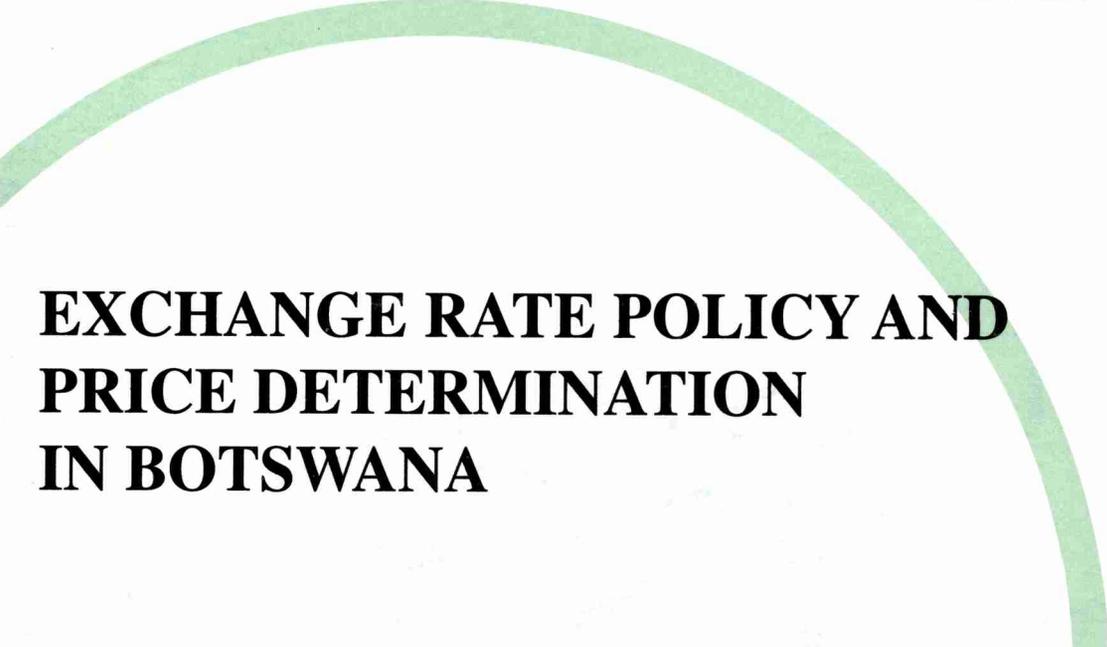# EXCHANGE RATE POLICY AND PRICE DETERMINATION IN BOTSWANA

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Exchange rate policy and price determination in Botswana

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Acknowledgements

Abstract

The dominant influence of South African goods on the Botswana CPI basket leads to the expectation that South African prices have a significant role in determining prices in Botswana. This paper examines Botswana's price and inflation relationships and their interaction. Cointegration analysis is used to develop a dynamic error correction model that establishes the link between long-run equilibrium prices and short-run inflation. Results show that the exchange rate (and South African prices), rather than money, are cointegrated with prices, supporting theoretical predictions of a dominant long-run equilibrium relationship between prices and the exchange rate in a pegged exchange rate regime with capital controls. In the short run, both domestic prices and imported inflationary pressures determine growth in the price level each month. This suggests that monetary, exchange rate and fiscal policy can be used to temper inflation in the short run. Changes in the exchange rate and prices will only have short-term price competitiveness effects, however. Over time adjustment back to the equilibrium real exchange rate occurs.

I. Introduction

Background

In contrast to many countries in sub-Saharan Africa, Botswana has enjoyed rapid economic growth over the past 25 years, during which time it has become one of the world's leading diamond exporters. Botswana has managed to avoid many of the problems experienced by other developing country mineral exporters; its success has been attributed to the high quality of macroeconomic and public financial management, and to its relationships with international mining companies (Colclough and McCarthy, 1980; Harvey and Lewis, 1990; Parkinson, 1992). The government has in general subjected its spending proposals to thorough appraisal, avoiding the tendency to spend all of its revenues. Instead, it has accumulated surpluses in recognition of the limits of the absorptive capacity of the economy. It has also refrained from nationalization and instead embarked on joint ventures with multinational mining companies, insisting on free shareholdings in return for the ceding of mineral rights; in the case of the diamond industry, the financial arrangements give the government an estimated 75%–80% share of the profits. It must be pointed out, however, that diamond mining in Botswana is so profitable that the residual share of profits gives a very high rate of return on capital to the private shareholders.

Exchange rate policy, discussed in more detail below, has avoided Dutch disease problems. Much of the mineral revenue accruing to the government has been used to finance the provision of social services such as health, education, water supplies, etc. As a result, Botswana has one of the best levels of social provision in sub-Saharan Africa, when measured in terms of indicators such as infant mortality, adult literacy and life expectancy. It is one of only three countries in mainland sub-Saharan Africa that reach the "medium" category in UNDP's human development index (UNDP, 1993: 135–137).

Rapid growth of exports and the capital inflows needed to finance investment in the minerals sector have led to consistent balance of payments surpluses and accumulation of substantial foreign exchange reserves, which now represent around 30 months of import cover. In the domestic economy reserves accumulation has not resulted in unwarranted inflation as these inflows have been largely sterilized through budgetary surpluses and the consequent accumulation of government deposits with the central bank. Also, balance of payments surpluses have enabled the country to use exchange rate policy for purposes other than balance of payments stabilization.

As would be expected for a small mineral exporter, the economy is highly open; the total of exports and imports is well over 100% of GDP. This openness makes the country

highly vulnerable to external shocks and exchange rate policy changes, an important tool for macroeconomic management. The growth of GDP is closely tied to export performance, while imports exert a major influence on domestic prices. Exports and imports are highly polarized both by type and direction: diamonds make up around 80% of total exports and are priced in U.S. dollars, while imports are dominated by food and manufactures, with some 80% originating from neighbouring South Africa. South Africa's domination of Botswana's import trade reflects not only geographical proximity but their common membership in the Southern African Customs Union (SACU), dating back to 1910.

Despite the record of success, the 1990s have seen a slowing of economic growth, giving rise to increased emphasis on the need to diversify the economy away from its extreme dependence on diamonds, by promoting new sources of economic growth, employment and exports (Republic of Botswana, 1991). Given the poor potential of Botswana's agricultural sector and the small size of the domestic market, the main emphasis is on production of export-oriented manufactured goods. It is in the context of promotion of such non-traditional exports (i.e., beyond the major minerals and beef) that the potential use of the nominal exchange rate in improving Botswana's export price competitiveness becomes critical.

Research issues

Economic reform programmes in developing countries often stress the importance of exchange rate policies in stimulating the competitiveness of non-traditional exports. Typically, this involves devaluation of the nominal exchange rate in order to alter the real exchange rate and improve the incentive structure facing producers across the economy. However, it is not clear that such a policy will always work since devaluation also increases the price of imports, and hence pushes up domestic inflation. Therefore, in the short run, there may be conflict between these two key exchange rate policy objectives–stable prices, which require exchange rate stability, and export price competitiveness, which requires devaluation. On the other hand, if other macroeconomic policies could be used to keep inflation in Botswana below that in trading partners, then export competitiveness could be improved without devaluation.

In the case of Botswana, the exchange rate policy emphasis has typically been on an anti-inflation objective, due to the high import content of both consumer and producer goods traded in the country. The exchange rate has therefore tended to appreciate against that of its main trading partner (South Africa), reducing the impact of imported inflation. More recently, however, attention has focused on the need for economic diversification and export competitiveness, and since 1990 the currency has not been allowed to appreciate against the rand. Fortunately for the country, this policy did not result in loss of competitiveness for a long period in the 1980s because a rising nominal exchange rate against the rand was offset by lower domestic inflation.

The exact nature and timing of the linkages between the nominal exchange rate, foreign prices and domestic prices, which together determine the real exchange rate, are of crucial

importance for a small open economy. They centre on the extent of "pass-through" of changes in foreign prices and the exchange rate to domestic prices, and the time it takes for this to happen. On the other hand, the extent of the pass-through determines the extent to which there is in fact a conflict between the anti-inflation and competitiveness objectives over the long run.

Our study investigates the determinants of inflation, and in particular addresses the question of whether a long-run relationship exists between nominal exchange rates and prices in Botswana. The results from this investigation will enable a more accurate assessment of the effectiveness of nominal exchange rate policy in influencing the real exchange rate to promote the domestic production of and trade in non-traditional exports and import substitutes. The study examines the short- and long-run dynamics of price formation in Botswana. It considers the speed at which foreign price and nominal exchange rate changes are transmitted to domestic prices, as well as the importance of other factors (such as monetary policy) in price determination. The policy issues being addressed are therefore two. The first is whether devaluation is effective in boosting export price competitiveness. The second issue concerns the factors that determine prices and inflation in Botswana in the long run and short run. We hope that the results will inform the choice of appropriate exchange rate and monetary policies in Botswana.

Objectives of the study

The general objective of the study is to provide policy makers in Botswana with information on the possible effects of exchange rate policies. More specifically, the objective is to determine the extent to which nominal exchange rate depreciation and foreign price changes pass-through to domestic prices, thereby ascertaining the extent to which the nominal exchange rate can be used as a tool to influence the real exchange rate.

Organization of the report

The report is organized in six chapters, including this introductory chapter. The next chapter reviews both the theoretical and the empirical literature on exchange rate and inflation that is relevant to our study. Whereas the literature review provides an analytical background for the specification of our model, institutional and policy framework is provided by an overview of Botswana's monetary and exchange rate policies in the third chapter. This chapter also contains a brief survey of inflationary process in the country and a preliminary (heuristic) assessment of nominal exchange rate pass-through in Botswana, concentrating on trade with South Africa. The fourth chapter presents the hypotheses of the study and detailed specification of the model that is later estimated. In the fifth chapter we present the econometric results based on an autoregressive distributed lag (ADL) model. The results are on time series characteristics of the data on the variables in the model and from estimation of the error correction model (ECM). The former set

of results is based on stationarity and cointegration tests, and the latter covers the estimation of both an over-parameterized ADL equation and a parsimonious equation with a lagged error correction term. The last chapter contains conclusions and policy implications drawn from the analysis.

II. Experiences with exchange rates and inflation

The choice of an appropriate exchange rate regime, and the broad thrust of exchange rate policy, is a crucial component of macroeconomic policy in any country. The exchange rate issue has been particularly prominent in developing countries in recent years following the introduction of IMF and World Bank stabilization and adjustment policies. These frequently include devaluation and the introduction of new exchange rate management policies, along with trade liberalization measures.

When devaluation is pursued, the aim is to improve international competitiveness and hence stimulate the performance of the tradeable goods (exports and import-substitutes) sector. Manipulation of the nominal exchange rate is used as a policy instrument to achieve changes in the real exchange rate, which is the ultimate policy target. Whether or not this is possible depends on the operating economic linkages and the nature of economic policies pursued, both of which will vary from one economy to another. Using a fixed exchange rate as a nominal anchor for low inflation may lead to deteriorating competitiveness if domestic inflation is above international levels. Conversely, pursuing competitiveness through nominal devaluation may increase the domestic price level and hence contribute to inflation, through the impact of higher priced imported goods. Kiguel (1992: 1) sums up exchange rate policy objectives as follows:

> Exchange rate policy is usually driven by two different, and many times conflicting, objectives: first, to support a competitive real exchange rate, and second, to serve as a nominal anchor for low inflation. The former objective is generally pursued to support the expansion of the exportable and import competing sectors, and as a way to ensure a strong position in the balance of payments. The latter objective is important to the extent that low inflation and macroeconomic stability create a favourable environment for long term growth.

