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Toward an Understanding of Economic Growth in Africa: A Reinterpretation of the Lewis Model

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Summary. — We develop a model economy that has many of the features of Lewis (1954) but that also includes an in-between sector as described by Lewis (1979). Our model underscores the importance of the following determinants of structural change: (i) productivity growth in the agricultural sector; (ii) productivity growth in the nonagricultural sector and; (iii) the terms of trade. Public investment enhances productivity growth in all sectors but when it is financed by foreign inflows, it also causes a real exchange rate appreciation leading to a contraction in the open modern sector. These results provide a partial explanation for recent patterns of growth in Rwanda and elsewhere in Africa where the nontradables or what we call the in-between sector has expanded more rapidly than the tradable sector. Our results also highlight the dilemma faced by poor countries in dire need of public investment with a very limited tax base.

Key words — dual-economy model, Africa's growth, structural change, Dutch disease, Rwanda

An economy does not divide into a capitalist sector hiring workers for factories and other large units on the one hand, and a small farming sector on the other hand. In between are units of production of all sizes, and in particular a great number of one-to-five-man undertakings in manufacturing, transport and a wide range of services—often nowadays called the informal sector. Some of this activity belongs in the modern sector as we have defined it; i.e., it will expand with economic development; the rest—e.g., some of the handicrafts and some of the services—belong to the traditional sector in that they will contract.

The expansion of small scale activity in the modern sector is an important part of the development process. This is not because it is a temporary resting-place for migrants from the countryside seeking jobs in large scale enterprise. In LDCs, no less than in MDCs (as we shall see in our next section) jobs in large scale urban enterprises are not normally awarded to people who have no connections. It is rather because this sector of the economy is useful in its own right, meeting genuine market needs, and providing a lot of employment in the process.

[—*Arthur Lewis, "The Dual Economy Revisited*]

1. INTRODUCTION

Africa's recent economic growth has sparked a heated debate over its sources and sustainability. Some argue that growth across the continent is fundamentally a result of a mining boom and rising commodity prices (Lipton, 2012). The underlying tone of this message is that when commodity prices collapse, so too will Africa's growth rates. A more fundamental concern is that Africa's recent growth has not been accompanied by adequate structural change (see, among others, the UN Economic Commission for Africa [2014] and the (African Center for Economic Transformation [2014]). What has been seen as poor prospects for industrialization has led some to argue that we need to manage our expectations about Africa's future growth prospects (Rodrik, 2016a).

In this paper, we argue that Africa's recent growth is not well understood. We do know that the growth has not been driven by labor-intensive large-scale manufacturing in the way it was in many developing Asian countries (McMillan, Rodrik, & Verduzco-Gallo, 2014). But we are equally ignorant about the roles that domestic markets and small- and medium-size enterprises have played in Africa's recent growth. In many Asian countries, large declines in the employment share in agriculture were matched by significant increases in the employment share in labor-intensive and export-oriented manufacturing. Instead, the recent and significant decline in the employment share in agriculture in most African countries has been accompanied by a proliferation of small- and medium-size enterprises in manufacturing, transportation, construction, and a wide range of services (McMillan *et al.*, 2014).

Because such enterprises often operate in the informal sector, they are typically viewed as backward and unproductive and as an employer of last resort (La Porta & Shleifer, 2014; Levy, 2008; Loayza & Rigolini, 2011). In fact, there is a tendency by researchers to lump them all together into what Lewis (1954) described as the traditional sector. But as Lewis (1979) clearly points out, such enterprises exhibit a wide range of heterogeneity with many looking more like modern than traditional-sector firms. Further, he says, these "in-between" enterprises play a very important role in the develop-

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ment process meeting genuine market needs and providing sorely needed employment in the process.

This in-between sector has been growing more rapidly in most African countries than large-scale modern manufacturing (McMillan *et al*., 2014). Thus, Africa's growth cannot be explained without considering the contribution of such activities. This represents a challenge because counting activity in this sector is difficult; many of the businesses are unregistered and their owners often do not keep accounts. The practical ramifications of these issues are well illustrated by the recent national account rebasing in Nigeria and Ghana. In Nigeria, officials discovered an additional 89% of value-added that was mostly accounted for by small and informal manufacturing and services. A similar exercise was done in Ghana in 2007 and also revealed an additional 60% of gross domestic product (GDP), again, mainly derived from small businesses.

These businesses often produce the same goods and services as those produced in the formal modern sector albeit of a different quality (Rothenberg *et al*., 2016). Next to the Four Seasons hotel in Tanzania's Serengeti, there are hotels for those on a more modest budget with chairs, beds, food, and drinks all made by local businesses. Meanwhile, practically everything at the Four Seasons is imported (including the customers!) except of course the labor. In a national accounting sense, the productivity of the housekeeper at the Four Seasons will be multiples of the productivity of the housekeeper in the local hotel because the Four Seasons is highly capital intensive and not because the workers are of a different quality nor because they are doing different jobs. There are thousands of local hotels that provide decent jobs whereas there is (so far) only one Four Seasons with a handful of jobs. Thus, as large amounts of labor exit from agriculture, as Filmer and Fox (2014) predict, many of those laborers will end up owning, operating or working for small businesses. The implication is that economic performance across the continent of Africa is likely to be affected by the performance of these small firms.

We already have some evidence pointing to the potential of small firms in the informal sector in Africa. For example, using the 1-2-3 surveys, Grimm, Krüger, and Lay (2011) study the return to capital in SMEs in urban areas in seven West African countries. They find evidence of significant heterogeneity in profitability as well as evidence of underinvestment in seemingly profitable activities by small firms. Randomized controlled trials in several countries across continents also provide some evidence to support the view that there are constrained microenterprises that would grow if they had access to capital (De Mel, Suresh, & Woodruff, 2008; Dodlova, Göbel, Grimm, & Lay, 2015; Fafchamps, McKenzie, Quinna, & Woodruff, 2014; Grimm *et al*., 2011; McKenzie & Woodruff, 2008; McKenzie, 2015]. Perhaps the most relevant to this paper is recent work by Banerjee, Breza, Duflo, and Kinnan (2015) showing the heterogeneous impact of microfinance on borrowers. Specifically, in line with our thinking about the in-between sector, not all small firms have the potential to expand when offered credit. They classify the owners of microenterprises into "gung-ho" and "reluctant" entrepreneurs and show that unlike "reluctant" entrepreneurs, "gung-ho" entrepreneurs benefitted significantly from access to microfinance. Thus, there appears to be a growing body of evidence that supports the idea that whereas some microenterprises belong in the traditional sector as conceptualized by Lewis (1954), many do not.

So, where does this leave us? In our view, the coexistence of "in-between" and large-scale activities within a given sector for producing similar products or services is not a sign of the failure of the development process. Instead, it is an indication of a kind of dualism within the modern sector. When seen this way, it opens our minds to thinking about the development process in a different way. For example, the in-between sector can now be a meaningful part of a growth strategy. As Temple (2005) points out, the central problem policymakers face in developing countries is not simply how to raise growth rates, but rather, which policies will promote *labor-intensive* growth and raise the incomes of the poorest members of society. The in-between sector as conceptualized by Lewis (1979) contributes to this kind of labor-intensive growth.

