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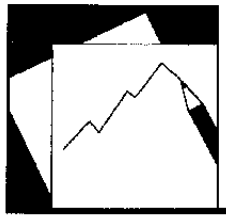

IMF Working Paper

The Macroeconomic Impact of HIV/AIDS in Botswana

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The Macroeconomic Impact of HIV/AIDS in Botswana

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Abstract

This paper provides an overview of the potential macroeconomic effects of HIV/AIDS in Botswana, focusing on the key channels through which the pandemic is likely to affect the economic outlook and on the uncertainties involved. To estimate the impact of HIV/AIDS, a dual-economy equilibrium model is constructed and simulated under different scenarios. Depending on exactly how AIDS affects the outlook, GDP growth is projected to fall from around 5½ percent a year without the pandemic to between 1½ and 2½ percent a year with AIDS. Non-negligible redistribution effects across sectors and labor skill categories are also likely to arise. Finally, the paper draws attention to the potential effects of HIV/AIDS on the long-term fiscal position of Botswana, highlighting the need for increased international support and/or lower drug prices so that the widespread introduction of anti-retroviral drug treatments is feasible.

JEL Classification Numbers: O41, O55, J11

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I. INTRODUCTION

The HIV/AIDS pandemic in sub-Saharan Africa and other parts of the developing world threatens to be a humanitarian and economic catastrophe of almost unprecedented proportions. The closest parallels in terms of disease-driven disasters may be found in the outbreaks of bubonic plague in the fourteenth century.[2] From a broader perspective, comparisons could also be drawn with the major wars and political purges of the twentieth century. In Botswana—the country with the highest HIV prevalence rate, according to official data—the unfolding disaster now overshadows what should otherwise be seen as an African success story, especially in terms of prudent resource management and well-directed economic development.

A few indicators illustrate the scale and implications of HIV/AIDS in the case of Botswana:

- Recent estimates indicate that nearly 300,000 of the 14-49 year old population—36 percent of this group—are infected with HIV.

- Life expectancy has fallen sharply: by some estimates, this has declined from 60 years in 1990 to 40 at present, and is projected to fall to under 30 by 2010.

- The death rate per thousand population has accelerated from 15 in 1990 to 30 in 2000, and is projected to reach 45 by 2007; in the absence of AIDS, the "normal" death rate would have declined steadily to around 11 per thousand over this period.

- On current projections, by 2010 two children out of five would be orphans—totaling more than 200,000 orphans.

Far from being a somewhat abstract and distant threat, the effects of the pandemic are increasing evident in the day-to-day life and planning of individuals and organizations. Few families appear untouched, with extended family structures called on to provide care and

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[2] Even this analogy is weakened by the fact that the bubonic plague hit unexpectedly (albeit repeatedly), with each outbreak exacting a heavy death toll within a short space of time. In contrast, the onset of AIDS for HIV-positive patients follows with a substantial lag (usually of eight to ten years) but with a high degree of certainty for those without access to anti-retroviral drug treatments. As discussed in the paper, the drawn-out impact of HIV/AIDS may have important implications for social and economic behavior. For discussion of the bubonic plague, including some parallels with AIDS, see McNeill (1998). The impact of the plague is also discussed in Tuchman (1978).

support. The frequency of funerals, dominated by those of the young, has increased sharply.[3] Rising death rates threaten the provision of key public services; for example, the death rate among primary teachers has increased tenfold since 1994, from 0.7 to 7 per thousand, and around 100 agricultural extension officers out of 3,000 were lost to AIDS in 1999. Institutions in the private sector report various measures to protect their operations, including the requirement of AIDS insurance by banks as part of their lending and a buildup of skilled personnel in various organizations as a buffer against expected losses.

The human consequences of AIDS will become worse, at an accelerating pace, over the next few years. While there is inevitably some uncertainty about how much wider the pandemic will spread, and how quickly it will pass, the future of those currently infected with HIV is tragically predictable and unavoidable. As discussed below, current treatment options—that is, those that are both available and affordable—may help reduce new infections, provide greater comfort for the sick, and delay death in some cases. But premature death, generally within around 10-12 years of initial infection, is nevertheless almost certain for those currently afflicted in the absence of advanced treatment.

There is substantial uncertainty, however, about the macroeconomic impact of HIV/AIDS, the focus of this paper. These economic implications are the subject of a growing literature of country-specific and more general studies, many of which draw on demographic projections and a range of other assumptions to model the long-term impact of HIV/AIDS on GDP, GDP per capita, and related variables.[4] Such a model is also included in the current paper. As in other work in this area, particular attention is paid to the sensitivity of model results to variations in the underlying assumptions. A key concern in this regard is to reflect in model simulations what might happen if the approaching acceleration in AIDS-related deaths leads to profound change in social and economic conditions—including, for example, a collapse of domestic and external investor confidence. With few if any historical parallels to draw on, the ability of Botswana (or any other economy) to withstand a shock of the magnitude of the AIDS disaster will be unclear for some time.

The paper is organized as follows. Subsection B provides an overview of the macroeconomic effects of HIV/AIDS, focusing on the key channels through which the pandemic is likely to affect the macroeconomic outlook and on the uncertainties involved. Subsection C presents model-based estimates of the impact of HIV/AIDS on output and other key macroeconomic variables. The potential effects of HIV/AIDS on the long-term fiscal

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[3] For example, funerals in rural villages (where one-half of the population resides) now commonly occur throughout each weekend and may soon spread into weekdays, rather than being Saturday-only ceremonies as in the past.

[4] See references cited in Subsection C.

position of Botswana are considered briefly in Subsection D, and Subsection E concludes. Details of the theoretical model and of the data are given in the Appendix.

II. Macroeconomic Overview of the Implications of HIV/AIDS

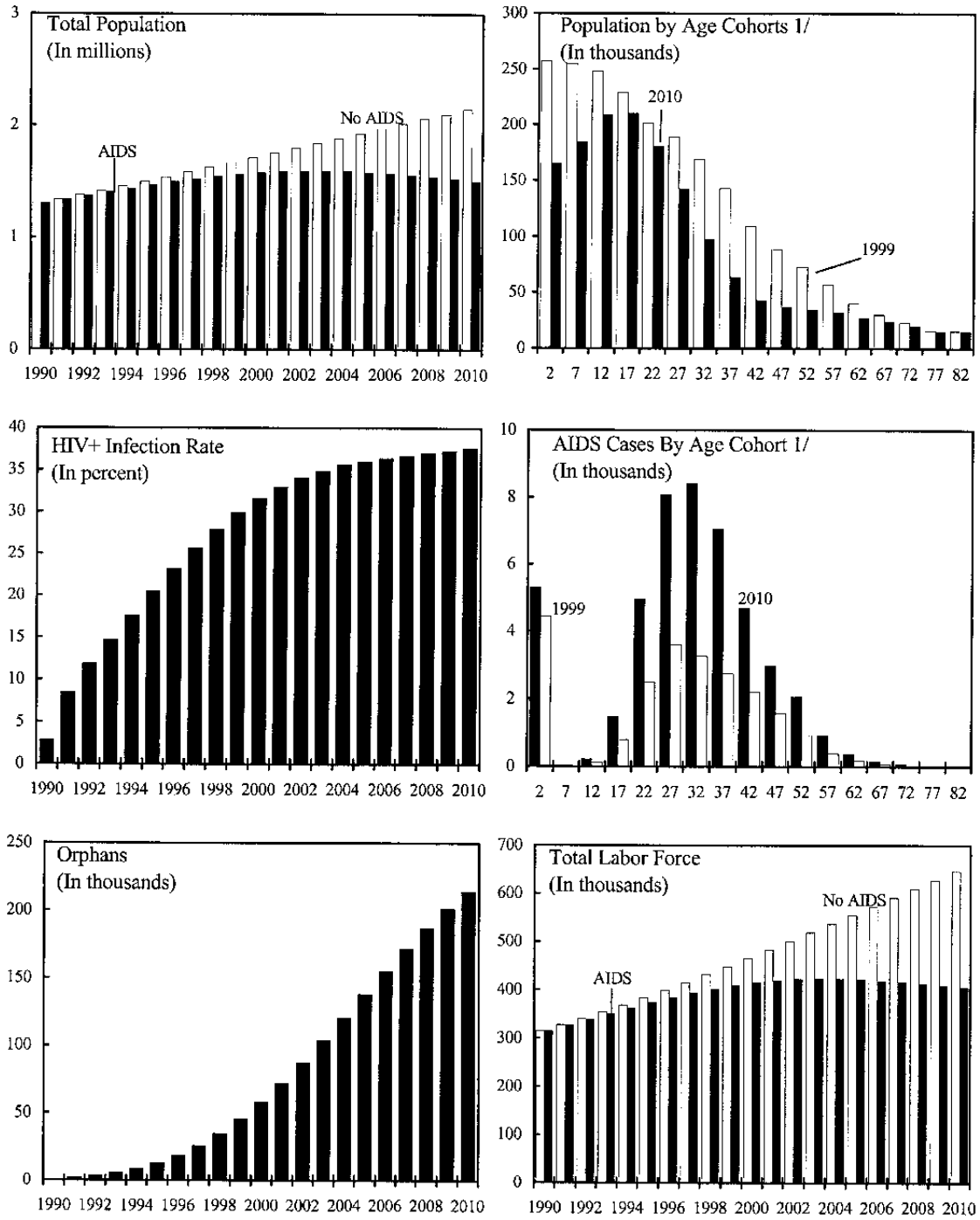
As noted above, there is now a rather substantial literature applying standard models of economic growth to an assessment of the long-term effects of HIV/AIDS on economic performance, particularly in sub-Saharan Africa. In the specific case of Botswana, for example, a recent comprehensive report by the Botswana Institute for Development Policy Analysis (BIDPA, 2000) applies a Cobb-Douglas model to derive projections of the effect of HIV/AIDS on aggregate and per capita output out to 2021, on the distribution of income among different groups, and on the long-term fiscal position of Botswana. These results are drawn on and, in some cases, updated and extended in the current paper, using a similar framework. This approach focuses, therefore, on the possible effects of HIV/AIDS on the medium- to long-term productive capacity of the economy.[5] Several channels of influence can be identified, including the impact on labor supply, on saving and investment, on financial intermediation, and, more broadly, on prospects for economic diversification. These linkages are considered briefly in the following sections.

