aggregated 18-sector model; that is, we assumed that foreign inflows will grow more slowly than those in recent years, and, in order to minimize the adverse effect of an overvalued real exchange rate on tradables, including on agricultural import substitutables and exportables, we assumed that the ratio of total foreign inflows to GDP is stable or slightly falls. Assumptions on the set of other exogenous variables can be found in Table A.2 in the appendix.

In order to model the poverty effect of future growth, we developed a microsimulation model and linked it to the CGE model. In the microsimulation model, all households sampled in EICV 3 are included as consumers, and their consumption, together with their sample weights, is linked to the consumption of individual representative household groups defined in the CGE model. Thirty such representative households groups are defined in the CGE model according to five income quintiles that are further broken down into four provinces for the rural households, and Kigali and the rest of the urban areas for urban residents. Consumption across 54 commodities for the individual representative households in the CGE model is endogenously and simultaneously determined with the households' incomes, which are received from their engagement in agricultural and nonagricultural production activities (as income for labor, land, and capital) and from government transfers and international remittances. Detailed discussion about a standard dynamic CGE model can be found in Diao and Thurlow (2012).

Scenarios of the 54-Sector Dynamic CGE Model

Before we introduce the scenarios of the disaggregated CGE model, it is necessary to explain the different settings for labor supply and land mobility, for which different assumptions will affect the simulation outcomes. Four types of labor are defined in the model, agricultural family labor plus three types of hired labor defined by level of skill. Agricultural family labor is employed only in agricultural production, and its supply is fixed with an exogenous annual growth rate of 2.5 percent by the design of the model (based on the rural population growth rate). The three types of hired labor are assumed to be not fully employed, implying that this labor supply is driven by demand and is affected by the wage rates, which differ across types of labor.[7] Demand for hired labor comes from 54 sectors. When supply of and demand for the 54 commodities differ across sectors over time, relative prices for these commodities change, as well as returns on land, capital, and wage rates. The normal wage rates are defined as a response to an endogenous consumer price index with elasticity of 1.4 for unskilled labor and 2.05 for the other two types of skilled labor (that is, a 1 percent increase in consumer price index is associated with a 1.4 percent increase in the nominal wage rate for the hired unskilled labor and a 2.05 percent increase in the case of the other two types of skilled labor).[8]

Land is an important factor for crop production, and land expansion through investing in marshland development, terracing, and other types of land-development projects is still considered as a way to increase crop production in the government's agricultural investment plan. Considering that targets in area expansion differ across crops in the Strategic Plan for Agricultural Transformation in Rwanda—Phase III (PSTA III) (for example, there are specific targets for increasing cultivated areas for wheat, coffee, or other crops) and also considering that substitution in land or relocation of land may not exist between some crops (for example, between coffee and wheat) and across provinces, the model assumes land to be crop specific, and crop area is thus exogenously changed over time. Specifically, we apply the historical trends in crop area to develop the model's base run—that is, land area for different crops grown according to their historical trends shown in the data—and the growth rate is specific to the crop and province. In the growth option scenarios, we assign additional land growth rates to some crops according to the information in PSTA III and other relevant government documents. Table A.3 in the appendix displays the actual growth rates used in the model simulations.

There are seven livestock subsectors in the model, and their stock (or capital) is assumed to grow exogenously. Without additional information, the annual growth rate for livestock capital stock is set at 4 percent in the base run for all subsectors and across four provinces.

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[7] This is a reasonable assumption because according to the authors' calculation using the EICV 3 data for 2010/2011, two-thirds to three-quarters of individuals who reported working in the year of the two seasons, or in the last week, actually worked part time—that is, less than 300 hours in the whole year of the two seasons (when asked by seasons) or less than 39 hours per week (when asked about the last week).

[8] The elasticity is arbitrarily chosen. However, we chose this elasticity such that the total labor supply including agricultural family labor will grow at a reasonable rate of 4.2 percent in the base run per year, a rate higher than the annual population growth rate, which has been 2.6 percent in recent years.

The leading factor to help the country meet its agricultural and overall growth targets is productivity growth. Different from the 18-sector model applied in Section 2, in which productivity is an endogenous variable influenced by public investment and the real exchange rate, the productivity (TFP) growth rates are exogenous variables in the disaggregated model, such that they are used to simulate the growth targets, including targets for yields in the case of crop production, for output in the case of livestock, and for value-added in the case of nonagricultural sectors. The TFP growth rate for crop production in the base run is specific to the crop and the province, using information about historical trends in yield growth at crop and province level. In alternative growth scenarios, we add to the base-run growth rate for the relevant crops, livestock production, or nonagriculture. The TFP growth rate for livestock production is only subsector specific, without provincial difference due to lack of provincial information (see Table A.4 in the appendix for TFP growth rates in the base run and in different growth scenarios).

Besides the base run, we consider five simulation scenarios, which are defined in Table 3.1.

Table 3.1 Scenarios and their assumptions

Scenario	Assumptions on land or livestock stock growth	Assumptions on TFP growth
(1) Base run	• Growth rates for food crop areas defined at crop level and differ across provinces • Historical trends considered for defining annual growth rate in food crop area expansion, ranging from 1.5 percent for sorghum to 3.4 percent for Irish potatoes • A growth rate of 3.5 percent defined for coffee and tea area expansion • A growth rate of 2 percent defined for area expansion in pyrethrum and other small export crops as a group (for example, horticulture and others) • Growth rate of 3 percent in the stock for livestock	• TFP growth rate for food crops chosen to target historical trends in crop yields • The exogenous TFP growth rate is chosen at sector level to target the historical trends in crop yield, because annual growth in yield is endogenous. Resulting yield growth rate ranges from 0.7 percent for rice to 4 percent for Irish potatoes per year • TFP growth rate in export crops and livestock chosen to make the growth rate in the relevant subsectors reasonable but higher than their historical trends • The choice of TFP growth rate also considers whether the overall growth rate of 5.7 percent for agriculture GDP in recent years (2005–2012) can be reproduced • TFP growth rate for nonagricultural sector chosen to reproduce as closely as possible the recent growth trends in nonagricultural GDP. • However, it is expected that GDP growth rate is lower than that in recent years (8 percent) due to the assumed slowdown of foreign inflows, as demonstrated in sector 2 of the 18-sector model

Table 3.1 Continued

Scenario	Assumptions on land or livestock stock growth	Assumptions on TFP growth
(2) Food crop–led growth	• Food crops include all crops other than coffee, tea, and pyrethrum and other small export crops as a group • Only six crops on which information about growth target is available are considered in this scenario: wheat, maize, rice, Irish potatoes, cassava, and beans • Additional area growth assumed only for these six crops • Growth assumptions related to other crops' areas and stock of livestock same as in base run	• Additional TFP growth rate for six food crops chosen to target as closely as possible their yields planned in government documents • No additional TFP growth rate for other food crops, export crops, livestock, and nonagricultural sectors
(3) Export crop–led growth	• Export crops include three commodities and a commodity group: coffee, tea, and pyrethrum and other small export crops as a group • Additional area growth assigned to them according to the areas targeted by 2018 in a set of government documents • Growth assumptions for all other sectors and livestock are same as in base run	• Additional TFP growth rate for the four export crops chosen to target as closely as possible their production levels planned in government documents • Additional TFP growth rate also assigned to a few service sectors in order to make sure that these sectors can grow at a similar rate as in base run • No additional TFP growth rate for food crops, livestock, and other nonagricultural sectors
(4) Livestock-led growth	• Additional growth in the stock for cattle, milk, poultry, and egg production assumed • No additional growth in the stock for other livestock production • Assumptions for all other sectors are same as in base run	• Additional growth in TFP for cattle, milk, poultry, and egg production assumed • No additional TFP growth in other livestock production • No additional TFP growth for crops and nonagricultural sectors
(5) Agriculture-led growth	• Combination of (2) through (4)	• Combination of (2) through (4)
(6) Agriculture and nonagriculture	• Same as (5)	• Doubling base run's TFP growth rate for all nonagricultural sectors • TFP growth assumptions for the agricultural sectors are same as in (5)

Source: Authors.
Notes: GDP = gross domestic product; TFP = total factor productivity.

Discussion of Simulation Results of the Dynamic CGE Model for Rwanda

Base Run

The base run is designed to reproduce a growth rate for GDP and agricultural GDP similar to their historical trends in 2006–2012. However, with the assumption that foreign inflows will grow more slowly in the model's scenario designs, including the base run, than in the recent years, predicted by the 18-sector simulation results in Section 2, the growth rate of the economy is expected to be possibly lower than the 8 percent of historical record. Moreover, the analysis of Section 2 shows that with different growth rates of foreign inflows, the structure of the economy and growth rate at sector level will differ. Thus, the model's base run is not expected to reproduce exactly the same growth rate at sector level.

Table 3.2 reports the historical GDP and sector GDP growth rates and the growth rate for the same variables as the model base run result. It should be noted that while the model makes assumptions on a set of exogenous growth rates including, for example, growth rate in TFP and foreign inflows, the economic growth rates for both GDP and sector-level GDP are endogenous variables in the model.

Table 3.2 Historical growth rates and endogenous growth results of the model's base run (percent)

Variable	Historical growth (2006–2012)	Model's base-run results (2013–2020)
GDP	8.1	7.7
Agricultural GDP	5.7	5.8
Food crops	6.2	5.7
Export crops	2.9	7.2
Livestock	3.3	5.7
Others	3.0	5.7
Industry GDP	9.9	7.8
Construction	14.1	7.6
Manufacturing	6.0	8.6
Service GDP	9.5	8.9

Source: Column 1, National Account, Rwanda, MINECOFIN (2013a); column 2, authors' 54-sector dynamic computable general equilibrium model simulation result.
Note: GDP = gross domestic product.

With foreign inflows growing more slowly in the model's base run for 2013–2020 (4.9 percent per year) than in recent years (24 percent per year), the model's base run obtains an average annual growth rate of 7.7 percent for the total economy's GDP over the period 2013–2020. While this growth rate is lower than the recorded annual growth rate of 8.1 percent on average for 2006–2012, it is still higher than the GDP growth rate in this period if the five fastest-growing nontradable sectors discussed in the Introduction are excluded.[9] As expected, because of slowed growth in investment and hence in construction, the industrial GDP growth rate falls to 7.8 percent per year in the model's base run for 2013–2020.[10] While the simulated growth rate in industry as a whole in the base run is lower than its actual growth in 2006–2012, the growth rate for the manufacturing sector, which is part of industry, is much higher than its historical level, at 8.6 percent per year for 2013–2020 versus 6.0 percent in 2006–2012. This result further confirms the finding of Section 2 in which we argued that an overvalued exchange rate due to foreign aid–financed investment will hurt the tradable sectors, and almost all manufacturing subsectors are tradable.

The simulated growth rate for agricultural GDP is similar in the base run for 2013–2020 to the actual growth rate in 2006–2012, indicating that while the majority of agricultural products are made to meet domestic demand and are less internationally tradable, in terms of growth effect, the sector as a whole seems to be less sensitive to the possible impact of overvaluation of the real exchange rate.[11]

[9] Excluding the five fastest-growing sectors, the GDP growth rate fell to 6.7 percent per year in the period 2006–2012.

[10] As shown in Table 3.2, construction as a subsector of GDP grew at 14.1 percent per year in 2006–2012 (National Account, MINECOFIN 2013a). Such rapid growth explained 13 percent of growth in total GDP in this period. In the model's base-run simulation, this subsector's annual growth rate is 7.6 percent. Assuming that construction would have grown at 7.6 percent per year in 2006–2012, keeping all other sectors growing at their actual rates, the recalculated industrial GDP annual growth rate is 6.7 percent for 2006–2012.

[11] The negative effect of an overvalued real exchange rate on productivity, including agricultural productivity, which was simulated in Section 2, was not considered here. However, even with this effect, as shown in Section 2, growth in the agricultural sector is less sensitive to the change in real exchange rate given that the tradable part of the agricultural sector is much smaller than the less tradable part.

However, within agriculture, the growth rate for food crops is slightly lower in the model than in the recent history, while the growth rate for export crops and livestock is higher in the model than in the data. Given that both export crops and part of livestock are highly internationally tradable, these subsectors of agriculture seem to be more sensitive to the change in real exchange rate, indicating that the real exchange rate does matter for promoting exports, including agricultural exports.

The service sector's growth rate in the base run is also lower than that of its recent history in 2006–2012, but the difference between the historical data and the model result is much more modest than that in the case of industry growth.[12] This result seems to indicate that while the service sector is dominated by nontradable activities, its linkage with the tradable part of the economy is strong. That is to say, service growth will be less affected if the tradable part of the economy can grow more rapidly even if construction, and hence the nontradable part of the industry sector, grows relatively slowly.

To better illustrate the differential impact of different foreign inflow growth on economic growth, Table 3.3 provides a comparison of the model results for its base run under different growth assumptions on foreign inflows. While the results displayed in Table 3.3 show that it is possible for the economy to continue its current growth momentum with similar high growth in foreign inflows, the tradable sectors are vulnerable to inflows that cause overvaluation of the real exchange rate (the last two columns of Table 3.3). This result is obtained without considering the endogenous effect of change in the real exchange rate on productivity growth, as we have done for the 18-sector model in Section 2. In this section, the productivity coefficients (TFP) in the 54-sector model are exogenous.[13] To minimize the impact of an overvalued real exchange rate on growth in the tradable agricultural and nonagricultural sectors, which are expected to become the leading sectors of future growth in the government's development strategy, for this report, all discussions in this section are consistent with the assumption of a low growth rate in foreign inflows, which is 4.9 percent per year.[14]

We also consider the poverty effect of growth in the base run. By linking the microsimulation model to the CGE model and assuming a 2.6 percent annual population growth rate (based on recent population growth trends World Bank 2014), not only will the national poverty rate continue to fall, but the absolute number of the poor will also decline, even with an annual growth rate for GDP slower than 8 percent in the next seven years. The poverty reduction result for all the scenarios will be jointly discussed in a separate subsection later.

[12] Assuming that the two fast-growing service subsectors, trade and education, would have grown at a rate similar to the model result (7.7 percent and 8.7 percent per year for the trade and education subsectors of services, respectively), the recalculated annual growth rate for the service sector is 8.3 percent in 2006–2012, while the model result of the annual growth rate is 8.9 percent for the service sector as a whole for 2013–2020.

[13] While productivity growth is exogenous and defined at the sector level in the model, growth in TFP for the economy as a whole is comparable with its historical trends in 1999–2012.

[14] The similar results discussed in this section for different growth assumptions on foreign inflows are available upon request from the authors.

Table 3.3 Historical growth rate and growth results of the base run with different growth rates in foreign inflows, 2013–2020 (percent)

		Model result of base run (2013–2020)		
Variable	Historical growth rate (2006–2012)	Low growth assumption in foreign inflows	Midlevel growth assumption in foreign inflows	High growth assumption in foreign inflows
Growth rate in foreign inflows	23.9	4.9	10.0	16.8
Change in real exchange rate (base year = 1.00)	0.87	1.09	0.96	0.73
GDP	8.1	7.7	8.2	8.4
Agricultural GDP	5.7	5.8	5.8	5.9
Food crops	6.2	5.7	5.8	5.9
Export crops	2.9	7.2	7.1	5.5
Livestock	3.3	5.7	5.6	5.3
Others	3.0	5.7	6.0	6.3
Industry GDP	9.9	7.8	9.1	9.6
Construction	14.1	7.6	9.8	11.0
Manufacturing	6.0	8.6	8.7	8.1
Service GDP	9.5	8.9	9.2	9.3

Source: Column 1, National Account, Rwanda, MINECOFIN (2013a); columns 2–4, authors' 54-sector dynamic computable general equilibrium model simulation result.

Notes: The historical growth rate for foreign inflows is calculated based on balance-of-payment data for the "current account balance including grants," and available data are for 2006–2011. A similar calculation applies to change in the real exchange rate, in which the real exchange rate in 2006 is 1 and the ending year is 2011 (Rwanda, MINECOFIN 2013a). GDP = gross domestic product.

Food Crop–Led Growth

Scenario 2 is designed to assess the impact of food crop–led growth on total agricultural growth, overall economic growth, and poverty reduction. Agricultural growth obviously needs to be supported by all of its subsectors, and this scenario, together with the next two scenarios, is not designed to consider which subsector alone can lead agricultural growth. Instead, decomposing growth at agricultural subsector level helps us better understand whether different subsectors make differential contributions to both growth and poverty reduction. In the three subsector-focused growth scenarios, we assume that the targets defined in the government's planning documents are achievable in general. The simulations modify only those targets that were set too high. We first discuss the necessary modification of the targets for the six food crops before we start the discussion of the model results.

According to the calculation in the national account (Rwanda, MINECOFIN 2013a), food crops account for 83–85 percent of agricultural GDP. While this subsector is unlikely to grow as rapidly as many other small and export-oriented subsectors, such as pyrethrum or horticulture, given the size of this sector, it is obvious that without significant growth achievement in food crops, it is unlikely the country will have higher growth rates for either agricultural GDP or total GDP.

