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Commodity Booms in Botswana and the Permanent Income Hypothesis

August 1990
(pdf version October 2000)

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Abstract

Many countries have experienced difficulties managing commodity export booms. Botswana, an exception, has avoided excessive increases in goverrment expenditure during boom periods, instead building up international reserves and goverrment balances at the central bank to be used when the boom ended. The country has, in fact, followed a savings path that is consistent with the life cycle-permanent income hypothesis, the appropriate policy response to temporary booms in the absence of liquidity constraints. This paper estimates the size of the booms and busts in the diamond sector, making different assumptions about the time series behavior of mining GDP and dianond export revenues. It then uses these estimates to test the life-cycle permanent income hypothesis for Botswana.

Acknowledgments

This research was assisted by a grant from the Joint Committee on African Studies of the Social Science Research Council and the American Council of Learned Societies, with funds provided by the national Endowment for the Humanities and the Ford Foundation. This research was motivated by a study (Hill and Mokgethi, 1989) prepared for the Economic Development Institute of the World Bank. I would like to thank John Cuddington, David Ross, and Stephen Younger for comments on earlier drafts.

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Technical assistance in the preparation of the current version of this document has been provided by Monica Mocanasu, graduate assistant in the Department of Economics and Finance of the School of Business, Montclair State University

I. Introduction

Botswana is endowed with large supplies of diamonds. The mining and quarrying sector, primarily diamonds, accounted for about 45 percent of GDP in 1987/8.[1] Diamond exports were approximately 85 percent of total exports in 1987. In addition, mineral revenues have accounted for a large proportion of total government revenues every year since 1975. Large diamond export receipts, normally considered a benefit, can make macroeconomic management difficult. A boom in export receipts can result in "Dutch disease" effects taking place in the economy that can then lead to balance of payments problems, instability in income, and less diversification than might otherwise occur.

Botswana has avoided many of the economic problems that other primary commodity exporters in both Africa and Latin America have not, by adopting appropriate macroeconomic policies in response to variable diamond receipts. Guided by two objectives - avoiding "the circumstances where a severe package of austerity measures is needed to decrease imports" and "encouraging diversification" - Botswana has not experienced severe balance of payments crises as a result of fluctuations in receipts from its main commodity export. The policies adopted have included avoiding excessive increases in government expenditure during boom periods, instead building up international reserves and government balances at the central bank to be used when the boom ended. In addition, through management of the nominal exchange rate, real exchange rate appreciation has been avoided.

This paper examines Botswana's savings response to booms and busts in the diamond sector. This decision is an important part of Botswana's macroeconomic management of variability and uncertainty in the diamond sector. Other aspects of Botswana's policy response to booms and busts are discussed in Hill and Mokgethi (1989). Section II briefly reviews the theoretical work on the effects of commodity windfall gains on the economy and the appropriate policy responses. The savings-consumption decision is shown to be a major component of the optimal policy package. Section III presents alternative estimates of the size of the booms and busts in the diamond sector in Botswana over the last two decades, making different assumptions about the time series behavior of mining GDP and diamond export revenues. Section IV discusses tests of whether the savings-consumption decisions adopted have been appropriate. The actual allocation of savings in Botswana between alternative assets is also briefly discussed. Section V concludes.

II. The Effects of Windfall Gains on the Economy

A boom in an economy's export sector can give rise to a variety of economic effects, collectively referred to as the "Dutch disease. •' These effects have been explored at length in the literature and are only briefly reviewed here (see Corden (1983, 1984), Corden and Neary (1982)). In particular, the increased export revenues will tend to appreciate the real exchange rate, leading to a loss of competitiveness and hence a fall in output in other tradable goods sectors.

If the rise in prices in the boom sector is permanent, the changes in relative prices and competitiveness bring about an efficient reallocation of resources (Corden (1983), Edwards (1984)). If the boom is only temporary, but the government acts as if it were permanent and allows the effects discussed above to take place, including excessive real exchange rate appreciation and increasing wages, then balance of payments crises, instability of income growth, reduced diversification, and wasted resources are likely to result. If the boom is temporary, resources will be wasted in the foret of transition costs, perhaps taking the foret of unemployed resources, as resource allocation responds to the changed profit conditions

[1] The GDP figures reported in Statistical Bulletin, December 1988, are preliminary

if expectations about the boom's permanence are incorrect. Even if private agents realize that the boom is temporary and decide not to reallocate resources, profitability will decline in the nonboom tradable sector. If financial markets do not allow borrowing against future earnings, then the nonboom tradable sector may decline.

The appropriate policy response to a temporary boom is to avoid the macroeconomic effects and structural changes that would only be appropriate for a permanent price increase. (See Cuddington (1986a), (1988) for a more detailed discussion.) First, current spending should be kept in line with expected long run revenues, not with short run receipts. When a country's income increases temporarily, the appropriate response is to save a large percentage of the windfall, spreading the increased consumption allowed by the boom over time. The country should follow a consumption and savings path that would be consistent with the life cycle-permanent income hypothesis applied to the whole country. It is this aspect of the appropriate response to booms that is tested below.

Increased savings, in turn, should be allocated between domestic investment and foreign assets. Increased saving should be invested domestically only if profitable compared to investing in foreign assets. An important consideration is the economy's absorptive capacity for new investment, which may justify spreading any increased domestic investment out over time. Finally, keeping the real exchange rate from appreciating will avoid unnecessary and unjustified resource reallocations away from the nonboom traded goods sectors, and any accompanying transition costs. To what extent there will be pressure for the real exchange rate to appreciate will depend in part on what has happened to savings. For example, if the government receives the windfall (either directly or by taxing it away from the private sector), and saves it in the foret of foreign assets, then demand will not increase and the monetary base will remain unchanged, two channels through which there may be pressure on the real exchange rate.

III. Booms and Busts in the Diamond Sector in Botswana

The Botswana economy is extremely open. Total exports and imports respectively accounted for approximately 80 percent and 50 percent of GDP in 1987. The main commodity export is diamonds, accounting for 85 percent of total export receipts in 1987. The diamond sector's contribution to GDP and GDP growth rates has, however, been variable. Booms have occurred when new diamond mines have come on line.[2] The first diamond discovery in 1967 resulted in the Orapa mine. The second, in 1969, led to the Letlhakane mine. The third source of diamonds is at Jwaneng, where production started in 1982.

Booms and busts have also occurred in the world diamond sector when unexpected price changes have occurred in the diamond market and when exports or the quality of diamonds mined have deviated from previously expected levels. For example, between 1976/77 and 1979/80, actual diamond production in carats was close to levels predicted in the National Development Plan 1976-81, but sales values were much higher because of unexpectedly large annual price increases, ranging from 20 percent to 35 percent.[3] Then the world diamond market collapsed during the early 1980s, with unit values dropping over 20 percent in 1981 and a further 12 percent in 1982. In addition, Botswana's diamonds are sold through the DeBeers Central Selling Organization (CSO), as negotiated in five-year marketing agreements. When the CSO was unable to maintain sales, it imposed export

[2] One could think of the boom in expected permanent income actually taking place when the diamonds are discovered, not when the mine comes on line and production actually begins.

[3] Republic of Botswana, 1980 , P. 186.

quotas on producers including Botswana. Diamond prices and exports have since recovered.