A. Impact on labor supply

HIV/AIDS will have a dramatic effect on labor supply in Botswana, and hence on the economic outlook more generally. Demographic profiles incorporating the effects of HIV/AIDS indicate that the total population and labor force will start declining later this decade as the HIV infection rate and AIDS cases continue to climb, whereas the labor force would have increased substantially in the absence of AIDS (Figure 1). The effects of the pandemic on productivity and human capital are also likely to be significant. Productivity will suffer as a result both of AIDS-related health problems among workers themselves—leading, for example, to increased sick leave, reduced work intensity, and increased labor turnover—and as individuals take time away from work to care for sick family members, attend funerals, and meet other such responsibilities. The prospects for growth and diversification in Botswana will be set back by the loss of skilled labor—a particularly serious concern, given that skill shortages are already problematic and that there is probably limited scope for substitution using unskilled labor, which is currently in excess supply. While the relative returns to investment in skills and training are likely to increase, this trend could well be dominated by the weakening in incentives and opportunities for such investment that would arise from a combination of sharply reduced life expectancies, a

[5] Demand-side effects, such as might arise from changes in consumer or investor confidence, are usually handled by varying the associated model parameters (e.g., for saving and investment rates) rather than by being modeled explicitly, but this is clearly an area where there is scope for further extensions and elaborations of the models involved.

Figure 1. Botswana: Selected Demographic Indicators, 1990-2010



Source: ABT Associates, South Africa; and Fund staff estimates.
1/ For each age cohort the horizontal axis reports the corresponding median age.

decrease in general economic confidence, and potential shortages of personnel able to provide training.[6]

B. Impact on saving and investment

A further key channel for the macroeconomic impact of HIV/AIDS may come through saving and investment. With national saving currently exceeding investment by a substantial margin, as reflected in a high and rising level of foreign exchange reserves, Botswana does not face the same degree of financing constraint on investment as other African countries. How long the current situation will prevail is unclear. Overall, the risks for both the saving and the investment outlook are probably on the downside, although not necessarily to the same degree.

On the saving side, changes in the sectoral composition of growth—involving, in particular, lower growth in the high-saving mining sector, partially offset by stronger growth in nonmining areas—would likely lead to lower private saving in the period ahead. Adding in the effects of HIV/AIDS, saving is likely to decline further as a share of GDP (see Section III). There is some evidence, more generally, that the saving rate in developing countries may be negatively related to the HIV prevalence rate.[7] Considering private saving, while some people (notably those with scarce skills and rising earnings) may be able to increase their saving, the bulk of households will probably be compelled to reduce both saving and non-AIDS related consumption in order to finance additional health care costs, cover the costs of additional dependents, and meet other adverse effects of AIDS on family expenditure or income. Public saving will almost certainly decline as a share of GDP, particularly as a result of increased government spending on health and various forms of social support. On the assumption that anti-retroviral drug treatments (ARTs) are *not* made generally available, BIDPA (2000) finds that national saving would probably still be largely enough to finance the current rate of investment (around 25-26 percent of GDP). Potential financing constraints could be further eased by drawing on Botswana's unused international borrowing capacity and its foreign reserves.

The outlook for saving and investment is uncertain, however. HIV/AIDS may significantly change investment prospects. Shortages of skilled labor, and its higher cost, would tend to increase the demand for investment at a given level of output. But this may

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[6] Anticipating losses among current personnel and growing difficulties in finding replacements, several companies report that they are building up a buffer stock of skilled labor, and an accountancy college has doubled its student intake (apparently with sizable AIDS deaths expected among future graduates).

[7] World Bank (2000).

well be offset by the negative effects on investment resulting from the impact of AIDS on economic growth, on confidence, and on other aspects of the investment climate. The impact of HIV/AIDS on health care spending and hence on saving may be more severe than suggested above, particularly as estimates of HIV prevalence rates have increased substantially since the BIDPA study.

The outlook for saving would be further affected by the widespread introduction of ARTs. The government has recently signaled its intention to make such treatments generally available to HIV+ patients, a move made possible in part by the significant lowering in drug prices by some of the major pharmaceutical companies together with the possible use of generic alternatives. Even at sharply lower prices, however, the introduction of ARTs could pose a substantial fiscal burden—largely as a result of the sheer number of patients that would potentially be eligible, coupled with the fact that these treatments represent ongoing, lifetime expenditures rather than once-and-for-all outlays. Furthermore, substantial investment in upgrading and extending the health sector infrastructure would be required in order to support the relatively sophisticated monitoring and treatment regimes that are needed to make ARTs fully effective (including preventing drug-resistant strains of the HIV virus from developing). Overall, bringing ART costs within manageable levels would require a combination of increased international support, including recently announced and possibly further reductions in drug prices, combined with restraint in nonpriority areas of the domestic budget. Exploring the details of these support measures is beyond the scope of this paper, but the composition of such a package would clearly have a significant influence on the outlook for the fiscal position, national saving, the external balance, and other macroeconomic variables.

C. Impact on the banking sector

The banking sector in Botswana also faces a range of potential pressures as a result of HIV/AIDS. These could include possible increases in loan losses, as mortality rates rise among borrowers, and business sector difficulties—including in the banking sector itself—as a result of skill shortages. Several factors would tend to mitigate these concerns, however. First, with substantial foreign ownership, the banks have access to a wider base of funding and expertise than would be available to purely domestically owned and operated banks. Second, banks' business lending is concentrated in a few large corporations (including some multinationals) and parastatals, rather than spread over a wide range of small and medium-sized enterprises. To the extent that this lending (especially to parastatals) could carry explicit or implicit government guarantees, banks' own exposures to corporate financial difficulties may be limited. Third, risks associated with personal loans to public sector and parastatal employees (who total nearly one-half of formal employment) appear to be reduced through automatic source deductions of loan payments and, in at least some cases, through a

form of guarantee.[8] Fourth, banks now require that unsecured personal lending be backed by AIDS insurance.[9] Given the uncertainties over current and future HIV prevalence, this insurance should help to transfer the associated financial risks not just outside the banking sector but also outside Botswana, as at least some of the insurance carriers are part of large international groups.

Nevertheless, some important risks and uncertainties remain. There may be sizable moral hazard problems arising from the loan insurance and guarantee schemes, particularly in a context where AIDS is leading to a significant drop in the life expectancy of those affected. With many individuals apparently already over-leveraged,[10] and banks not fully insulated against loan losses (for example, the public sector guarantee appears be limited to 80 percent of each loan), banks may still have substantial exposure to future defaults. Such difficulties could be exacerbated if companies providing AIDS insurance have underestimated the scale of the pandemic. A further uncertainty arises from the future path of national savings and, hence, the extent of banks' ability to provide intermediation services. While banks are currently awash with liquidity (as indicated by their extensive investment in Bank of Botswana certificates), this situation could turn around if saving—both private and public—diminishes as a result of an AIDS-induced economic slowdown and sharply increased spending on health care. As noted above, increased skill shortages may also constrain banks' ability to provide a full range of services and increase their costs. Indeed, some banks already report difficulties in attracting a full complement of staff, and the costs of medical insurance, pensions, and other benefits are rising rapidly.[11]

D. A broader outlook: prospects for economic growth and diversification

Given the enormity of the human problem arising from AIDS, the macroeconomic effects of the pandemic—as suggested by most recent studies and the current paper—could be viewed as surprisingly modest. In the BIDPA analysis, for example, GDP growth in Botswana declines by 1 to 2 percent a year as a result of AIDS. Using more recent demographic projections that incorporate higher rates of HIV prevalence, the current paper

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[8] The extent of and basis for these guarantees is not entirely clear, but it appears that the loans are backed in some cases by future pension rights and other benefits accruing to the borrower.

[9] One estimate indicated that this insurance cost 500 Pula per year on a 10,000 Pula personal loan (i.e., equivalent to an additional 5 percentage points on the loan rate).

[10] This observation is based on discussion with the individual banks.

[11] For example, supplementary medical insurance premia have reportedly increased by over 40 percent over the last three years.

estimates that nonmining GDP growth would fall by 3 to 4 percent a year on average over the coming decade (see Section III). Nevertheless, it may be surprising that output and incomes continue growing at all when one-third to one-half of the current working age population is expected to die within about ten years.

One perspective on this concern is that Botswana may be relatively well-placed economically to withstand the human devastation imposed by AIDS, at least compared with other sub-Saharan African countries. Around 60 percent of GDP is generated through the mining sector, itself accounting for 30 percent of output, and the public sector (including utilities and public sector construction). These activities provide a strong and reasonably robust base for the economy, particularly given that the mining sector is not a large employer (with total employment of only around 8,000 people) and hence may be less susceptible to future skill shortages than growing and/or more labor intensive sectors.

However, both mining and government appear unlikely to be major sources of future growth—or at least, not as important as in the past. Mining production is now plateauing, with little additional capacity planned, so that the sector will not add significantly to economic growth directly or indirectly (e.g., through the government sector). The need for diversification, involving private sector development and drawing on foreign investment and expertise, is therefore widely recognized. But prospects of moving toward a more diversified economic structure would appear to be particularly threatened by HIV/AIDS. Three reasons can be noted. First, as argued above, AIDS is likely to aggravate current skill shortages, reduce human capital investment, and hence add to the difficulties already apparent in the economy in supporting a wider range of activities. Second, the climate for physical investment—both from domestic sources and drawing on foreign capital—may deteriorate markedly as the impact of AIDS takes its toll on economic activity and confidence. Third, a less tangible but possibly significant risk could come from a broader weakening in the fabric of society as mortality rates, orphan numbers, dependency ratios, and other sources of social pressure rise to unprecedented levels.

The model simulations reported in the next subsection address some of these concerns. Attention is given, for example, to the macroeconomic implications of a larger shock to productivity and investment than assumed in previous estimates of the effects of AIDS (including the BIDPA analysis). From this perspective, the model assesses the impact of AIDS on the economy under different hypothetical scenarios accounting for:

- a permanent decline in the rate of capital inflows;
- a permanent decline in the rate of capital accumulation;
- a permanent decline in total factor productivity; and
- greater losses of working time associated with each AIDS case.

III. Modeling the Economic Impact of AIDS

A. The model

The theoretical framework adopted in this paper closely follows earlier attempts to model the macroeconomic impact of AIDS.[12] It is based on a Solow growth model that has been modified to allow for two sectors (formal and informal) and two labor skill categories (skilled and unskilled). These enhancements allow the model to take into account key features of Botswana's economy, namely, the shortage of skilled labor and a high capital intensity in the formal sector.

