3

Sustaining Growth in the Long Term

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The question of how to achieve rapid and sustained growth has challenged economists for generations. As Robert Lucas (1988) has famously remarked, "the consequences for human welfare involved in questions like these are staggering: once one starts to think about them, it is hard to think about anything else." The potential contribution of economic growth to well-being has been demonstrated by the achievements of various East Asian countries over recent decades. At the same time, it is patent that not all countries have been able to replicate these successes, with economic performance in sub-Saharan African countries being of particular concern. The World Bank, for example, remarks that global poverty is increasingly coming to assume an African face owing to the "slow and erratic" rates of economic growth across the continent over the last thirty years (Ndulu, 2007). Thus, although experiences of individual countries have been diverse, the importance of understanding what may be required to promote robust economic growth in Africa cannot be overstated.

After achieving independence from Portugal in 1975, Mozambique rapidly became embroiled in a prolonged and complex civil war. The conflict period was marked by severe economic decline. This was accompanied by substantial internal dislocation and structural changes in the economy related to attempts at achieving socialist control (until 1985), followed by gradual market liberalization (from 1985 onward). Following the attainment of peace in 1992, which was confirmed by democratic elections in 1994, Mozambique has witnessed rapid economic growth and poverty

reduction. Aggregate real income grew at an average annual rate of 7.7 percent from 1993 to 2005 with improvements evident across a wide range of development indicators. (See Chapters 1 and 2 for further discussion; see also Mozambique Ministry of Planning and Development, 2006b.)

Despite these impressive achievements, the long-term nature of the development challenge cannot be ignored. The country ranks 168 out of 177 countries in terms of overall human development; the poverty headcount remains above 50 percent; and average life expectancy—about 42 years[1]—is among the lowest in the world. The Mozambican authorities recognize the central importance of economic growth, considering it to be a necessary condition for both poverty reduction and the achievement of broader development targets such as those incorporated in the United Nations Millennium Development Goals (MDGs). Rough estimates, however, indicate the extent of the future growth challenge. If Mozambique were to maintain real per capita growth of 6 percent per year, a higher rate than has been achieved by China during recent decades, it would take almost 40 years for it to attain South Africa's 2003 per capita income of US$10,346.[2]

Despite the central role accorded to output growth, there is no consensus as to how it can be increased or sustained over the long run (Easterly, 2007). This is clear from the continued controversy over the determinants of rapid growth in the newly industrialized economies (NIEs) of East Asia (see Sarel, 1995), and, more recently, in India and China.[3] As a point of departure for this chapter, however, it is useful to highlight the conceptual distinction between proximate and "deep" determinants of growth. The latter refer to the microeconomic causative processes behind output growth, focusing on dynamics in specific markets over time as well as political economy influences on policy choices. The former take a broader perspective, looking at the patterns of change in macroeconomic aggregates, including overall efficiency. Although the two approaches are complementary, an aggregate focus is essential to developing a coherent overall framework for understanding past dynamics and, thus, identifying core processes of interest. This is the objective of this study. More specifically, the following questions are asked:

[1]Figures from UNDP (2006).

[2]Calculations are based on purchasing-power-parity (PPP) measures of income using estimates from World Bank (2005c).

[3]The NIEs include Hong Kong SAR, Korea, Singapore, and Taiwan Province of China.

- What have been the aggregate determinants of Mozambican growth to date;
- What are the challenges to sustaining growth over the long run; and
- What might other low-income countries learn from the Mozambican experience?

To enable this study to provide an evidence-based response, rigorous quantification of the past (proximate) sources of economic growth is undertaken using a growth accounting methodology. This tells us that the rapid rates of growth achieved since the early 1990s, averaging 7.5 percent per year, have been based on strong contributions from all principal growth drivers, namely accumulation of physical capital (public and private), improvements in human capital quality, and productivity gains. The pattern of growth can thus be described as having been relatively "unbiased," in the sense that no single aggregate determinant of growth appears to have been dominant.[4] At the same time, however, there is evidence to suggest that overall productivity growth has been supported largely by stabilization and adjustment gains related to postwar recovery. Consequently, prospects for sustaining productivity growth over the long term are uncertain. These issues are considered further, based upon an understanding of past growth dynamics, via a simple macroeconomic growth projections model. The results from this exercise confirm the importance of maintaining an unbiased growth pattern in which sustained productivity improvements play a central role. They also show that institutional strengthening, strategic management of foreign aid, and continued expansion of access to education at all levels will be critical.

In pursuing the analysis, a number of specific research contributions are made. First, rather than focusing only on aggregate factors of production, an index decomposition technique is used to quantify the contributions of both labor and physical capital stock subfactors. With regard to labor, this involves elaborating new estimates of changes in human capital quality via education for the period. Second, rigorous (cointegration) techniques are applied to assure the quality of the growth accounting estimates. Third, in order to understand observed changes in total factor productivity, the part explained by movements in capacity utilization is estimated. Fourth, with respect to the projections model, this study employs a new proxy for absorptive-capacity constraints associated with foreign aid. Moreover, the

[4]There is an intricate vocabulary surrounding patterns of growth. Thus, the term "unbiased" is used to avoid confusion with terms such as "balanced" or "complementary."

inclusion of this proxy and the specification of the model are validated by calibration on historical data.

The remainder of this chapter is structured as follows: the next section gives a brief review of the academic growth literature, concentrating on insights into the question of sustaining growth in developing countries; the third section describes the technique of growth accounting, reviewing its basis in economic theory before moving to a description of the empirical method and data sources adopted here. The growth accounting results are presented in the fourth section, starting with a review of previous studies for Mozambique, followed by the findings and analysis of this exercise. The fifth section presents the macroeconomic-growth-projections model that is used to quantify the aggregate impact of emerging policy challenges. The sixth section reflects on these findings to provide some general lessons for sub-Saharan Africa; the final section presents some conclusions. Note that to enhance readability technical aspects are reserved for separate appendixes.

By way of a caveat, this analysis does not make specific reference to the economic impact of a handful of large industrial projects (known as megaprojects) initiated in the postwar period. Close consideration also is not given to the potentially large output contribution from future natural resource extraction initiatives. This is not to deny their economic importance. To date, however, these activities have been foreign owned, have enjoyed generous fiscal benefits, and have shown only minimal backward linkages. As such, their contribution to past domestic (national) income growth has been limited. Their future role also raises a range of specific policy issues that are more appropriately treated separately, as in Chapters 1, 8, and 9.

Understanding Sustained Growth

Previous research that has sought to identify how public policy can promote sustained growth typically employs cross-country econometric methods. On the one hand, these are used because growth accounting, which focuses on proximate growth determinants (see the next section), is not suited for quantifying the contributions of individual microeconomic policy choices to growth. On the other hand, there is an absence of counterfactual evidence at the country level that can be used to estimate a robust relationship between growth outcomes and policy choices. Although cross-country econometric methods can be extremely powerful, their limitations have been noted widely and particularly in relation

to growth dynamics (for example, Durlauf, Johnson, and Temple, 2005; Temple, 2000). Observing a significant correlation between a given policy variable and output growth does not signify a robust one-way causative relationship. Moreover, if policies can be understood as rules mapping states of the world to actions (World Bank, 2005a, Chapter 8), one can hardly expect average regression results for an aggregate policy measure to indicate the best conditional rules (policies) and implementation measures for a specific country to follow. There is also, of course, the separate matter of how cross-country differences in these policies should be measured.

Both in light of these concerns and in recognition of the endogeneity surrounding policy choices, much recent scholarship views generic policy prescriptions with skepticism. Past growth is traced to specific aspects of geography, political-institutional history, and factor endowments. Thus, as set out in Rodrik (2004), policymakers are advised to focus on specific distortions at the country level. This is not to say, however, that the cross-country regression literature has nothing to offer. Perhaps its clearest advice applies to how economic growth can be undermined. Research indicates numerous factors that weaken growth in a quantifiable way across countries over time. These include armed conflict, extreme economic and political polarization, unsustainable management of public finances (for example, high fiscal deficits), hyperinflation, and political instability, to name just a few. For exchange rate valuation, although there is some evidence that undervaluation can boost growth via export competitiveness, a clearer empirical result is that substantial exchange rate volatility undermines growth (Berg, Ostry, and Zettelmeyer, 2006). Of course, the origins of these growth-inhibiting factors are often in deeper political economy processes; even so, the historical record suggests that many countries have failed to achieve the minimal political and economic preconditions needed to support sustained growth.

A second insight derives from economic theory. This tells us that the proximate determinants of economic growth are enhancements in factor productivity and the accumulation of stocks of physical and human capital. These variables, described here as aggregate growth drivers, provide a consistent framework for thinking about growth. In other words, policies to enhance growth must be expected to have an impact on at least one of them. On this basis, a noteworthy characteristic of sustained growth episodes has been the realization of consistent gains across each of these growth drivers. Recent research on East Asia, for example, interprets the "remarkable" growth rates achieved in some countries as being precisely due to the combination of rapid factor accumulation with sustained productivity enhancements (IMF, 2006, Chapter 3). Simply put, as long as we

accept some form of diminishing returns to factor accumulation, aggregate productivity must be integral to sustained growth. This point is supported by scholarship that investigates the specific factors associated with sustained, as opposed to temporary, growth episodes. A broad finding is that consistent productivity gains are present in the former episodes but absent in the latter. Hausmann, Pritchett, and Rodrik (2005), for example, find that the partial impact of positive terms of trade shocks is confined to temporary growth spurts. In contrast, deeper institutional reforms that hold implications for market functioning (efficiency) are associated with sustained growth episodes, although these are highly idiosyncratic in nature. These arguments are confirmed by the considerable weight of research that posits a strong relationship between high-quality institutions and rapid productivity growth (for example, Bosworth and Collins, 2003; IMF, 2006).