In order to examine how Botswana has responded to variability in the diamond sector, it is necessary to have an estimate of the size of the booms and busts. To get an estimate of the relative sizes of the booms and busts in the sector, several alternative methods have been used. Booms and busts in both real diamond export revenues per capita and in real GDP per capita in the mining sector have been calculated.[4]

To calculate the boom (or bust) actual levels are compared to expected levels. Expected levels have been proxied by the government's own projections and by the fitted values from three alternative regressions estimating the time series behavior of diamond export revenues and mining GDP. First, it was assumed that the variable follows a deterministic exponential time trend: lny(t) = a + btime + e(t). Deviations from trend, e(t), can be represented by an ARMA process A(L)e(t) = B(L)u(t) where u(t) is white noise. With first order autocorrelation of the errors, for example, A(L) = 1-pL' and B(L) = 1. Deviations from trend equal the booms or busts.

This model is called trend stationary (TS) by Nelson and Plosser (1982) and implies that the long run behavior of the variable is completely deterministic. Deviations around trend are by assumption cyclical or temporary and do not change the future expected path or trend of the variable. Such a model can be fitted to the Botswana data on real per capita mining GDP and real per capita diamond exports. lny is the log of real per capita mining GDP and lnder is the log of real per capita diamond export revenues. There is a large one time shift in diamond production around 1970, so a dummy variable, DUM, that equals 1 before 1971 and zero thereafter is included in the regressions.[5] For real per capita mining GDP, the results are:[6]

lny(t) = 2.22 + .18time -2.05DUM + u(t)
(.43) (.03) (.39)

Standard errors in parentheses
1964-1987 (data for 1986 and 1987 are preliminary)
$R^2 = .94$
DW = 1.97
F(2,21) = 175.32

For real per capita diamond export revenues, the results are similar:[7]

lnder(t) = 2.68 + .20time -3.30DUM1 + u(t)
(.22) (.02) (.33)
1968-1987
$R^2 = .96$
DW = 1.63

[4] The CPI has been used to calculate real variables. The GNP deflator is dominated by diamond prices.

[5] If the dummy variable is excluded, the error term appears autocorrelated.

[6] For both diamond export revenues and mining GDP, the Durbin Watson suggests that the errors are not autocorrellated. The regressions were rerun, using a maximum-likelihood technique (the Prais-Winsten estimator). The coefficient estimates remained virtually unchanged and the estimate of rho was close to zero and not significantly different from zero. In addition, a multivariate ARMA procedure was used and yielded almost identical results.

[7] Diamond export revenues jump up in 1970. DUMI equals 1 before 1970 and zero thereafter.

$F(2,17) = 234.97$

Alternatively, the variable can be assumed to be what Nelson and Plosser (1982) refer to as difference stationary (DS):

$$\ln y(t) - \ln y(t-1) = b + e(t)$$
$$A(L)e(t) = B(L)u(t), \quad \text{where } u(t) \text{ is i.i.d.}$$

A random walk with or without drift are special cases of this model where e(t) = u(t). The residuals equal the booms and busts. In this case, however, the booms and busts are permanent rather than cyclical. If e(t) does not equal u(t), but the model is DS, the Beveridge-Nelson(1981) procedure can be used to decompose the time series into permanent and temporary components. In fact, for Botswana, assuming the model is DS, Box-Jenkins methodology suggests the e(t) = u(t). Fitting a DS model to the Botswana data on mining GDP, assuming e(t) = u(t) yields:[8]

$$\ln y(t) - \ln y(t-1) = \underset{(.153)}{.207} + \underset{(.733)}{.985}DUM2 + u(t)$$

1965-1987
R^2=. 08
DW=2.81
F(1,21)=1.81

The results for per capita diamond export revenues are similar:

$$\ln der(t) - \ln der(t-1) = \underset{(.100)}{.274} + \underset{(.437)}{2.286}DUM3 + u(t)$$

1969-1987
R^2=. 59
DW = 1.94
F(1,17) = 27.35

It is difficult to choose one of these time series models over the others, particularly given the limited time series data available for Botswana. Appendix A presents and discusses several tests for choosing between these models. It is not possible to reject the null hypothesis that the process is DS. However, as discussed in DeJong, et .al. (1988), these tests have low power against TS alternatives.[9] Given that it is not possible to choose statistically between these models with any confidence, booms and busts have been calculated under each alternative model. Table 1 reports estimates of the booms and busts in diamond exports and in mining GDP as a proportion of the expected value using the alternative measures of expected levels.[10] Diagrams 1 through 6 plot the levels of the alternative measures of the real per capita booms against time.

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[8] Assuming the model is DS, BOX-Jenkins ARIMA methodology suggests that e (t) = u(t). (Note to me-extend to transfer function results.) Therefore, as in the TS model, the errors appear to be uncorrellated. There is some evidence of a unit moving average root, suggesting that a TS process better fits the data. This is discussed in greater detail in Appendix A.

[9] Whether macroeconomic time series follow a TS or DS process is a major area of research in domestic macroeconomics. Starting with Nelson and Plosser (1982) , it has been argued that many macroeconomic series are DS. These conclusions are being challenged more recently by Faloavin (1988) and DeJong (1988), among others. There ,as yet ,seems to be no consensus view: "the controversy over the stationarity issue does not appear to be in danger of resolution anytime soon (Flavin (1988))."

[10] The estimate of the boom based on trend values was calculated as:

exp(Iny(t)) - exp(Iny(t)) where
exp(Iny(t)) = a + btime + cDUM

Table 1
Booms and Busts in Per Capita Real Diamond Exports and Mining GDP as a Proportion of Expected values

1.A Diamond Exports

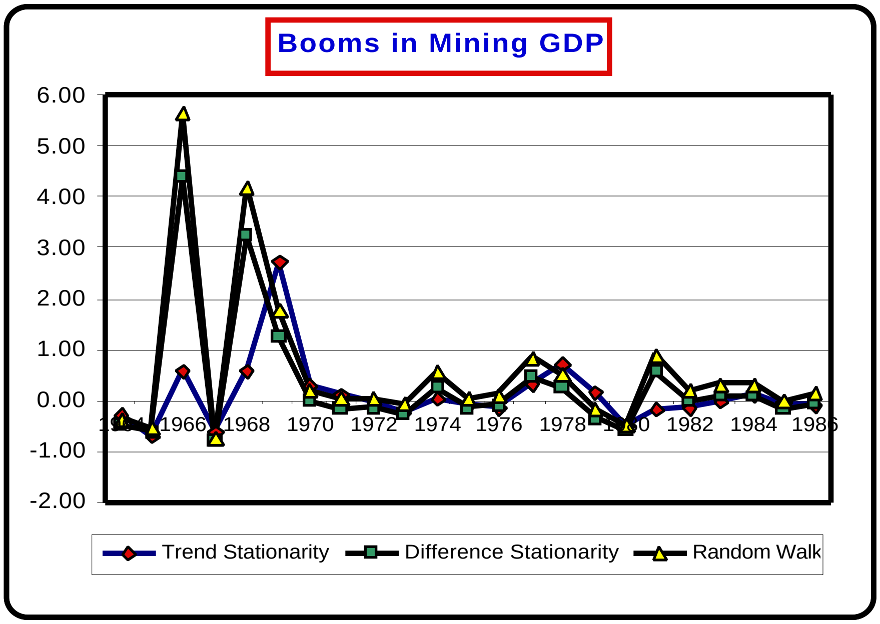
	Based on Government Projections	Based on Trend Values	Based on Random Walk with Drift	Based on Random Walk no Drift
1968	-	-0.20	-	-
1969	-	0.25	0.44	0.90
1970	-	-0.51	0.04	0.34
1971	-	-0.25	0.40	0.85
1972	-	0.99	1.48	2.26
1973	-	0.45	-0.33	-0.12
1974	-	0.49	-0.05	0.25
1975	-	0.10	-0.32	-0.10
1976	0.19	-0.11	-0.25	-0.01
1977	0.00	-0.23	-0.20	0.05
1978	0.39	-0.10	-0.08	0.42
1979	0.14	0.54	0.59	1.09
1980	0.10	0.39	-0.17	0.09
1981	-0.31	-0.46	-0.64	-0.53
1982	-0.15	-0.31	0.19	0.56
1983	-0.14	-0.06	0.27	0.67
1984	-0.03	-0.08	-0.09	0.19
1985	0.78	0.15	0.16	0.53
1986	0.68	-0.07	-0.25	-0.02
1987	1.86	0.26	0.26	0.66

using the coefficients from the regression reported in the text. The estimate of the boom based on a random walk model with drift was calculated as:

exp(Iny(t)) - exp(Iny(t)) where
exp(Iny(t)) = exp(Iny(t-1) + b + cDUMi)
using the coefficients from the DS regression reported in the text.