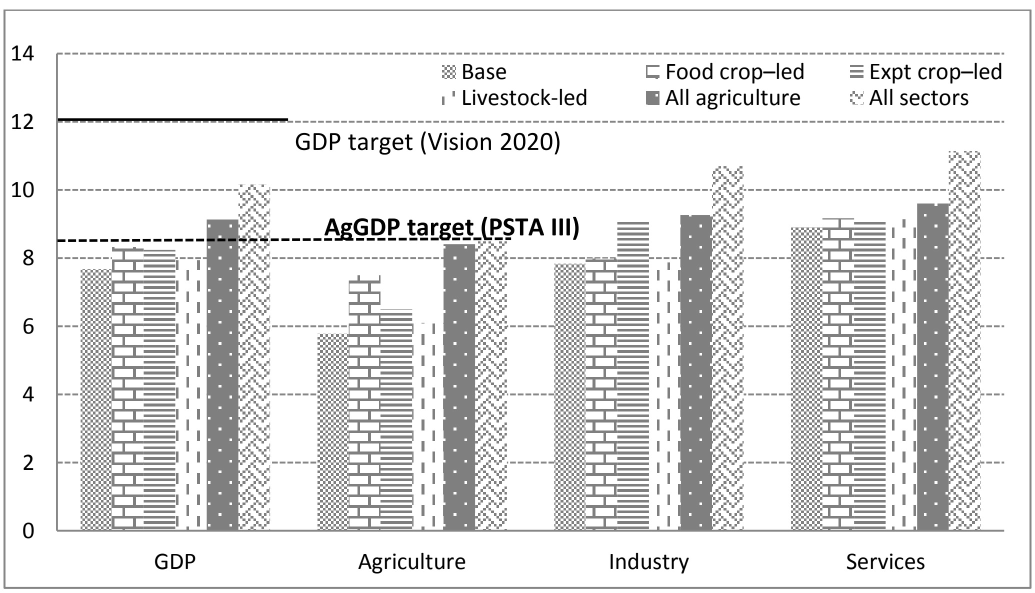
The first panel of Table 3.4 displays the recent performance of the six major food crops that are targeted for additional growth in government planning. The yields of maize, wheat, and cassava had double-digit annual growth rates in 2005–2012, while the actual yields for maize and wheat in 2012 were still quite low (cassava not so low). The second panel of Table 3.4 shows the targets stated in government documents. As we can see, the yield targets set for maize and wheat are quite high, requiring a 14 percent and a 20 percent annual growth rate, respectively, in 2013–2018. This expectation seems to be too optimistic to achieve, and thus we modify the targets in the model simulation for these two crops' yield growth in 2014–2020 (see panel 3 of Table 3.4). Even the much more modest targets for yield growth for these two crops still require an 8.5–9.3 percent annual growth rate, a rate that still would take a huge effort to realize. Correspondingly, for the same reason, we also reduce the yield targets for Irish potatoes, cassava, and beans (see panel 3 of Table 3.4). Moreover, considering Irish potatoes and cassava are already big crops, cultivated on 182,000–183,000 ha of land, we chose more modest area growth rates for these two crops in the model simulation (4.8–4.7 percent instead of 7–9 percent per year). Although we modified the growth expectation for these crops in their yield improvement and area development, the total effect of growth in these six crops, together with their linkage effect on the rest of the economy, is still impressive. That is, even with the adjustment in some growth targets for the food crops, if the modified growth targets can be realized, food crop–led growth will still be the most important driver for agricultural GDP to achieve its growth target. This can be clearly seen from Figure 3.1, which displays the annual growth rate for GDP and sector GDP under all growth scenarios.

Table 3.4 Historical growth, targets, and model results for six food crops, 2005–2018

	Level of 2012		Annual growth rate (2005–2012)		Target by 2018		Annual growth rate (2013–2018)		Model result				Annual growth rate	
Crop	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area		Yield			
									2018	2020	2018	2020	Area	Yield
Maize	254	2.3	11.4	13.4	286	5.0	2.0	14.2	318	347	3.7	4.3	4.2	8.5
Wheat	35	2.2	5.8	14.1	63	6.5	10.3	20.0	55	66	3.8	4.5	8.9	9.3
Rice	15	5.7	2.4	5.3	20	6.0	5.3	0.8	19	20	6.4	6.5	4.3	1.6
Irish potatoes	183	12.8	4.0	5.9	277	25.0	7.1	11.9	239	262	17.6	19.3	4.8	4.8
Cassava	182	14.9	3.9	10.3	306	20.0	9.0	5.0	235	258	18.7	20.0	4.7	3.5
Beans	480	0.9	5.2	5.4	481	2.0	0.1	13.3	520	536	1.3	1.4	1.6	4.8

Source: Columns 1–4, crop assessment data, MINAGRI (2014); columns 5–8, various unpublished government documents used for preparing PSTA III; columns 9–14, authors' 54-sector dynamic computable general equilibrium model simulation results.

Figure 3.1 Model result of annual growth in GDP and sector GDP, 2013–2020 (percent)



Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.
Notes: AgGDP = agricultural value-added; GDP = gross domestic product; PSTA III = Strategic Plan for Agricultural Transformation in Rwanda—Phase III.

The dash line across Figure 3.1 indicates the 8.5 percent target for agricultural GDP annual growth reported in the government's strategy documents. It shows that the gap between the growth rate for agricultural GDP in the base run and the 8.5 percent target is mainly narrowed by the growth led by productivity improvement and area expansion of the six targeted food crops. Actually, under food crop–led growth, 1.7 percentage points of additional growth is added to agricultural GDP annually, which makes the agricultural GDP growth rate reach 7.5 percent per year. The contribution of food crop–led growth to overall GDP growth is also impressive. Under this scenario, an additional 0.65 percentage point of growth is added to the annual GDP growth rate; that is, the annual GDP growth rate rises to 8.3 percent under this scenario versus 7.7 percent for the base run.

The importance of food crops to total agricultural and overall economic growth is not only due to the size of this subsector in the economy but also due to its strong linkage effects to the rest of the economy. To illustrate these linkage effects, we calculated growth multipliers for different agricultural subsectors when they are chosen as growth-leading sectors in relevant scenarios. The result shows that the growth multiplier is 1.32 when growth is led by food crops. This explains the strong linkage effects of food crops with the rest of the economy: when food crop value-added increases by RWF (Rwandan francs) 1 million in constant prices, GDP increases by 1.32 million; that is, RWF 1 million is food crops' own growth while RWF 0.32 million is from growth in other sectors. The other way to see the strong linkage effect of food crops on the economy outside agriculture is to use a growth measure. In this measure, a 1 percent additional growth in food crops would stimulate 0.11 percent growth in the nonagricultural sector.

In their production process, most food crops use few intermediate inputs; therefore, why would food crop production have such strong multiplier or linkage effect on the rest of the economy? For a poor country like Rwanda, the strongest linkage effect from agricultural growth to the rest of the economy is through consumption linkages. Given that about 80 percent of the population in Rwanda lives in rural areas, engaging in agriculture either full time or part time, increasing food crop production will increase their income either in kind, in the form of increased home food consumption, or in cash when the commodities are sold at market. Increased income from selling their products will be spent on food and nonfood items that are not produced by rural households at home. To meet this increased rural demand for marketed commodities, producers in the other agricultural or nonagricultural sectors will increase their production, which further creates job opportunities. Indeed, the model result shows that about 2.1 percent additional jobs (which can be self-employed or informal activities) will be created in the non–food crop sectors (in agriculture and nonagriculture) under the food crop–led growth scenario, which results in increased production in the sectors outside food crops to meet increased demand for various commodities by rural households. This finding is not unique to Rwanda. In the literature, researchers who studied the Green Revolution effect in some Asian countries consistently found such a strong multiplier effect as an outcome of agricultural growth (see, for example, Binswanger and Quizon 1986; Haggblade, Hammer, and Hazell 1991; Datt and Ravallion 1998; Otsuka 2000; and Irz et al. 2001). The multiplier effect is stronger in a country with limited land but abundant labor, similar to the case we analyze here for Rwanda.

Export Crop–Led Growth

Limited information is available on the performance of Rwanda's export crop sector in recent years, because crop assessment data collected by the Ministry of Agriculture (MINAGRI) covers only food crops. We have to depend on data shown in national accounts to assess the performance of the export crop sector.

The growth rate for export crops as part of agricultural GDP reported in the national account is very low, at 2.9 percent per year in 2006–2012. As a component of agricultural GDP, export crops accounted for 2.8 percent of total agriculture in 2012 (Table 3.5). We also calculated the contribution of export crops to the increased agricultural GDP in 2006–2012 in Table 3.5, which is only 1.2 percent. That is, 1.2 percent of increased agricultural GDP is from the growth in export crops. It is highly likely that export crops as a category in the national account cover only two major traditional export crops, coffee and tea, and their contribution to GDP is indirectly captured by the growth in a subsector of manufactures called "beverages and tobacco" in the national account. However, the growth rate for this subsector is also low, at 3.8 percent per year, lower than the growth rate for food processing, which is 5.4 percent, and lower than that of manufactures as a whole, which is 6.0 percent (Table 3.2).

Table 3.5 Performance of agricultural subsectors in 2006–2012

Subsector	Growth rate 2006–2012	Share in AgGDP 2012	Contribution to increased AgGDP 2006–2012
Agricultural GDP	5.7		
Food crops	6.2	84.9	91.8
Export crops	2.9	2.8	1.2
Livestock	3.3	4.5	2.5
Forestry	3.0	6.8	4.0
Fisheries	2.8	1.1	0.4

Source: National Account, Rwanda, MINECOFIN (2013a).
Notes: AgGDP = agricultural value-added; GDP = gross domestic product.

Coffee and tea are the most important export commodities (for both agriculture and total exports) in Rwanda, and another way to evaluate their performance is to see the ratio of their exports to GDP (both at current prices). Exports in total accounted for only 7.4 percent of Rwanda's GDP in 2011. While this represents a doubled share since 2000, the share for coffee and tea exports in GDP fell, from 2.7 percent in 2000 to 2.2 percent in 2011. Hides/skin and pyrethrum are the third and fourth most important agricultural export commodities, while their export share in GDP has been as small as 0.2 percent in 2011. The major increases in total exports are "other exports" and "reexports," accounting for 0.8 percent and 0.6 percent of GDP, respectively, in 2011, rising from a minimum share of less than 0.3 percent in total in 2001 (and no data available for 2000). While part of "other exports" can be agricultural commodities, without knowing what they are, we did not consider them in the model simulation.
The government has planned quite ambitious targets for production expansion and exports of coffee, tea, pyrethrum, and other horticulture. Given that we do not have a stand-alone sector for horticulture, we consider a significant increase in the "other export" subsector, which is actually much larger than horticulture alone, in the model.

Table 3.6 summarizes the exogenous growth targets in the model for growth in both yield and area expansion for the four export crops included in the model. As we mentioned before, to be able to allow the service sector to be more supportive to export expansion, we simultaneously increase the productivity (TFP) growth rate of four relevant service sectors.

Table 3.6 Growth assumption in the model

Sector	Yield/TFP annual growth rate (percent)		Area in 2012 (1,000 ha)	Targeted area by 2020 (1,000 ha)	
	Base run	Export-led growth		Base run	Export-led growth
Coffee	4.1	3.3	43.7	57.5	98.7
Tea	3.2	3.4	20.7	27.3	51.1
Pyrethrum	3.6	1.3	0.2	0.3	1.1
Other exports	3.6	6.9	0.2	0.2	5.0
Trade	2.1	2.5			
Transport	2.8	3.6			
Communication	3.0	3.9			
Finance	2.0	2.8			

Source: Authors.
Note: TFP = total factor productivity.

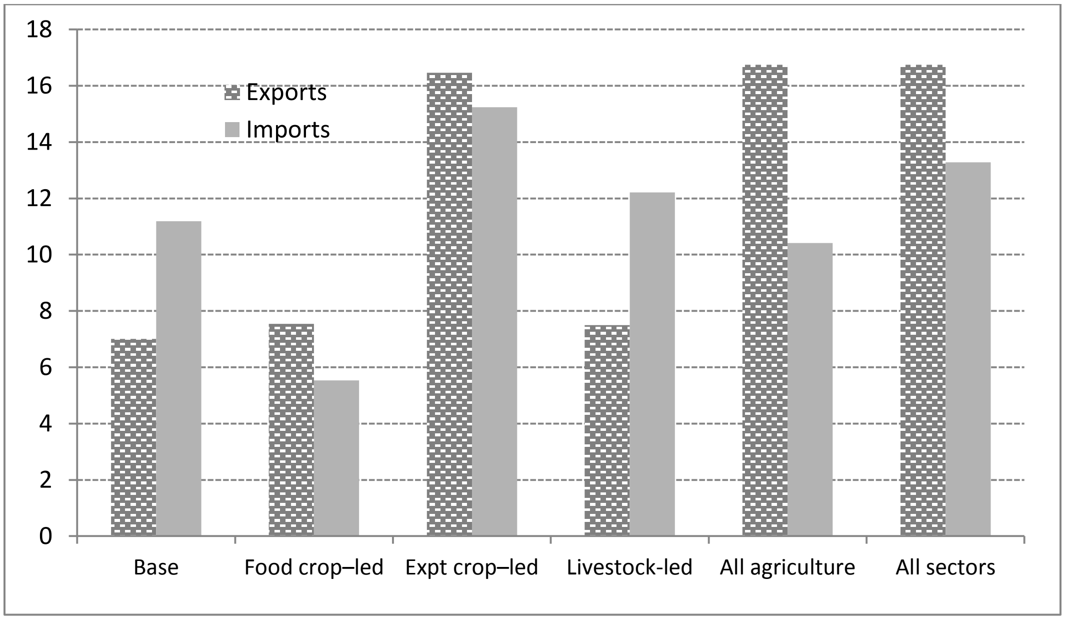
With their small share of agricultural GDP (see Table 3.5), it is unlikely for export crops to generate a significant growth effect for the agricultural sector as a whole even if their growth rate is extremely high. Moreover, even with an extremely high growth in nontraditional export crops (represented by "other exports" in Table 3.6) through an assumption of rapid area expansion, from an initial 200 ha to 5,000 ha by 2020 (see Table 3.6), the contribution of nontraditional export crops to both overall economic growth and total export crop growth is modest given their initial tiny size in the economy. The model result under the export crop–led growth scenario indicates that with an annual growth rate of 22 percent for the four export crops together in 2013–2020 (and 75 percent growth for the nontraditional export crops per year), which represents an extremely ambitious target, the annual rate of agricultural GDP and GDP rises, respectively, by 0.71 and 0.57 percentage points from that in the base run. One might further increase the growth rate of export crop production (to, for example, 50 or 75 percent per year) by assuming that much more rapid area expansion is possible, but the simulation will become awfully unrealistic, given that in the current scenario design, area planted in coffee and tea has already more than doubled (130 percent increase) from the current level, and coffee or tea cannot be grown everywhere in Rwanda.

Growth in export crops will of course lead to a significant growth in total agricultural exports (Figure 3.2). In the base run, agricultural exports, including exports of coffee and tea that are actually considered as part of exports from the food processing industry, grow at 7 percent annually, doubling their actual annual growth rate in 2006–2011. The reason that the model's base run results in a much higher agricultural export growth is the model's assumption of balanced foreign inflows, which avoids appreciation of the real exchange rate and hence benefits the exportables, including the agricultural export sectors. Under the export crop–led growth scenario, agricultural exports will grow at 16.8 percent and total exports at 11.3 percent annually. In the base run and compared with the level of 2012, agricultural exports will increase by $204 million[15] in constant prices by 2020. With export crop–led growth, the difference in agricultural exports between 2012 and 2020 will rise to $600 million. The agricultural sector is a trade surplus sector, with its exports $170 million more than its imports in 2011. The further expansion of export crops at a very rapid pace will allow the surplus in agricultural trade to increase significantly. The model result shows that under export crop–led growth, agricultural trade surplus can reach $550 million by 2020, and this surplus will help the country overcome its foreign currency constraint in developing its manufactures and in importing energy products.

It is understandable for the government to choose export promotion as one of the most important priorities in its strategy, given that the country needs to diversify its export products and markets and to ensure a more stable macroeconomic environment, which in turn underpins the broader competitiveness of the economy and allows structural transformation to take place. Diversification in exports includes efforts in both agriculture and nonagriculture, and often involves FDI that will bring in new technology and varieties. Even an agricultural export promotion strategy often requires attention in many areas outside agriculture. In most cases, export promotion, if it is to be a success, requires the creation of new sectors that often do not yet exist in the country. From this point of view, the current CGE model, which is based on the existing economic structure, may underestimate the potential of such new export-oriented commodities and their contribution to broad economic growth and transformation. The underestimation also comes from a shortcoming of the model that was mentioned in Section 2: the model is not in a position to simulate FDI, which is shown by experiences in other countries to be a crucial component of an export promotion strategy. The model results illustrate that tripling the current agricultural trade surplus in the next seven to eight years will require an annual growth rate of more than 20 percent for the export-oriented sectors. In order for these sectors to grow at such a pace, FDI to establish new sources for exports, from commodities or activities that are yet to exist in the country, is important.

[15] All dollar amounts in trade are in US dollars.

Figure 3.2 Model result of annual growth rate in agricultural trade, 2013–2020 (percent)



Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Livestock-Led Growth

Similar to the case of export crop–led growth, limited data are available on the performance of the livestock sector at the commodity level, rather than the aggregated national account data shown in Table 3.5. While the "one cow per poor rural family" program is reported to have made significant progress in recent years, the outcomes do not show up in the macrodata that we used for the assessment. Calculated from the national account data, the livestock growth rate was 3.3 percent per year in 2006–2012, only slightly higher than the population growth rate of 2.6 percent in this period. Considering that Rwanda's income elasticity of demand for livestock products is relatively high for a low-income country, livestock growth seems to barely match the growth in domestic demand for it. As a poor country, Rwanda has extremely low per capita livestock product consumption, which implies that there is plenty of room for livestock to grow and such growth can help poor farmers not only for income generation but also for improving their nutrition outcomes.

With the constraint of the model in which only seven primary livestock sectors—cattle, sheep/goats, swine, poultry, raw milk, eggs, and other primarily livestock products—are included, the model considers only two major interventions discussed in the government's planning documents: those for milk and cows (which we included in cattle) and those for poultry and eggs.

Table 3.7 presents the growth result of the three scenarios of the model for livestock as a whole (value-added), output of the six major livestock products, and two nonagricultural sectors in which livestock products are used as intermediate inputs. Additional growth in the livestock sector and its individual products under livestock-led growth is the result of 50–100 percent increases (exogenous) in their TFP growth rate, a 50 percent (exogenous) increase in the growth rate for the stock of cows, and a 150 percent (exogenous) increase in the growth rate for the stock of poultry, all compared with their levels in the base run. On the other hand, additional growth in the two nonagricultural sectors under the livestock-led growth scenario is primarily due to the production linkage effects from and increased supply of the livestock products that are their intermediate inputs; that is, there is no an assumption on additional (exogenous) increases in these two nonagricultural subsectors' TFP growth rate. While there are important consumption linkage effects from increasing farmers' income due to additional growth in livestock production to many nonagricultural sectors, with their small size in agriculture, such linkages seem to be quite modest and can be considered as a subsidiary effect in the case of these two nonagricultural sectors.