The effectiveness of exchange rate policy in pursuing these two objectives depends crucially on the nature and timing of linkages between the nominal exchange rate, import prices and inflation. If domestic inflation is largely determined by import prices and the exchange rate, the initial improvement in competitiveness resulting from a devaluation may eventually be mostly or completely offset by the consequent increase in domestic prices. Indeed, in the extreme case where the pass-through of exchange rate changes to domestic prices is complete, nominal exchange rate devaluation cannot be used to boost long-run competitiveness. In this case there is no conflict between inflation and competitiveness objectives in the long run; exchange rate changes will simply fully affect inflation.

Exchange rate regimes in developing countries

Developing countries have over time adopted a variety of exchange rate regimes, including fixed, floating and crawling peg systems. The choice of a regime often reflects the priority objective of the exchange rate policy pursued. A fixed exchange rate (whether against a single currency such as the U.S. dollar, or a basket of currencies) typically reflects priority being given to the anti-inflation objective, the purpose being to minimize the impact of imported inflation and to provide a signal for policy and commitment to low inflation and macroeconomic stability objectives. Emphasizing competitiveness, however, would tend to call for a more flexible exchange rate regime, whereby inflationary impulses are accommodated (or validated) through regular devaluations.

Both types of regime can be problematic, with effectiveness depending on a range of factors relating to both the structural characteristics of the economy and accompanying macroeconomic policies. Under a fixed exchange rate regime, or even a "tablita" type crawling peg regime, where the aim is to make domestic inflation converge on a preannounced rate of devaluation, the rate of domestic inflation is inevitably higher than the rate of devaluation. In the short (to medium) term, therefore, domestic prices will increase faster than foreign prices and competitiveness will decline. The crawling peg experiences of the Southern Cone countries of Latin America in the 1970s and 1980s illustrate this point. Inflation there declined more slowly than anticipated and led to sustained appreciation of the real exchange rate; similar results were experienced by countries adopting fixed nominal exchange rates. The problem of real exchange rate appreciation is exacerbated if wages are indexed to inflation, as this makes it more difficult to bring down domestic inflation.

The experience of the CFA countries in West Africa typifies the problems of fixed exchange rate regimes. These countries have fixed exchange rate against the French franc. This arrangement enabled these countries, including Senegal, to experience zero inflation in the late 1980s and early 1990s, which might have improved their competitiveness. Unfortunately, this was not enough to reverse the previous real exchange rate appreciation of the CFA franc. As a result, there was a devaluation of the CFA franc in January 1994. The experience of Senegal after the devaluation is interesting. As would be expected, there was an initial surge in inflation, but within 18 months of the devaluation, inflation had been contained and prices began to fall.

Attempts to achieve real depreciations through an aggressive policy of large nominal devaluations have not been particularly successful either (examples are Colombia and Mexico in the mid 1980s). Initial depreciations of the real exchange rate and improvements in competitiveness were largely wiped out in the medium term by the high inflation that resulted. Such policies led to real exchange rate appreciation and induced greater instability in the real exchange rate.

Edwards (1989) carried out a systematic analysis of the effectiveness of a policy of nominal devaluation, focusing on the sustained impact on the real exchange rate as an important indicator of effectiveness. This approach focuses on the real exchange rate as an intermediate target, the channel through which devaluations seek to influence external

sector balance, i.e., the ultimate targets of the current account and the balance of payments. The effectiveness of a devaluation is measured by the "Effectiveness Index", which is essentially real exchange rate elasticity with respect to nominal exchange rate, and it "provides an index of the degree of erosion experienced by the real exchange rate during the years after the devaluation [such that] a value of one means that the nominal exchange rate adjustment has been fully transferred into a one-to-one *real* devaluation. . . . the value of this ex post elasticity measures in a very broad sense what percentage of the devaluation has been effective, in the sense of being translated into a real devaluation" (Edwards, 1989: 255–259).

Edwards' results illustrate the difficulties of using nominal devaluation to secure a real depreciation. Out of 29 cases of stepwise devaluation (in an otherwise fixed exchange rate regime), in 17 cases the index of effectiveness had a value greater than one-third (the criterion for "success") after three years. Therefore nearly half of the countries were unable to sustain a significant real depreciation following nominal devaluation, and in several countries the real exchange rate actually appreciated after three years compared with what it had been before devaluation. Among nine crawling peg countries, in all cases the real exchange rate had depreciated three years after devaluation, but this was typically achieved through further devaluations to accommodate the resulting inflation. Therefore, although real devaluations were more typically achieved, these were often at the cost of increased inflation.

Similar experiences with devaluation and inflation in African countries have formed the basis of critical views towards the orthodox stabilization approach, such as that emanating from the UN Economic Commission for Africa in its African Alternative Framework for Structural Adjustment Programmes (UNECA, 1989). This criticism contends that exchange rate devaluations are a major factor accounting for the relatively high rate of inflation experienced in many African countries in recent years (Canetti and Greene, 1992). If this is correct, then attempts to improve competitiveness through nominal exchange rate depreciation will be (partially) offset by the resulting domestic price inflation. Furthermore, higher inflation is a problem in its own right, and conflicts with the inflation reduction objective of macroeconomic stabilization.

Modeling inflation

The effectiveness of exchange rate policy depends on the price formation process in an economy, and therefore on the factors that determine inflation and the magnitude and timing of their respective effects. Furthermore, the exchange rate regime in place will influence the relative importance of the different determinants of prices. There is considerable disagreement, at both theoretical and empirical levels, on the importance of different factors. Monetarists tend to emphasize the importance of the money supply and of policies to control money supply growth, on the assumption that the money supply is exogenous. Others emphasize the importance of demand pressures, structural factors such as imperfect markets, and cost pressures, including those emanating from prices of imports. From this perspective, they argue that monetary expansion is not in itself a

cause of inflation but it simply reflects other, more fundamental, causes of inflation, making the money supply endogenous. We will consider some of the theoretical approaches used in modeling inflation in developing countries, with particular emphasis on the role of exchange rates, prices of import and monetary factors. This will be followed by the results of some empirical analyses of price formation in developing countries.

Purchasing power parity

The simplest approach to price determination in an open economy is that of purchasing power parity (PPP). This stems from the Law of One Price, which states that any commodity in a unified market has a single price. Therefore, for any commodities that can be traded between two countries without transportation and other costs, the price must be the same in the two countries, due to arbitrage. If the foreign (world) market price for a commodity is P^f, the domestic price (P) for that commodity must therefore be:

$$P = E.P^f \tag{1}$$

where E is the exchange rate expressed in domestic currency units per one unit of foreign currency. PPP results from extending the Law of One Price from one commodity to the basket of commodities that determines the average price level in a country. The simplest form of PPP relationship is therefore expressed in Equation 1 if P and P^f are interpreted as the prices of baskets of commodities. Inflation results either directly from higher import prices, or indirectly as a higher domestic price for imports (EP^f) leads to increased demand for domestic goods, the price of which will increase until equilibrium is restored when Equation 1 again holds.

This form of PPP – sometimes termed absolute PPP–is an oversimplification, based on a number of assumptions, including (1) that there are no natural barriers to trade; (2) that there are no artificial barriers, such as tariffs or quotas; (3) that all goods are internationally traded; and (4) that the domestic and foreign price indexes have the same commodities, with the same weighting (Sachs and Larrain, 1993: 299). A less restrictive version of PPP (relative PPP) holds that even when there are barriers to trade, as long as these barriers are stable over time, percentage changes in P should approximately equal percentage changes in EP^f.

$$\Delta P/P_{-1} = \Delta EP^f/(EP^f_{-1} \tag{2}$$

which can be approximated as:

$$\Delta P/P_{-1} = \Delta E/E_{-1} + \Delta P^f/P^f_{-1} \tag{3}$$

i.e., domestic inflation is equal to the sum of the rate of currency depreciation plus the rate of foreign inflation.

Empirical investigation generally indicates that in practice, PPP alone does not explain

the relationship between exchange rates and prices particularly well, especially in the short run. PPP tends to perform better for countries that are geographically close to each other, and where trade linkages are high (Pilbeam, 1992; Frenkel, 1981). However, PPP appears to work well for high inflation countries (such as many in Latin America) that have also suffered rapid exchange rate depreciations.

PPP and the real exchange rate

The real exchange rate (RER), according to one common definition,can be defined as the nominal exchange rate multiplied by the ratio of the foreign price level to the domestic price level:[1]

$$RER = E.P^f/P \tag{4}$$

where E, P and P^f are as defined earlier. Changes in the RER result from changes in E, P, or P^f, and can be approximated as:

$$\Delta RER/RER_{-1} = \Delta E/E_{-1} + \Delta P^f/P^f_{-1} - \Delta P/P_{-1} \tag{5}$$

Combining this with Equation (3) (relative PPP), yields:

$$\Delta RER/RER_{-1} = \Delta E/E_{-1} + \Delta P^f/P^f_{-1} - (\Delta E/E_{-1} + \Delta P^f/P^f_{-1}) = 0 \tag{6}$$

Therefore, changes in the nominal exchange rate (E) cannot be used to alter the RER, which remains constant. Any improvement in competitiveness resulting from devaluation (increase in E) will be completely offset by an equal increase in domestic prices P.

This is essentially a long-run relationship since adjustment may not be instantaneous. It may take time for an initial depreciation (increase) of the RER to be offset by domestic price increases. If this model holds, there is a long-run relationship between domestic prices and the nominal exchange rate (holding foreign prices constant), but there is no long-run relationship between the nominal and real exchange rates.

Monetarist view

The PPP approach holds that inflation results from either increases in foreign prices (P^f) or nominal exchange rate devaluations. Monetarists put a somewhat different emphasis on the causes of inflation, however, arguing that it is essentially a domestic phenomenon stemming from money supply growth in excess of the growth rate of money demand. They also assert that money supply is exogenous and can be controlled by the authorities.

A simple form of the monetarist model of the determinants of inflation is as follows:

$$P = k + M - aY + bC \tag{7}$$

where P is prices, Y is real income, C is the opportunity cost for holding money, and M the money supply (all expressed as changes or rate of growth). Changes in velocity are captured by the constant term, k. This is based upon Harberger's (1963) model of inflation in Chile, and has been fairly widely used in empirical analysis (see, e.g., Bhalla, 1981; Saini, 1982). It is derived from the money demand function, and hypothesises that inflation will vary, *ceteris paribus*, positively in relation to the rate of change of the money supply and negatively with the rate of change of real income. It assumes that the price equation and the underlying demand for money equations represent long-term relationships.

It is important to note that often when changes in the money supply are assumed to be exogenous, exchange rates are floating. If the exchange rate is fixed and the capital account is open, money supply becomes endogenous, responding to changes in the (exogenous) exchange rate.

The monetarist approach can be compatible with the PPP approach. With a floating exchange rate, a change in the money supply will be reflected in a change in the nominal exchange rate, which will affect domestic prices through the PPP mechanism.

The monetarist model is typically amended to incorporate the effects of a lagged adjustment process. Whereas in developed countries the rate of interest may be used to measure the cost of holding money (C), in developing countries with underdeveloped financial markets and financial repression this is considered inappropriate. Harberger and others therefore used changes in past inflation rates as a measure of the cost of holding cash. Taking account of both of these changes, the model then becomes:

$$P_t = \alpha_0 + \alpha_1 M_t + \alpha_2 M_{t-1} + \alpha_2 (\Delta P_{t-1}/P_{t-1}), \qquad (8)$$

where $(\Delta P_{t-1}/P_{t-1})$ is the rate of inflation in the previous period.

Hybrid models and empirical results

The monetarist model in Equation 8 is essentially a demand-related model of inflation and does not independently incorporate any structural or cost-push causes of inflation; cost increases are simply reflected in changes in the money supply if the monetary authorities follow an accommodating policy to prevent real output from falling. This model therefore does not reflect cost-push inflation which is a potentially serious problem in small open developing countries, where increases in foreign prices may be a primary cause of domestic inflation, (Edgren, Faxen and Odhner, 1969; Parkin, 1977). One approach is therefore to augment the standard monetarist model to incorporate these cost-push factors directly.

