Monetary Policy Experience in a Mineral Dependent Economy: The Case of Botswana

Ita Mannathoko*
African Economic Research Consortium Network Member, Economist and Consultant
Gaborone, Botswana

c/o 108 Prado Lane, Clarksburg MD 20871
moving to Washington DC, 20431 (from November 1, 2018)

* Corresponding author: Ita Mannathoko. E-mail: gwamem@gmail.com; mobile: +267 7488 6499
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Abstract

This paper uses the experience of Botswana, a largely successful mineral-dependent developing economy, to investigate a challenging episode when the monetary policy regime failed to contain inflation. Accounting equations are used to estimate the net cost and sustainability of sterilization interventions and to compile a “degree of monetary autonomy” (DOMA) index suited to the country’s excess liquidity context; while two-stage least squares regressions measure the extent of sterilization and of offsetting flows. The results explain sub-optimal monetary policy outcomes in the first decade of the 2000s, and the subsequent recovery after 2012, finding a sharp deterioration and subsequent recovery in the degree of monetary autonomy – which in turn can be traced to the presence or absence of policy inconsistencies in the wake of pension policy changes. The paper proposes a process to track policy consistency and preserve monetary policy autonomy, and offers remedial measures for recurring inconsistencies.

Keywords: Monetary policy, sterilization, excess liquidity, Botswana, capital flows, corporate deposits, pension policy, reserve management, monetary autonomy, inflation, real exchange rate
1. Introduction

Resource-rich mineral exporters face the challenge of managing large, lumpy monetary inflows through the current account. For many such exporters, these large inflows derive from a single sector. In such cases, the use of a managed exchange rate regime alongside sterilization interventions to avoid excessive inflation, excessive currency appreciation and loss of competitiveness is well established both in practice and in the Dutch Disease literature.\(^1\) By pegging or otherwise targeting the exchange rate through foreign exchange interventions, policy makers can help limit Dutch Disease tendencies and avoid placing upward (appreciation) pressure on the domestic currency, displacing domestic production with imports of tradable goods, and decreasing the competitiveness of domestic manufacturing (Corden and Neary, 1982; Corden, 1984; Wijnbergen, 1984b). At the same time, sterilization interventions\(^2\) limit the rapid monetary expansion that large foreign exchange inflows entering the banking system can cause.

This paper presents a particularly interesting story about the monetary policy experience of Botswana, a mineral exporting country that is widely cited as an African success story and model for prudent governance. Botswana’s stellar record, however, does not mean that the country has not had its fair share of policy challenges. While its monetary policy regime followed the above prescription, there was a decade in the 2000s when the policy failed to contain inflation. The paper seeks to determine why this happened by analyzing this period of adverse experience for monetary policy outcomes in the two-target two-instrument policy regime, providing useful lessons on the importance of well defined transmission mechanisms and careful structuring and coordination of macroeconomic policy decisions. It also illustrates the significant influence that foreign reserve and pension fund resources can have on monetary policy outcomes, showing how the treatment of these resources matters to monetary policy.

The approach taken is to examine the effectiveness and efficiency of monetary policy over a period including the 2000s decade of missed targets. This is done by (i) tracking the evolution of monetary policy autonomy (constructing an index) for the period 1991-2015; (ii) measuring and tracking the net fiscal cost of sterilization over time both prior to and after the great recession of 2008-09, and then determining when sterilization was sustainable and when it was not; and (iii) investigating the relationship between sterilization, new capital flows and monetary policy efficiency for the periods before and after the great recession (covering 2002 to 2015) by using

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\(^1\) The term "Dutch disease" originates from a crisis in the Netherlands in the 1960s that resulted from discoveries of vast natural gas deposits in the North Sea. The vast receipts from gas exports caused the Dutch guilder to appreciate significantly, making exports of all its non-gas products uncompetitive on the world market. Relatively recent research on resource rich economies (Aliyev R., 2012) confirms findings in the earlier literature, showing that an exchange rate peg softens the negative effects of Dutch Disease and stabilizes the economy.

\(^2\) Sterilization refers to monetary operations that reverse monetary increases in the economy. It can take various forms, such as raising reserve requirements, shifting government deposits from commercial banks to the central bank, central bank borrowing from commercial banks, or the sale of debt instruments in open market operations.
econometric estimation of the degree of sterilization (sterilization coefficient) and of offsetting financial flows (the offset coefficient).

The next section provides an overview of the pertinent literature, while Section 3 describes Botswana’s experience with sterilization. Section 4 presents net sterilization cost and sustainability calculations, and the approach used to compile the degree of monetary autonomy index, Section 5 describes the monetary reaction function and capital flow equations used in regressions to assess the efficiency of sterilization, Section 6 lays out the data, descriptive statistics and results from the analyses in Sections 4 and 5; and Sections 7 and 8 provide conclusions and policy recommendations from the study.

2. Overview of the literature

Sterilization is the most commonly used monetary policy process for managing large capital (or current) account inflows (Reinhart and Reinhart, 1998). Empirical studies of the efficacy of these interventions in developed countries suggest that they have often been successful, though the issue of whether or not sterilized intervention can serve as a fully independent policy tool continues to be debated. In developing countries, success has been mixed (Dominguez 2009). Nevertheless, some economies have been successful in the sustained and intense sterilization needed for sizeable foreign exchange reserve accumulation. Asian countries have had success over extended periods (Helmut Reisen, 1993). Various studies confirmed a rising accumulation of foreign reserves following the Asian crisis in the years prior to the global crisis and great recession of 2008-09, reflecting a greater intensity of sterilization by developing countries in Asia and Latin America (Aizenman and Glick, 2009). Magnus Saxegaard’s (2006) empirical work on African countries noted the importance of sterilization, finding that excess liquidity weakened the monetary policy transmission mechanism and thus the ability of monetary authorities to influence demand conditions in the economy.

Thus by pegging or otherwise targeting the exchange rate through foreign exchange interventions and sterilizing the resultant liquidity, mineral exporters can limit Dutch Disease tendencies as noted by Corden and Neary, 1982; Corden, 1984; Wijnbergen, 1984b. Without sterilization, large current account surpluses and capital inflows could generate enough excess liquidity in the banking system to accelerate the growth of credit, cause inflation and lead to loss of monetary control; or they could pressure the real exchange rate to appreciate, affecting macroeconomic variables in a way that hampers policy objectives such as price stability, exchange rate stability, and export promotion (Fernandez-Arias and Montiel, 1995).

Research on sterilization in Botswana

Though little if any published work has been done on sterilization policy in Botswana, there are a few papers alluding to the effectiveness of the Bank of Botswana Certificates (BoBCs) used for sterilization. While investigating the efficacy of auction systems used in the sale of BoBCs, Kone (1996) reviewed the performance of BoBCs in mopping up excess liquidity from 1991 to 1996,
given the objectives of attaining price stability and positive real interest rates comparable to those in world financial markets. He surmised that since their introduction in 1991, BoBCs had been effective in mopping up excess liquidity, re-establishing positive real interest rates and cutting down credit growth in Botswana. The desired outcome was to have real interest rates at an equilibrium level that would keep the economy at its production potential over time, such that real rates below this equilibrium could be deemed inflationary, while real rates above the equilibrium would be associated with stagnation and disinflation.

In 2001, Masalila and Phetwe also described how the volume of BoBCs auctioned by Bank of Botswana was based on an estimate of excess liquidity where the excess liquidity to be absorbed was “specified by the central bank relative to a given level of real interest rates”, with the focus on keeping real interest rates positive at levels comparable to those in major international financial markets. In more recent years, Bank of Botswana has indicated that its liquidity management is determined in the context of an inflation forecasting framework that estimates an output gap to represent aggregate demand pressures (Bank of Botswana, 2015a).

On the effectiveness of monetary policy, several monetary policy reaction function (MFR) studies have been conducted. Bleaney and Lisenda (2001) used an MFR for interest rates to study monetary policy in Botswana in the post liberalization era after 1990 and found a countercyclical response of the Bank of Botswana’s Bank Rate to both real private sector credit and inflation. Setlhare (2004) specified a modified version of the MFR in Setlhare (2002) and used OLS regressions to estimate the function for the Bank of Botswana over the period 1977-2000, finding that monetary authorities had been systematic in conducting policy and that inflation (directly and indirectly via the real exchange rate) was an important variable of policy interest. Setlhare (2013) investigated the monetary policy transmission mechanism in Botswana including over the period 2005-2011 when a crawling exchange rate peg regime was in place, employing a structural identification scheme to allow for simultaneous interaction between monetary policy and exchange rate variables. There was evidence of simultaneity between monetary policy and the real exchange rate. The results showed only weak transmission of monetary policy to inflation, through both interest rate and exchange rate variables.

**Sterilization cost and sustainability, and monetary policy autonomy**

The cost and efficacy of sterilization has been debated much both in the literature and by policy makers. Frenkel (2010) discusses the notion of the impossible “trilemma,” referring to the inability of monetary authorities to influence both the exchange rate and interest rate, given an open capital account. He shows that the traditional trilemma holds only if the exchange rate is over-valued. It does not hold in the short to medium term with an undervalued exchange rate as the country accumulates foreign exchange reserves (rather than drawing on them) in order to maintain the lower exchange rate level. In this case, the sustainability question does not concern the adequacy of foreign reserves, but rather is determined by how much domestic interest (paid on domestic liabilities) can exceed foreign interest (earned on foreign assets) adjusted for the
exchange rate, and still be maintainable. This is the measure used by this paper and described in Section 4, to determine the sustainability of sterilization interventions.

Given this definition of sustainability, intensifying sterilization can thus generate hurdles in the guise of rising fiscal costs and concerns regarding the ability to continue with this policy. In an unsustainable scenario, the interest cost paid by policy makers on the domestic liabilities used to sterilize exceeds interest earned on foreign assets made available to support monetary policy. The net cost of sterilization arises from this difference between high-yielding domestic debt and low-yielding foreign assets (e.g. Calvo, 1991).

It can also happen that new speculative capital inflows occur in response to the interest rate differential as the domestic rate rises further above foreign rates, and this in turn necessitates more sterilization and exacerbates the sterilization cost problem. Reinhart and Reinhart (1998) documented sterilization experiences through open market operations that showed that domestic interest rates rose when sterilization began, and that short-term flows as a share of total capital flows also rose as a result of an increase in the short-term interest rate. Ishii et al.’s (2006) work on sterilizing countries confirmed that sterilization was more effective when domestic debt issued and corresponding foreign assets were imperfect substitutes. Kawai and Takagi (2008) confirmed that the interest rate differential (and sterilization cost) rises as substitutability declines, and vice-versa, so greater effectiveness from low substitution can also mean more limited sustainability as cost rises. Masson (1995) describes the United Kingdom case in 1992, where policy makers had over time allowed the level of domestic interest rates to so far exceed target rates (close to international rates), that eventually the extent of output contraction forced the government to abandon its exchange rate target. Some countries are able to contain the interest rate differential between domestic debt and foreign assets, and limit the volume of debt instruments issued in order to sterilize. This then helps to contain the cost and enables the sustainability of monetary operations.

This difference between domestic and foreign (adjusted) interest rates (interest cost and interest earnings, respectively) helps to define how much monetary policy autonomy the central bank has. Frenkel’s 2010 analysis suggests that the closer the currency is to overvaluation, the less monetary autonomy and efficiency the authorities’ sterilization policies will achieve. He shows that the degree of monetary autonomy is higher the lower the ratio of the stock of the central bank’s remunerated liabilities (in this case, BoBCs and reverse repurchase agreements – or “reverse repos” for short) to the stock of international reserves (valued in domestic currency). This reasoning allows the construction of a “degree of monetary autonomy index” DOMA, in Section 4.

**Efficiency of sterilization**

If inflation is not contained when sterilization is used to limit excess liquidity in the banking system, this calls the efficiency of monetary policy into question. Theory on the efficiency of
sterilization under an open capital account considers two channels. Under the theory of interest rate parity, capital inflows respond to and negate interest rate differentials caused by higher domestic interest rates in the wake of sterilization interventions. Alternatively, a trade-off may emerge between monetary policy autonomy (control of bank reserves) and control of foreign exchange reserves (e.g. Herring and Marston, 1977). The empirical literature on sterilization policy highlights these considerations. If sterilization raises the level of interest rates to the extent of encouraging further capital inflows under an open capital account, as observed in several emerging market economies such as Indonesia and Malaysia in the 1990s (Reinhart and Reinhart, 1998), then the policy can become ineffectual. If sterilization tightens monetary conditions despite a genuine demand for credit, apart from raising fiscal costs (via excessive bond or certificate issuance), it can suppress private sector growth as seen in the United Kingdom case (Masson, 1995) or else create further incentive for locals to borrow from abroad, adding unintended exchange rate risk to the domestic loan portfolio. Reinhart and Reinhart (1998) found in some cases that interest rates increased if the demand for money rose and deduced that by sterilizing, the monetary authorities were not accommodating the increased demand for money, and were forcing the money market to clear at a higher interest rate. There are also country examples where sterilization was constrained in preventing real currency appreciation over the medium term, because monetary policy autonomy was short-lived (as domestic and foreign interest rates moved towards parity with capital inflows), or because inflation rose over time (IMF, 2007; Schadler, 2008).