Table 3.7 Model result for annual growth rate in livestock and relevant nonagricultural sectors (percent)

Sector	Base run	Livestock-led growth	Agriculture + nonagriculture
Total livestock	5.7	12.2	11.8
Bovine cattle	5.1	8.9	9.0
Sheep and goats	4.1	6.8	6.6
Swine	4.9	7.5	7.9
Poultry	4.4	10.8	10.4
Raw milk	7.3	18.1	17.3
Eggs	7.1	16.7	15.8
Meat, fish, and dairy products	5.6	7.1	8.1
Hotels and restaurants	5.3	10.3	10.0

Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

With a doubling of the growth rate in the livestock sector, from 6 percent in the base run to 12 percent in the livestock-led growth scenario, agricultural GDP and total growth rates rise by 0.32 and 0.27 percentage points, respectively. Considering its small size in agricultural GDP (4.5 percent—see Table 3.4), the simulated contribution of livestock growth to overall economic growth is impressive. This is particularly true for its linkage effect on the two nonagricultural subsectors—livestock processing and hotels and restaurants. The annual growth rate in these two sectors rises by 1.5 and 5.0 percentage points, respectively, as an outcome of increased livestock supply at lowered prices. For this reason, livestock-led growth has the strongest multiplier effect: for each RWF 1 million increase in livestock value-added, GDP will increase by RWF 2.06 million, both at constant prices; the additional RWF 1.06 million is the result of the multiplier effect, and it all comes from the increases in the nonagricultural GDP.

Agriculture-Led Growth and the Role of the Nonagricultural Sector in Agricultural Growth

We now combine growth led by food crops, by export crops, and by livestock to evaluate (1) whether the additional growth from the agricultural subsectors that are individually analyzed supports the growth target for the agricultural sector as a whole and (2) what will be the implication of this agricultural growth for overall economic growth (that is, growth in GDP). We then combine agricultural and nonagricultural growth to evaluate (1) the role of nonagricultural growth in agricultural growth and (2) whether the growth target for GDP can be achieved.

As displayed earlier in Figure 3.1, consistent with the assumptions applied in the subsector growth scenarios, agricultural GDP will grow at 8.4 percent annually in 2013–2020, a growth rate close to its target (8.5 percent). At this level of agricultural growth and without an assumption of additional growth in TFP for the nonagricultural sector, GDP grows at 9.1 percent per year in the same period. Measured by growth creation effect, an additional 1 percentage point growth rate in the agricultural sector leads to an additional 0.34 percentage point growth rate in the nonagricultural sector. Such growth linkage effects from agriculture to nonagriculture come from both consumption linkages (in the case of food crop growth) and production linkages (in the case of export crop and livestock growth). These linkages create employment opportunities (in both formal and informal sectors) outside agriculture. While the number of employment opportunities in the agricultural sector increases modestly, partially due to the model assumption that the supply of agricultural family labor grows at a given and exogenous growth rate of 2.5 percent annually, the number of employment opportunities in the nonagricultural sector grows significantly. Considering 2020 only, the model result shows that employment increases by 5.1 percent in the nonagricultural sector from its level in the base run when additional growth occurs in the agricultural sector

In the final scenario, we bring in additional growth in the nonagricultural sector. Without additional information for modeling nonagricultural growth potential, we simply doubled the TFP growth rate for all nonagricultural sectors while keeping all exogenous growth assumptions for TFP in the agricultural sector, together with the assumptions on land or livestock stock expansion, the same as under the previous agriculture-led growth scenario. This combination growth scenario shows that the GDP growth rate reaches 10.2 percent per year, 1.3 percentage points short of the targeted growth rate of 11.5 percent.

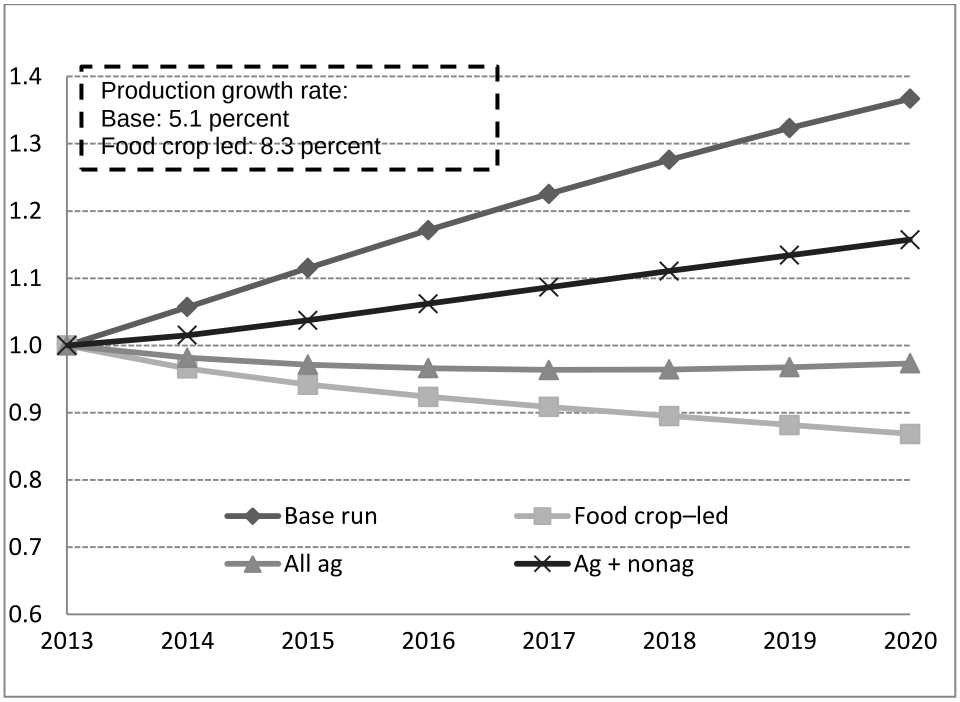
One important finding for this scenario is the linkage effect from nonagricultural growth to agricultural growth: an additional 1 percentage point growth rate in the nonagricultural sector leads to an additional 0.05 percentage point growth rate in the agricultural sector, and the agricultural growth rate rises to 8.5 percent in this scenario instead of 8.4 percent in the agriculture-led growth scenario; that is, accelerated growth in nonagriculture is helping the agricultural sector achieve its growth target. In a poor and landlocked country like Rwanda, whether growth is from agriculture or nonagriculture, it generally generates income for common people, which leads to strong consumption linkages to the rest of the economy, in which most production is for the domestic market. This type of growth reflects that Rwandan economic development is still in its early stage and is less dependent on trade than are other economies; that is, domestic demand instead of international trade is the leading force for growth. At this development stage, broad and balanced growth can have the most effective outcome not only in income equality and hence poverty reduction (which will be discussed later) but also in the pace of growth—that is, through strong linkage effects of the economy across different sectors, growth in one sector stimulates growth for other sectors.

Price Effect of Fast Growth

When growth occurs in the sectors whose products are mainly for meeting domestic demand, one of the concerns is its adverse price effect. Indeed, if growth is not the result of productivity improvement, such an adverse price effect can hurt producers, since at lower prices, producers' profit (including returns on farmland and family labor in the case of agriculture) can fall at higher production levels with a lowered price. Thus, it is necessary to check on this adverse price effect when a high growth target is set for agriculture.

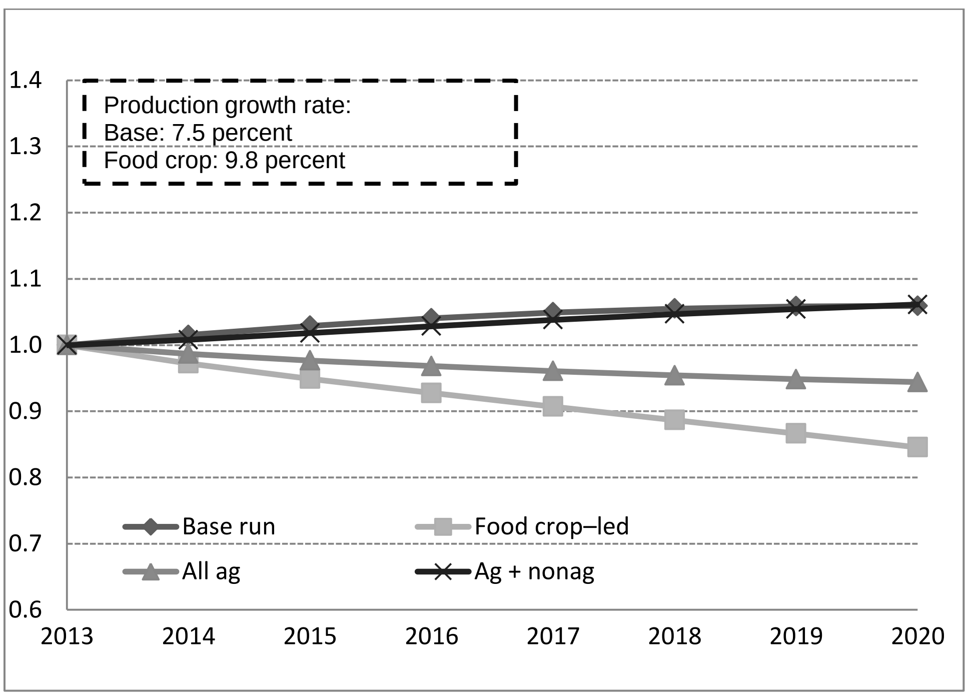
We selected four agricultural commodities in which high growth targets are simulated for evaluating the price effect of their growth; results are displayed in Figures 3.3–3.6. Also these four commodities, cassava, Irish potatoes, maize, and raw milk, are less tradable in the current economic structure, indicating that they are more vulnerable for a possibly adverse price effect as a result of rapid growth in their production when their products cannot easily go to regional or international market, or substitute for imports.

Figure 3.3 Model result of real producer price for cassava (2013 = 1.0), 2013–2020



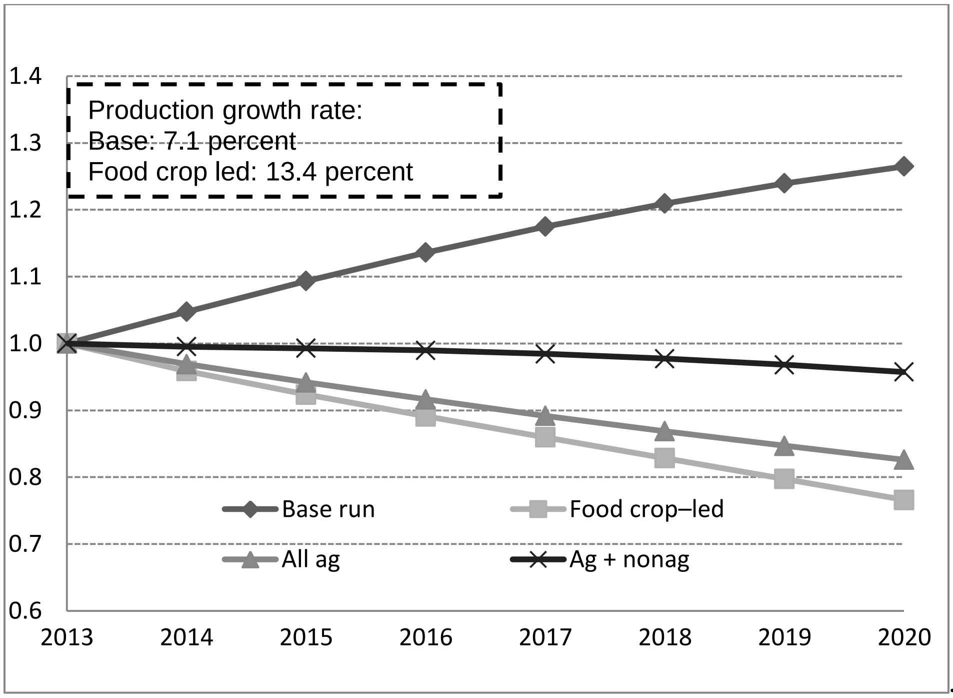
Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Figure 3.4 Model result of real producer price for Irish potatoes (2013 = 1.0), 2013–2020



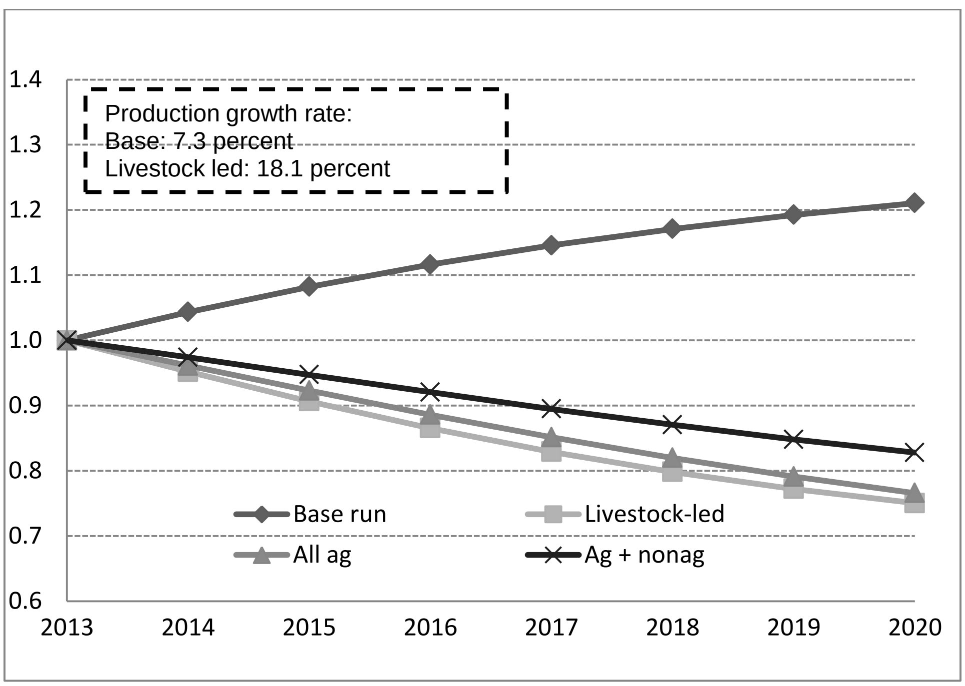
Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Figure 3.5 Model result of real producer price for maize (2013 = 1.0), 2013–2020



Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Figure 3.6 Model result of real producer price for raw milk (2013 = 1.0), 2013–2020



Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

The first message from Figures 3.3–3.6 is that in the base run along the current growth trend, prices for the four staple agricultural commodities relative to the producer price index (that is, the real prices for the commodities) will increase over time, indicating that demand for them grows more rapidly than their supply, and additional growth in their production is possible without hurting their producers. With their already quite impressive growth rate in the base run, a growth rate seen in recent history, ranging from 5.1 percent for cassava to 7.5 percent for Irish potatoes, why do the prices for these staple commodities, for which income elasticity of demand is rather low, continue to rise over time? Two factors can explain these rising price trends in the model's base run. First, the economic growth rate is high, and even higher in the nonagricultural sectors. At a 7.7 percent annual growth rate for GDP (in the base run), even with 5–8 percent growth in these agricultural products, their real prices will be higher in the future than now. Second, Rwanda is still poor and there is plenty room for increasing consumption of the basic staple food among the majority of people, particularly rural people. These two reasons imply that to control inflation for a fast-growing economy like Rwanda, it is necessary to keep agriculture growing at a rapid pace.

The second message from the same figures is that without additional growth from the nonagricultural sector, accelerated agricultural growth alone does create an adverse price effect on basic staple products. This is particularly true: the higher the growth rate for a staple product, the greater the adverse effect on its price. For example, with an annual growth rate of 10–18 percent for Irish potatoes, maize, and raw milk, and without additional growth from the nonagricultural sector, the real prices for these three products fall by 15–25 percent by 2020, compared with their current prices. Yet an average farmer still benefits because the increase in the production of these three staple products is in the range of 80–220 percent by 2020, also compared with production in 2013. However, in reality, not all farmers can adopt the more productive technology and hence benefit from the growth led by this productivity gain. Farmers who keep using the traditional technology while facing a declining market price for the products they produce for the market will be hurt. Thus, it is necessary to keep the adverse price effect in check when rapid agricultural growth is promoted.

The third message of the figures discussed here is that additional growth from the nonagricultural sector is necessary for overcoming the adverse price effect that results from rapid agricultural growth. As shown in the figures, with additional nonagricultural growth, at a similar growth rate for staple production, the real producer price for cassava and Irish potatoes starts to rise instead of falling while the decline in the prices for the other two products, maize and raw milk, is much more modest, in the range of 5–15 percent.

Structure of the Economy and Economic Growth

Will the Rwandan economy look different by 2020 with rapid growth such as that discussed above, and will more employment opportunities be created with such rapid growth? We try to answer these two questions by comparing the economic and employment structures of today with those of 2020 under the two scenarios: the base run and combined agricultural and nonagricultural growth. Ignoring the price effect on structural change (that is, sector GDP will be measured at constant prices instead of current prices), we further consider different types of agriculture, industry, and services according to their role in trade. In the 54-sector SAM of Rwanda for 2011, we defined import-substitutable sectors as those with imports accounting for more than 15 percent of domestic demand (including final and intermediate demand) and exportable sectors as those with exports accounting for more than 15 percent of sector output. We call the rest of the subsectors "less internationally tradable" or "nontradable." We also keep manufactures as a separate sector to see whether it benefits from rapid growth in the next 10 years. Table 3.8 reports the economic structure according to the definition laid out here.