The estimate of the boom based on a random walk model without drift is simply y(t) - y(t-1).

Figure 1
Booms in Mining GDP
(Real 1980 Pula)



1.B Mining GDP

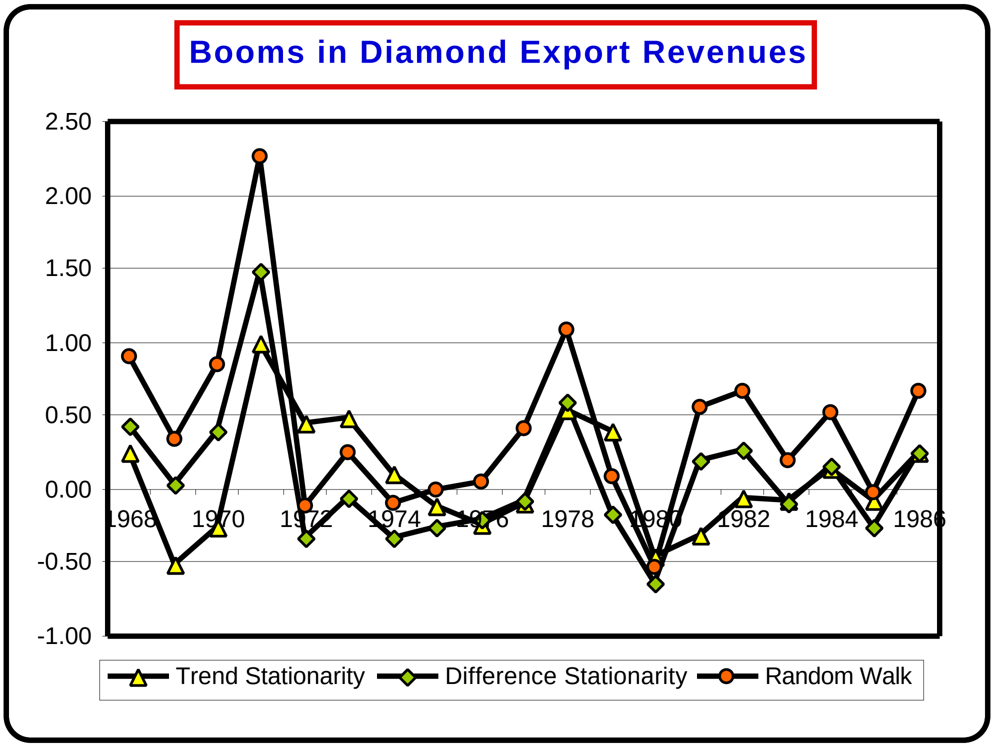
	Based on Government Projections	Based on Trend Values	Based on Random Walk with Drift	Based on Random Walk no Drift
1964	-	0.37	-	-
1965	-	-0.27	-0.48	-0.36
1966	-	-0.71	-0.62	-0.53
1967	-	0.59	4.40	5.65
1968	-	-0.63	-0.78	-0.73
1969	-	0.60	3.26	4.23
1970	-	2.74	1.27	1.79
1971	-	0.32	0.00	0.23
1972	-	0.14	-0.16	0.03
1973	-	0.01	-0.14	0.06
1974	-	-0.21	-0.24	-0.06
1975	-	0.05	0.28	0.57
1976	0.14	-0.07	-0.14	0.05
1977	-0.22	-0.13	-0.09	0.12
1978	0.38	0.34	0.50	0.85
1979	0.16	0.73	0.26	0.54
1980	0.16	0.19	-0.34	-0.18
1981	-0.41	-0.48	-0.57	-0.47
1982	-0.31	-0.16	0.56	0.91
1983	-0.31	-0.13	0.00	0.23
1984	-0.17	-0.02	0.10	0.35
1985	1.13	0.11	0.09	0.35
1986	-	-0.06	-0.18	0.01
1987	-	-0.08	-0.05	0.17

Source: National Development Plans 1968-1973, 1970-1975, 1973-1978, 1976-1981, 1979-85, 1985-91, and Statistical Bulletin, various issues. Note: (- indicates currently not available.)

* Projections were taken from the most recent National Development Plan. For example, if both the NDP 1968-1973 and 1970-75 projected GDP and diamond exports for 1973, the NDP 1970-75 projections were used.

The general picture that emerges is that 1979 was a boom year, 1981 was a bust year, and by 1985 a substantial boom was in progress.[11] In 1987, there is also a large boom in diamond export revenues, reflecting sales from stockpile. The alternative measures of the booms and busts follow similar patterns. The relationships between the alternative measures is as expected. The random walk models have earlier turning points than the trend models. The random walk with drift models turn down more and earlier than the simple random walk models. Remembering that diamond exports on average from 1975 to 1985 accounted for about 50 percent of total exports, which in turn accounted for on average over 50 percent of GDP, and that mining and quarrying GDP accounted for on average 25 percent of total GDP, these booms and busts have been large relative to the size of the Botswana economy. As an example, using the TS model for mining GDP, the booms in 1979 and 1985 equalled 12.5 percent and 6 percent, respectively, of total GDP.

Figure 2



In Botswana, the government directly receives the income from diamonds. The government has two primary sources of revenue: customs revenues and mineral revenues, mostly from diamonds. Botswana receives customs revenues from the South African Customs Union. Receipts depend on Botswana's imports and the agreed revenues sharing formula. Revenues from diamonds are determined by long-term agreements with DeBeers. These agreements do not eliminate variability in this source of revenue, but they do limit the government's short-run flexibility in raising revenue. Uncertainty about diamond export receipts therefore directly creates uncertainty about government revenue. Also, customs revenue is closely linked to major new projects in the mining sector, with a lag. When a large amount of construction is being done in the mining sector, imports are high because