The two sectors are characterized by Cobb-Douglas production functions. Each exhibits constant returns to scale in which output is calculated as a function of inputs (labor and capital) and productivity. Theoretical details of the model, its parameters, and data sources are discussed in the appendices.

The model comprises three labor markets: skilled labor in the formal sector, unskilled labor in the formal sector, and unskilled labor in the informal sector (all skilled workers are assumed to be employed in the formal sector). The three labor markets behave differently. In the skilled formal market, wages adjust to equate demand and supply. In the unskilled formal sector there is a fixed minimum wage, which is assumed to be higher than the equilibrium wage. As a result, unemployment arises among unskilled workers in the formal sector. These unemployed workers make up the supply of labor in the informal sector, where market forces operate to equate demand and supply.

The model incorporates the impact of AIDS on the economy in several ways:

- The major and most direct effect of the pandemic is captured by the change in the size and age structure of the labor force.
- The model takes into account lower productivity of AIDS-affected workers by measuring effective labor supply in terms of efficiency units.
- AIDS-related health spending is assumed to affect both consumption and saving behavior and, therefore, capital accumulation. Following Cuddington and Hancock (1995), increases in health care expenditures are assumed to be met by reductions in

[12] Among the recent studies that have attempted to calibrate the effect of HIV/AIDS on economic growth, see Over (1992), Arndt and Lewis (2000), Bonnel (2000) and ING Barings (2000) for South Africa; Cuddington (1993) for Tanzania; Cuddington and Hancock (1995) for Malawi; BIDPA (2000) for Botswana; and Haacker (2000) for a cross-country analysis.

saving (80 percent) and nonhealth consumption (20 percent). Capital formation in the informal sector is assumed to be limited by the amount of saving generated in the sector itself. By contrast, investment in the more capital-intensive formal sector can make use of domestic and foreign saving. The model also provides for transfers from the formal sector to the informal sector to support health care spending in the latter.

The model is calibrated to reproduce the actual values of nonmining output and other key variables for 1998/99. It focuses on the nonmining sector to avoid special features associated with diamond production—including the fact that the diamond industry, with its small number of workers and high capital intensity, would be less affected by AIDS than other industries. The main demographic data and projections that underlie model results are shown in Figure 1.

B. Simulation results: AIDS scenario versus a counterfactual no-AIDS scenario

This part of the paper develops scenario projections of key macroeconomic variables under alternative AIDS assumptions, including a no-AIDS counterfactual scenario. The model provides equilibrium levels and growth rates for nonmining output, capital stock, consumption, AIDS-related health spending, and output per worker in both formal and informal sectors up to 2010. Furthermore, it generates outcomes for employment and wages for skilled and unskilled workers over the same simulation horizon. It also permits changes in key parameters to test the sensitivity of results to assumptions on indirect AIDS effects, including its impact on labor efficiency and foreign investment.

The no-AIDS counterfactual scenario

Under the assumption of no AIDS, nonmining GDP would grow at an annual rate of 5.7 percent between 1999 and 2010 (or 2.2 percent in terms of output per worker), leveling off at a rate of 5.2 percent toward the end of the simulation horizon (Table 1, Table 2, and Figure 2). Capital accumulation is the main contributor to output growth over the period, reflecting the large capital share that is assumed to characterize the formal sector and this sector's 92 percent share of the nonmining economy.[13] Labor's contribution to growth diminishes over the period because growth of the working-age population would have slowed even without the AIDS crisis.

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[13] Whereas the formal sector features a capital-output ratio close to 2 and a capital share parameter of 0.80, the informal sector is assumed to be highly labor intensive, with a capital-output ratio around 0.97 and a capital share parameter of 0.05. Total factor productivity (TFP) is also assumed to grow at different rates in the two sectors: 0.4 percent in the formal sector and 0.05 percent in the informal sector. This seems to be broadly consistent with the duality of the Botswana economy and the binding labor constraints characterizing its formal sector.

Growth in the formal sector (5.8 percent) is faster than in the informal sector (3.6 percent), as the rate of capital accumulation is substantially higher in the former (4.7 percent versus 0.2 percent). Total employment grows, on average, by 0.8 percent, with skilled labor accounting for two thirds of employment growth in the formal sector. Wages increase in both sectors and for both skill categories, at rates mainly reflecting the different pace of growth characterizing the two sectors.

The AIDS baseline scenario

The AIDS baseline incorporates the projected effects of AIDS on the population and labor force. With AIDS, growth in the nonmining economy would slow to 2.4 percent a year over the period 1999-2010 and stabilize at 1.4 percent in 2010, compared with 5.2 percent in the no-AIDS scenario (Table 1, lower panel and Table 3). This reduction in economic growth comes mainly through two channels. First, with AIDS, both national consumption and national saving are assumed to fall in order to finance AIDS-related care. As a consequence, capital accumulation would slow and its contribution to growth would diminish to about 1.2 percent a year—almost 3 percentage points below the no-AIDS counterfactual. Second, the direct impact of AIDS on Botswana's labor force would cut nonmining growth by about 1 percent, compared with the no-AIDS counterfactual. The overall projected reduction in economic growth due to AIDS—around 4 percentage points—is larger than in the BIDPA (2000) study because the estimated prevalence of HIV/AIDS in Botswana has increased since the BIDPA study was prepared.[14] In addition, the current model incorporates the feedback effects of lower saving on capital accumulation and, therefore, on potential output growth. Estimates in Arndt and Lewis (2000) suggest that the implications of HIV/AIDS for growth prospects in South Africa may be broadly similar to those for Botswana found in the current paper.

AIDS is likely to affect the formal and informal sectors differently because of differences in capital intensity. In the formal sector, the impact of AIDS through the capital accumulation channel can be expected to outweigh the impact through the labor force channel, because this sector is capital intensive. Therefore, and because capital accumulation remains positive throughout the simulation period while the labor force declines, the formal sector expands over the simulation period, albeit at a much reduced pace. By contrast, the decline in labor supply growth—eventually turning negative—in the AIDS scenario has a larger impact on output in the labor-intensive informal sector. Output in this case falls off at the end of the period, as the number of workers in the economy begins to decline.

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[14] A 4 percentage point reduction in nonmining growth implies approximately a 2.8 percentage point reduction in total economic growth (4 percentage points times the 70 percent share of nonmining activity in the economy).

Labor productivity developments also reflect differences in the two sectors. Formal sector productivity is higher in the AIDS scenario than in the no-AIDS counterfactual because the capital-labor ratio rises under the impact of AIDS. In contrast, labor productivity in the informal sector is slightly lower in the AIDS scenario because the capital-labor ratio declines compared with the no-AIDS case. In consequence, and because wages are driven by labor productivity, the model suggests that AIDS would widen both the wage gap between skilled and unskilled workers in the formal sector and the wage differential for unskilled labor between the two sectors.

Table 1. Botswana: Alternative AIDS Scenarios, Selected Years 1/
(Contributions to output growth, percent)

A. No-AIDS counterfactual scenario

	TFP	Labor Efficiency	Labor	Capital	Nonmining Output
1999	0.38	0.00	0.94	4.81	6.14
2001	0.38	0.00	0.90	4.72	6.01
2003	0.38	0.00	0.86	4.60	5.85
2005	0.38	0.00	0.81	4.49	5.69
2007	0.38	0.00	0.76	4.31	5.47
2010	0.38	0.00	0.69	4.12	5.20

B. AIDS baseline scenario

	TFP	Labor Efficiency	Labor	Capital	Nonmining Output
1999	0.38	-0.10	0.45	3.10	3.82
2001	0.38	-0.13	0.26	2.72	3.23
2003	0.38	-0.13	0.06	2.23	2.54
2005	0.38	-0.13	-0.13	1.75	1.87
2007	0.38	-0.05	-0.19	1.40	1.54
2010	0.38	-0.05	-0.22	1.28	1.38

Source: Fund staff estimates.

1/ Output values calibrated on non-mining GDP, constant prices 1998.