A final ancillary effect of sustained, sizeable sterilization interventions can occur through commercial bank balance sheets, distorting banks’ incentive to lend. Empirical studies examining the role of bank net worth in loan supply using aggregate data show that bank liquidity or capital can have a significant effect on lending, and that these effects are stronger when monetary policy is tight (Romer and Romer, 1990; Bernanke and Blinder, 1992; Kashyap et al., 1993; Hoshi et al., 1993; Ueda, 1993; and Ramey, 1993). In some cases, when banks are left with little liquidity, they may tend initially to decrease loans (Kaoru Hosono and Daisuke Miyakawa, 2014; Stein 1998). Jayaratne and Morgan (2000) used bank-level data to study the relationship between bank liquidity and loans, while Bernanke and Lown (1991), Peek and Rosengren (1997), Woo (1999), and Ito and Sasaki (2002) used bank-level data to examine the relationship between bank capital and loans. Kashyap and Stein (2000), Favero et al. (1999), and Hosono (2006) also used bank-level data to investigate the bank lending channel of monetary policy.

3. Policy context and sterilization experience in Botswana

Botswana has both an active exchange rate policy and an active monetary policy (liquidity management and sterilization). Bank of Botswana states that the managed exchange rate regime targets a stable real effective exchange rate that would ensure that domestic producers of tradeable goods and services are competitive (Bank of Botswana, 2015c p.119 paragraph 5.8).
At the same time, the principal objective of monetary policy is articulated as promoting and maintaining price stability (Bank of Botswana, 2015c p.91). The regime has evolved over time to the current structure with a crawling peg exchange rate, where the Bank of Botswana’s inflation objective and the real exchange rate target are pursued with both BoBCs (open market operations) and the exchange rate as instruments.

**Monetary policy and inflation**

Botswana’s discovery and mining of diamonds in the 1970s and early 1980s led, by 1983 to trade surpluses that replaced trade deficits dating back to the country’s independence in 1966. The 1990s through to 2007 were thus characterized by high and rising trade surpluses, sustained up until the great recession of 2008-09. With persistent large trade surpluses in a pegged exchange rate regime, there came the challenge of sterilizing large amounts of excess liquidity in the banking system in a sustainable, cost-effective manner that curbed inflationary pressures without compromising competitiveness, or discouraging lending by banks.

In the 1980s and 1990s prices in Botswana were anchored by an exchange rate peg and dependent primarily on South African prices; however inflation was also influenced by US inflation, to a lesser extent by changes in non-mineral GDP growth, and to an even lesser extent by changes in narrow money, with changes in interest rates having little influence (Atta, Mannathoko and Jefferis, 1996). From the mid-1980s until interest rate liberalization and the adoption of open market operations in 1991, inflation remained above 10 percent, however following liberalization, inflation assumed a downward trend that was sustained through to the end of the 1990s when it reached 6 percent. During the 1990s, furthermore, exchange rate and monetary policy achieved a stable, competitive, real effective exchange rate (REER) at a low enough level to support output diversification. Analyzing the period 1985-2004, Iimi (2006 b) confirmed the REER alignment in the 1990s with the long run equilibrium real exchange rate; this was further affirmed by World Bank (2005). The period after the 1990s, however, saw some policy changes; the outcome of which was significant REER appreciation after 2000 (Figure 1).

What policy changes occurred? In 1999 exchange controls were abolished followed by a change in the policy focus; the de-facto policy shifted away from reliance on the exchange rate as a price anchor to a new exchange rate rule where the exchange rate’s movement was guided by the inflation differential with trading partner countries (see Annex I. Annex II also gives the monetary policy timeline).

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3 The use of two instruments is common in systems with sterilization interventions. Authorities tend to rely purchases and sales of foreign exchange, and on open–market operations to neutralize effects on the policy interest rate (Benes et al, 2011).

4 Inflation dropped to single digits in August 1996. Subsequently, an updated consumer price basket was introduced in November 1996. Inflation dropped to 6 percent towards the end of the 1990s.

5 See Bank of Botswana Annual Economic Reports from the 1990s.
The central bank’s Monetary Policy Statement (1999) states that “The (new) policy stance is consistent with having a stable real exchange rate in Botswana, in which changes in nominal exchange rates mirror the differential between Botswana’s rate of inflation and that of our major trading partners.” .... “Bank of Botswana wants to avoid having to devalue the nominal exchange rate in order to maintain a stable real exchange rate.” The central bank still appears to follow this rule, as Bank of Botswana’s exchange rate policy statement (2014 Annual Report, page 23) notes that “the rate of depreciation of the NEER was slightly lower than the differential between domestic and trading partner countries’ inflation.” Annex I provides more detail.

While the aim of the above rule seems to have been to keep the real exchange rate constant by containing imported inflation via nominal exchange rate movements, if it was followed as described above, it may have taken away the exogenous nominal anchor provided by the peg in the 1990s. Adams and Gros (1986) point out that such a rule is likely to lead to a host of monetary problems, where countries risk losing control over the inflationary process, since the rule may serve to index both the nominal exchange rate and money supply (through the balance of payments), to the price level. Their findings may explain why the 1999 shift from a peg with discrete adjustments in response to shocks - to this exchange rate rule did not work. Furthermore, this policy choice was adopted when monetary flows in the banking system were increasing.

An inflation objective (target)\(^6\) was added to the monetary policy framework in 2002, with monetary policy now guided by the principal objective of achieving a low, sustainable and

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\(^6\) The Bank of Botswana’s 3 to 6 percent “inflation objective” range is an approximate inflation target. Normally, inflation targeting refers to a monetary policy regime characterized by public announcement of an official target range for inflation and by explicit acknowledgement that low inflation is the most crucial long-run objective of the monetary authorities. Bank of Botswana has done both these things; the difficulty, however, is that its regime did not satisfy all the standard pre-requisites for a full inflation targeting regime – namely a single target, predictable
predictable level of inflation (Bank of Botswana 2006a). This new approach still failed to contain inflation however, as the price anchor that the peg provided had been weakened. In contrast to the 1990s, the REER appreciated as seen in Figure 1 and the pula currency become overvalued. Authorities then devalued the pula in 2005. The introduction of a crawling peg in 2005 – which may still follow the real exchange rate rule cited earlier, depending on how one interprets the monetary policy statements of the time (Annex I) also failed to stem inflation, and real exchange rate appreciation resumed again a couple of years after the 2004-05 pula devaluation.

After successful monetary policy outcomes in the 1990s, the ineffectiveness of the new monetary policy regime after 2000 was more or less self evident as inflation remained outside the target range about 90 percent of the time over the 2002-2012 decade (Figure 2).

While Bank of Botswana acknowledged that inflation had “until recently (2013), generally been outside the desired range” it went on to say that this result “cannot be attributed to the failure of monetary policy, but is rather an indication that inflation was mostly driven by factors outside the scope of monetary policy” (Bank of Botswana, 2015c p. 92). The Bank cites factors such as monetary relationships and central bank independence – hence the “inflation objective” wording. In particular, while the Bank of Botswana Act does allow for reasonable central bank independence, the policy regime is such that government decisions relating to the management of foreign reserves can affect monetary policy autonomy. In addition, both exchange rate and monetary policies are active policies that influence each other and have different targets. While the relationship between monetary policy instruments and inflation was relatively stable in the 1990s, after the introduction of the inflation objective regime post 2000, Bank of Botswana struggled to maintain a stable, predictable relationship.
upward adjustments in administered prices and government levies, and the impact of the global food and oil price shocks as being responsible for the consistent missing of the target range. However, a review of inflation based on the central bank’s adjusted CPI indexes which exclude these exogenous factors (CPIT removes short-term volatilities and CPIXA excludes administered prices) shows annual averages for the indexes that display a similar pattern to that of CPI inflation; being consistently above the objective range from 2006 when they were first published to 2012. Like inflation for the overall CPI index, they only fell within the inflation objective range in 2013.

If one specifies the principal monetary policy objective according to law, where, under the Bank of Botswana Act, its principal objective is “first and foremost to promote and maintain monetary stability”, that objective was also not met after 2000; money (M2) as share of gross domestic expenditure rose from 23 percent at the end of 2000 to 55 percent at the end of 2007. It is not surprising, therefore, that over this period inflation rose.

Public sentiment also considered the ineffectiveness of the policy to be self-evident. Consultations held with key stakeholders during 2006, to gauge views on monetary policy and related economic development issues (Chibba, 2007) included two questions of interest: (i) In your view, what is keeping inflation high in Botswana? (ii) Do you agree with the Bank of Botswana’s tight monetary policy? Chibba’s main finding from the consultations was that the private sector in Botswana “had become increasingly disenchanted with very high interest rates that had prevailed for far too long with limited and questionable results in tackling inflationary pressures.” Ninety per cent of the stakeholders interviewed believed that the central bank’s monetary policy was wrong. The monetary authorities, however, appear to have believed that external developments were to blame for the missed inflation targets and made no further adjustments to their policy approach after 2005.7

**Sterilization policy and transmission**

Botswana has had sterilization interventions via open market operations since 1991. A review of sterilization policy experience and its transmission reveals somewhat complex interactions. With the liberalization in 1991 away from direct interest rate controls and use of the central bank’s call account to absorb excess liquidity, monetary authorities adopted open market operations, using Bank of Botswana Certificate (BoBC) sales to absorb excess liquidity in the banking system (see Annex II for sterilization policy timeline). As noted earlier, sterilization was necessary under a pegged exchange rate regime, where the large monetary injections from persistent large trade

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7 It would appear that monetary authorities sought to improve fiscal-monetary policy complimentarity by discouraging repeated, large, discrete wage and administered price increases. They do not appear to have considered changing their policy approach beyond the introduction of a crawling peg intended to negate the need for discrete devaluations with a crawl.
surpluses caused a structural surplus of liquidity in the banking system, and liquidity in excess of absorptive capacity could lead to falling short-term interest rates and push up inflation. The central bank used open market operations to draw the excess money out of the banking system and hold it on its balance sheet.

**Figure 3: Transmission Channels for Monetary Policy (Sterilization)**

The banking system’s balance sheet was thus asset driven, with the central bank essentially acting as depositor (rather than lender) of last resort, taking “deposits” from banks by selling them securities which then appeared as liquid assets on the banks’ balance sheets (banks generally had no need to borrow from the central bank). As shown by the transmission channels in Figure 3, BoBC sales (that respond to inflows from export receipts, foreign reserve management choices and capital flows) could therefore impact commercial banks’ balance sheets even while they helped determine the central bank’s policy interest rate. The central bank would draw from the market, the amount of liquidity consistent with a level of short-term interest rates that would affect demand conditions in the economy as desired (Bank of Botswana, 2015c). The

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8 In most developed countries, the central bank has to deal with a structural deficit of liquidity in the market, such that the banking system’s balance sheet is liability driven. The central bank then lends money to commercial banks through open market operations to make up for the deficit.

9 From Figure 3, it is expected that changes in the policy interest rate affect commercial bank interest rates, asset prices, demand for Pula (which affects the nominal Pula exchange rate to the extent that it is allowed to adjust by the crawling peg exchange rate mechanism), and people’s expectations of future interest rates, economic growth, and inflation - which in turn also affect asset prices and the demand for Pula assets and securities (Current practice is that Bank of Botswana will tend to tighten monetary policy i.e. sterilize more to reduce net domestic assets NDA, in response to the central bank’s inflation forecasting system which generates equilibrium values for output, real exchange rates and real interest rates, that provide benchmarks for the description of a “neutral” monetary policy stance which does not contribute to changes in inflation – see Phetwe, 2013). Large BoBC sales are also likely to affect commercial bank balance sheets and banks’ propensity to lend. While Bank of Botswana reports tend to discuss the commercial bank interest rate channel, this study recognizes that the multiple channels in Figure 6 may impact aggregate demand pressures and inflation in varying degrees.
purchase and sale of BoBCs thus influenced the cost and quantity of loanable funds with the BoBC rate being the central bank’s de facto policy rate – in that it informed the benchmark Bank Rate that signals commercial banks to reset their interest rates.

Figure 3 also illustrates that even as the exchange rate peg is set through currency operations, this has implications for liquidity levels which in turn influence BoBC sales and interest rates. The exchange rate for its part influences demand for foreign goods and services and therefore imported inflation. This means that the two monetary and exchange rate objectives need to be pursued in a consistent manner. The structure of the peg and weighting of currencies in the basket for the exchange rate peg must also be properly informed, as they matter in determining whether or not the peg supports exchange rate policy objectives. Furthermore, as cross-currency movements (between currencies in the exchange rate basket) change the relative weights of the currencies in the basket; these weights also need to be tracked and corrected periodically.

