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Drought in Southern Africa: A Study for Botswana

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Introduction

Large parts of sub-Saharan Africa experience both low average rainfall and periodic and severe droughts. In a worst-case scenario these droughts precipitate famines, widespread loss of life and massive social and economic upheavals. In such circumstances it is not surprising that governments face strong incentives to engage in drought relief measures both on humanitarian and economic grounds. However, the policy choices are not straightforward. Low rainfall and high temperatures in many of Africa's drought prone areas severely limit arable production and encourage extensive livestock production. Consequently the implications of drought for livestock and crop production are likely to differ.

In the event of a drought crop production will fall off rapidly, and thereby induce of shortfall in supply by domestic producers. However, livestock are more resilient to drought provided supplies of drinking water can be maintained. As the shortage of fodder develops so farmers must respond by reducing in livestock numbers, but the declining price for livestock resulting from both supply and demand side changes will induce a reluctance to sell livestock. Nevertheless any additional livestock income will, at least in the short term, compensate for the decline in crop income.[2] But any reduction in the breeding herd, or delay in reproduction, will reduce livestock off-take rates, and therefore income, in subsequent years. Consequently the relative prices of food products will change appreciably, and the sequencing of price changes will differ. These responses raise questions about the ordering and magnitudes of drought relief programmes.

For many African economies the consequences of drought go beyond issues of food availability and the preservation of rural economic relationships. Increases in the demand for

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2 The approach to the sale of livestock taken in this paper is essentially deterministic: farmers sell livestock because they are short of fodder. There is a large literature on the use of livestock as buffer stocks against the effects of drought, e.g., Fafchamps *et al*., (1998), Kinsey *et* al., (1998) and Binswanger and McIntire (1987), which is not addressed.

food imports, coupled with reduction in export supply, imply a potential for balance of payments problems. These will be compounded by pressure for increases in government expenditure to ameliorate the affects of the drought at a time when government income is under pressure, implying a potential for internal balance problems. With many African economies undertaking structural adjustment programmes, the implications of droughts for such programmes has been a source of interest, e.g., Elbadawi (1996), Marquette (1997). Consequently the macroeconomic implications of droughts are often of appreciable concern.

The analyses reported in this paper relates to Botswana; an economy that is in many ways atypical in Africa. Botswana is constrained by neither internal nor external balance problems, and while its export base is very narrow (85 percent of exports are diamonds), its agricultural sector is not dissimilar to many of the drought prone countries in Africa. Agriculture remains the dominant employer, productivity is low, which explains the small contribution to GDP, and range of options open to farmers is limited. Thus Botswana provides a useful, if not ideally, case study for drought.[3] An argument reinforced by a practical consideration; Botswana is the only country in sub-Saharan Africa that produces full input-output tables and uses SAMs to benchmark its national accounts.

The remainder of the paper is organized as follows. The next section reviews the background and context, and is then followed by a section that provides an overview of the data and the computable general equilibrium (CGE) model. The policy experiments are described and the results are presented in the fourth section, and lead on to the final section of concluding comments.

Background and Context

Botswana is a large (581,730 km^2) landlocked country in southern Africa with a small population (approx 1.61 million).[4] At independence in 1966 Botswana was one of the poorest countries in world, even to the extent that the administrative capital was located outside of its national boundaries at Mafeking. For many years prior to and after independence Botswana was heavily dependent upon remittances from migrant labourers working in the gold mines of South Africa (Lucas, 1985, and Lucas and Stark, 1985) and aid transfers from the UK. Remittances from migrant mine labour remain an important source of income (CSO, 1999, Table 2.6.2), although these have declined sharply in recent years and are likely to continue to do so as the South African gold mining industry contracts. Since their discovery in early 1970s diamonds

3 It could be argued that the absence of concern over internal and external balances allows the analyses to proceed without distraction.

4 The country is approximately 10 percent larger than France, which has a population of 58 million. The population estimate is from CSO (1999), although there are reasons to be cautious about population statistics in Botswana because of the HIV/AIDS epidemic. The population at the 1991 census was 1,326,796.

have dominated the economy, to the extent that Botswana is the world's largest diamond producer.

Botswana has been hailed as the success story of Africa over the last 30 years. Between 1982/3 and 1997/8 GDP per capita increased by 99 percent while the population increased by 57 percent. Good governance has enhanced the benefits of economic growth. For more than a decade Botswana has run surpluses on the current account, and thereby accumulated large overseas reserves, and, in most years, on the government budget. In part this has been motivated by a conscious policy of managing the exchange rate to counter the worst adverse effects of 'Dutch Disease' (see Leith, 1997). This has not stopped the country reaping benefits from the diamond boom. Investment in physical and human capital has been, and remains, substantial. The story is not however one of unqualified success. Attempts to diversify the economy have met with relatively little success; the public sector is now, arguably, over large and siphoning off the best (qualified) members of the labour force; the HIV/AIDS epidemic, with an estimated 36 percent of the 15 to 49 year old population HIV positive (UNAIDS, 2000), threatens to wipe out many of the gains of recent decades; and substantial poverty remains, especially in the rural areas (BIDPA, 1996). As in most of southern Africa the incidence of poverty and the performance of the agricultural sector are related.

The growth of income and population has been accompanied by a rapid urbanization of the economy: the 1971 Census classified 9.5 percent of the population as urban, whereas by the 1991 Census 45.7 percent were classified as urban.[5] While the majority of the population are still resident in rural areas and agriculture contributes less than 4 percent of GDP, agriculture remains the largest 'employer', accounting for some 25 percent of employment in 1991 (CSO, 1998, Table 2.6.9), and many other rural employment activities will be dependent upon agricultural performance. Furthermore, the large proportion of first generation urbanites has an important consequence: most urban residents retain close family links with rural communities and agriculture, and many are owners of cattle.

The Benguela current dominates the country's climate and agriculture. Annual rainfall is low, only the eastern border area receives more than 500 mm in a 'typical' year; is concentrated in the summer months; is highly variable and subject high run-off and evaporation rates due to the temperatures (Government of Botswana, 1997, pp 3 – 10). The availability, or more accurately the lack, of water is the major determinant of agricultural performance.[6] Consequently the agricultural potential of the country is very low; the production of grains is substantially less than domestic demand and limited to sorghum and other coarse grains, with

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5 The classification scheme arguably overstates the rate of urbanization. "An area is defined as urban if it has a population of 5,000 or more and the proportion of its workforce engaged in traditional agriculture is less than 25 percent." On this basis there were only 5 (urban) towns in 1971 and by 1991 there were an addition 21 (urban) 'villages' (CSO, 1999, p 8).