In this paper, we model an economy that has many of the features of Lewis (1954) but that also includes an in-between sector a la Lewis (1979). We begin with a conceptual framework that includes three sectors—an open modern sector, a closed modern sector including the in-between sector and an agricultural sector. Using this framework, we highlight the importance of structural change in the growth process of developing countries. In a second step, we endogenize structural change and model it as a function of demand-side and supply-side factors to emphasize the interaction between technological progress and structural change.

This analytical work delivers two key results. First, for many African countries where food is primarily locally produced and consumed, productivity growth in the agricultural sector is a pre-condition for structural change. This is not new but it is worth emphasizing given the low levels of agricultural productivity that still prevail in most of Africa. Second, productivity growth in the nonagricultural sector is also a fundamental determinant of structural change. While it is well known that differential productivity growth across sectors is a determinant of structural change, the mechanisms for delivering productivity growth that we focus on in this paper are different and are meant to capture the reality of Africa's economies. In particular, we focus on public investment and the way in which it is financed as a driver of structural change.

We use these results to inform our investigation into the following question: how do Africa's prospects for future growth and structural change depend on public investment that is financed by foreign inflows? We focus on foreign inflows because of the role of foreign inflows in financing public investment and because of public investments role in driving economy-wide productivity growth in low income countries. We perform this analysis using data from Rwanda because Rwanda is characteristic of many of the high-growth countries in Africa whose growth has not been driven by natural resource exports. However, the results are generalizable to a country where foreign inflows come primarily from natural resources. Using a general equilibrium model we simulate two growth scenarios: one based on continued high growth in foreign inflows, and the second based on a substantially lowered growth rate of such inflows.

We find that the composition of economic growth differs significantly depending on the assumptions about foreign inflows. This is because foreign inflows that are used to finance infrastructure investment can also cause real exchange rate appreciation. More investments in infrastructure improve the broad economy's productivity across all sectors, while an appreciation of the real exchange rate makes exortables less competitive. The result is growth that is primarily led by the closed part of the economy in which the in-between sector is dominant. When public investment is less dependent on foreign inflows for financing, the open sector becomes the primary engine of structural change and growth. Although public investment is lower and as a result the productivity growth associated with this investment is lower, because the open sector is significantly more productive than the closed

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sector, growth need not suffer as a result of slow growth in foreign inflows. These results highlight the critical role of public investment in Africa and the way in which it is financed as a determinant of Africa's structural change and economic growth.

We are certainly not the first to come up with our own interpretation of the Lewis (1954) model. And to be clear, in this paper, we do not seek to formalize the Lewis model. Many researchers have done that in a variety of ways; for a recent treatment of alternative micro-foundations of the Lewis model, readers are referred to Wang and Piesse (2013). Instead, we combine insights from Lewis (1954) with Lewis's own reflections on the original model 25 years later (Lewis, 1979) to better conceptualize growth as a development process in modern Africa.

The remainder of this paper is organized as follows. In Section 2 we develop a conceptual framework that highlights the role of structural change in the growth process and then develop a model that endogenizes structural change. In Section 3 we apply this framework to Rwanda to simulate and analyze alternative growth scenarios. Section 4 concludes.

2. A CONCEPTUAL FRAMEWORK AND A MODEL ADAPTED FROM LEWIS

How can we best describe and conceptualize what know about current-day Africa? Recent evidence points to an important kind of dualism within sectors. To this end, we develop a conceptual framework of growth and structural change based on the extent to which goods are tradable in international markets. Among other things, this framework highlights the potential of the in-between sector to play a role in the growth process via structural change. We then endogenize structural change and model it as a function of demand-side and supply-side factors to emphasize the interaction between technological progress and structural change.

(a) *Conceptual framework: adaptation of Lewis' dual economy model*

Our over-arching conceptual framework is based on Rodrik (2014). We modify this framework in the following ways. We define an economy composed of the following three sectors: open nonagricultural (O), closed nonagricultural (C) and agricultural (A) sectors. The open sector is the collection of current formal tradable nonagricultural activities including modern services in addition to modern manufacturers. Like the manufacturing sector in Rodrik (2014), our open sector is highly integrated with the global market—that is, the technology and hence productivity in the open sector is at or close to international standards. Our closed sector includes the in-between economy—micro, small and medium enterprises that are treated as part of the informal economy and the nontradable formal services sectors. In other words, our closed sector produces mainly for domestic markets.

We explicitly model the agricultural sector since it has been an important source of productivity growth in many African countries over the past decade or so. Based on the empirical evidence, the relative productivities of each of the three sectors, $\pi_i = \frac{y_i}{y}$, are defined to obey the following condition:

$$\pi_O > \pi_C > \pi_A$$

We assume that all the three sectors grow as a result of investment in fundamentals, which is different from the original Rodrik (2014) framework in which only the manufacturing and service sectors benefit from such investments. For a more elaborate discussion of this type of growth see Rodrik (2014). Thus, productivity growth in each of our three sectors is defined as follows:

$$\hat{y}_O = \beta(\ln y_O^* - \ln y_O) + \gamma_O(\ln y^*(\Theta) - \ln y) \tag{1}$$

$$\hat{y}_C = \gamma_C(\ln y^*(\Theta) - \ln y) \tag{2}$$

$$\hat{y}_A = \gamma_A(\ln y^*(\Theta) - \ln y) \tag{3}$$

where y denotes economywide output per worker and y_i sector output per worker for $i = O, C, A$ standing for open, closed and agricultural, $\hat{y}_i$ the sector's growth rate in output per worker. y_O^* denotes the global productivity frontier in manufacturing and β is the unconditional convergence coefficient for the country's manufacturing. Θ denotes the economy's broad capabilities including both human capital and institutional quality, and Θ determines the economy's potential (or steady-state) labor productivity, $y^*(\Theta)$, to which labor productivity in each sector converges at the rate γ_i.

Employment shares in the three sectors are given by α_O, α_C, and $(1 - \alpha_O - \alpha_C)$. Thus, total real GDP per worker in this economy is given by:

$$y = \alpha_O y_O + \alpha_C y_C + (1 - \alpha_O - \alpha_C) y_A \tag{4}$$

Totally differentiating (4) and re-arranging terms yields the following equation for labor productivity growth:

$$\hat{y} = \alpha_O \pi_O \beta(\ln y_O^* - \ln y_O) + (\alpha_O \pi_O \gamma_O + \alpha_C \pi_C \gamma_C + \alpha_A \pi_A \gamma_A) \times (\ln y^*(\Theta) - \ln y) + (\pi_O - \pi_A) d\alpha_O + (\pi_C - \pi_A) d\alpha_C \tag{5}$$

In this framework, there are three broad sources of productivity growth defined in Eqn. (5). The first is the productivity growth that arises as a result of unconditional convergence in the open sector (the first term of Eqn. (5)), which Rodrik (2013) and others have shown to hold in the data for manufacturing. This is the first source of productivity growth. The second source of productivity growth is the growth in each sector that arises as a result of investment in fundamentals (the second term of Eqn. (5)). The third source of productivity growth is structural change (the third term in Eqn. (5)). Given that both the open (O) and closed (C) sectors have relative productivity levels higher than in agriculture, increases in employment shares in any of the two sectors increases economywide labor productivity growth (i.e., when $d\alpha_i$ is positive for O and C, and $\sum_i d\alpha_i = 0$).

