"Diamonds aren't Forever: A Dynamic CGE Analysis of the Mineral Sector in Botswana"
Preliminary DRAFT

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1. Introduction

Botswana is heavily dependent upon export revenue from diamond sales. The financial crisis of 2008-2009 reduced export revenue and Botswana's GDP declined. Compared to other mineral producing regions, Botswana was able to dampen the effect of the financial crisis by increasing public expenditures. However, high fiscal deficits will be difficult to sustain. Botswana will need to consider the effects of new and existing mining projects on macroeconomic aggregates such as tax revenues, employment and GDP.

In this paper, we analyze the effects of changes in production and trade of diamonds in Botswana using a dynamic computable general equilibrium (CGE) model. We address the question, "what is the optimal extraction rate when producers make inter-temporal decisions?" The insights from this analysis also will be useful for other developing countries with natural resource deposits.

To focus on mineral sectors in Botswana, we develop an aggregate social accounting matrix (SAM) for 2007, with agriculture, mining, diamonds, manufacturing and services sectors. Factor markets include labor, capital, land and natural resources. There are rural and urban households as well as an enterprise account. To construct the SAM, we use national accounts for Botswana, the production relationships evident in the latest input-output table for Botswana, and we estimate transaction flows between factors, households, the government and the rest of the world. We include information on remittances, income flows associated with foreign ownership of factors, and aid transfers.

The dynamic simulation framework is an expanded version of the 1-2-3t model developed in Devarajan and Go (1998) where producer and consumer decisions are both intra- and inter-temporally consistent. The representative consumer maximizes the present value of the utility of consumption; producers maximize the present value of profits, and there are forward-looking investment and adjustment cost functions.

In addition, we specify the external debt accumulation carefully in order to examine issues of foreign aid, borrowing, and revenue from natural resource in developing countries. Following the literature regarding borrowing constraints or imperfect debt market for developing countries by authors such Bhandari, Haque, and Turnovsky (1990), we employ an upward sloping supply curve of external debt and there is a risk premium that rises with external debt.

We develop insights on the optimal extraction rate for minerals, taking into account inter-temporal behavior of consumption, investment, and trade. We also consider the implications of a borrowing constraint on the results.

1. Background

The economy of Botswana is often cited as a prime example of the potential for economic success in Africa. Since independence Botswana has achieved impressive rates of economic growth and succeeded in transforming its economy from one that was heavily dependent on remittances from migrant labour employed in the South African economy into an economy that has achieved high rates of growth while maintaining macroeconomic stability and accumulating large external reserves. In large part this is undoubtedly attributable to the discovery of diamonds and the consequent income from the exporting of raw diamonds through the Central Selling Organisation (de Beers). The extent of domestic employment generated directly by the diamond industry has been small and the available evidence indicates that the extent of domestic value added from diamonds has been low. Nevertheless, Botswana has been able to use the funds from diamonds to transform the indigenous labour force from a base of agricultural/rural labour that earned low incomes, largely, in pastoral agriculture, supplemented through migration to the South African unskilled/low skilled labour market, into a largely literate and well educated labour force with little dependence on migrant labour. But manufacturing still only accounts for a small proportion of the economy and the absorption of skilled workers on Botswanan labour market has been dominated by the government and service activities.

In recent years Botswana has suffered enormously from the HIV/AIDS pandemic. In the current context this cannot be ignored since the pandemic has had major effects upon the demographic structure of the economy while the implications for the education and training of the labour force remain uncertain.

A very large part of Botswana's success is a consequence of the discovery of diamonds and the subsequent good economic management. However there is evidence that diamond reserves are being rapidly depleted and that competition in the diamond market is becoming more robust, both to the development of other sources of diamonds, including synthetic diamonds, and challenges to the Central Selling Organisation's cartel. Consequently Botswana is entering into a period in which it will need to review its macroeconomic policy management. It is this review to which this study will contribute.

2. Data

The data used in the model will be based on a Social Accounting Matrix (SAM) for Botswana together with satellite accounts that record data on natural resources, primarily diamonds, factors, primarily labour, and households. However the latest official SAM for Botswana is for 1996/7 and there are a number of reasons to conclude that this SAM is not appropriate for the purposes of this study, e.g., changes in economic structure, changes in demographic

structure, changes in tax revenues, etc. Consequently it will be necessary to estimate an updated SAM. By necessity this SAM will have to small/aggregated; and dependent upon limited primary data, and will therefore entail a degree of estimation.

The national accounts data, and other data available from the Botswana Central Statistical Office (CSO) do provide many of the control totals required for such an updating exercise, but there are notable omissions that are relevant to all calibrated and estimated models of Botswana (see below).