**Commercial banks: sector structure, balance sheets and profits**

As reflected in the policy transmission chart (Figure 3), sterilization policy through BoBC sales has influenced the performance of Botswana’s banking sector (deposit-taking institutions) through their balance sheets. The banking sector was very small in the early 1990s, dominated by two foreign banks - Barclays and Standard Chartered, which had operations in Botswana dating as far back as the 1950s. It has since developed rapidly. In the fifteen years to 2009, the sector grew at an average 11.2 percent per annum in real terms, dominating market capitalization in the Botswana Stock Exchange. Private banks still dominate the banking sector (Table 1) which has assets equivalent to about 50 percent of GDP. The sector had eleven commercial banks in 2014 – mainly foreign owned, with three listed on the Botswana Stock Exchange (BSE).10 There was also one merchant bank. Government banks (including two deposit takers) are not major players in the sector.

There have been various bank closures over the years, including the Bank of Credit and Commerce in 1991, Zimbank Botswana in 1993, Botswana Cooperative Bank in 1995 and Kingdom Bank in 2015.11 Four private institutions are classified as large banks in the market today (where a large bank is defined as having total assets that constitute 10 percent or more of the aggregate banking sector). The concentration of banks is high, with 70 percent of total bank assets owned by the top three banks (IMF, 2014), increasing the likelihood of a weaker transmission mechanism and the risk that one of these individual banks might at some point be considered too big to fail. As at December 31, 2014, Barclays Bank of Botswana, First National

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10 Two offshore banks and one offshore holding company were also listed on the BSE.

11 Moffat and Valadkhani (2011) analyzed the technical efficiency of Botswana banks and found that two foreign banks and one parastatal savings bank were consistently among the most efficient institutions, while two other parastatals - a bank and a lending institution, and one private bank were consistently the least efficient. They found that the size of the institutions (asset base) had no bearing on efficiency.
Bank of Botswana, Stanbic Bank Botswana and Standard Chartered Bank Botswana – all foreign banks - qualified as large banks.

Table 1: Relative Market Share of Private and Public Banks

<table>
<thead>
<tr>
<th>% Market share (assets)</th>
<th>As at end of</th>
<th>2010</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Market share (loans and advances)</td>
<td>88</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>% Market share (deposits)</td>
<td>98</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>

Source: Banking Supervision Annual Reports for respective years, Bank of Botswana

Note: Market share refers to private banks’ share out of all institutions (private and government institutions)

Commercial banks’ balance sheets are impacted by large inflows or export receipts as the (crawling) peg exchange rate regime limits price adjustment via exchange rate appreciation. During periods of large inflows, the banking system has been characterized by excess liquidity (reflecting the surplus of savings over investment). This alongside sterilization policies used to absorb the excess liquidity influenced the structure of commercial banks’ balance sheets. BoBCs constituted a significant share of bank assets, with their share exceeding that of loans and advances after a 2006 decision to restrict purchases of BoBCs to commercial banks (Table 2).

Table 2: Commercial Bank Balance Sheets

<table>
<thead>
<tr>
<th>% of total bank assets</th>
<th>1995 – 2005 (average)</th>
<th>2007 (with restriction of BoBC sales to banks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans &amp; Advances</td>
<td>50%</td>
<td>37%</td>
</tr>
<tr>
<td>BoBCs</td>
<td>21%</td>
<td>45%</td>
</tr>
<tr>
<td>Balances due from foreign banks, and other assets</td>
<td>29%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Source: Botswana Financial Sector Overview 2010-11

The restrictions on direct purchases of BoBCs resulted in a significant expansion of bank balance sheets - with a major inflow of deposits into banks from entities that had previously purchased and held BoBCs directly, but were now not allowed to do so. This included institutional investors who had invested significant amounts of Botswana Public Officers’ Pension Fund (BPOPF) inflows in BoBCs after 2000. With the sharp increase in holdings of BoBCs in 2006 (Figure 4), total assets of the banking sector increased by 50 percent in the six months from December 2005 to June 2006 (Bank of Botswana’s Bank Supervision Annual Reports). Financial assets other than loans and advances (mainly BoBCs) now made up a sizeable portion of bank balance sheets. Thus sterilization measures now had an important impact on bank operations and profits (Jefferis and Kenewendo, 2011).
Banking sector assets (just six commercial and merchant banks at the time) reached over 46 percent of GDP in 2006. Corresponding to the rise in bank BoBC holdings, loans as a share of deposits dropped from 70 percent in 2004-05 to 44 percent in 2007. Thus this lower ratio largely reflected the rise in deposits. Funds that had previously been used by non-bank corporates to buy BoBCs now took the form of deposits in banks, lowering the loan/deposit ratio. Pension fund (and other non-bank financial institutions’) BoBC holdings were replaced by pension fund (and other) regular and BoBC – linked deposits in banks. Figure 4, therefore does not necessarily reflect a direct crowding out of loans by BoBCs, but may rather reflect the sharp increase in bank deposits by institutional investors in 2006-07. The boost to deposits stimulated lending over the next few years. Credit growth rose from just 7% in 2005 to a peak of 28% in 2008 before declining to 12% in 2010.

With rapid credit growth, the ratio of loans to deposits recovered to 64% in 2011. At this point, increased lending had contributed to a sharp decline in liquidity ratios between 2007 and 2011. This allowed Bank of Botswana to effect a sharp reduction in BoBC issuance in 2011. With the reduction in BoBCs issued to and held by banks, and the resultant loss of interest earnings from BoBCs, banks needed new income sources and the extra liquidity in banks went to new loans, with credit growth rising from 12% in 2010 to 26% and 24% in 2011 and 2012, before declining again to 6% in 2016-17. Nevertheless, by the end of 2017 the ratio of loans to deposits had risen to 85%. Most of the new liquidity from the reduction in BoBC holdings by banks was channeled into increased intermediation, while a portion went to accommodate the 2011 increase in primary reserve requirements.

12 See Bank of Botswana’s 2011 Banking Supervision Annual Report, Chart 17, p.16
Botswana banks had had high levels of profitability following the introduction of BoBCs in 1991 (Table 3). The high profitability of the banks continued into the 2000s, peaking in 2006-07 at levels far above the international norm. Interest earned on BoBCs was a sizeable contributor to banks’ total income until 2012.13 Since the 2007-08 global crisis and subsequent great recession however, the profitability of the Botswana banking sector has been in decline with a significant drop in return on equity and in the share of income from investments and securities relative to total income. The income share from securities dropped from over 35 percent in 2007 to 26 percent in 2010, 8 percent in 2012 and 4.5 percent in 2014.

<table>
<thead>
<tr>
<th>Table 3: Banking Sector Size and Profit Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banking assets /GDP (%)</td>
</tr>
<tr>
<td>Assets (Pula billions)</td>
</tr>
<tr>
<td><strong>Profitability ratios</strong></td>
</tr>
<tr>
<td>Return on equity – ROE (%)</td>
</tr>
<tr>
<td>Return on average assets – ROAA (%)</td>
</tr>
<tr>
<td>Income on investments and securities to total income – includes BoBCs (%)</td>
</tr>
</tbody>
</table>

Source: Banking Supervision Annual Reports for various years, Bank of Botswana
Note: ROE measures after tax profit against shareholders' funds
ROAA measures after tax profits as a percentage; shows how efficiently a financial institution’s assets are employed.
*Income on investments and securities is represented here by interest earned on just BoBCs. The value shown is for 2007. The same value for 2009 was 26.

Bank of Botswana’s 2013 Banking Supervision Annual Report noted that reduced BoBC holdings had impacted bank profitability adversely, while the 2011 Banking Supervision Annual Report noted that given declining profits and the new low interest rate environment, a trend of growing reliance on non-interest income such as bank charges to boost profitability, had emerged.

Beyond the banking sector, the overall development of the Botswana financial sector over time alongside the opening of the capital account in 1999 are also important considerations for this paper as they may have impacted the efficiency and cost of sterilization. An overview of developments in the non-bank financial sector after the opening of the capital account in 1999 is therefore provided below.

**The non-bank financial sector and inflows**

The non-bank financial institutions (NBFIs) sector in Botswana is now larger than the banking sector; and it has more local ownership than the latter. In addition to this, cross linkages between NBFIs and commercial banks have become significant, with NBFIs’ wholesale deposits

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13 In commercial bank balance sheets, usually deposits are the primary liabilities of banks, while reserves and loans are their primary assets. The banks’ investment portfolios tend to be a smaller portion of assets, and serve as the primary source of liquidity. With sizable sterilization, however, the sterilization securities in the investment portfolio can end up dominating bank assets – competing with loans as the primary assets of the bank.
constituting about 40 percent of banks’ liabilities (IMF, 2014). In 2010, the combined assets of the pension and insurance sub-sectors alone accounted for 49.5 percent of GDP, compared with 41 percent of GDP for the banking sector’s assets (IMF, 2010). In 2015 and beyond, total assets of NBFIs accounted for well over 50 percent of GDP (Bank of Botswana, 2018). The NBFI sector covers numerous entities including the Botswana Stock Exchange (BSE) and stock-broking firms, insurance companies, pension funds, asset managers, credit institutions (non-bank lenders) including Letshego which is listed on the BSE and other smaller lenders, microfinance institutions, collective investment undertakings (CIUs), development finance parastatals (such as the Botswana Development Corporation, the National Development Bank and the Citizen Entrepreneurial Development Agency), and statutory funds such as the Motor Vehicle Accident Fund and the National Petroleum Fund.

The influence of this sector on liquidity in the banking sector via corporate deposits and capital flows into the country has been significant. During the years from 2002 to the great recession, the newly privately run Botswana Public Officers’ Pension Fund (BPOPF) brought in new capital flows seeking domestic investment opportunities (Table 4). The government decision to draw down significantly on the country’s foreign reserves to fund past liabilities in the pension fund and to transfer its management to the private sector resulted in a large inflow of funds allotted via BPOPF to private fund managers in Botswana and a correspondingly large increase in demand for domestic investment opportunities that could not be contained by the very limited Government bond issuance.

Table 4: Government transfers to BPOPF and its private investment inflows (Pula millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Government Transfers to BPOPF (Flow)</th>
<th>Value of domestic investments by BPOPF (as at year end)</th>
<th>Share of domestic investments in total investments of BPOPF (as at year end)</th>
<th>Fiscal cost of sterilizing excess liquidity (interest paid as a share of non-mining GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>2,201.3</td>
<td>962.6</td>
<td>50.45</td>
<td>3.5 percent</td>
</tr>
<tr>
<td>2003</td>
<td>6,048.2</td>
<td>5,031.8</td>
<td>51.24</td>
<td>4.5 percent</td>
</tr>
<tr>
<td>2004</td>
<td>2,609.5</td>
<td>5,680.0</td>
<td>48.10</td>
<td>3.6 percent</td>
</tr>
<tr>
<td>2005</td>
<td>1,781.6</td>
<td>35.74</td>
<td>3.8 percent</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>737.4</td>
<td>7,019.2</td>
<td>37.74</td>
<td>4.1 percent</td>
</tr>
<tr>
<td>2007</td>
<td>46.8</td>
<td>9,821.7</td>
<td>37.74</td>
<td>3.9 percent</td>
</tr>
<tr>
<td>2008</td>
<td>197.6</td>
<td>9,897.5</td>
<td>36.91</td>
<td>3.8 percent</td>
</tr>
<tr>
<td>2009</td>
<td>178.8</td>
<td></td>
<td>2.6 percent</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>164.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>0.9</td>
<td>17,161.3</td>
<td>43.05</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>2.4</td>
<td>18,299.3</td>
<td>40.59</td>
<td></td>
</tr>
</tbody>
</table>

Source: Botswana Public Officers Pension Fund, BPOPF Annual Reports (and Bank of Botswana Reports for last column)

Notes:
1. Year ending 31st March
2. Transfers by government from foreign reserves / savings into the BPOPF (Pula millions)
   This is different and separate from annual budgeted employer contributions
3. Value as at 30 Sept 2002 of BPOPF investment portfolio invested in Botswana (Pula millions)
4. Value as at 31 Dec 2003 of BPOPF investment portfolio invested in Botswana (Pula millions)
5. Share of BPOPF investment portfolio invested in Botswana (percent)
6. Calendar year calculations by author
Botswana was already operating in an excess liquidity environment at the time due to large mineral receipts - with limited opportunities for portfolio investment within the economy. In the year that government began to transfer funds to the newly privatized pension fund for public officers, money that had previously been sterilized in government savings was transferred to the private pension fund industry, thus portfolio inflows rose in the system, though there were no significant new listings on the stock exchange to absorb more money and the fixed income market was underdeveloped with little new issuance of debt by firms (Poddar, 2002). The Botswana Stock Exchange Index rose by over 69 percent that year, and at the same time a significant amount of the new funds went to the direct purchase of Bank of Botswana Certificates (Poddar, 2002).