The analytical framework summarized in Eqn. (5) helps us to better understand the key channels of productivity growth. In particular, this framework highlights the potential for structural change led growth given the dualistic nature of Africa's economies. This framework also underscores the importance of understanding drivers of structural change in order to better understand why Africa's structural change at present differs from East Asia in the past. For example, in an aggregate sense, this framework already points to the role that modern manufacturing has played in the growth process in East Asia. But to understand the deeper determinants of structural change, we need a model that endogenizes structural changes.

(b) *Endogenizing structural change*

Formal models of structural change are typically designed to focus on a few specific aspects of structural change. Among these models, the most representative focus either on demand-side forces or supply-side forces (Herrendorf, Rogerson, & Valentinyi, 2013). In analytical models focusing on the

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demand-side forces, the key assumption is that the demand for food is income inelastic or Engel's Law. Because of Engel's Law, productivity growth releases labor for the industrial sector in both a closed economy setting with neutral technical change and an open economy with global productivity growth. This mechanism plays an important role in e.g., Murphy, Shleifer, and Vishny (1989), Matsuyama (1992, Section 2), Laitner (2000), and Gollin, Parente, and Rogerson (2002). This treatment of agriculture implies that agricultural productivity growth (at least in a closed economy setting) is a key determinant of the timing of industrialization.

Whether agricultural productivity has an important effect on the timing of industrialization depends on the extent to which an economy is open to international trade. In a small open economy model, structural change is led by growth in the industrial sector's productivity, i.e., structural change is supply driven. Supply-side causes of structural change emphasize either differences in productivity or in capital intensity across sectors. It is intuitive that different sectors will grow at different rates owing to different rates of technological progress (Buera & Kaboski, 2009; Ngai & Pissarides, 2007; Sposi, 2015). Moreover, it is quite common for different sectors to have different factor proportions. In this case capital-intensive sectors tend to grow more rapidly if the country's growth path is characterized by capital deepening. In this case, the Rybczynski theorem predicts that growth will be non-balanced (Acemoglu & Guerrieri, 2008). Thus, the supply side mechanisms for structural change are capital deepening and technological progress that differ across sectors leading some sectors to expand (or contract) relative to others.

However, Rodrik (2015) shows that technological progress and hence productivity growth in manufacturing can lead to deindustrialization (declining share of manufacturing labor) when demand for manufacturing goods is inelastic. This finding indicates that while isolating demand-side and supply-side factors can make analytical models more tractable and conceptually more transparent, the actual patterns of structural change in developing countries (also in advanced economies) require models that combine demand-side and supply-side factors.

For this reason, we develop a model that captures both demand-side and supply-side factors in structural change. As will become clear in what follows, our model is consistent with the conceptual framework laid out in the previous section of this paper.

We consider a three-sector model economy corresponding to the three sectors we defined in our conceptual framework. Demand for agricultural goods is income inelastic, while demand for nonagricultural goods is income elastic. To simplify the model, we assume that the closed and open sectors produce a similar nonagricultural good. Thus, we define a nested two-stage utility function; in the first stage the utility function is defined over two consumption goods—agriculture and nonagriculture, and in the second stage, it is defined by a substitution relationship between the nonagricultural goods produced by the open and closed sectors. For tractability, we use the Stone–Geary utility function for the first stage:

$$U(D_A, D_N) = \beta \log(D_A - \gamma) + \log(D_N) \tag{6}$$

where D_A is demand for agricultural goods and D_N for nonagricultural goods; $\gamma > 0$ indicates that the demand for agricultural goods is income inelastic. D_N is produced from the closed and open sectors. For this part of the analysis, we first assume that D_O and D_C are perfectly substitutable, i.e., $D_O + D_C = D_N$. In a second step, we will relax this assumption.

Labor is the only productive factor and its' total supply is fixed at unity. By ignoring the technological differences in producing Y_O and Y_C, the total share of employment in the open and closed nonagricultural sectors is $\alpha = \alpha_O + \alpha_C$, and $0 < \alpha < 1$. Production functions in both agricultural and nonagricultural sectors exhibits diminishing marginal returns to labor and are defined as follows:

$$Y_N = A_N \alpha^{\theta_N} \tag{7}$$

$$Y_A = A_A (1-\alpha)^{\theta_A} \tag{8}$$

where Y_A and Y_N are outputs of agriculture and nonagriculture, A_A and A_N are parameters capturing the productivity of these two sectors, and $0 < \theta_i < 1$ for both sectors. Without loss of generality we assume that $A_N > A_A$ such that the following relationship for average labor productivity holds: $Y_N/\alpha > Y_A/(1-\alpha)$. At the most general level, the consumer's maximizes utility based on the choices between agricultural and nonagricultural goods; this allows us to first focus on the demand-side factors that drive structural change.

Assuming that agriculture is non-tradable and nonagriculture is tradable, and also assuming that x is net exports from the nonagricultural sector (and x can be negative to represent net imports), we have the following goods-market clearing conditions:

$$D_A = Y_A \tag{9}$$

$$D_N + x = Y_N \tag{10}$$

Using (7)–(10) and assuming that labor is fully employed and mobile between the agricultural and nonagricultural sectors, we have

$$A_A (1-\alpha)^{\theta_A} = \gamma + \beta (P_N/P_A)(A_N \alpha^{\theta_N} - x) \tag{11}$$

We first consider $x = 0$ in (11) to simplify the analysis and obtain the following equation:

$$\beta \frac{\theta_A}{\theta_N} \alpha (1-\alpha)^{\theta_A - 1} - (1-\alpha)^{\theta_A} = -\gamma / A_A \tag{12}$$

Totally differentiating (12) and rearranging terms yields:

$$\left\{ \frac{\beta \theta_A}{\theta_N} [(1-\alpha)^{\theta_A - 1} + (1-\theta_A)\alpha(1-\alpha)^{\theta_A - 2}] + \theta_A (1-\alpha)^{\theta_A - 1} \right\} d\alpha = \frac{\gamma}{A_A^2} dA_A \tag{13}$$

where

$$\frac{\beta \theta_A}{\theta_N} [(1-\alpha)^{\theta_A - 1} + (1-\theta_A)\alpha(1-\alpha)^{\theta_A - 2}] + \theta_A (1-\alpha)^{\theta_A - 1} > 0.$$

Eqn. (13) shows that when both the agricultural and nonagricultural sectors are nontradable, structural change is demand driven and is uniquely determined by productivity growth in the agricultural sector, i.e., labor moves into the nonagricultural sector ($d\alpha > 0$) when productivity grows in the agricultural sector ($\hat{A}_A = \frac{dA_A}{A_A} > 0$). This is a common finding in the literature emphasizing the demand-side factors of structural change we cited above.