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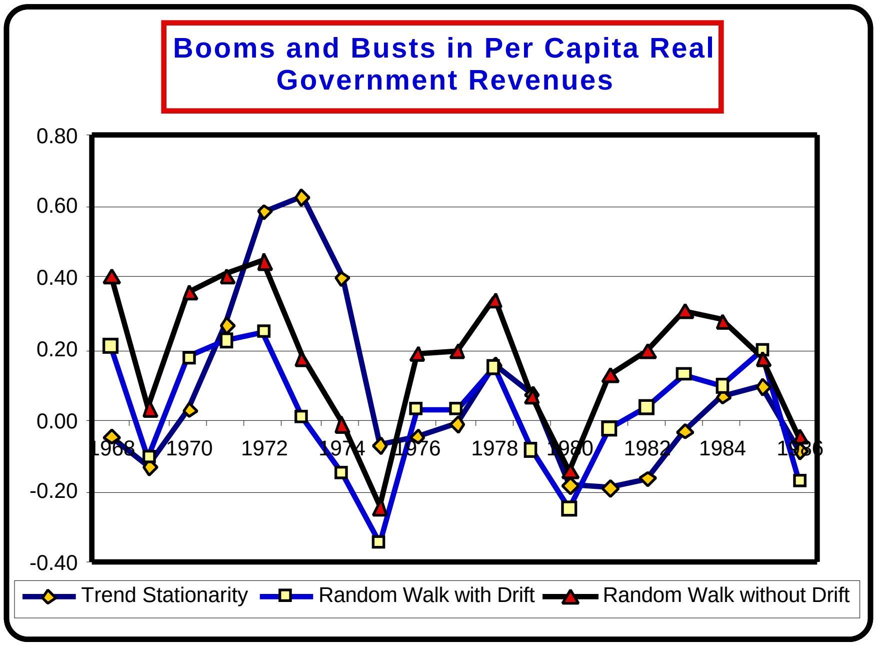
[11] Several other alternative measures of the boom were calculated. The method used by Gelb (1986) applied to Botswana yielded estimates sf the boom that were positively correlated with those reported in the text. The method calculated the expected value by assuming that the ratio of mining GDP to nonmining GDP would equal its 1976-79 average and that expected nonmining GDP equaled its actual value.

of increased demand for imported inputs. In addition, any increased labor income resulting from expansion of the mining sector results in additional increases in imports.[12]

Since the government is the major recipient of mineral income, booms and busts in government revenue have also been calculated. Government revenues move closely with both diamond exports and mining GDP, as expected. Table 2 shows booms and busts in government revenues relative to expected levels, using the government's own projections, trend values, and predicted values from a DS model with and without trend as alternative measures of expectations.[13] (The government has consistently underestimated revenue.)[14]

Figure 3



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[12] Lewis and Mokgethi, (1983), pp.76-77.

[13] The equations used to calculate the booms reported in Table 2 are:

TS
ingovrev(t) = 3.81 + .14time + e(t) (.41) (.0.03)
e(t) = .65e(t-1) = u(t)
(.17)

1968-1987 R'= . 7 9 F(1,18) -72.09

DS
Ingovrev(t) - Ingovrev(t-1) -.148 + u(t)
(.04)
1969-1987 R2 = . 4 0 DW = 1.38 F(1.18) = 13.74

[14] As with mining GDP and diamond export revenues, using the Dickey Fuller test (see Appendix A), it is not possible to reject the pull that real per capita government revenue follows a DS process. In contrast to the results for mining GDP and diamond export revenues, there is not evidence of a unit moving average root. Instead, there is an autoregressive component to the error term.Using the Nelson-Beveridge method for calculating the change in the permanent component of government revenue results in an increase greater than the error. given uncertainty about whether the true model is TS or DS, using these ds results would be undesirable.

Figure 4
Random Walk Boom Estimates
(Real 1980 Pula, per capita)

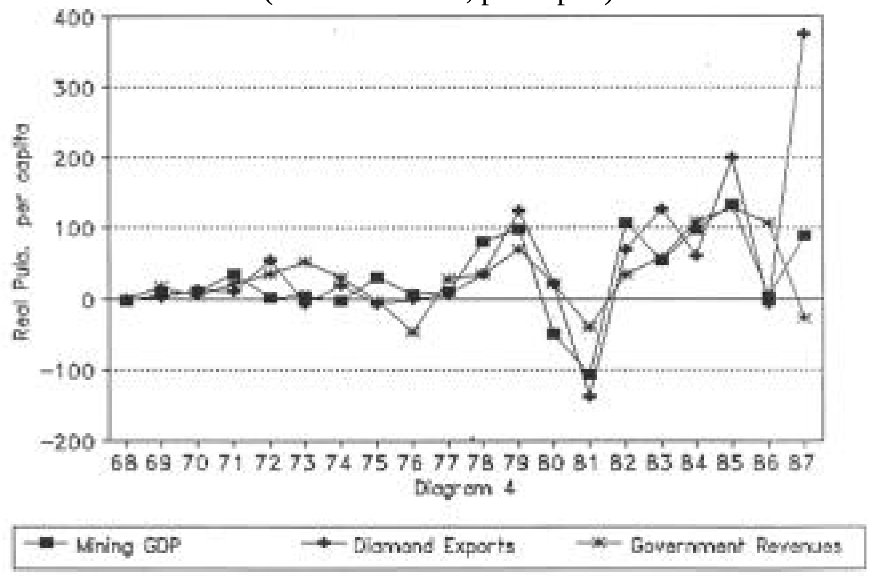

Figure 5
Trend Stationary Boom Estimates
(Real 1980 Pula, per capita)

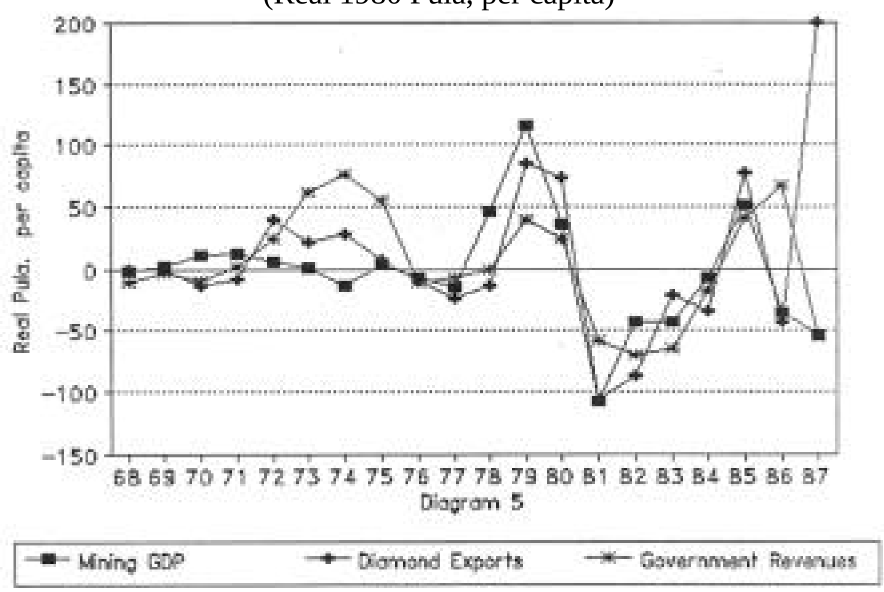

Figure 6
Difference Stationary Boom Estimates
(Real 1980 Pula, per capita)