6 The unit of currency is the pula, which in Setswana means water.

little or no capacity to grow maize, wheat or rice (CSO, 1999c). Extensive cattle rearing dominates agricultural production, and the country is typically a net exporter of beef. The importance of cattle in the economy is well illustrated by two facts; the national accounts report cattle numbers and the cattle population, 2.5 million in 1995, is greater than the human population. The low productivity of the agricultural sector means that Botswana has long been dependent upon imports of staple food products (see CSO, 1997). Drought is a recurrent feature of Botswana's climate, with periodic and severe droughts. The drought of the early 1980s saw crop production decline to about 65 percent of the long-term mean in 1982 and 1983 and to 85 percent in 1984. "Drought has been persistent since the early 1980s" (Government of Botswana, 1997, p 6), with a particularly bad year in 1991/2.[7] Climatically and agriculturally Botswana is similar to many other countries in sub-Saharan Africa that have low agricultural productivity, due to water shortages, are subjected to periodic droughts and where agriculture is characterised by extensive cattle/livestock rearing.

There is little doubt that drought generates severe problems for the rural population of Botswana; but the macroeconomic affects are remarkably muted. While the drought in the early 1980s saw a pronounced fall in agriculture's contribution to GDP, GDP continued to grow strongly throughout the period (CSO, 1998, Table 2.1.2). This is not altogether surprising: agriculture only contributed a small part of GDP, and the country was experiencing a period of sustained investment led growth, largely driven by the mining industry. However the national accounts may understate the true impact of the drought for the same reason they are likely to understate the true importance of the agricultural sector; namely home production for home consumption within the rural economy. There is also the problem of disentangling the effects of a drought from any underlying growth within an economy; arguably the counterfactual should exclude the effects of growth.

Data and Model

Data

The data used for this study are primarily derived from the Social Accounting Matrix (SAM) for 1993/4 (CSO, 1999b).[8] The SAMs for Botswana are remarkably detailed and have followed the same basic structure since the SAM for 1985/6. The SAM for 1993/4 has 164 accounts; of which 54 are commodity accounts; 41 are activity accounts; 12 are factors accounts; 22 are institutional accounts with 8 households accounts, 8 enterprise accounts and 8 government accounts; 9 redistribution accounts; 14 are capital accounts; 5 are Rest of the World accounts;

7 Agricultural statistics for the early 1990s are not available.

8 This is the seventh SAM that has been produced for Botswana. Since the first SAM, for 1975, the national accounts for Botswana have been heavily influenced by the underlying concepts of a SAM, and the CSO has now adopted a strategy of producing new a SAM every 3 years.

and 7 are Asset accounts. For purposes of this study the published SAM has been reorganised and aggregated to produce a real economy SAM with 106 accounts, i.e., excluding the asset accounts. The main changes were to eliminate the redistribution accounts using the method of apportionment (Pyatt, 1989), aggregate the enterprise, capital and rest of world accounts to form single accounts. The entries for the mixed income factor account were allocated between labour and capital using secondary data and an account for the factor land was added.[9] The treatment of marketing margins was also adjusted; this required a revision to the commodity accounts. A list of the accounts in the final 106 SAM is given in Appendix 2.

Table 1 A 'Macro' SAM for Botswana 1993/4 (P millions)

	Commodities	Activities	Factors	Households	Enterprises	Taxes	Government	Capital	Rest of World
Commodities	1,957.4	6,418.8	0.0	3,691.4	380.4	0.0	3,243.7	2,838.1	5,421.8
Activities	16,775.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Factors	0.0	10,372.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.9
Households	0.0	0.0	3,785.3	23.0	337.4	0.0	100.6	-0.9	77.9
Enterprises	0.0	0.0	6,171.7	78.0	0.0	0.0	342.7	-3.2	859.8
Taxes	940.2	-16.0	0.0	106.8	1,260.2	0.0	0.0	0.0	0.0
Government	0.0	0.0	383.7	149.6	2,196.4	2,291.2	0.0	-6.3	203.4
Capital	0.0	0.0	18.4	283.2	2,132.9	0.0	1,527.9	0.0	-1,134.0
Rest of World	4,279.0	0.0	12.2	-9.4	1,142.4	0.0	3.1	0.7	0.0
Totals	23,951.6	16,775.0	10,371.3	4,322.6	7,449.7	2,291.2	5,218.0	2,828.4	5,428.0

An indication of the structure of the economy can be gathered from the 'macro' SAM that is derived from the 106 account SAM used to calibrate the model and is reported in Table 1. Certain features deserve a brief mention. The economy is open with imports and exports accounting for 17.9 and 22.6 percent of commodity supply and demand respectively. Intermediate inputs account for 38.3 percent of activity inputs with primary factors accounting for 61.8 percent. Households provide 15.4 percent of domestic demand, closely followed by government (13.5 percent) and investment (11.8 percent). Marketing margins are relatively high, accounting for 8.2 percent of commodity transactions.

The government's income comes almost equally from taxes (39 percent) and royalties from enterprises (37.4 percent), and direct taxes on enterprises, but not households, make a substantial contribution to tax revenue. The rate of tariffs was high, but the revenue was not critical for the government. The government surplus, at 11.2 percent of income, was appreciable, as was the surplus on the current account. Investment was buoyant relative to activity gross output. Overall the image is of a strong economy, albeit an economy that is heavily dependent for government revenues on the diamond industry via the enterprises account.

9 The treatment of mixed income and land needs further refining. The present distribution of transactions involves a number of crude assumptions.