Now we allow for international trade such that $x \neq 0$, and treat the price of non-agricultural goods P_N as an endogenous variable and x as an exogenous variable (similar to Rodrik (2015)). Thus, Eqn. (13) is redefined as follows:

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$$\beta\frac{\theta_A}{\theta_N}\alpha(1-\alpha)^{\theta_A-1}-\beta\left(\frac{\theta_A(1-\alpha)^{\theta_A-1}\alpha^{1-\theta_N}}{\theta_N A_N}\right)x-(1-\alpha)^{\theta_A}=-\frac{\gamma}{A_A} \tag{14}$$

Totally differentiating (14) and rearranging terms yields:

$$d\alpha=\psi\left(\Gamma\hat{A}_A-Z\hat{A}_N+\frac{\alpha}{Y_N}dx\right) \tag{15}$$

where

$$\psi=\left\{\left[1+\frac{\alpha}{(1-\alpha)}(1-\theta_A)\frac{D_N}{Y_N}-(1-\theta_N)\frac{x}{Y_N}\right]+\frac{\theta_N}{\beta}\right\}^{-1}>0,\ \forall x\neq 0,$$

$$\Gamma=(1-\alpha)\frac{\theta_N}{\beta\theta_A}\frac{\gamma}{Y_A},\ \text{and}\ Z=\alpha\frac{x}{Y_N}$$

Eqn. (15) shows that once the nonagricultural sector becomes tradable and the sector's trade is exogenously determined, both changes in the productivity of the nonagricultural sector and changes in trade flows (x) start to affect structural change in addition to changes in productivity in the agricultural sector. In this case, if $x>0$, i.e., if the country is a net exporter of the nonagricultural good, $d\alpha$ is positive with $\hat{A}_A>0$ and negative with $\hat{A}_N>0$. Furthermore, the nonagricultural sector expands (i.e., α increases) with increases in trade surpluses (x). However, if $x<0$, i.e., if the country is a net importer of the nonagricultural good, $d\alpha$ is positive with both $\hat{A}_A>0$ and $\hat{A}_N>0$, but the nonagricultural sector shrinks with increases in imports.

We now introduce the consumers' choice between goods produced in the open and closed parts of the nonagricultural sector. We define D_N as a composite good over D_O and D_C:

$$D_N=(\mu D_O^{\rho}+(1-\mu)D_C^{\rho})^{1/\rho} \tag{16}$$

where the parameter μ reflects the relative importance of the similar goods produced by the open and closed sectors in consumer demand and the parameter ρ determines the elasticity of substitution between the good produced by the open and closed sectors. The production functions are now defined for Y_O and Y_C separately to allow for technologies to differ across these two sectors. [1]

$$Y_O=A_O\alpha_O^{\theta_O} \tag{17}$$

$$Y_C=A_C\alpha_C^{\theta_C} \tag{18}$$

To simplify the model, we further assume that the closed sector is non-tradable, while the open sector is tradable.

We represent the demand side in rates of change form, with a "hat" above a variable denoting proportional changes:

$$\hat{D}_O-\hat{D}_C=-\varepsilon(\hat{P}_O-\hat{P}_C) \tag{19}$$

where $\varepsilon=\frac{1}{1-\rho}$ is the elasticity of substitution in consumption between the closed and open goods, and ρ is the parameter in (16). The two goods-market clearing equations for the closed and open sectors are:

$$D_C=Y_C \tag{20}$$

$$D_O+x=Y_O \tag{21}$$

Similar to Eqn. (14) we assume that prices are determined endogenously and net trade flows are exogenous. The Comparative statics for the employment share of the open sector delivers the following:

$$d\alpha_O=\Psi\left[\left(\frac{\varepsilon-\lambda}{\varepsilon}\right)\hat{A}_O-\left(\frac{\varepsilon-1}{\varepsilon}\right)\hat{A}_C+\frac{1}{\varepsilon}\frac{dx}{D_O}\right] \tag{22}$$

where

$$\Psi=\left[\frac{1}{\alpha_O}(1-\theta_O)+\frac{1}{\alpha-\alpha_O}(1-\theta_C)+\frac{1}{\varepsilon}\left(\frac{\lambda}{\alpha_O}\theta_O+\frac{1}{\alpha-\alpha_O}\theta_C\right)\right]^{-1}>0$$

$$\lambda=\frac{Y_O}{D_O},$$

and $=\alpha_O+\alpha_C$.

Like Rodrik (2015), a lower trade surplus in the open sector ($dx<0$) results in a smaller employment share in the open sector and a larger employment share in the closed sector ($d\alpha_O<0$). Note that a reduction in the trade surplus is formally analogous to an adverse demand shock for the open sector, which causes a secular shift in demand toward the closed sector's goods. In this case, the open sector shrinks.

Again, similar to Rodrik (2015), the relationship between technological progress ($\hat{A}_O$ and $\hat{A}_C$) and α_O depends critically on the size of the elasticity of substitution in demand between open and closed goods. However, recall that in the utility function, demand for the nonagricultural good is elastic in a developing economy. Thus, it is reasonable to assume that demand for both the closed and open nonagricultural goods is also elastic, i.e., $\varepsilon>1$. In this case, α_O (the share of employment in the open nonagricultural sector) is increasing in technological progress in the open sector ($\hat{A}_O$) and decreasing in technological progress in the closed sector ($\hat{A}_C$) as long as the trade surplus is less than the domestic demand for the open good. This is also the same as the finding in Ngai and Pissarides (2007).

Rodrik (2015) also considers a small open economy case using the same model. This consideration is important for us since most African countries are price takers in world markets. In this case, x is endogenous and P_O is a parameter. In this case, the comparative statics for the employment share of the open sector yields:

$$d\alpha_O=\left[\frac{1}{\alpha_O}(1-\theta_O)+\frac{1}{\alpha-\alpha_O}(1-\theta_C)\right]^{-1}[\hat{P}_O+\hat{A}_O-\hat{A}_C]. \tag{23}$$

The impact of technological change on the employment share of the open sector is similar as in (22) but it does not depend on the elasticity in this case. That is, for a small open economy, trade has the effect of de-linking the supply side of the economy from the demand side (Rodrik, 2015). The additional comparative statics effect on α_O in this small open economy is that an increase in the relative price of goods in the open sector works just like technological progress in the open sector. This relative price effect as a driving force in shaping the patterns of structural change is important for many African countries and will be explicitly modeled in the next section when a CGE model is applied to a country case assessment.

(c) *Summary*

The dual nature of Africa's economies implies significant differences in labor productivity across sectors. The

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implication of these sectoral differences in productivity is that structural changes that reallocate labor from less to more productive sectors can be a potent source of growth in African economies. We outline this mechanism explicitly in our conceptual framework. This framework makes it clear that a deeper understanding of economic growth in Africa demands a better understanding of the drivers of structural change. To this end, in the second part of this section, we present a model that endogenizes structural change. Our analytical work reveals two key findings. First, for many African countries where food is primarily locally produced and consumed, productivity growth in the agricultural sector is a pre-condition for structural change. This is not new but it is worth emphasizing given the low levels of agricultural productivity that still prevail in most of Africa. Second, productivity growth in the nonagricultural sector is also a fundamental determinant of structural change. While it is well known that differential productivity growth across sectors is a determinant of structural change, the mechanisms for delivering productivity growth that we focus on in this paper are different and are meant to capture the reality of Africa's economies. We have shown that when the nonagricultural economy is divided into its' open and closed components, structural change may be led either by exports or by domestic demand.