The influence of these new flows on liquidity was reflected in the sharp increase in BoBC issuance. From the end of 2000 to the end of 2007, BoBCs issued increased by Pula12, 904 million, which was close to the amount of the transfer from Government to the BPOPF. Large private capital flows were thus an important new development that deserved careful treatment by monetary authorities. Nevertheless, authorities continued to rely primarily on BoBCs for sterilization despite rising costs. Prior to 2001, the interest cost paid on sterilization instruments had remained well below 3 percent of non-mining GDP. From 2002 through 2008 however, this fiscal cost rose above 3 percent of non-mining GDP, peaking at 4.5 percent in 2003 (Table 4). Box 1 traces the path of BPOPF flows and their influence on liquidity.

**Box 1: BPOPF Inflows and Liquidity – 2001 to 2011**

2001: Decision is made to transfer significant funds (in excess of M2 plus all BoBCs held) from national reserves to the Botswana Public Officers’ Pension Fund (BPOPF).

2002: From 2001-2005 over Pula 12.5 billion is transferred to institutional investors managing BPOPF portfolios. A large portion of the inflows to the Botswana market purchase BoBCs. Corporate deposits also grow by 60 percent in 2001, compared to an average 25 percent in the five years to 2000. Large increase in excess liquidity in banks; BoBC issuance escalates.

2006: Central bank restricts BoBC auctions to banks. As a result, institutional investor deposits in banks rise sharply. Liquidity remains high in commercial banks. New deposits boost credit growth, but not enough to curb excess liquidity. BoBC issuance remains high.


2011: In the wake of the decline in bank liquidity, central bank cuts BoBC issuance sharply. Credit growth gets a boost: with liquidity no longer going to BoBCs, banks seek new interest income to replace lost BoBC interest income. Ratio of credit to deposits rises from 44 percent in 2007 to 88 percent in 2014 and 85 percent in 2017. From 2011 onwards banks’ excess liquidity and the central bank’s BoBC issuance remain low.

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14 Non-mining GDP is the relevant comparator here. Since the government strategy is to use windfall receipts (mineral revenues) to develop the non-mining economy, the applicable opportunity cost relates to non-mining GDP.
4. Measuring sustainability of sterilization and monetary policy autonomy

This section describes calculations used to estimate the cost and sustainability of sterilization, and to construct an index tracing movements in the degree of monetary policy autonomy. Calculations are based on the central bank balance sheet (illustrated in Table 5). The left hand side shows assets, dominated by foreign exchange reserves, while the right hand side shows liabilities, including those that serve to sterilize excess liquidity.

| Table 5: Summary of Bank of Botswana Balance Sheet (Pula billions, calendar year-end) |
|---------------------------------|----------|--------|--------|--------|--------------------|----------|--------|--------|--------|
| Foreign exchange reserves       | 11.96    | 58.52  | 50.85  | 60.27  | Currency in circulation | 0.30     | 1.36   | 1.92   | 2.09   |
| Government Bonds                | 0.00     | 0.09   | 0.04   | 0.02   | Private bank balances | 0.09     | 1.07   | 0.04   | 0.16   |
| Property and Equipment          | 0.08     | 0.14   | 0.20   | 0.27   | Bank reserve requirements | 3.25     | 3.00   | 3.57   |
| Other                           | 0.02     | 0.09   | 0.12   | 0.14   | Government and other balances | 6.75     | 1.31   | 3.41   | 2.36   |
|                                 |          |        |        |        | Bank of Botswana certificates | 1.45     | 16.62  | 17.64  | 11.48  |
|                                 |          |        |        |        | Dividend to government    | 0.45     | 0.23   | 0.18   | 0.47   |
|                                 |          |        |        |        | Other liabilities         | 0.09     | 0.14   | 0.18   | 0.07   |
|                                 |          |        |        |        | Shareholders' funds       | 2.92     | 38.11  | 24.91  | 39.59  |
| **Total Assets**                | 12.06    | 58.84  | 51.21  | 60.70  | **Total Liabilities**     | 12.06    | 58.84  | 51.21  | 60.70  |

Source: Various Bank of Botswana Annual Reports

The Bank of Botswana sterilizes the expansionary impact of current account receipts and reserve accumulation by selling domestic liabilities such as Bank of Botswana certificates (Table 5), in this way decreasing money available in the banking system and pushing interest rates back up to the desired level.

**Sterilization: calculating net cost and sustainability**

To sterilize, the central bank increases its liabilities. For most of the increase, it pays interest. Adapting the methodology used by Frankel, R. (2007), in any given year t, the net cost of sterilization, \( s_t \), must be the difference between interest paid on domestic liabilities used to sterilize and interest earned on the corresponding foreign assets purchased with the surplus funds. Therefore:

\[
S_t = i_t L_t - (r_t R_t) e_t^* 
\]

where: \( S_t \) = the net cost of sterilization,
\( i_t \) = domestic interest rate paid on each liability (BoBC or reverse repo)
\( r_t \) = the interest rate earned on foreign reserves (all reserves or all minus Pula Fund)

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15 1 billion = 1000 million
16 2007 - 2011: Current account balances of Government, commercial banks, parastatal bodies and others, are repayable on demand and are interest free, except for the Debswana Tax Holding Account.
17 This value includes reverse repurchase agreements which also serve to sterilize money supply.
18 In 2010, “other liabilities” include foreign liabilities of P0.71 billion.
19 In the 1994 balance sheet this item is denoted as “Capital and Reserves”
L = the value of each (remunerated) domestic liability outstanding in a given period
R = the value of foreign assets accumulated in a given period (all reserves or minus
       Pula / wealth fund)
e* = dE/E is the exchange rate used to convert the foreign currency interest earned to local
currency.

Thus, iL = the short-run domestic interest cost (financial cost of remunerated liabilities),
rR = the international interest earned,
(rR) e* = returns to international reserves invested by Botswana in Pula.

i is the domestic interest paid against remunerated liabilities issued such as BoBCs and reverse
repurchase (repo) agreements. No interest is paid on other liabilities such as currency, reserve
requirements, private bank balances and government and parastatal balances at the Bank of
Botswana, thus i is either the BoBC rate or the reverse repo rate. The net sterilization cost each
year can be thought of as:

\[ s_t = L_{1t} (i_{BoBC})_t + L_{2t} (i_{repo})_t + L_{3t} (i_{base money})_t + L_{4t} (i_{bank balances})_t + L_{5t} (i_{govt balances})_t - (rR)_t e^* \]  (2)

As the interest paid on base money, bank balances (including reserve requirements) and
government and parastatal balances is zero, L, L and L help to sterilize at zero cost. The
larger L, L and L are as a share of total liabilities:

(i) the lower the overall sterilization cost and the more sustainable the policy is; and
(ii) the less upward pressure there is likely to be on the domestic interest rate, i.

Two sterilization cost series are constructed, where the first s is based on r representing
interest earned on all foreign savings (i.e. interest earned on both the liquidity and Pula funds);20
while the second s, is based on rL being interest earned only on the liquidity fund (in a
scenario where the current generation of policy makers cannot access the intergenerational Pula
wealth fund or its returns). This distinction is made because while Bank of Botswana describes it
as a sovereign wealth fund, the Pula Fund (managed by the central bank – see World Bank, 2015
pp.61, 69, 72, Figure 85) is in practice not managed to ensure inter-generational savings; access
to the Pula Fund is not blocked – consequently there have been episodes of substantial outflow
from the Pula Fund,21 and it has also been used for stabilization purposes, in addition to

20 Bank of Botswana maintains a primary international reserve, generally referred to as the liquidity portfolio, used to
ensure the timely availability of foreign currency at a reasonable price. It provides a buffer for short term trade and capital
account requirements. It has two tranches; one for short-term and the other for medium-term funding. The current
benchmark for the liquidity portfolio is six months import cover. The residual from the liquidity portfolio goes into a
second fund called the Pula Fund. This is a long-term investment portfolio established in 1994 in order to preserve part
of the income from diamond exports for future generations. Foreign exchange reserves in excess of expected medium term
requirements are transferred to the Pula Fund.

21 The first large outflow was with the sizeable transfer from reserves to the Botswana Public Officers Pension Fund after
2001, and the second followed the 2008 global crisis which period has again seen a significant erosion in reserves; in part
to maintain the liquidity portfolio which suffered significant depletion after 2008. The WAVES/World Bank analysis
shows that the current level of savings in the Pula Fund is far from sufficient to serve an inter-generational savings role.
The Pula Fund was only 100 percent of GDP in 2000, and by 2016 it had declined even further to just 30 percent of GDP.
supplementing the liquidity fund. The Pula Fund was 40 percent of GDP in 2013 (and 32 percent of GDP in 2016), down from 120 percent of GDP in 1998. I estimate sustainability under both the latter de facto scenario and the former (de jure) scenario.

For sterilization to be sustainable, the cost of servicing liabilities in a given year, $i_L$, cannot exceed interest earnings on the foreign assets bought with the surplus funds, $(rR)e^*$, that is $i_L \leq (rR)e^*$ must hold. This means that the net sterilization cost, $s^t_j$ calculated for each distinct year $t$, is sustainable as long as $s^t_j = i_t^t L^t - (r^t R^t) e^{t^*}$ is zero or negative. Therefore the sustainability condition is:

$$s^t_j \leq 0$$  \hspace{1cm} (3)

**Estimating and tracking monetary policy autonomy**

Accounting methods were used to construct an index that tracks the degree of influence or “reach” of monetary policy, otherwise known as monetary policy autonomy, under this sterilization regime. To track increases or reductions in the degree of monetary policy influence, a monetary policy autonomy index, DOMA was constructed, based on a derivation by Frankel (2010). It compares the volume of instruments (Bank of Botswana Certificates, BoBCs and reverse repurchase agreements) that the central bank has sold to commercial banks in order to reduce the amount of money in the banking system, with the stock of foreign exchange reserves.

$$\text{DOMA} = \frac{\text{stock of foreign reserves}}{\text{stock of BoBCs and reverse repurchase agreements}}$$

The more BoBCs that are sold to banks when compared to the stock of foreign reserves, the less monetary policy influence there is (as per Frankel, 2010). While reducing the stock of foreign reserves relative to that of BoBCs, also reduces monetary policy influence.

In addition, the more BoBCs that are sold, the more interest the central bank has to pay out to banks, while reducing the stock of foreign reserves reduces the interest earned on foreign reserves invested abroad. Thus there is a higher net fiscal cost in both cases.

Using all international reserves $R^A$, the index reflecting the degree of monetary policy autonomy at time $t$, $\text{DOMA}_t$ is calculated as:

$$\text{DOMA}_t = \frac{\text{Reserves}_t}{\text{(remunerated liabilities)}_t}$$  \hspace{1cm} (4)

Frenkel showed that given the ratio of the stock of a central bank’s remunerated liabilities (Bank of Botswana Certificates and reverse repurchase agreements) to the stock of international reserves (valued in domestic currency), i.e. $1/\text{DOMA}$, then if the ratio is less than unity, the maximum sustainable policy rate $i^{\text{max}}_t$ can be higher than the foreign interest rate, $r$ for interest earned on foreign reserves, and there still be a positive degree of monetary autonomy.
5. Framework for estimating the efficiency of sterilization

This section seeks to determine if sterilization efficiency was compromised in the first decade of the 2000s. Time series econometrics is used to investigate the extent to which monetary authorities were able to contain the quantity of money in the banking system (liquidity) using sterilization. The literature normally estimates coefficients measuring the degree of sterilization and the degree of offsetting inflows in one of four ways: by estimating the sterilization coefficient from the central bank reaction function; by calculating the offset coefficient using the portfolio balance approach and the monetary approach to the balance of payments; by estimating both sterilization and offset coefficients from the minimization of a loss function by the central bank – where the function is subject to constraints reflecting the transmission mechanism of the economy; or by estimating both sterilization and offset coefficients from separate functions.

The last approach is used in this paper, to examine the efficiency of sterilization policy; with the possibility of transitory monetary policy autonomy effects or trade-offs between sterilization measures and capital flows, being considered. The approach examines two regressions: (1) the estimation of the sterilization coefficient, based on the estimation of the monetary policy reaction function, MFR (e.g. Cumby, Huizinga and Obstfeld, 1981b); and (2) the estimation of the offset coefficient – capturing offsetting capital flows, usually based on the theoretical framework in Kouri and Porter (1974), who derived a model of international capital flows for a small open economy with a fixed exchange rate regime. The Kouri and Porter model gives a capital-flow equation that responds to monetary policy, reflecting the co-dependent nature of capital flows and monetary policy measures.

Ouyang et al (2007), Ljubaj (2010) and others derived the Cumby and Obstfeld monetary policy reaction function by assuming that the central bank sterilizes the monetary effects of capital inflows from abroad by changing its (net) domestic assets. Kouri and Porter (1974) and Obstfeld (1980) point out that in a country practicing sterilization policy with an open capital account; it is likely that sterilization activities, reflected in changes in net domestic assets (ΔNDA), will depend on what’s happening to foreign exchange reserves – reflected in changes in net foreign assets (ΔNFA), and vice-versa. They surmise that this simultaneity then makes it likely that the explanatory variable ΔNFA in the MFR equation is in fact endogenous and not exogenous. Likewise, the explanatory variable ΔNDA in the capital-flow equation is also likely to be endogenous.