2.1 Economic Data

The core economic data required to generate a SAM are collected by the CSO but the primary data have not been consolidated into a published SAM for more than decade. The CSO do publish summary reports of the key surveys (secondary data), specifically

1. national accounts;
2. surveys of agriculture, mining, manufacturing and services;
3. household income and expenditure surveys;
4. labour force surveys;
5. family health surveys;
6. trade data – imports and exports;
7. energy data; and
8. government accounts.

In addition to these data the SAM for 1996/7 is also available.

It is uncertain to what extent the national accounts have been fully reconciled and an assessment of the survey data, in comparison to the national accounts data, indicates the existence of non-trivial differences, which will inevitably increase the extent of estimation required in deriving the SAM. By way of illustration Table 1 reports the (summary) Commodities & Activities reported in the national accounts and the expenditure items identified in the latest household income and expenditure survey. While some closing of the gap can be achieved by using more detailed national accounts categories a gap will inevitably remain.

Table 1 Reported Categories – National Accounts and HIES

Commodities & Activities	**Household Expenditure Categories**
Agriculture	Food
Mining & quarry	Drink and Tobacco
Manufacturing	Clothing and Footwear
Water & Electricity	Housing Costs
Construction	Household Goods and Services
Trade, Hotels & Restaurants	Medical/Health care
Transport & Communications	Transport
Financial & Business Services	Communications
General Government	Recreation and Culture
Social & Personal Services	Education
	Restaurants and Hotels
	Miscellaneous Goods and Services

The preliminary review of the data sources indicates that the accounts in the estimated

SAM will differ appreciably from those used in the SAM for 1996/7 because the reported secondary data are not aligned with the accounts of the earlier SAM. The anticipated accounts contained in the SAM are reported in Table 2. The proposed SAM for the study is slightly larger than the minimum requirement – it is
hoped that this will allow for some flexibility in the construction of the SAM and provide the possibility of deriving slightly more insightful results. However until the final stages of the project it will not be possible to guarantee the accounts in the SAM. This is because the reliability of the data, the extent to which data from different sources can be reconciled and the degree of estimation required cannot be known in advance. Furthermore the model may also produce evidence that requires the SAM to be re estimated in light of inconsistencies thrown up by the modelling and simulation exercises.

Table 2 Anticipated Accounts

Accounts

Commodities
& Activities Agriculture ***Factors*** Natural Resources
Mining & quarry Land
Food Capital
Drink and Tobacco Skilled Labour
Clothing and Footwear Unskilled Labour
Other Manufacturing Agricultural Labour
Construction ***Households*** Towns
Water & Electricity Villages
Trade, Hotels & Restaurants Rural
Transport & Communications ***Enterprises***
Financial & Business Services ***Government*** Commodity Taxes
General Government Activity Taxes
Medical/Health care Direct Taxes
Education General Government
Social & Personal Services ***Investment*** Savings/Investment
Stock Changes
Trade Rest of the World

2.2 Natural Resource Data

While the SAM will provide the core economic transactions data it will be necessary to compile additional satellite account data. These data will be concerned primarily with the factor accounts. Data on the quantities of labour, capital and land will represent the first stage, these will then be supplemented with estimates of the quantities of factors supplied by different households and how these will change over time. These data are standard components of fully articulated CGE models.

The core additional data requirement for this study related to natural resources.
Estimates will be required of the known and exploitable reserves of diamonds and the ratios of gem to industrial diamonds in the reserves. It will also be necessary to identify any constraints – maxima and minima – on extraction rates. Estimates will also be required for other natural resources – stocks and viable extraction rates. For coal such estimates have already been acquired but this leaves other mineral resources, including diamonds. A particularly important consideration will be the extent to which reserves can be exploited; it is difficult to envisage

Botswana being a large exporter of unprocessed coal, due to transport distances and costs, and there is obvious uncertainty about the possibilities for generating electricity for export to neighbours (South Africa?). Other mineral based products may be more amenable to export in a part processed state, due to their value to weight ratio. Without full information about natural resources the results will inevitably be limited,

3. The Computable General Equilibrium (CGE) Model

A CGE model is a member of the 'whole economy' class of models that are price driven and solved to determine the simultaneous (constrained) optima for all representative agents identified in the model: consumers, producers, households, government etc. The CGE model used here is a dynamic model formulated as a policy optimisation model; this accommodates the fact that the time profiles of the costs and benefits will be sensitive to the sequencing of events and interventions, and avoids restrictive assumptions associated with intertemporal optimisation models.

The specific CGE model, DYNAGE, is based upon the STAGE, developed for the analysis of economic policy options in various developing countries. The development of these models was influenced by criticisms that an earlier generation of models failed to accommodate key features of the structure of African (and other developing) economies. The dynamic model used here involves a synthesis of the comparative static STAGE model and intertemporal optimisation models.