Saini (1982) introduces the growth rate of import prices into the model in Equation 8 to obtain the following equation:

$$\dot{P}_t = \alpha_0 + \alpha_1 \dot{M}_t + \alpha_2 \dot{M}_{t-1} + \alpha_3 \dot{M}_{t-2} + \alpha_4 \dot{Y}_t + \alpha_5 \Delta \dot{P}_{t-1} + \alpha_6 \dot{P}m_t \qquad (9)$$

where *Pm* is the rate of growth of import prices. This may be interpreted as decomposing inflation into two independent parts, one entirely dependent upon domestic developments and the other on external factors . . . the domestic component of inflation is fully accounted for by movements in the money, income and expectations variables . . the second part of inflation is then entirely due to the behaviour of import prices (Saini, 1982: 873–874).

A similar approach was taken by Bhalla (1981), who augmented the standard monetarist model with both import prices and the relative price of food, to represent food supply shocks. Bhalla applied the basic and hybrid monetarist reduced form models to 29 developing countries for the period 1956–1975. He also applied a different, real activity model, explaining inflation in terms of excess aggregate demand, augmented by price expectations. Results show that the basic monetarist model is far better at explaining inflation than the real activity model. However, the hybrid monetarist model performs best. Bhalla notes that "the structural variables, relative food prices and import price inflation, turn out to be important . . .[and that this] is a relatively stringent test of the role of the structural variables in the generation of inflation since part of their effect may already be captured by the money-supply and excess-demand variables" (Bhalla, 1981: 85). Import prices were found to be significant for 16 of the 29 countries. The importance of import prices is confirmed when the inflation model is applied to pooled data on 28 of the countries over the period 1971–1975.

Saini (1982) finds somewhat different results in applying the hybrid monetarist model to six moderate-inflation Asian countries over the period 1953–1980. The author concludes that the results "do not lend strong support to the monetarist explanation of inflation . . . monetary discipline as a tool for controlling inflation may not be very effective in moderate inflation countries" (Saini, 1982: 880). However, the addition of the import price variable improves the results, and is significant in five of the six countries.

A more recent model incorporating both monetarist and cost-push features has been developed by Chhibber (1992) and applied to a number of African economies. In the model, general inflation is a "weighted average of inflation in traded goods prices ($\dot{P}_t$), non-traded goods prices ($\dot{P}_n$) and controlled-price goods ($\dot{P}_c$)

$$\dot{P} = \alpha_1 \dot{P}t + \alpha_2 \dot{P}n + (1 - \alpha_1 - \alpha_2)\dot{P}c \tag{10}$$

where: $0 < \alpha_1$ and $\alpha_2 < 1$

Inflation in traded goods prices is determined according to the absolute PPP model (Equation 1), which makes it equal to foreign price inflation and a change in the nominal exchange rate. Non-traded goods prices are determined according to a mark-up applied to unit wage costs (W) and the costs of imported inputs (Mc). The mark-up is not fixed but is modeled as a function of excess demand in the economy, which is proxied by excess real money balances (EMB). Chhibber (1992) justifies the use of this proxy on the ground that there exist limited ranges of financial assets and small degrees of substitution between money and other financial assets in developing countries. This

produces the following simplified mark-up equation for inflation in non-traded goods:

$$\dot{P}^n = b_1 EMB + b_2 \dot{MC} + b_3 \dot{W} \tag{11}$$

where: $b_2 + b_3 < 1$ and $b_1 > 0$.

Excess real money balances, on the other hand, are given by excess real money supply over real money demand:

$$MB = Log(M/P) - Log(Md/P) = \dot{P} + Log(M/P - 1) - Log(Md/P) \tag{12}$$

with the money demand function specified as:

$$Log[Md/P] = d_0 + d_1 Logy + d_2 i + d_3 \dot{P}^e \tag{13}$$

where $\dot{p}^e$ is the expected rate of inflation.

Combining equations (10) to (13) gives the overall inflation equation as:

$$\dot{P} = f_1(\dot{P}^f + \dot{E}) + f_2 \dot{W} + f_3 Log(M/P - 1) + f_4 i + f_5 \dot{P}^e + f_6 \dot{P}c + f_7 Logy \tag{14}$$

This is a more general model than those used by Saini (1982) and Bhalla (1981). Chhibber (1992) considers the model capable of identifying the basic sources of inflation in the African context: imported inflation ($\dot{p}^f$), inflation due to the cost-push effect of devaluation ($\dot{E}$), wage-push inflation ($\dot{W}$), demand-pull inflation (EMB), and inflation arising from the control and subsequent decontrol of prices ($\dot{p}_c$).

Chhibber applies this model to four different types of policy regimes present in Africa, which vary according to the type of exchange rate regime, openness of the capital account and degree of price control. Although the estimation and simulation results vary according to policy regime, he concludes "there is no doubt that there is a direct cost-push effect from exchange rates to prices" (Chibber, 1992: 139). He also found that the degree of devaluation pass-through varies widely, and as a result, saw no evidence of a unique relationship between devaluation and inflation (Chibber, 1992: 141). For Zimbabwe, around one-third of a devaluation is wiped out by higher inflation and in Ghana the result of devaluation was lower inflation; in other countries higher inflation wipes out the devaluation completely. A key element in the varying response is the impact of devaluation on the budget deficit, and the extent to which the deficit is monetized; the more the deficit increases and the greater proportion of it is financed by money creation, the more inflation will rise. In Ghana, for example, inflation fell because devaluation led to a reduced budget deficit, and because prices already incorporated the cost-push effects of parallel exchange rate depreciation–the official devaluation simply formalized the status quo.

Previous empirical work on inflation in Botswana

A number of researchers have modeled the price/exchange rate relationship in Botswana. The first is by Huda (1987), who estimated a simple log-linear model of price determination in Botswana with different lag structures for the impact of nominal exchange rate on domestic prices. The best results, based on monthly data for the period 1980–1986, were as follows:

$$\ln CPI = 1.068 + 0.782\ln SAPPI + 0.149\ln(R/P) - 0.423\ln(R/P)_{-2} \tag{15}$$

where CPI is Botswana CPI, SAPPI is South Africa producer price index, and R/P is rand/pula nominal exchange rate. Although the coefficient of -0.421 for nominal exchange rate lagged two months was significant at 1% level, Huda (1987: 220) concluded that the impact of nominal exchange rate changes on the price level was small. He further explains the relatively small impact of exchange rate changes by the oligopolistic nature of Botswana's wholesale sector and the lack of competition, which enable importers to absorb the beneficial impact of currency appreciation in their profit margins while passing on the negative impact of depreciation to consumers. This is a classic explanation of why nominal exchange rate changes may not pass through to domestic prices, often found in pass-through literature, such as those by Mann (1986) and Kasa (1992).

Ncube (1992) estimated a similar model, using annual data and without any lags. His results showed a coefficient of nominal exchange rate of -0.13, which was significant at 5% level. The estimation methodology used in both studies appears to have overestimated the speed at which domestic price levels adjust to changes in nominal exchange rate in Botswana; the first (Huda, 1987) imposed a maximum lag of two months, while the second (Ncube, 1992), presumably because annual data were used, allowed for no lagged effect.

Leith (1991), on the other hand, using the same basic formulation as the one used by Huda (1987), avoided this problem by recognizing the possibility that a disequilibrium might persist for a considerable period during adjustment process. He specified a distributed lag model for price equation based on "a lagged adjustment mechanism whereby the change in the Botswana price index is a function of the difference between the equilibrium relationship and the actual level in the previous period" (Leith, 1991: 310). He obtained the following regression results based on this partial adjustment model:

$$\ln CPI = 0.244 + 0.3961\ln SAPPI + 0.05461(R/P) + 0.95744\ln CPI_{-1} \tag{16}$$

The results indicate that while the immediate effect of a nominal exchange rate change is very small, it feeds through to prices over a long period–it takes 15 months to eliminate half of the discrepancy between the actual and equilibrium price level. Over time, 100% of the foreign price level and exchange rate changes pass through to the Botswana price level.

Leith's results therefore suggest that there is a trade-off (albeit of short-run duration) between the inflation and export competitiveness objectives of exchange rate policy,

because the adjustment of domestic prices to changes in foreign prices and the exchange rate is not instantaneous; in fact the longer (shorter) is the lag in the adjustment process, the greater (smaller) is the trade-off between the two objectives. In contrast to the conclusions from the two earlier studies on Botswana, therefore, we can infer from Leith's results that there is little possibility of raising the real exchange rate, in the long run, as a result of depreciation; indeed, in the long run exchange rate policy can only affect the rate of inflation and can have no effect at all on competitiveness. If this is true, then a more appropriate policy would be to appreciate the pula against the rand by an amount equal to the RSA inflation rate, achieving low inflation in Botswana without any deterioration in competitiveness. In other words, the apparent conflict between the two objectives of exchange rate policy disappears. However, once the dynamics of price adjustment are considered it becomes clear that the objectives do conflict, at least in the short run. Through nominal exchange rate depreciation, Botswana can achieve a short-run improvement in competitiveness, but at the cost of higher inflation. Alternatively, through appreciation, Botswana can achieve an inflation rate lower than that in RSA in the short run, but at the cost of reduced competitiveness.

In practice, however, appreciation of the Botswana pula against the rand in the 1980s did not reduce the competitiveness of Botswana exports, owing to the feedback of the appreciation into lower domestic inflation. The policy trick used during this period was to appreciate the pula slowly enough to ensure that exporters were not seriously affected during the period between the appreciation of the pula and its feeding back into lower rate of inflation than in South Africa.

A different perspective on the same issue is presented by Salkin (1989), who used an input-output model to forecast the impact of a 25% appreciation of the pula. The input-output coefficients, upon which the forecasts were based, were derived from a multisectoral model of the Botswana economy. This enabled him to trace the sectoral response to nominal exchange rate changes. For example, the model indicated that 25% appreciation would reduce costs in the "other manufacturing" sector by 13.4%; in other words, competitiveness would be reduced in this sector as the lower costs are insufficient to compensate for the higher (foreign currency equivalent) prices caused by the appreciation. The conclusion is that appreciation reduces competitiveness, and the corollary is that depreciation increases competitiveness. Leith (1991) and Salkin (1989), consequently, draw different conclusions. This is because, unlike the former's model, the latter's model permits only static (i.e., short-run) analysis, which does not allow long-run impact of nominal exchange rate devaluation to be transmitted to domestic prices.

Of the three econometric studies on the relationship between nominal exchange rate and the price level in Botswana cited above, those by Leith (1991) and Huda (1987) were cast within the pass-through framework, but owing to non-availability of monthly series for other potentially relevant regressors, such as GDP, factors other than foreign price and nominal exchange rate were not included in the model to be tested. On the other hand, although Ncube (1992) derived a model for price formation that included GNP and real money supply as additional regressors, the results were poor so far as the coefficient of nominal exchange rate was concerned.

All three studies use traditional approach to econometric study, i.e., a specific to general approach. In addition, regressions were undertaken without testing for stationarity of the variables involved, and consequently, the possibility of spurious correlation was not eliminated, or reduced by means of using first differences. One consequence of this approach is that if domestic prices are not stationary but are in fact integrated of order one [i.e., I(1)], the coefficient on lagged prices will be biased upwards, thus underestimating the speed of adjustment coefficient.[3]

Only one study to date (Masale, 1993) has attempted to overcome the problem of spurious correlation by testing for stationarity of variables and applying recent developments in time series econometrics in the form of cointegration analysis, which enable the identification of both long-run relationships and short-run dynamics. Using quarterly data over the period 1976–1992, she found that the relevant variables (Botswana and South African prices, and the rand/pula exchange rate) were indeed non-stationary. However, testing for cointegration between the exchange rate and relative prices (Pd/P^f) yielded inconclusive results that did not confirm the existence of a long-term relationship. Estimation of a short-term relationship between the variables (using first differences in view of the non-stationarity noted above) also led, rather surprisingly, to a rejection of the PPP model.[4]

Our model is an improvement over that of Masale in a number of ways that will be discussed more fully in the next chapter. Most notably, we use monthly data and incorporate a wider range of foreign price and exchange rate variables into the model, reflecting Botswana's broader trade pattern rather than just South African influences.