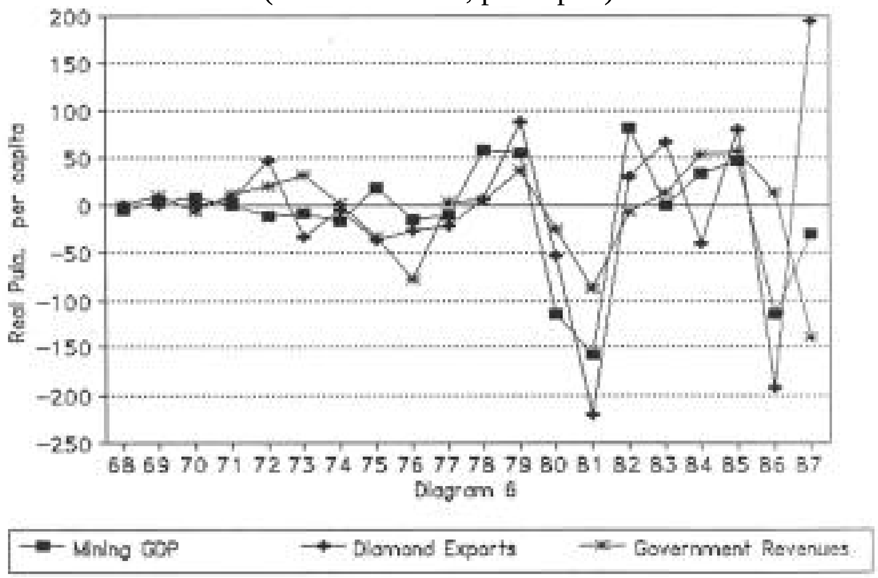

Table 2
Booms and Busts in Per Capita Real Government Revenues

	Based on Government Projections*	Based on Trend**	Based on Random Walk with Drift***	Based on Random Walk without Drift***
1968	0.38	-0.22	-	-
1969	0.80	-0.04	0.21	0.41
1970	0.16	-0.13	-0.10	0.04
1971	0.09	0.03	0.18	0.36
1972	0.17	0.27	0.22	0.41
1973	0.27	0.59	0.25	0.45
1974	0.53	0.63	0.01	0.18
1975	0.74	0.40	-0.15	-0.01
1976	0.14	-0.07	-0.34	-0.24
1977	0.08	-0.04	0.03	0.19
1978	0.18	-0.01	0.03	0.20
1979	0.11	0.16	0.15	0.34
1980	0.16	0.08	-0.08	0.07
1981	0.08	-0.18	-0.25	-0.14
1982	0.19	-0.19	-0.02	0.13
1983	0.26	-0.16	0.04	0.20
1984	0.50	-0.03	0.13	0.31
1985	0.64	0.07	0.10	0.28
1986	-	0.10	0.20	0.18
1987	-	-0.08	-0.17	-0.04

Source: National Development Plans 1968-73, 1970-75, 1973-78, 1976-81, 1979-85, 1985-91, and Statistical Bulletin,various issues.

Note: - indicates not currently available.

* Projections were taken from the most recent National Development Plan.

** expressed as a proportion of the trend value

*** expressed as a proportion of the expected value

IV. Botswana's Savings Response to Booms and Busts: Testing the Life Cycle Permanent Income Hypothesis

A. Introduction

When a country experiences a temporary boom in income, the appropriate response is to save a large percent of the windfall. In contrast to many developing countries, Botswana appears to save boom income. Total consumption, public and private, is smoothed over time and does not increase in response to boom income. Since the government receives the boom income, its spending behavior is important in explaining this result. Like total consumption, government expenditures, measured by government consumption or recurrent expenditures, are also smoothed over time. Through fiscal policy, the government saves boom income.

B. Total Consumption

Cuddington (1988) and Rajaram (1985) report increases in the ratio of government consumption to GDP during boom periods in Colombia and sub-Sahara Africa respectively. This means that the governments were not successfully smoothing consumption over time. In contrast, in Botswana both public consumption and total consumption relative to GDP are negatively associated with booms in the diamond sector.[15]

In fact, if the country as a whole is following a rational savings policy, its consumption (and savings) behavior would be consistent with the life cycle-permanent income hypothesis (LCPIH). Total consumption, public plus private, would be smoothed over time, and transitory booms in GDP would be saved. Hall (1978), Flavin (1981, 1985), and Nelson (1987) discuss empirical tests of the life cycle-permanent income hypothesis for consumers in the United States. Similar tests are applied here to the Botswana data to test whether the country as an aggregate follows an optimal consumption and savings path. Hall demonstrates that if consumption behavior is consistent with the LCPIH, then consumption should follow a random walk plus trend.[16]

The empirical implication is that current consumption should depend on consumption lagged one period, but no other variables lagged one or more periods. The intuition is that any information about permanent income contained in past variables, in particular past income, would already have been incorporated into estimates of permanent income and

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[15] Regressing total consumption relative to GDP and public consumption relative to GDP against all the alternative measures of the boom, the coefficient on the coefficient on the boom is always negative. In most cases, although not all, the coefficient is significantly different from zero at the 5% level.

[16] Hall (1978) demonstrates that the marginal utility of consumption should follow a random walk plus trend. Whether consumption itself follows a random walk plus trend depends on the foret of the utility function. For a quadratic utility function, consumption will follow random walk:

Ct = bo + gct_I + et

bo = c (r-d) / (1=r)

g = (l+d) / (l+r)

where

r = real interest rate d = rate of time preference c = bliss level of consumption

A quadratic utility function, however, implies increasing absolute risk aversion, an unrealistic assumption about behavior toward risk. As discussed by Nelson (1987), if the utility function exhibits constant relative risk aversion (CRRA),then the log of consumption will follow a random walk with trend, assuming a constant real interest rate. In addition, the variance of result, tests of the life cycle hypothesis should include the effects of any new information, the innovation, on both permanent income and the variance of permanent income.

therefore would be reflected in consumption lagged one period. There would be no additional predictive power for current consumption beyond what was already incorporated in lagged consumption. As discussed by Hall (1978, p. 977-8), such a test can be used to reject the life cycle hypothesis in favor of a model with liquidity constraints or a model where consumers nonoptimally or incorrectly calculate permanent income.

Estimating in first difference form, using real per capita income and consumption, public plus private, the results for Botswana are: [17]

$$c(t) - c(t-1) = \underset{(9.19)}{21.36} + \underset{(.053)}{.004}y(t-1) + u(t)$$

1965-68, 1974-85

$R^2 = .00$

Adding c(t-1) to the right hand side to test whether consumption follows a random walk yields:

$$c(t) - c(t-1) = \underset{(26.15)}{16.82} + \underset{(.072)}{.013}c(t-i) - \underset{(.112)}{.014}y(t-1) + u(t)$$

These results suggest that consumption does follow a random walk and that the country has followed a consumption pattern consistent with the LCPIH.[18]

Flavin (1981) estimates a structural model of consumption and income that allows her to examine how changes in current income provide information about permanent income and therefore affect current consumption. "Income innovations," deviations in current income from previously expected levels, can lead to changes in current consumption without being inconsistent with the LCPIH to the extent that they signal changes in permanent income. For example, in Botswana increases in diamond export revenues and therefore increases in total GDP could lead to increased current consumption and not be inconsistent with an optimal savings path, as long as the increased diamond export revenues implied increased permanent income.

One can attempt to estimate to what extent income innovations signal changes in permanent income and test whether consumption is excessively sensitive to income innovations and therefore not consistent with the LCPIH. Flavin's structural model involves an income and consumption equation.

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[17] Changing to log form leaves the results unchanged. Using 1974 to 1985 yields similar results:

$$c(t) - c(t-1) = \underset{(14.25)}{27.17} - \underset{(.074)}{.027}y(t-1) + u(t)$$

D.W. = 2.2 RI = .01

[18] Using the Prais-Winsten procedure to correct for autocorrelation, taking into account the discontinuous time period, the conclusions remain unchanged.

$$c(t) - c(t-1) = \underset{(9.983)}{23.785} + \underset{(.045)}{.013}y(t-1) + e(t)$$

1965-68, 1974-85 p = -.2 R2 = .03

If the equations are estimated over the longest continuous time period for which data are available, again the conclusions remain unchanged and estimates of p are not significantly different from zero.

$$y_t = u_1 + p_1 y_{t-1} + p_2 y_{t-2} + \ldots . e_{1t} + 0 e_{1t-1} + \ldots .$$
$$c_t = u_2 + u_c c_{t-1} + u_4 e_{1t} + B_0 y_t + B_1 y_{t-1} + e_{2t}$$

Income (y_t) is modelled as an ARMA time series.[19] The white noise error term (e_{1t}) represents the new information on permanent income in current income. Consumption (c_t) will therefore depend on the income innovation, with the expected coefficient depending on the parameters of the time series model of income. Since the consumption equation includes the income innovation, e_{1t}, to test whether consumption is excessively sensitive to income, current and lagged income are added to the equation.