The preceding should not be taken to weaken the case for factor accumulation. Investment in physical capital is one of the few variables robustly and positively associated with growth in cross-country regressions (for example, Levine and Renelt, 1991).[5] From a developing country perspective, sustained investments in core public goods (for example, infrastructure) may be necessary to reduce private transaction costs, resolve coordination problems, and thus stimulate private sector growth. Also, referring once again to the experience of the NIEs, investment in export-related industries has been a characteristic feature of their growth success. Without these sector-specific investments, it is hard to envisage how these countries would have been able to move up the global value-chain (IMF, 2006). Although private and public investment can be critical, the experience of many African countries shows that accumulation is not sufficient, in itself, to generate growth (Easterly, 1997). Indeed, recent improvements in African growth rates since the late 1990s have been ascribed to productivity growth linked to improved macroeconomic stability and the quality of public financial management (Carey, Gupta, and Pattillo, 2005).

With respect to the accumulation of human capital, even scholars who question the nature of the link between growth and education do not hold that improvements in human capital quality via education are irrelevant. As Pritchett (1996) argues, the education puzzle is more about finding a consistent relationship between the (weak) macro and (strong) micro evidence for the productivity-enhancing effects of education. Part

[5]Interpretation of this relationship, however, is not straightforward, given the potential simultaneity between investment and output growth (see Durlauf, Johnson, and Temple, 2005).

of this puzzle is methodological. Especially at the cross-country level, it has not been resolved how to adjust for either differences in the quality of education outcomes, on which there is only poor information, or the match between labor supply and employment demand. These difficulties echo those encountered in identifying a robust relationship between foreign aid and growth. Relevant here is Tarp's (2006) reminder of the iron law of regressions—that with a "dirty" dependent variable (growth), noisy data, and weak proxies, results are biased toward zero. Michaelowa's (2000) survey of evidence for returns to education in Africa confirms the depth of these methodological difficulties, concluding that there are no reliable estimates of the effect of education on growth. Findings from growth accounting exercises that include adjustments for education also must be interpreted with caution. The relative volatility of growth rates compared with the smoother but slower rate of change in human capital quality means that these types of results provide no clear basis on which to derive benchmark estimates of the elasticity of income with respect to education.

In sum, although a policy blueprint for sustained growth cannot be expected, the literature does provide guidance in a number of areas. First, a broad set of preconditions must be in place for growth to "stick." Second, activities that generate a relatively unbiased pattern of growth should be encouraged. For developing countries with large aid inflows, the binding constraint in this regard may not be aggregate investment. Rather, combining human capital improvements with continued productivity gains in strategic sectors may be the fundamental challenge.

Growth Accounting

Theoretical Framework

The central idea behind growth accounting, which finds its origins in the work of Solow (1957), is to explore the proximate determinants of economic growth based on an aggregate production function. In general terms, aggregate output is expressed as a function of accumulated factor inputs and their use-efficiency; that is, $Y = F$ (factors, efficiency). A key empirical problem underlying any growth accounting exercise is how to move from a general functional form to a valid, workable representation of this relationship. For this, it is standard to make two core assumptions: efficiency changes are taken to be Hicks-neutral, in the sense that they apply equally across all factors of production; and factor prices are used

as proxies for factor marginal social products. (For elaboration, see Barro, 1998.) Of course, these are not necessary simplifications and a range of other approaches have been used in the literature (see Caselli, 2005). Relaxation of these assumptions, however, generates considerable empirical complications that fall beyond the scope of this study and, therefore, are not considered.

It should be emphasized that growth accounting typically focuses on real changes on the supply side of the economy. As such, it does not quantify movements in nominal prices or terms of trade in either international or intersectoral terms. This means that various microeconomic determinants of accumulation and reallocation of resources may not be identifiable. For example, the effect of macroeconomic policies pertaining to exchange rate management or inflation control are not captured under this framework and therefore are necessarily excluded from the analysis for Mozambique. In recognition of their importance, however, these issues are discussed in depth in other chapters in this volume, including the contributions in Chapters 6 and 10.

Among the theoretical and empirical difficulties involved in growth accounting, two particular issues are relevant to this study. First, calculation and interpretation of factor efficiency remain controversial. This dimension is often directly associated with technical innovation and is described as total factor productivity (TFP). As set out in Hulten (2001), however, it is more appropriate to understand this term as reflecting a broad range of efficiency effects, including those deriving from differences in organization, institutional quality, and technical innovation. Moreover, since growth-accounting methods generally calculate TFP as a residual, it also captures errors arising from bias or mismeasurement in the other variables. As such, residual TFP (the term used hereinafter) may be little more than a "measure of our ignorance" (Abramovitz, 1956). What this means is that interpretation of movements in residual TFP can be ambiguous, necessitating additional analysis outside the aggregate growth accounting framework.

Second, methodological choices are important, since growth accounting results are sensitive to both measurement techniques and underlying assumptions (Jorgenson, 2005; Sarel, 1995). For this reason, accounting methods have been elaborated in numerous ways, with particular effort being focused on the measurement of labor and capital as well as how they enter the production function. Numerous studies have shown that the role of residual TFP growth typically falls once one accounts for movements in the quality or productivity of factor inputs. To put it another way, since factor inputs can embody technological and efficiency gains, the inclusion

of quality-adjusted factors, as opposed to only their raw amounts, tends to considerably boost the estimated growth contribution of factor accumulation, with a corresponding reduction in residual TFP. This result has been shown to hold for both developed economies (see the references and estimates in Jorgenson, 2005) and cases of sustained growth in developing countries. For example, both Young (1994) and Bosworth, Collins, and Chen (1995) conclude that East Asian growth successes can be attributed principally to significant and sustained investments in human and physical capital rather than "miraculous" productivity growth alone.

Empirical Implementation

From the preceding review, an important message is that growth accounting must pay careful attention to measurement, making adjustments for factor quality where possible. The methodology adopted here permits the disaggregation of physical and human capital into various subcomponents via an index-decomposition approach. This technique is used to aggregate the effects of unequal changes in raw inputs (quantities) and marginal productivities (returns) into a meaningful composite growth measure for a given set of factors. The first step is to define real output in standard fashion as:

$$Y = A(K)^{a}(W)^{1-a}, \quad (1)$$

where Y denotes real output, A a measure of TFP, K physical capital, W a measure of economic services from human capital, and a the marginal social product of capital. When $0 \leq a \leq 1$, this is a Cobb-Douglas function, a special case of the translogarithmic function for which changes between two periods can be estimated by:

$$\ln(Y_t / Y_{t-1}) = \ln(A_t / A_{t-1}) + \bar{\theta}_K \ln(K_t / K_{t-1}) + \bar{\theta}_W \ln(W_t / W_{t-1}), \quad (2)$$

where $\bar{\theta}_i$ gives the average share of factor i in total factor payments over the two periods (Young, 1994). This equation forms the core of the methodology applied in this study. It represents a Tömqvist-translog index employed widely in the growth analysis literature as a discrete time approximation of the Divisia index.[6] The chain properties of the Tömqvist index are attractive, meaning it can be used as an aggregator for both physical and human capital subinputs. In other words, one can apply equation (2) in a hierarchical fashion to build up a detailed understanding of the contributions

[6]For discussion of index number theory with reference to economic growth, see Dean and Harper (1998).

of subfactors, such as different categories of labor and capital, to output growth. At the highest level of aggregation shown here, TFP is calculated as a residual, assuming that all other variables are known.

Although this represents a robust framework to estimate the contribution of various subfactors to aggregate growth, construction of the required indices can be problematic. Where data are inadequate, dirty, or unreliable, it is common for analysts to employ raw factor inputs and ignore quality adjustments. Although this has been true of the majority of previous growth accounting exercises for Mozambique (see subsection "Previous Studies" in the section "Accounting for Mozambican Growth" below), this study does not conform to that pattern. Rather, the required data series are constructed from a wide range of official Mozambican sources, including census, household survey, educational enrollment, and macroeconomic information. The relevance of this effort is underlined by the considerable socioeconomic changes that have swept Mozambique over the past 30 years. With respect to the quality of human capital, for example, education of the indigenous population was neglected during the colonial period, and on the eve of independence, approximately 93 percent of the population was illiterate. In response, education has remained a major policy priority, and considerable advances have been made in the educational profile of the population. Thus, these changes should be addressed within the growth accounting analysis.

Details of the methods used to estimate both the human capital and the physical capital stock series are summarized in Appendix I. For the former, the stocks of workers are split into three education categories (unskilled workers, those with primary education, and workers with at least a secondary education). For physical capital stocks, the disaggregation is between the public and the private sectors. At this point, it is worth highlighting four specific challenges encountered in constructing the required growth accounting data series. These are deriving robust estimates for (1) the starting value used to initialize the physical capital stock series; (2) the depreciation rate to apply to the physical capital stock; (3) the shares of aggregate factors in total output; and (4) the impact of changes in capacity utilization. Although it is known that decomposition results can be sensitive to different assumptions for these unknowns, numerous studies resort to standard rules of thumb (for example, cross-country averages) rather than rigorous, country-specific estimates. For Mozambique, the former tactic is not likely to be reliable, given the nature of the period in question. For example, the standard assumption of a constant annual rate of physical capital depreciation of about 5 percent is not coherent owing to the long-term effects of civil conflict as well as relatively rapid structural changes to

the economy. In addition, although capacity utilization is often taken to be a cyclical phenomenon, and thus immaterial to long-term growth accounting, changes in usage may be particularly important in Mozambique given the previously mentioned events.

In keeping with the emphasis of this paper on measurement quality, econometric techniques are used to estimate the above unknowns. For the first three, an iterative process is employed to select values that optimize the overall fit of the relationship described in general form by equation (1). Details of the procedure, which requires the relevant variables to be cointegrated, are given in Appendix II, Cointegration Technique. With respect to capacity utilization, no direct adjustments are made to the growth accounting data. As a result, the effect (if any) of variations in capacity usage is incorporated in the overall estimate of residual TFP. The method adopted thus involves attempting to isolate the changes in residual TFP explained by variations in capacity utilization. To do so, changes in capacity utilization are proxied by movements of the output-capital ratio around its long-term trend. This derives from the assumption of a stable long-run (trend) relationship between output and the capital stock under competitive conditions. Further details of this technique are set out in Appendix II, Capacity Utilization.[7]

Accounting for Mozambican Growth

Previous Studies

Before presenting the results of this study, it is useful to review previous growth accounting exercises for Mozambique. As shown in Table 3.1, findings from these studies do not tell a consistent story. Even the contribution of labor force growth, perhaps the most straightforward factor input to measure, differs considerably between the studies. Clearly part of this variation derives from differences in the periods covered, data sources used, and methodologies applied. With regard to the underlying data, where Mozambique features as part of a multicountry study, it is common to employ secondary sources, such as international data sets, rather than original data. These differences underline the sensitivity of growth accounting results to methodological choices. Perhaps the only tenta-

[7]Studies employing similar methods include Young (1994) and Schwerdt and Turunen (2006); see also Kamps (2004) for discussion of disaggregation of the public sector's physical capital stock.