Factors affecting exchange rate pass-through

One of the factors affecting the size of the pass-through from exchange rate changes to domestic prices is the size and openness of the economy: the larger and less open the economy, the smaller and/or slower will be the pass through. But even in the United States (the largest and probably the least open economy in the world) there is some feedback. Dornbusch (1988: 252), for example, estimates that the impact of a 10% dollar appreciation on the price level ranges between one and two percentage points.

In more open economies the pass-through is likely to be larger, all other things being equal. This is particularly true in the case of small economies (ministates), which are typically among the most open in the world (Galbis, 1984). The greater the proportion of imports in GDP (and in the consumer price index), the more direct will be the impact of changes in the exchange rate (and foreign prices) on domestic prices. In very open economies the CPI tends to be dominated by foreign prices. Exchange rate changes tend to produce immediate and strong effects on domestic prices, similar to those of foreign price changes. This not only affects tradeables but also non-tradeables via the effect on wages and producer prices. The feedback effect from exchange rate changes to prices is therefore much greater than in larger, less open economies. Therefore, in very open economies the scope for using the nominal exchange rate to influence export competitiveness, because of the impact on inflation, is limited. Because of this, Galbis

(1984) concludes that "ministates would in general be ill advised to rely on exchange rate flexibility as a tool of stabilisation policy" and instead they should "rely on stable effective exchange rates in their pursuit of domestic stabilisation".

The analysis given above assumes that the Law of One Price holds for tradeable commodities (after allowing for any price differences that may emerge due to tariffs and transport costs). However, there is substantial evidence that the Law of One Price does not hold in practice, and that price differentials for the same goods in different countries are too large to be explained solely by transportation costs or trade taxes. Furthermore, these differentials appear to persist for long periods of time, which is not compatible with reliance on arbitrage to equalize prices. Kasa (1992) notes that these differentials also tend to follow a pattern, in that when a nation's currency appreciates (depreciates), the prices of its imports tend to rise (fall) relative to the prices of the same goods in other countries (the phenomenon of "pricing to market"). In other words, the reduction in the domestic currency price of an import, which one would expect to occur as a result of an appreciation, does not fully occur.

A number of reasons have been advanced to explain the failure of the Law of One Price in practice (e.g., Isard, 1987; Krugman, 1989; Dornbusch, 1987; Mann, 1986). First, there are the risks and other costs associated with discovering and taking advantage of price differentials. Second, producers may take advantage of opportunities for price discrimination in markets with different demand elasticities. Third, economic agents cannot distinguish between permanent and temporary exchange rate changes. A fourth explanation, which is connected with the price discrimination argument, focuses on market structures, and the lack of perfect competition in product markets. In the case of oligopolistic markets, reductions in the domestic currency cost of imports may be taken by producers in the form of increased profits rather than domestic price reductions. This would also lead one to expect an asymmetric response to exchange rate changes, in that nominal exchange rate appreciations would not lead to a price reduction, although depreciations would lead to a price increase; hence profit margins would vary.

III. Botswana's monetary and exchange rate policies

Exchange rate policy

Since leaving the Rand Monetary Area and introducing its own currency (the pula) in 1976, Botswana has used exchange rate policy to pursue either anti-inflation or export competitiveness objectives, with more emphasis being given to the former. Although initially tied to the U.S. dollar, the pula has since 1980 been pegged to a basket of currencies including the SA rand, the SDR (as a convenient proxy for the major world currencies) and in recent years, the Zimbabwe dollar. The nominal external value of the pula has been set by a managed or "dirty" float mechanism, and can be changed by either altering the exchange rate of the pula against the basket or changing the composition of the basket. In addition, the pula is affected by cross exchange rate movements involving other currencies. The main movement in the past resulted from the steady depreciation of the SA rand against the U.S. dollar during the 1980s, which—as a result of the polarized structure of Botswana's external trade—led to significant terms of trade gains.

For most of the period since 1976 the pula has been allowed to appreciate against the rand, thus mitigating the effects of imported inflation during a period when inflation in South Africa was rising. Furthermore, this has served to distance the pula from what was increasingly perceived internationally as a weak currency, so as not to damage the investment climate in Botswana (Gaolathe and Hudson, 1989: 8). There have been a number of small devaluations, however. The first was in 1982, as part of a package of adjustment measures adopted in response to a short-lived balance of payments crisis following the imposition of quotas on diamond exports in 1981. More recently, in mid 1990, the Bank of Botswana (BOB) became concerned about the appreciation of the pula, and in order to raise the competitiveness of Botswana exports, devalued the pula twice, by 5% in August 1990 and September 1991. Figure 1 illustrates three bilateral nominal exchange rates for the pula.

Exchange rate management in Botswana originally emphasized moderation of the effects of imported inflation on the cost of living in Botswana, but in recent times it has been increasingly used to keep rising domestic costs of production from pricing Botswana's goods out of regional markets (Republic of Botswana, 1993: 19). The issue about the trade-off between price stabilization and competitiveness of exports still remains, however. A cursory examination of the data suggests that the two devaluations of 1990 and 1991 might have contributed to a sharp rise in Botswana's inflation rate, which increased from 10.6% in mid 1990 to over 17% by late 1992. This is a question that can be resolved only empirically.

Figure 1: Nominal exchange rate in the pula
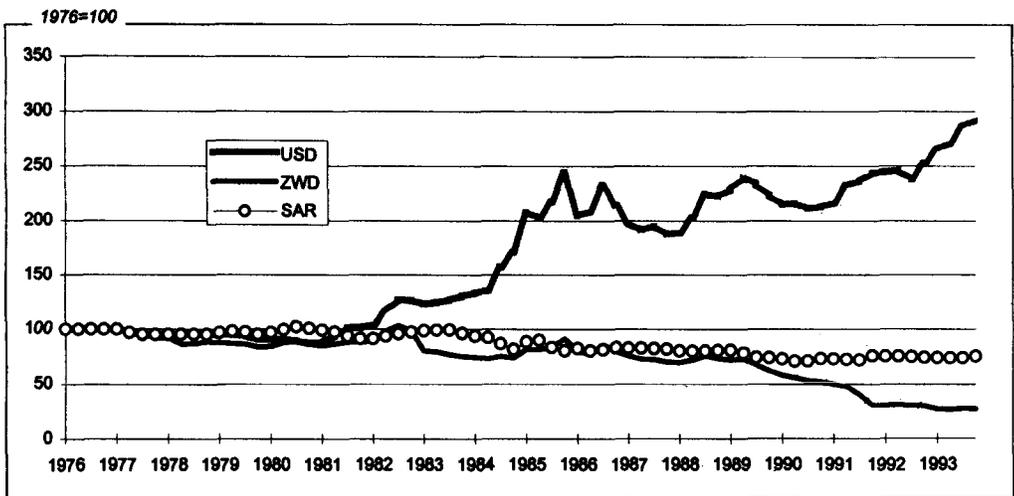
The real exchange rate

Underlying changes in the nominal exchange rate has been a consistent policy of maintaining a stable real exchange rate for the pula against the currencies of Botswana's major trading partners, reflecting the determination of the government and the BOB to avoid the dangers of mineral-led Dutch disease appreciation.

Real exchange rate stability is illustrated in Figure 2, which shows the multilateral real exchange rate (MRER)[5] (or real effective exchange rate) from 1976 to 1992. This has shown little deviation from its initial value (100) over this period, having varied between 89 and 109, and with an average of 99.

Maintaining a stable MRER against a basket of currencies whose cross exchange rates are themselves variable means that bilateral real exchange rates (BRERs)[6] are much more volatile than the MRER, as illustrated in Figure 3. The BRER against the SA rand, however, has been the most stable, reflecting the relatively high weight of that currency in Botswana's trade (excluding traditional exports) and in the currency basket to which the nominal value of the pula is pegged. By the end of 1992, the pula/rand BRER index had declined to only 94, compared with a base year (1976) value of 100.

Although Botswana experienced increasing competitiveness from 1984 to 1988, possibly benefiting from relatively low inflation, this has been reversed since 1989 as South Africa has succeeded in containing and reducing its inflation rate. The pula/US$ BRER has shown greater variability, and in particular underwent substantial depreciation in 1984 and 1985 when the nominal value of the rand fell sharply against the dollar as South Africa's political and economic crisis intensified. This was followed by appreciation of the BRER over the next two years, as increasing inflation in South Africa, and subsequently in Botswana, counteracted the benefits of nominal depreciation; by the end of 1987 the pula/US$ BRER had returned to its 1984 level. In recent years the large inflation differential between Botswana and the US has not been fully compensated by nominal depreciation, and as a result the BRER has appreciated (competitiveness has declined) since the mid 1980s. This illustrates the difficulties Botswana's non-traditional exporters would have faced in becoming established in markets outside the SACU area.

The pula/Zim$ BRER was relatively stable between 1978 and 1989, but has since appreciated substantially, falling by 50% between 1989 and 1991. This has caused major problems for Botswana exporters who had earlier succeeded in penetrating the Zimbabwe market.

One thing that should be pointed out is the dilemma that Botswana faces in its exchange rate policy in an environment where the currencies of its trading partners move against each other. For example, when the rand depreciates against the U.S. dollar, Botswana becomes more compettitve against the rest of the world, and there is a windfall gain on exports and foreign exchange reserves and Botswana does not have to initiate a policy response. If the rand appreciates against the U.S. dollar, the opposite will result. However, a policy response of depreciating the pula against the U.S. dollar in order to maintain competitiveness would cause higher inflation via imports from South Africa. Similarly, when the Zimbabwe dollar collapsed in the early 1990s, there was little that Botswana could do to maintain the competitive position of Botswana exporters to Zimbabwe. The two small depreciations of the pula that took place were inadequate to restore the competitive position of Botswana exporters to Zimbabwe, while at the same time fueling inflation because of more expensive imports from South Africa.

Inflation

Botswana's inflation rate has shown substantial variation over the past 20 years but has never reached the excessively high levels seen in some other developing countries. Given the openness of the economy, it has been subject to a great deal of external influence, particularly from South Africa, but between 1982 and 1992 Botswana's inflation remained consistently below that of South Africa, due, it is widely believed, to the appreciation of the pula against the rand. Between 1983 and 1987 Botswana's inflation averaged 9%, compared with 15% in South Africa. Since that time, however, Botswana's inflation has been rising steadily, from 8.1% in 1987 to a peak of 16.5% in 1992, the highest annual rate since 1973. Also in 1992, Botswana's inflation surpassed that of South Africa, a situation believed to have been caused to a large extent by the two devaluations of the pula in 1990 and 1991, as well as increasing domestic inflationary pressures.