If $B_i = 0$, then consumption would show no excess sensitivity to income, supporting the LCPIH.[20] Note that income is endogenous to consumption and that the error term in the consumption equation, e_{2t}, affects the error term in the income equation, e_{1t}. Therefore, both e_{1t} and y_t are correlated with e_{2t} in the consumption equation. The consumption equation can be estimated by instrumental variables to deal with the simultaneity problem.[21] Diamond export revenue innovations and mining GDP innovations are used as instruments for total income innovations. While income and income innovations will depend on consumption, diamond export revenue innovations and mining GDP innovations do not. Current income is instrumented by past income and current mining GDP, assumed exogenous to current consumption.

The change in consumption was regressed on the GDP boom (or bust) and the current level of GDP, instrumented as discussed above. The expected coefficient on the GDP innovation depends on the effect that the innovation has on permanent income, which in turn depends on whether GDP follows a TS or DS process. If one believes it follows a deterministic tune trend, the change in permanent income associated with a GDP innovation can be calculated. Permanent income from GDP (y^P) for an infinitely lived country equals the annuity rate times the present discounted value of current and expected future income from GDP (EX_{t+s}), or:

$$Y^P t = r \, [\, (1/ (l+r) \,)^s EX_{t+s} \,]$$

The real rate of return, r, is assumed constant. Given a shock to GDP in time t, the change in expected permanent income from the previous period will be:[22]

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[19] Flavin (1981) originally estimated the model assuming income followed a Tg process, by defining Yt as the deviation from an exponential time trend.

[20] There is a large recent literature on testing the LCPIH for the U.S. An important issue is whether GDP follows a deterministic time trend or a random walk. If GDP follows a random walk but is assumed to follow a time trend, then tests of the LCPIH will be biased toward rejection. See Nelson(1987) and his bibliography. As discussed below, this does not turn out to be a problem for Botswana.

[21] This ignores the fact that the equations are seemingly unrelated regressions, and therefore the estimates would be inefficient. The structural model could be estimated simultaneously by FIML to get efficient estimates. I am trying to do this.

[22] EtXt - Et_1Xt = Vt

EtXt = eao+alt + ut

$$Y^p t = r \left[(1/(1+r))^s (E_t X_{t+s} - E_{t-l} X_{t+s}) \right]$$
$$Y^p t = r v_t$$

where v_t equals $E_t X_t - E_{t-l} X_t$ or the boom or bust. Adding the GDP innovations to the consumption equation, the expected coefficient on the innovation is the real interest rate, some number around .05.

If GDP is assumed to follow a random walk, then the change in permanent income equals the innovation: $yp_t = v_t$.[23] In contrast to the TS model, a deviation or shock today changes expectations about values in the future, leading to a much larget change in expected permanent income. A coefficient on the innovation in this case equal to one would be consistent with the LCPIH.

If GDP follows a random walk plus drift, the change in permanent income is greater than the innovation:

$$y^P_t = (1/(i+r))^s \exp(sb + \ln y(t)) - (1/(i+r))^{S-1} \exp(sb + \ln y(t-1)$$

$$= v(t)(1+((1+b)/(1+r))+((1+b)/(1+r))2 + ...)$$

In fact, if b>r, then the terni in brackets does not converge.

To further test the LCPIH, in each the TS, random walk, and DS cases, current GDP is added to the equation to test whether consumption is excessively sensitive to current income, having already taken into account the information in the innovation. The results are reported in Table 3. The coefficient on the innovation varies from .13 to .23. Although in most cases significantly different from zero, the estimates are not significantly different from sonie small number. If GDP is a stationary process, the results are approximately consistent with the LCPIH.[24] If however GDP is in fact nonstationary, then the data for Botswana are not consistent with the LCPIH, because consumption is "too smooth".

Consumption should vary more than it in fact does, as revisions in expected permanent income are equal to or largei than innovations in current income.[25] These results suggest that the country assumes booms are temporary in nature and Baves the major proportion of them. In addition, there are costs to assuming permanent booms to be temporary, as well as costs to assuming temporary booms to be permanent. Botswana' s response to uncertain booms is consistent with the costs of assuming temporary booms to be permanent being

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Et_1Xt = ea0+ait

EtXt Et_1Xt _ ea0+alt (eut - 1) = Vt

Etxt+1 - Et-1Xt+1 = e°0+al(t-1) - ea0+al(t+1) = 0

A deviation from trend today does not change expectations about trend values in the future. This implies that a shock today has a very small effect on permanent income, the real rate times the shock and therefore should have a small effect on current consumption.

[23] YPt = r(1/(1+r))s(EtXt+s – Et-1Xt+s) – Vt.

[24] This contrasts with findings for the U.S. , where consumption is too sensitive to current income if income is assumed to be a stationary process (Flavin (1985).)

[25] See Deaton (1987) for a discussion of excess smoothness of consumption in the United States.

relatively larger than the costs of assuming permanent booms to be temporary. A precautionary demand for savings could help to explain these results, but only if booms are associated with increased estimates of the variance of the tune series (see Hill (1989).)

The hypothesis that the coefficient on current GDP is equal to zero cannot be rejected, supporting the LCPIH for Botswana. If both current GDP and lagged total GDP are added to the equations, the F statistic for the hypothesis that the coefficients on current and lagged GDP are both zero are all below 1.0, well under the critical point of the F distribution of 4.74 at the 5 percent level, again supporting the LCPIH for Botswana.

Because the consumption data include expenditures on durables, the results will be biased toward rejection of the LCPIH. This strengthens the findings in favor of the LCPIH in Botswana. Working in the other direction, however, mining GDP and diamond export revenues include DeBeers' profits and therefore income not at Botswana's disposal. The actual boom revenue received by Botswana would be smaller than estimated and therefore the amount consumed out of the actual revenue received by Botswana larger. Using the innovation in government revenue per capita as the measure of the boom avoids this problem.[26] The results are qualitatively similar to those using GDP, supporting the conclusions that Botswana saves boom income .

[26] Government revenue may however be endogenous to consumption through government tax revenue. In Botswana, this primarily results from income taxes. Trade taxes, because of the customs union agreement with South Africa, respond with a lag and therefore are not endogenous to current consumption. In addition, since consumption depends on total GDP, this regression is misspecified since it leaves out a relevant RHS variable -- the boom in non-government revenue GDP. If this is not correlated with the included estimate of the boom, then the reported coefficients would be unbiased but the estimated variances would be biased up, lending greater support to the conclusion that only a small proportion of booms is consumed.