The other data used to calibrate the CGE model are recorded as a satellite account for the Factor:Activities accounts. Statistics for employment were provided by the CSO using activity and factor classifications matched to those in the SAM. Unfortunately these are only currently available for the activities identified in the 1992/3 SAM. In addition the CSO provided estimates of the average numbers of hours worked each week by different types of labour. Labour services are therefore recorded as hours per year. Gross capital stock estimates are published in the SAM for those activities recording gross operating surpluses. For several industries, mostly agriculture, neither gross operating surpluses nor gross capital stocks are recorded. Rather transactions are recorded in terms of mixed income, i.e., payments to labour, capital and land. Data from the agricultural survey was used to estimate the imputed value of family labour services and imputed rental payments for land; the residuals were attributed to capital.[10]

Model[11]

The CGE model is a member of a class of models developed as part of the MERRISA (Macroeconomic Reform and Regional Integration in Southern Africa) which is co-ordinated by the International Food Policy Research Institute in Washington. The most notable feature of the model is that it allows for secondary production, i.e., activities (industries) are allowed to produce more than one commodity. This feature permits the model to draw directly upon SAMs produced in accordance with the UN System of National Accounts, and hence avoids the reduced form SAMs that characterise the majority of CGE models that follow Dervis *et al*., (1982). This is particularly relevant when modelling food systems since the food systems, and in particular agriculture, are typically characterised by multi-product industries (farms). It also means that exports are from the commodity accounts rather than the activity accounts. The model is specified as a mixed complementarity problem (see Rutherford, 1995, and Lofgren and Robinson, 1997), allows for the modelling of transport and marketing margins, and includes provision for modelling the effects of 'own-production for own-consumption' upon the economy, although the data for Botswana do not currently allow this to be implemented.

The model is in the general class of neoclassical models. The modelling of production relations and factor demands allows for substitutability between factors, i.e., capital for labour, and between different types of labour, they are treated, in general, as imperfect substitutes. Similarly, full employment is not assumed in the general case. The mapping of income to the institutional accounts is in fixed proportions of income after tax and savings. However the information on factors ensures that changes in production activities are reflected by changes in household income levels.

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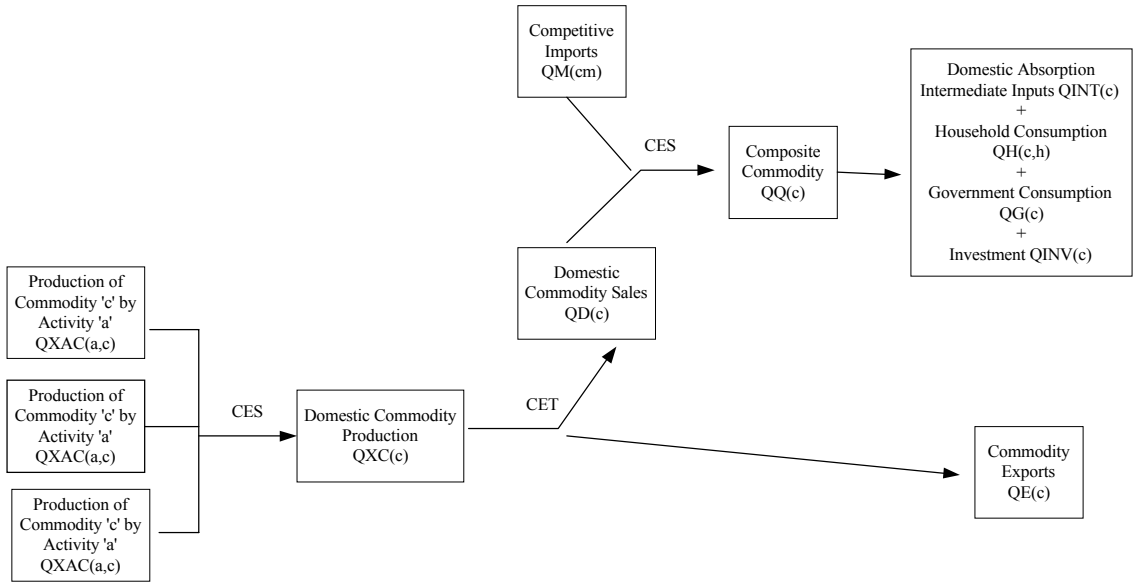
10 The interpretation of the 'return to land' is arguably ambiguous given that 70 percent of land is designated as 'communal land' (See Government of Botswana, 1997, p 229 and Chapter 14).

11 A detailed technical specification of the model is available, on request, from the author.

The quantity flows for the model are illustrated in Figure 1. The model makes extensive use of the Armington assumption, i.e., imperfect substitution (Armington, 1969). Activities choose the quantities of different commodities to produce on the basis of relative prices and the ease of substitutability expressed as a series of constant elasticity of transformation (CET) functions. The decision rule is profit maximisation. Domestic production is sold on either the domestic market or exported on the basis of relative prices and the ease of substitutability. Domestic outputs are then combined with imported commodities to produce composite commodities that are distributed to domestic final demand categories. The Armington assumptions for trade and factor markets are typical of many CGE models, however the modelling of exports from the commodity accounts is different, but necessary for multi-product industries. A consequence of the Armington assumption is that the impacts of changes in world prices on the economy depend upon the elasticities (degrees) of substitutability and the share of imports/exports in the composite commodities/domestic production. This typically reduces the sensitivity of the model to the specification of the elasticities of substitution.