The estimation of sterilization and offset coefficients shown in Annex III equations (6’) and (7’) is done with two-stage least squares regression analysis using quarterly data for the period from 2001 quarter 4 to 2015 quarter 4. Quarterly rather than annual data is used as the regression equations have mainly monetary variables which tend to respond quickly to changes in the economic environment.\footnote{ Exchange rate fluctuations are netted out of the data (valuation

\footnote{It was not possible to secure some of the pertinent monthly series – hence the use of quarterly data.}
adjustment) to ensure only sterilization and offset effects are measured. Given the use of quarterly rather than monthly data, the explanatory variables are not lagged as the monetary policy response to a change in a given variable usually occurs within the same quarter.\textsuperscript{23} The absence of lags also allows for more degrees of freedom.

In the capital flow equation, the coefficient on the explanatory variable, $\Delta$NDA is the offset coefficient, while that on the explanatory variable $\Delta$NFA in the monetary reaction function, is the sterilization coefficient. A small offset coefficient $\beta_l$ alongside a large sterilization coefficient $\alpha_l$ imply that the central bank has a high degree of monetary policy independence (autonomy) and is able to neutralize the impact of capital and mineral receipt inflows effectively and sustainably. On the other hand, a large offset coefficient implies an ineffective sterilization policy whose impact is not sustained.

Annex III provides the specifications for the monetary policy reaction function and the capital flow equation estimated for Botswana. The approach taken to interpret co-efficient estimates is also explained there.

6. The data and results

Data

Unless otherwise specified, all data for tables, charts and analysis are taken from Bank of Botswana annual reports and financial statistics. Data for real interest rate differentials are sourced from Bank of Botswana and International Financial Statistics, IFS. For the net sterilization cost and monetary autonomy calculations, these are based on accounting identities and the analysis includes the period 1991 to 1999 (prior to the abolition of exchange controls), and the subsequent period after 1999 when sterilization occurred under an open capital account. For the econometric analysis, the period from 2002 as government began transfers to the public officers’ pension fund and a new policy approach was adopted; to 2015 - is assessed. The possibility of a structural break in 2008/09 is also taken into account.

For the net sterilization cost and sustainability calculations, Bank of Botswana annual reports provide pre-calculated values of the domestic interest cost of sterilization instrument issuance, $i_iL_i$ for both BoBCs and reverse repurchase agreements - and of the interest earnings on foreign exchange reserves in pula currency, Re* (for all reserves). The data suggests that the two series trend together though the interest earned on foreign exchange reserves seems to fluctuate significantly. The data show a sharp upward trend in the domestic interest (cost) paid out on BoBC’s from the early 2000s through 2008. The annual data was entered in the accounting equations (1) and (3) used to estimate the annual cost of sterilization and its sustainability.

\textsuperscript{23} An ADL equation would be needed to determine how long sterilization was sustained before it was negated by new flows, but part of the monthly data series needed to explore lag structures in this way, was not available for this research.
Series for the stock of remunerated liabilities $L$ (used to sterilize) and of foreign reserves $R$ were also sourced from Bank of Botswana Annual Reports. They are used in equation (4) to compile the degree of monetary policy autonomy index, DOMA.

For the monetary policy reaction function and the capital flow regressions, natural logarithms were taken for all variables except interest rates, interest rate differentials and the exchange rate. For these latter three variables, a plot of exchange rates suggests that they are non-stationary (have a trend) but not exponentially so – so they do not require logs, while the real interest rate differential plot appears stationary. The time series characteristics of these and the other variables in Annex III equations (6’) and (7’) were determined via unit root testing using the standard Augmented Dickey-Fuller (ADF) unit root test (Annex Table IV.2). All variables were found to be I(1) with stationary first differences except for the real interest rate differential which was already stationary, I(0). The (stationary) regression instruments tested were the change in the exchange rate and the change in the money multiplier. Given the possibility of a structural break around 2009, the econometric models are estimated for the full period Q4 2001 – Q4 2015 including a structural break in Q3 2009, as well as for the sub periods Q4 2001 - Q1 2009 and Q4 2009 – Q4 2015.

The variables in the accounting equations (1) and (4) for net sterilization cost and monetary autonomy as well as the regression variables for Annex III equations (6’) and (7’) are shown in Annex Table IV.1.

**Net sterilization cost and sustainability: results**

A net sterilization cost series, $s$ is constructed from 1991 when BoBCs were introduced, to 2014. This is a conventional measure calculated from equation (1) and shown in Figure 5. Figure 5 allows comparison of the net fiscal cost of sterilization in the 1990s with the net fiscal cost in the 2000s. The calculations show that this net cost (defined as the difference between interest paid on liabilities used to sterilize, and that earned on foreign reserves) was contained from 1991 when BoBCs were first introduced through 1999. However, it rose significantly after 2001 as the privately run Botswana Public Officers Pension Fund brought substantial investment funds transferred from government savings (foreign exchange reserves), into the country (as described earlier in Box 1).

The *net* sterilization cost is sustainable as long as it is zero or negative. Two measures are considered. If one chooses to include interest earned by the sovereign wealth fund i.e. by the Pula Fund, to finance sterilization operations (i.e. “all reserves”), then the net sterilization cost reached unsustainable levels from 2002 through 2006. If instead the assumption is made that interest earned on the Pula Fund belongs to future generations and is not available to help finance current sterilization operations, then the data suggests that sterilization operations have been unsustainable from 1992 to 2013.
For the sterilization cost - all reserves series in Figure 5, the 2007 recovery in sustainability (net cost below zero) was due to a sharp 40 percent increase in foreign exchange reserves - reflecting in part the highest trade surpluses ever recorded in Botswana from 2005 through 2007, rather than a reduction in the interest cost of BoBCs issued by the central bank. The BoBC interest cost continued to rise. After 2010, however, continued sustainability was enabled by the dissipation of excess liquidity pressures (mirrored by trade deficits seen in the wake of the great recession and increased lending) and lower new BPOPF flows. There was a corresponding decline in BoBC issuance from 2011 onwards and therefore a decline in the domestic interest cost of BoBCs issued. Thus in the wake of the great recession, sterilization outcomes were more positive as sterilization became less important (more need for credit and lower excess liquidity pressures).

**Monetary policy autonomy: results**

The DOMA index reflecting the degree of monetary policy autonomy is calculated from equation (4). It is a simple index given by the ratio of foreign reserves to domestic liabilities issued (both in local currency) and illustrates how the accumulation of the pula value of foreign exchange reserves contributes to improved monetary autonomy – serving as an anchor, while the increased issuance of domestic liabilities (sterilization) erodes monetary policy autonomy.

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\[ NB: \text{Devaluation boosts the pula value of foreign reserves while sustained pula appreciation erodes the value.} \]
This analysis establishes that the influence or “reach” of monetary policy was severely eroded in the 2000s, as shown by the shaded area in Figure 6. The DOMA index (base 1991=100) deteriorated from an average between about 50 and 100 in the 1990s to under -200 in 2004. Monetary policy influence as measured by DOMA only recovered to the 50-plus range in 2013; the same time that inflation dropped (and stayed) within the target range.

The relatively high monetary policy autonomy in the 1990s (Figure 6), reflects the strong reserve accumulation (under a pegged exchange rate regime with some capital controls), averaging 174 percent of non-mining GDP (110 percent of GDP) and 27 months import cover between 1990 and 2001. After 2000, the sharp deterioration in the degree of monetary policy autonomy DOMA, seen between 2001 and 2004 coincided with the abolition of exchange controls and reflected the transfer of significant foreign exchange reserves to the privately run Botswana Public Officers’ Pension Fund. As seen earlier (Box 1), the transfer fed a parallel increase in private sector flows in the country. 2005 – 2008 saw a partial recovery in the degree of monetary policy autonomy, as reserves rose relative to GDP. A sharp increase in inflows via the trade account had fed into reserve accumulation before DOMA was eroded again between 2008 and 2010 by draw-downs from foreign reserves in the wake the great recession. In the 2000s, foreign reserves dropped to an average 92 percent of non-mining GDP (68 percent of GDP) and 16 months import cover for the period 2002 - 2015.

DOMA was supported post-2010 by the sharp reduction in the issuance of domestic liabilities following a sustained decline in bank liquidity ratios, as discussed earlier. This helped, by 2013, to restore monetary policy autonomy to levels last seen in the 1990s. In 2013 enough monetary
policy autonomy was attained to allow sterilization to be effective and inflation to fall within the target range.

**Efficiency of sterilization: results**

Table 6 summarizes the results of the estimated monetary policy reaction function and the capital flow equation, providing the sterilization and offset coefficients. The detailed results are provided in Annex Table IV.3.

Table 6

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterilization Coefficient, $\alpha_1$</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Capital Flow Offset Coefficient, $\beta_1$</td>
<td>-0.9</td>
<td>-0.78</td>
<td>-0.9</td>
</tr>
<tr>
<td>Net effect</td>
<td>Almost fully offset</td>
<td>partly sterilized</td>
<td>Almost fully offset</td>
</tr>
<tr>
<td>Effective?</td>
<td>no</td>
<td>yes, somewhat</td>
<td>no</td>
</tr>
</tbody>
</table>

For both the monetary policy reaction function and the capital flow equation, three sets of estimations are shown – for the full period Q1 2002 to Q4 2015, and then for the pre and post great recession sub-periods. The net effect over the full sample period produced a sterilization coefficient of -1 and an offset coefficient of -0.9. The pre-crisis sample produced the same sterilization and offset coefficients, while the post-crisis sample had a large sterilization coefficient $^{25}$ but a lower offset coefficient (suggesting lower offsetting flows). Were there enough data points to estimate the offset coefficient for the period after 2013 when excess liquidity had declined, it is likely that it would be even lower.

The high offsetting capital flows prior to the crisis resulted in a weaker net-sterilization effect and correspond to the poor monetary policy outcomes in the sub-period to 2009. The post 2009 sub-period shows a reduction in offsetting flows, dissipation of excess liquidity pressures and increased monetary autonomy.

The model for the monetary policy reaction function (in Annex III) has GDP growth as an additional explanatory variable, with the expectation that it would have a positive effect on net domestic assets. The insignificance of real GDP growth in the estimated monetary policy reaction function (Annex Table IV.3) suggests, however, that reserve accumulation effects and the sterilization of these effects overwhelm any effects of GDP growth on domestic monetary expansion.

$^{25}$ Authorities boosted reserve accumulation since 2013 despite lower real GDP growth (probably reflecting the authorities’ post-crisis decision to allocate more funds towards long term savings in international reserves, alongside increased SACU transfers and foreign borrowing by government). More rapid reserve accumulation in recent years corresponds to the large sterilization coefficient in this period.

[27]
Additional variables in the capital flow model include the current account and real interest rate differential (see Annex III). In the estimated capital flow equation, the current account balance was a significant explanatory variable in the pre-crisis period, but not after the crisis. This probably reflects the collapse of the trade account in the wake of the global crisis alongside the surge in rough diamond imports\textsuperscript{26} with the relocation of diamond sorting to Botswana, leading to a weakened contribution to net foreign assets.\textsuperscript{27} As expected, the real interest rate differential was not a significant explanatory variable for capital inflows, suggesting flows were influenced more by domestic public sector pension managers’ decisions to increase the domestic portfolio regardless of movements in the real interest rate differential – as long as higher domestic returns prevailed.

7. Conclusions

This paper provides a new narration of the monetary policy story in Botswana that clarifies the change in policy performance from the 1990s to the 2000s and why sterilization policy failed to contain inflation during the period 2002-2012. It explains how starting in 1999 some policy choices eroded monetary policy autonomy and triggered offsetting flows and how the absence of effective remedial measures led to costly outcomes. The accounting and econometric analyses point to how the loss of monetary policy autonomy alongside new flows had economic and financial costs. The findings highlight the need for a mechanism to track and preserve monetary policy influence.

The sharp contrast seen in monetary policy performance in the 1990s compared to the 2000s is consistent with findings in other studies on monetary policy in Botswana. Studies on policy performance in the 1990s (Kone, 1996; Masalila and Phetwe, 2001; Setlhare 2004), also found that monetary policy in Botswana was effective at that time. While Setlhare (2013) and Chibba (2006) found there was limited policy effectiveness in the 2000s. This study’s findings suggest an explanation for this difference; for why policy outcomes changed in the 2000s. The results help to explain Setlhare’s “unexplained findings”.

After 1999, new public sector pension policies and reserve management changes led to new additional flows – but no new policy measures were initiated to properly accommodate the new money. While aggressive sterilization interventions mopped up the additional excess liquidity

\textsuperscript{26} While rough diamond exports recovered, showing an upward trend after 2010, net rough diamond exports (deducting rough diamond imports) show a somewhat volatile downward trend, with a possible recovery in the trend only evident in 2016.