Table 3:
Tests of the LCPIH in Botswana:
The Effects of Innovations in Total GDP on Consumption Behavior
(dependent variable - c(t) - c(t-1), c = total consumption: standard errors in parentheses)

Boom in:	constant	boom	current level	$R^2(\bar{R}^2)$	DW[1]	F	SER
Total GDP[1]							
TS							
(1)***	18.39 (15.39)	0.23 (0.11)	0.03 (0.02)	.30(.19)		2.76	21.22
(2)**	38.78 (32.25)	0.15 (0.09)	-0.02 (0.04)	.24(.08)	3.2	1.46	22.75
DS with trend							
(3)**	31.09 (31.07)	0.13 (0.08)	-0.01 (0.03)	.22(.05)	2.6	1.29	23.08
(4)*	20.74 (8.17)	0.14 (0.09)	-0.003 (0.03)	.19(.06)		1.45	23.36
Random Walk							
(5)*	26.67 -19.51	0.16 -0.1	-0.02 -0.03	.19(.06)		1.43	23.36
(6)**	39.84 (32.42)	0.15 (0.09)	-0.03 (0.04)	.24(.08)	2.6	1.46	22.76
Government Revenue [2]							
TS							
(7)**	23.95 (11.75) p = -.48 (0.25)	0.18 (0.11)	0.00 (0.04)	.33(.18)	2.2	2.23	21.41
(8)****	22.15 (13.81) p = -.4	0.18 (0.11)	0.03 (0.03)	.20(.04)		1.23	22.55
DS with trend							
(9)**	47.21 (16.06) p = -.50 (0.25)	0.28 (0.16)	-0.07 (0.05)	.33(.18)	2.3	2.22	25.14
Random Walk							
(10)**	47.21 (16.06) p = -.50 (0.25)	0.33 (0.18)	-0.12 (0.07)	.33(.18)	2.3	2.22	21.42

Notes: * = 1966-68, 1974-85
** = 1974-1985
*** = 1965-1968, 1974-1985
**** = 1968, 1974-1985

1. For continuous time periods, the equations were corrected for autocorrelation. With the exception of equation (2), the estimates of p were not significantly different from zero. In all cases, the coefficient estimates remain substantially unchanged. OLS results are reported. For discontinuous time periods, the Prais-Winsten procedure was used. Again, the coefficient estimates remain unchanged.
2. The equations reported have been corrected for autocorrelation.

Data on consumption are not available for 1969, 1970, and 1972. This plus the lag structure explains the time periods used.

C. Fiscal Policy

Fiscal policy has been the major policy tool used by the government to pursue its objectives of avoiding external debt problems, stabilizing growth, and promoting diversification. The government's fiscal policy response to boom income explains the country's total consumption response to variable income.

Government expenditures are based on long-terni expectations of revenues. When export receipts from diamonds increase, and therefore government revenues increase, government expenditures do not rise directly to any significant degree. Instead, the government builds up foreign exchange reserves and balances at the Bank of Botswana to use when revenues are low.

Booms in government revenue have resulted in increases in the government recurrent surplus and not in increases in spending. Regressing the rate of change in recurrent expenditures or public consumption on the boom in government revenues, the coefficient ors the revenue boom is not statistically different from zero for all three measures of the boom.

Table 4
The Government's Spending Response to Booms in Government Revenues

	constant	boom	current level	R^2 (RI)	DW'	F	SER
Using Government Consumption as the Dependent Variable (c (t) - c(t-1»)							
TS							
(1)*	10.65	-.065	.019	.09(-.11)	2.5	.46	13.46
	(9.80)	(.084)	(.031)				
DS with trend							
(2)*	8.85	-.031	.025	.04(-.17)	2.5	.18	13.85
	(13.11)		(.120)	(.042)			
Random Walk							
(3)*	8.85	-.036	.040	.04(-.17)	2.5	.18	13.85
	(13.11)		(.139)	(.056)			
Using Government Recurrent Expenditure as the Dependent Variable (lnc(t) - lnc(t-1))							
TS							
(4)**	.062	.029	.003	.01(-.11)	2.48	.15	.083
	(.144)	(.060)	(.026)				
DS with trend							
(5)**	.072	-.023	.001	.01(-.12)	2.41	.06	.083
	(.144)	(.071)	(.027)				
Random Walk							
(6)**	.068	-.009	.003	.00(-.12)	2.44	.00	0.08
	(.145)	(.078)	(.027)				

Notes: * = 1974-1985

** = 1969-198

In the regression using government recurrent expenditures, the boom in government revenue is measured relative to revenue in the previous period.

1 Each equation was corrected for autocorrelation. The parameter estimates remained substantially unchanged and the estimate of p was not significantly different from zero in each equation. OLS results are reported.

By saving revenue booms, the government has been able to maintain a fairly constant growth rate in real expenditures over time. For example, in 1979/80 the government ran a surplus when revenues boomed. Then in 1981/82 when mineral royalties and dividends declined by P36 million, the recurrent surplus declined by P24 million while expenditure levels were maintained.

D. Domestic Investment and International Reserves

The government has to decide how to allocate savings between international reserves and domestic investment. Government investment in Botswana as measured by development expenditure has been based on long-run revenues, as has recurrent expenditure. Therefore, booms in revenue have not lead to much increase in development expenditures above previously planned levels.[27] Using the three alternative measures of the boom in government revenue, at most 25% of the boom is used to increase development expenditures. As a result, unexpected gains have mainly been saved in the foret of international reserves, and not increased domestic investment. International reserve accumulation has therefore closely mirrored booms and busts in the diamond sector. At the end of 1987, reserves equalled almost 21 months of imports, having equaled seven months of cover in 1983.

In addition to accumulating reserves, the government discussed the benefits of repaying the remaining amount due on a commercial Eurodollar loan taken out in 1982. It decided

[27] Using the trend values as expected values to calculate the boom, per capita real development expenditures were regressed on the boom in revenues

development = 41.92 + .26revenue boom + 4.85time + u(t)
expenditures (11.71) (.13) (1.03)

1969-85 R2 = .67(.62)

Assuming government revenues follow a DS process with drift:

development = 48.25 + .12revenue boom + 4.97time + u(t)
expenditure (12.74) (.15) (1.14)

1969-85, R2 = . 59 (. 53)

Assuming government revenues follow a random walk:
development = 48.56 + .11revenue boom + 4.54time + u(t)
expenditure = (12.80) (.15) (1.30)

1969-85, R2 = .59(053)

In all three cases, correcting for autocorrelation left the coefficient estimates on the revenue boom unchanged, and the estimate of rho was not significantly different from zero at the 10 percent level.

that since the rate of return on the foreign exchange reserves was higher than the rate of interest on the loan, paying the loan back early would not be advantageous. By 1985, the situation had changed enough that in the end the loan was paid off somewhat ahead of schedule, the final payment being made in July 1985 instead of May 1986.

Whether the allocation of savings between international reserves and domestic investment has been optimal depends on the rate of return on international reserves relative to domestic investment. The government's decisions regarding the allocation reflect concerns that greater domestic investment would push the rate of return below the return on international reserves and that investment now would be at the expense of greater domestic investment in the future. The decision to invest in foreign reserves is considered a decision about the timing of increased domestic investment allowed by booms, as much as a static allocation decision based on relative rates of return between foreign assets and current domestic investment.

The allocation of savings to international reserves is starting to be questioned in Botswana. Initially, large reserve accumulation was not considered excessive by the Bank of Botswana or the Ministry of Finance and Development Planning, although there were obvious pressures to spend the money. The government justified the reserve accumulation because projections of future export earnings suggested that this level of surplus would not continue. The current boom has continued long enough that the government is currently reconsidering the appropriate division between international reserves and development expenditures. During the autumn of 1987, Parliament approved a proposal to consider a number of "major economic development initiatives" that would use a portion of the accumulated reserves for big investments in areas that are major bottlenecks to economic development of the economy. However, although there is concern, there is certainly not a consensus that the past allocation of savings to international reserves has been suboptimal.