3. TAKING THE FRAMEWORK TO THE DATA

In this section of the paper, we calibrate a CGE model of Rwanda using the insights developed about African economies in Section 2. In particular, we use the CGE to assess the combined effects of investments in fundamentals financed by foreign grants, and changes in the real exchange rate on the closed and open modern economies and in turn their respective roles in shaping the country's patterns of growth and structural change. While the bare bones of this CGE model are contained in the simple general equilibrium (GE) model presented in Section 2, the CGE model is further tailored to reflect the actual economy of Rwanda. We choose Rwanda because Rwanda has been one of the fastest growing countries in Africa over the past decade and a half. While Rwanda is not heavily dependent on resource-based commodity exports, it has been dependent on foreign aid for financing public investments.

(a) *Rwanda's recent economic performance*

During 1999–2014, Rwanda's annual GDP growth was 7.7%, and its' annual growth in GDP per capita was 5%—both historical highs. Relative to other countries in Africa, Rwanda has the highest population density in Africa at 416 persons per square kilometer (in 2012). The country is poor in natural resources and heavily reliant on rainfed agriculture, and landlocked. This makes Rwanda's recent achievements even more impressive. Rwanda's performance is widely believed to have been significantly bolstered by its government's commitment to policy and institutional reform and investment in infrastructure, agriculture, education, and health. According to the World Bank's *Doing Business 2014,* Rwanda ranks 32nd in the ease-of-doing-business ranking worldwide and ranks second in Africa after South Africa. Rwanda is also considered to be the second-most-reformed economy in the world over the last five years, as well as being the first in the East African Community by this measure (World Bank, 2013).

Rwanda's growth has also been broad-based, leading to rapid reductions in poverty without increasing inequality. Based on the *Integrated Household Living Conditions Surveys 2* and *3* (or EICV2 and EICV3) (Rwanda, National Institute of Statistics, 2007, 2012), the national poverty rate has been lowered by 12 percentage points between 2005–06 and 2010–11. Between 2005–06 and 2010–11, per capita real income increased by almost 40% for the poorest 20% of households, more than 20% for the second and third quintiles of households, slightly less than 20% for the fourth quintile of households, and much lower for the richest top 20% of households.

While Rwanda's recent growth is encouraging, the country still faces a number of important challenges. When we look further into the role of structural change in recent growth, we see that the nontradable sectors seem to lead recent growth in the economy. For example, five subsectors of the economy have a growth rate 50% greater than overall GDP growth during 1999–2012, and all of those sectors are more or less nontradable (Table 3.1).

The nontradable sectors' growth, particularly growth in construction and education, is often the result of public investment. During 2006–12, the annual average growth rate in investment reached 15%, and 77% of that investment has been in construction. Part of the construction boom is due to heavy investment in infrastructure by the public sector, which benefits the broad economy across all sectors.

The data during 2007–11 show that public investment as a share of total capital formation was 51% in 2007 and rose to 64% in 2011. The government of Rwanda has increased its' tax revenue in recent years, while spending under the government current (noncapital) expenditure account is still more than its tax revenue. Thus, public investment still has to be heavily financed through external sources. Over the 2000–11 period, foreign grants received by the government grew at 8% per year, and such growth has accelerated to 20% per year in 2006–11. In total, foreign inflows through non-private channels are equivalent to 70–96% of total capital formation during 2007–11.

In the development literature, until recently, cross-country growth regressions consistently show a negative relationship between foreign inflows and long-term growth (Rajan & Subramanian, 2011). Rodrik (2008) argues that the overvalued exchange rate, as a result of foreign inflows, is a fundamental reason for this inverse relationship between foreign aid and growth.

In the case of Rwanda, foreign inflows—measured as the share of the deficit in the current account—have grown at more than 15% annually, and such growth further accelerated after the debt relief in 2006 with the average annual growth rate reaching 28% for the 2006–11 period. The ratio of the trade deficit to GDP increased from 14% in 2006 to 22% in 2012 (National Account, MINECOFIN, 2013).

While foreign inflows help finance Rwanda's public investment, benefiting the broad economy across sectors, they can also cause the real exchange rate to appreciate, negatively affecting growth in the tradable sectors. However, as demonstrated in the analytical model of Section 2, the overvalued real exchange rate that hurts the tradable sectors can actually help the nontradable sector grow.

Summarizing, Rwanda's recent patterns of growth and structural change combined with the fact that small enterprises dominate the nonagricultural economy make it an ideal case in which to explore the implications of foreign-financed public investment and changes in the real exchange rate on the structure of economic growth. To do this, we modify the dynamic CGE model and the social accounting matrix (SAM) of Rwanda developed by Diao, Bahiigwa, and Pradesha (2014) to incorporate the characteristics of an African economy that

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Table 3.1. *The five fastest-growth sectors in the Rwandan economy (1999–2012)*

	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 and 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, MINECOFIN (2013).
Note: GDP = gross domestic product.

we argued are critical to understanding Africa's recent growth in Section 2. Namely, the CGE disaggregates many economic sectors in agriculture, industry and services into open and closed sub-sectors, such that the economy can be classified into two sub-components: an open economy and a closed economy. Rather than laying out all of the assumptions embedded in the CGE model, we delegate most of them to Appendix A, and only introduce the assumed relationship between public investment and changes in real exchange rate and sectoral productivity growth in the sub-section below. This explanation is intended to help readers understand the dynamics of the model and the results of the simulations.

(b) *Public investment, real exchange rate, and productivity in the CGE model*

As demonstrated by the comparative statics of the simple GE model in Section 2, productivity growth is a key driving force behind the structural change. Many factors can lead productivity growth in either a closed- or an open-economy setting. For example, Gollin and Rogerson (2014) develop a closed-economy model with three geographic locations: (1) cities, (2) rural areas relatively close to cities, and (3) remote rural areas. They find that improvements in transportation infrastructure (which is a typical public investment) have a significant effect on the population living in remote rural areas by making it easier for them to move from subsistence agriculture into manufacturing; the share of workers living in close-by rural locations remains virtually unchanged.

In our model, we explicitly include a public sector to conduct infrastructure investment, in addition to other functions of a typical government does in a CGE model. To be able to explicitly model the link between productivity growth and foreign inflows, we assume that productivity growth is primarily an outcome of public investment in fundamentals (infrastructures, education, and so forth) and public investment is mainly financed by foreign grants. We set the elasticity of TFP growth to public investment equal to 0.28; this was calculated using data from Rwanda on public spending and productivity growth for the past 15 years (Diao *et al.*, 2014).