Table 3.8 Structure of the economy with rapid economic growth

Sector	Annual growth rate, combined growth scenario (percent)	Share of GDP in constant prices (percent) 2011	Base run 2020	Combined growth 2020
Agriculture total	8.5	33.7	28.5	29.0
Import substitutable	11.9	1.3	1.0	1.4
Exportable	19.6	1.3	1.2	2.2
Less internationally tradable	7.7	31.1	26.3	25.4
Industry total	10.7	18.1	18.4	18.8
Import substitutable	11.8	2.7	3.2	3.2
Exportable	12.7	3.9	3.7	4.5
Nontradable	9.7	11.5	11.5	11.1
Manufacturing	12.7	6.9	7.5	8.3
Services total	11.1	48.2	53.2	52.1
Import substitutable	14.0	8.1	11.1	11.1
Exportable	10.0	2.1	1.9	2.1
Nontradable	10.5	38.0	40.1	38.9

Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.
Note: GDP = gross domestic product.

At the aggregated level and considering agriculture, industry, and services as three different components of total GDP, the direction of structural change, whether under the base run or with more rapid growth under the agricultural and nonagricultural combined growth scenario, seems to follow the recent trends observed in the last 10 years; that is, the declining share of agriculture is mainly replaced by an increased share of services in GDP, while the share of industry is more or less the same. However, under the combined growth scenario, the fall in the agricultural share of GDP is slightly less than that in the base run, although the growth rate for services is much higher than for agriculture in this scenario. While the broad economic structure might not alter much from its current pattern, we are more interested in possible structural change within these three broad economic sectors.

We start discussing agriculture first. It is worth pointing out that both the agricultural import-substitutable sector (which includes wheat and rice) and the exportable sector grow more rapidly than the less internationally tradable ones under the combined growth scenario (11.9 percent and 19.6 percent for import substitutable and exportable, respectively, and 7.7 percent for less tradable—see first column of Table 3.8). However, it is also worth pointing out that both import-substitutable and exportable agriculture are small components of total agriculture, together about 2.6 percent of total GDP in the current economic structure (second column of Table 3.8). Without accelerated growth in the tradable part of agriculture, these sectors' shares of GDP in 2020 in the base run shrink further along a more rapid decline in the less tradable agriculture's share of GDP (third column of Table 3.8). However, under the combined growth scenario, GDP shares of import-substitutable and exportable agriculture rise, particularly for the exportable, which almost doubles its current level (last column of Table 3.8). While the GDP share of agriculture in total and of the less tradable part of agriculture in particular will shrink to 29 percent and 25.4 percent by 2020, respectively, under the combined growth scenario, agriculture will become more competitive internationally, although the domestic market will still play the most important role in its growth.

The industry sector will have a double-digit growth rate, at 10.7 percent annually, under the combined growth scenario. Similar to the case of agriculture, the growth rate for tradable industry, particularly for exportable industry, is higher than for the nontradable part of industry, which is dominated by construction. Exportable industry includes mining and exportable manufactures (coffee and tea are exported after simple processing and hence are included as part of manufactures in the industry sector), and growth in exportable industry is mainly from the latter. While industry's share in GDP by

2020 will be similar under the base run and the combined growth scenario, the structure of industry will change slightly as the share of exportable industry rises to 4.5 percent by 2020 in the combined growth scenario, from its current level of 3.9 percent (the share falls to 3.7 percent by 2020 in the base run). We also report the manufacturing sector separately in Table 3.8. Most manufacturing subsectors are tradable, either import substitutable or exportable. With an annual growth rate of 12.7 percent under the combined growth scenario, the manufacturing share of GDP rises to 8.3 percent by 2020 from its current level of 6.9 percent. While the manufacturing sector is still small, this is an encouraging sign for structural change.

Services will grow more rapidly than the other two sectors of the economy under the combined growth scenario. However, exportable services grow less rapidly than other parts of services.[16] In the simulation of the combined growth scenario, a 9.6 percent annual growth rate is assumed for this subsector's TFP, higher than that for most other industrial and service subsectors. However, because this subsector uses more skilled labor than unskilled, and because the wage rate for skilled labor rises faster than that of unskilled labor in the model, the sector that is skilled labor intensive will be unable to grow as rapidly as other sectors that use more unskilled labor.[17] While it is true that this result depends on the assumption of wage-to-price elasticity and a lower elasticity might lead to a different result, it does indicate the sensitivity of some sectors (in this case, exportable services) to the wage rate. When the wage rate for any type of labor rises, its impact on different sectors' labor demand differs, depending heavily on whether a sector employs this type of labor more intensively than other sectors.

We now turn to the job creation of the growth. Rwanda has not conducted labor or manufacturing surveys for a long time, and the initial structure of employment across sectors in the SAM should be seen with caution. Thus, we turn to module 6 of EICV 3—economic activity in the last 12 months and the last seven days—for a better understanding of the employment structure at present in the Rwandan economy.[18] Module 6 of EICV 3 includes a set of questions regarding the occupation of all members of households sampled. Both agricultural and nonagricultural activities are covered, and unpaid jobs, paid jobs, and self-employment are distinguished. Moreover, the paid nonagricultural activities are further categorized according to 29 industrial categories.

In response to the survey, 29,082 individuals reported working at least one hour in the last seven days, and an additional 3,442 individuals reported working at least one hour in the last 12 months. This group of individuals forms the dataset for us to analyze the occupation structure in the current Rwandan economy. There are 23,328 individuals who report not working either in the last seven days or in the last 12 months. However, most of them are either students (77.6 percent) or too young to work (13.4 percent). That is to say, if we consider adult individuals at least 15 years old, almost everybody worked in Rwanda and the number of observations for adult individuals who claimed not to work is less than 5 percent of the adult population.

However, not all workers worked full time. According to the calculation of EICV 3 reported in Table 3.9, more than one-third of individuals who reported working in the last 7 days worked for 20 or fewer hours, and this is particularly true for those who worked but reported working in unpaid jobs (more than 50 percent of these respondents worked for 20 or fewer hours in a week). When more job opportunities are created by growth, it is highly possible that many people who are working now will work longer hours per day, in addition to those who will be new workers joining the working class.

[16] Exportable services are mainly tourism related. In the SAM they are defined as the hotel and restaurant subsector. According to the SAM, export services account for 50 percent of the production of the hotel and restaurant subsector, making it a highly exportable sector.

[17] Four types of labor are defined in the model: agricultural family labor, unskilled labor, skilled labor, and highly skilled labor. Agricultural family labor is employed only in the agricultural sector and its supply grows exogenously at a fixed growth rate of 2.5 percent. Unskilled labor is employed in both agricultural and nonagricultural sectors, while skilled and highly skilled labor are employed in nonagricultural sectors only. The supply of the three types of labor other than agricultural family labor grows endogenously, led by the demand for them, while their wage rates (relative to their initial level) are linked to the ratio of current consumer price index (CPI) over the initial level of CPI at a given wage-to-price elasticity. The initial elasticity for unskilled labor is 1.40, while it is set at 2.05 for the two types of skilled labor to capture a standard fact: skilled labor is relatively in shortage and the wage rate for it usually increases more than that for unskilled labor, which is in abundant supply.

[18] EICV 3 covered the period of two agricultural seasons in 2010/2011.

However, the model cannot distinguish either part-time from full-time jobs/workers or formal (paid) from informal (self-employed and unpaid) employment. The discussion about job creation in this subsection should therefore be understood from a broad perspective. Moreover, since the supply of labor is endogenously driven by the demand for it in the model, the growth rate of the labor force (excluding agricultural family labor) can be much higher than the growth rate for the population when the economic growth rate is high because, as shown in Table 3.9, not only are new workers hired but current workers can work more hours.

Table 3.9 Employment distribution according to working hours (total working individuals of 32,524 = 100)

Thresholds	Paid	Self-employed	Unpaid	Total
≤ 10 hrs.	6.9	1.7	7.0	15.5
> 10 hrs. to ≤ 20 hrs.	10.3	2.4	8.2	20.8
> 20 hrs. to < 40 hrs.	23.0	5.4	11.6	40.0
≥ 40 hrs.	16.5	4.9	2.2	23.6

Source: Authors' calculation using Integrated Household Living Conditions Survey 3 (2010/2011).

Only paid occupation information is available at the sector level in EICV 3. Corresponding to the economic structure discussed above, we grouped the sectors by agriculture, industry, and services, and reported the percentage of sample observations in different sectors in Table 3.10 for the paid jobs. To avoid a problem of double counting, if a person reported paid work in both agriculture and nonagriculture, we considered the person as a nonagricultural worker. If the person reported paid jobs in both industry and service sectors, we considered the person as an industry employee. We excluded from Table 3.10 those who did not identify sectors for their paid jobs. Table 3.10 also breaks out industry into the respective occupation shares of manufacturing and construction, and services into private services, two subsectors of private services, and public services. Moreover, we report shares by three different working-hour breakdowns.

Table 3.10 Employment structure of paid jobs by hours per week (11,061 paid workers with identified sectors = 100)

Sector	All hours	≥20 hours	≥40 hours
Agriculture	48.6	44.6	23.6
Industry	19.4	20.3	23.2
Manufacturing	3.5	3.8	5.1
Construction	13.0	13.4	14.7
Services	32.0	35.1	53.2
Private services	21.8	23.2	34.5
Trade, hotels & restaurants	11.5	11.7	15.5
Other personal services	10.8	11.6	19.0
Public services	10.2	11.9	18.7
Total	100	100	100

Source: Authors' calculation using Integrated Household Living Conditions Survey 3 (2010/2011).

Considering all observations with at least one hour of paid work in a week, 48.6 percent of the sample individuals worked in the agricultural sector, while 19.4 percent and 32.0 percent, respectively, worked in industry and services (first column of Table 3.10). However, when we consider only full-time paid jobs, the share for agriculture in total full-time employment falls to 23.6 percent and rises for industry and services to 23.2 percent and 53.2 percent, respectively (last column of Table 3.10).

Most industry-sectors jobs are in construction, with the share of construction in total paid employment at 13.4–14.7 percent in Table 3.10, equivalent to more than two-thirds of industrial jobs. This is consistent with the economic structure of the industry sector, in which construction is the most important and fastest growing subsector. However, construction seems to be more labor intensive than the industry sector as a whole: in terms of GDP, its share in industry is about 50 percent, while in terms of paid employment, its share is 67 percent.

Services provided 32 percent of paid jobs if all observations with different working hours in a week are considered. However, if we consider full-time paid jobs only, the share rises to 53 percent (last column of Table 3.10). Within services, public sectors including government administration, health, and education provided one-third of employment opportunities. This is consistent with the structure of the services sector in GDP; that is, about one-third of the services GDP is from public-related services. For private services, the shares of market-related activities, such as working for trade and for hotels and restaurants, and of personal services are similar if all the different working hours are included. When we consider full-time employment only, more people worked as personal service providers rather than as traders or other service providers in markets.

While unpaid and self-employed workers are not identified by their sectors, information on their working hours is available. It is necessary to include them to get a complete picture of the employment structure of the economy as a whole. To do this, we have to make two assumptions: we assume that all unpaid and undefined paid jobs are in agriculture and all self-employed jobs are in the private services (in trade and in hotels and restaurants). With such assumptions, we now can show a full employment structure for Rwanda in 2011.

When all employment—paid, unpaid, self-employed, and part time or full time—is included, the employment structure becomes quite interesting. The first column of Table 3.11 seems to be consistent with our general understanding of the country's employment structure; that is, about 70 percent of the population currently works in agriculture (of the rural population, it is about 80–85 percent of the population), while within nonagriculture, almost 80 percent work in the services sector. However, most work in agriculture is not full time, and if we consider only full-time jobs, the shares for agricultural versus nonagricultural employment are reversed: about 70 percent of full-time jobs are in nonagriculture, but again, almost 80 percent of these are in services. The second important fact of Table 3.11 is the strikingly tiny share of manufacturing in employment. Manufactures provided only 3.2 percent of total full-time employment, versus about one-third of the full-time jobs provided by construction and a quarter of jobs provided by the public services.

Table 3.11 Employment structure of all jobs by hours per week (32,524 workers = 100)

Sector	All hours	≥20 hours	≥40 hours
Agriculture	69.7	57.1	32.1
Industry	6.6	9.8	14.6
Manufacturing	1.2	1.8	3.2
Construction	4.4	6.5	9.2
Services	23.7	33.1	53.4
Private services	20.2	27.4	41.7
Trade, hotels & restaurants	16.7	21.8	29.8
Personal services	3.5	5.6	11.9
Public services	3.5	5.7	11.7
Total	100	100	100

Source: Authors' calculation using Integrated Household Living Conditions Survey 3 (2010/2011).

With all types of employment included, we can obtain a rough picture of the relative labor productivity across sectors. We do this by comparing the employment share of a sector with its share in GDP; that is, if the employment share is lower than the GDP share for a sector, this sector's labor productivity is lower than the national average. Keeping in mind that the employment measure is from EICV 3 according to self-reporting of individual households, it must be used with caution. However, the picture depicted in Table 3.12 generally reflects the fact observed in cross-country data among poor developing countries.[19] The most important fact displayed by Table 3.12 is the extremely low labor productivity in agriculture and personal services in comparison with the other sectors. When we further look at the productivity comparison for full-time employment only, that is, assuming that the full-time workers would be able to produce all the outputs produced by all types of workers, manufacturing labor productivity is still twice the productivity of most other sectors. This implies that Rwanda has plenty of room to increase its total labor productivity by creating more jobs in high-productivity sectors, particularly in manufacturing, and by facilitating labor mobility out of the low-productivity agricultural and service sectors. We will come back to this statement when we discuss the cost of growth in Section 4.

Table 3.12 Comparison of labor productivity (manufacturing = 1.00)

Sector	Share of GDP	Share of employment, all	Labor productivity, all	Share of employment, full time	Labor productivity, full time
Agriculture	34.0	69.7	0.08	32.1	0.48
Industry	17.4	6.6	0.45	14.6	0.54
Manufacturing	7.0	1.2	1.00	3.2	1.00
Construction	8.8	4.4	0.34	9.2	0.44
Services	48.6	23.7	0.35	53.4	0.41
Private services	36.2	20.2	0.31	41.7	0.40
Trade, hotels & restaurants	35.2	16.7	0.36	29.8	0.54
Personal services	1.0	3.5	0.05	11.9	0.04
Public services	12.4	3.5	0.61	11.7	0.48

Source: GDP share, National Account, MINECOFIN (2013a); employment share, authors' calculation using Integrated Household Living Conditions Survey 3 (2010/2011).
Note: GDP = gross domestic product.

We now turn to the employment structure of the SAM and the CGE model results discussed in Table 3.13. In the first panel of the table, we report the sector share of employment with and without agricultural family labor. While we used information from EICV 3 similar to that discussed above for constructing the SAM, with the labor mobility assumption (that is, each type of labor is allowed to move across sectors in the model), it is unlikely that the CGE model will duplicate exactly the employment structure we discussed above in Tables 3.11 and 3.12. As shown in Table 3.13, without agricultural family labor, the share of employment in agriculture is 35.3 percent of total employment, and it is 71.0 percent with family labor included. The share for agricultural employment without family labor is close to the share of full-time employment shown in the fourth column of Table 3.12. In both cases (agriculture with and without family labor), the employment share of industry is higher than that in Table 3.12, which makes the share for service employment lower than that in Table 3.12.

[19] See, for example, Rodrik (2013), who uses a ratio of 4:1 to describe the relationship between manufacturing labor productivity and the low-productivity part of economy, including agriculture and informal services.

Table 3.13 Where are the new employment opportunities created by economic growth?

Sector	Share in total employment under combined growth scenario: Without family labor 2011	Without family labor 2020	With family labor 2011	With family labor 2020	Growth rate: Base run, Without family labor	Base run, With family labor	Combined growth, Without family labor	Combined growth, With family labor	Share in additional employment opportunities: Base run 2020, change from 2013, Without family labor	Base run 2020, change from 2013, With family labor	Combined growth from base run, 2020, Without family labor	Combined growth from base run, 2020, With family labor
Agriculture total	35.3	32.3	71.0	63.4	5.0	3.1	5.9	3.4	28.0	49.7	32.1	32.1
Agriculture, import substitutable	1.8	1.6	2.3	2.3	3.3	2.5	6.0	4.8	0.9	1.3	4.2	9.9
Exportable agriculture	2.9	3.3	2.7	3.2	7.6	6.2	8.4	6.6	4.0	4.5	2.8	2.3
Less international tradable agriculture	30.7	27.4	66.0	57.9	4.8	3.0	5.7	3.1	23.1	44.0	25.1	19.9
Industry total	31.9	36.8	14.3	19.9	6.9	6.9	8.7	8.7	39.5	27.6	63.3	63.3
Industry, import substitutable	2.6	3.5	1.2	1.9	9.4	9.4	10.1	10.1	5.0	3.5	2.4	2.4
Exportable industry	3.3	3.8	1.5	2.1	5.5	5.5	9.2	9.2	3.1	2.1	13.2	13.2
Nontradable industry	26.0	29.5	11.7	16.0	6.8	6.8	8.5	8.5	31.5	22.0	47.7	47.7
Manufacturing	6.8	8.2	3.1	4.4	7.7	7.7	9.0	9.0	9.7	6.8	10.5	10.5
Services total	32.7	30.9	14.7	16.7	5.9	5.9	6.0	6.0	32.5	22.7	4.6	4.6
Services, import substitutable	7.4	8.6	3.3	4.6	8.5	8.5	8.5	8.5	12.0	8.4	0.2	0.2
Exportable services	1.9	1.1	0.8	0.6	0.5	0.5	-0.2	-0.2	0.1	0.1	-1.0	-1.0
Nontradable services	23.5	21.2	10.5	11.5	5.3	5.3	5.6	5.6	20.4	14.2	5.3	5.3
Total					5.9	4.2	6.9	4.7				

Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Total labor demand and hence labor supply grows at 5.9 percent and 4.2 percent per year in the base run, without and with agricultural family labor, respectively. The corresponding growth rates rise to 6.9 percent and 4.7 percent in the combined growth scenario, indicating that rural labor will move from agriculture to nonagriculture in the growth process. In both scenarios, the labor growth rate differs across sectors and is much higher for industry than for the other two sectors (see columns 3 and 4 in the table). In the combined growth scenario and without agricultural family labor, employment share in industry reaches to 36.8 percent in 2020, replacing agriculture as the biggest hiring sector in the economy (column 2). As expected and consistent with the economic structure, most labor is employed in the less tradable sectors either in agriculture or nonagriculture, and excluding agricultural family labor, the nontradable sectors in total (without distinguishing across sectors) hire about 80 percent of labor at present and also by 2020 with rapid growth under the combined growth scenario.