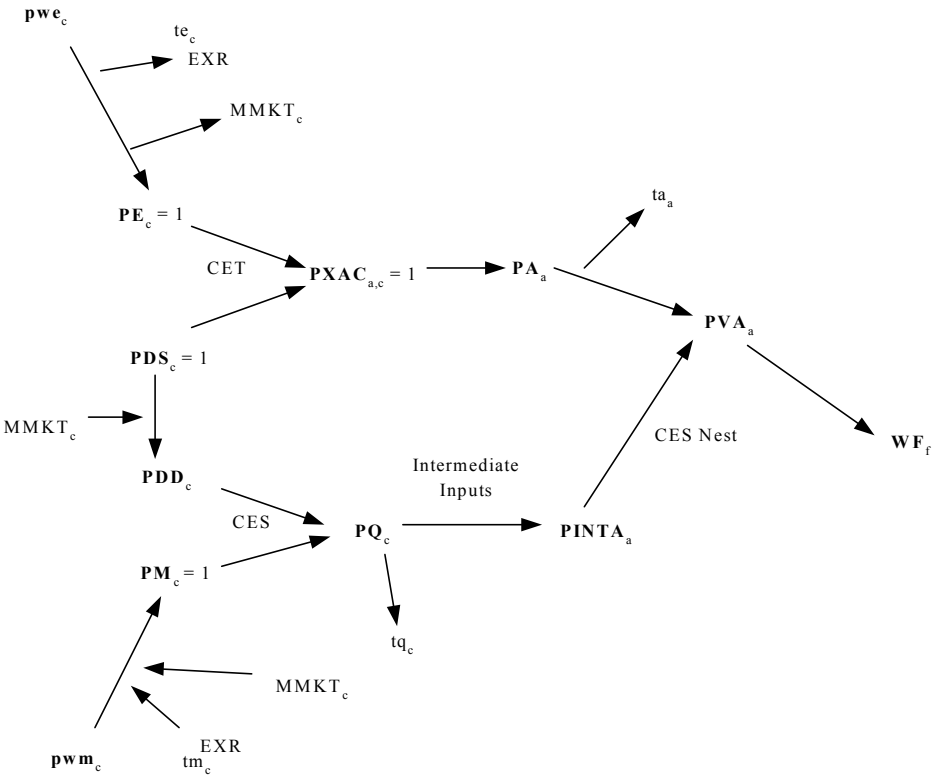
Figure 1 Quantity Flows



The decisions about the quantities of commodities produced by domestic activities, exported, imported and allocated to different categories of final demands are based upon relative prices. Consequently, the price system is critical to the operation of the model. Moreover the price system encompasses the governments' price policy instruments. Figure 2 provides a schematic illustration of the price system in this model. Since governments have a wide range of price/tax instruments the price system is inevitably moderately complex. Product taxes have three specifications; tariff rates export tax rates and sales tax rates. Taxes on production can be of two forms; indirect tax rates on production and value added tax rates. The modelling of marketing margins increases this complexity. The marketing margins serve to introduce wedges between the prices paid by consumers of a commodity and its suppliers.

Marketing margin rates are endogenously determined by the efficiency with which marketing services are produced. The other tax instruments are direct/income tax rates for households and enterprises.

Figure 2 Price System



where

EXR = exchange rate;
$MMKT_c$ = marketing margins;
PA_a = output price of activity a;
PDD_c = demand price for commodity c produced & sold domestically;
PDS_c = supply price for commodity c produced & sold domestically;
$PINTA_a$ = price of intermediate aggregate;
PE_c = price of exports;
PM_c = price of imports;
PQ_c = price of composite good c;
PVA_a = value added price;
pwe_c = world price of exports;
pwm_c = world price of imports;
PX_c = average output price;
$PXAC_{a,c}$ = price of commodity c from activity a;
te_c = export tax rates;
tm_c = tariff rates on imports;
tq_c = sales tax rates;
ta_a = producer tax rates.

Policy Experiments

The policy experiments conceive of the impact of a drought as a three-cycle process. In the first, or drought, cycle the productivity of all three agricultural activities is presumed to decline, thereby appreciably reducing output of livestock and crops, but simultaneously farmers reduce herd sizes thereby supplying extra livestock to the market. In the second, or recovery, cycle agricultural productivity rates return to their pre-drought levels, but while the outputs of crops and livestock have increased the market supply of livestock products is constrained by the restocking decisions of farmers. In the final cycle the economy returns to its base level of performance.

Table 2 **Outputs by Agricultural Activities** (1993/4)

	Traditional Agriculture Cattle	Traditional Agriculture Other	Freehold Farms
		%	
Cattle	100.00	0.00	65.67
Other Livestock	0.00	34.96	3.29
Fruit, Vegetables & Nuts	0.00	9.63	15.41
Cereals	0.00	51.93	14.67
Other Agricultural Produce	0.00	3.47	0.96
		Value (P million)	
	86.30	126.70	94.10

The choice of closure rules is important. The capacities of the mining industries, especially diamond mining were fixed. In part this can be justified by reference to the operation of the Central Selling Organisation, through which all Botswana's diamonds are sold, and the time horizon of the model. If capacities of these activities are not fixed the dominance of the mining industry as a source of export earnings means that the effects of the policy experiments upon the trade, and trade related prices, are overwhelmingly offset by small increases in the export of diamonds. For each of the agricultural activities factor inputs and capacity are fixed. This amounts, in the drought cycle, to an assumption that inputs are pre committed to agriculture, and in the recovery cycle to a presumption that the Government has been successful in avoiding permanent migration to the urban sector. Otherwise it is assumed that inputs are fully flexible across activities.[12] However, the model presumes that government transfers to institutions, including households, are fixed at their base level; this allows the model to identify the decline in household incomes associated with the drought and recovery. On the other hand it is assumed that the level of investment activity remains constant, i.e., the model is investment driven. This reflects the capacity of the government budget to maintain investment rates during the drought. But, the investment during the one cycle does not feed into the determination of capital stocks in the subsequnet cycle. Similarly, it is presumed that technical

12 A short run closure rule wherein capital was made activity specific throughout was also implemented (see below for further comment).

efficiency rates remain constant throughout the period, other than those changed explicitly by the policy experiments. This is a simple attempt to separate out the effects of the policy experiments from any underlying growth. Finally, the exchange rate is fixed to reflect government policy of a managed exchange rate.[13] The numeraire was the producer price index.

The reported results are for subsets of the experiments implemented. For the drought cylce, technical efficiency in crop production was presumed to decline rapidly but in the production of livestock it was assumed to decline less rapidly; hence the overall decline in technical efficiency reflects the shares of output by the three different agricultural activities. With respect to destcoking it was assumed that the rate of destocking increased as the severity of the drought increased, and that the destocking rate for cattle was slower than for other livestock. The reported drought cycle experiments, Experiment A and Experiment B, thus involve reduction in technical efficiency of between 20 and 52.5 percent and destocking rates of between 10 and 30 percent of the output of each during the base year (see Table 3). For the recovery period crop productivity is assumed to return, immediately, to the base period levels, but livestock productivity is presumed to be slightly above the base period due to the implied reductions in stocking densities; 5 and 3 percent extra for 'Traditional Agriculture Cattle' and 'Freehold Farms', respectively. The reported restocking rates are 12.5 or 17.5 percent of total output of cattle and other livestock in the base period.