Table 3.1. Comparative Growth Accounting Evidence
(Annual rates of growth, in percent)

Period	Region /Country	Source	ΔY	Decomposition of ΔY			
				ΔA	ΔK	ΔL	ΔH
1960–96		(a)	1.7	0.9	0.8	0.1	
1960–2000		(b)	0.5	0.3	0.1		0.1
1960–2002	**Mozambique**	**(c)**	**3.6**	**0.3**	**2.3**	**1.0**	
1995–2000		(b)	4.9	3.7	1.1		0.1
1997–2002		(d)	8.6	3.5	3.2	1.3	0.6
1960–2000	Africa	(e)	3.2	–0.1	0.5	2.5	0.3
	East Asia	(e)	6.7	1.0	2.3	2.9	0.5
	Latin America	(e)	4.0	0.2	0.6	2.8	0.4
	South Asia	(e)	4.6	1.0	1.0	2.3	0.3
1990–2000	Africa	(e)	2.3	–0.5	–0.1	2.5	0.4
	East Asia	(e)	5.7	0.5	2.3	2.4	0.5
	Latin America	(e)	3.3	0.4	0.2	2.4	0.3
	South Asia	(e)	5.3	1.2	1.2	2.5	0.4

Sources: (a) Sulemane (2001); (b) Ndulu and O'Connell (2003); (c) Aka and others (2004); (d) Benito-Spinetto and Moll (2005); and (e) Bosworth and Collins (2003).

Notes: Estimates for East Asia exclude China; for source (e), regional estimates are GDP weighted; where labor (L) contribution is absent, all figures are in per worker terms; and where ΔH is absent, no adjustment is made for human capital quality.

tive conclusion one might make is that residual TFP growth has been an important feature of Mozambique's recent growth success. Over the long run, however, there is no unambiguous evidence for a consistent upward trend in this productivity measure.

Referring to international comparisons, which are shown in the bottom portion of the table, low-productivity growth appears to have been typical of African growth experiences over the last forty years. This point is made by Aka and others (2004), who argue that the disappointing growth seen across most of sub-Saharan Africa since 1960 can be traced to a bias toward factor accumulation (capital investment) and an absence of productivity gains. As shown in Table 3.1, the only aggregate growth driver for which Africa records a reasonable comparative performance (excluding labor growth) is human capital improvement. Following the discussion in the section "Understanding Sustained Growth," differences in regional growth experiences indicate that where one or more growth drivers records a relatively weak performance, sustained output also tends to be poor. This is evident for both Latin America and Africa. These estimates support the argument that successful periods of sustained growth typically depend on robust (unbiased) contributions from all growth drivers.

Results

Turning to the present growth accounting analysis, statistical tests confirm that it is appropriate to employ the optimization procedure based on the cointegration framework described in Appendix II, Cointegration Technique.[8] The results from this exercise are summarized in Table 3.2. As expected, the model gives an extremely strong overall fit, and the cointegration measure is highly significant, as desired. The aggregate factor shares are plausible and corroborate estimates based on social accounting matrices for Mozambique (Arndt and others, 1998; Arndt, Jensen, and Tarp, 2000; and Tarp and others, 2002) that put the share of capital in output at approximately 30 percent. Also, consistent with the impact of civil war, the depreciation rate is estimated to have followed a declining trend, falling from 18 percent to 6 percent over the period, with the midpoint coinciding exactly with the peace agreement reached in 1992.

Employing these results to finalize the growth accounting series, the decomposition technique allows us to split the contribution from human capital (W) either into the three education-based categories or into the separate effects of changes in labor force quantity (L) and quality (H). Table 3.3 gives the latter presentation, while Table 3.4 splits the capital and labor contributions into more detailed subfactor components. In both tables, the growth decomposition is given for the overall period (1980–2004) as well as for specific subperiods bounded by points of structural change (for example, civil war and immediate postwar reconstruction). Figure 3.1 shows the evolution of indices of the major growth components over the full period based on the annual rates of growth used to estimate equation (2).

With respect to residual TFP, Table 3.3 distinguishes between its estimated trend component, taken from the regression results, and remaining noise. Since residual TFP measures tend to capture numerous efficiency effects, however, the methodology described in Appendix II, Capacity Utilization, is applied. Table 3.5 summarizes these results, decomposing residual TFP into three components: the part explained by changes in capacity utilization, a remaining deep trend, and unexplained noise. From these decompositions, and as plotted in Figure 3.2, movements in residual TFP appear to be explained almost entirely by changes in capacity utilization. As discussed in the same appendix, however, where TFP changes are lumpy in nature owing to, among other things, large foreign direct invest-

[8]In other words, augmented Dickey-Fuller tests do not reject the null hypothesis that the variables in equation (A2) have unit roots, while a linear combination of them is stationary.

Table 3.2. Estimation of Long-Run Production Function

	Coefficients	Standard error
Capital stock *(K)*	0.28	(0.08)
Quality-adjusted labor *(W)*	0.72	(0.08)
TFP trend (1980–91)	–0.02	(0.00)
TFP trend (1992–2004)	0.03	(0.01)
Postwar dummy	–0.71	(0.13)
Constant	–2.60	(0.31)
Observations	25	
Log likelihood	53.65	
Average depreciation rate (1980–91)	15.25	
Average depreciation rate (1992–2004)	9.00	
Cointegration test†	–4.07	

Source: Author's calculations

Notes: All coefficients are significant at the 1 percent level; † denotes the value of the *t*-statistic calculated as per Engle and Granger (1987). TPF denotes total factor productivity.

ment (FDI) inflows and/or structural changes, this decomposition methodology may not accurately separate utilization changes from productivity effects. Given the tumultuous economic changes in Mozambique over the period, the strength of this finding must be treated with caution. Even so, micro evidence supports the view that capacity-utilization changes have broadly followed the trajectory indicated in Figure 3.2. According to Biggs, Nasir, and Fisman (1999), for example, firm-level capacity usage was less than 30 percent in 1989, rising to 48 percent in 1998. More recent surveys (Byiers and Rand, 2007) confirm that utilization rates have continued to rise, climbing to around 59 percent by 2005. Thus, these results can be regarded as indicative, but not precise, estimates of underlying determinants of residual TFP.

Civil War Decline

Reflecting on the results, output decline from 1980 to 1992 can be understood primarily in terms of physical capital contraction and productivity losses. With respect to the former, although the value of the public sector capital stock remained broadly stable in real terms during the period, private sector stocks suffered significant real reductions (see Table 3.4). This derives principally from the fact that public sector investment continued at a moderate pace through the war years, averaging 8 percent of GDP. In contrast, private sector investment was negligible, averaging only 1.3 percent. This differentiated pattern clearly indicates the higher sensitivity of private sector investment to economic stability and structural conditions.

Table 3.3. Aggregate Growth Decomposition

		ΔTFP			ΔW	
	ΔY	Trend†	Noise‡	ΔK	ΔL	ΔH
1980–91 (civil war)	–1.72	–2.13	–0.12	–0.66	0.81	0.38
	(100)	(124.1)	(6.9)	(38.3)	(–47.1)	(–22.3)
1992–98	5.22	2.62	–0.95	1.84	1.31	0.40
	(100)	(50.2)	(–18.2)	(35.2)	(25.1)	(7.7)
1999–2004	7.37	2.62	–1.51	3.84	1.50	0.92
	(100)	(35.6)	(–20.5)	(52.2)	(20.3)	(12.4)
1980–2004 (full)	2.58	0.44	–0.71	1.20	1.13	0.52
	(100)	(17.1)	(–27.6)	(46.4)	(43.8)	(20.3)

Source: Author's calculations.

Notes: Figures in parentheses are in percent; † is derived from the results shown in Table 3.2; and ‡ denotes remaining, unexplained residual TFP movements. TFP denotes total factor productivity.

Declines in productivity during the civil war are evident in both overall and trend estimates for residual TFP. In broad terms, this accords with evidence for the period that documents major shortages of primary inputs, electricity blackouts, and transportation difficulties (Arndt, Jones, and Tarp, 2007). As was to be expected, much of this is captured by the capacity-utilization component, suggesting that the remaining trend decline in factor productivity (efficiency) was less intense, at only –0.6 percent per year (versus –2.3 percent overall). Illustrated in Figure 3.2, the capacity-utilization component shows an extremely sharp decline during 1980–85, followed by a period of relative stabilization through 1990. The former result is consistent with a rapid tightening of production constraints during the early 1980s owing to the deteriorating conflict and foreign exchange shortages, which were compounded by extensive price controls. The flatter trend of the latter period coincides with the introduction of economic stabilization and adjustment measures beginning in 1985 that are likely to have eased certain production constraints.

Changes in capacity utilization, however, are not the entire story, given the remaining trend decline in deep TFP. A number of effects may be behind this. First, the pervasive disruption caused by conflict, including internal displacement, is likely to have generated substantial (heightened) inefficiencies in market functioning. This may be particularly the case in labor markets despite (slow) expansion of access to education during the civil war. The trend decline in deep TFP therefore may reflect the negative productivity spillovers from market inefficiencies associated with the war. Second, the civil war was marked by a series of natural disasters, including both floods and droughts (Hall and Young, 1997). Given the residual nature of TFP and the high frequency of these disasters, it is plausible that

Table 3.4. Subfactor Growth Decomposition

			ΔK		ΔW		
	ΔY	ΔTFP	ΔK_g	ΔK_p	ΔU	ΔEP	ΔES
1980–91 (civil war)	–1.72	–2.25	0.22	–0.88	0.26	0.78	0.16
	(100)	(131.0)	(–13.0)	(51.3)	(–15.0)	(–45.3)	(–9.1)
1992–98	5.22	1.67	0.58	1.26	0.58	0.79	0.34
	(100)	(32.0)	(11.2)	(24.0)	(11.1)	(15.2)	(6.5)
1999–2004	7.37	1.11	1.33	2.52	0.25	1.31	0.85
	(100)	(15.0)	(18.0)	(34.2)	(3.4)	(17.8)	(11.6)
1980–2004 (full)	2.58	–0.27	0.60	0.59	0.35	0.92	0.38
	(100)	(–10.4)	(23.5)	(22.9)	(13.5)	(35.6)	(14.9)

Source: Author's calculations.