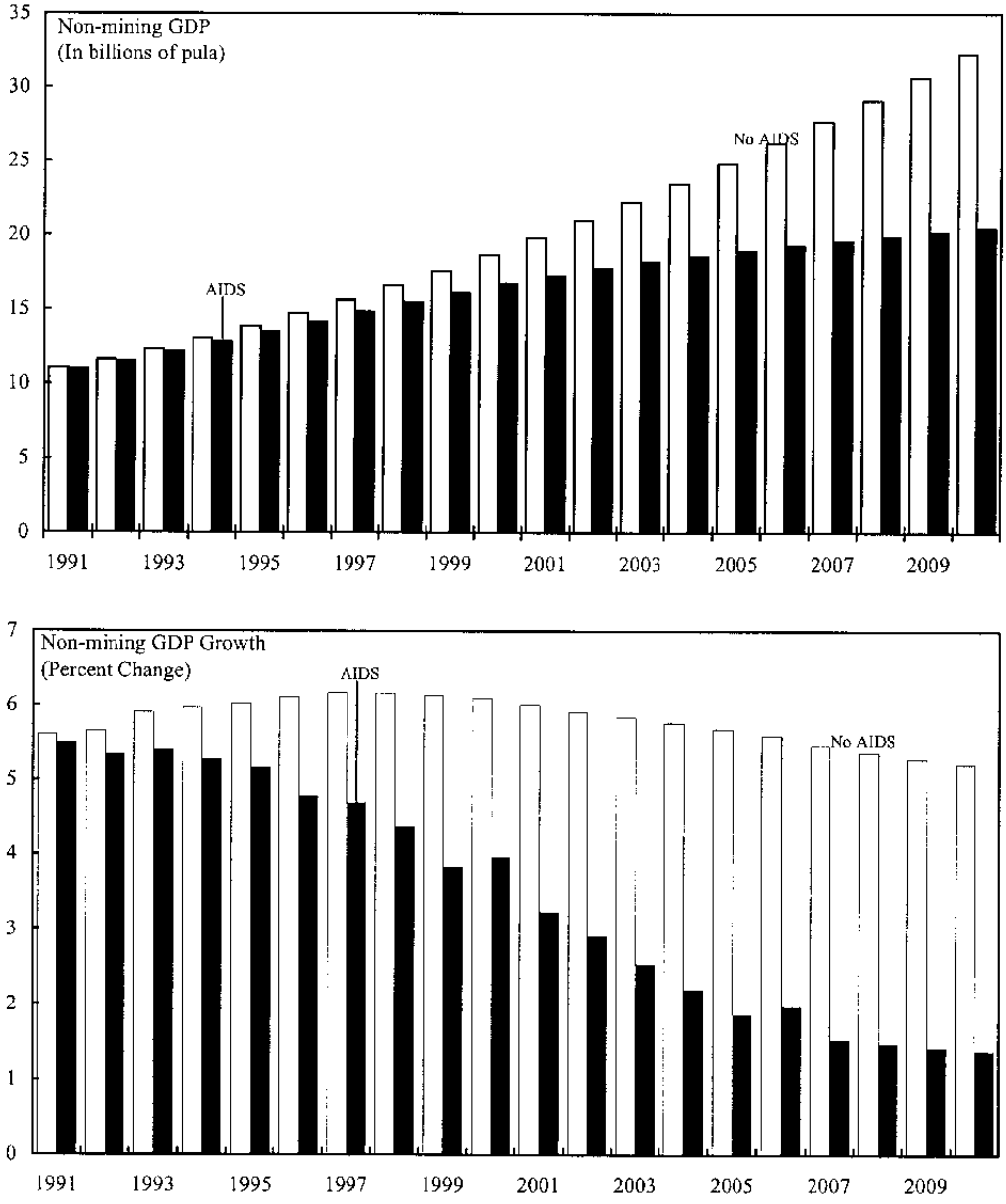
Table 2. Botswana: No-AIDS Counter factual Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	6.14	6.01	5.85	5.69	5.47	5.20	5.70
Formal sector	6.25	6.12	5.96	5.80	5.58	5.31	5.81
Informal sector	4.12	3.95	3.75	3.54	3.32	3.01	3.58
Capital Stock growth							
Non-mining economy	4.81	4.72	4.60	4.49	4.31	4.12	4.49
Formal sector	5.07	4.97	4.85	4.72	4.53	4.32	4.72
Informal sector	0.20	0.19	0.18	0.17	0.16	0.14	0.17
Distribution Effects							
Output per worker growth							
Non-mining economy	2.16	2.19	2.21	2.26	2.20	2.22	2.21
Formal sector	2.42	2.44	2.45	2.48	2.39	2.39	2.43
Informal sector	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Labor Market							
Employment growth							
Non-mining economy	3.90	3.74	3.56	3.35	3.20	2.92	3.42
Formal sector	3.81	3.66	3.48	3.29	3.16	2.90	3.36
of which:							
Skilled	4.13	3.97	3.79	3.59	3.39	3.04	3.62
Unskilled	3.67	3.53	3.36	3.16	3.06	2.84	3.25
Informal sector	4.06	3.89	3.69	3.48	3.26	2.96	3.52
Wages growth							
Skilled wages	2.10	2.13	2.15	2.18	2.16	2.25	2.17
Unskilled wages (F)	2.55	2.56	2.58	2.61	2.49	2.45	2.54
Unskilled wages (I)	0.28	0.26	0.25	0.24	0.17	0.12	0.21

Source: Fund staff estimates.

1/ Constant prices 1998.

Figure 2. Botswana: AIDS and No AIDS Scenarios, 1991-2010



Source: ABT Associates, South Africa; and Fund staff estimates.

Table 3. Botswana: AIDS Baseline Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Nonmining economy	3.82	3.23	2.54	1.87	1.54	1.38	2.36
Formal sector	4.00	3.44	2.75	2.08	1.71	1.54	2.55
Informal sector	1.44	0.58	-0.27	-1.02	-1.02	-1.18	-0.34
Capital Stock growth							
Nonmining economy	3.10	2.72	2.23	1.75	1.40	1.28	2.06
Formal sector	3.33	2.93	2.40	1.88	1.50	1.36	2.21
Informal sector	0.06	0.03	-0.01	-0.04	-0.04	-0.05	-0.01
AIDS-related health spending (percent of GDP)							
Nonmining economy	1.09	1.24	1.44	1.61	1.62	1.60	1.45
Formal sector	0.73	0.87	1.00	1.11	1.10	1.08	1.00
Informal sector	5.29	5.83	7.30	8.75	9.31	10.05	7.88
Distribution Effects							
Output per worker growth							
Nonmining economy	1.99	2.14	2.25	2.33	2.22	2.25	2.27
Formal sector	2.21	2.33	2.42	2.47	2.29	2.31	2.40
Informal sector	-0.37	-0.46	-0.45	-0.44	-0.15	-0.13	-0.31
Labor Market							
Employment growth							
Nonmining economy	1.79	1.08	0.28	-0.44	-0.67	-0.85	0.09
Formal sector	1.78	1.10	0.33	-0.37	-0.57	-0.75	0.15
of which:							
Skilled	1.77	0.98	0.12	-0.64	-0.90	-1.06	-0.07
Unskilled	1.79	1.14	0.41	-0.26	-0.43	-0.62	0.24
Informal sector	1.82	1.04	0.18	-0.58	-0.87	-1.05	-0.03
Wages growth							
Skilled wages	2.22	2.45	2.64	2.74	2.64	2.63	2.64
Unskilled wages (F)	2.20	2.29	2.34	2.35	2.15	2.18	2.31
Unskilled wages (I)	-0.36	-0.52	-0.58	-0.63	-0.41	-0.38	-0.47

Source: Fund staff estimates.

1/ Constant prices 1998.

C. Alternative scenarios and sensitivity analysis

Estimates of the macroeconomic consequences of AIDS are subject to considerable uncertainty. In particular, the full extent of HIV infection and the progression of the disease are unclear, as is the possibility of a medical breakthrough. Other uncertainties relate to model assumptions, especially the many embedded parameters, the true values of which are largely unknown. The robustness of model results to changes in these parameters can be assessed through sensitivity analysis. The following variations from the baseline AIDS scenario are considered:

- ***The rate of capital inflows.*** The rate of capital inflows is reduced from 0.4 of nonmining GDP in the baseline case to 0.2.

- ***The rate of capital accumulation***. The rate of capital accumulation in the formal sector is reduced by 2 percentage points through an increase in the depreciation rate of the capital stock from 7 percent to 9 percent.

- ***The rate of total factor productivity (TFP)***. AIDS halves TFP growth in both the formal and informal sectors.

- ***Working time losses associated with each AIDS case.*** These are assumed to double compared with the base case, as a result of increased time off by workers for sick leave and to look after sick family members.

Permanent decline in the rate of capital inflows

If the rate of capital inflows is reduced from 0.4 to 0.2 of nonmining GDP, both GDP and output per worker are reduced by 0.4 percent a year on average (Table 4). This is because in the model a reduction in the rate of capital inflows reduces the rate of capital accumulation in the formal sector, thereby slowing down the corresponding rates of GDP and productivity growth. As a consequence, demand for both skilled and unskilled labor falls significantly in this sector and the wage differential for unskilled labor between the two sectors shrinks. The informal sector is not affected, as foreign capital flows only to the formal sector.

Permanent decline in the rate of capital accumulation in the formal sector

On the assumption that the pandemic generates a permanent reduction of 2 percentage points in the rate of capital accumulation in the formal sector, the model indicates that GDP growth would decline to an average of around 1.6 percent a year from 2.4 percent under the base scenario (Table 5). This shock is comparable to a permanent reduction in investor confidence in the formal sector. By construction, the impact on the informal sector is the same as under the baseline AIDS scenario. As a result, both output and productivity growth

in the formal sector fall by around 0.8 percent. The wage gap between unskilled labor in the formal and informal sectors thereby declines.

Permanent reduction in the rate of total factor productivity growth in both sectors

If TFP growth is halved in both the formal and informal sectors, the nonmining economy is projected to grow by 1.4 percent on average, representing a fall of around one percentage point a year compared with the AIDS baseline scenario (Table 6). Compared with the baseline, both sectors now have slower capital accumulation, together with weaker wage and output per worker growth.

Doubling working time losses associated with AIDS cases

If working-time losses double, then effective labor supply expressed in terms of efficiency units would decrease in both sectors. Under this scenario, nonmining GDP growth is reduced on average by 0.3 percentage point compared with the AIDS baseline (Table 7). Given its higher labor intensity, the informal sector would be more affected than the formal sector. Not surprisingly, output per worker and wages in both sectors are lower than in the AIDS baseline scenario.

An AIDS scenario with multiple shocks

A further scenario is estimated incorporating a combination of the shocks outlined above, although at reduced intensity in most cases.[15] Nonmining GDP growth in this scenario falls to 1.3 percent on average over the next ten years (Table 8). It is noteworthy that the growth rate arising from multiple small shocks is only 0.1 percentage points lower than that of the earlier scenario incorporating a larger TFP shock alone. Even under multiple shocks, the major reason for slower growth than in the baseline is the reduction in TFP growth. However, lower rates of capital inflows and falling investor confidence further reduce the rate of capital accumulation and GDP growth in the formal sector. At the same time, doubling working-time losses exacerbates the contraction of the informal sector. As a consequence, the wage differential between unskilled labor in the two sectors rises compared with the AIDS scenario (and in fact is restored to the no-AIDS wage gap, despite the lower level of wages), whereas the gap between skilled and unskilled wages in the formal sector is comparable to that of the baseline AIDS scenario.

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[15] Specifically, the rate of capital inflows is reduced to 0.3 of nonmining GDP (compared with 0.4 in the baseline scenario); the rate of capital accumulation is reduced by 1 percentage points; TFP growth is reduced by one-fourth in both sectors (i.e., 0.3 percent rather than 0.4 percent in the formal sector); and working-time losses double, as in the previous scenario.