E. Conclusions

Unexpected booms in export earnings should be a benefit, but if mismanaged can result in unstable growth and external debt crises. The appropriate response to temporary booms is to save the windfall and invest it in the highest return alternative. This paper suggests a way of testing whether a country has followed appropriate policies in terms of whether the windfall is saved. Botswana has allocated the savings primarily to international reserves. Whether this allocation decision has been optimal would be an interesting extension. Another interesting extension would be to apply similar techniques to countries that have not saved boom income and, as has been done in the U.S. consumption literature, try to determine whether deviations from the LCPIH result from liquidity constraints or myopia.

Under some circumstances, it may be possible to distinguish deviations from the LCPIH that result from liquidity constraints from those that result from suboptimal government policy. Many developing countries in fact face liquidity constraints in international financial markets. If this, rather than irrational decision makers, explains why temporary booms are not saved, the welfare implications are quite different.

Another issue raised by these findings is whether there is a precautionary demand for savings in Botswana. The tests of the LCPIH discussed above assume that there is no precautionary demand for savings, which is consistent with a quadratic utility function. This implies increasing absolute risk aversion, an unappealing assumption. More realistic utility functions result in precautionary savings which in turn would change the tests of the LCPIH (see Hill (1989).)

Mismanagement of booms has probably not resulted from a misunderstanding of the appropriate policy responses suggested by economic analysis. A clearer understanding of the actual economic costs and benefits of alternative policy responses may however be taking place as country experience accumulates. Botswana provides an example of the economic benefits of adopting appropriate policies. This, plus evidence from other countries on the costs of mismanagement, may contribute to countries in the future avoiding past mistakes.

Appendix A
Testing for a Unit Root

Several tests for unit roots are discussed below. For Botswana, given the limited time series data available, it is not possible to choose statistically with any confidence between the TS and DS specifications. Therefore, the booms and busts have been calculated assuming the series follow both a TS and a DS process. These tests would be of greater relevence for countries with more data available.

Dickey and Fuller (1981) have proposed a test for determining whether a time series follows a deterministic (TS) or stochastic (DS) trend (assuming there is no moving average component of the error term.) Assume only an AR1 process to start.[28]

lny(t) = a + btime + clny(t-1) + u(t)

Dickey and Fuller (1981) have developed test statistics for testing the null hypothesis that c = 1 and b = 0. If lny (t) follows a random walk with or without drift the usual t statistics are not t distributed. Dickey and Fuller have calculated the distributions and these can be used to test c = 1. As an example, the following regressions were run for mining GDP over 1972-1987, avoiding for the moment the shift in the mean evident in the data between 1970 and 1971:

lny(t) - lny(t-1) = .16 + e(t) SER = .32 SSE = 1.53 (.08)

lny(t) - lny(t-1) = 1.79 + .13time-.761ny(t-1) + e(t)
(.64) (.05) (.26)

SER = .27 SSE = .93

To test whether the coefficient on lny(t-1) equals zero, calculate: t = (-.76)/.26 = -2.89

Using Table 8.5.2. in Fuller (1976), we cannot reject the null hypothesis of a unit root at the 10% level. Alternatively, we can test the hypothesis that b = 0 and c = 1 against the alternative, by calculating an F statistic:

F = (1.53-.93)/(2(.93/13)) = 4.19

Using Dickey and Fuller (1981) Table VI, one fails to reject the null of a first order autoregressive process with a unit root at more than a 10% level. Note that using the usual t and F distributions (statistical tables) would bias the results in the direction of rejecting the null of a unit root. In all cases of these tests on the Botswana data, however, failure to reject the null may in large part be due to the lack of power of the tests resulting from the relatively small sample sizes.

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[28] The following model incorporates both the TS model and the DS model as special cases:

Iny(t) = a + bt + u(t)/(1-oL)

Iny(t) - olny(t-1) = a(1-oL) + bt(1-oL) + u(t)

Iny(t) = A + Bt + CIny(t-1) + u(t)

where A = a(1-o) + bo, B = b(1-o), and C = o

If o < 1, TS holds. If o =1, DS holds.

Said and Dickey (1984) discuss a test for unit roots in ARMA models of unknown order. It involves approximating an ARMA model with a higher order AR model. The short time series available for Botswana makes it difficult to implement the Said-Dickey test with any confidence. Nonetheless, the model was estimated assuming successively AR(1) to AR(6) lag polynomiale. The t statistic on the lagged value of mining GDP ranged between -2.21 and -3.47. In all cases but one, (using Fuller (1976), p. 373, tt, for n=25) it is not possible to reject the pull of a unit root at the 10 percent level. In one case, it is possible to reject the pull at the 10 percent level but not the 5 percent level.

Using the longer time period 1964 through 1987, there is evidence in the data of a one time change in the mean between 1970 and 1971. Perron (1989) has shown that Dickey-Fuller tests are biased toward not rejecting the null of a unit root when the sample with the break is used. Using only part of the sample to avoid the break, as done above, reduces the power of the test. (Again, in the Botswana case, however, even the full sample is small and the tests have low power.) Perron (1989) has designed test statistics which allow for the one time break, assuming no trend and that the break is part of the maintained hypothesis.

Here, the TS and DS models are nested with the dummy variables included. Therefore, the following regression was run:

.lny(t) - lny(t-1) = a + btime + clny(t-1) + dDUM + eDUMl + u(t)

The null hypothesis of a unit root plus a one time shift in the data is that b = c = d = 0. The F statistic is 5.23. On the basis of standard F tables, the null of a unit root plus a one time shift in the data is rejected at the 5 percent level. Without a one time shift in the data, however, Dickey-Fuller have shown that standard test statistics are biased toward rejecting the pull. On the basis of Dickey-Fuller (1981) Table VI, p. 1063, one would fail to reject the hypothesis of a unit root plus a one time shift in the data. The table is calculated assuming no break in the data however.

Perron has shown that the Dickey Fuller tests are biased toward not rejecting the pull of a unit root when the sample with the break is used. This is shown for nontrending series taking the break as part of the maintained hypothesis. Assuming the bias works in the saine direction for trending series, one is left with uncertainty about whether the model is TS or DS. (Note that there is a problem with taking the break in the data as part of the maintained hypothesis when the data series has a trend, since the break depends on the nature of the trend, whether it is stochastic or deterministic, which is what one is trying to test for.)

Given that one cannot reject the null of a unit root in many cases, I next assumed mining GDP follows a DS process and estimated the following model using ARIMA methodology:

lny(t) - lny(t-1) = b + e(t)
A(L)e(t) = B(L)u(t)

where A(L) and B(L) are polynomial lag operators and u(t) is white noise. The results are quite sensitive to the precise time period used. For several periods, however, one cannot reject the hypothesis that the error of the first difference of lny(t) exhibits a unit root in the moving average term. This in fact suggests that the process y(t) is stationary around a deterministic trend. (See Campbell and Mankiw (1987).) If the process follows:

lny(t) = a + btime + u (t)

but one estimates:

lny(t) - lny(t-1) = b + e(t) then, e(t) = u(t) - u(t-1) or O = 1,
where B(L) = 1-OLI

In addition, using multivariate ARMA methodology to estimate:

lny(t) = a + btime + e(t)
A(L)e(t) = B(L)u(t)

there is no evidence of autocorrelation in the error term. As shown by Nelson and Kang (1981), if in fact the process was a random walk, the residuals from the regression of the variable on time would be autocorrelated.

Given that the data do not definitively distinguish between the two alternative representations, the boom has been calculated assuming mining GDP follows both a TS and a DS process. If diamond export revenues are used rather than mining GDP, the results are qualitatively the saure. Therefore the boom in diamond export revenues has also been calculated assuming revenues follow both a TS and a DS process.

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