If we consider additional employment opportunities created by growth, excluding agricultural family labor, 40 percent of increased labor in the base run goes to the industrial sector, dominated by the nontradable part of industry (that is, construction). However, including agricultural family labor, the agricultural sector still employs the largest fraction of increased labor; that is, more than 50 percent of the increased labor is employed in agriculture, a result consistent with a recent World Bank report for Africa south of the Sahara as a whole (Filmer and Fox 2014).

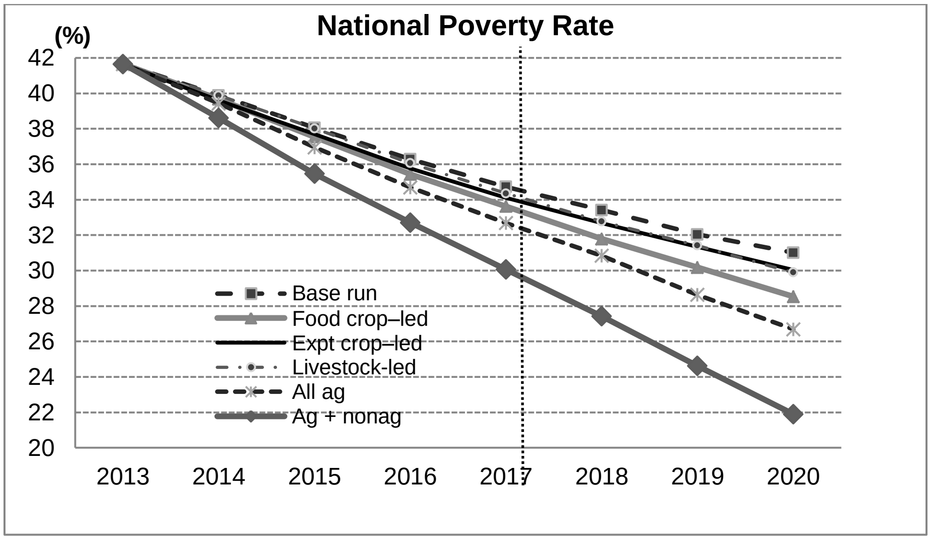
When growth further accelerates under the combined growth scenario, more employment opportunities are created, and again, such opportunities are predominantly created by the industry sector (column 11). In 2020, 48 percent of new workers are hired by the nontradable part of industry due to accelerated growth, compared with 2020 in the base run, while 10.5 percent of new employment opportunities will be created by manufactures (column 11) under the same scenario in the same year. The exportable industry sector also increases its share in new hiring under the combined growth scenario (13.2 percent, column 11), while only 3.1 percent of increased employment opportunities are in this sector in 2020 in the base run, compared with 2013 (column 9).

The model result for the services sector's employment creation seems to be surprising, given that the services share of GDP will continue to rise from its current level (Table 3.8). However, as shown in Table 3.7 and compared with the base run, the share of services in GDP falls by a percentage point under the combined growth scenario, from 53.1 percent in the base run, both in 2020. This decline in the services share of GDP results in less of an increase in employment opportunities in this sector; that is, compared with 2020 in the base run, the services sector provides only an additional 4.6 percent of job opportunities under the combined growth scenario. In summary, the accelerated growth we simulated under the combined growth scenario will create some employment opportunities in the tradable part of the economy, particularly in exportable agriculture and manufacturing, for which the shares of newly created employment opportunities double their shares in GDP. However, considering the huge labor productivity gap between the exportable manufacturing sector and the other economic sectors, the magnitude of such labor mobility is rather modest and itself is unlikely to be a major driver of growth. Many tradable sectors in Rwanda are relatively labor intensive and have the potential to create more employment opportunities and hence to drive overall economic growth. The constraint for employment opportunity creation seems not to be the level of productivity of these sectors; instead, the capability of the country to expand the size of these sectors seems to be constrained by limited private investment, particularly foreign investment. We will come back to this challenge in Section 4.

Assessing the Poverty Reduction Effect of Fast Growth

Finally, we come to analyze the poverty reduction effect of alternative growth options. While we already discussed the benefit of balanced growth in the previous subsections, decomposing growth alternatives helps us link growth from different subsectors to the outcome of poverty reduction (Figure 3.7). We discuss both the poverty rate effect and the impact of growth on the numbers of poor.

Figure 3.7 Model result for poverty reduction, 2013–2020



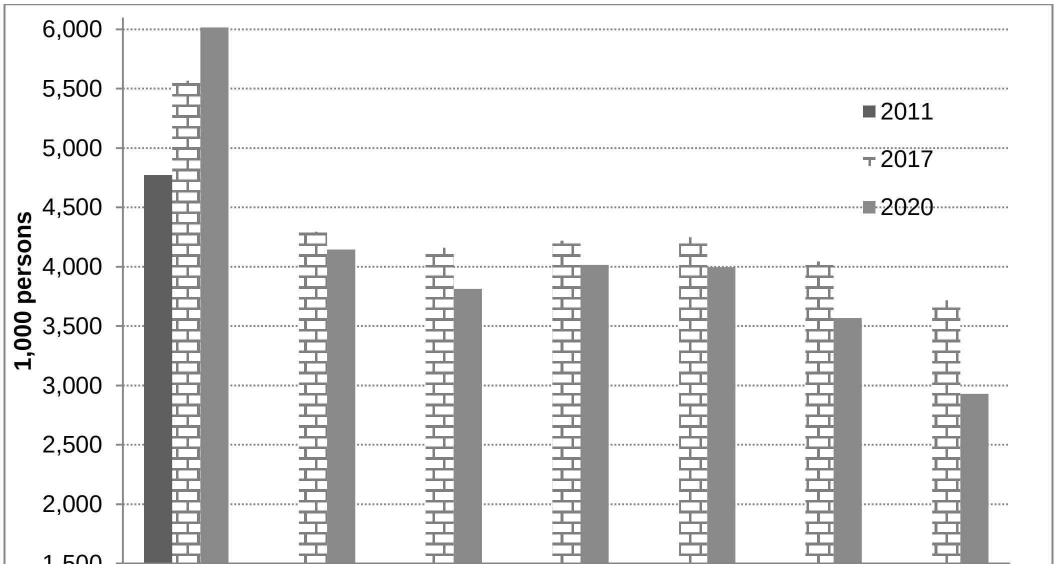
Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

The national poverty rate was 45 percent in 2011 (EICV 3). Along the model's base run, the poverty rate will fall to 34.7 percent by 2017 and 31 percent by 2020 (Figure 15). While Rwanda is unlikely to meet Millennium Development Goal 1 (MDG 1) on time (that is, by 2015), the country will be able to achieve this goal by 2020, that is, to halve the 2000 poverty rate of 60.3 percent, even along its current growth path. With additional growth in agriculture and nonagriculture under the combined growth scenario, the poverty rate can fall to 30.1 percent by 2017 and to 22 percent by 2020. That is, Rwanda can achieve MDG 1 by 2017 with more rapid growth as described in the previous subsections. Agricultural growth alone will help the country reduce the poverty rate to 32.7 percent by 2017 and 26.7 percent by 2020. Within the agricultural sector, the most poverty-reducing effect, as expected, comes from growth led by food crops, and under this scenario, the poverty rate falls to 33.6 percent by 2017 and to 28.5 percent by 2020. That is to say, food crop–led growth can play the most important role in achieving MDG 1 earlier.

The poverty reduction effect can also be seen from the change in the absolute number of poor persons. If the 2011 national poverty rate of 45 percent remained fixed until 2020, at a population growth rate of 2.6 percent, the number of poor would become 5.57 million by 2017 and 6.02 million by 2020 (as shown in the first column of the table under Figure 3.8). If the country moved along its current economic growth trend, as simulated in the base run, the number of poor in 2017 would be below 4.3 million and by 2020 would fall further, to 4.1 million; that is, Rwanda would not only manage to lower its poverty rate along its current growth trends, but it would also reduce the absolute number of poor by 480,000 and 630,000 in 2017 and 2020, respectively, from its level in 2011.

As we argued in the introduction, in the recent years between 2005 and 2010, broad-based growth has benefited the poor by raising their real income even though they are yet to move out of poverty. For this reason, we further check the impact of stimulated growth on per capita income according to different income groups and locations, rural or urban.

Figure 3.8 Number of poor persons under alternative growth scenarios, 2011–2020



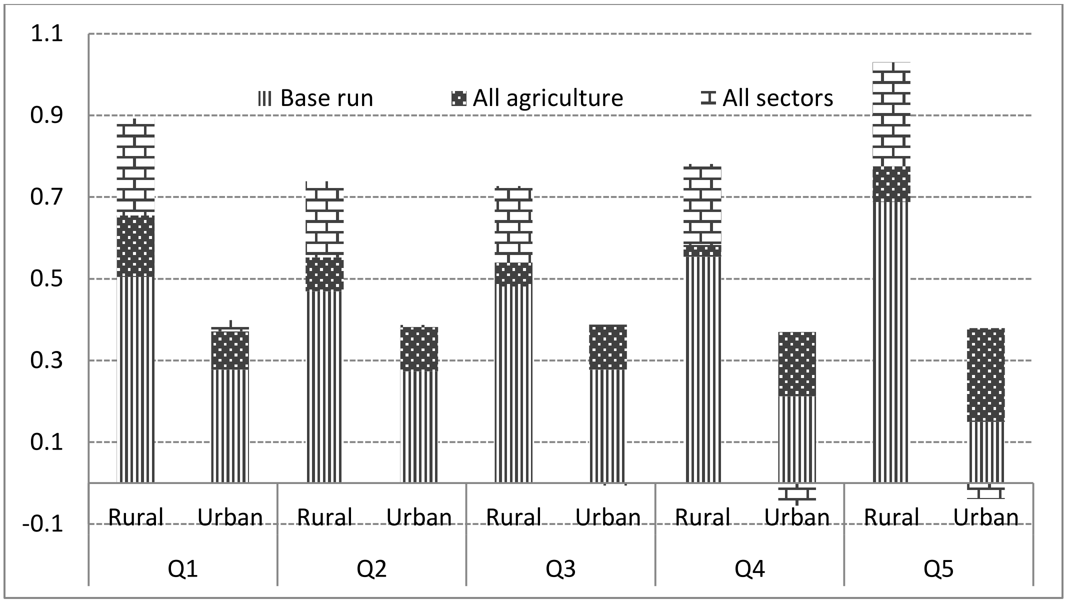
	At current poverty rate	Base run	Food crop–led	Expt crop–led	Livestock-led	All ag	Ag + nonag
2011	4,774						
2017	5,569	4,297	4,161	4,221	4,251	4,045	3,720
2020	6,015	4,145	3,815	4,015	3,997	3,567	2,928

Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

The bars in Figure 3.9, which measure the increase in real income per capita from its level in 2013, are consistently longer for rural households than for urban households across all income groups. This indicates that compared with the current level of income, rural households will benefit more from future growth than urban households.[20] The second message of Figure 3.9 is that most gains in household income come from the base run; that is, even if the economy just continues its current growth momentum, both rural and urban households benefit, and their income will rise in the range of 15–70 percent in the period of seven years (2013–2020). The third message is that an average poorest-quintile or richest-quintile rural household benefits more from growth than other rural households in the middle, while the benefit for urban households seems to be similar across income groups. The fourth message is that most income gains for rural households actually occur under the scenario of combined agricultural and nonagricultural growth, instead of agricultural growth only, while on the other hand, agriculture-led growth benefits urban households more than rural households. The main reason for this is the adverse price effect, which makes agriculture-led growth benefit consumers more (most urban households are food consumers only) than producers (rural households are both consumers and producers).

[20] However, that does not imply that in absolute terms income gains for rural households are necessarily more than for urban households, given that within each income quintile group the level of per capita income for urban households is higher than that for rural households. For example, per–adult equivalent income for urban households is 4–7 percent higher than that for rural households in the same income quintile for the first three low-income groups and more than 100 percent higher for the richest group (EICV 3).

Figure 3.9 Increases in per capita income by 2020 under different growth scenarios (compared with 2013)



Source: Authors' 54-sector dynamic computable general equilibrium model simulation result.

Summary of Section 3

To assess the relationship between subsector growth and total agricultural growth and between overall economic growth and poverty reduction, this section develops a 54-sector dynamic CGE model for Rwanda. In keeping with the spirit of a scenario-based inquiry, this section raises a set of key questions for future growth and structural transformation of the Rwandan economy.

By assuming a growth rate in foreign inflows much lower than that in recent history, the scenario-based analysis of this section tries to avoid the adverse effect of an overvalued real exchange rate associated with increased foreign inflows on the tradable sectors of the economy. While productivity growth is exogenous and defined at the sector level, growth in TFP for the economy as a whole is comparable with its historical trends in the period 1999–2012. However, with slowed foreign inflows to finance investment, the simulated growth rate of the construction sector in the base run is lower than its recent record of 2006–2012. This, together with the slowdown in capital accumulation, leads to a lower annual growth rate for GDP in 2013–2020 than in 2006–2012. However, the GDP growth rate of 7.7 percent per year is still much higher than the growth rate in 2006–2012, excluding the five fastest-growing sectors from the total GDP. While the growth rate of industry is much lower in the simulated base run, due to a lowered growth rate for the construction sector, manufacturing growth is faster than that in recent years, indicating the sensitivity of the tradable industrial sector to the overvaluation of the real exchange rate. Both agricultural and service sectors are less sensitive to foreign inflows and their induced overvaluation of the real exchange rate due to their stronger linkages with the rest of the economy. This indicates that because Rwanda is a low-income country at its early stage of development, the domestic market plays a crucial role in stimulating growth, and such linkage effects, which are primarily led by strong consumption linkages, can be further enhanced by promoting growth in the tradable part of the economy.

Three agricultural subsector–led growth scenarios are designed in this section. In reality, it is almost impossible for any such subsector to grow without growth supports from its sister sectors in agriculture. But decomposing their growth can help us understand whether these subsectors of agriculture will play different roles in broad economic growth, structural change, and poverty reduction.

Food crops, which include some commodities that can be regionally and internationally tradable but exclude crops produced for export only, account for 83–85 percent of agriculture. The size of this subsector makes it clear, even without sophisticated modeling, that the modest growth in food crops will have a much bigger effect on overall agricultural and economic growth than fast growth in smaller subsectors (export crops and livestock). Additional productivity growth and area expansion in only six food crops leads the annual growth rate of total food crops to increase by 2.1 percentage points from the base run, which results in an additional 1.7 and 0.65 percentage points of annual growth in agricultural GDP and overall GDP, respectively, in 2013–2020. The growth contribution of food crops to overall economic growth is not just due to its big size in agriculture, and the model simulation of food crop–led growth displays its strong multiplier effect; that is, through the consumption linkage effect a 1 percent growth in food crops generates a 0.11 percent growth in nonagriculture, both annually.

The simulation of export crop–led growth demonstrates the important role of this agricultural subsector on foreign exchange earnings. Rapid growth in the traditional export crops can generate foreign income quickly, a much more efficient method than targeting nontraditional exports, for which the growth rate can be extremely high, starting from a tiny initial base. Tripling the growth rate of export crops directly leads to a tripling of agricultural export earnings. When the labor force is underemployed, growth in the export sector also creates more employment opportunities. Thus, with a 22 percent annual growth rate in export crops as a subsector of agricultural GDP, additional annual growth in agricultural GDP and total GDP is 0.71 and 0.57 percentage points, respectively. Considering its small size in overall GDP, the growth impact of the export crop sector is impressive, particularly for overall economic growth. However, even with 22 percent annual growth, export agriculture continues to be a small sector in GDP. From its initial size of only 1.3 percent of GDP and after tripling its growth rate, export agriculture is still smaller than a single crop like maize in terms of share of GDP.

The data for livestock are rather limited. While the one cow per poor rural family program is reported to have made significant progress in recent years, the outcome seems not to show up in the macrodata. In the national account, livestock is only about 4.5 percent of agricultural GDP, higher than the 2.8 percent for export crops, but even smaller than the size of forestry (6.8 percent). The growth rate of livestock in recent years is reported as 3.3 percent in the national account, only slightly higher than the 3 percent population growth. Nevertheless, we simulated an extremely optimistic growth scenario for the cow/milk and poultry sector in the livestock-led growth simulation, which results in a 12 percent annual growth rate for the subsector as a whole. However, with its small size in the economy, a 12 percent annual growth rate in the livestock subsector is associated with 0.32 and 0.27 percentage points of additional annual growth in agricultural GDP and total GDP, respectively. The good news is that livestock growth also has the strongest multiplier effects, which concentrate in two nonagricultural subsectors, both having livestock products as important intermediate inputs. That is to say, the linkage effect for livestock growth on the nonagricultural sector is in the downstream production process, not through the consumption effect as observed in growth led by food crops.

When the three subsectors' growth is combined and simulated in an agriculture-led growth scenario, total agricultural GDP will grow at 8.4 percent and GDP at 9.1 percent annually. With strong multiplier effects of agricultural growth on nonagricultural growth, an additional 2.6 percent annual growth in agriculture creates 0.9 percentage points of additional annual growth in the nonagricultural sector. When agricultural growth is combined with additional growth in the nonagricultural sector by doubling the productivity of all nonagricultural sectors, the annual growth rate of GDP rises to 10.2 percent and of agricultural GDP to 8.5 percent; that is, agricultural growth also benefits from the multiplier effects of nonagricultural growth: the additional 0.1 percentage point of annual growth in agricultural GDP stimulates an additional 1.5 percent annual growth in nonagricultural GDP.

The model simulation, that is, combining additional growth in both agriculture and nonagriculture, did not result in an 11.5 percent annual growth rate for GDP, a growth target set by the government for Rwanda to become a lower-middle-income country by 2018. However, the simulated growth structure is much healthier than the current pattern of growth, in which the manufacturing growth rate of 12.7 percent is the highest among all main economic sectors and construction grows at only 9.7

percent. Together with much lower growth in foreign inflows, if Rwanda can achieve the growth structure described by the model simulation, it can expect that growth will be more sustainable than in the current pattern.