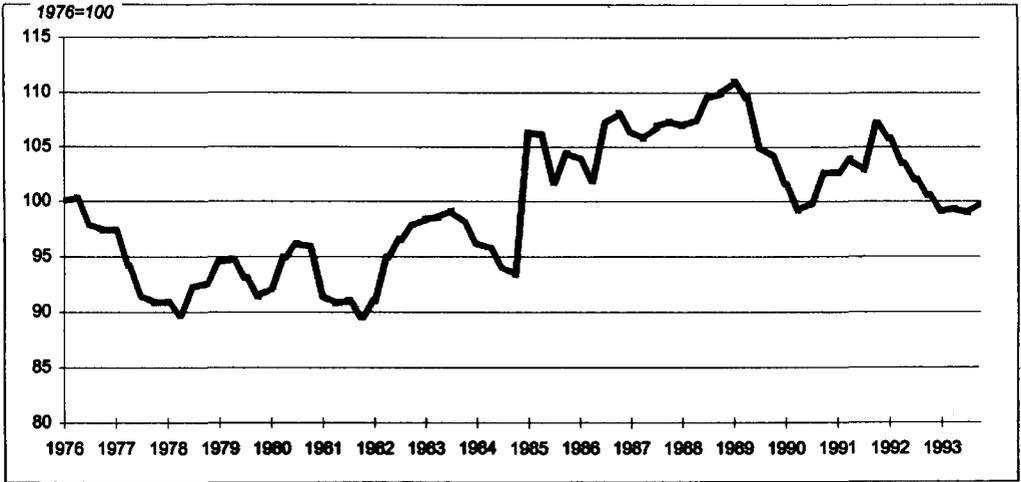**Figure 2: Multilateral Real Exchange Rate**

1976=100

Figure 3: Bilateral real exchange rates of the pula
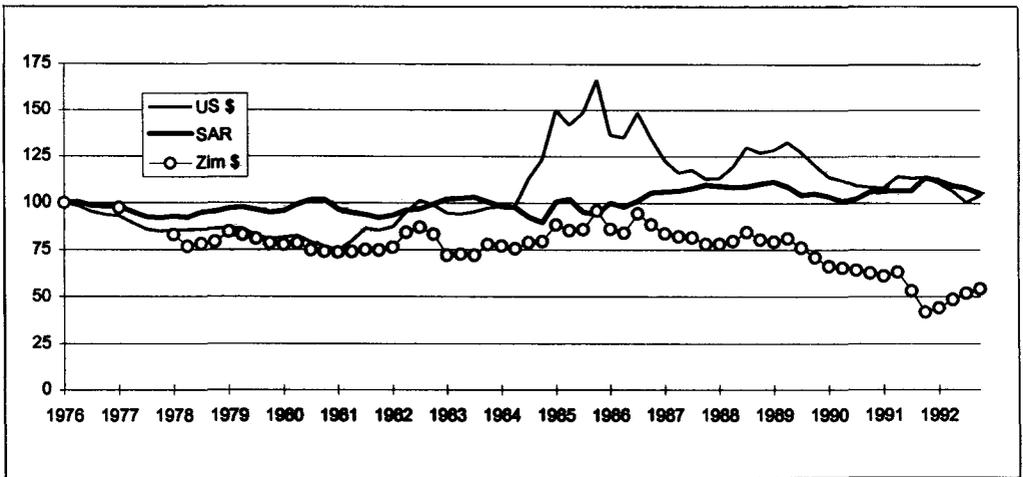
Although not all inflation is imported, in practice domestic prices tend to move fairly closely in line with import prices. Over the five years to December 1992, the imported tradeables component of the CPI rose at an average annual rate of 13.1%, while the domestic (tradeables and non-tradeables) component increased by 12.6 %.

Monetary policy

As Table 1 demonstrates, the composition of money supply in Botswana is unusual by developing country standards, reflecting the accumulation of mineral revenues as government savings and foreign reserves. Rapid economic growth, combined with relatively tight exchange controls on capital movements, created excess liquidity in the financial system. Although the thrust of monetary policy has changed over time the interest rate has been used as monetary policy instrument most of the time. For much of the 1980s, for example, the emphasis was on keeping interest rates low in order to reduce excess liquidity by stimulating the demand for loanable funds. In this respect the policy was only partially successful, but also had the adverse result of negative real interest rates and the accompanying incentive distortions for both savers and borrowers.

Table 1:   Composition of money supply

Domestic credit to government (Dcg)	-5629
Domestic credit to the private sector (Dcp)	1563
Foreign assets (R)	10526
Other items (net)	-3920
Broad money (M + QM)	2540

Source: Bank of Botswana, 1993 Annual Report.

Under a pegged exchange rate regime, the exchange rate is exogenous and used as a policy target. With international capital mobility (i.e., in the absence of capital controls) the money supply becomes endogenous; any change in the money supply causing money market disequilibrium will be offset by international capital flows in response to differentials between domestic and foreign interest rates. With capital controls, however, these differentials can persist and adjustment to money market disequilibrium is via the effect of lower domestic interest rates on savings and investment, the current account and the reserves, and hence on the money supply.[7]

In Botswana interest rate arbitrage is prevented by capital controls. This allows interest rates to be controlled by the BOB (although the mechanism has now changed from direct controls to open market operations). Control exercised in the past prevented domestic interest rates from falling to reflect the full impact of excess money supply growth (via reserves inflows); in a sense, the BOB was supplementing private money demand by acting as a deposit taker of last resort to the commercial banking sector. Although there is insufficient private money demand to restore equilibrium in the money market, the BOB effectively creates demand through its sterilization function.

Figure 4: Pula/rand exchange rate and Botswana/South Africa Inflation Differential
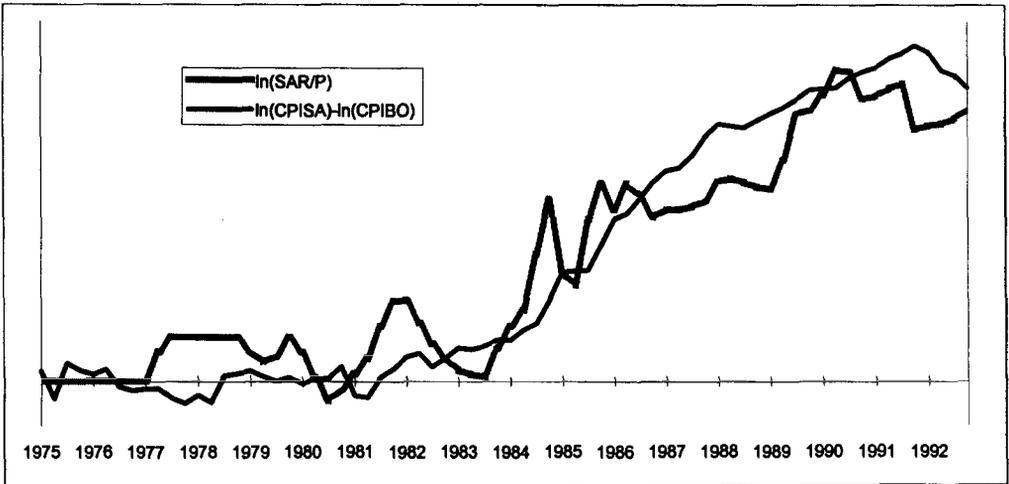
Figure 5: Nominal and Real Exchange Rates
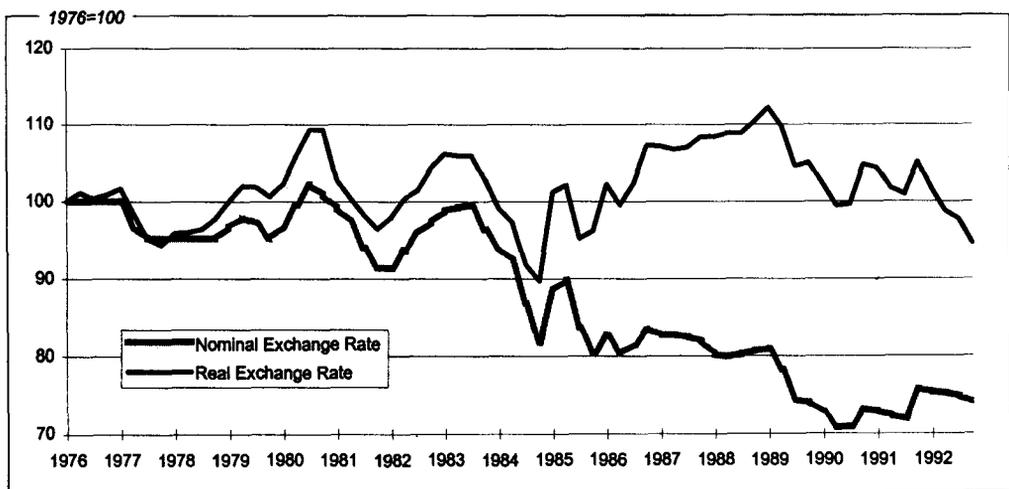
While capital controls exist, Botswana has some scope for independent monetary policy and the money supply is at least partially exogenous. This position is reinforced by other mechanisms, including government's control over its own spending (which makes up a major proportion of aggregate demand) and the fact that the exchange rate is not permanently fixed but in fact operates as a managed float, giving some of the benefits of a flexible exchange rate.

Preliminary assessment of nominal exchange rate pass-through in Botswana

The absolute PPP relationship (Equation 1) would denote 100% pass-through of the nominal exchange rate (and foreign prices) to domestic prices. A logarithmic transformation of this relationship yields:

$$p = e + p^f \; or \; e = p - p^f, \tag{17}$$

where lower case letters represent logs.

A preliminary examination of the extent of pass-through can be obtained by plotting Equation 17. If absolute PPP holds, we would expect the two series (p and e + pf) to track each other closely (although the closeness would be reduced by any lag in the adjustment process). As Figure 4 shows, there does appear to be a close relationship.

Another way of examining this relationship in a descriptive manner is to consider the relationship between the nominal and real exchange rates over time. If there is complete pass through, then any changes in the nominal exchange rate will not be reflected in the real exchange rate, and nominal exchange rate changes will be wholly offset by price changes. Figure 5 compares the nominal and real bilateral exchange rates between the pula and the SA rand, and indicates that although the BRER moves closely with the nominal exchange rate (NER) in the short term, over the longer term the NER has displayed a downward trend (appreciation of the pula) while the BRER has not, providing support for the hypothesis that in the long term the pass-through is very high, suggesting that prices do respond to exchange rate changes, but that the process is slow.

IV. Hypotheses and model specification

Hypotheses of the study

Consistent with the study objectives, three hypotheses were formulated:

1. In the long run, there is a 100% pass-through of nominal exchange rate and foreign price changes to domestic price.
2. In the short run, there is less than 100% pass-through of nominal exchange rate and foreign price changes to domestic price.
3. In the short run, domestic influences play a role in determining changes in the domestic price.

Specification of the model

The real exchange rate

We demonstrated earlier that the real exchange rate equation is basically definitional. It is important, for the purpose of further discussion, that this identity be reformulated to reflect Botswana's trading patterns:

$$RER_i = (P^f_i E_i/P) \qquad (18)$$

where RER_i is the real exchange rate of the pula with respect to the currency of the ith trading partner of Botswana; E_i is the nominal exchange rate, defined as Botswana pula per unit of the currency of the ith trading partner of Botswana; P is the domestic price; $P^f i$ is the foreign price, i.e., the price prevailing in the ith trading partner of Botswana (i = South Africa, Zimbabwe and rest of the world, proxied by USA).

As may be recalled, this equation measures the degree of competitiveness of local producers of exportables or importables. It can be inferred from the equation that the real exchange rate (or degree of competitiveness) increases with a rise in foreign price (P^f) and an increase in the nominal exchange rate (E) – i.e., with devaluation of the pula – and decreases whenever domestic price (P) rises, and vice versa.

The pass-through model

When the nominal exchange rate (E) is a policy variable and the foreign price (P^f) is exogenous, then the growth path of domestic price (P) becomes an important determinant of the growth path of the real exchange rate. The determination of the domestic price becomes crucial to the analysis of the effects of nominal exchange rate changes on the real exchange rate.

Central to the relationship between changes in the nominal exchange rate and domestic prices is the extent, duration and timing of the pass-through to domestic prices. As discussed earlier, in its simplest form the pass-through model is based on the law of one price, which states that "under condition of perfect competition in domestic and international goods markets the exchange rate equates the domestic currency price of similar trade goods produced at home and abroad" (Mann, 1986: 367). The law can be expressed as follows:

$$P^m = P^f.E \tag{19}$$

where P^m is the domestic currency price of imports.