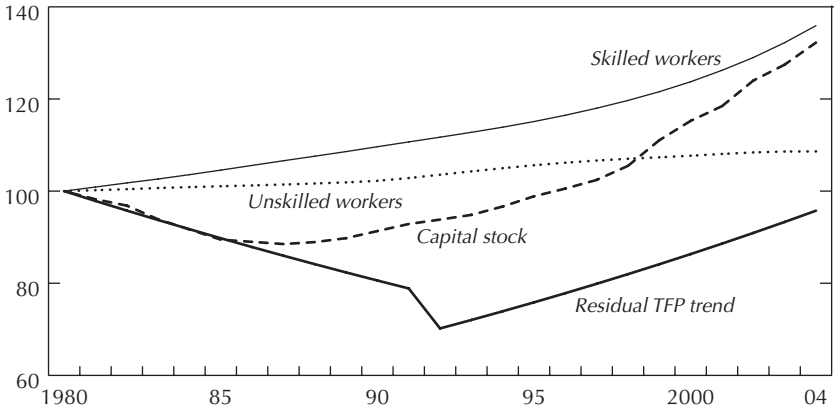
Notes: Figures in parentheses are in percent; only residual total factor productivity (TFP) is shown; K_g and K_p denote government and private sector capital stocks; *U* denotes unskilled workers; *EP* and *ES* denote workers with primary and secondary school qualifications, respectively.

the negative TFP trend may also be capturing the harmful impact of these events on total output.

Postwar Recovery

Turning to the period beginning in 1992, accumulation (rehabilitation) of the physical capital stock consistently explains a large part of output growth (around 45 percent). The breakdown of physical capital's contribution into private and public sector components (Table 3.4) reveals the comparatively larger role of private capital accumulation in the postwar phase, for which it explains two-thirds of capital's overall contribution to growth. Echoing the dominance of private sector capital stock contraction during the war, this highlights the central role of private sector recovery in Mozambique's postwar success. In comparison with the more stable public sector savings, private sector savings have grown rapidly in the postwar phase, reaching an average rate of 12.8 percent of GDP during 1999–2004. In particular, private sector investment has been boosted by inflows of new (as opposed to returning) foreign investment. According to Bank of Mozambique statistics, FDI was almost zero during the civil war and grew only negligibly in the immediate postwar phase. Recently, however, Mozambique has experienced a comparative FDI boom, receiving an average of around US$250 million per year, which is equivalent to 6 percent of its GDP, in such investments. While a large portion of this refers to a small number of large, capital-intensive industrial projects, one should not discount the considerable number of smaller investors in tourism and other industries that have provided a stimulus to the construction sector, employment creation, and, thus, output growth. That this has occurred

Figure 3.1. Indices of Major Growth Components Based on Growth Accounting Results
(Indexed at 1990 = 100)



Source: Author's calculations.
Note: TFP = total factor productivity.

primarily in the later postwar period attests to the need for economic and political stability to be credible before external investors are willing to move. In turn, these findings underline the essential contributions of enhanced macroeconomic stability and institutional reforms in improving the business environment.

This is not to negate the critical contribution of public sector investment to postwar growth. In this context, it should be highlighted that foreign aid to Mozambique has financed, on average, the totality of government investment both during and after the civil war (Arndt, Jones, and Tarp, 2007). With recent increases in net aid to the government, deriving in part from considerable bilateral and multilateral debt cancellation, the estimated contribution of public sector investment to aggregate output growth has risen to 18 percent for 1999–2004 (see Table 3.4). These estimates, however, do not fully capture the positive spillover effects (externalities) from investments in both public infrastructure and education. Given the paucity of these goods at the end of prolonged conflict, the magnitude of social returns to public investments (and, by association, foreign aid) is likely to have been significant for Mozambique. Of course, and as is discussed further in the next section, this statement should not be taken as arguing that one can expect high returns from aid in the future.

Table 3.5. Decomposition of Overall Residual TFP Growth

	Δ*TFP*	ΔCapacity†	Trend‡	Noise††
1980–91 (civil war)	–2.25	–2.25	–0.59	0.59
	(100)	(100.0)	(26.0)	(–26.0)
1992–98	1.67	1.44	0.57	–0.33
	(100)	(86.0)	(34.0)	(–20.0)
1999–2004	1.11	1.38	0.57	–0.84
	(100)	(124.7)	(51.3)	(–76.0)
1980–2004 (full)	–0.27	–0.27	0.04	–0.04
	(100)	(100.1)	(–14.7)	(14.6)

Source: Author's calculations.

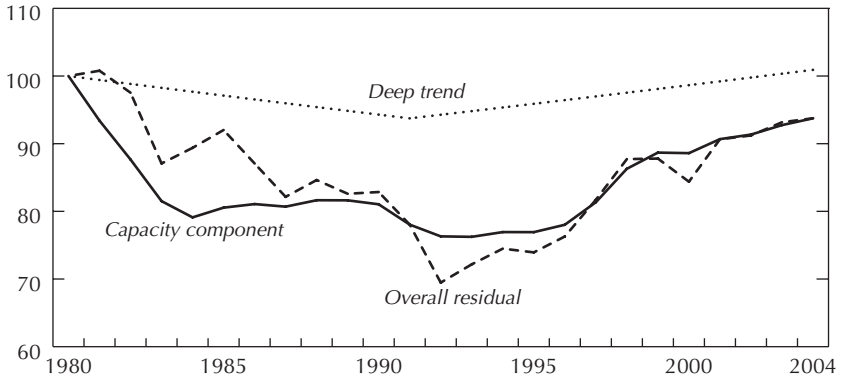
Notes: Figures in parentheses are in percent; † denotes the component explained by changes in capacity utilization; ‡ denotes the deep trend in total factor productivity (TFP) growth after adjusting for capacity utilization; and †† denotes the remaining unexplained (short-term) variation.

Changes in the quality of human capital are also an important part of the growth story. If one focuses on the pure gain associated with changes in education (Δ*H* in Table 3.3), it will become apparent that its relative and absolute contribution to output growth has risen consistently throughout the postwar period. When expressed in terms of a percentage point contribution to growth, the 0.92 estimate for 1999–2004 is also extremely impressive by global standards (see Table 3.1).[9] This figure reflects the extremely low educational base, even by African standards, from which Mozambique has progressed. For example, according to the estimates developed here, in 1980 a staggering 93 percent of the economically active working population had no formal educational qualifications. This had declined to 85 percent by 1992 and then to 74 percent in 2004, a fall of 11 percentage points in the postwar period alone. Thus, sustained investments in education, which were in large part financed by foreign aid, have made a central contribution to postwar growth.

A review of the structure of changes in the workforce is of further interest. First, there has been a distinct upward shift in the overall rate of growth of the active labor force compared with the civil war period (Table 3.4), reflecting not only the absence of conflict but also more general improvements in health and incomes since 1992. This growth has not been equally distributed across all labor categories, however. Even in terms of pure numbers (that is, ignoring productivity differences), the cohort of skilled workers has grown much more rapidly than the unskilled cohort. Table 3.4 shows that the growth contribution of unskilled workers has followed a declining trend in the postwar period, explaining less than

[9]Of course, this estimate for Mozambique refers to a relatively short time frame; the challenge, as discussed in the next section, will be to maintain this performance.

Figure 3.2. Decomposition of Residual Total Factor Productivity
(Indexed at 1980 = 100)



Source: Author's calculations.

5 percent of aggregate growth since 1999. Consistent with the government's emphasis on expansion of the primary education sector, workers with a primary education have made the largest contribution of all labor categories to total value added in the postwar period. The cohort with a secondary school education, however, has witnessed the fastest expansion since 1992, explaining 11.6 percent of total value added for 1999–2004, against 6.5 percent for 1992–98. As such, the contribution of skilled labor to growth is being increasingly driven by secondary-level education, suggesting that further expansion at this level and beyond will be necessary to support future employment demands.

Turning to residual TFP, Table 3.4 shows that this measure has made a 1.4 percentage point (or 23 percent) annual average contribution to postwar output growth. Although this recovery is somewhat lower than the rate of decline during the civil war (–2.3 percentage points a year), the size of the TFP residual should be interpreted with caution. As noted previously, the civil war years were affected by a series of natural disasters. In contrast, and aside from notable exceptions, the postwar period has been more benign, on average. In fact, this point helps explain the substantially higher trend rate of residual TFP growth in the postwar period (2.6 percent), compared with the overall residual (1.4 percent). The lower value reflects the large shocks attributable to severe droughts in 1992 and massive floods in 2001. To put it another way, the effects of these disasters are captured by the negative noise term in Table 3.3. Despite this difference,

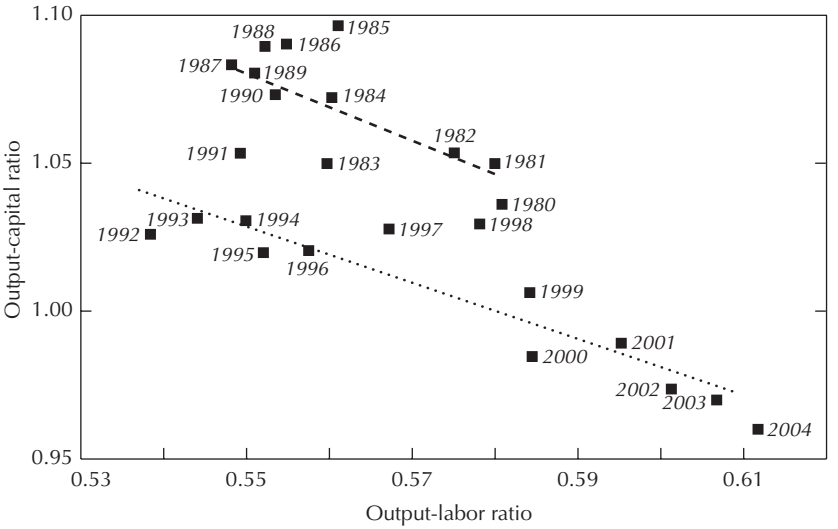
the overall rate of residual TFP growth is far from disappointing by international standards. As shown in Table 3.1, East Asian countries achieved an average annual rate of residual TFP growth of about 1 percent for 1960–2000. The detailed tables in Ndulu and O'Connell (2003), based on the same approach and period, not only confirm this result but also reveal that of all sub-Saharan African countries in the sample, only Mauritius achieved an average rate of residual TFP growth exceeding 1 percent. Furthermore, if the larger underlying trend in residual TFP growth is used as a comparator, Mozambique's performance since 1992 ranks alongside the residual TFP growth rates achieved by both India (1.6 percent) and China (3.8 percent) since the late 1970s (as estimated in Bosworth and Collins, 2006). In sum, postwar growth has been supported by sustained gains in factor productivity as measured by residual TFP.