Table 3 Shocks for the Reported Policy Experiments

	Drought Cycle		**Recovery Cycle**	
	Experiment A	Experiment B	Experiment C	Experiment D
Efficiency Changes (proportion of base level)				
Traditional Agric Cattle	0.8	0.7	1.05	1.05
Traditional Agric Other	0.65	0.475	1.00	1.00
Freehold Farms	0.75	0.625	1.03	1.03
Stock Changes (share of base output level)				
Cattle	-0.1	-0.2	+0.125	+0.175
Other Livestock	-0.15	-0.3	+0.125	+0.175

Results

All the results are expressed as percentage changes relative to the base year, i.e., before the drought. The discussion begins with a brief consideration of the macroeconomic effects, Table 4. After that the discussion moves successively to selections of quantity changes for activities (Table 5) and commodities (Table 6), factor incomes (Table 7) and finally institutional (household and enterprise) incomes (Table 8). Rather than discussing the results for the drought cycle and then the recovery cycle, the results for each cycle are contrasted with each other.

Unsurprisingly the drought adversely affects both total GDP and consumption, although it is noticeable that as the severity of the drought increases so the adverse impact upon GDP

13 These closure conditions could all be challenged.

accelerates faster than for consumption. At first sight the relatively small reduction in GDP may be surprising; but this reflects both the small contribution of agriculture to GDP, the non recognition of home production for home consumption, and the degree of adjustment to the shock allowed in the model. Much more surprising are the aggregate trade effects. Total imports decline, reflecting the reduction in the level of economic activity, whereas total exports increase, which reflects in part the capacity restrictions placed on the mining industry but also the increasing relative attractiveness of non-domestic markets, associated with the decrease in domestic consumption, and also the reductions in the cost of factors and hence increased competitiveness. Consequently the seemingly anomalous result of an increase in foreign savings, i.e., surplus on the current account, in a period when the economy is under stress. Similarly the government accounts seem anomalous. Government income falls, albeit only slightly,[14] but government savings, i.e., budget surplus, rises. In part the results for the government and trade accounts are related; the policy experiments presume a non-response to the drought by the government. As expected the cost of living, measured by a base weight consumer price index, rises. But the price changes are far from uniform, indeed the price index for investment falls, and therefore despite the real investment being fixed investment expenditure declines, which partially explains the increase in government savings.[15] The CPI hides the extent to which there are income distribution consequences of price changes; for most food items the prices increases are several percentage points or more (See Appendix Table A1).

Table 4 Macroeconomic Results

	Drought Cycle		Recovery Cycle	
	Experiment A	Experiment B	Experiment C	Experiment D
Total GDP	-0.89	-1.36	-0.09	-0.13
Total consumption	-0.98	-1.38	-0.82	-1.19
Total exports	0.12	0.43	-0.23	-0.29
Total imports	-0.24	-0.31	-0.20	-0.29
Foreign savings	1.49	3.21	-0.93	-0.91
Government income	-0.45	-0.66	-0.09	-0.15
Government savings	1.11	2.03	-0.51	-0.61
Total investment value	-1.39	-2.52	0.89	1.28
Consumer price index	0.52	0.76	0.11	0.15

Source: Model results

The results for the recovery cycle are more interesting. The combined effect of reduced capacity for livestock production and the rebuilding of herds (and flocks), has a limited negative impact upon GDP, but the impact upon aggregate consumption is close to that for the drought cycle. During this period both total exports and imports decline, and the surplus on the

14 The small scale of the reduction in government income reflects the heavy dependence of government income on revenues associated with mining.

15 Government savings account for some 54 percent of total savings.

current account falls, albeit only by one percent (P 11.34m). The affect on government income remains slightly negative, but the impact on government savings is reversed, as is the effect on the cost of maintaining real investment. While the CPI suggests limited price changes it is noticeable that the increase in the cost of meat products in the recovery period (3.16 percent) is nearly as great as in the drought period (3.87 percent).

Table 5 Volume Changes for Selected Activities

	Drought Cycle				Recovery Cycle			
	Experiment A		Experiment B		Experiment C		Experiment D	
	Output	Value Added	Output	Value Added	Output	Value Added	Output	Value Added
Traditional Agric Cattle	-20.00	-20.00	-30.00	-30.00	-2.35	-2.35	-2.35	-2.35
Traditional Agric Other	-35.00	-35.00	-52.50	-52.50	-1.53	-1.53	-1.53	-1.53
Freehold Farms	-25.00	-25.00	-37.50	-37.50	2.44	2.44	2.44	2.44
Meat Processing	-7.08	-6.18	-5.90	-5.04	-11.84	-10.53	-16.38	-14.59
Dairy & Other Agric Processing	0.04	0.78	0.07	1.20	0.21	0.29	0.16	0.26
Textiles	14.68	14.83	22.71	22.95	4.34	4.38	6.18	6.24
Chemicals	-1.38	-1.15	-2.08	-1.75	0.33	0.37	0.39	0.46
Transport & equipment	2.85	3.06	4.28	4.59	1.24	1.31	1.64	1.73
Metal Products	2.94	3.14	4.40	4.70	1.27	1.33	1.68	1.77
Manufacturing	-0.36	-0.14	-0.63	-0.29	0.36	0.39	0.45	0.50
Hotels & Restaurants	3.13	3.15	4.81	4.85	1.30	1.31	1.64	1.65
Central Government	-0.81	-0.61	-1.38	-1.07	0.22	0.24	0.24	0.27

Source: Model results

These results confirm the importance of managing responses to drought with a consideration for the recovery period. The extent to which destocking can be limited, and hence the supply restriction in the recovery period limited, suggests the hang over from a drought can be reduced. This model has assumed that the crop sector responses instantly to the end of drought.