\textsuperscript{27} With the collapse of the trade account, the current account balance has been sustained by government transfers. From 2012 there has been a doubling of inward government transfers in the current account, with the increase reflecting the sharp boost in Southern African Customs Union (SACU) receipts to Government. In the wake of the great recession it is SACU transfers rather than export receipts or inflows that have accounted for the current account surpluses. SACU receipts primarily reflect consumption (imports from SACU) rather than production, and unlike trade (diamond) receipts which contribute to rents and government saving, they go directly to government revenue in the recurrent budget and so would have little influence on net foreign assets.
during this period, the impact was transitory as the interventions were offset by similarly large new flows (some going to purchase BoBCs directly - up until 2006) with 90 percent of the sterilization being negated, leaving the excess supply of money in the domestic economy only slightly changed despite high interest rates. The offsetting flows explain the higher domestic monetary pressure, poor inflation performance and upward pressure on the real exchange rate in the first decade of the 2000s. Monetary and exchange rate policies were not able to contain real exchange rate appreciation and overvaluation of the Pula currency occurred. While an attempt was made to correct for the overvaluation in 2004-05, the correction was not sustained over time.

Efforts to curb domestic inflationary pressures with repeated sterilization of the new flows incurred additional fiscal cost. Due to the large sales of financial instruments (mainly BoBCs), rising to exceed 20 percent of GDP, the fiscal burden of servicing these instruments rose sharply with annual interest payments to a handful of foreign banks reaching over Pula 2 billion. This interest burden rose to average almost 4 percent of non-mining GDP per annum from 2002 through 2008, peaking at 4.5 percent in 2003. The fiscal cost reached unsustainable levels when it exceeded interest earned on foreign reserves.

The loss in monetary policy effectiveness after 2000 was thus driven by domestic liquidity expansion from the accompanying policy choices. The shift in the approach to implementing monetary policy at the start of the 2000s including the move from a fixed to a crawling exchange rate peg regime was unable to accommodate the decision to transfer significant foreign exchange reserves to Botswana private sector pension fund managers (managing government officers’ pensions) following the post 1999 abolition of exchange controls. Monetary policy emphasis shifted away from the exchange rate as a price anchor towards relying more on monetary operations to control inflation at a time when other policy choices were causing a dramatic weakening of monetary policy autonomy. The econometric analysis (diagnostics in Annex IV) also confirms how for the period up to the global recession, changes in net foreign assets (NFA) and in net domestic assets (NDA) were interrelated and endogenously determined in the monetary system. Diagnostics further reveal, however, that since the de-facto regime changed from a fixed peg to a crawling peg regime in the latter period, the flexibility the crawl introduced affected the simultaneity between ∆NFA and ∆NDA, and the endogeneity of what had been the dependent explanatory variable in both the monetary policy reaction function and the capital flow equation was negated.

It is also possible that the new approach from 2000 which sought to give monetary policy a stronger role, in fact indexed both the nominal exchange rate and money supply to prices – in line with the warnings in Adams and Gros (1986). This contrasted with the 1990s when the focus on the pegged exchange rate regime (alongside some capital controls) and adequate reserve accumulation enabled higher monetary policy autonomy and successful policy outcomes. The harmony or complimentarity between monetary, exchange rate, foreign reserves and public pension policy choices that was sustained through the 1990s and that preserved monetary policy autonomy, was subsequently lost in the 2000s. While the high degree of monetary policy
autonomy attained in the 1990s served to illustrate that sterilized monetary intervention can in fact serve as an adequately independent policy tool in an economy such as Botswana (driven by large mining export receipts); subsequent changes in the 2000s highlighted the cost of loss of policy complimentarity. What matters is the combination of policies in play that influence sterilization outcomes; the right combination of policy measures can provide successful outcomes, while the wrong combination will hamper the independence and effectiveness of sterilization as a policy tool.

The DOMA index analysis shows how the influence or reach of monetary policy in this type of sterilization regime is associated with specific policy choices, including:

- large expansion or contraction in the volume of remunerated financial instruments (BoBCs and reverse repurchase agreements) sold by the central bank to commercial banks;
- decisions to draw-down or conversely to accumulate foreign reserves; or
- decisions to make (or allow) large adjustments to the Pula exchange rate (since this affects the pula value of foreign reserves used in the DOMA index).

Box 2 summarizes this association of monetary policy influence, with different policy choices.

<table>
<thead>
<tr>
<th>Policy</th>
<th>Action</th>
<th>Monetary Autonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monetary</td>
<td>Scaling up BoBC issuance</td>
<td>Erosion of autonomy (influence)</td>
</tr>
<tr>
<td></td>
<td>Cutting back on BoBC issuance</td>
<td>Increased autonomy</td>
</tr>
<tr>
<td>Reserves / Fiscal</td>
<td>Significant drawdown of reserves</td>
<td>Erosion of autonomy</td>
</tr>
<tr>
<td></td>
<td>Scaled up reserve accumulation</td>
<td>Increased autonomy</td>
</tr>
<tr>
<td>Exchange Rate</td>
<td>Sustained Pula appreciation</td>
<td>Erosion of autonomy</td>
</tr>
<tr>
<td></td>
<td>Devaluation of Pula</td>
<td>Increased autonomy</td>
</tr>
</tbody>
</table>

The plot of the DOMA index suggests that the degree of monetary policy influence in Botswana needs to recover to the 50 and above DOMA index range (1991 = 100) for it to be enough to support monetary stability and contain inflation. In the 2000s this influence declined to as low as -200, far below the 50 index level as was shown in Figure 6.

In the period since the great recession, monetary policy autonomy recovered with the DOMA index breaching the 50 cut-off point and inflation falling within the target range after 2012. Increased monetary autonomy was now anchored by reserve accumulation with lower BoBC issuance, and a high degree of sterilization could be sustained supported by lower offsetting flows. The post crisis stagnation of corporate deposits and the decline in bank liquidity provided space for monetary pressures and inflation to subside, and for lower BoBC issuance. Lower BoBC issuance in turn further spurred credit growth helping to raise intermediation ratios and contain excess liquidity. While the sharp reduction in excess liquidity pressures in the wake of the great recession has taken the pressure off sterilization for now; it is possible that the current regime could again face large new flows in the future.
The evidence from this study therefore informs suggestions on how, with a large surge in flows in the future, policy performance could be improved and the fiscal cost of sterilization mitigated, with results from both the accounting and econometric analyses providing some insight. For example, had better sterilization modalities been designed to handle the new flows caused by the transfer of the government pension fund to private management, the adverse outcomes seen in the 2000s could have been avoided or contained. More thoughtful treatment of public pension funds would have helped - such as keeping them as privately run funds - but still on the central bank balance sheet or preparing special long-term investment vehicles to better capture large new flows at lower cost than occurred – while re-directing the interest paid by government on sterilization instruments away from foreign entities that repatriate these funds, to entities that would retain the funds in-country, contributing to the development of Botswana. Rapid re-accumulation of reserves after the large drawdowns would also have helped. Given the specific context of the new flows in Botswana, policy makers had enough information on magnitudes and timing of potential new private flows to predict and plan for them. In the absence of such preparations, this left only BoBCs to absorb the new flows.

Currently, monetary policy depends on a crawling peg exchange rate regime alongside the sale of financial instruments (BoBCs) to influence imported inflation and to manage liquidity (quantity of money) in the banking system. This allows it to contain overall inflation. Monetary interventions are guided by an inflation forecasting framework that estimates the output gap in the medium term (several years), while exchange rate setting serves (in part) to contain imported inflation. However current outcomes may not be sustainable as imported inflation will rise at some point necessitating further appreciation of the pula currency and leading to more real appreciation and erosion of competitiveness for non-mining producers. Given the forgoing, reconsideration and monitoring of currency weights alongside monitoring of the interactions between monetary, foreign reserve/fiscal and exchange rate policy choices is needed to avert both uncompetitive outcomes and monetary autonomy deterioration in the future.

8. Policy Recommendations

On the policy front, this paper provides four key lessons: First, the movement of monetary policy autonomy should be measured and monitored; a simple index (DOMA) was constructed to this end. Among other things, the DOMA index illustrates the importance of reserve accumulation as an anchor for monetary policy autonomy in this monetary and exchange rate regime. Second, a mechanism is required that will track monetary, exchange rate and fiscal/reserve management policy inconsistencies on an ongoing basis, to help avert episodes of sustained inflation and loss of price competitiveness. Such a mechanism is proposed in this section. Third, the need to guard against inadvertently implementing an inappropriate exchange rate rule and the need to revisit

28 It is important to confirm that currency weights support a competitive exchange rate (for non-mining producers) and that cross-rate movements between the South African rand and the SDR (which comprise the Pula basket) have not changed the relative weights of the two currencies in the basket.
the exchange rate formula in response to domestic and external shocks should not be ignored, as shocks are the channels through which new policy inconsistencies are introduced. Fourth, the shifts seen via the econometric analysis from an endogenous monetary reaction-capital flow system to an exogenous one, have implications for policy outcomes; and so as non-bank financial markets develop and grow in Botswana, attention should be given to tracking the new effects on policy outcomes of financial flows affecting the liquidity system.

This paper proposes a simple framework to track the joint impact of policy choices on the degree of influence that monetary policy has. As seen earlier in Box 2, in a regime such as Botswana’s different policy choices can have positive or negative associations with the degree of influence that monetary policy has. The proposed DOMA tracking framework illustrated in Box 3 below for 2001-2016 helps in tracking the consistency between policies that is needed for policy effectiveness. It interprets developments in monetary autonomy and identifies what actions would rectify the loss of monetary policy influence. (Where corrective actions were in fact taken in the past, the actions are marked with an asterisk *).

The DOMA tracking framework should ideally be used to take a pre-emptive stance. Had it been applied in the 2000s, for example, then in 2002 as the DOMA index crossed below zero, corrective action could have been taken – with policy makers absorbing the surge in inflows of money with government or central bank long-term paper, probably in the 15-30 year maturity range; not with BoBCs. Currency devaluation and reserve accumulation would also have been undertaken earlier. This would have helped to prevent a decade of missed inflation targets, monetary instability, repeated real Pula appreciation and loss of price competitiveness.

<table>
<thead>
<tr>
<th>DOMA Event</th>
<th>Cause</th>
<th>Impact</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>sharp erosion of monetary autonomy 2001-2004</td>
<td>Significant drawdown of foreign reserves and Pula appreciation outweighs low stable BoBC issuance</td>
<td>Higher inflation, monetary instability, loss in price competitiveness, recession for non-mining producers</td>
<td>devaluation* – accumulate reserves*</td>
</tr>
<tr>
<td>partial recovery of monetary autonomy 2005-2008</td>
<td>Scaled-up reserve accumulation and Pula devaluation, outweighing scaled-up BoBC issuance</td>
<td>High inflation and monetary instability continue; but net positive impact for non-mining industry due to price competitiveness boost from the Pula devaluation; their real GDP growth rises to an average 12.9 percent in 2006-09</td>
<td>absorb earlier surge in inflows with adequate govt or central bank long-term paper, not BoBCs</td>
</tr>
</tbody>
</table>
### Box 3: Monetary Policy Influence (DOMA) Tracking Framework

<table>
<thead>
<tr>
<th>DOMA Event</th>
<th>Cause</th>
<th>Impact</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>erosion of monetary autonomy 2009-2010</td>
<td>High BoBC issuance, and significant drawdown of foreign reserves to historically low reserves/GDP ratio</td>
<td>Inflation remains above target.</td>
<td>- devaluation - replace BoBCs with long term paper – accumulate reserves</td>
</tr>
<tr>
<td>restoration of monetary autonomy 2011-present</td>
<td>Reduced BoBC issuance (enabled by lower liquidity and lower post global crisis imported and domestic inflationary pressures) and maintenance of stable foreign reserves/GDP levels, alongside pula depreciation against the dollar (assuming foreign reserves are primarily dollar denominated)</td>
<td>Low inflation and monetary stability sustained. Since the global recession, inflation has been contained in part by significant pula appreciation against the rand dampening already low import prices; however, the resultant real pula appreciation makes this an unsustainable policy strategy. Continued real pula appreciation and/or further drawdowns of foreign reserves will eventually erode monetary autonomy</td>
<td>- accumulate enough reserves to ensure DOMA is kept in the proximity of 100 in the 1991=100 index - reverse pula appreciation</td>
</tr>
</tbody>
</table>

In the framework illustrated in Box 3, it is important for both monetary and fiscal authorities to guard against actions that bring about the erosion of monetary policy autonomy (influence) below the 50 level on the DOMA index shown (with a 1991=100 baseline). Policy makers will benefit from measuring and monitoring monetary policy influence in order to ensure that the various policy choices that affect it are effectively managed to avert its excessive erosion.

Beyond this, consideration should be given to a re-calibration of the exchange rate formula to better anchor prices and ensure that the recurring erosion of price competitiveness due to real exchange rate appreciation does not occur. In this way, non-mining producers can then operate in a stable, predictable and competitive price and real exchange rate environment; enabling them to grow rapidly and to contribute to diversification, job creation and structural transformation.

### Funding

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this paper are exclusively those of the author. The author is also solely responsible for content and any errors.