A fundamental question for Mozambique, however, is whether this pattern of TFP growth can be sustained as opposed to being a temporary, post-conflict phenomenon. Three arguments warn against an overly optimistic interpretation of the recent Mozambican TFP record. First, the capacity-utilization decomposition suggests that postwar changes in the TFP residual have been driven largely by an improvement in utilization rates. As such, deep postwar TFP growth may have been more modest, at about 0.57 percent (trend).[10] Notably, however, the component of residual TFP growth associated with capacity utilization does not indicate an immediate postwar recovery (see Figure 3.2). Sustained gains were evident only after 1995, following the consolidation of peace by means of multiparty elections in 1994, and continued through 2005, albeit at a slower rate more recently. This reveals that post-conflict recovery is long term in nature and remains an ongoing process.

Second, complementary evidence supports the general argument that productivity has not shown unambiguous aggregate gains in recent years. In contrast to an expected trend increase in the output-capital ratio owing to productivity improvements, Figure 3.3 shows that this ratio has followed a declining path during the postwar period, indicating a bias toward capital accumulation rather than (intensive) productivity enhancements. At the sectoral level, research summarized in Benito-Spinetto and Moll (2005) for the agricultural sector suggests that yields for many crops have remained stagnant since the mid-1990s and, in many cases, have remained below prewar levels. Although this is not to ignore isolated cases of relative success, such as in the tobacco sector, postwar growth in smallholder farm-

[10]Of course, although this growth rate is inferior to those of East Asian countries, it is far superior to the African average, as may be seen in Table 3.1.

Figure 3.3. Scatter Plot of Output-Capital and Output-Labor Ratios, by Year



Source: Author's calculations.

ing, which accounts for the vast majority of agricultural output, appears to have been based on the return of populations to rural areas and trend expansion in land use, rather than robust productivity jumps. Finally, and taking a longer-term view, none of the TFP measures suggest that there has been an unambiguous upward shift in aggregate productivity (efficiency) since 1980. For 1980–2004, the growth rate of overall residual TFP is estimated to have averaged –0.27 percent; the underlying trend in the same residual has averaged 0.44 percent; and the deep trend has averaged only 0.04 percent. These results imply that any long-term productivity improvements have been moderate at best.

In summary, postwar growth in Mozambique has been founded on robust (unbiased) contributions from all principal growth drivers. Solid improvements in the quality of the human capital stock have accompanied significant capital deepening and residual TFP growth. Even so, the sustainability of observed productivity gains remains in doubt. Evidence suggests that during the civil war Mozambique was producing at a point well within its production-possibilities frontier. Postwar growth in residual TFP appears to have been dominated by movement toward this hypothetical frontier rather than outward movements of the frontier itself. Although

recovery of this nature is a necessary foundation for future productivity gains, maintaining growth rates at their recent high levels may become increasingly difficult as easy gains from postwar recovery diminish.

Toward Sustained Growth

Quantitative Model

Based on the preceding analysis of past growth patterns, this section considers the challenges of future growth. Taking an aggregate production function as a starting point, simple behavioral dynamics are added in order to specify endogenous and exogenous sources of growth over time. Described formally in Appendix III, the model focuses on the relationship between output growth, productivity, and factor investment for 2005–30. In this respect, it has a broad affinity with World Bank "investment gap" models (for an overview, see Tarp, 1993, Chapter 4) although, in this case, variables referring to external accounts are not included. A critical assumption underlying this exercise is that necessary growth preconditions hold over the long term. Thus, referring back to the discussion in the section "Understanding Sustained Growth" above, these imply that macroeconomic policies are not highly distortionary and achieve reasonable stability across key policy targets such as the real exchange rate. In sum, the model aims to highlight aggregate challenges that may differentiate between episodes of sustained rapid growth and disappointing low-growth performances.

Adding simple behavioral functions to the growth accounting framework allows the relationship between growth and specific policy challenges to be illuminated. Two particular issues are reflected in the model echoing concerns identified in the government's recent Poverty Reduction Strategy Paper (Mozambique Ministry of Planning and Development, 2006b). First, the prevalence of HIV/AIDS in the working population is assumed to affect (negatively) labor force growth, investment, and human capital quality as suggested in the literature.[11] Second, foreign aid is included as a core source of funds to finance public investment. This reflects Mozambique's historical dependence on aid, the low (current) rates

[11]See the contributions in Haacker (2004) and, for Mozambique, Arndt (2006). Note that the model does not account for some of the more complex dynamics associated with HIV/AIDS, such as the lag between infection and symptom onset, or the role of antiretroviral therapies.

of domestic saving, and the sheer scale of the development challenge. The baseline assumption, discussed later on, is that aid is stable at 12 percent of GDP, versus almost 25 percent of GDP in the postwar period. In light of both Mozambique's macroeconomic record and international moves toward the scaling-up of external aid, this is not wholly unreasonable.

It would be naïve, however, to assume that foreign aid is always growth enhancing. Two further variables are therefore introduced to capture some of the more complex effects surrounding foreign aid. The first is the government investment share *j*. Assuming, for simplicity, that aid directly enhances growth only via government investment (see equation (A11) in Appendix III, Behavioral Dynamics), *j* reflects the point that where aid finances recurrent consumption, its long-term growth effects may be reduced. As discussed in Yang, Gupta, and Powell (2005), use of aid to fund domestic recurrent expenditure, as opposed to investment, may undermine growth via Dutch disease effects. The second variable is a measure of aid-related absorptive capacity *f*, proxied by the ratio of external aid to total investment.[12] The hypothesis is that a relatively high level of aid may generate negative side effects. While formal modeling of absorptive capacity is in its infancy (for a discussion, see Bourguignon and Sundberg, 2006), and no comprehensive treatment is attempted here, numerous scholars argue that returns to aid may be diminishing after some saturation point is reached or even turn negative at high levels (Lensink and White, 2001). In the model, absorptive-capacity pressures operate through private investment and improvements in the quality of human capital. The former is intended to reflect investment efficiency and incentive effects, while the latter reflects labor market effects, including the challenge for Mozambique of maintaining educational quality in the face of rapid, aid-financed expansion of the school network. (See Arndt, Jones, and Tarp, 2007.)

The model is employed to examine growth scenarios generated from different assumptions. As a starting point, it is helpful to set out a "base case" against which other scenarios can be compared, the objective being to create a plausible but positive growth path that follows smoothly from current conditions. The values chosen for the exogenous variables under this scenario are summarized in Table 3.6. The majority of these are based on recent trends in the Mozambican data and need little justification. Of note is the choice of 1.4 percent growth in exogenous TFP, which is equal to the average value of overall residual TFP growth during the postwar

[12]Note that this should not be confused with the national accounting concept of absorption; see also Yang, Gupta, and Powell (2005).

Table 3.6. Sensitivity of 2030 Income per Worker to Simulations of Individual Changes in Calibrated Parameters and Base Case Exogenous Variables

Description		Label	Value†	SE	ΔY/L by 2030‡ –%	ΔY/L by 2030‡ +%
Variables	Labor force growth	n	2.55		5.6	–4.2
	HIV/AIDS prevalence	v	15.60		10.9	–12.6
	Government revenue in GDP	r	15.00		–17.8	19.2
	Aid in GDP	x	12.00		–10.1	11.3
	Government investment share	j	0.40		–31.3	35.8
	FDI in GDP	z	5.00		–8.2	8.0
	TFP growth	a	1.00		–21.1	27.0
Parameters	p (lag growth)	ρ_0	0.50	0.00	–0.1	0.1
	p (government investment)	ρ_1	0.33	0.00	–0.2	0.2
	p (absorptive capacity)	ρ_2	–0.11	0.02	–0.1	0.1
	p (inflation)††	ρ_3	0.00	0.02	.	.
	ΔH (government investment)	η_0	0.19	0.02	–5.7	6.1
	ΔH (private investment)	η_1	0.02	0.01	–2.1	2.2
	ΔH (absorptive capacity)	η_2	–0.58	0.06	–1.7	1.7

Source: Author's calculations.

Note: † denotes base case values for exogenous variables (top) and calibrated parameter estimates (bottom) as explained in the text; ‡ denotes the percentage change to per worker income in 2030 versus the base case: simulations for variables represent shifts of ±50 percent; simulations for parameters are equal to ±2 standard errors (SE); †† denotes that a parameter is not simulated, since it is excluded from the model.

period. Clearly, this is higher than the trend rate of deep TFP growth and remains relatively strong in comparison with long-term estimates for many developing regions, including East Asia (see Table 3.6). The plausibility of this assumption is discussed later on.

Model Calibration

To validate the model and to enhance its realism for Mozambique, the model parameters are calibrated econometrically. Specifically, a Seemingly Unrelated Regression (SUR) technique (Zellner, 1962) is employed based on the growth accounting data set and additional historical data. Equations (A12) through (A14) in Appendix III, Behavioral Dynamics, are estimated in this manner and the results are summarized in Table 3.6, giving both the estimated values and the standard errors for each of the parameters.[13]

[13]Although the final TFP equation includes no parameters, it is added to the SUR system as a form of control, including only a constant plus a postwar dummy variable on the right-hand side. In no case is adjustment made for HIV/AIDS prevalence v owing to its limited impact in the past. To remove noise, variables are smoothed using a Hodrick-Prescott filter. Estimation of equation (A10) is discussed in Appendix III, Behavioral Dynamics.