Table 4. Botswana: Lower Rate of Capital Inflows Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	2.97	2.61	2.15	1.68	1.55	1.32	1.99
Formal sector	3.11	2.79	2.36	1.91	1.76	1.51	2.19
Informal sector	1.46	0.59	-0.26	-1.02	-1.02	-1.18	-0.33
Capital Stock growth							
Non-mining economy	2.24	2.09	1.85	1.57	1.42	1.23	1.70
Formal sector	2.44	2.28	2.01	1.71	1.54	1.33	1.85
Informal sector	0.07	0.04	0.00	-0.03	-0.04	-0.05	-0.01
AIDS-related health spending (percent of GDP)							
Non-mining economy	1.26	1.45	1.70	1.91	1.92	1.91	1.72
Formal sector	0.86	1.04	1.20	1.33	1.33	1.30	1.20
Informal sector	5.30	5.83	7.30	8.74	9.31	10.05	7.88
Distribution Effects							
Output per worker growth							
Non-mining economy	1.16	1.51	1.86	2.13	2.23	2.19	1.90
Formal sector	1.32	1.69	2.04	2.30	2.34	2.28	2.04
Informal sector	-0.36	-0.45	-0.44	-0.44	-0.16	-0.14	-0.30
Labor Market							
Employment growth							
Non-mining economy	0.47	0.27	0.06	-0.13	-0.19	-0.23	0.01
Formal sector	0.35	0.21	0.05	-0.10	-0.14	-0.18	0.01
of which:							
Skilled	0.21	0.12	0.01	-0.08	-0.11	-0.12	-0.01
Unskilled	0.15	0.09	0.03	-0.02	-0.04	-0.05	0.02
Informal sector	1.73	0.99	0.18	-0.55	-0.83	-1.00	-0.03
Wages growth							
Skilled wages	1.33	1.80	2.25	2.58	2.69	2.60	2.28
Unskilled wages (F)	1.32	1.64	1.95	2.19	2.20	2.15	1.95
Unskilled wages (I)	-0.34	-0.51	-0.57	-0.62	-0.41	-0.39	-0.46

Source: Fund staff estimates.

1/ Constant prices 1998.

Table 5. Botswana: Lower Rate of Capital Accumulation Scenario
(Percentage change, unless otherwise noted)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	2.55	2.25	1.79	1.30	1.18	0.98	1.62
Formal sector	2.66	2.42	2.00	1.52	1.38	1.17	1.81
Informal sector	1.44	0.58	-0.27	-1.02	-1.02	-1.18	-0.34
Capital Stock growth							
Non-mining economy	1.82	1.74	1.50	1.20	1.06	0.91	1.34
Formal sector	1.99	1.91	1.65	1.32	1.17	0.99	1.47
Informal sector	0.06	0.03	-0.01	-0.04	-0.04	-0.05	-0.01
AIDS-related health spending (percent of GDP)							
Non-mining economy	1.37	1.59	1.88	2.13	2.15	2.16	1.91
Formal sector	0.94	1.15	1.34	1.50	1.50	1.49	1.34
Informal sector	5.29	5.83	7.30	8.75	9.31	10.05	7.88
Distribution Effects							
Output per worker growth							
Non-mining economy	0.75	1.16	1.51	1.75	1.86	1.85	1.54
Formal sector	0.88	1.32	1.67	1.90	1.96	1.93	1.67
Informal sector	-0.37	-0.46	-0.45	-0.44	-0.15	-0.13	-0.31
Labor Market							
Employment growth							
Non-mining economy	0.48	0.28	0.06	-0.14	-0.20	-0.24	0.01
Formal sector	0.35	0.21	0.05	-0.10	-0.14	-0.18	0.01
of which:							
Skilled	0.21	0.12	0.01	-0.08	-0.11	-0.12	-0.01
Unskilled	0.15	0.09	0.03	-0.02	-0.04	-0.05	0.02
Informal sector	1.73	0.99	0.18	-0.55	-0.83	-1.00	-0.03
Wages growth							
Skilled wages	0.89	1.43	1.88	2.18	2.31	2.25	1.90
Unskilled wages (F)	0.87	1.27	1.58	1.79	1.82	1.81	1.57
Unskilled wages (I)	-0.36	-0.52	-0.58	-0.63	-0.41	-0.38	-0.47

Source: Fund staff estimates.

1/ Constant prices 1998

Table 6. Botswana: Lower TFP Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	2.86	2.27	1.57	0.90	0.57	0.41	1.39
Formal sector	2.98	2.42	1.73	1.07	0.70	0.54	1.54
Informal sector	1.42	0.55	-0.29	-1.05	-1.05	-1.21	-0.36
Capital Stock growth							
Non-mining economy	2.32	1.94	1.46	0.98	0.64	0.51	1.29
Formal sector	2.51	2.11	1.59	1.07	0.69	0.55	1.40
Informal sector	0.05	0.03	-0.01	-0.04	-0.04	-0.05	-0.01
AIDS-related health spending (percent of GDP)							
Non-mining economy	1.18	1.37	1.63	1.86	1.89	1.93	1.67
Formal sector	0.80	0.97	1.14	1.29	1.30	1.32	1.16
Informal sector	5.31	5.84	7.33	8.78	9.35	10.10	7.92
Distribution Effects							
Output per worker growth							
Non-mining economy	1.05	1.18	1.29	1.36	1.25	1.27	1.30
Formal sector	1.19	1.32	1.41	1.45	1.28	1.29	1.39
Informal sector	-0.40	-0.49	-0.48	-0.47	-0.18	-0.16	-0.33
Labor Market							
Employment growth							
Non-mining economy	0.46	0.27	0.06	-0.13	-0.19	-0.23	0.01
Formal sector	0.35	0.21	0.05	-0.10	-0.14	-0.18	0.01
of which:							
Skilled	0.21	0.12	0.01	-0.08	-0.11	-0.12	-0.01
Unskilled	0.15	0.09	0.03	-0.02	-0.04	-0.05	0.02
Informal sector	1.73	0.99	0.18	-0.55	-0.83	-1.00	-0.03
Wages growth							
Skilled wages	1.20	1.43	1.62	1.72	1.62	1.61	1.62
Unskilled wages (F)	1.19	1.27	1.32	1.34	1.14	1.17	1.30
Unskilled wages (I)	-0.38	-0.54	-0.61	-0.65	-0.44	-0.41	-0.49

Source: Fund staff estimates.

1/ Constant prices 1998.

Table 7. Botswana: Higher Work Loss due to AIDS Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	3.68	2.92	2.21	1.51	1.37	1.21	2.11
Formal sector	3.89	3.14	2.43	1.73	1.54	1.37	2.31
Informal sector	1.03	0.04	-0.81	-1.57	-1.25	-1.39	-0.72
Capital Stock growth							
Non-mining economy	3.06	2.54	2.04	1.52	1.28	1.15	1.91
Formal sector	3.29	2.74	2.19	1.64	1.37	1.23	2.05
Informal sector	0.05	0.01	-0.03	-0.06	-0.05	-0.06	-0.02
AIDS-related health spending (percent of GDP)							
Non-mining economy	1.11	1.26	1.48	1.67	1.67	1.67	1.50
Formal sector	0.74	0.89	1.03	1.14	1.14	1.13	1.03
Informal sector	5.45	6.05	7.67	9.29	9.93	10.79	8.34
Distribution Effects							
Output per worker growth							
Non-mining economy	1.85	1.82	1.92	1.97	2.05	2.08	2.02
Formal sector	2.09	2.03	2.10	2.12	2.12	2.13	2.16
Informal sector	-0.79	-1.00	-0.99	-0.99	-0.38	-0.34	-0.70
Labor Market							
Employment growth							
Non-mining economy	1.79	1.08	0.28	-0.44	-0.67	-0.85	0.09
Formal sector	1.78	1.10	0.33	-0.37	-0.57	-0.75	0.15
of which:							
Skilled	1.77	0.98	0.12	-0.64	-0.90	-1.06	-0.07
Unskilled	1.79	1.14	0.41	-0.26	-0.43	-0.62	0.24
Informal sector	1.82	1.04	0.18	-0.58	-0.87	-1.05	-0.03
Wages growth							
Skilled wages	2.10	2.15	2.32	2.39	2.47	2.45	2.40
Unskilled wages (F)	2.08	1.99	2.01	2.00	1.98	2.01	2.07
Unskilled wages (I)	-0.77	-1.06	-1.12	-1.17	-0.64	-0.59	-0.85

Source: Fund staff estimates

1/ Constant prices 1998.

Table 8. Botswana: AIDS Multiple Shock Scenario
(Percentage change, unless otherwise stated)

	1999	2001	2003	2005	2007	2010	Average
Macroeconomic Impact							
GDP growth 1/							
Non-mining economy	2.36	1.92	1.40	0.88	0.81	0.57	1.27
Formal sector	2.49	2.10	1.61	1.10	0.99	0.73	1.45
Informal sector	1.01	0.03	-0.82	-1.58	-1.26	-1.40	-0.74
Capital Stock growth							
Non-mining economy	1.83	1.64	1.34	1.01	0.84	0.63	1.18
Formal sector	2.00	1.80	1.47	1.11	0.92	0.69	1.29
Informal sector	0.05	0.01	-0.03	-0.06	-0.05	-0.06	-0.03
AIDS-related health spending (percent of GDP)							
Non-mining economy	1.32	1.54	1.84	2.10	2.14	2.17	1.88
Formal sector	0.90	1.10	1.30	1.46	1.48	1.49	1.31
Informal sector	5.45	6.05	7.67	9.29	9.94	10.80	8.35
Distribution Effects							
Output per worker growth							
Non-mining economy	0.56	0.83	1.12	1.33	1.49	1.43	1.18
Formal sector	0.71	1.00	1.29	1.48	1.56	1.49	1.30
Informal sector	-0.80	-1.01	-1.01	-1.00	-0.39	-0.35	-0.71
Labor Market							
Employment growth							
Non-mining economy	0.47	0.28	0.06	-0.14	-0.20	-0.24	0.01
Formal sector	0.35	0.21	0.05	-0.10	-0.14	-0.18	0.01
of which:							
Skilled	0.21	0.12	0.01	-0.08	-0.11	-0.12	-0.01
Unskilled	0.15	0.09	0.03	-0.02	-0.04	-0.05	0.02
Informal sector	1.73	0.99	0.18	-0.55	-0.83	-1.00	-0.03
Wages growth							
Skilled wages	0.72	1.11	1.50	1.75	1.91	1.81	1.53
Unskilled wages (F)	0.70	0.96	1.20	1.37	1.42	1.36	1.21
Unskilled wages (I)	-0.79	-1.07	-1.14	-1.18	-0.65	-0.60	-0.87

Source: Fund staff estimates.

1/ Constant prices 1998.