The model simulates a more optimistic agricultural growth scenario; that is, achieving 8.5 percent annual growth for the agricultural sector in a period of seven years would indeed be a historical record not only in Africa but also in the world in recent history. Rwandan agriculture will continue to depend on rainfall for most crop production in the near future, and thus, growth fluctuation due to weather conditions is unavoidable for agriculture. While it might be possible for agriculture to grow even more in a good year, it will be very hard to keep the average annual growth rate at this level for seven years. Thus, we need to keep in mind that the achievability of such growth is difficult and needs time to materialize.

We also checked the adverse price effect that is often associated with rapid growth in agriculture, in which most products are produced to meet domestic demand. The model result shows that with more rapid growth in the nonagricultural sector, rapid growth in agriculture is unlikely to be constrained by market opportunities at home. Relative prices for some fast-growing agricultural commodities may fall, but in most cases, the declines are modest. This result seems to indicate that Rwanda's domestic market still has enough room for agriculture to grow, when there is strong growth in its nonagricultural economy. Combined with the simulation result discussed above for export crop growth, it indicates that while promoting export growth is important for foreign exchange earnings, from a growth point of view, Rwanda's economic growth in the near future will be more domestic market–oriented instead of led by exports.

However, sustainable longer-term growth needs to come from economic structural change, and labor and resources should move to more productive sectors, more often being manufactures, which lead productivity growth for the whole economy. Unfortunately, the simulation did not display a significant structural change among the three main economic sectors of GDP that differs from its current trends in which a declining share of agriculture in GDP is replaced by an increasing share of services while the share of industry in GDP is more or less the same. While the Rwandan economic structure may look similar by 2020 to the way it is today, and the nontradable or less tradable part of the economy still dominates GDP, the model did show the encouraging sign of structural change within each main economic sector: the tradable part of the economy grows more rapidly and hence its share in the sector's GDP rises. A caveat of the model that may limit its capability to assess structural change and related rapid economic growth is that it is unable to model FDI, which is often a necessary condition for expansion of manufactures to lead significant structural change.

Rwanda's growth will continue to lead poverty reduction, not only in terms of the national poverty rate but also in the absolute number of poor in the population. With less than 8 percent GDP growth and 2.6 percent population growth per year in the base run, Rwanda will be able to achieve MDG 1 by 2020. More rapid growth is associated with more rapid reduction in poverty, and at a 10 percent GDP growth rate, Rwanda will be likely to halve its 2000 poverty rate by 2018. In all scenarios, the absolute number of poor will be smaller than that in 2011 even with rather rapid population growth. The pattern of growth simulated in the analysis also seems to be helpful for avoiding the rise in income inequality that is often accompanied by rapid economic growth. The poorest income group and rural households in all income quintiles seem to consistently benefit more than others from rapid growth, which is the pattern we have already seen in the recent growth between 2005 and 2011.

In conclusion, growth similar to or slightly faster than that of recent experience is possible for Rwanda, and growth will continue to contribute to broad development goals such as poverty reduction. Challenges Rwanda faces are the structure of its growth, and hence the transformation led by structural change, and sustainable growth. Rwanda urgently needs to explore all possibilities to expand the tradable part of its economy in agriculture, manufactures, and services by attracting more private (often foreign) investments. It seems to become obvious that before such investment can reach a large scale, Rwanda's economic structure is unlikely to change tremendously in next 10 to 20 years. Because of the continuous dependency on domestic-oriented economic activities for growth, it is necessary to manage growth expectations.

4. ASSESSING GROWTH FEASIBILITY AND PUBLIC INVESTMENT COST

The Rwandan government has invested heavily in physical and human capital in recent years. While a more rigorous assessment of the growth impact of public investment goes beyond the scope of this report, it is quite obvious that economic growth has benefited considerably from this investment. Thus, future economic growth requires this growth momentum in public investment to continue and become even stronger. In this section, we first link the total public investment to economywide growth to assess the feasibility of the overall economic growth target and the cost of such growth if it is to be accelerated.

Economywide Productivity Growth and Public Investment

The growth impact of public investment is often associated with the fact that it produces a set of public goods necessary for growth, such as roads, irrigation systems, schools, and hospitals. To capture this growth impact of public investment, we first conduct a simple growth accounting exercise to obtain the TFP for the economy as a whole for 1999–2011. We then use the relationship between TFP growth and public investment growth in this period to set up a baseline for measuring the growth impact of public investment in the model simulations.

We use macroeconomic data for this exercise; that is, we decompose economic growth in terms of total GDP by factor accumulation and TFP changes. Three factors are considered—labor, land, and capital—and a Cobb-Douglas production function is assumed for the value of GDP in its real terms, that is,

$$Y = A \cdot LB^{\alpha_1} LD^{\alpha_2} K^{\alpha_3}, \tag{1}$$

where *Y* is the level of GDP in time *t*; *LB*, *LD*, and *K* are, respectively, labor force, land, and capital in time *t*; *A* is the measure of TFP; and α_i is the share parameter for each factor input in the GDP production function. We obtained the share parameters, α_i, from the SAM we constructed for Rwanda in 2011 as well as the levels of labor force and total crop area in 2011. The stock of capital is an unknown variable, and the estimation of its initial level does affect the calculation of the level and growth of TFP. We started with the value of capital employed in the economy in 2011 in the SAM. With an assumption about the average return rate on capital, we obtained the stock of capital for 2011. We then calculated the time series of labor force, land, and capital backward to 1999 by applying the information from World Bank (2014) for growth in labor force and gross private capital formation, and from MINAGRI (2014) for growth in crop area in this period. We then used a capital depreciation rate to adjust the net capital formation, resulting in an average TFP growth of 3.14 percent per year in the period 1999–2011. This result is consistent with Martinez and Mlachila (2013) in terms of the contribution of TFP to GDP growth. In Martinez and Mlachila (2013), the annual TFP growth rate in 2005–2008 is 2.17 percent for the low-income country group in Africa south of the Sahara, and the annual GDP growth rate is 6.6 percent for this country group in the same period—that is, about one-third of GDP growth is due to TFP growth. While Rwanda belongs to this group, its GDP growth performance is much better than the group average in Martinez and Mlachila (2013). The annual growth rate of GDP in 2005–2008 is 9 percent for Rwanda, indicating that a TFP growth rate for Rwanda higher than the group average is possible.

The result of the growth accounting analysis shows that about 20.5 percent of growth in GDP comes from increased labor use, 3.6 percent from area expansion, and 43.0 percent from capital accumulation. With an average growth rate of 3.14 percent per year, TFP growth contributed one-third of GDP growth in 1999–2011.

We then compared TFP growth with the growth in public capital formation in the same period. The ratio of the TFP growth rate over the public capital formation growth rate is 0.22 if we use the average growth rate for TFP and public capital formation, and is 0.52 if we take the simple average as the annual ratio. That is, 1 percent annual growth in gross capital formation through public investment is associated with 0.22–0.52 percentage points of annual growth in TFP in 1999–2011. This range of elasticity for TFP to public investment is then used to assess the feasibility of the growth options simulated in Section 3.

To be able to assess whether growth in public investment in the model simulation is consistent with GDP growth, particularly with growth in TFP, we developed a production function for total GDP similar to that in equation (1). Levels of real GDP, labor force, land, and capital in this GDP function are endogenous results from the model simulations, while TFP is calculated as a residual term, similar to that in a standard growth accounting exercise.

We focus on the two scenarios of base run and combined growth for assessing growth feasibility for the economy as a whole. In the base run, growth in the three production factors contributes 73 percent of GDP growth on average, slightly higher than the result from the growth accounting analysis for 1999–2011. That is to say, about 27 percent of GDP growth is the result of productivity gain, and TFP grows at 2.0 percent annually in 2013–2020 in the base run. In the same scenario, public investment grows at 7.11 percent per year, much lower than that in recent years. For example, public gross capital formation grew at 14.4 percent annually in 1999–2011. The modest growth in public investment in the base run is due to the assumption of much more modest foreign aid to finance public investment than the growth of foreign grants in recent years. The ratio of TFP growth to public investment growth is 0.24 in the first year of the simulation (2012) and slowly rises to 0.29 toward the end of the simulation (2020). Compared with the elasticity for TFP growth associated with public investment obtained from our simple exercise discussed above, this result seems to show that economywide TFP growth (as a result of an exogenous assumption about the sector-level TFP growth rate) is consistent with the endogenous result of the growth in public investment in the base run. This seems to further imply that it would be achievable for the economy to grow at 7.7 percent annually in 2013–2020 when the public investment annual growth slows to 7.1 percent with much less dependency on foreign grants.

We then turn to the final simulation in which growth is accelerated in both the agriculture and nonagriculture sectors. Most growth acceleration in this scenario is due to exogenous increases in the sector-level TFP growth rate. Under this scenario, the economywide TFP growth rate rises to 3.9 percent per year in 2013–2020. While the growth rate in foreign grants to finance public investment is the same as in the base run, growth in public investment also accelerates, primarily due to increased domestic revenue sources as an outcome of economic growth.[21] The growth of public investment starts at 8.8 percent in 2013, the same in all scenarios, and eventually accelerates to more than 11.0 percent per year and averages 11.6 percent per year in 2013–2020. The ratio of TFP growth over the growth of public investment is 0.40, almost 50 percent higher than that in the base run. This implies that unless productivity growth is 50 percent more responsive to public investment, 10 percent of annual GDP growth for the economy as a whole is not supported by growth in public investment in the same scenario.

If the growth impact of public investment is at a level similar to that in base run—that is, if the growth elasticity of TFP with respect to public investment is 0.28 on average—to support the 10 percent annual growth in GDP and hence 3.9 percent productivity growth requires public investment to grow at 14 percent per year in 2013–2020, 2.4 percentage points more than the annual growth rate of public investment obtained in the model. Measured in Rwandan francs at constant prices, this implies that in total for the next seven years between 2014 and 2020, it will take RWF 875 billion more for the government to finance its public investment in order to achieve 10 percent economic growth in 2013–2020. This amount of public spending is equivalent to 20 percent of the total public investment in 2014–2020 as a simulation result of this scenario. Put differentially, public investment will be 20 percent short of supporting 10 percent per year economic growth in 2014–2020.

It is possible that TFP can grow more rapidly than in the past at the same level of public investment, if the lag effect of this investment is considered. Indeed, infrastructural investment has sped up in recent years, and the growth impact of this increased investment has yet to be captured in the data used for the growth accounting analysis. For example, if elasticity of TFP with respect to public

[21] We assume that government current expenditure in real terms (that is, the volume terms of recurrent spending items) grows at 7 percent and government transfers to households at 8 percent annually in all scenarios.

investment rose by 15 percent, to be at 0.32 instead of the 0.28 that is in the base run, the additional public investment required to support 10 percent economic growth will be less than 2 percent of total public investment in 2014–2020; that is, with a slight improvement in the efficiency of public investment, and hence a slightly higher elasticity of TFP to such investment, it is possible that the level of public investment in the model's combined growth scenario can support 10 percent annual economic growth.

In Section 3, we also discussed an alternative option for productivity growth: through the expansion of tradable sectors, particularly manufacturing, labor could move out of traditional economic sectors with lower productivity and into those with higher productivity. This will create growth in both labor productivity and TFP constantly. As Rodrik argues, if 1 percent of labor can be moved to manufacturing per year, with manufacturing productivity being four times the average productivity of the traditional sectors and hiring 5 percent of labor currently, the result would be a 3 percentage point increase in income growth per capita (2013, 30). Thus, with increased private investment (particularly foreign investment), it is possible for the economy to grow at 10 percent per year or more even without further increases in public investment. This type of investment also creates more decent employment opportunities in the tradable part of the economy, particularly in manufacturing.

However, a private sector–led productivity growth strategy, a strategy that has been implemented by many East Asian countries, requires the scale of such investment and its growth to reach a level that has yet to be seen in Rwanda. In other words, to implement this strategy would require that the country attract private investment reaching a scale equivalent to four times its current capacity of manufacturing in the next seven years. This is obviously a huge challenge to put into practice.

The government has considered a planned high level of public and private investments to support the higher growth target. Indeed, the three-year public investment plan for 2013/2014 through 2015/2016 is ambitious, and more than two-thirds of the increases in its budget are infrastructural investment, dominated by road construction. On the other hand, estimated foreign grants will be unable to grow at a pace matching the investment plan, and the level of foreign grants may fall instead of increase in real terms. This seems to give the government two options: (1) manage the growth expectation by lowering the growth target or (2) finance the ambitious investment plans through foreign borrowing. While investing in road and other infrastructure continues to be necessary for Rwanda in order to further improve the investment environment for the private sector, as this report has argued, when an investment plan is too ambitious and results in excessive foreign inflows through nonprivate channels, it could have an adverse impact on longer-term growth, particularly for the tradable sector of the economy.

Agricultural Productivity Growth and Public Investment

Following an analytic framework similar to the one we used to assess the relationship of economywide productivity growth and public investment, we turn to this relationship for the agricultural sector. On the one hand, there is limited information to assess TFP change in the aggregated agricultural sector, for the reasons we mentioned in Section 3 when we discussed the growth scenarios for export crops and livestock. On the other hand, information for food crop production is available. Given that food crops account for more than 80 percent of agricultural value-added, we focus on food crop agriculture for productivity assessment. As we discussed in Section 3, due to seasonality, most agriculture-related labor activities are not full-time, year-round jobs. Thus, because labor input in agricultural production is unlikely to be measured correctly using the number of agricultural workers, it is relatively hard to measure TFP for the agricultural sector. Moreover, considering that Rwanda is a land-constrained economy for agriculture, we focus on land productivity for the agricultural productivity assessment (Table 4.1).

Table 4.1 Measures of productivity in food crops

Indicator	Year/ Period	Cereals	Roots and tubers	Legumes	Bananas	Oilseeds, vegetables and fruits	Total food crops
Share in food crop GDP	2006	18.5	29.6	16.2	18.8	17.0	
	2011	20.5	30.5	17.7	14.1	17.2	
Share in food crop area	2006	19.4	25.7	23.9	22.3	8.6	
	2011	21.1	26.4	27.5	17.9	7.1	
GDP per ha (constant RWF 1,000)	2006	316.8	381.8	224.9	279.5	652.1	332.2
	2011	374.3	442.9	246.2	302.6	929.2	383.7
GDP annual growth rate	2006–2011	8.1	6.6	7.8	0.0	6.2	5.9
Area annual expansion rate	2006–2011	3.8	2.9	4.8	-1.3	-0.9	2.4
GDP per ha growth rate	2006–2011	4.2	3.6	2.8	1.3	7.1	3.4
Contribution to food crop GDP growth							
Due to land expansion		47.7	44.3	63.4	0.0	0.0	41.4
Due to increased value-addition		52.3	55.7	36.6	100.0	100.0	58.6
Contribution to food crop GDP growth (weighted by group's GDP share in 2006)		26.2	33.7	21.8	0.1	18.1	

Source: Authors' calculation using data from the following: shares of food crop value-addedand food crop area, MINAGRI (Rwanda, MINAGRI 2014); constant value of GDP is available only for total food crops in MINECOFIN (Rwanda, MINECOFIN 2013a), so we use the nominal GDP shares for the five food crop groups to split the total food crop GDP in constant Rwandan francs and calculate the annual growth rate.

Note: GDP = gross domestic product; RWF = Rwandan francs.

Land productivity is usually measured by crop yields. In order to be able to compare productivity across different crops and consider land productivity for total agriculture as well as for different subgroups of food crops, we use value-added per ha to measure productivity. As shown in Table 4.1 (rows 5–6) value-added per ha varies across crops and as expected, the group of oilseeds, vegetables, and fruits has the highest value-added per ha in both years, while the legumes group has the lowest value-added per ha. However, over time the crops with high value-added per ha may not grow more rapidly than the crops with low value-added per ha. For example, vegetable and fruit crop areas fell between 2006 and 2011, causing the fraction of total crop area allocated to this group of crops to decline from 8.6 percent in 2006 to 7.1 percent in 2011.

GDP per hectare for food crops in total grew by 3.4 percent per year in 2006–2011, a growth rate higher than the annual growth rate of food crop area expansion (at 2.4 percent). This implies that almost 60 percent of food crop GDP growth comes from improvement in land productivity while 40 percent is due to land expansion. Across different crop groups, the contribution of land productivity is consistently higher than land expansion in most crops, except for legumes, for which land expansion is a dominant factor in GDP growth.

We now turn to public expenditure in agriculture and measure its relationship with agricultural growth.[22] The definition of agricultural budget varies across countries. According to the United Nations Classification of Functions of Government (COFOG), the broader agricultural share in Rwanda was about 13.6 percent of the total government budget in 2010 when forestry, water for production, and issues related to agricultural land—which are directed by the Ministry of Land, Housing and Community Amenities—are included (MINECOFIN 2013d). However, detailed budget information is available only

[22] A more rigorous assessment of the impact of public investment in agriculture on agricultural productivity requires not only data on public expenditure but also the actual investments. While PSTA II did a wonderful job for planning this type of investment, information about its investment outcomes, which are crucial for the targets set under PSTA III, is still limited and incomplete. Thus, we can discuss only agricultural public expenditure instead of investment in this report.

for MINAGRI, whose share has been around 5 percent of the total government budget in recent years.[23] Thus, we consider only MINAGRI's data for agricultural public expenditure in the analysis. Table 4.2 first displays the current situation.

Table 4.2 Total and agricultural public expenditure

Expenditure	2007	2008	2009	2010	2011	2012	2007–2012	2008–2012
Total, million RWF	383,911	485,503	649,471	736,786	852,753	990,100		
MINAGRI, million RWF	10,654	23,360	28,992	34,920	47,067	45,916		
MINAGRI as percent of total	2.8	4.8	4.5	4.7	5.5	4.6		
Annual growth rate measured in 2007 constant RWF (percent)								
Total		9.5	21.2	10.9	9.5	9.1	12.0	12.6
MINAGRI		89.9	12.5	17.7	27.6	-8.3	24.1	11.5
Public expenditure as share of GDP								
Total expenditure in total GDP	18.8	18.8	21.8	22.5	22.3	22.5		
Agriculture expenditure in AgGDP	1.5	2.8	2.9	3.3	3.8	3.3		
Agriculture expenditure total GDP	0.5	0.9	1.0	1.1	1.2	1.0		

Source: Authors' calculation from Rwanda, MINECOFIN (2013a).
Note: AgGDP = agricultural gross domestic product; GDP = gross domestic product; MINAGRI = Ministry of Agriculture; RWF = Rwandan francs.