The impact of the reduction in technical efficiencies for the agricultural activities during the drought period produces the reported declines in output and value added. The reduction in availability of livestock feeds through into the output of the meat processing industry; interestingly as the severity of the drought increases, and the presumed destocking rates increase, so the adverse impact upon meat processing diminishes. Since it is presumed that the export prices is unaffected these results may understate the impacts because it would be expected that carcass quality and dressing out rates will fall, and increasingly so as the drought deepens. As would be expected given the fall in GDP, the value added affects for most activities are negative, although generally small outside of agriculture. More interesting are the output levels for industries that experience increasing competitiveness; in particular these are textiles, transport & equipment, metal products and hotels & restaurants. These are the industries most responsible for foreign exchange earnings and which the model closure rules allow to respond. However, it is arguable that the appreciable increases in capital stock

associated with these output expansions are unrealistic in such a short run scenario, and hence the adverse impact of the drought cycle will be understated by the model results.[16]

Table 6 Volume Changes for Selected Commodities

	Drought Cycle					
	Experiment A			Experiment B		
	Domestic Sales	**Exports**	**Imports**	**Domestic Sales**	**Exports**	**Imports**
Cattle	-22.03	-36.43	-14.95	-33.08	-50.23	-24.08
Other Livestock	-30.32	-32.26	-29.42	-47.26	2.19	-59.67
Fruit veg & Nuts	-12.48	-46.34	5.57	-19.77	-64.09	9.25
Cereals	-32.04	-82.09	12.97	-48.36	-94.39	21.02
Other Agricultural Produce	-32.55	-76.52	0.23	-49.29	-91.76	0.78
Meat & Products	-4.52	-24.09	4.99	-5.90	-29.72	6.21
Dairy Products, Oils & Fats	-4.81	-22.07	3.12	-7.35	-32.08	4.90
Other Food	-0.76	0.58	-1.28	-1.15	0.59	-1.82
Textiles & Clothes	9.71	15.05	2.12	14.94	23.29	3.39
Hides & Skins	-1.34	-3.94	-0.01	-2.14	-6.20	-0.04
Chemicals, Plastics & Petroleum	-1.61	0.87	-2.26	-2.43	1.19	-3.37
Paper & Products	0.20	6.65	-1.83	0.05	8.84	-2.65
Bricks Glass & ceramics	-0.64	1.08	-0.96	-1.02	1.42	-1.46
Metals & Metal Goods	0.61	3.71	-0.21	0.91	5.54	-0.30
Other manufacturing	-0.40	1.32	-0.69	-0.61	1.73	-0.96
Water	-0.49	0.00	-2.38	-0.45	0.00	-3.25
Central Government	-0.81	-0.81	-0.81	-1.38	-1.38	-1.38
	Recovery Cycle					
	Experiment C			Experiment D		
Cattle	-0.25	-25.18	12.76	-0.20	-34.99	19.80
Other Livestock	0.20	-45.05	28.22	0.48	-54.10	38.63
Fruit veg & Nuts	1.00	6.46	-0.90	1.20	8.65	-1.36
Cereals	-0.76	-2.08	-0.15	-0.76	-0.86	-0.56
Other Agricultural Produce	-0.87	-0.12	-1.15	-0.92	2.19	-2.05
Meat & Products	-3.04	-17.85	3.81	-4.33	-23.79	5.07
Dairy Products, Oils & Fats	-0.05	0.55	-0.18	-0.10	1.23	-0.47
Other Food	-0.12	1.49	-0.72	-0.29	2.19	-1.19
Textiles & Clothes	2.81	4.45	0.39	3.97	6.35	0.46
Hides & Skins	0.13	0.08	0.23	0.19	0.22	0.28
Chemicals, Plastics & Petroleum	0.19	1.29	-0.12	0.21	1.75	-0.24
Paper & Products	0.57	3.19	-0.29	0.73	4.30	-0.44
Bricks Glass & ceramics	0.18	1.31	-0.14	0.19	1.78	-0.25
Metals & Metal Goods	0.38	1.66	0.02	0.49	2.20	0.00
Other manufacturing	0.12	1.36	-0.21	0.09	1.68	-0.33
Water	-0.67	0.00	-1.31	-1.01	0.00	-1.90
Central Government	0.22	0.22	0.22	0.24	0.24	0.24

Source: Model results

The recovery cycle produces a number of interesting results. The capacity constraints on livestock production are partly offset by the presumption of small, but short term, increases in

16 Experiments with a short-run closure rules, capital stock fixed by activity and capital and labour fixed by activity, confirm this conclusion.

technical efficiency associated with reduced stocking rates. Because of the different compositions of output by each agricultural activity the net results differ, to the extent that even with the capacity constraints the small freehold farm industry achieves increased production.[17] The adverse impact upon the meat processing industry increases however as the supply of animals for slaughter is restricted by restocking. Otherwise the affect on output by other activities is generally positive, and where it is not the affect is small.

During the drought cycle domestic sales[18] of all agricultural commodities drop appreciably, as do exports, although exports only account for less that 0.75 percent of total agricultural commodity sales.[19] The changes in import patterns are more interesting, and relevant since imports account for an average 28.8 percent of agricultural commodity supplies. Because of destocking imports of livestock decline, although imports only account for 5.5 percent of livestock imports, but imports of other agricultural commodities rise appreciably. The severity of the drought is important since the magnitudes of the changes increase rapidly as the drought deepens. Elsewhere the imports of food products also increase appreciably, while the important exports of meat products decline sharply. The results reported for other commodities, Table 5, demonstrate how the patterns of import and export changes generate the seemingly anomalous decline in aggregate imports, and increase in aggregate exports.

Table 7 Factor Incomes Results

	Drought Cycle		Recovery Cycle	
	Experiment A	Experiment B	Experiment C	Experiment D
Prof & Tech Employees Cit	-0.85	-1.26	-0.20	-0.32
Prof & Tech Employees NonCit	-0.66	-0.98	-0.16	-0.25
Admin & Manag Employees Cit	-1.34	-1.99	-0.12	-0.20
Admin & Manag Employees NonCit	-0.86	-1.25	-0.04	-0.08
Clerical Employees Citizens	-1.07	-1.65	-0.15	-0.26
Clerical Employees NonCitizens	-1.44	-2.15	0.02	0.02
Skilled Manual Citizens	-0.63	-0.88	-0.20	-0.29
Skilled Manual NonCitizens	-0.06	-0.06	0.01	0.01
Unskilled Employees	-1.18	-1.77	0.01	0.00
Farm Employees	-12.19	-19.56	2.71	3.33
Gross Operating Surplus	-0.52	-0.77	-0.12	-0.16
Land	-14.94	-24.55	3.53	4.40

Source: Model results

17 Note that output in this context is inclusive of the stock changes, which do however affect the quantities supplied to markets.

18 Note that in this context domestic sales are defined as sales out of current production, i.e., exclusive of the sales on the domestic market from destocking.

19 There is an anomaly in the case of Other Livestock exports under experiment B, which results in exports rising. This is completely consistent with the relative price changes and would appear to be a consequence of the interaction of declining efficiency and destocking. A similar anomaly occurs for Cattle in another experiment.