IV. Fiscal Implications

HIV/AIDS is likely to lead to a significant increase in public expenditures in the years ahead, especially because of rising health spending. With output growth expected to slow, public revenues will also be lower than in a no-AIDS context. Largely because of the uncertainty surrounding prospective health spending—particularly the types of HIV/AIDS treatments that will be available, their cost, and likely take-up rates—it is not possible to arrive at a single "most probable" fiscal profile for Botswana over the next five to ten years. This section aims, instead, to indicate the rough order of magnitude of some public expenditure scenarios implied by AIDS and its consequences, drawing where possible on the model results presented in Section III. The current assessment does not address in detail a broader concern relating to the operations and efficiency of the public sector itself—whether there is a risk that rising rates of illness and death, especially among skilled personnel, will significantly impair the ability of public agencies to administer tax systems and spending programs, provide quality advice and support to government, and handle other responsibilities.

A. Health care

In the central AIDS scenario presented in Table 3, annual AIDS-related health spending is projected to rise by around 1½ percent of GDP over the next ten years. This apparently mild impact is based, however, on conservative assumptions regarding treatment approaches. First, such treatments essentially take the form of palliative care for those with AIDS—comforting the sick but, ultimately, probably not prolonging their life significantly in most cases. An alternative approach that extends to the provision of anti-retroviral treatments (ARTs), which can delay or even stop the development of full-blown AIDS among those infected with the HIV virus, is considered briefly below. Second, lifetime AIDS treatment costs per patient are assumed to equal the level of average annual earnings that prevailed in 1998/99, equivalent to around 40 percent of GDP per capita. These costs appear to vary widely from country to country, and costs of over 100 percent of GDP per capita have been observed in several countries.[16]

The increased health spending noted above applies to the full nonmining economy; the model as specified does not distinguish between public and private sector impacts. However, with the bulk of health spending—and almost all AIDS-related expenditures—currently financed by the public sector, it would appear reasonable to assume that most of the

[16] See Haacker (2000). It should be noted, however, that even in countries where treatment costs per patient exceed 100 percent of GDP per capita, actual expenditure per patient may well be less than assumed in Botswana because of the latter's relatively high level of GDP per capita.

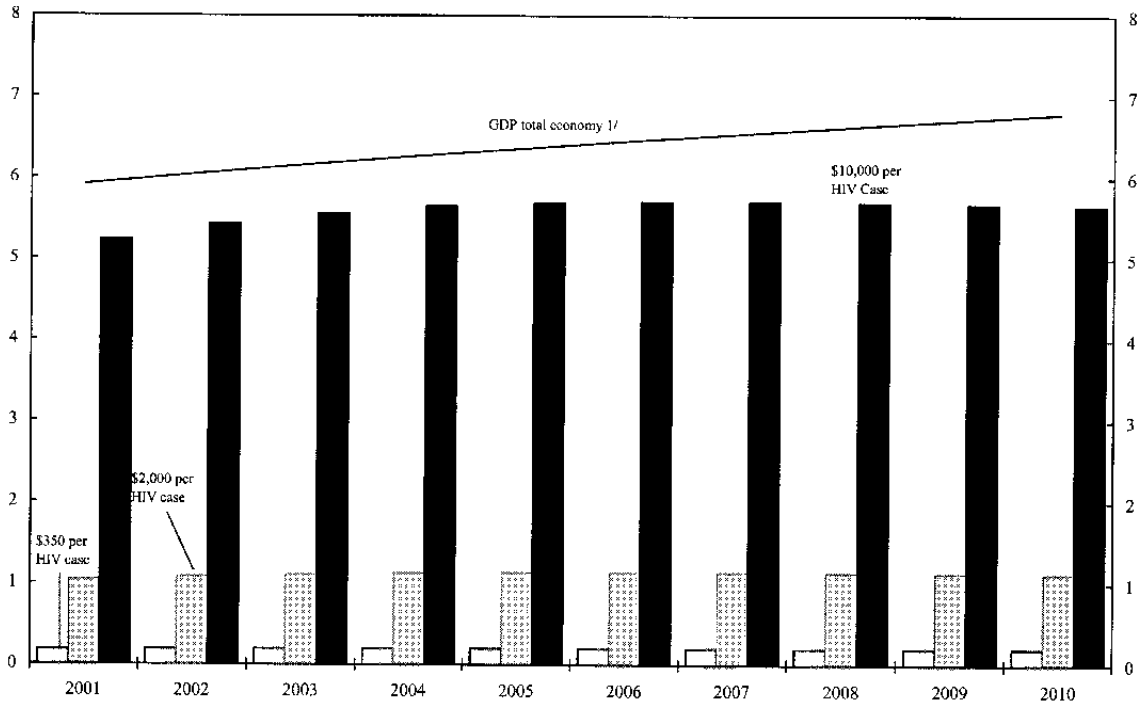
1½ percent of GDP increase in spending would also come from the public sector. Under the assumed model parameters, 20 percent of increased health spending is financed through a reduction in nonhealth consumption, and 80 percent through reduced saving. Hence, public saving might decrease by around 1 to 1¼ percent of GDP per year under these assumptions. Under the "multiple shock" scenario presented in Table 8, public saving could decline by over 1½ percent of GDP. These estimates would, however, rise rapidly—indeed, at a disproportionate rate—if higher treatment costs are assumed, because national saving (and, hence, capital accumulation and economic growth) would decline as health care costs rise.

The estimates above do not provide for introduction of the combination therapies that are now widely used in advanced economies. As noted in Section II, the Botswana government has recently indicated its intention to make ARTs generally available to HIV+ patients, a move made possible by sharp reductions in drug prices. To illustrate the implications of different ART prices, at western levels—amounting to at least $10,000 per patient per year—such treatment costs would have been prohibitive from an economic and budgetary perspective (Figure 3). This would remain the case even if take-up rates were substantially less than the 100 percent level assumed in the figure. If prices were reduced to around $2,000 per year, ARTs could still absorb close to 20 percent of current GDP or nearly 40 percent of total government revenue. At prices of around $350, however—as recently proposed by some drug manufacturers—the implied health spending appears to be much more fiscally feasible. Nevertheless, there is still substantial uncertainty at this stage about how rapidly these treatments can be introduced, about prospective take-up rates, and about the actual prices at which the drugs can be acquired. For example, the expenditure illustrations above do not include any provision for further development of the health sector infrastructure that is needed to support these regimes, including laboratory construction, staffing, and training. Increased international support—both technical and financial—is likely to be needed if the hope for rapid and widespread adoption of advanced-treatment options is to be realized.

B. Other areas of public spending

The spread of HIV/AIDS will also affect other areas of public spending. In particular, there are likely to be pressures for a significant rise in spending on social support, given the expected increases in poverty and in the number of orphans. Analysis in BIDPA (2000) of the effects of HIV/AIDS on income distribution suggests that there could be a 10 percent increase in individuals with incomes below the poverty line after ten years (compared with the no-AIDS scenario), and that a 3 to 4 percent increase in real public spending (equivalent to around 1¼ to 1½ percent of GDP) would be needed to alleviate this rise in poverty. Updated estimates would almost certainly be higher than these, given the increase in HIV prevalence rates indicated by more recent data, together with the slower rates of economic growth suggested by the current paper. With the number of orphans expected to explode to

Figure 3. Botswana: Illustrative HIV Treatment Cost Scenarios, 2001 to 2010
(In billions of U.S. Dollars)



Source: ABT Associates, South Africa; and Fund staff estimates.

1/ Total economy GDP is obtained by combining nonmining GDP, as projected by the model in Section III, with actual mining GDP in 1998/99, assuming the latter will grow by 1 percent a year in real terms from 2001 onwards.

over 200,000 by 2010 (compared with around 60,000 at present), increased spending on orphans' allowances could amount to a further 1 to 2 percent of GDP.[17]

A further source of public spending pressure could come from higher labor costs as skill shortages drive up wage rates. Recruitment and training costs are also likely to increase as rising mortality among public employees leads to higher labor turnover. These employment-related items could increase public spending by ½ to 1 percent of GDP, including a small offset that comes from lower public sector pension expenditures.[18] In the education sector, expenditure "savings" implied by lower numbers of school-age children may be largely counterbalanced both by the higher costs of recruiting and paying teachers (included in the preceding estimate), and increased demands on this sector to meet the education and skill needs of the economy.

C. Revenues

HIV/AIDS may affect the prospective flow of public revenues through changes both in the revenue base and in effective tax rates on that base. The largest impact on revenues will come from the slowdown in GDP growth, which leads to a nonmining economy that is around one-third smaller by 2010 than under a no-AIDS scenario (see Figure 2). In addition, there is a risk that the revenue share of GDP could fall (in the absence of offsetting policy adjustments). Such a decline could result, for example, from increased difficulties in tax administration, if labor turnover and skill shortages rise sharply in the public sector, and possibly also from reduced tax compliance as AIDS-related economic and social pressures increase. Unrelated to AIDS, changes in the composition of the economy—notably, the expected slowing of growth in the mining sector, which generates around two-thirds of current government revenues—may also reduce the revenue share of GDP. Interest earnings on Botswana foreign exchange reserves, contributing around 14 percent of current government revenues, would also decline if these reserves are drawn on to finance public spending. But substantial uncertainty and controversy surrounds the issue of how the reserves should be used, including whether they should support the cost of ARTs and other areas of health spending.

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[17] As in BIDPA (2000), this estimate is based on an orphans' allowance of P 216 per month. Actual spending would depend in part on how many orphans register for and then receive this benefit.

[18] Estimates from BIDPA (2000). As with other spending components, updated estimates may well be higher, given the increase in estimated HIV prevalence rates since the BIDPA study.

V. Conclusions

The principal conclusions of the analysis are as follows:

- AIDS will have a significantly negative impact on the rate of economic growth in Botswana over the coming decade. Simulations incorporating a range of potential effects on the nonmining economy arising from the epidemic suggest that the rate of GDP growth in the nonmining sector could fall from a projected 5½ percent a year without AIDS to between 1½ and 2½ percent a year on average with AIDS. As a result, in 2010 the economy would be 33 to 40 percent smaller than it would have been without AIDS.

- The major impact of AIDS comes from projected lower rates of growth in effective labor productivity and capital accumulation. As would be expected, the labor-intensive sectors are particularly affected through the labor supply channel, while growth in capital-intensive sectors is reduced mainly as a result of slower capital accumulation.

- Nonnegligible redistribution effects across sectors and labor skills are also likely to arise as a result of AIDS. These stem from changes in the relative growth rate of the formal and informal sectors compared with the growth of their labor supply. The main sectoral impact on income distribution arises from the shortage in skilled labor, from a shift of unskilled labor from the informal to the formal sector, and from a shrinking of the unskilled wage differential between the two sectors.