The dynamic simulation framework is an expanded version of the 1-2-3t model developed in Devarajan and Go (1998), where producer and consumer decisions are both intra- and intertemporally consistent. In the basic model the representative consumer maximizes the present value of the utility of consumption; producers maximize the present value of profits. This solution drives the forward-looking investment decisions. The model was designed to analyse trade liberalization and macroeconomic and fiscal adjustments to exogenous shocks, which would allow its application to the analyses of financial crises and returns on Botswana's international assets. The parsimonious structure of the model is achieved with the basic 1-2-3 model at its core whereas in this instance we will extend the number of agents in the model substantially.

Features of the DYNAGE model include an extended treatment of the capital account. In particular the model is formulated to analyse the implications of overseas debts and/or assets, unrequited transfers and remittances. All these features are relevant to Botswana and represent both current and historical realities. Moreover part of Botswana economic strategy has been to manage the resource boom, primarily associated with diamonds; this model is structured to incorporate this dimension of Botswana's economic policy. Since a key factor behind the management of the 'Dutch disease' implications is the real exchange rate the focus on the real exchange rate in this model is ideal in the present context.

As in the 1-2-3t model, the domestic interest rate affecting consumption and investment is a form of risk-adjusted interest parity reflecting the cost of foreign borrowing. Hence, the domestic discount rate will depend on both and the forward evolution of the real exchange rate. For consumers, the appropriate real exchange rate is the relative price of imports and

domestic goods; for the producer, it is the relative price of exports and domestic goods. In the steady state, the economy would reach a balanced-growth path, the change in the real exchange rate ceases, and the domestic discount rate settles back to its long run path. In a forward-looking framework, and for dynamic consistency, consumers correctly anticipate this and the rate of time preference adjusts immediately in the first period and is used throughout the time horizon. Hence, the rate of time preference may also change with each simulation. While the economy would reach a balanced-growth path if it was solved for a sufficiently long time period, it will not do so for the simulations in this study. This is because the time period will be truncated in these simulations so as to reflect known realities. Thus the solutions can be referred to as constrained inter temporal optima where the constraints are those imposed exogenously, e.g., world diamond prices, the operation of the central selling organisation, etc.

Model Extensions for Botswana

The extensions proposed for this study are:
1. Add accounts to track Botswana's overseas assets (the base model typically assumes that developing African economies have net overseas debts rather than assets).
2. Model the stocks of natural resources, diamonds, copper/nickel, etc., so that the extraction rates can be exogenously fixes or the optimal rates can be endogenously determined.

Simulations
The simulations will explore:
1. The economic implications of different extraction rates of diamonds?
2. What is the optimal extraction rate for diamonds? How sensitive is this result to elasticities and other parameters.
3. What are the implications for Botswana's net overseas assets? What is the optimal draw down rate?
4. What is the impact on macroeconomic variables such as employment, the real exchange rate, and GDP growth?
The results from these simulations will provide insights into
a. the need for macroeconomic adjustment;
b. the implications of alternative measures that will help maintain fiscal balance;
c. the implications of the existing taxation regime;
d. alternative taxation regimes and their future revenue effects; and
e. possible measures, including assistance programs, that the GoB may wish to consider in order to ensure macroeconomic stability.
These analyses will be combined with a review of the Botswanan economy subsequent to the financial crises of 2009/2010 to inform the content of the final report that will summarise the policy options available to Botswana and other international agencies.

4. Constraints

The binding constraints on the project are primarily data driven. Not only are there difficulties

associated with the derivation of the requisite economic data there are also substantial uncertainties surrounding the natural resource data, specifically

1. how large are the known and exploitable reserves of diamonds, and what are the likely ratios of gem to industrial diamonds in the reserves;
2. what are the likely implications for the diamond markets over the next 50 years,
   a. is the central selling organisation sustainable and can it maintain control over global diamond prices,
   b. what are the implications for natural diamonds of the developing synthetic diamonds;
3. what other natural resources does Botswana possess that may permit the development of alternative extractive activities;
4. the magnitudes of Botswanan external resources are uncertain as are the potential rates of return on these resources; and
5. what are the future human resources available to Botswana in light of the HIV/AIDS pandemic.

It will be possible to mitigate the effects of these constraints through the use of sensitivity analyses but it will not be possible to derive unambiguous conclusions due to the uncertainties that attached to many of these constraints; rather many of the results will be reported as bounds as well as measures of central tendency. Hence to a large extent the project's conclusions will be dependent upon assumptions that will have to be made, and therefore will be qualified.