Excluding inflation, which is subsequently dropped from the model, all parameters are significant at the 1 percent confidence level. All significant parameters are also of the expected sign, being negative for absorptive capacity and positive otherwise.[14] Of note are the strong positive results relating to government investment in both the private investment and the human capital growth functions. The latter underlines the key role of (public) education in boosting labor productivity; the former indicates the complementarity between public and private investment in Mozambique as discussed above in the subsection "Postwar Recovery." In sum, the calibration method provides empirical support for the specification.

Confirmation of the suitability of the calibrated parameters is given by sensitivity tests. Employing the base case values for the exogenous variables, a variation of two standard errors (negative and positive) in each of the parameters is simulated. For each simulation, the impact is measured as the percentage change in per worker income in 2030 versus the base case level. As indicated in Table 3.6, the average absolute impact of the simulation yields a very small (1.7 percent) change in 2030 income. The largest impact from the simulation is 6 percent (parameter η_0), reflecting the key role of government investment in human capital growth in the model. Note, however, that the calibration is based on historical trends, which saw extremely rapid growth of human capital, particularly in the postwar period. Thus, this same parameter is adjusted by a factor of 0.75 under the base case scenario, reflecting the arithmetic logic behind the assertion that as average education levels rise, maintaining a constant rate of human capital growth will become increasingly difficult. Despite this adjustment, the sensitivity tests indicate the model is stable with respect to moderate measurement error in the parameters.

Policy Results

Insights regarding the opportunities and threats to sustained growth are given by the sensitivity tests applied to the exogenous variables (Table 3.6). These simulate the impact on per worker income in 2030 of a 50 percent variation in the base case values. The scenarios given in Table 3.7 go further, showing the impact on the overall pattern of growth of different (combined)

[14]Although the negative sign on the absorptive-capacity parameters is based on past trends, this principally reflects the fact that, at the height of the civil war, foreign aid was the only major source of investment finance. The value for *f* peaked at the end of the war, declining consistently thereafter to a fourth of its peak value by 2004.

Table 3.7. Long-Term Growth Scenario

Scenario	Period	ΔY	$\Delta Y/L$	ΔTFP	ΔK	ΔH
Base case	2005–15	5.34	3.57	1.31	1.67	0.59
	2016–30	4.76	3.04	1.30	1.16	0.58
Zero HIV/AIDS	2005–15	7.33	4.78	1.41	2.40	0.97
	2016–30	6.50	3.95	1.41	1.58	0.96
Weak education	2005–15	4.66	2.90	1.31	1.54	0.05
	2016–30	3.97	2.25	1.30	0.90	0.04
Negative	2005–15	2.67	0.96	0.65	0.22	0.09
	2016–30	2.66	0.94	0.65	0.21	0.08
Positive	2005–15	7.26	4.93	1.66	2.39	0.88
	2016–30	5.82	3.97	1.63	1.55	0.79

Source: Author's calculations.

Notes: Projections are based on the model set out in Appendix III; contribution of labor force growth is given by the difference between ΔY and $\Delta Y/L$; scenarios are described in the text; all figures are average annual growth rates.

assumptions for both the exogenous variables and parameter values. The main policy issues revealed by these two exercises are discussed below.

Base case potential

The base case holds inherent interest, projecting average annual real output growth of 5.3 percent (3.6 percent per worker) through 2015, followed by a slightly slower rate from 2016 to 2030.[15] This scenario reflects trends in the recent data and suggests that prospects for sustained economic growth are good, in turn confirming the World Bank's (2005b) baseline forecast of a 5 percent annual potential growth rate for the country over the long term. This upside potential can be traced to various features of the Mozambican economy (discussed further later on), including the valuable demonstration effect of successful growth and poverty reduction since 1992. Under this scenario, the relative composition of growth is highly comparable to the country's postwar experience, indicating a continuation of an unbiased growth pattern. Even so, with diminishing returns to new investments and moderate expectations of productivity growth, the base case suggests that the 7.5 percent average growth rate achieved over 1992–2004 may not be sustained easily. Moreover, this scenario presumes that the government is able to facilitate a successful graduation from postwar recovery to ongoing economic transformation. As already indicated with regard to productivity growth, this task may become increasingly demanding as the nature of the growth challenge evolves.

[15]Unless otherwise indicated, references to output growth are stated in aggregate, rather than per worker, terms.

Productivity growth

A salient result from the sensitivity tests is the comparatively large impact of movements in the exogenous component of TFP growth. A 50 percent increase in this component generates a 27.0 percent increment in income per worker by 2030 compared with the base case. Slightly smaller contractions derive from a 50 percent reduction, with the difference owing to the dynamic structure of the model. Even under the base case, the contribution of TFP growth to total output growth remains around 25 percent. It is recognized that to the extent that such strong rates of TFP growth are realistic for Mozambique, the potential for catch-up is enormous. This is quantified by estimates in Eifert, Gelb, and Ramachandran (2005) based on firm-survey data, which suggest that Mozambican TFP is not only less than a third of China's but also one of the lowest in their sample of African and Asian countries. The potential for technological enhancement is clear in the agricultural sector, where use of irrigation technology, fertilizer, and improved seeds remains minimal (see Arndt, Jones, and Tarp, 2007; and World Bank, 2005b). Scope for significant TFP gains also comes from second-generation reforms aimed at strengthening public institutions and regulatory structures. As was discussed above, institutional quality has been robustly associated with overall levels of productivity and economic development (see also Rodrik and Subramanian, 2004). Institutional upgrading is consistently highlighted as a key policy priority for Mozambique. For example, a recent review conducted by the main foreign donors (jointly with the government) singles out justice sector weaknesses as a major preoccupation (Mozambique Ministry of Planning and Development, 2006a). In addition, an effective regulatory structure pertaining to land access and use is likely to become increasingly essential, given the considerable growth potential of agriculture and tourism. This point is well understood by the Mozambican government, and numerous institutional reforms are envisaged under the current poverty reduction strategy. Although these are likely to be challenging, the model indicates that failure to achieve institutional reform could seriously jeopardize future growth potential.

Capital investment

Both the sensitivity tests and the growth scenarios underline the need to maintain high levels of investment in fixed capital. Under the base case, effective investment averages approximately 18 percent of GDP, of which about half is from the private sector. To achieve this, the policy focus evidently falls on raising domestic savings—for example, via financial deepening—and continuing to attract foreign investment. Given Mozambique's reasonable natural resource base and strategic location

close to South Africa, prospects for foreign investment remain good. The growth challenge, however, will be to ensure strong backward linkages from new investments. With respect to the public sector, the model confirms the importance of maintaining a robust investment share *j*. A dramatic cut in this share to 20 percent of total available public funds generates a 31 percent fall in 2030 income per worker (Table 3.6) or a decline of almost 2 percentage points in annual output growth compared with the base case. Evidently, results of this size assume that social returns to public investment will remain high and that public and private investment will continue to be complementary. This is certainly plausible, given the relatively limited coverage of public services and infrastructure (for example, potable water and roads) throughout the country; however, ensuring public investments are well targeted and effectively maintained will be vital to achieving sustained output growth.

Public financial management

As discussed previously, the sustainable financing of public investment will be a key challenge. This, in turn, raises the question of the appropriate mix of foreign and domestic contributions to public funds. Although the sensitivity tests indicate a sizable response of final output to changes in both domestic revenues and external aid, they also indicate that domestic revenue is a preferred financing mechanism, given the potential absorptive-capacity problems surrounding external aid (discussed later in this chapter). In comparison with the base case, this suggests that a gradual replacement of external aid by domestic revenue would generate small growth gains over the long term. The validity of such a scenario, however, depends on how any disincentive effects arising from increases in the overall tax burden compare with gains from reductions in reliance on external aid. Evidently, such questions go beyond the scope of the model. The more general policy message, however, is that fiscal policy choices are highly relevant and must be based on an understanding of critical growth constraints and opportunities. Careful management of the overall aid portfolio and ongoing development of the government's technical capacity in these areas are therefore relevant priorities.

Absorptive capacity

As is well understood, the final impact of fiscal policy depends on the combination of revenue and expenditure effects. Thus, aid management must embrace the efficiency and effectiveness of aid-financed expenditure. The pertinence of this observation is underlined by simulations of large increases in the absorptive-capacity parameters. For example, a tripling

of η_2 in the human capital growth function (equation (A13)) generates a 0.5 percentage point fall in annual output growth compared with the base case. Alternatively, the sensitivity tests for the investment share *j* indicate that a reduction of the share of aid devoted to investment goods logically reduces average public investment, generating a corresponding decline in output growth. As a result, paying close attention to the intertemporal mix of investment and consumption in government expenditure is advised. This is particularly relevant where there are increasing demands on recurrent expenditures linked to the cumulative impact of (aid-financed) public investments.[16]

HIV/AIDS

The model clearly shows that the HIV/AIDS epidemic has considerable potential to weaken future growth. The base case employs official government estimates that put the current prevalence at 15.6 percent of the working population, growing to 16.8 percent in 2010, at which point it stabilizes. Although these rates are high in global terms, the task of containing prevalence below 20 percent is critical in light of the experiences of other countries in southern Africa (for example, Botswana). The potential growth impact of the epidemic can be gauged from Tables 3.6 and 3.7. The latter shows that under a hypothetical scenario of 0 percent prevalence (zero HIV/AIDS), annual growth would be approximately 2 percentage points greater than in the base case. In support of the model, these orders of magnitude are highly consistent with alternative estimates for both Mozambique (for example, Arndt, 2006) and other countries where prevalence is relatively high. Thus, effective actions to reduce the spread and nefarious economic effects of the epidemic will be crucial to realizing sustained economic growth.