- The fiscal situation in Botswana will almost certainly deteriorate as a result of HIV/AIDS. Even under quite conservative assumptions about AIDS treatment strategies, public expenditures could rise by over 5 percent of GDP as a result of higher healthcare spending, together with increased social support and public sector employment costs. Public revenues could also fall as a share of GDP if economic and social pressures lead to weaker tax administration and compliance. Fiscal pressures could be substantially higher if anti-retroviral drug treatments are made generally available, highlighting the need for increased international support and/or lower drug prices to make such treatments feasible.

THEORETICAL MODEL

This appendix provides analytical details of the theoretical model used in Section III. Parameters are given in Table 9.

A. Health spending allocation

The immediate impact of AIDS is on health spending. Following Cuddington and Hancock (1995), AIDS-related health care costs incurred by individuals in the formal and informal sectors are represented by H_f and H_i, respectively.

$$H_f = m_f a_f L_f + m_f^c a_f^c N_f^c \tag{1}$$

$$H_i = m_i a_i L_i + m_i^c a_i^c N_i^c \tag{2}$$

where m is the yearly medical cost per AIDS cases, a is the number of adult AIDS cases, L is labor force, and N^c is the population below 15 years. Subscript f and i denote formal and informal sector, respectively, whereas superscript c stands for children whose parents are working in either sector[19].

B. Capital accumulation and consumption

Health care expenditures in (1) and (2) are met by reducing both saving and consumption. Moreover, the model assumes that informal sector capital formation is limited by the amount of saving generated by the sector itself. Foreign reserves are available only for investment in the more capital-intensive formal sector. Nonetheless, the model allows for transfers from the formal to the informal sector as a form of medical insurance. The capital accumulation process in the two sectors of the economy can be represented as follows:

$$\Delta K_{f,t} = \sigma_f Y_{f,t} + \sigma_{ff}(Y_{f,t} + Y_{i,t}) - x_f(H_{f,t} + \omega H_{i,t}) - \delta_f K_{f,t-1}$$

$$\Delta K_{i,t} = \sigma_i Y_{i,t} - x_i(1-\omega)H_{i,t} - \delta_i K_{i,t-1}$$

where σ denotes the saving rate, foreign saving is assumed to be a fixed share of real national GDP, and δ is the depreciation rate. Note that x represents the proportion of AIDS-related medical costs that are paid for by reducing saving in either sector, whereas ω is the

[19] Note that children and child AIDS-related health costs are allocated across formal and informal sectors in the same proportion as the adult population.

Table 1. Botswana: Initial Model Parameters

Symbol	*Description*	*Value*	*Symbol*	*Description*	*Value*
	Formal Sector			***Informal Sector***	
m_f	Yearly medical cost per adult AIDS cases	14,495	m_i	Yearly medical cost per adult AIDS cases	14,495
m_cf	Yearly medical cost per children AIDS cases	14,495	m_ci	Yearly medical cost per children AIDS cases	14,495
σ_f	saving rate	0.4	σ_i	saving rate	0.4
σ_ff	Rate of capital inflow	0.4			
x_f	AIDS costs met by reducing saving	0.8	x_i	AIDS costs met by reducing saving	0.8
ω	Rate of AIDS costs transfers	0.8	1−ω	rate of AIDS costs transfers	0.2
δ_f	depreciation rate	0.07	δ_i	depreciation rate	0.07
α_f	constant - production function	4.1	α_i	constant - production function	1,110
γ_f	exogenous technological trend	0.004	γ_i	exogenous technological trend	0.0005
β_s	skilled labor share of output	0.12			
β_u	unskilled labor share of output	0.08	β_i	unskilled labor share of output	0.95
λ_s	productivity lost per AIDS case - skilled	1			
λ_u	productivity lost per AIDS case - unskilled	1	λ_i	productivity lost per AIDS case-unskilled	1
ρ1_s	constant - age efficiency	6.2			
ρ2_s	linear term - age efficiency	0.067			
ρ3_s	quadratic term - age efficiency	-0.0012			
ρ1_u	constant - age efficiency	5.6	ρ1_u	constant - age efficiency	5.6
ρ2_u	linear term - age efficiency	0.027	ρ2_u	linear term - age efficiency	0.027
ρ3_u	quadratic term - age efficiency	-0.0006	ρ3_u	quadratic term - age efficiency	-0.0006
w_s	wage - skilled	21,245			
w_u	wage - unskilled	6,281	w_i	real wage – unskilled	3,538
Y_f/Y	share of total output - formal	0.92	Y_i/Y	share of total output - informal	0.08
K/Y_f	capital-output ratio	1.95	K/Y_i	capital-output ratio	0.97

share of medical costs incurred by individual in the informal sector that are covered by reducing formal sector saving. Rearranging yields:

$$\Delta K_{f,t} = [\sigma_f + \sigma_{ff}(1+\frac{Y_{i,t}}{Y_{f,t}}) - x_f(\frac{H_{f,t}}{Y_{f,t}} + \omega\frac{H_{i,t}}{Y_{f,t}})]Y_{f,t} - \delta_f K_{f,t-1}$$

$$\Delta K_{i,t} = [\sigma_i - x_i(1-\omega)\frac{H_{i,t}}{Y_{i,t}}]Y_{i,t} - \delta_i K_{i,t-1}$$

Expressed as a proportion of the total number of workers employed in each sector, the corresponding capital accumulation processes reduce to:

$$\Delta k_{f,t} = [\sigma_f + \sigma_{ff}(1+\frac{Y_{i,t}}{Y_{f,t}}) - x_f(\frac{H_{f,t}}{Y_{f,t}} + \omega\frac{H_{i,t}}{Y_{f,t}})]y_{f,t} - \frac{\delta_f + n_f}{1+n_f}k_{f,t-1}$$

$$\Delta k_{i,t} = [\sigma_i - x_i(1-\omega)\frac{H_{i,t}}{Y_{i,t}}]y_{i,t} - \frac{\delta_i + n_i}{1+n_i}k_{i,t-1}$$

where lower letters indicate levels per worker and n stand for the rate of population growth in each sector.

The steady-state capital stock for the two sectors can, be derived by letting Δk_f and Δk_i equal to zero and solving for $\bar{k}_f$ and $\bar{k}_i$, respectively. It follows:

$$\bar{k}_f = \frac{1+n_f}{\delta_f + n_f}[\sigma_f + \sigma_{ff}(1+\frac{Y_{i,t}}{Y_{f,t}}) - x_f(\frac{H_{f,t}}{Y_{f,t}} + \omega\frac{H_{i,t}}{Y_{f,t}})]y_{f,t} \quad (3)$$

$$\bar{k}_i = \frac{1+n_i}{\delta_i + n_i}[\sigma_i - x_f(1-\omega)\frac{H_{i,t}}{Y_{i,t}})]y_{i,t} \quad (4)$$

The above medical expenditure and saving equations imply non-medical consumption equal to:

$$C_f = (1-\sigma_f)Y_f - (1-x_f)H_f - (1-x_f)\omega\ H_i$$

$$C_i = (1-\sigma_i)Y_i - (1-x_i)(1-\omega)H_i$$

for the formal and informal sector, respectively. Dividing both sides of the consumption equations by total labor force in the corresponding sector (i.e. L_f and L_i) yields expressions for consumption per worker by sector.

$$c_f = (1-\sigma_f)y_f - (1-x_f)h_f - (1-x_f)\omega\, h_i \tag{5}$$

$$c_i = (1-\sigma_i)y_i - (1-x_i)(1-\omega)h_i \tag{6}$$

C. Production functions and efficiency units

In line with BIDPA (2000), output in both sectors can be represented by a Cobb-Douglas production function exhibiting constant returns to scale. Specifically, the formal sector employs three inputs: skilled labor, unskilled labor, and capital. The informal sector, instead, uses only two factors: unskilled labor and capital. The corresponding production functions are given below.

$$Y_f = \alpha_f e^{\gamma_f (t-t_0)} Z_s^{\beta_s} Z_u^{\beta_u} K_f^{(1-\beta_s-\beta_u)} \tag{7}$$

$$Y_i = \alpha_i e^{\gamma_i (t-t_0)} Z_i^{\beta_i} K_i^{(1-\beta_i)} \tag{8}$$

where Z indicates effective labor supply measured in efficiency units. The term γ represents an exogenous technological trend, while the constant term α is used to calibrate the model to fit the data in the base year 1998. Finally, the β's signify the shares of output attributable to each factor.

AIDS impacts directly on labor supplies by changing the size, the structure, and the level of experience (i.e. efficiency) of the labor force. Following Cuddington and Hancock (1995) we measure effective labor supply in the formal sector in terms of efficiency units.

$$Z_s = \sum_{j=15}^{64} (1-\lambda_s a_{j,s}) \left[\rho_{1s} + \rho_{2s}(j-15) + \rho_{3s}(j-15)^2\right] L_{j,s}$$

$$Z_u = \sum_{j=15}^{64} (1-\lambda_u a_{j,u}) \left[\rho_{1u} + \rho_{2u}(j-15) + \rho_{3u}(j-15)^2\right] L_{j,u}$$

where L_j is the number of workers in cohort j, a_j is the number of AIDS cases in cohort j, and λ is the fraction of work-year lost per AIDS case as a result of sick leave or absence for care of an AIDS-infected family member. As the productivity gains from work experience cannot be evaluated directly, as in Cuddington and Hancock (1995) we assume a non-linear relationship between earnings and productivity which is proxied by a second order polynomial with parameters ρ's. In this way, we can also derive indices of experience for each skill category.

$$\bar{\rho}_s = \frac{Z_s}{L_s} \tag{9}$$

$$\bar{\rho}_u = \frac{Z_u}{L_u} \tag{10}$$

Plugging these indices into the formal sector production function, we obtain:

$$Y_f = \alpha_f e^{\gamma_f (t-t_0)} \left(\overline{\rho}_s^{\beta_s} \overline{\rho}_u^{\beta_u}\right)\left(L_s^{\beta_s} L_u^{\beta_u}\right) K_f^{(1-\beta_s-\beta_u)} \tag{11}$$