The results for the recovery cycle indicate that restocking after the drought has a substantial adverse affect on meat product exports. The adverse consequences of the drought also persist with the consequence of making domestically produced non-agricultural products more competitive, and thereby raising exports. Behind these affects lie two important forces. During the drought cycle, aggregate factor incomes decline for all factor categories (see Table 6), sharply for farm employees and land and also for some factors used in some industries. This reduces costs in the economy; and thereby making the economy's products more competitive. At the same time household incomes fall, cutting back demand and contributing to the increasing attractiveness of the export markets.

During the recovery cycle factor incomes are still, on the whole, below those before the drought: the obvious exceptions being farm employees and land, which are agriculture specific. At the same time, household incomes have still not returned to their pre-drought levels. Consequently exports markets retain their extra attractiveness, and that is the case for most commodities. But the restocking activities reduce exports of meat products sharply and produce the overall negative impact on export levels.

Table 8 Institution Income Results

	Drought Cycle		**Recovery Cycle**	
	Experiment A	Experiment B	Experiment C	Experiment D
Urban Households Wage Income	-0.50	-0.62	-0.61	-0.95
Urban Households Self employed	-2.56	-3.97	0.09	-0.01
Urban Households Transfers	0.91	1.94	-2.22	-3.50
Rural Households Wage Income	-0.78	-1.10	-0.41	-0.65
Rural Households Self employed	-4.26	-6.78	0.50	0.49
Rural Households Transfers	1.27	2.52	-2.32	-3.64
Non Citizen Households	-0.47	-0.62	-0.33	-0.53
Enterprises	-0.52	-0.77	-0.12	-0.17

Source: Model results

The income distribution affects of the drought are of some interest. The households that lose are those households who realise the majority of their incomes from self-employed activities. The spreading of this across both rural and urban households reflects the close links that remain between rural and urban households in Botswana, and the extent to which many urban households retain an interest in agriculture through cattle and land ownership. Those households largely dependent upon wage income lose out far less: the fall in returns to land leaves them largely unaffected and the major force affecting them appears to be downward pressure on wage rates. Similar forces explain the decline in income to non-citizen households. On the other hand, households whose primary income sources are transfers experience an increase in incomes.

During the recovery cycle the pattern of changes alters substantially. Self employed households see incomes rises, but the extent of the increase is inversely related to the depth of the drought and hence the degree of restocking; to such an extent that urban households lose out, very marginally, if the rate of restocking is high. Urban wage earning households continue to lose out, but actually by slightly more during the recovery cycle than the drought cycle, while the adverse impact on rural wage earning households diminishes. The same applies to non-citizen households. However, households' dependent upon transfers lose out appreciably during the recovery cycle.

Concluding Comments

Droughts are a feature of life in large parts of sub-Saharan Africa. By definition droughts herald substantial reductions in food production in the affected regions and the potential for famines. Even if the response to a drought avoids a famine, a drought will destabilise rural production relationships, reduce rural incomes and exacerbate rural poverty and inequality while inducing rural-urban migration. Furthermore, a drought is likely to destabilise the macroeconomy and put pressure upon both the internal and external balances, thereby compromising the independency of government policy. The analyses reported in this paper have sought to examine these issues.

While many of the results are consistent with past macroeconomic evidence there are reasons to be cautious in their interpretation and the conclusions drawn. There are two substantial areas that need further research. First, the results of these, and other, analyses suggest that there may be benefits from redefining the household groups.[20] This seems to be most relevant for wage earning households where the rapid urbanization of the economy since the mid-1980s, for when these definitions were first adopted. The second is the important issue of the omission of home production for home consumption. This is a very hard (data) problem to address, but insights into rural poverty and the implications for rural communities of government policies and shocks imply that the rewards may be substantial.[21]

Nevertheless the results are of interest and highlight some important considerations. First, the observed practice of destocking during a drought period and restocking thereafter has obvious agronomic appeal. It is however not without its adverse implications; in particular it means that the policy responses to drought should not be limited to the drought cycle and that responses during the drought cycle should be formed with an awareness of the forces that will operate subsequently. The policy of providing feeding stuffs during a drought, and thereby

20 There is a strong similarity between the patterns of income sources from factors for urban and rural wage earning households.

21 The emphasis on agricultural commodity trade in on-going global and regional trade negotiations add to the incentive to address this data issue.

supporting livestock numbers, indicates an awareness of this in Botswana.[22] Second, the non-food sectors of the economy are relatively unaffected by a drought. This is consistent with observations of how urban dwellers often experience few adverse consequences from a drought. Third, the shift in relative factor incomes suggests appreciable incentives to migrate. This model assumes that such incentives do not generate of lag in the recovery of crop production associated with family having migrated. If such migration does take place then the recovery period will inevitably be more costly. And fourth, for a well endowed, and relatively rich, economy like Botswana, the (crude) economic cost of countering the macroeconomic costs of a drought may be relatively low. This suggests that for less well-endowed economies the timely availability of aid in times of drought may be very beneficial. But the aid should continue well into the recovery cycle to avoid sterilizing the benefits of earlier aid transfers.

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22 The potential impact upon land degradation of such a policy is beyond the scope of this research.

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Appendix 1 Selected Price Changes