Excluding 2007, in which the fraction of total public expenditure as agricultural expenditure was very low, the share of agriculture in total public expenditure was about 5 percent in 2008–2011. We further calculated the ratio of public expenditure over GDP, shown in the third panel of Table 4.2, which shows that while total public expenditure as a share of GDP was more than 20 percent in recent years, agricultural spending was equivalent to only 1 percent of GDP, or about 3–4 percent of agricultural GDP. While the Rwandan government has significantly increased its budget allocation to agriculture since 2007, the growth in agricultural budget has slowed down in the most recent years. Excluding the big allocation jump in 2008, the growth in agricultural spending is similar to that of total public expenditure, at 11.5 percent per year since 2009.

Similar to the case of economywide TFP and public investment, we associate agricultural productivity growth (measured as growth in agricultural GDP per ha) with agricultural public expenditure, assuming that such expenditure helps farmers improve their land productivity. The ratio of agricultural productivity growth to agricultural public spending growth is 0.296, indicating that 1 percent growth in agricultural public spending is associated with 0.296 percent growth in agricultural productivity. While this result is higher than the cross-country regression analysis of Fan (2008), which is 0.208, considering that in Rwanda almost 90 percent of agricultural spending is development expenditure instead of spending on daily government operations (MINECOFIN 2013d), the higher productivity-to-expenditure elasticity in Rwanda than in cross-country regression analysis is reasonable.[24] While land

[23] According to the most recent public expenditure review in the agricultural sector, for 2008–2010, the differences in the agricultural shares of total budget between broadly defined agriculture according to COFOG and MINAGRI are much smaller in 2008 and 2009 (that is, the differences are only 0.6 and 1.8 percentage points, respectively). The gap jumped to 6.2 percentage points in the 2010 budget—that is, 13.6 percent according to COFOG definition versus 7.4 percent for MINAGRI (MINECOFIN 2013d).

[24] A relatively high productivity-to-spending elasticity is also related to the measure of productivity, which in our case is agricultural GDP per ha instead of TFP, the latter used by Fan (2008). For example, in the model base run, agricultural GDP per ha grows at 3.2 percent per year, 50 percent higher than the TFP of the agriculture growth rate, which is 2.1 percent. If the

productivity is not the same thing as TFP, considering that Rwanda is a land-constrained country with abundant rural labor, it makes sense to conduct the comparison with agricultural productivity using land productivity as a proxy, and using TFP for the economy as a whole. If we agree with this argument, the elasticity for agricultural productivity with respect to agricultural public expenditure, which is 0.296, is comparable with the elasticity of economywide TFP with respect to total public investment over a similar historical period, which is 0.22, as discussed in the first part of this section.

We now move on to assess the cost of agricultural growth for the government. Again, we focus on two scenarios, base run and combined growth, for the assessment, and will come to other scenarios only when necessary. In the base run, agricultural productivity measured by agricultural GDP per ha grows at 3.2 percent per year, slightly lower than but very similar to the 3.4 percent annual growth rate calculated from the data for 2006–2011. We also calculated the TFP and factor contribution to agricultural growth as part of the model result, similar to what we did for the economy as a whole. Growth in labor, land, and capital together contributes 64 percent of agricultural GDP growth on average in the base run. That is to say, corresponding to 3.2 percent land productivity growth, TFP (including export crops and livestock in addition to food crops) grows at 2.1 percent annually in 2013–2020 in the base run.

In the model simulations, we cannot distinguish agricultural from nonagricultural public investment. Following recent trends, therefore, we first assume that agricultural spending grows proportionally to total public investment—that is, that the fraction of total public investment as agricultural spending is constant at 5 percent. This implies that agricultural spending will also grow at 7.11 percent per year, similar to the growth of total public investment in the base run. Again, similar to the situation for total public investment discussed in the first part of this section, this growth rate is lower than its historical trend, which is 11.5 percent in recent years (2008–2012). Because of the declining growth rate for total and agricultural public investment, the ratio of agricultural GDP per ha growth to agricultural public investment growth is 0.45 on average, much higher than the elasticity of 0.296 obtained from the calculation discussed above. However, the ratio of agricultural TFP growth to agricultural public investment growth is 0.29, which is similar to the elasticity of economywide TFP and total public investment obtained in the base run.

If the elasticity of agricultural productivity growth (measured by land productivity) with respect to the growth in agricultural spending stays at the same value we obtained from the historical data analysis (that is, 0.296), then what should be the required growth in agricultural spending and what will be its share of total public spending? We conduct a simple exercise using the model result to address these two questions. Table 4.3 displays the required agricultural investment for all scenarios. The first three columns of Table 4.3 are the model results of agricultural GDP growth and the contribution of factors and TFP to this growth. It is interesting to see the differential contributions of TFP and factor growth to agricultural growth under the three different agricultural subsector–led growth scenarios. For example, under food crop–led growth, each 1 percent of agricultural growth requires more than 0.5 percent of productivity growth (that is, productivity growth contributed to more than 50 percent of agricultural GDP growth under this scenario). In the case of export crop–led growth, only 0.43 percent TFP growth is required to support 1 percent of agricultural growth. Under livestock-led growth, 87 percent of agricultural growth will come from increased production factors and only 13 percent from TFP growth.

elasticity were measured by TFP growth (which is not available to us) to spending growth, the value of the elasticity would be expected to be much lower than 0.296.

Table 4.3 Agricultural productivity growth and required public expenditure in agriculture

Variable	AgGDP growth rate	Contribution of factor growth to AgGDP growth	Contribution of TFP growth to AgGDP growth	Growth in agricultural productivity measured by land productivity	Required growth in agr. spending at elasticity of 0.296	Share of required agr. spending in total government spending (2020)
Initial level	5.7			3.4	11.5	5.0
Base run	5.8	63.6	36.4	3.2	10.8	6.2
Food crop–led	7.5	49.5	50.5	4.3	14.5	7.4
Export crop–led	6.5	57.2	42.8	3.5	11.7	6.4
Livestock–led	6.1	87.0	13.0	3.5	11.9	6.4
Agriculture	8.4	64.3	35.7	4.7	16.0	7.7
Agr. + nonagr.	8.5	65.0	35.0	4.8	16.0	6.6

Source: Authors' 54-sector dynamic computable general equilibrium model simulation result, except for the initial values of agGDP and agricultural productivity growth rates, which are calculated from the historical data (Rwanda, MINAGRI 2014, and Rwanda, MINECOFIN 2013a).

Notes: AgGDP = agricultural gross domestic product; TFP = total factor productivity.

Because of the differential role of TFP growth in agricultural growth under different scenarios, the required growth in agricultural public investment differs as well. By assuming that 1 percent growth in agricultural public investment is associated with 0.296 percent growth in agricultural productivity (measured by land productivity), 3.2 percent annual growth in agricultural productivity in the base run requires an annual growth rate of 10.8 percent for agricultural spending. At this level of growth and without changing the growth rate for total public investment, which is 7.11 percent per year, the fraction of total public spending for agriculture is about 6.2 percent by 2020 in the base run. Under the scenario of combined agriculture and nonagriculture growth, the agricultural productivity growth rate is 4.8 percent per year, while under the agriculture–led growth scenario, the agricultural productivity growth rate is 4.7 percent. This indicates that an additional 0.1 percentage point of land productivity growth is led by resource reallocation due to change in relative prices when nonagricultural growth creates more income. Thus, we assume that the required growth in agricultural public investment should be the same under both scenarios, at 16.0 percent per year. Under the combined agriculture and nonagriculture scenario, growth in total public investment is 11.6 percent per year, which implies that as a share of total public investment, agricultural spending will be 6.6 percent by 2020 under this scenario. While the required growth in agricultural spending is higher than the growth in total public spending, the fraction of total spending for the agricultural sector is still smaller than in many other developing countries outside Africa.

Compared with the other two subsector-led growth scenarios, additional agricultural growth led by food crops has to come mainly from productivity improvement, which indicates a greater requirement for agricultural public spending to support this growth. Agricultural growth led by export crops or livestock seems to be driven by resource expansion. This is possible considering the small size of these sectors relative to food crops in the agricultural economy. From this point of view, attracting private-sector investment aimed at expanding export crop area and scaling up livestock production might be more important than making direct public investment in these sectors. In other words, the role of the government in promoting growth of export crops and livestock may depend less on direct investment in these sectors than on creating a better environment for the private sector to invest.

In summary, the analysis of Section 4 shows that current public investment growth momentum seems to support the ambitious growth targets for agriculture and for the economy as a whole. The challenge is how to finance such rapid growth in public investment. If public investment continues to depend on foreign aid or foreign borrowing, it may be able to support rapid economic growth but is unlikely to lead to the structural transformation of the economy, a result that may hurt longer-term sustained growth.

More growth in food crops has to come from productivity improvement, which depends more on public investment. To support 8.5 percent agricultural growth, in which growth in food crops will play a dominant role, public agricultural investment has to grow more rapidly than it has in recent years. While a higher growth in agricultural public investment is necessary for this level of growth in food crops, the resulting public resource allocation to the agricultural sector is not surprisingly high; that is, the fraction of public resources to invest in agriculture will continue to be below 7 percent.

Expansion of the export sector and livestock through private investment will contribute to agricultural growth with relatively less dependency on direct public-sector investment in agriculture. The main role of the government in such a pattern of growth is to create an environment more attractive for the private sector, implying that policy and institutional factors may matter more than direct public investment.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This report assesses the future growth prospects of Rwanda. By combining a growth diagnosis of the past with a scenario-based analysis for the future, the report analyzes growth challenges and opportunities Rwanda is expected to face in the next 5–10 years. For such an analysis, particularly in the scenario analysis, the report puts more focus on agriculture and analyzes its growth at the subsector level. The growth targets set by the government for the whole Rwandan economy and its agricultural sector have been taken into consideration in the scenario analysis. Specifically, the scenario analysis provides an assessment of the feasibility of growth targets and the implications of growth on structural change, employment creation, household income growth, and poverty reduction. The report also assesses the required public investment to support such growth, both for the economy as a whole and for agriculture in particular. The key findings of the report have been summarized at the end of each chapter, and thus we conclude the report with the following major policy implications:

1) Rwanda is experiencing its best growth performance since independence. Growth success is accompanied by heralded progress in reducing poverty. Such growth and poverty reduction momentum is expected to continue for the next 5–10 years. However, recent growth in Rwanda depends heavily on foreign aid and other nonprivate foreign inflows to finance investment, and the pace of future growth thus will be conditional on whether such inflows will continuously grow or not. Slowed economic growth is possible when the level of growth of foreign grants starts to fall.
2) If Rwanda continues to receive increased foreign aid to finance public investment, economic growth is expected to be as rapid as in recent years, but structural change in the economy will continue to be slow. Similar to what has occurred in recent years, the driver of structural change will continue to be the few rapidly growing nontradable sectors that directly benefit from public investment and public service spending, such as construction, education, and some private service sectors. Declining agricultural share in GDP will be replaced by the shares for these rapidly growing nontradable sectors, particularly service sectors, while the manufacturing sector will continue to experience a stagnant or declining share of total GDP.
3) When foreign inflows that are mainly channeled through nonprivate sectors grow too rapidly, the real exchange rate, measured by domestic prices against world prices, will appreciate. This appreciation will negatively affect the tradable sector's growth, including growth from export agriculture and services, and from import-substitutable manufactures and the creation of employment in formal sectors. This has been the case in recent years, and it may possibly continue in the next 5–10 years.
4) Putting the above factors together, one of the key messages of this report is that Rwanda is facing a dilemma or trade-off in its future growth in next 5–10 years: rapid growth without structural change versus relatively slow growth with possible structural change. Managing growth expectations seems to be necessary for helping Rwanda to develop its tradable sectors and bring a more sustainable structural change and growth to the economy. While managing growth expectations is a necessary condition for structural change to occur, it is not sufficient. Without enough growth in private, particularly foreign private, investments to create significant growth for the economy as a whole, the Rwandan economy will continue to depend on domestic (and possibly regional) markets more than on international markets for growth opportunities.
5) Against the broad background for future economic growth summarized above, we recommend a threefold strategy for agriculture to play an active role in Rwanda's future economic growth:
    a. If overall economic growth continues to be as rapid in the next 5–10 years as it has been in recent years, and if the growth continues to be supported by a

similar level of foreign-financed investment, meeting domestic market demand will be a first dominant force to lead agricultural growth. In this case, less internationally tradable food crops and livestock will need to grow more rapidly, similar to what has happened in recent years, and this growth will be driven primarily by market forces from increased domestic demand as an outcome of increased household income from rapid growth for the economy as a whole. This type of agricultural growth may not be able to contribute to structural change, but it will benefit farmers both through income generation and by improving food and nutrition security, and it will benefit consumers, particularly urban consumers, by ensuring an adequate food supply at reasonable and stable domestic prices.

b. Exploring regional market demand is part of the growth strategy under this scenario when agriculture is led by growth in food crops and livestock. The regional market differs significantly from the international market for Rwanda's agriculture but is close to the domestic market in nature, inasmuch as most agricultural commodities traded in the region are similar to goods produced for local demand, such as maize, Irish potatoes, dry beans, and livestock and livestock products. The regional market is also less sensitive to the overvaluation of the real exchange rate that will hurt agricultural exports going to international markets because, in most cases, commodities exported to neighboring countries are less tradable internationally. Regional trade of foodstuffs is also often complementary when it has a dominant seasonal pattern, and hence it is less of a *threat* to farmers of neighboring countries, a fact that may keep such trade from creating much controversy or political tension among neighboring countries.

c. When overall economic growth slows due to lowered foreign aid and when the issue of overvaluation of the real exchange rate is corrected, export agriculture will grow more rapidly and will increase its role in leading total agricultural growth. While broadening the international trade basket and exploring nontraditional export niche markets are important, Rwanda's international trade will continue to be dominated by its two traditional export commodities, coffee and tea. Thus, increasing value addition or price premium by improving the quality of these two commodities in their production and processing is important.

6) Different components of this agricultural growth strategy require different types of government support and policy interventions and environment. Agricultural growth led by productivity improvement in the broad food crop sector depends less on the correction of overvaluation of the real exchange rate, but requires more public investment to support it, than similar requirements of the other components of the agricultural growth strategy. Without accelerated growth in agricultural public investment, the 8.5 percent target for agricultural annual growth, in which growth in food crops has a dominant role, will be difficult to achieve. On the other hand, agricultural growth led by internationally tradable export crops depends heavily on the correction of overvaluation of the real exchange rate. In this case, the facilitative role of the government in promoting private investments to lead such growth is more crucial than direct agricultural investment by the government.

7) Rwanda should continue to improve its institutional and infrastructural environment for ease of doing business and increase its efforts to attract foreign investors to help the country develop its labor-intensive manufacturing sector, a key sector for both economic structural transformation and employment creation. However, the recent growth trajectory and possible future growth along this path indicate that it is unrealistic to expect that the pace of manufacturing growth will be fast enough to considerably scale up its role in broad economic growth and job creation in the next five years. That is to say, while Rwanda is similar to many East Asian countries in terms of being labor abundant and land constrained, it may not be able to attain an East Asian style of growth and structural change in the near term. On the other hand, agricultural transformation in Rwanda has started in recent years, and this transformation has occurred in a broad base led by transformation of the food and livestock production systems; that is, it occurred not just in a few high-value products. Measured by land productivity, more than 60 percent of recent growth in food crops is from productivity improvement, an encouraging and positive sign of agricultural transformation. Thus, it can be expected that the role of agriculture in Rwanda's future growth will be further enhanced during the continuous transformation process of agriculture. More employment opportunities will be created when agriculture becomes more productive and more market oriented, both directly in agriculture and for agriculture along entire supply chains. Agricultural growth–induced foreign investment is also possible, and such investment may help the broad economic transformation and thus will eventually lead to a different type of successful structural transformation.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1 Share of gross domestic product across sectors

Number	Sector	GDP share (%)
1	Wheat	0.45
2	Maize	3.05
3	Paddy rice	0.87
4	Sorghum	1.56
5	Potatoes	3.23
6	Sweet potatoes	2.95
7	Cassava	2.57
8	Roots	0.30
9	Pulses	4.94
10	Vegetables	2.59
11	Fruits	0.57
12	Bananas	3.82
13	Oil seed	1.62
14	Coffee	0.44
15	Tea	0.44
16	Pyrethrum	0.04
17	Other exports	0.02
18	Bovine cattle	0.80
19	Sheep and goats	0.11
20	Swine	0.07
21	Poultry	0.09
22	Milk	0.45
23	Eggs	0.08
24	Other livestock	0.06
25	Forestry	2.25
26	Fisheries	0.39
27	Mining	1.36

Number	Sector	GDP share (%)
28	Meat, fish, and dairy products	0.38
29	Processed cereals	0.39
30	Processed coffee	0.75
31	Processed tea	1.25
32	Bakery, processed sugar	0.10
33	Traditional beverages	0.98
34	Modern beverages	0.55
35	Tobacco	0.25
36	Textiles	0.36
37	Wood and paper	0.26
38	Chemicals	0.35
39	Nonmetallic minerals	0.61
40	Furniture and other manufacturing	0.65
41	Electricity, gas, and water	0.36
42	Construction	9.48
43	Retail and wholesale trade	13.76
44	Hotels and catering	2.10
45	Transports	4.96
46	Communication	2.98
47	Finance and insurance	3.14
48	Real estate	4.73
49	Business services	1.85
50	Repair	0.72
51	Public administration	5.73
52	Education	5.74
53	Health	1.54
54	Other services	0.93
	Total share	**100.00**

Source: Authors' 54-sector dynamic computable general equilibrium model.
Note: GDP = gross domestic product.