References


[34]
BIS (2005), Foreign Exchange Market Intervention in Emerging Markets: Motives, Techniques and Implications, BIS Papers No. 24, Bank for International Settlements, Basel


Canales-Krilonenko, Jorge Ivan (2003), Foreign Exchange Intervention in Developing and Transition Economies: Results of a Survey, IMF Working Paper 03/95, International Monetary Fund, Washington DC


Frankel, Jeffrey (1994) Sterilization of Money Inflows: Difficult (Calvo) or Easy (Reisen)? IMF Working Paper WP/94/159, International Monetary Fund


Frenkel, Roberto (2010), Sustaining Sterilization Policy, G-24 Policy Brief No. 16


[36]


Ljungwall, Xiong and Yutong (2009) Central Bank Financial Strength and the Cost of Sterilization in China, CERC working paper No.8, Stockholm School of Economics


Mmegi Newspaper (2012a) “BoB interest expense falls to 10-year low”, 22 June, Gaborone, Botswana

Mmegi Newspaper (2012b) “BoB eyes further cuts to excess liquidity”, 03 July 2012, Gaborone, Botswana


Obstfeld, Maurice, Jay Shambaugh and Alan Taylor (2004), The Trilemma in History: Tradeoffs among Exchange Rates, Monetary Policies and Capital Mobility, NBER Working Paper 10396


Ouyang, Alice Y. and Ramkishen S. Rajan (March 2007), Reserve Accumulation and Monetary Sterilization in Singapore and Taiwan


Schadler, Susan, Maria Carkovic, Adam Bennett, and Robert Kahn (1993) Recent Experiences with Surges in Capital Inflows, Occasional Paper 108, International Monetary Fund


Annex I

Was the De Facto Policy in the 2000s based on an Exchange Rate Peg or on a Real Exchange Rate Rule?

“Several countries have adopted exchange rate rules that consist in depreciating the nominal exchange rate in line with a measure of the difference between inflation at home and abroad. ... to keep the real exchange rate constant. ... (Examples studied) suggest that the monetary authorities may no longer be able to control inflation if they set the nominal exchange rate according to a real exchange rate rule.”

Adam and Gross (1986), IMF Staff Papers

<table>
<thead>
<tr>
<th>Year</th>
<th>Monetary Policy Statements (excerpts quoted from statements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Bank of Botswana tries to keep the real exchange rate stable by having changes in the nominal exchange rate mirror changes in the inflation differential.</td>
</tr>
<tr>
<td>2002</td>
<td>Bank of Botswana targets the inflation rate needed to achieve stability in the real effective exchange rate and defines this target using the inflation differential with trading partners.</td>
</tr>
<tr>
<td>2003</td>
<td>Exchange rate policy aims to keep the nominal effective exchange rate of the Pula stable. The Bank seeks to achieve a rate of inflation that, at a minimum, will maintain relative stability in the real exchange rate and avoid the need for a devaluation of the Pula.</td>
</tr>
<tr>
<td>2004</td>
<td>The Bank aims to keep the nominal effective exchange rate of the Pula constant. Specifically, the policy is to peg the value of the Pula to a basket of currencies comprising the South African rand and the International Monetary Fund’s Special Drawing Right (SDR).</td>
</tr>
<tr>
<td>2006</td>
<td>(Crawling band exchange rate regime introduced in 2005). The Pula continued to be pegged to a basket of currencies comprising the South African rand and the IMF Special Drawing Right (SDR).... The crawling band arrangement adjusts the Pula in small continuous steps, based on the differential between the Bank’s inflation objective and the forecast inflation for trading partner countries on a forward looking basis.</td>
</tr>
<tr>
<td>2007</td>
<td>The objective of monetary policy is price stability, which also contributes towards achieving REER stability through attaining the level of inflation that is not higher than the average inflation of trading partner countries. To the extent that Botswana’s inflation objective is higher than the average inflation of trading partner countries, the nominal exchange rate has to crawl downwards in order to avoid the appreciation of the REER.</td>
</tr>
<tr>
<td>2008</td>
<td>The objective of monetary policy is price stability, which also contributes towards achieving a stable REER through attaining a level of inflation that is in line with the average inflation of trading partner countries. To the extent that Botswana’s inflation objective is higher than the average inflation of trading partner countries, the nominal exchange rate will crawl downwards to attain stability of the REER.</td>
</tr>
<tr>
<td>2009</td>
<td>Since 2005, the Bank has been implementing the crawling band exchange rate mechanism that is aimed at maintaining international competitiveness of domestic producers. In the short term, this is achieved through stabilising the real effective exchange rate (REER). In this arrangement, the annual rate of crawl for the nominal effective exchange rate (NEER) is determined on the basis of the differential between Botswana’s inflation objective and the forecast inflation for trading partner countries.</td>
</tr>
<tr>
<td>2010</td>
<td>In part, stability of the REER is attained through adjustment of the NEER of the Pula, but it could also be realised when domestic inflation is equal to inflation in trading partner countries. Thus, in instances where the inflation objective is higher than the forecast inflation in trading partner countries, a downward crawl of the NEER would be required to maintain international competitiveness of exports and domestic tradeable goods.</td>
</tr>
<tr>
<td>2011</td>
<td>If Botswana’s inflation differs from that of trading partners, a stable REER is attained through the adjustment of the NEER of the Pula. ... An important feature of the model is adjustment of the nominal effective exchange rate (through adjustment to the rate of crawl) in line with the inflation objective and underlying real trends.</td>
</tr>
<tr>
<td>2014</td>
<td>.... implementation of the crawling band exchange rate policy to support competitiveness of local producers.</td>
</tr>
</tbody>
</table>
Annex II

### Sterilization Policy Timeline

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-1980s</td>
<td>Monetary policy framework comprises both a managed exchange rate (peg) and an active monetary policy. June 1980 the country shifted its currency from a US$ peg to a basket (Rand and SDR) peg. Bank of Botswana used direct interest rate controls. Bank of Botswana Call Account used to absorb excess liquidity. Monetary policy allowed negative real interest rates to promote lending; but this enabled an inflationary environment amid rapid fiscal expansion (Govt. of Botswana, World Bank, 1989). Policy of low interest rates seen to cause disintermediation as banks turned away large deposits that they could not earn a profit on.</td>
</tr>
<tr>
<td>Middle 1980s</td>
<td>Growing mineral revenues and large balance of payments surpluses led to pervasive excess liquidity (Leith, 1996), derived from a structural excess of savings (from diamond sales) over investment. Attempts to use the call account at Bank of Botswana to mop up excess liquidity (sterilize) were unsuccessful as the real call rate at the time was negative. By extension, the real prime lending rate of commercial banks was negative. This approach was later seen by some as a tax on banks. Government and parastatals' deposits at Bank of Botswana also played a dominant role in sterilization, though this role was later reduced.</td>
</tr>
<tr>
<td>1991</td>
<td>Liberalization: Monetary policy reforms replaced controls on interest rates with market determined rates. In May 1991 open market operations with Bank of Botswana Certificate sales were used to absorb excess liquidity in the banking system. Call Account at Bank of Botswana discontinued.</td>
</tr>
<tr>
<td>Late 1990s – 2001</td>
<td>Bank Rate used as a signaling device. Reserve requirements used sparingly to help curb liquidity – seen to put commercial banks at a disadvantage vis-à-vis other institutions that provided similar services (Masalila and Phetwe, 2001). Theory also suggests that excessive reserve requirements may push up bank interest rates. Bank of Botswana reliant almost exclusively on BoBC sales to sterilize extra liquidity. BoBCs initially auctioned to a broad base including the whole financial sector (banking and non-banking) and major corporates; and could be held by individuals and firms through brokers or banks. Measures taken to refine the liquidity management framework with the introduction of short-term liquidity forecasting. BoBCs expected to achieve positive real interest rates (measured by effective yield on 3-month BoBCs) comparable to those prevailing in world financial markets, and to help attain price stability (Bank of Botswana Annual Reports). 1998 Monetary Policy Statement introduced. September 1998, repurchase agreements (repos) and reverse repurchase agreements (reverse repos) introduced to facilitate day-to-day liquidity management by commercial banks between BoBC auctions. Available to banks for periods ranging from overnight to one month (see Bank of Botswana Annual Reports). Secured Lending Facility (SLF) an additional short-term liquidity management tool. February 1999 exchange controls abolished and capital account opened. 1999 shift from an exchange rate peg with discrete adjustments in response to shocks, to a real exchange rate rule guided by the domestic-price inflation differential.</td>
</tr>
<tr>
<td>2000s</td>
<td>2002 - Annual objective for inflation of 4-6 percent introduced; 2005 – shift from a standard exchange rate peg to a crawling peg regime. 2006 - rolling 3-year inflation objective of 3-6 percent introduced. Commercial bank credit growth used as an intermediate target (BoB). The target growth for credit was defined as expected growth rate for GDP plus the inflation objective and two percentage points added to accommodate financial deepening (Bank of Botswana, 2015c). Policy tended to keep interest rates high through the sale of large volumes of BoBCs, in an effort to control liquidity and inflation. Policy also imposed restraints on bank charges and interest rate spreads (Jeffers and Kenewendo, 2011) in an effort to improve intermediation.</td>
</tr>
<tr>
<td>2006</td>
<td>March 2006 - BoBC auctions restricted to six commercial and merchant banks (nine banks in 2012). The rationale offered was that non-bank regulation was not in place at that time. Non-bank regulation has now been in place for at least five years (Regulator established in 2008) but the restrictions remain. Commercial banks’...</td>
</tr>
</tbody>
</table>
Sterilization Policy Timeline

<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-2010</td>
<td>Great recession saw collapse of mining GDP, halving its contribution to total GDP with a steep drop from 28.3 percent of GDP in 2007 to 13.5 percent of GDP in 2012; substantial decline in mineral export receipts. Created a post-crisis environment after 2010 with much lower liquidity pressures. Level of primary reserve requirements increased from 3.25 percent to 5 percent in February 2006 and from 5 percent to 6.5 percent in November 2010 and to 10 percent in 2011. Contributed to sterilization. 2008 – credit growth target dropped.</td>
</tr>
<tr>
<td>-&gt;2011</td>
<td>BoBCs sold in weekly auctions with maturities of 2 weeks to 1 year. Repurchase and reverse –repurchase agreement system manages short-term liquidity fluctuations. BoBC rate remains the policy rate. The Bank Rate is supposed to represent the charge by Bank of Botswana on loans to banks – however, little if any such borrowing occurs due to persistent excess liquidity in the banking system. The Bank Rate derives from movements in the BoBC rate and serves primarily as a signalling devise to banks, to adjust their rates.</td>
</tr>
<tr>
<td>2011</td>
<td>Noticeable decline in excess liquidity sustained (Bank of Botswana, 2013). Less sterilization needed. July and November 2011, the Bank of Botswana increased commercial banks' primary reserve ratios and capped Bank of Botswana Certificates (BoBCs) at P10 billion. Intention being to reduce the interest cost the Bank of Botswana was paying on outstanding BoBCs by reducing the amount of BoBCs available for auction, while limiting the liquidity held by banks (Mmegi Newspaper, 2012b). Reverse repurchase agreements allowed banks to invest funds overnight with the Bank of Botswana earning an interest rate pegged at 4.5 percent since December 2010.</td>
</tr>
<tr>
<td>2015</td>
<td>Low liquidity – Outstanding BoBCs declined from P17.7 billion end 2010 to P4.6 billion February 2015. April 1, 2015 primary reserve requirements halved from 10% to 5%, releasing over Pula 2 billion to augment commercial banks' loanable funds (Bank of Botswana, 2015b).</td>
</tr>
</tbody>
</table>
Annex III

Model Specifications for Monetary Policy Reaction Function and Capital Flow Equation

Following Ouyang et al (2007) and others, the Cumby and Obstfeld monetary policy reaction function (MFR) is given by:

$$\Delta NDA_t = \alpha_1 (CA+K)_t + \gamma_1 X_{it} + \varepsilon_t$$  \(5\)

where $\Delta NDA$ is the change in the central bank’s net domestic assets, $\alpha_1$ captures the degree of sterilization, CA is the current account balance, $K$ is the capital account balance and $X$ is the vector containing other variables that could also affect monetary policy actions.

As the sum of current and capital account balances (CA + K) in period $t$ is equal to the change in the central bank’s net foreign assets $\Delta NFA$ (from period $t-1$ to $t$)\(^{29}\), equation (5) can be written as:

$$\Delta NDA_t = \alpha_1 \Delta NFA_t + \gamma_1 X_{it} + \varepsilon_t$$  \(6\)

Equation (6) is a simplified monetary policy reaction function, where the coefficient $\alpha_1$ ranging between -1 and 0, measures the degree of sterilization (sterilization coefficient).