P^m changes proportionately with E, if P^f is constant. However, the foreign price (P^f) may be assumed as equal to the cost of producing the commodity in the foreign country (C^f) plus a markup or profit margin (M^f), which enables us to reformulate the model as:

$$P^m = (C^f + M^f).E \tag{20}$$

Assuming that the foreign cost of production (C^f) does not change, then variation in profit margin would lead to less than 100% pass-through of changes in nominal exchange rate to domestic prices.

If the assumption of perfect competition is relaxed, and firms therefore earn more than normal profit, then it is possible to explain short-run changes in the pass-through relationship in terms of short-run changes in profit margins. Hence, recognition of variation in profit margins of producers or suppliers introduces flexibility in the relationship between nominal exchange rate and the domestic price. The pass-through model therefore need not be an identity, and consequently the extent of the pass-through becomes an empirical issue.

The micro foundation of the results may be provided by reference to the approach used by Krugman (1986) in explaining why prices of imports into the United States might not have fallen to the full extent of the appreciation of the U.S. dollar. Although this "pricing to market" behaviour of exporting firms may be used to explain the reason for incomplete pass-through of nominal exchange rate changes to domestic prices, the model used by Krugman (1986) cannot be used in its entirety to explain pricing to the Botswana market by firms in South Africa, since South African firms do not adopt discriminating pricing policies in the Botswana market vis-a-vis the South Africa market.

The theoretical basis of our analysis therefore rests not on the monopolistic behaviour of South African firms that export to the Botswana market, but instead with the monopolistic behaviour of distributing firms in Botswana.

We begin the exposition of the micro foundation with the assumption that the Botswana firm that sells a commodity imported from South Africa faces the following demand curve:

$$P^m = \varnothing(Q) \tag{21}$$

where P^m and Q are, respectively, the price and quantity of the imported commodity sold in the Botswana market. For a unit of the commodity sold, the firm incurs three types of costs: unit rand price (P^f) at which the commodity is purchased; freight and insurance cost in rand per unit of the commodity (F); and distribution cost and a markup in local currency. Consistent with the exposition of Krugman (1986), this last item may be interpreted as adjustment costs, which are a function of the rate of growth of the quantity of the commodity sold in the Botswana market, i.e., $h(\dot{Q})$.

The firm's instantaneous profit may therefore be represented by

$$\Pi = P^m Q - P^f Q.E - EQ.E + h(\dot{Q}) \tag{22}$$

It is conventional to assume that a firm faced with such a profit function will maximize the present value of the stream of profit. Assuming therefore that the unit price and cost variables grow at constant rate of α, and E is constant, the firm's optimization behaviour becomes that of maximizing a stream of net earnings or profits over an infinite time horizon, represented by the following function:

$$V = \int_0^\infty e^{-(r-\alpha)t}[P^m Q - P^f Q.E - FQ.E + e^{-\alpha t}h(\dot{Q})]dt \tag{23}$$

This equation may be represented in a general form as

$$g(Q,t) = f(Q,\dot{Q},t)dt \tag{24}$$

in which case the necessary condition for solution is given by the following "Eulers equation" (Sargent, 1979; 75; Intrilligator, 1971: 310):

$$\frac{df}{dQ} - d\left[\frac{df/\dot{dQ}}{dt}\right] = 0 \tag{25}$$

Hence, the necessary condition for maximization of Equation (23) is

$$e^{-(r-\alpha)t}[P^m - P^f.E - F.E + e^{-\alpha t}r.h'(\dot{Q})] = 0 \tag{26}$$

Rearranging, this necessary condition becomes:

$$^m = P^f.E + F.E - e^{-\alpha t}r.h'(\dot{Q}) \tag{27}$$

The results indicate that for profit to be maximized, the pricing policy of the monopolist must be such that the price at which the imported commodity is sold in Botswana covers the purchase price and unit freight and insurance cost (both converted into domestic currency by the nominal exchange rate) and a change in markup or adjustment cost.

The results also indicate that P^m can deviate from $P^f E$, as a result of a change in insurance and freight (i.e., $F.E$) or more importantly for our analysis, as a result of firms in Botswana adjusting their markup. If h' is positive, then the law of one price breaks down and hence a change in the nominal exchange rate will not be fully reflected in domestic prices. Consequently, the degree to which nominal exchange rate changes passes through to domestic prices of imports in Botswana will depend on the pricing behaviour of domestic distributors. It is hypothesized that since most of the distributors in Botswana are monopolists, or oligopolists with a high degree of collusion, there is the possibility that at least in the short run, the pass-through of nominal exchange rate variations to the domestic prices of imports will not be complete.

The full model

Our model extends the pass-through models outlined above by including additional variables as regressors. It postulates an autoregressive distributed lag model, within the framework of the general to specific approach to econometric modeling (Hendry, 1986; Banerjee et al., 1993). It also borrows from the work by Chhibber (1992) that was reviewed earlier.

Following Chhibber (1992), the domestic price level in Botswana is assumed to be a weighted average of the price level of tradeables (P^m) and non-tradeables (P^n).

$$P = \beta P^m + (1-\beta)P^n, \tag{28}$$

where $0 < \beta < 1$.

However, Chhibber (1992: 131) postulates that "for traded goods, the domestic inflation is equal to the change in the foreign price plus the change in the nominal exchange rate". Our discussion of nominal exchange rate and foreign price pass-through have demonstrated that proportionality between P^m and $E.P^f$ in the short run is an empirical issue and will depend on movements in the markup imposed by importers. This can be modeled as a function of excess demand in the same way that Chhibber models non-tradeable prices. For the prices of both tradeables and non-tradeables, we use a modified

version of Chhibber's markup model:

$$P^m = \mu(P^f.E,y,M,R) \tag{29}$$

and

$$P^n = \lambda(P^f.E,y,M,R), \tag{30}$$

where, y is real output, M is money supply and R is the nominal rate of interest.

Assuming that the composition of tradeables and non-tradeables in the basket used to compute the domestic price index (P^m) remains constant, equations (29) and (30) can be combined to obtain the following equation for the domestic price level:

$$P = f(P^f,E,M,R,y). \tag{31}$$

We expect all the coefficients on the variables in the model to have a positive sign, except for real income.

It will be noted that unit labour costs and price control variables, which are important in Chhibber's specification, are absent from our specification. There are reasons for this omission. Wages in Botswana, for most of the years in the period of study, were indexed to the rate of inflation, and as such cannot be assumed to be exogenous;[8] furthermore, data on wages are incomplete. Given these two considerations we excluded unit labour costs from our specification. Unlike most of the countries in sub-Saharan Africa that constitute the sample for the study by Chhibber (1992), price controls are insignificant in the Botswana economy, and therefore little will be lost by excluding this variable from our specification.

Empirical correlates for variables in the price equation

Three exchange rate measures are of interest: the exchange rate between the Botswana pula and the South African rand; the exchange rate between the Botswana pula and Zimbabwe dollar, and the exchange rate between the Botswana pula and the U.S. dollar. The selection of pula/rand exchange rate is motivated by the fact that most non-traditional exports of Botswana are directed to South Africa, while most of Botswana's imports originate from South Africa. Zimbabwe is Botswana's second largest customer for its non-traditional exports, and a substantial proportion of Botswana's imports also originate from Zimbabwe. Therefore, the movement of the pula/Zimbabwe dollar real exchange rate is important to the country. The pula/U.S. dollar real exchange rate is used as a proxy to measure the competitiveness of Botswana in foreign markets other than South Africa and Zimbabwe.

Each real exchange rate is measured with data on nominal exchange rate and corresponding foreign price. Consequently, P^f and E in Equation 31 should each be interpreted as a vector of three elements: P^f = [CPISA, CPIZM, CPIUS], E = [NERSA,

NERZM, NERUS]. Prices in Botswana (CPIBO), South Africa (CPISA), Zimbabwe (CPIZM), and the United States (CPIUS) are proxied by the consumer price indexes in the respective countries. The nominal exchange rates are redefined as foreign currency per pula. Hence, NERSA is rand per pula, NERZM is Z$ per pula, and NERUS is US$ per pula. Money (M) is proxied by the narrow definition of money (M1), which we designate as MON1, while the savings deposit rate is used as a proxy for R, i.e., the opportunity cost for holding M1. Lastly, non-mining gross domestic product (YNM) is used as a proxy for y.

Monthly data were collected on the CPIBO, CPISA, CPIZM, CPIUS, NERSA, NERZM, NERUS, MON1 and R. Non-mining GDP was interpolated using the technique developed by Diz (1970) and used by Ndele (1990).

V. Presentation and analysis of results

The ADL model

In a general form, the pass-through model is represented by the following autoregressive distributed lag (ADL) model:

$$A(L)CPIBO_t = B(L)CPISA_t + C(L)CPIZM_t + D(L)CPIUS_t + F(L)NERSA_t +$$
$$G(L)NERZM_t + H(L)NERUS_t + I(L)MON1_t + J(L)R_t + K(L)YNM_t + U_t \quad (32)$$

where L is a lag operator, A, B, C, D, F, G, H, I, J and K are vectors of coefficients to be estimated, and U is an error term.

For easy reference, the variables appearing in the ADL model and their units of measurement are summarized in Table 2. The redefinition of nominal exchange rates as units of foreign currency per one unit of pula should particularly be noted. In this case, the price of a tradeable in pula is also redefined as the foreign price divided by the nominal exchange rate. As will be seen later, these variables were generated to be used in the stationarity and cointegration tests.

Table 2: Variables appearing in the model

Original data variables

NERSA	Rand-pula exchange rate (nominal) - SA rand per putt
NERUS	US dollar - Pula exchange rate (nominal) - dollars per pula
NERZM	Zimbabwe dollar - pula exchange rate (nominal) - Zim$ per pula
CPIBO	Botswana consumer price index (1985=100)
CPISA	South Africa consumer price index (1985=100)
CPIUS	U.S. consumer price index (1985=100)
CPIZM	Zimbabwe consumer price index (1985=100)
MON1	Narrow definition of money stock in Botswana - currency outside the banidng system + demand deposits (millions of current pula)
R	Nominal rate of interest proxied by savings deposits rate
YNM	Non-mining GDP at 1985 constant prices (millions of pula)

Generated variables

CPNSA	CPISA4VERSA
CPNUS	CPIUSAVERUS
CPNZM	CPIZMIVERZM

Source of data: IFS (all variables except for YNM, obtained from the Botswana Central Statistics Office)

Time series characteristics of the data in the price equations

The first characteristic we tried to establish about the data on the variables that enter into the price equation is the order of integration (or stationarity) of each of the series. For this purpose three additional variables (CPNSA, CPNUS and CPNZM) were generated.[9] We used PC Give (Hendry, 1989) to test for the stationarity of each of the variables, and for cointegration of the dependent variable (CPIBO) with each of the independent variables. The tests used are Sargan-Bhargava Durbin-Watson (SBDW) and Augmented Dickey-Fuller (ADF) unit root tests (see Banerjee et al., 1993).