Education

Consistent with the analysis of past sources of growth, the modeling exercise confirms that continued improvements in labor force quality via education will be necessary to sustain future growth. This is indicated by the role of human capital in the base case scenario, which explains about 11 percent of output growth to 2030. In comparison with the estimates given in Table 3.1, such a long-term return to education would be at the upper end of international experiences. Even so, prospects for achieving this must be considered reasonable, given the comparatively low average

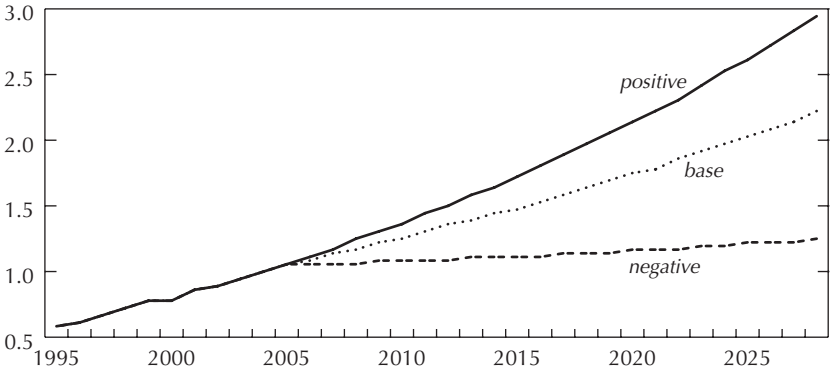
[16]A clear example of this challenge may be found in the Mozambican education sector (among others) during recent years, as discussed in Arndt, Jones, and Tarp (2007).

levels of education in the workforce and the substantial external funding available to the sector. Additionally, and as implied by the growth accounting results, a core challenge will be not only to expand access but also to ensure a high quality of education that meets the needs of modern businesses. It follows that enhancements to labor market efficiency would also contribute to the subsequent allocation of improved human capital to productive employment. The risks to output growth associated with only weak improvements in the quality of human capital are demonstrated by the "weak ΔH" scenario (Table 3.7), which shows negligible growth in human capital quality over the forecast period, simulated by large reductions in the investment parameters within the human capital function. Although this ignores possible wider spillover effects on private investment and productivity growth, the result remains marked: a reduction in annual growth of around 0.7 percentage point compared with the base case is forecast. Thus, continued education and worker training will be a key part of any future growth success.

Unbiased growth

The previous scenario brings into focus an important general point—improvements in any single growth driver are unlikely to sustain rapid growth. This is supported by the final two scenarios in Table 3.7. In each case, they combine a range of moderate changes in relevant directions to the exogenous variables and parameters. The "negative" scenario results in an annual growth rate of 2.7 percent (or 1.0 percent per worker), equivalent to a real increase of only 27 percent in real income per worker during 2004–30. As depicted in Figure 3.4, this would fall far short of a sustained rapid growth trajectory and demonstrates that the policy challenges involved in achieving long-term growth are hardly trivial. In turn, this scenario affirms that the government's target of sustaining annual real growth at 7 percent through 2009 (Mozambique Ministry of Planning and Development, 2006b) cannot be achieved by "business as usual." By the same token, however, there are plausible grounds for optimism. With moderate improvements across the base case exogenous variables and selected parameters, the model shifts into a higher gear that enables the achievement of rapid, sustained growth (also Figure 3.4). Under these positive assumptions, absolute real income per worker is projected to rise more than threefold by 2030, which is equivalent to an annual aggregate growth rate of 7.3 percent (or 4.9 percent per worker). Moreover, the scenario confirms that sustained growth will depend on improvements across all aggregate growth drivers, reaffirming the need for second-generation institutional reforms, sustained public investment, and educational strengthening.

Figure 3.4. Scenarios of Tendencies in Real Income per Worker
(Constant 1980 prices indexed at 2004 = 1; projections cover 2005–30)



Source: Author's calculations.

Lessons for Sub-Saharan Africa

Before concluding, it is relevant to consider what lessons we might draw from this analysis for other sub-Saharan African countries. Despite the difficulty of making meaningful generalizations from country-specific studies, the Mozambican case is relevant from the point of view of illuminating the dynamics of sustained post-conflict growth from an extremely low base. Various sub-Saharan African countries, including the Democratic Republic of the Congo, Liberia, and Sierra Leone, fit this broad description and may wish to replicate certain features of the Mozambican growth experience.

A basic question, however, is whether the Mozambican pattern of growth should be held up as a positive example. If one refers only to the analysis of proximate growth determinants, the response from this study is favorable. The analysis has shown that the pattern of growth in Mozambique has been relatively unbiased, with robust contributions from all growth drivers deriving from both private and public sector activity. At a highly aggregated level, this growth pattern is comparable to episodes of sustained growth observed in other countries, such as the NIEs as well as China and India more recently. This is not to say that at a deeper microeconomic level, Mozambican growth shares similar features with growth in East Asia. Profound differences in industrial structure, export composition, and institutional conditions suggest that such an argument cannot

hold. The message of this study is straightforward but bears repeating: to achieve sustained growth, physical capital accumulation must be accompanied by productivity gains and educational improvements.

A few specific lessons can also be taken from this analysis. First, although there can be high social returns to sustained investments in public goods in settings such as Mozambique, private sector initiative is essential. Thus, raising domestic private savings and attracting foreign investors may be appropriate public policy priorities, as long as backward linkages can be assured. Second, this study has underlined the importance of effective, growth-oriented management of aid-financed public investments. Absorptive-capacity constraints and Dutch disease effects are not immaterial to long-term growth prospects in high-aid settings. Third, early investments in the education system, in both conflict and post-conflict situations, are essential to sustain growth over the long term. Expanding access to education should not, however, be undertaken without paying attention to educational quality or the structure of demand for educated workers. Indeed, the recent evidence for Mozambique indicates that there has been a relatively large contribution from highly skilled workers in particular. Finally, the importance of maintaining the necessary preconditions for growth, such as macroeconomic stability and sound public financial management, cannot be overemphasized. Here the argument for "good" institutions is strongest—promoting a virtuous circle linking institutional improvements to productivity to economic growth may, indeed, be the linchpin of sustained growth.

Conclusion

This chapter has discussed the challenge of sustaining growth in Mozambique. A review of cross-country evidence suggests that, at the policy level, there are no simple rules to follow. Even so, the starting point must be to avoid large-scale economic distortions and political errors that undermine incentives to pursue long-term output growth. Sustained growth episodes are unlikely to depend on one growth driver alone; rather, accumulation of raw factors of production must be accompanied by enhancements in their quality and overall productivity levels. The analysis of Mozambique's past growth performance, based on a rigorous growth accounting framework, suggests that physical capital accumulation has played a fundamental role. Sustained advances in education and improvements in overall factor productivity (residual TFP), however, have generated a relatively unbiased pattern of growth. At a very aggregate

level, this pattern has broad similarities with episodes of sustained growth that have occurred in other countries, such as the NIEs of East Asia. Even so, the estimated gains in Mozambique's factor productivity appear to have been driven largely by postwar recovery in capacity-utilization rates. Consequently, as Mozambique approaches its technology frontier, the task of sustaining strong productivity growth may become more demanding.

Realistic long-term growth scenarios for Mozambique show the sensitivity of future growth rates to current policy challenges. These include sustaining public and private investment, improving average education levels, and minimizing the impact of the HIV/AIDS epidemic. Although foreign aid is likely to continue to play a critical role in support of public spending, the quality of investment will depend on effective management of absorptive-capacity pressures. This means that strengthening government capacity in aid management and expenditure analysis should be given priority. Furthermore, the accumulation of (high-quality) factors of production alone is unlikely to be sufficient to sustain growth. A critical challenge is thus to enhance productivity via technological catch-up and second-generation institutional reforms. Actions to address binding constraints in these areas will be essential to ensuring that the Mozambican success story continues.

Appendix I. Data Series

Human Capital Series

For the human capital series, economically active persons are subdivided into three categories based on their highest level of completed education.[17] These are (1) primary school (either EP1 or EP2); (2) secondary school (ES1 or above); and (3) no formal education. The focus on educational categories takes as its point of departure the assumption that education represents a long-term economic investment; that is, this study assumes a positive relationship among education, economic productivity, and wages (income). International microeconomic evidence generally supports this proposition (for example, Harmon, Oosterbeek, and Walker, 2003), which is confirmed for Mozambique by poverty studies showing a consistent association between higher levels of education and a lower incidence of

[17]This section draws on the human capital stock data in Jones (2006), where the estimation procedure is described in finer detail.

poverty (Fox, Bardasi, and Van den Broeck, 2005; Maximiano, Arndt, and Simler, 2005).

Annual student matriculation figures for the primary and secondary levels (taken from Instituto Nacional de Estatística (INE), 2005) are used to construct perpetual inventory-type stocks similar to those used in estimation of the fixed capital stock. Although methods of this kind are found in the literature for both single- and cross-country studies (for example, Ahuja and Filmer, 1995; Barro and Lee, 1993), they typically require long time-series data on repeat and dropout rates. Although these data are available for recent years in Mozambique, they are not sufficient for the time horizon of interest. Instead, survival probabilities implicit in the data are used, such as the ratio of EP2 to EP1 students,[18] as well as information in education transition matrices estimated in Arndt and Muzima (2004). The latter can be used to determine the likelihood that a given student will repeat, progress beyond, or exit a given scholastic level. Finally, in order to fix the series for each category, concrete data points from the 1997 census and the 2002/2003 household survey are used. These are sufficient to build a consistent time series that reflects the gradual improvements in educational efficiency (lower dropout and repetition rates) recorded over time.

To move from raw stocks to quality-adjusted inputs, it is necessary to focus on value added. The flow of services from a given worker can be described as a function of wages and hours worked. Ignoring the latter for the time being, and following Nehru, Dhareshwar, and Development Economics Department (1994), an aggregate quality-adjusted human capital measure can be defined as the product of the size of the labor force and an index of human capital quality. Formally,

$$W = LH = L\sum_{i=1}^{r} (p_i \varphi_i), \tag{A1}$$

where p_i denotes the share of the total active labor force in category i and φ_i denotes a measure of their average wage relative to a base (unskilled) category. Note that the contribution to changes in this aggregate measure owing to each category can be estimated via a Tömqvist decomposition described in equation (2) in the text.

[18]The abbreviations EP1 and EP2 refer to the two cycles of primary school (Escola Primária); ES1 and ES2 refer to the first of two cycles of secondary school (Escola Secundária) in Mozambique.