Table A.2 Macroeconomic indicators (% annual growth rate, 2012–2020)

Macroeconomic parameter	Growth rate
Government consumption spending	7.00
Government transfers to households	8.00
Foreign payments to government	4.90
Household remittances	8.00
Foreign savings	4.90

Source: Authors' 54-sector dynamic computable general equilibrium model.

Table A.3 Assumption of growth rate in area expansion / stock of livestock at crop/livestock subsector level across regions (%, 2012–2020)

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Wheat–South	2.00	8.88	2.00	2.00	8.88	8.88
Wheat–West	2.00	8.88	2.00	2.00	8.88	8.88
Wheat–North	3.05	8.88	3.05	3.05	8.88	8.88
Wheat–East	2.00	8.88	2.00	2.00	8.88	8.88
Maize–South	2.76	3.31	2.76	2.76	3.31	3.31
Maize–West	1.06	1.69	1.06	1.06	1.69	1.69
Maize–North	4.34	4.78	4.34	4.34	4.78	4.78
Maize–East	6.14	6.75	6.14	6.14	6.75	6.75
Rice–South	1.50	4.30	1.50	1.50	4.30	4.30
Rice–West	2.42	4.30	2.42	2.42	4.30	4.30
Rice–North	1.50	4.30	1.50	1.50	4.30	4.30
Rice–East	1.50	4.30	1.50	1.50	4.30	4.30
Sorghum–South	1.50	1.50	1.50	1.50	1.50	1.50
Sorghum–West	1.50	1.50	1.50	1.50	1.50	1.50
Sorghum–North	1.50	1.50	1.50	1.50	1.50	1.50
Sorghum–East	1.50	1.50	1.50	1.50	1.50	1.50
Potato–South	3.03	4.75	3.03	3.03	4.75	4.75
Potato–West	3.15	4.75	3.15	3.15	4.75	4.75
Potato–North	3.65	4.75	3.65	3.65	4.75	4.75
Potato–East	4.54	4.90	4.54	4.54	4.90	4.90
Sweet potato–South	2.00	2.00	2.00	2.00	2.00	2.00
Sweet potato–West	2.00	2.00	2.00	2.00	2.00	2.00
Sweet potato–North	2.00	2.00	2.00	2.00	2.00	2.00
Sweet potato–East	2.00	2.00	2.00	2.00	2.00	2.00
Cassava–South	3.04	4.95	3.04	3.04	4.95	4.95
Cassava–West	2.63	4.12	2.63	2.63	4.12	4.12
Cassava–North	2.00	4.12	2.00	2.00	4.12	4.12
Cassava–East	2.48	4.95	2.48	2.48	4.95	4.95
Other roots–South	1.00	1.00	1.00	1.00	1.00	1.00
Other roots–West	1.00	1.00	1.00	1.00	1.00	1.00
Other roots–North	5.66	5.66	5.66	5.66	5.66	5.66
Other roots–East	1.00	1.00	1.00	1.00	1.00	1.00

Table A.3 Continued

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Beans–South	1.50	1.50	1.50	1.50	1.50	1.50
Beans–West	1.97	1.97	1.97	1.97	1.97	1.97
Beans–North	1.52	1.52	1.52	1.52	1.52	1.52
Beans–East	1.50	1.50	1.50	1.50	1.50	1.50
Vegetable–South	1.00	1.00	1.00	1.00	1.00	1.00
Vegetable–West	1.82	1.82	1.82	1.82	1.82	1.82
Vegetable–North	2.71	2.71	2.71	2.71	2.71	2.71
Vegetable–East	1.82	1.82	1.82	1.82	1.82	1.82
Banana–South	2.10	2.10	2.10	2.10	2.10	2.10
Banana–West	3.21	3.21	3.21	3.21	3.21	3.21
Banana–North	2.24	2.24	2.24	2.24	2.24	2.24
Banana–East	2.10	2.10	2.10	2.10	2.10	2.10
Fruit–South	1.00	1.00	1.00	1.00	1.00	1.00
Fruit–West	3.69	2.95	3.69	3.69	3.69	3.69
Fruit–North	1.46	1.46	1.46	1.46	1.46	1.46
Fruit–East	1.00	1.00	1.00	1.00	1.00	1.00
Oilseeds–South	2.42	2.42	2.42	2.42	2.42	2.42
Oilseeds–West	2.20	2.20	2.20	2.20	2.20	2.20
Oilseeds–North	2.28	2.28	2.28	2.28	2.28	2.28
Oilseeds–East	2.20	2.20	2.20	2.20	2.20	2.20
Coffee–South	3.50	3.50	11.65	3.50	11.65	11.65
Coffee–West	3.50	3.50	11.31	3.50	11.31	11.31
Coffee–North	3.50	3.50	11.63	3.50	11.63	11.63
Coffee–East	3.50	3.50	11.63	3.50	11.63	11.63
Tea–South	3.50	3.50	13.19	3.50	13.19	13.19
Tea–West	3.50	3.50	13.19	3.50	13.19	13.19
Tea–North	3.50	3.50	13.19	3.50	13.19	13.19
Tea–East	2.00	2.00	13.19	2.00	13.19	13.19
Pyrethrum–South	2.00	2.00	24.85	2.00	24.85	24.85
Pyrethrum–West	2.00	2.00	24.85	2.00	24.85	24.85
Pyrethrum–North	2.00	2.00	24.85	2.00	24.85	24.85
Pyrethrum–East	2.00	2.00	24.85	2.00	24.85	24.85

Table A.3 Continued

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Other export crops–South	2.00	2.00	63.80	2.00	63.80	63.80
Other export crops–West	2.00	2.00	63.80	2.00	63.80	63.80
Other export crops–North	2.00	2.00	63.80	2.00	63.80	63.80
Other export crops–East	2.00	2.00	63.80	2.00	63.80	63.80
Bovine cattle–South	3.00	3.00	3.00	4.50	4.50	4.50
Bovine cattle–West	3.00	3.00	3.00	4.50	4.50	4.50
Bovine cattle–North	3.00	3.00	3.00	4.50	4.50	4.50
Bovine cattle–East	3.00	3.00	3.00	4.50	4.50	4.50
Sheep and goat–South	3.00	3.00	3.00	3.00	3.00	3.00
Sheep and goat–West	3.00	3.00	3.00	3.00	3.00	3.00
Sheep and goat–North	3.00	3.00	3.00	3.00	3.00	3.00
Sheep and goat–East	3.00	3.00	3.00	3.00	3.00	3.00
Swine–South	3.00	3.00	3.00	3.00	3.00	3.00
Swine–West	3.00	3.00	3.00	3.00	3.00	3.00
Swine–North	3.00	3.00	3.00	3.00	3.00	3.00
Swine–East	3.00	3.00	3.00	3.00	3.00	3.00
Poultry–South	3.00	3.00	3.00	7.50	7.50	7.50
Poultry–West	3.00	3.00	3.00	7.50	7.50	7.50
Poultry–North	3.00	3.00	3.00	7.50	7.50	7.50
Poultry–East	3.00	3.00	3.00	7.50	7.50	7.50
Milk–South	6.00	6.00	6.00	15.00	15.00	15.00
Milk–West	6.00	6.00	6.00	15.00	15.00	15.00
Milk–North	6.00	6.00	6.00	15.00	15.00	15.00
Milk–East	6.00	6.00	6.00	15.00	15.00	15.00
Eggs–South	6.00	6.00	6.00	12.00	12.00	12.00
Eggs–West	6.00	6.00	6.00	12.00	12.00	12.00
Eggs–North	6.00	6.00	6.00	12.00	12.00	12.00
Eggs–East	6.00	6.00	6.00	12.00	12.00	12.00
Other livestock–South	3.00	3.00	3.00	3.00	3.00	3.00
Other livestock–West	3.00	3.00	3.00	3.00	3.00	3.00
Other livestock–North	3.00	3.00	3.00	3.00	3.00	3.00
Other livestock–East	3.00	3.00	3.00	3.00	3.00	3.00

Source: Authors' 54-sector dynamic computable general equilibrium model.
Note: Growth rates in 2012/2013 are the same as in base run; growth rates for other scenarios are for 2014–2020.

Table A.4 Assumption of growth rate in total factor productivity at crop/livestock subsector level across regions (%, 2012–2020)

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Wheat–South	4.85	10.67	4.85	4.85	10.67	10.67
Wheat–West	4.85	10.67	4.85	4.85	10.67	10.67
Wheat–North	4.85	10.67	4.85	4.85	10.67	10.67
Wheat–East	0.40	10.67	0.40	0.40	10.67	10.67
Maize–South	3.18	9.05	3.18	3.18	9.05	9.05
Maize–West	3.18	9.05	3.18	3.18	9.05	9.05
Maize–North	3.02	9.05	3.02	3.02	9.05	9.05
Maize–East	3.23	9.27	3.23	3.23	9.27	9.27
Rice–South	0.34	1.86	0.34	0.34	1.86	1.86
Rice–West	0.35	1.94	0.35	0.35	1.94	1.94
Rice–North	0.21	1.13	0.21	0.21	1.13	1.13
Rice–East	0.35	1.94	0.35	0.35	1.94	1.94
Sorghum–South	1.95	1.95	1.95	1.95	1.95	1.95
Sorghum–West	2.92	2.92	2.92	2.92	2.92	2.92
Sorghum–North	2.92	2.92	2.92	2.92	2.92	2.92
Sorghum–East	1.50	1.50	1.50	1.50	1.50	1.50
Potato–South	1.50	5.23	1.50	1.50	5.23	5.23
Potato–West	3.99	5.23	3.99	3.99	5.23	5.23
Potato–North	3.99	5.23	3.99	3.99	5.23	5.23
Potato–East	3.79	5.23	3.79	3.79	5.23	5.23
Sweet potato–South	2.00	2.00	2.00	2.00	2.00	2.00
Sweet potato–West	3.99	3.99	3.99	3.99	3.99	3.99
Sweet potato–North	2.00	2.00	2.00	2.00	2.00	2.00
Sweet potato–East	2.00	2.00	2.00	2.00	2.00	2.00
Cassava–South	1.50	4.06	1.50	1.50	4.06	4.06
Cassava–West	2.45	4.06	2.45	2.45	4.06	4.06
Cassava–North	2.59	4.06	2.59	2.59	4.06	4.06
Cassava–East	2.59	4.06	2.59	2.59	4.06	4.06
Other roots–South	2.72	2.72	2.72	2.72	2.72	2.72
Other roots–West	4.23	4.23	4.23	4.23	4.23	4.23

Table A.4 Continued

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Other roots–North	4.23	4.23	4.23	4.23	4.23	4.23
Other roots–East	4.00	4.00	4.00	4.00	4.00	4.00
Beans–South	2.30	3.95	2.30	2.30	3.95	3.95
Beans–West	3.03	4.74	3.03	3.03	4.74	4.74
Beans–North	2.30	3.95	2.30	2.30	3.95	3.95
Beans–East	2.30	3.95	2.30	2.30	3.95	3.95
Vegetable–South	4.00	4.00	4.00	4.00	4.00	4.00
Vegetable–West	3.98	3.98	3.98	3.98	3.98	3.98
Vegetable–North	3.30	3.30	3.30	3.30	3.30	3.30
Vegetable–East	3.80	3.80	3.80	3.80	3.80	3.80
Banana–South	3.33	3.33	3.33	3.33	3.33	3.33
Banana–West	3.33	3.33	3.33	3.33	3.33	3.33
Banana–North	3.33	3.33	3.33	3.33	3.33	3.33
Banana–East	3.33	3.33	3.33	3.33	3.33	3.33
Fruit–South	3.08	3.08	3.08	3.08	3.08	3.08
Fruit–West	4.35	4.35	4.35	4.35	4.35	4.35
Fruit–North	3.98	3.98	3.98	3.98	3.98	3.98
Fruit–East	3.76	3.76	3.76	3.76	3.76	3.76
Oilseeds–South	4.00	4.00	4.00	4.00	4.00	4.00
Oilseeds–West	3.92	3.92	3.92	3.92	3.92	3.92
Oilseeds–North	4.00	4.00	4.00	4.00	4.00	4.00
Oilseeds–East	4.00	4.00	4.00	4.00	4.00	4.00
Coffee–South	2.00	2.00	7.00	2.00	7.00	7.00
Coffee–West	2.00	2.00	7.00	2.00	7.00	7.00
Coffee–North	2.00	2.00	7.00	2.00	7.00	7.00
Coffee–East	2.00	2.00	7.21	2.00	7.21	7.21
Tea–South	1.20	1.20	6.00	1.20	6.00	6.00
Tea–West	1.20	1.20	6.00	1.20	6.00	6.00
Tea–North	1.20	1.20	6.00	1.20	6.00	6.00
Pyrethrum–South	1.20	1.20	10.36	1.20	10.36	10.36

Table A.4 Continued

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Pyrethrum–West	3.00	3.00	10.36	3.00	10.36	10.36
Pyrethrum–North	3.00	3.00	10.36	3.00	10.36	10.36
Pyrethrum–East	3.00	3.00	10.36	3.00	10.36	10.36
Other export crops–South	3.00	3.00	26.58	3.00	26.58	26.58
Other export crops–West	3.00	3.00	26.58	3.00	26.58	26.58
Other export crops–North	3.00	3.00	26.58	3.00	26.58	26.58
Other export crops–East	3.00	3.00	26.58	3.00	26.58	26.58
Bovine cattle–South	1.22	1.22	1.22	3.66	3.66	3.66
Bovine cattle–West	1.22	1.22	1.22	3.66	3.66	3.66
Bovine cattle–North	1.22	1.22	1.22	3.66	3.66	3.66
Bovine cattle–East	1.22	1.22	1.22	3.66	3.66	3.66
Sheep and goat–South	1.22	1.22	1.22	3.66	3.66	3.66
Sheep and goat–West	1.22	1.22	1.22	3.66	3.66	3.66
Sheep and goat–North	1.22	1.22	1.22	3.66	3.66	3.66
Sheep and goat–East	1.22	1.22	1.22	3.66	3.66	3.66
Swine–South	1.22	1.22	1.22	3.66	3.66	3.66
Swine–West	1.22	1.22	1.22	3.66	3.66	3.66
Swine–North	1.22	1.22	1.22	3.66	3.66	3.66
Swine–East	1.22	1.22	1.22	3.66	3.66	3.66
Poultry–South	1.22	1.22	1.22	3.66	3.66	3.66
Poultry–West	1.22	1.22	1.22	3.66	3.66	3.66
Poultry–North	1.22	1.22	1.22	3.66	3.66	3.66
Poultry–East	1.22	1.22	1.22	3.66	3.66	3.66
Milk–South	1.46	1.46	1.46	4.39	4.39	4.39
Milk–West	1.46	1.46	1.46	4.39	4.39	4.39
Milk–North	1.46	1.46	1.46	4.39	4.39	4.39
Milk–East	1.46	1.46	1.46	4.39	4.39	4.39
Eggs–South	1.46	1.46	1.46	4.39	4.39	4.39
Eggs–West	1.46	1.46	1.46	4.39	4.39	4.39
Eggs–North	1.46	1.46	1.46	4.39	4.39	4.39

Table A.4 Continued

Sector	Base run	Food crop–led	Export crop–led	Livestock-led	All agriculture	Agriculture + non-agriculture
Eggs–East	1.46	1.46	1.46	4.39	4.39	4.39
Other livestock–South	1.46	1.46	1.46	2.93	2.93	2.93
Other livestock–West	1.46	1.46	1.46	2.93	2.93	2.93
Other livestock–North	1.46	1.46	1.46	2.93	2.93	2.93
Other livestock–East	1.46	1.46	1.46	2.93	2.93	2.93
Forestry	0.12	0.12	0.12	0.12	0.12	0.24
Fisheries	0.12	0.12	0.12	0.12	0.12	0.24
Mining	0.70	0.70	0.70	0.70	0.70	1.40
Meat, fish, and dairy products	2.10	2.10	2.10	2.10	2.10	6.30
Processed cereals	1.50	1.50	1.50	1.50	1.50	3.00
Processed coffee	1.20	1.20	5.40	1.20	5.40	5.40
Processed tea	2.25	2.25	5.63	2.25	5.63	5.63
Bakery, processed sugar	1.20	1.20	1.20	1.20	1.20	2.40
Traditional beverages	0.90	0.90	0.90	0.90	0.90	4.50
Modern beverages	0.25	0.25	0.25	0.25	0.25	1.50
Tobacco	0.15	0.15	0.15	0.15	0.15	1.20
Textiles	0.50	0.50	0.50	0.50	0.50	1.50
Wood and paper	0.50	0.50	0.50	0.50	0.50	1.50
Chemicals	1.00	1.00	1.00	1.00	1.00	3.00
Nonmetallic minerals	0.30	0.30	0.30	0.30	0.30	1.20
Furniture and other manufacturing	1.50	1.50	1.50	1.50	1.50	3.75
Electricity, gas, and water	1.00	1.00	1.00	1.00	1.00	3.00
Construction	0.50	0.50	0.50	0.50	0.50	1.00
Retail and wholesale trade	2.10	2.10	2.52	2.10	2.52	3.78
Hotels and catering	4.00	4.00	4.00	4.00	4.00	9.60
Transports	2.80	2.80	3.64	2.80	3.64	5.60
Communication	3.00	3.00	3.90	3.00	3.90	5.40
Finance and insurance	2.00	2.00	2.80	2.00	2.80	4.00
Real estate	2.10	2.10	2.10	2.10	2.10	3.78
Business services	3.00	3.00	3.00	3.00	3.00	5.40
Repair	2.10	2.10	2.10	2.10	2.10	3.78
Public administration	3.00	3.00	3.00	3.00	3.00	6.00
Education	3.00	3.00	3.00	3.00	3.00	5.40
Health	3.00	3.00	3.00	3.00	3.00	5.40
Other services	2.10	2.10	2.10	2.10	2.10	3.78

Source: Authors' 54-sector dynamic computable general equilibrium model.
Note: Growth rates in 2012/2013 are the same as in base run; growth rates for other scenarios are for 2014–2020.

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