Table A1 Demand Price for Commodities Produced & Sold Domestically

	Drought Cycle		Recovery Cycle	
	Experiment A	Experiment B	Experiment C	Experiment D
Cattle	2.94	4.29	4.17	6.28
Other Livestock	0.40	-8.59	8.56	11.31
Fruit veg & Nuts	6.36	10.71	-0.66	-0.89
Cereals	18.36	32.66	0.18	0.03
Other Agricultural Produce	14.01	25.57	-0.12	-0.42
Mining	-0.02	-0.03	-0.01	-0.01
Sand Gravel Cement	-0.12	-0.17	-0.03	-0.05
Meat & Products	3.19	4.07	2.29	3.16
Dairy Products, Oils & Fats	2.63	4.11	-0.07	-0.16
Other Food	-0.22	-0.30	-0.21	-0.32
Beer & Soft Drinks	0.65	1.06	-0.13	-0.19
Other Beverages & Tobacco	0.23	0.37	-0.02	-0.02
Textiles & Clothes	-2.41	-3.53	-0.81	-1.16
Hides & Skins	0.41	0.64	0.02	0.01
Chemicals, Plastics & Petroleum	-0.30	-0.44	-0.13	-0.19
Paper & Products	-0.76	-1.03	-0.32	-0.43
Bricks Glass & ceramics	-0.20	-0.28	-0.13	-0.19
Metals & Metal Goods	-0.37	-0.54	-0.15	-0.20
Other manufacturing	-0.19	-0.26	-0.14	-0.18
Water	-0.63	-0.95	-0.22	-0.30
Electricity	-0.55	-0.82	-0.20	-0.27
Construction	-0.36	-0.53	-0.14	-0.18
Wholesale & Retail Margins	-0.66	-0.98	-0.23	-0.31
Hotels & Retaurants	-0.87	-1.31	-0.34	-0.45
Rail Transport	-0.86	-1.28	-0.28	-0.40
Road Transport	-0.62	-0.93	-0.16	-0.22
Air Transport	-0.80	-1.21	-0.28	-0.37
Communications	-0.67	-1.01	-0.23	-0.31
Finance & Insurance	-0.68	-1.02	-0.22	-0.29
Business Services	-0.29	-0.46	-0.03	-0.04
Rent	-1.08	-1.60	-0.50	-0.68
Ownership of Dwellings	-0.69	-1.04	-0.30	-0.39
Central Government	0.00	0.00	0.00	0.00
Education	-0.46	-0.69	-0.13	-0.19
Health Private	-0.55	-0.79	-0.28	-0.44
Health Subsidised	-2.65	-3.67	-1.49	-2.16
Domestic Services	-0.66	-0.95	-0.27	-0.43
Personal Services	-0.60	-0.89	-0.24	-0.32

Source: Model Results

Table A2 Output Price by Activity

	Drought Cycle		Recovery Cycle	
	Experiment A	Experiment B	Experiment C	Experiment D
Trad Agric Cattle	4.52	7.30	1.64	2.22
Trad Agric Other	14.25	22.52	3.23	4.08
Freehold Farms	7.29	11.83	1.64	2.73
Hunting Fishing & Gathering	-0.53	-0.81	-0.21	-0.28
Mining Diamonds	0.01	0.02	0.00	0.01
Copper Nickel	-0.06	-0.09	-0.01	-0.02
Coal	-0.14	-0.21	-0.03	-0.05
Soda Ash	-0.51	-0.77	-0.18	-0.25
Other Mine	-0.05	-0.08	0.00	-0.01
Meat Processing	1.27	0.84	2.78	4.01
Dairy & Other Agric Processing	0.81	1.28	-0.10	-0.16
Beverages	0.79	1.28	-0.10	-0.14
Textiles	-0.26	-0.38	-0.08	-0.12
Chemicals	-0.21	-0.30	-0.11	-0.16
Transport & equipment	-0.19	-0.28	-0.07	-0.09
Metal Products	-0.21	-0.31	-0.08	-0.10
Manufacturing	-0.14	-0.18	-0.13	-0.18
Water	-0.62	-0.93	-0.21	-0.28
Electricity	-0.55	-0.81	-0.20	-0.27
Construction	-0.36	-0.53	-0.13	-0.18
Trade	-0.61	-0.91	-0.23	-0.30
Hotels & Restaurants	-0.61	-0.92	-0.24	-0.32
Rail Transport	-0.50	-0.74	-0.17	-0.23
Road Transport	-0.43	-0.64	-0.16	-0.21
Air Transport	-0.56	-0.84	-0.20	-0.27
Other Transport	-0.42	-0.63	-0.16	-0.21
Communications	-0.65	-0.97	-0.22	-0.30
Banking & Insurance	-0.64	-0.96	-0.21	-0.29
Business Services	-0.62	-0.93	-0.23	-0.30
Ownership of Dwellings	-0.69	-1.04	-0.30	-0.39
Central Government	-0.31	-0.44	-0.15	-0.21
Domestics Services & Trad'l Doctors	-0.66	-0.95	-0.26	-0.42
Other Personal Services	-0.56	-0.83	-0.22	-0.29
PNPISH	-0.44	-0.67	-0.11	-0.16

Source: Model Results

Appendix 2 SAM Accounts

Commodity Accounts	Activity Accounts	Factor Accounts
Cattle	Trad Agric Cattle	Prof & Tech Employees Citizen
Other Livestock	Trad Agric Other	Prof & Tech Employees NonCitizen
Fruit veg & Nuts	Freehold Farms	Admin & Manag Employees Citizen
Cereals	Hunting Fishing & Gathering	Admin & Manag Employees Non Citizen
Other Agricultural Produce	Mining Diamonds	Clerical Employees Citizens
Mining	Copper Nickel	Clerical Employees NonCitizens
Sand Gravel Cement	Coal	Skilled Manual Citizens
Meat & Products	Soda Ash	Skilled Manual NonCitizens
Dairy Products, Oils & Fats	Other Mine	Unskilled Employees
Other Food	Meat Processing	Farm Employees
Beer & Soft Drinks	Dairy & Other Agric Processing	Gross Operating Surplus
Other Beverages & Tobacco	Beverages	Land
Textiles & Clothes	Textiles	
Hides & Skins	Chemicals	**Household Accounts**
Chemicals, Plastics & Petroleum	Transport & equipment	Urban Households Wage Income
Paper & Products	Metal Products	Urban Households Selfemployed
Bricks Glass & ceramics	Manufacturing	Urban Households Transfers
Metals & Metal Goods	Water	Rural Households Wage Income
Other manufacturing	Electricity	Rural Households Selfemployed
Water	Construction	Rural Households Transfers
Electricity	Trade	NonCitizen Households
Construction	Hotels & Restaurants	
Wholesale & Retail Margins (by 4)	Rail Transport	**Tax Accounts**
Hotels & Retaurants	Road Transport	Direct Taxes
Rail Transport	Air Transport	Sales Taxes
Road Transport	Other Transport	Tariffs
Air Transport	Communications	Export Taxes
Communications	Banking & Insurance	Value Added Taxes
Finance & Insurance	Business Services	Indirect Taxes
Business Services	Ownership of Dwellings	Factor Taxes
Rent	Central Government	
Ownership of Dwellings	Domestics Services & Trad'l Doctors	**Other Accounts**
Central Government	Other Personal Services	Enterprises
Education	PNPISH	Government
Health Private		Capital Account
Health Subsidised		Rest of the World
Domestic Services		
Personal Services		