In the absence of time-series wage data, household survey evidence is used to measure the consumption premiums associated with different levels of education. Given the existence of numerous nonsalary forms of income, as well as diverse earnings sources, consumption data are generally seen to be a reliable guide to well-being in developing countries (Ravallion, 1992). One can further assume that consumption is a good proxy for differences in hours worked; in other words, consumption is a final outcome variable that is, among other things, a function of hours worked and income earned. On this basis, the productivity increment owing to education can be estimated from a Mincerian-type regression in which consumption is regressed on the level of education and a vector of control variables.[19] Although time-series data are not available to evaluate whether these consumption premiums have moved over time, the household survey undertaken in 1996/97 indicates that, at least through 2002, they have remained broadly stable. Also, during the 1980s, despite greater scarcity of educated workers, socialist wage and price controls are likely to have dampened wage differentials. As a result, it is reasonable to assume that relative productivity differences owing to education have remained stable over time. This refers only to the relative increment and not the wage rate per se.

Physical Capital

The total physical capital stock is disaggregated into government and private sector components. Consistent with other studies, real capital stocks are estimated by means of the perpetual inventory method, which requires estimates of gross investment, the rate of stock depreciation, and a starting value. Investment data are taken from official government statistics at an economy-wide level, while government budget execution accounts give the public sector component (INE, 2005). Gross private sector investment can thus be calculated as the residual. Note, however, that government investment has been largely dependent on external aid throughout the period, and a substantial portion of this aid has not been

[19]The results are based on the most recent nationally representative household survey (2002/03) and are highly comparable to findings from similar regressions on the same data set (for example, Fox, Bardasi, and Van den Broeck, 2005). Note that the consumption indicator is available only for households, while the education measure is available for individuals. This represents a source of bias in the results for which no adjustment is attempted. The estimates used here are given by the simple average of results from individual- and household-level regressions. See Jones (2006) for further discussion.

registered in the government accounts. Estimates in Arndt, Jones, and Tarp (2007) suggest that, even in recent years, official figures for aid to the public sector are underestimated by at least 10 percent and, further, exclude the investment (activities) of the large number of nongovernmental organizations (NGOs) that support public service provision. To adjust for these errors, official investment figures are therefore inflated by a factor of 10 percent.

To estimate the share of these sectoral stocks in capital's total value added, social accounting matrices (SAMs) developed in the postwar period (see the subsection "Results" under "Accounting for Mozambican Growth" above) indicate that private sector profits constitute about 40 percent of total payments to capital. On this basis, the capital series is initialized assuming the weights of the public and private sectors in total capital are both 50 percent. This is a plausible assumption, given the adoption of socialist central planning at that time and, thus, the widespread nationalization of economic production. Over time, these weights are adjusted according to the respective size of each stock in total physical capital. This results in a private sector share of about 42 percent for the postwar period, which is consistent with the SAM findings.[20] Appendix II, Cointegration Technique, describes the method used to complete the physical capital stock series.

Appendix II. Estimation

Cointegration Technique

To estimate the critical parameters needed to complete the physical capital stock series (namely the starting value, the rate of depreciation, and its aggregate share in value added), the cointegration technique applied to Uganda in IMF (2005) is followed. This is based on the two-step cointegration procedure set out in Engle and Granger (1987). As an extension to the former study, however, the depreciation rate is not fixed but rather is permitted to follow a time trend (slope).

Formally, an iterative procedure is run to select values for d, d_0, and K_0 that maximize the significance of the Engle and Granger test statistic calculated from the residual series e_t, defined from

$$\ln Y_t = \ln A_0 + ct + a \ln K_t + (1 - a) \ln W_t + e_t, \qquad \text{(A2)}$$

[20]Simulations indicate that the growth accounting results are largely insensitive to moderate changes in these underlying assumptions.

$$K_t = I_t + K_{t-1}(1 - d_0 + dt). \quad \text{(A3)}$$

In estimating equation (A2), trend TFP growth is allowed to vary between the civil war and postwar periods. The resulting error series e_t thus gives short-term variations in output unexplained by either trend TFP growth or changes in the other variables.

Capacity Utilization

Capacity utilization can be defined generically as the ratio of actual output (Y) to potential output (Y^*). An economic definition of Y^* is the level of output that corresponds to competitive equilibrium, assuming that technology and the capital stock are (quasi-)fixed inputs (Berndt and Fuss, 1989). Thus, when the ratio Y/Y^* is unity, the firm faces no incentives to alter its fixed capital stock, since both short-run and long-run marginal costs are tangential. Given that this definition focuses on new investment (or divestment), at an aggregate level it is plausible to use movements of the output-capital ratio around its long-term trend as a proxy for changes in capacity utilization. This derives from the well-known property of a stable output-capital ratio in neoclassical growth models under steady-state growth, which is also reflected in the projections model described in Appendix III. Even where productivity is improving, consistent with an upward trend in Y^*/K_t, short-run variations around the trend can be interpreted as indicative of changes in capacity utilization rather than in productivity. Obviously, this assumes that competitive conditions prevail and that changes in productivity (or TFP) are relatively gradual, thus generating a smooth underlying trend in the output-capital ratio.

Two steps are required to estimate the contribution of changes in capacity utilization to changes in residual TFP. First, define

$$\Delta u_t - (Y_t/K_t) - \psi_t, \quad \text{(A4)}$$

where u_t denotes a proxy measure of capacity utilization and ψ_t refers to the long-run (optimal) output-capital ratio calculated by applying a Hodrick-Prescott filter to the observed historical series.[21] Second, undertake a simple regression of the relationship

$$\Delta A_t = c_0 + \gamma_0 \Delta u_t + e_t, \quad \text{(A5)}$$

[21]The smoothing parameter is chosen as $\lambda = 400$, which is 25 percent of the default value for quarterly data.

where c_0 denotes the intercept and e_t the residual error. Assuming the coefficient on Δu_t is positive and significant as desired (and the overall model is meaningful), the null hypothesis of no relationship between TFP and capacity utilization can be rejected. In turn, the remaining unexplained variation in ΔA can be interpreted as indicative of deep movements in TFP arising from technological innovation and other factors. Finally, as with the overall residual TFP series, changes in deep TFP can then be split into civil war and postwar trends as well as remaining noise.

Appendix III. Projections Model

Macroeconomic Framework

For the projections model, a behavioral side is added to a growth accounting framework. Thus, consider the standard Cobb-Douglas aggregate production function where A denotes a Hicks-neutral efficiency parameter, K denotes physical capital, L denotes the labor force, and H a labor force quality (education) index. Ignoring prices, real output per worker is given by

$$Y/L = y = A(k)^a(H)^{1-a}, \tag{A6}$$

where k denotes the capital-labor ratio (K/L). Thus the growth rate of per capita income, Δy, is defined as:

$$\Delta y = \Delta A + a\Delta k + (1 - a)\Delta H. \tag{A7}$$

Recognizing that $\Delta k = \Delta K - \Delta L$, and following the standard practice of defining the net change in capital as the sum of government and private sector investment *minus* depreciation, that is, $(g + p)Y - dK$, one can restate the model as

$$\Delta y = \Delta A + \Delta H + a[(g + p)\psi - d - \Delta L - \Delta H], \tag{A8}$$

where g denotes government investment as a ratio of GDP, p denotes the investment ratio of the private sector (including FDI), d denotes the rate of capital depreciation, and ψ denotes the aggregate output-capital ratio.

Behavioral Dynamics

To add a behavioral side, the following variables are added: the natural rate of labor force growth (n); the proportion of the labor force infected

with HIV/AIDS (v); the level of foreign aid in GDP (x); domestic government revenue as a ratio of GDP (r); the government's investment share (j), representing the proportion of total government revenue channeled to investment activities; foreign direct investment in GDP (z); inflation (i); an exogenous component of TFP growth ($\bar{\Delta}A$); and a proxy for absorptive-capacity constraints related to external aid (f). Ignoring time subscripts for the current period, the following relationships are then defined:

$$f = x/(g + p) \tag{A9}$$

$$\Delta L = \min(n, n^*) \tag{A10}$$

$$g = j\,(r + x)(1 - v) \tag{A11}$$

$$p = (z + \rho_0 \Delta Y_{t-1} + \rho_1 g + \rho_2 f + \rho_3 i)(1 - v) \tag{A12}$$

$$\Delta H = (\eta_0 g + \eta_1 p + \eta_2 f)(1 - v) \tag{A13}$$

$$\Delta A = \bar{\Delta} A - 0.5 v \Delta A_{t-1}. \tag{A14}$$

Econometric calibration of the model is discussed in the text section "Toward Sustained Growth" in subsection "Model Calibration." Note that the inclusion of HIV/AIDS effects in equations (A11) through (A14) essentially follows the empirical approach set out in Haacker (2002). Note that growth in human capital quality is affected, both directly and indirectly, by HIV/AIDS prevalence—the indirect effect occurs through changes in investment, while the direct effect refers to the productivity loss owing to increased illness and reduced average experience in the workforce. The impact of HIV/AIDS prevalence on labor force growth in equation (A10) is modeled as the lower value of the labor force growth rate unadjusted for HIV/AIDS effects (n) and an estimated adjusted rate (n^*). For the latter, an econometric estimate of the relationship $n^* = \beta_0 v + \beta_1 n$ is made (for 1998–2010), taking the dependent variable as the official forecast for labor force growth adjusted for the base case HIV/AIDS prevalence. Both parameters are significant at the 1 percent level, with $\beta_0 = 0.15$ and $\beta_1 = 1.6$.[22] Note, however, that since this is not a formal economic relationship, these parameters are not included in the sensitivity tests (also the section "Toward Sustained Growth"). Two further fixed modeling assumptions can be noted. First, physical capital depreciation d

[22] Since the model is implemented in discrete time, the increment to capital in time t refers to savings made in the previous period.

is set at 7 percent, which is the average rate for the past 5 years estimated in the cointegration exercise. Second, the share of physical capital in total product *a* is estimated at 35 percent; this is slightly higher than the historical growth accounting estimate, but reflects the substantial capital deepening that has accompanied postwar growth (see the subsection "Postwar Recovery" in the text).

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