Foreign inflows can also affect the productivity growth through its effect on the real exchange rate, which is based on previous work in the literature (see, for example, Rodrik [2008] and Johnson, Ostry, and Subramanian [2007]). In the CGE model, we take into account the effect of the real exchange rate on productivity growth only for the tradable sectors in the open economy.[2] Following the above literature, in the model if the real exchange rate depreciates or appreciates, we assume that the productivity growth rate in the open economy's tradable sector is to increase or decrease. Based on the literature, an elasticity of 0.72 is chosen for the relationship between changes in the real exchange rate and productivity growth.[3] For example, if the real exchange rate depreciates by 10%, it affects the TFP growth rate for the tradable sectors in the open economy through the coefficient associated with the public investment variable. Assuming that the initial TFP growth rate is 2.50%, the 10% depreciation in the real exchange rate results in an increase in the TFP growth rate to 2.68% (i.e., 2.5×1.071, since the $REX_t^{0.72}$ changes from $1.0^{0.72} = 1$ to $1.1^{0.71} = 1$), while for the nontradable sectors in the closed economy, the productivity growth rate remains at 2.50%—this is because it is solely determined by public investment. In other words, we assume that the real exchange rate does not directly affect productivity growth in the closed part of the economy.

On the other hand, when the real exchange rate appreciates, the TFP growth rate in the open economy's tradable sectors is negatively affected. For example, if the real exchange rate appreciates by 10%, the TFP growth rate falls from 2.50% to 2.32% in the open economy's tradable sectors (i.e., 2.5×0.927, since the $REX_t^{0.72} = 0.90^{0.72} = 0.927$), and remains at 2.50% for all other sectors. The mathematical presentation of the relationships between changes in the real exchange rate, public investment and growth in the tradable sectors' productivity can be found in Appendix Eqns. (20a)–(20b). These equations are akin to Eqn. (5) of Section 2 and are particularly relevant to Eqn. (5)'s coefficients of γ_i and β.

(c) *Growth scenarios*

We consider two scenarios based on different assumptions about the growth in foreign inflows for the period 2013–25. These two scenarios are developed to help us understand patterns of growth and structural change in Rwanda using a CGE model consistent with the analytical framework we describe in Section 2. We focus specifically on the role of foreign grants in shaping the patterns of growth and structural change in the simulations. This is because at this stage in Rwanda's development, tax revenues are insufficient to cover Rwanda's public investment plans. That is expected to change in the medium to long run, but since we are concerned with the near future, we ignore them in our simulations. The multiple driving forces behind structural change analyzed in Section 2 can all be linked to these foreign inflows in the CGE model. Doing this helps us to understand some of the mechanisms driving structural change in a developing country like Rwanda.

In the first scenario, foreign grants received by the government are assumed to grow continuously at 15% per year, a growth rate similar to that seen in recent years; we call this scenario the "more-foreign-grant-dependent" scenario. In the second scenario, the growth rate in foreign grant inflows falls to 6.5% per year, and the ratio of foreign inflows to GDP falls over time. We call this the "less-foreign-grant-dependent" scenario. In both scenarios, the elasticities of TFP growth with respect to growth in public investment and changes in the real

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exchange rate are the same. Thus, there are two channels in the model through which foreign inflows influence the growth rate. First, increased foreign grants facilitate economic growth by financing additional public investment that leads to higher productivity growth in both closed and open sectors. Second, foreign inflows can negatively affect the open economy's productivity growth if they lead to the appreciation of the real exchange rate. On net, the impact of foreign inflows on growth depends on which force dominates.

Table 3.2 shows the results of the simulations. One can see that, based on the parameters used in the model and the current economic structure calibrated from the data, the impact of different increases in foreign grant inflows on overall GDP growth is rather modest, that is, the difference between the two scenarios' GDP growth rates is less than 0.1 percentage point, while the difference in the assumed foreign grant inflow growth rates is considerable; the growth rate of foreign inflows in scenario one is 2.5 times that in scenario two. Put differently, the positive and negative effects of foreign grant inflows through the two main channels discussed above on economywide growth seem to balance each other out.[4]

By contrast, the way in which public investment is financed has a significant impact on the composition of economic growth. At the sector level, higher growth in foreign inflows benefits industrial growth as a whole but not manufacturing in the open economy. Growth in the closed economy benefits from increased foreign grant inflows, while growth in the open economy falls by 0.7 percentage points per year with more foreign inflows. The benefit of increased foreign inflows to growth in the closed economy goes only to its nonagricultural sector, whose growth rate is 0.34 percentage points higher when the rate of growth in inflows is high. That is to say, with high foreign inflows and for the economy as a whole, growth of the closed economy is more important than the growth of the open economy. For the open economy as a whole, nonmanufacturing growth is more important than manufacturing growth when the level of foreign inflows is high—leading to an appreciation in the real exchange rate.

While the overvalued real exchange rate lowers prices for imported intermediates, which benefits the sectors that use such inputs more intensively, lower output prices mitigate such benefits to the tradables sector. As expected, the simulation results show that the sectors hurt the most by increased foreign inflows are the tradables in the open economy, particularly the exportables, as their annual growth rate falls by almost 4 percentage points when the foreign inflow growth rate is high (Table 3.2).

These findings are not surprising and are consistent with the Dutch Disease literature (see, for examples, Adam & Bevan, 2004; Adenauer & Vagassky, 1998; Amuedo-Dorantes & Pozo, 2004; Buiter & Purvis, 1983; Corden & Neary, 1982; Davis, 1995; Devarajan et al. 1997; Djankov, Montalvo, & Reynal-Querol, 2008; Matsuyama, 1992; Rajan & Subramanian, 2011; Usui, 1996; Younger, 1992). In our model by design, increased foreign inflows finance growth in public investment, leading to construction booming. Without considering intermediate input demand, construction sector increases the employment of labor and capital during booming, and such productive factors have to be released from other sectors. This "resource movement effect" seems to be understandable for the tradable sectors, and it leads to lower exports and increased imports when tradable sectors cut domestic production. For the nontradables, the excess demand leads a real exchange rate appreciation, i.e., the prices for the nontradables rise.

Without additional intermediate demand of construction booming on the other nontradables, the real exchange rate appreciation restores the equilibrium without increasing (more likely decreasing) the production of the nontradables other than construction while lowering the tradable production. However, the construction sector employs not only productive factors but also intermediate inputs produced by both closed and open economy. Such excess intermediate demand coming from the construction booming not only puts more pressures on the real exchange rate to appreciate, but also leads to the expansion of non-tradable production through the "spending effect" identified in Corden and Neary (1982). This, together with Engel's Law, also explains why the benefit of increased foreign inflows to growth in the closed economy goes only to its nonagricultural sectors. This is because few agricultural goods are intermediate goods in construction and demand for the agricultural good is income inelastic.