Testing for stationarity of the series

Unit root tests are used to determine the order of integration of each series considered. Such tests were conducted on the data using the following data generating process (DGP):- $yt = \alpha + \rho y_{t-1} + u_t$. The results of the tests are given in Table 3, with lower case used to represent the natural log of a variable. The unit root test statistics in this table may be compared with their corresponding critical values in Table 4. For the ADF test, a test statistic that is less (more negative) than the critical value confirms that the first difference is stationary and the series is I(1). For the SBDW test, a value that is less than the critical value indicates a rejection of the hypothesis that the series (first difference in this instance) is stationary. It is clear from these comparisons that although both SBDW and ADF tests reject stationarity of each of the variables at 5% significance level, both tests indicate that each of the variables is I(1), i.e., integrated of order one, except for non-mineral GDP, which is I(2). The order of integration results for exchange rates, and prices support the expectation that exchange rates and prices are random walks. The results suggest furthermore that money, interest rates and real income growth also follow a random walk. This implies that "any dynamic specification of the model in the levels of the series . . . . is likely to be inappropriate, and may be plagued by problems of spurious regression" (Adam, 1992: 25). The possibility exists that the foreign prices or monetary variables could be cointegrated with domestic prices, in which case, "we might be guided towards an error-correction form" (Adam, 1992: 25.), by virtue of Granger-Engle Representation Theorem (Engle and Granger, 1987).[10]

Testing for cointegration

Much of the exchange rate literature (efficient markets hypothesis), concludes that exchange rates appear to follow a random walk. This leads us to expect that the bilateral exchange rate series will be I(1). If this is so, then for absolute PPP to hold, a long-run (linear) relationship will have to exist between the exchange rate and relative prices. A long-run relationship will hold only if relative prices are also I(1) and the residuals of the

OLS regression between prices and the exchange rate are I(0). In other words, the price and exchange rate series must be cointegrated.

Table 3: Test statistics for unit root tests on variables (in logs)

Sample size	Variable	SBDW	ADF	Longest lag	Order of integration
204	cpibo	1.80	-12.0	11	1
204	cpisa	1.79	-12.8	5	1
204	nersa	2.16	-15.5	10	1
204	cpnsa	1.89	-14.9	8	1
204	nerus	1.83	-12.8	9	1
204	cpius	0.63	-14.0	7	1
204	cpnus	1.80	-12.9	8	1
184	cpizm	1.94	-3.7	6	1
184	nerzm	1.92	-6.77	5	1
184	cpnzm	1.50	- 4.0	5	1
204	r	2.01	-14.3	11	1
102	monl	2.77	-14.3	4	1
201	ynm	2.92	-13.2	11	2

Source: Authors' calculations.

Table 4: Critical values for unit root tests

Test	Statistic type	Sample size	C- value 5%
Unit root ADF	t	100	-2.89
		200	-2.86
Sarghan Barghava	DW	100	0.39
		200	0.20

Source: Adam (1992), Tables 2(a) and 2(b) - taken from Banerjee et al., (1993).

Cointegration testing is used here to establish whether the correlation observed between selected pairs of economic variables in this study is attributable to a spurious or coincidental relationship—or whether a linear long-term economic relationship between the variables can in fact be inferred. So by establishing that cointegration exists, we validate the linear regression; we confirm the likelihood of a long-term structural relationship by proving the absence of spurious correlation. Cointegration further allows us to specify a process of dynamic adjustment between the cointegrated variables. An

error correction specification is used. The error correction specification has proved to be one of the most efficient dynamic representations in that it encompasses all other dynamic specifications (see Engel and Granger, 1987).

The SBDW and ADF tests were performed on the residuals of each regression shown in Table 5. There is cointegration if the residuals are stationary. We use the same criteria as before (under stationarity testing) to compare the test statistics with the cointegration critical values given in Table 6.

Table 5: Test statistics for cointegration tests

Sample size	Regression	Long-run Coefficient	R^2	SBDW	Residual ADF
204(1976-94)	cpibo on cpnsa	0.92 (4.16)	0.99	0.22	-3.5
121 (1976-86)	cpibo on cpnsa	0.95 (1.05)	0.99	0.38	-4.4
97 (1986-94)	cpibo on cpnsa	1.02 (1.27)	0.99	0.18	-3.4
204	cpibo on cpisa	0.78 (4.83)	0.99	0.02	-1.0
204	cpibo on cpnus	0.79 (12.3)	0.95	0.05	-1.7
198	cpibo on cpnzm	1.19 (18.6)	0.86	0.07	-1.5
204	cpibo on monl	0.52 (26.3)	0.77	0.21	2.4
204	cpibo on r	0.74 (48.3)	0.14	0.03	-2.8
204	cpibo on ynm	1.19 (15.0)	0.91	0.01	-1.8

Note: All variables are expressed as logs. Standard errors (expressed as percentages) are in parentheses.

Table 6: Critical values for cointegration tests

Test	Statistic type	Sample size	Number of variables	Critical value 5%
Cointegration	ADF	100	2	-3.17
		200	2	-3.25
Sarghan Barghava	DW	100	2	0.38
		200	2	0.20

Source: Banerjee et al. (1993), Table 7.1.

It is clear from the results that only South African prices denominated in pula (CPNSA) appear to be cointegrated with Botswana prices. This confirms the presence of a stable long-run relationship between Botswana prices and the ratio of South African prices and the rand-pula exchange rate, validating purchasing power parity between the two countries. Evidence of cointegration is strongest over the period 1976 to 1986, though this evidence remains in a slightly weaker form when the series is extended to 1994. For the latter period, 1986–1994, evidence of cointegration is marginal, with some conflict seen between the two stationarity tests on the residuals. None of the other variables show cointegration with Botswana prices under either the SBDW test or the ADF test, whereas cointegration with the price of tradeables from South Africa, denominated in pula, is confirmed by both tests. The SBDW statistic exceeds the critical level of 0.2 for the periods 1976–1986 and 1976–1994, whereas the ADF statistic is less than the critical level of -3.25 for all three periods of 1976–1986, 1986–1994 and 1976–1994.

Concentrating on the cointegrating regression covering the full period 1976–1994, the high R^2 value for this regression suggests there is little evidence of bias, but as a second consistency check, we compared the values of the coefficients of the static regression with those of the long-run solution to the equivalent ADL model. The two equations are given in Table 7 (standard errors are given in parentheses, expressed as percentages since they are standard errors on log values). We see from these equations that the coefficients of the ADL and static cointegrating regression are not significantly different. This allows us to accept that the cointegrating regression is valid. It will further be noted that, as expected, the coefficient of CPNSA in this regression is close to unity.

Table 7: Consistency check for solution to cointegrating regression

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Cointegrating regression

cpibo =0.395 +0.92cpnsa
     (2.70)(0.48)

Long-run solution to ADL (8 lags)

cpibo =0.443 +0.92cpnsa
     (2.29)(0.40)

The evidence of cointegration found here is in contrast to the findings of Masale (1993) (using quarterly data), and is presumably due to the use of monthly data and hence a much larger sample size.

ADL and error correction model

Having confirmed that cointegration exists, the residuals from the cointegrating regression can now be used as the error correction term in a dynamic error correction model. The

ECM term is incorporated in a statistically consistent model that relates short-run changes in Botswana prices to short-run changes in other variables, including South African prices. By including the error correction term (which represents adjustment towards the equilibrium real exchange rate between Botswana and South Africa), the model links the short-run change in domestic prices to the long-run relationship that exists between these prices and South African prices. It uses the error correction term to measure the feedback mechanism. Both short-run and long-run information is provided in the same model.

An overparameterized ADL equation is constructed, with the (stationary) first difference of the Botswana price (CPIBO) as the dependent variable, and the (stationary) differences of all other variables (lagged) as explanatory variables. Price data used were already seasonally adjusted and exchange rates have no seasonality, so seasonal dummies are not included in the over-parameterized equation. To check this, seasonal dummies were initially included; since none were significant, they were replaced by additional lags.

Investigation of the lag structure in this model was problematic since the desired combination of 12 lags on monthly data, and a high number of explanatory variables, would have led to an ADL exceeding the 40- variable limit imposed by PC Give. This necessitated a variable-by-variable investigation of the lag structure, which then provided guidance on the appropriate selection of lags to be retained in the ADL model.

Once the best performing lags had been selected and entered in the ADL model, insignificant variables (at the 10% level) in this preliminary regression were deleted. The ADL model also includes a lagged error correction term ECM^{t-1}, a constant term and a trend term. *PC Give* output for the period July 1980 to October 1993 is shown in Table 8. For any variable x , x i represents the ith lag on that variable in the equation shown in the table.

By simplifying the over-parameterized ADL (using statistical measures and algebraic transformations) in a way that improves the goodness of fit of the model as variables are reduced, *model parsimony* is achieved. An information criterion (the Schwartz criterion), which shows progressive *model parsimony* (as it becomes more negative), is used.[11] The Appendix contains diagnostic tests for the parsimonious model.

Important features to note in the equation include the significant, negative error correction term ec 1. This term estimates the feedback in the current period from last month's disequilibrium from the long-run (South African) price level relationship. The results suggest 2% of that disequilibrium feeds back into the current price change.

The coefficients on the first difference terms, on the other hand, provide an indication of short-run inflationary influences. (that is, the domestic price response to short-run changes in foreign prices, exchange rate, real income, interest rates and money).

It should be noted that in contrast to the study by Masale (1993) noted above, which imposes a lag structure on the short-term model, our approach is more flexible and does not impose any *a priori* restrictions on the lag structure. Investigation of the appropriate lag structure in the present case is facilitated by the much larger sample size, and permits an investigation of the timing of the various inflationary influences. More generally, the larger sample size allows a more comprehensive testing of the final parsimonious model.

Table 8: Modeling dcplb by OLS

Variable	Coefficient	Std error	HCSE	T-value	Partial
dcpib 1	.0951263	.05509	.07140	1.72673	.0206
dcpisa36	.2691574	.04716	.04724	5.70751	.1866
dcpisal 1	.1368422	.06821	.06344	2.00626	.0276
dersa 5	-.0285407	.01630	.01551	-1.75127	.0211
dcpiz 1	.0669055	.01642	.01706	4.07424	.1047
dcpiz413	.0360364	.01231	.01020	2.92720	.0569
derziml 1	-.0272316	.00863	.00768	-3.15682	
derziml6	.0186667	.00857	.00883	2.17893	.0324
dcpius	.7271022	.12540	.14239	5.79813	.1914
derusl69	-.0247244	.00556	.00457	-4.44686	.1999
derus 4	.0358603	.00890	.01027	4.02753	.1025
dr9	.0109926	.00426	.00551	2.58259	.0449
ddynm456	-.2899672	.08235	.08143	-3.52100	.0803
ddynm 12	-.1361378	.05651	.04931	-2.40905	.0393
dmonl 012	.0162301	.00547	.00696	2.96767	.0584
ec 1	-.0206237	.00829	.00774	-2.4~	.0418
Constant	-.0006943	.00153	.00148	-.45420	.0015
Trend	.000009124	.000008056	.00001	1.13260	.0090

Sample: 1980(7) to 1993(1 0) less 0 Forecasts

R^2 = 0.6018680 S.E.=0.0041025 F(17,142)= 12.63[.00001 DW = 2.069 RSS = .0023899079, for 18 variables and 160 Observations information Criteria:SC=-10.540717; HQ=-10.746193; FPE=.OM19

VI. Conclusions and policy implications

Conclusions

The results show that there is indeed a very strong influence in the long run of South African prices and of the nominal rand/pula exchange rate on Botswana prices. Some 92% of Botswana prices are determined jointly by these two factors. However, it appears that there has been some change in this relationship over time. The relationship appears to have been stronger from the mid 1970s to the mid 1980s than since that time. This is not entirely surprising; the Botswana economy has expanded rapidly over the past 20 years and as it has done so has become more independent from South Africa. The falling proportion of imported tradeables in the CPI basket reflects this trend. Furthermore, in recent years the impact of domestic policies on prices has increased, which has weakened the link between domestic and imported inflation.

In the short run the dynamics in the parsimonious ADL model show that all of the variables in the theoretical model (Equation 31) have an influence on Botswana prices, with the net effect of all variables having the expected signs. The combined effect of the variables is to explain 60% of changes in Botswana prices.