Similarly, for the informal sector, it holds:

$$Y_i = \alpha_i e^{\gamma_i (t-t_0)} \left(\overline{\rho}_i^{\beta_i}\right)\left(L_i^{\beta_i}\right) K_f^{(1-\beta_i)} \tag{12}$$

where:

$$\overline{\rho}_i = \frac{Z_i}{L_i} = \sum_{j=15}^{64} (1-\lambda_i a_{j,i}) \left[\rho_{1u} + \rho_{2u}(j-15) + \rho_{3u}(j-15)^2\right] \frac{L_{j,i}}{L_i} \tag{13}$$

We can rewrite equations (11) and (12) in terms of output per worker as:

$$y_f = \alpha_f e^{\gamma_f (t-t_0)} \left(\overline{\rho}_s^{\beta_s} \overline{\rho}_u^{\beta_u}\right)\left(\frac{L_s}{L_f}\right)^{\beta_s}\left(\frac{L_u}{L_f}\right)^{\beta_u} k_f^{(1-\beta_s-\beta_u)} \tag{14}$$

$$y_i = \alpha_i e^{\gamma_i (t-t_0)} \left(\overline{\rho}_i^{\beta_i}\right) k_i^{(1-\beta_i)} \tag{15}$$

Substituting back into equations (3) and (4) and rearranging, we can derive the steady-state capital stock in the two sectors as functions of income allocation between sectors, labor force allocation between skill categories, health care costs and labor efficiency indexes. These variables are assumed to remain unchanged throughout the simulation period (implicitly we are here assuming that AIDS does not generate any redistribution effect apart from the one on age/experience structure of the labor force.).

$$\overline{k}_f = \left\{ \frac{1+n_f}{\delta_f + n_f} \left[\sigma_f + \sigma_{ff}\left(1 + \frac{Y_{i,t}}{Y_{f,t}}\right) - x_f \left(\frac{H_f}{Y_f} + \omega \frac{H_i}{Y_f}\right) \right] \alpha_f e^{\gamma_f (t-t_0)} \left(\overline{\rho}_s^{\beta_s} \overline{\rho}_u^{\beta_u}\right)\left(\frac{L_s}{L_f}\right)^{\beta_s}\left(\frac{L_u}{L_f}\right)^{\beta_u} \right\}^{\frac{1}{\beta_s+\beta_u}} \tag{16}$$

$$\overline{k}_i = \overline{\rho}_i \left\{ \frac{1+n_i}{\delta_i + n_i} \left[\sigma_i - x_f (1-\omega) \frac{H_i}{Y_i} \right] \alpha_i e^{\gamma_i (t-t_0)} \right\}^{\frac{1}{\beta_i}} \tag{17}$$

D. Labor allocation

As in BIDPA (2000), we assume that the economy is divided into a formal and an informal sector. Labor is subsequently divided into skilled and unskilled categories. As we implicitly assume that all skilled workers are employed in the formal sector, the model

comprises three labor markets: skilled formal sector, unskilled formal sector, and unskilled informal sector.

The three labor markets behave differently. The skilled formal sector is assumed to be a perfectly competitive market, where wages adjust to equate demand and supply at any time. In the unskilled formal sector, instead, there is a fixed minimum wage that is higher than the equilibrium wage. As a result, unemployment arises among unskilled workers in the formal sector.

As labor demand in the informal sector is derived from the excess of unskilled labor supply in the formal sector, let us first focus on the allocation of skilled and unskilled labor within the formal sector. We assume that firms in the formal sector choose the optimal composition of skilled/unskilled labor as solution of a constrained minimization problem. Namely, we suppose that firms in the formal sector choose the skill composition of its labor force in such a way that the total cost of production is minimized subject to (i) a given production function, (ii) a given minimum wage for unskilled workers, (iii) a labor supply featuring long-run demographic constraints (i.e., the existence of a vertical long-run labor supply). Because of (iii), the constrained minimization problem can be restated in terms of average cost per unit of labor:

$$\min_{\frac{L_s}{L_f},\frac{L_u}{L_f}} w_s \frac{L_s}{L_f} + w_u \frac{L_u}{L_f} + i\bar{k}_f \tag{18}$$

$$\text{s.t. } \bar{y}_f = \alpha_f e^{\gamma_f (t-t_0)} \left(\bar{\rho}_s^{\beta_s} \bar{\rho}_u^{\beta_u}\right) \left(\frac{L_s}{L_f}\right)^{\beta_s} \left(\frac{L_u}{L_f}\right)^{\beta_u} \bar{k}_f^{(1-\beta_s-\beta_u)} \tag{19}$$

$$\text{s.t. } w_u = w_u^{\min} \tag{20}$$

Substituting out for $\frac{L_u}{L_f}$ in (19) and plugging it back into (18) - when (20) also holds true - we can minimize the average cost with respect to $\frac{L_s}{L_f}$. The first order condition yields the optimal conditional demand function for skilled labor in the formal sector.

$$\left(\frac{L_s}{L_f}\right)^* = \left(\frac{\beta_s w_u^{\min}}{\beta_u \rho_u w_s^*}\right)^{\frac{\beta_u}{\beta_s+\beta_u}} \left(\frac{\bar{y}_f}{\alpha e^{\gamma_f (t-t_0)}}\right)^{\frac{1}{\beta_s+\beta_u}} (\rho_s)^{-\frac{\beta_s}{\beta_s+\beta_u}} \left(\bar{k}_f\right)^{1-\frac{1}{\beta_s+\beta_u}} \tag{21}$$

Since the skilled labor market is assumed to be perfectly competitive, with wages w_s adjusting to equate demand and supply, then both L_s^* and w_s^* are directly observable in the market:

$$\left(\frac{L_s}{L_f}\right)^* = \left(\frac{L_s}{L_f}\right)^d = \left(\frac{L_s}{L_f}\right)^s \quad \text{and} \quad w_s^* = w_s.$$

By contrast, the equilibrium wage and equilibrium level of unskilled labor in the formal sector are not directly observable because the unskilled informal sector is not assumed to clear. We can, however, derive their sub-optimal values under constraints (19) and (20) by plugging equation (19) into equation (21). Rearranging, yields the classical result that the relative cost of any factor must be equal to the relative share of output attributable to that factor.

$$\frac{w_u^{\min}\overline{L_u}}{w_s^* L_s^*} = \frac{\beta_u}{\beta_s}$$

This implies that, in the formal sector, the optimal combination of labor across skills categories is such that:

$$\left(\frac{\overline{L_u}}{L_f}\right) = \frac{\beta_u w_s^*}{\beta_s w_u^{\min}}\left(\frac{L_s}{L_f}\right)^*. \tag{22}$$

Note that, if $w_u^{\min} = w_u^*$ then the unskilled labor market clears, with $\left(\frac{\overline{L_u}}{L_f}\right) = \left(\frac{L_u}{L_f}\right)^*$. Otherwise, if $w_u^{\min} > w_u^*$ then $\left(\frac{\overline{L_u}}{L_f}\right) < \left(\frac{L_u}{L_f}\right)^*$ and underemployment arises.

Underemployed unskilled workers in the formal sector make up the supply of labor in the informal sector, where market forces operate to equate demand and supply. The congruent share of unskilled labor accruing to the informal sector can, therefore, be derived from the excess of unskilled labor supply in the formal sector:

$$L_i = L_f \cdot \left[\left(\frac{L_u}{L_f}\right)^* - \left(\frac{\overline{L_u}}{L_f}\right)\right] \qquad \text{that is} \qquad L_u^* = L_u + L_i. \tag{23}$$

The system of equations (1)-(2)-(5)-(6)-(14)-(15)-(16)-(17)-(21)-(22)-(23) can thus be simulated under alternative AIDS assumptions to make medium-term projections for key economic variables. It permits variation of key parameters, enabling thereby identification of the areas where policy intervention may help to minimize the impact of AIDS on the economy.

THE DATA

In order to apply the model, it is necessary to calibrate it so that its projections match the actual (known) values of relevant economic variables in some base period. In this case 1998/99 is chosen as the base year. Besides providing updated nonmining GDP values, national account figures allow us to compute the level of capital stock for the whole economy. Moreover, by using the same data assumptions as in BIDPA (2000), it is possible to estimate the size of informal sector's GDP and capital stock. Average wage rates in the two sectors are obtained from the average monthly earnings published by Central Statistical Office (CSO).

Demographic and AIDS statistics have been taken from a study on the demographic impact of HIV/AIDS in Botswana published in August 2000 by the Abt Associates South Africa Inc. and commissioned by the Botswana Ministry of Finance and Development Planning with the support of the United Nations Development Programme.

Best estimate projections[20] indicate that 17 percent of the total population of Botswana was infected with HIV in 1999, versus the 11 percent prevalence rate in 1995 and the an expected 22 percent in 2010. Infection rates among adults aged 15-59 are substantially higher, estimated to rise from 21 percent in 1995, to 30 percent in 1999, and to over 37 percent in 2010 if no intervention or change of behavior is assumed. The data illustrates that the AIDS epidemic in Botswana is still at a relatively early stage, despite high prevalence. Less than 20,000 AIDS cases are projected for 1999, but the burden is expected to surge to more than 50,000 by 2010.

We draw on the Abt (2000) demographic study to obtain projections of the age profile of the Botswana population over time. Since updated employment data are not available (next Labor Force Statistics is due in 2005), we make use of the 1995/96 Labor Force Statistics to extrapolate data on the structure of the labor force up to 2010. To do this, we assume a fixed participation rate per age cohort. This implies that AIDS has no effect on the participation rate, while it can reduce total employment and total output.

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[20] Best demographic estimates for Botswana have been generated with the Spectrum AIM model, a model specifically designed to calculate the demographic consequences of the HIV virus. It is readily available from internet at http://www.tfgi.com. Its key assumptions are the following: (1) A common antenatal seroprevalence epidemic curve for all Districts, with District epidemics differing only in their timing. (2) Calibration of the projections against male/female age profiles of antenatal and reported AIDS case data. (3) Median adult survival times of 8.5 years from infection to AIDS, and one year after developing AIDS. Median child survival just under 2 years. (4) Average fertility reduction of 34 percent among HIV-infected women. (5) Mother-to-child transmission rates of 30 percent.

We also use estimates of AIDS cases to evaluate AIDS-related health spending and adopt a conservative approach regarding the AIDS treatment cost per patient. Namely, we let it be equal to the average wage prevailing in 1998/99. This is less than 40 percent of per-capita GDP in the same year (P 14,495 versus P 38,439). Note that the BIDPA report shows treatment costs per head ranging between 1 and 4 times per-capita GDP.

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