Different from most Dutch Disease literature, there is also a "productivity" effect of foreign inflows in our model when the foreign inflows are used to finance infrastructure investment. While in many African countries in the past, there are several examples about the misusage of foreign aid, the recent noteworthy infrastructure investments by the governments of Ethiopia, Rwanda, and many other African countries have been recognized as potential engines for productivity improvement (see for example Rodrik, 2016b). It is very important to capture this mechanism in our model. To better understand this mechanism or 'productivity effect', we present the relevant dynamic factors that lead to these growth outcomes in

Table 3.2. *Growth results of the model, average annual growth rate (2013–25)*

	More dependent on foreign grants	Less dependent on foreign grants
GDP	6.68	6.60
Agriculture	5.09	5.28
Industry	7.92	7.77
Manufacturing	5.67	7.22
Services	6.55	6.86
GDP, closed economy	6.61	6.50
Non-agriculture	7.92	7.59
GDP, open economy	5.98	6.69
Exportable	4.15	8.05
Importable	4.53	6.38

Source: The dynamic CGE model of Rwanda.
Note: GDP = gross domestic product. In the more-dependent-on-foreign-grants scenario, the foreign grant annual growth rate is 15%, while in the less-dependent-on-foreign-grants scenario, the growth rate is 6.5%.

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Table 3.3. *The dynamic factors that lead to the simulation results*

	More dependent on foreign grants	Less dependent on foreign grants
Annual growth rate		
Investment in real terms	10.09	8.40
Capital accumulation, open economy	4.58	4.49
Capital accumulation, closed economy	2.84	4.37

	2013, base-year	2025, the model results	
		More dependent on foreign grants	Less dependent on foreign grants
TFP growth rate led by public investment	2.55	3.68	3.42
Level of real exchange rate	1.00	1.65	0.86
Effect of real exchange rate on TFP growth rate	1.00	0.72	1.11
TFP growth rate applied to the tradable sector of the open economy	2.50	2.65	3.79

Source: The dynamic CGE model of Rwanda.
Note: TFP = total factor productivity. Real investment includes government investment, while capital accumulation is only for the private sector, that is, the capital employed in the production function.

Table 3.3. As Table 3.3 shows, increased foreign grant inflows lead to faster growth in investment. Private capital accumulation is thus stimulated in the open economy. A less straightforward outcome is that the private capital accumulation actually slows down in the closed economy; this is a result of higher relative returns to capital investment in the open economy. In other words, more private investment takes place in the open economy when foreign inflows grow more rapidly, thus slowing down the growth rate of capital accumulation in the closed economy.

The most important dynamic factor that leads to the different growth outcomes displayed in Table 3.3 seems to be the differences in productivity growth that are an outcome of increased public investment and changes in the real exchange rate. These different productivity effects are presented in the second panel of Table 3.3. As expected, when more foreign inflows lead to more public investment, it results in higher TFP growth rates associated with public investment in both closed and open economies. However, more foreign inflows also lead to real exchange rate appreciation. Compared with the second scenario in which the real exchange rate depreciates by 16% by 2025, the real exchange rate appreciates by 40% in the first scenario by 2025. Thus, in the first scenario, an overvalued real exchange rate lowers TFP growth, whereas in the second scenario real exchange rate depreciation augments TFP growth rates in the tradable sector. The joint effect of the real exchange rate appreciation (negative) and increased public investment (positive) lowers the productivity growth rate in the tradable sector of the open economy in scenario one. This explains the lower GDP growth rate already presented in Table 3.2.

The TFP and labor productivity growth outcomes at the sector level and for the closed and open economies as whole are presented in Table 3.4. Unlike the results presented in Table 3.3 (which are the one-to-one relationships between growth in the productivity parameters across sectors and growth in public investment and changes in the real exchange rate [endogenous] at a given elasticity), the aggregated growth rates for TFP and labor productivity presented in Table 3.4 are calculated from the general equilibrium results of the model. In calculating such TFP, we assume a Cobb-Douglas production function for the aggregated output (real GDP) and calculate TFP as the difference between such output and factor inputs with their share parameters determined by the Cobb-Douglas function (i.e., the Solow residual in the function is used as a measure of TFP). In calculating labor productivity, we simply divide GDP at constant prices by the quantity of labor.

The TFP growth results in Table 3.4 are more or less consistent in the direction with the GDP growth results across the aggregated sectors and between the closed and open economies presented in Table 3.2. However, the labor productivity results differ from the results for GDP especially for the closed economy. For example, GDP growth in the aggregated nonagricultural sector of the closed economy benefits from more foreign inflows in the first scenario. But labor productivity growth in the closed economy's nonagricultural sector is actually slightly lower in the first scenario than in the second scenario. The reason is that more unskilled labor is hired by the nonagricultural sector in the closed economy when there are more foreign inflows, and some of these sectors have labor productivity lower than the tradable sectors in the open economy.

This result is consistent with what we observe in recent years in many African countries, that is, the informal sector has become a dominant source of nonagricultural job creation. For example, Rodrik (2016a) shows that informality dominates African manufacturing. When more labor is hired by the informal sectors of the closed economy—which is typically very labor intensive—labor productivity falls as a result of increased hiring (at a given level of capital). Thus, there seems to exist a trade-off for the in-between sector between its contribution to economywide growth and growth in its overall sectoral labor productivity.

We have explained the mechanism behind the impact of foreign inflows on structural change, and we now further discuss its results using GDP shares of the closed and open economies displayed in Figures 3.1 and 3.2 for the two alternative scenarios. The initial output shares for the three subcomponents of the economy are roughly the same, with the share for the open economy being the highest at about 35% of GDP initially.

When economic growth is more dependent on foreign inflows, the share of the nonagricultural sector in the closed economy rises and the share for the open economy falls (Figure 3.1). On the other hand, when growth is less dependent on foreign inflows, the GDP share of the open economy rises over time and the GDP share for the closed economy falls; the GDP share of agriculture as a whole falls in both scenarios driven by the Engel's Law effect. Also with less dependency on foreign inflows, the magnitude of structural change (both in terms of the rising share of GDP for the open economy and the declining share of GDP for the closed economy) is much larger than in the first scenario.

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Table 3.4. *Productivity results from the model (average annual growth rate, 2013–25)*

	More dependent on foreign grants	Less dependent on foreign grants
TFP		
GDP total	2.87	3.01
GDP, open economy	2.51	3.11
GDP, closed economy	3.38	3.17
Agricultural GDP	3.02	2.92
Nonagricultural GDP	3.60	3.27
Labor productivity (GDP per worker)		
GDP total	3.74	3.90
GDP, open economy	2.99	3.52
GDP, closed economy	3.96	3.87
Agricultural GDP	3.05	3.14
Nonagricultural GDP	3.00	3.02

Source: The dynamic CGE model of Rwanda.
Note: Total factor productivity (TFP) is calculated by assuming a Cobb–Douglas production function for gross domestic product (GDP) or sector GDP, which is the model result, and is different from the TFP parameter applied to the model and discussed in the previous table. Also, TFP and labor productivity growth rate rises (or falls) over time in the model, and we report only the annual average in this table.