South African prices feed through with particularly strong effects in the 3rd, 6th and 11th months, so that after one year 70% of changes in South African prices have fed through into changes in Botswana prices.[12] Changes in the exchange rate against the SA rand also have the expected impact, but with some delay, and the overall impact is relatively small compared with the impact of SA price changes. The error correction (ECM) term is also strongly significant, indicating that in addition Botswana prices are adjusting by some 2% each month towards the long-term equilibrium level, according to the PPP relationship.

Changes in Zimbabwean prices also feed through to Botswana prices, but the overall effect is rather small, with only 14% of Zimbabwean price changes feeding through to Botswana prices after 13 months. Changes in the exchange rate against the Zimbabwe dollar do not have a strong overall effect, however, with the impact in the 11th month, which is in the expected direction, being largely offset in the 16th month. The small impact of Zimbabwean prices and exchange rate changes may be due to Zimbabwean exporters in fact pricing their exports in international currencies, rather than in Zimbabwe dollars.

The impact of U.S. prices is very substantial, with 72% of U.S. price changes feeding through immediately. This is surprising and cannot be easily explained given the rather

indirect links between U.S. prices and the Botswana economy. These links are through the approximately 15%–20% of Botswana imports that are derived from "rest of the world" sources (i.e., other than South Africa and Zimbabwe), and through an (unknown) proportion of imports from South Africa that are likely to originate on world markets and simply be traded through South African agents. While the eventual impact of price changes in these items is potentially significant, it is the speed of the impact that is surprising, especially so given that it is much faster than the impact of South African prices, where trade links are much more direct. Changes in the exchange rate against the U.S. dollar are also important, although small, with the expected impact in the first, sixth and ninth months offset by a large positive effect in the fourth month. These results suggest that the dynamics of U.S. price and exchange rate changes on Botswana prices need further investigation.

One noticeable result of the impact of U.S. and South African prices and exchange rates is that the coefficients on foreign prices are much larger than the coefficients on exchange rates. The PPP model ($P^d=P^f/E$) suggests that the impact of both foreign price and exchange rate changes should be the same. Part of the explanation of the difference may be the different lag structures, but even after the lagged effects have worked themselves through to Botswana prices, major differences between price and exchange rate effects remain. This may be explained in terms of the differential response of Botswana importers to changes in the pula price of imports originating from the two different sources. This differential response results from the uncompetitive structure of the import trade.

Given relatively high levels of inflation in South Africa, and lower but still positive inflation in the U.S., it follows that foreign prices only move in one direction (i.e., upwards). Exchange rates, however, tend to fluctuate in both directions, particularly against the SA rand. Therefore the impact of exchange rate changes (according to PPP) may be to increase or reduce Botswana prices depending on the direction of the exchange rate change. However, we suggest that the lack of competition among importers results in an asymmetric response to exchange rate changes. It is possible that if the rand/pula rate depreciates, importers fairly quickly increase their Botswana prices accordingly, so as to maintain their profit margins, but in the case of an appreciation, rather than reducing Botswana prices, importers absorb the impact in increased margins, due to the lack of competition. Another explanation of the response to exchange rate appreciation might be that traders do not cut their prices but postpone price increases resulting from South African inflation. The overall effect of this asymmetrical response to exchange rate changes is, therefore, a small impact of exchange rate changes on Botswana prices relative to the impact of foreign price changes.

Changes in domestic economic variables (narrow money supply [M1], rate of interest [r] and the rate of growth of the non-mining economy [ynm]) all have the expected impact on Botswana price changes. Hence, inflation (domestic prices) in Botswana is partly a demand pull and is also negatively influenced by the supply of goods and services. With respect to the demand pull explanation of inflation, our model postulates that this channel is through the effect of excess demand (proxied by excess real money balances) on the mark-ups applied domestically to both tradeable and non-tradeable commodities,

while the supply side is reflected in the downward effect of non-mining output, proxied by non-mining gross domestic product.

Policy implications

This study provides policy makers with an estimate of the proportions of foreign price and exchange rate changes that pass through to Botswana prices, and the approximate timing of these influences. This information assists with determining the impact of devaluations–particularly the length of time for which real depreciation will be sustained following devaluation. The analysis confirms the existence of a trade-off between inflation and export competitiveness objectives in real exchange rate targeting. An important distinction exists, however, between long-run and short-run effects. In the long run South African prices and the rand/pula exchange rate dominate Botswana prices. Therefore nominal exchange rate and foreign price changes almost completely feed back to domestic prices; hence there is limited scope for using the nominal exchange rate to influence the real exchange rate and export competitiveness. Any initial gains in competitiveness are eventually offset by price changes.

However, the speed of adjustment in the short run towards long-run equilibrium allows for some flexibility in exchange rate policy. Hence, we come to a policy prescription that is often associated with the International Monetary Fund for developing countries, that devaluation could be used as a tool to enhance competitiveness, and domestic monetary measures could be used to contain the short-run inflationary pressures that would result. Because adjustment to exchange rate changes is relatively slow, it takes a long time for domestic price changes to negate the gains in competitiveness that would result from the devaluation. Although a devaluation policy would be at the expense of higher prices in the long run, the real question is whether domestic prices fully adjust to the increase in import prices or whether some real depreciation occurs.

Our results further suggest that when targeting a particular real exchange rate to influence export price competitiveness, policy makers must take into account the fact that both South African and U.S. inflation have a short-run inflationary impact in Botswana. Inflation in those countries must be factored into the calculation of the targeted real exchange rate. There is also a need to respond to foreign price influences with domestic monetary policy measures in the short run.

Notes

1.   Recent theoretical work uses a different definition of the RER, based on the relative prices of tradeable and non-tradeable commodities, which has the advantage of summarizing the incentives within an economy that guide production across the tradeable and non-tradeable sectors. It also indicates the international competitiveness of a country's tradeables sector. Although in theoretical terms these two measures of the RER are quite different, in practice the distinction tends to disappear, due to the difficulties encountered in measuring the relative price of tradeables to non-tradeables, especially given the data constraints in developing countries.

2.   This is a macroeconomic model of Botswana popularly known by its acronym MEMBOT used by the Ministry of Finance and Development Planning, The Republic of Botswana.

3.   A variable is said to be stationary if it is integrated of order zero. Regression analysis carried out on non-stationary series gives results that are spurious, unless there is a long-run relationship between the dependent variable and one or a set of independent variables, i.e., if there is a cointegration relationship between the dependent variable and one or a set of the independent variables, in which case an error correction model could be specified and estimated.

4.   A variable y is cointegrated with another variable x if the residuals from regressing y on x is stationary, i.e., integrated of order zero.

5.   This is a trade weighted average of bilateral real exchange rates against the South Africa rand, Zimbabwe dollar and U.S. dollar. Weights are derived from the shares of trade with South Africa, Zimbabwe and the rest of the world, respectively, where trade includes imports and non-traditional exports. Traditional exports are excluded because their prices are fixed in U.S. dollars and export earnings (in foreign currency terms) are largely inelastic with respect to the exchange rate. The weights, which are calculated from trade shares in the late 1980s, are as follows: South Africa, 77.1%; Zimbabwe, 9.0%; and rest of the world, 13.9%.

6.   The BRER is calculated according to the formula E.CPI*/CPIBO, where E is the nominal exchange rate (measured as pula per unit of foreign currency), CPI* is the foreign consumer price index and CPIBO is the Botswana consumer price index. CPIs are used rather than producer price indexes (PPIs) owing to data problems. We could not obtain PPI series for Zimbabwe, while the PPI series for Botswana were too short for our purpose. CPIs are, however, usually good proxies for PPIs. Edwards (1989), for example, observed that RERs calculated according to CPIs and PPIs do not follow noticeably different paths.

7. The discussion and conclusion in this paragraph assume that capital controls are effective. International evidence suggest that capital controls work only temporarily. In the case of Botswana, however, they appear to have worked better than elsewhere because deposits are dominated by Bebswana and a few other large depositors who obey the capital control law.

8. It will be noted, however, that the government has been prepared to break the link between wages and inflation. In 1982, for example, a wage freeze was imposed during the collapse of the international diamond market. In 1994 another wage freeze was instituted for macroeconomic reasons.

9. The variables were generated as follows: CPNSA=CPISA/NERSA, CPNUS=CPIUS/NERUS, and CPNZM=CPIZM/NERZM.

10. Domestic prices cointegrating with foreign prices or a monetary variable means the existence of a long-run relationship between domestic prices and the relevant variable. If this is the case, then although regression at levels will tend to produce spurious results, it is possible to construct an error correction model that is able to discriminate between the long-run and short-run relationships between domestic price and its determinants.

11. A parsimonious model is a model that contains few explanatory variables, but explains at least as much as an alternative model, which has one more explanatory variable, is able to explain.

12. It is possible that the pass-through of foreign prices in the 3rd, 6th and 11th months might be due to three-month credits. We cannot confirm that this is the case, however.

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Appendix: Diagnostic tests

Table A1: Residual correlation test (order 12) (calculates the combined signdicance of the error terms)

LAG	1	2	3	4	5	6
COEFF	-.0833	.0334	-.0188	.0658	-.0899	.0316
SE's	.0932	.0929	.0921	.0913	.0898	.0828
LAG	7	8	9	10	1.1	12
COEFF	.0119	-.0466	.1395	.1373	-.0015	-.0061
SE's	.0822	.0819	.0820	.0828	.0838	.0828

F(12,118) =.72 [.7262]

Note: The low F-statistic (less than the critical value of about 4) implies acceptance of the hypothesis that the data are acceptable since the error terms have no "memory".

Table A2: LM test for error autocorrelation (backup for the DW test, which is not a sufficient test for error autocorrelation)

F-Form(13,129)	1.10[.36421	F-Form(6,136)	0.69[.6578]
F-Form(12,130)	0.83[.6148]	F-Form(5,137)	0.77[.5762]
F-Form(11,131)	0.92[.5260]	F-Form(4,138)	0.50[.7347]
F-Form(10,132)	1.01[.4361)	F-Form(3,139)	0.64[.5887]
F-Form(9, 1 33)	0.87[.55091	F-Form(2,140)	0.46[.6313]
F-Form(8,134)	0.64[.74601	F-Form(1,141)	0.90[.3452]
F-Form(7,135)	0.61[.7470]		

Note: The low F-statistics (of less than the critical value of about 4) imply acceptance of the null hypothesis of zero autocorretation.

Table A3:   LM ARCH test (autocorrelation test on squares of residuals)

F(13,116)	0.68[.7830]	F(6,130)	0.39[.8835]
F(1 2,118)	0.73[.7219]	F(5,132)	0.45[.8140]
F(1 1, 1 20)	0.81[.6303]	F(4,134)	0.58[.6772]
F(1 0, 1 22)	0.80[.6264]	F(3,136)	0.71[.5493]
F(9, 1 24)	0.73[.6836]	F(2,138)	0.99[.3740]
F(8,126)	0.36[.9407]	F(1,140)	1.95[.1648]
F(7,128)	0.92[.4932]		

Note: The low F-statistics (less than the critical value of about 4) imply acceptance of the null hypothesis
of zero autoregressive conditional heteroscedasticity (ARCH).

Table A4: Heteroscedasticity (White) test

F(34, 107) = .80211.7658]

Note: The low F-statistic (less than the critical value of about 4) imply acceptance of the null hypothesis
of unconditional homoscedasticity.

Table A5: Reset test (this tests misspecification due to non-linear relationships in the model)

F(1, 141) =   3.715 [.0559]
F(2, 140) =   1.883 [.1560]

Note: The low F-statistics (of less than the critical value of about 4), imply acceptance of the null hypothesis
that no linear relationships exist in the model

Table A6:   Jarque-Bera normality test (test of distribution of error terms)

CHI-SQUARED (2) = 49

Note: Chi-square statistics (of less than the critical value of about 2) indicate acceptance of the null
hypothesis that the error terms are normally distributed.

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