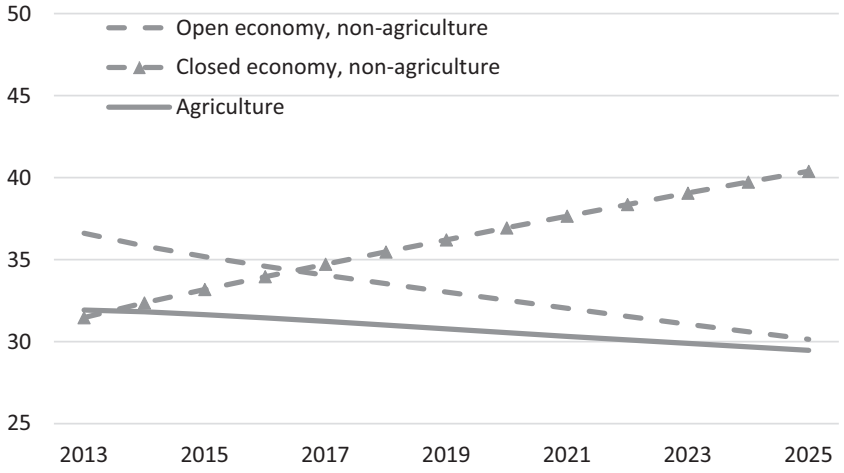

Figure 3.1. *Share of three sectors in GDP under more-foreign-grant-dependent scenario (%). Note: Shares are measured in current prices and total gross domestic product (GDP) is 100. Source: The dynamic CGE model of Rwanda.*

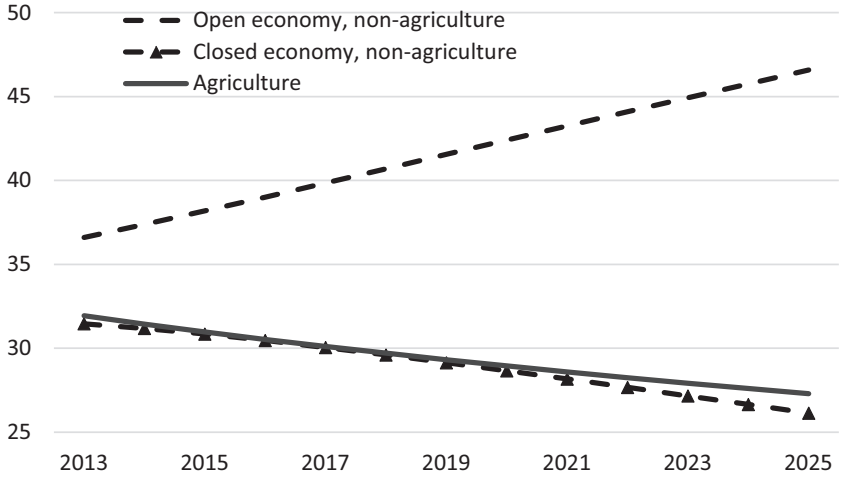

Figure 3.2. *Share of three sectors in GDP under less-foreign-grant-dependent scenario (%). Note: Shares are measured in current prices and total gross domestic product (GDP) is 100. Source: The dynamic CGE model of Rwanda.*

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4. CONCLUSION

In this paper we argue that Africa's recent and rapid growth is characterized by a unique set of circumstances. Unlike in Asia, where export-oriented manufacturing led structural transformation, growth in Africa has been dominated by growth in the sectors that largely serve domestic markets. Our view is that the features of Africa's recent growth call for a new way of thinking about growth in Africa, or a reinterpretation of the Lewis model.

To this end, we have developed a model economy that has many of the features of Lewis (1954) but that also includes an in-between sector as described by Lewis (1979). We begin with a conceptual framework that includes three sectors—an open modern sector, a closed modern sector including the in-between sector and an agricultural sector. We have used this framework to show that structural change and hence economic growth can occur as a result of increased employment in either the closed part of the economy or the open part of the economy or both. This is because productivity in these sectors is still greater than productivity in agriculture.

To understand the deeper determinants of structural change in Africa, we develop a simple structural model that incorporates both demand-side and supply-side determinants of structural change and that emphasizes the interaction between technological process and structural change. This analytic work underscores the importance of the following determinants of structural change in the African context: (i) productivity growth in the agricultural sector; (ii) productivity growth in the nonagricultural sector and; (iii) the terms of trade. Using these insights, we simulate future growth scenarios for Rwanda emphasizing the importance of the interactions between public investment and foreign inflows in shaping patterns of structural change and hence the composition of growth.

We find that the composition of economic growth in Rwanda differs significantly depending on the assumptions about the relationship between public investment and foreign inflows. Foreign inflows that are used to finance infrastructure investment may enhance productivity but they can also cause real exchange rate appreciation making exportables less competitive. Thus, the more dependent the economy is on foreign inflows to finance public investment, the more likely it is that structural change and growth will be led by the closed part of the economy in which the in-between sector is dominant. This seems to be what we have observed not only in Rwanda but also in many African countries recently. When growth is less dependent on public investment financed by foreign inflows, the open sector becomes the primary engine of structural change and growth. The economywide growth rate in this scenario is similar as in the first scenario because the reduction in the growth of public investment and foreign inflows which leads to a contraction of the closed modern sector is offset by an expansion of the relatively more productive open modern sector. These results provide a partial explanation for recent patterns of growth across Africa and highlight the critical role of public investment and the way it is financed as a determinant of structural change and economic growth. Our results also highlight the dilemma faced by poor countries in dire need of public investment with a very limited tax base.

NOTES

1. The combination of Eqns. (6) and (16) is similar as the utility function in Matsuyama (2009). However, it seems unlikely to derive an equilibrium solution analytically from this utility as Matsuyama does when this utility function is combined with the three production functions defined in our model, instead only two in Matsuyama (2009). Our strategy to define the utility in two stages makes our model tractable.

2. The real exchange rate is measured as the ratio of an international price index over the domestic producer price index, which is endogenous in the model.

3. The estimation of a causal relationship between changes in the real exchange rate and growth in productivity is a challenge that few researchers have tackled. The direct effect of the real exchange rate on economywide labor productivity is 0.54–0.67 for China using data for the period 1986–2007 in Guillaumont Jeanneney and Hua (2011), and the real exchange rate—TFP elasticity is 0.43–0.76 in pooled data for the EU12 in Berka, Devereux, and Engel (2014). The elasticity between an index of undervaluation of real exchange rate and growth in GDP per capita for all countries case is 0.017–0.086 in Rodrik (2008). The number of 0.72 is thus only a guesstimate in the case of Rwanda in our CGE model simulation. Since we assume that changes in the real exchange rate affect TFP in tradable sectors only, and tradable sectors account for about 40% of the economy in Rwanda as measured by GDP (see Appendix Table B1), we chose an elasticity with a relatively high value according to the literature we cite.

4. We should emphasize that the magnitude of the trade-off effect of foreign inflows through public investment and real exchange rate on overall growth is an empirical question. We did not purposely target such a similar growth result in total GDP when the levels of foreign inflows differ considerably. Moreover, when the foreign grant finances the public sector's recurrent spending, the reduction in foreign aid could lead to a fall in GDP intra-temporally, as the government needs to cut spending, leading the service sector to suffer. In our CGE model, and similar as in most other general equilibrium models, there is no maximization behavior for the government, e.g., the government does not choose the optimal level of its' total spending. Thus, one has to choose one of the government's spending variables exogenously and the remaining variables to be determined endogenously. Since our paper focuses on the impact of public investment (financed through foreign grants) on growth, we have to let the government recurrent spending be exogenously fixed, such that the government investment expenditure can be endogenously affected by the changes in foreign grant.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.worlddev.2016.12.008.