- When $\alpha_1$ is –1 sterilization is complete. The central bank fully neutralizes the increase in reserve money caused by the growth in the central bank’s net foreign assets, by reducing its net domestic assets (through BoBC issuance) by the same amount.\(^{30}\)

- When the value of the sterilization coefficient $\alpha_1$ is between -1 and zero, this means that the reserve money generated by the central bank’s intervention is not fully neutralized and some is left in the market; net domestic assets are reduced by less ($\Delta NDA < \Delta NFA$). Less sterilization has occurred.

- If $\alpha_1$ is 0 (no sterilization takes place), then the growth in net foreign assets translates into an equivalent increase in the domestic money supply.

For the MFR equation (6), changes in domestic monetary creation (represented by $\Delta NDA$) are determined by changes in foreign reserves (represented by $\Delta NFA$) and other independent explanatory variables. For explanatory variables in vector $X$ in equation (6) we take real GDP growth as the independent explanatory variable in the MFR equation. A positive sign is expected for the coefficient on real GDP because as real GDP increases, money supply and therefore NDA

\(^{29}\) $\Delta NFA$ can be thought of as the change in international reserves, $\Delta R$

\(^{30}\) In this scenario, the central bank purchases foreign exchange through interventions in the foreign exchange market and this creates reserve money; at the same time it uses BoBCs to withdraw all the money created from the market. Thus the change in reserve money is equal to zero, while the increase in NFA is equal to the reduction in the central bank’s NDA (due to increased liabilities via BoBC issuance).
increases. For the model to be statistically valid, the instrumental variables in the MFR regression need to be both correlated with the endogenous explanatory variable $\Delta NFA$, and uncorrelated with the residuals from the estimated model. The nominal exchange rate (SDR/Pula) is tested to ensure it satisfies these conditions (Annex IV gives rationale and results). The change in the exchange rate of the pula against the SDR was chosen as the instrument as the pula is pegged to a basket where the SDR is a key component.\textsuperscript{31} It serves as a nominal anchor. The central bank maintains the stability of the exchange rate through foreign exchange interventions which in turn impact changes in foreign exchange reserves (i.e. in net foreign assets) thus movements in the exchange rate are likely to be correlated with changes in net foreign assets. Since sterilization interventions (resulting in changes in net domestic assets) occur in response to reserve accumulation, changes in net foreign assets are likely to be endogenous to the system.

For the capital flow equation, the dependent variable is proxied by the change in the central bank’s net foreign assets ($\Delta NFA$), while the change in the central bank’s net domestic assets ($\Delta NDA$) which reflects the monetary policy sterilization action is the endogenous explanatory variable. In the standard capital flow equation, adjustment would be influenced by changes in the current account balance so this is included in the explanatory vector $Z$ in equation (7) below. In the Botswana experience, the inflows originated from a public sector pension policy decision that essentially transferred foreign reserves to domestic private entities that then brought some of the funds into the country. The influence of the real interest rate differential on capital inflows may not be a given; nevertheless, I used the capital flow regression to check whether the real interest rate differential as an independent variable in $Z$ based on interest rate parity theory (changes in capital flows are influenced by interest rate differentials), is a significant explanatory variable. If it is not, then its insignificance as an explanatory variable for capital flows probably reflects the special conditions under which sizeable capital inflows occurred in Botswana – where the inflows may have been influenced more by BPOPF wanting to and instructing domestic asset managers to increase the domestic component of the Botswana Public Officers’ Pension Fund (BPOPF) investment portfolio. For the instrumental variables in the regression, as before they need to be both correlated with the endogenous explanatory variable $\Delta NDA$ in equation 7, and uncorrelated with the disturbances. Tests are done to confirm this. Movement in the exchange rate of the SDR against the pula was again chosen as the instrument (Annex IV gives rationale). Since monetary sterilization is conducted via changes in net domestic assets, and by definition, sterilization is designed to offset the reserve accumulation effects of foreign exchange rate interventions that maintain the exchange rate peg, it follows that there’ll be correlation of the SDR/Pula exchange rate with changes in net domestic assets. Tests were also used to confirm the exogeneity of the instrument.

\textsuperscript{31} Initially the MFR regressions were run using changes in the exchange rates of the pula against both the rand and SDR as instruments, as the pula is pegged to a basket comprised of both the rand and SDR. However, the exchange rate against the SDR proves to be the more efficient instrument.
The capital flow equation is given as:

$$\Delta NFA_t = \beta_1 \Delta NDA_t + \delta' Z_j + \nu_i$$

(7)

where parameter $\beta_1$ is the offset coefficient. $\beta_1$ ranges between -1 and 0.

- When $\beta_1$ is -1, capital is fully mobile such that when authorities sterilize, the reduction in NDA is negated by an equal capital inflow which increases NFA, while the supply of money in the system remains unchanged. Sterilization is therefore not effective because the amount sterilized is replaced by new foreign exchange inflows of equivalent amount. This additional inflow then needs to be sterilized again.

- When $\beta_1$ lies in-between -1 and 0, then when authorities sterilize, the capital inflow still occurs, but it is less than the reduction in NDA, so part of the reduction in liquidity in the banking system due to sterilization is sustained.

- If $\beta_1$ is 0, then there is no capital inflow in the wake of sterilization and the policy is fully effective in controlling excess liquidity.

Theory tells us that the value of $\beta_1$ depends on the degree of capital mobility and the degree of substitution between foreign and domestic assets. With higher capital mobility and better substitution between foreign and domestic assets, $\beta_1$ is lower (closer to -1). Authorities then have less monetary policy autonomy (ability to control excess liquidity). With low capital mobility or low substitution between foreign and domestic assets, or both; $\beta_1$ is more than -1 and closer to 0. This suggests more monetary policy autonomy and should correspond to a high (absolute value) sterilization coefficient – reflecting a more efficient monetary policy.

Incorporating the variables selected for vectors X and Z as informed by Ouyang et al. (May 2007) and Ljubaj et al, 2010 (adapted to the Botswana context) into the MFR and capital flow equations gives equations (6’) and (7’) below.

$$\Delta NDA_t = \alpha_0 + \alpha_{1i} \Delta NFA_t + \alpha_{2i} \Delta GDP_{rt} + \epsilon_i$$

(6’)

$$\Delta NFA_t = \beta_0 + \beta_{1i} \Delta NDA_t + \beta_{2i} \Delta r_t + \beta_{3i} \Delta cab_t + \nu_i$$

(7’)

where:

$\Delta NDA_t$ = change in net domestic assets

$\Delta NFA_t$ = change in net foreign assets (less valuation adjustment)

$\Delta GDP_{rt}$ = real gross domestic product growth

$\Delta r_t$ = real interest rate differential (BoBC – US Treasury bill)

$\Delta cab_t$ = change in current account balance

with:
\[ \Delta x_{1} = \text{changes in the SDR exchange rate against the pula as the instrument in (6')} \text{ and (7')}^{32} \]

Given the simultaneity between \( \Delta NDA \) and \( \Delta NFA \) (as per Obstfeld, 1980 and Kouri and Porter, 1974), the MFR and capital flow equations are estimated concurrently using two-stage least squares (TSLS). Simultaneity should apply in the Botswana case for the MFR equation (6') and capital flow equation (7'). However, since the de-facto regime changes from a fixed peg to a crawling peg in the latter period examined – and the flexibility the crawl introduces may affect this simultaneity between \( \Delta NFA \) and \( \Delta NDA \), the endogeneity of the dependent explanatory variable has to be confirmed via diagnostic tests. Endogeneity of \( \Delta NFA \) in equation (6') and of \( \Delta NDA \) in equation (7') will be tested. For the capital flow equation, endogeneity of \( \Delta NDA \) may also be weakened by the role played by the public officers’ pension fund BPOPF, in bringing in capital inflows as the result of an exogenous policy shift. The inflows in this case are not determined solely by changes in the real interest rate differential but also by BPOPF policy decisions to increase their domestic presence – taking advantage of higher domestic returns based on the belief that their local fund managers understand the domestic economy and domestic risks. It is expected that these inflows may have played some role in offsetting sterilization efforts.

Studies that have estimated trade-offs between sterilization measures and capital flows, and between monetary policy autonomy and control of foreign exchange reserves with a framework including a monetary reaction function (MFR) and capital inflow offset measures, have used VAR models with predefined lag structures and no current period impact, or else have opted for the two-stage least squares (TSLS) method. This study needs to capture the immediate (current period) impacts of changes in explanatory variables (such as monetary and exchange rate variables) on the dependent variable so the VAR approach is not optimal. TSLS, an instrumental variables approach allowing simultaneity is used.

A small offset coefficient \( \beta_t \) alongside a large sterilization coefficient \( \alpha_t \) imply that the central bank has a high degree of monetary policy independence (autonomy) and is able to neutralize the impact of capital and mineral receipt inflows effectively and sustainably. On the other hand, a large offset coefficient implies an ineffective sterilization policy whose impact is not sustained.

---

\[ ^{32} \Delta M M_{1} = \text{changes in the money multiplier proved not to be a valid instrument for (7')} \]
Annex IV

Data Table, Unit Roots, Regression Results Table and Diagnostics

Annex Table IV.1: Variables used in estimation of net sterilization cost, monetary autonomy, MFR and capital flows

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eqn. 1 S</td>
<td>the net cost of sterilization</td>
</tr>
<tr>
<td>Eqn. 4 A</td>
<td>monetary policy autonomy index</td>
</tr>
<tr>
<td>Eqn. 6’ $\Delta$NDA (logs)</td>
<td>change in central bank’s net domestic assets (reflecting government deposits, BoBC issuance etc. less valuation adjustment)</td>
</tr>
<tr>
<td>Eqn. 7’ $\Delta$NFA (logs)</td>
<td>Change in central bank’s net foreign assets (approx. $\Delta$ foreign reserves)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eqn. 1 $L_1 i_{BoBC}$</td>
<td>the short-run domestic interest cost on BoBCs (financial cost of remunerated liabilities)</td>
</tr>
<tr>
<td>$L_2 i_{repo}$</td>
<td>the short-run domestic interest cost on reverse repurchase agreements (financial cost of remunerated liabilities)</td>
</tr>
<tr>
<td>$rRe^*$</td>
<td>the international interest earned on foreign reserves in Pula</td>
</tr>
<tr>
<td>Eqn. 4 R</td>
<td>the value of foreign assets accumulated in a given period</td>
</tr>
<tr>
<td>$L_1$</td>
<td>the value of domestic liabilities (BoBCs) outstanding in a given period</td>
</tr>
<tr>
<td>$L_2$</td>
<td>the value of domestic liabilities (rev. repos) outstanding in a given period</td>
</tr>
<tr>
<td>Eqn. 6’ $\Delta$NFA (logs)</td>
<td>change in net foreign assets (in reserves, $\Delta$R)</td>
</tr>
<tr>
<td>$\Delta$GDPR (logs)</td>
<td>real gross domestic product growth (annual)</td>
</tr>
<tr>
<td>$\Delta$XR (logs)</td>
<td>change in SDR-Pula exchange rate (regression instrument)</td>
</tr>
<tr>
<td>Eqn. 7’ $\Delta$NDA (logs)</td>
<td>change in central bank’s net domestic assets</td>
</tr>
<tr>
<td>$\Delta$CAB</td>
<td>Change in current account balance</td>
</tr>
<tr>
<td>$\Delta$XR (logs)</td>
<td>change in SDR-Pula exchange rate (regression instrument)</td>
</tr>
</tbody>
</table>

Note: BoB denotes Bank of Botswana Statistics; AR denotes annual report; IFS = International Financial Statistics
### Annex Table IV.2: Unit Root Tests Results

#### Regression Variables (all variables in logs)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels</th>
<th>First Difference</th>
<th>Order of Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept and Trend</td>
<td>Intercept and Trend</td>
<td></td>
</tr>
<tr>
<td><strong>Intercept</strong></td>
<td><strong>Intercept and Trend</strong></td>
<td><strong>Intercept and Trend</strong></td>
<td></td>
</tr>
<tr>
<td>Net Foreign Assets</td>
<td>-0.480386 (0.8871)</td>
<td>-3.611994 (0.3774)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Net Domestic Assets</td>
<td>-0.165586 (0.9366)</td>
<td>-1.585932 (0.7868)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Real GDP</td>
<td>-0.969074 (0.7583)</td>
<td>-4.796533 (0.0014)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Real interest rate differential (BoBC vs US T-Bill)</td>
<td>-2.349357 (0.1605)</td>
<td>-4.363715 (0.0052)</td>
<td>I(0)</td>
</tr>
</tbody>
</table>

#### Instruments Tested (all variables in logs)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels</th>
<th>First Difference</th>
<th>Order of Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept and Trend</td>
<td>Intercept and Trend</td>
<td></td>
</tr>
<tr>
<td>Money multiplier</td>
<td>-2.540999 (0.1112)</td>
<td>-2.509271 (0.3228)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Rand-Pula exchange rate</td>
<td>-1.613333 (0.4714)</td>
<td>-2.105684 (0.5349)</td>
<td>I(1)</td>
</tr>
<tr>
<td>SDR-Pula exchange rate</td>
<td>-0.973168 (0.7571)</td>
<td>-2.928643 (0.1613)</td>
<td>I(1)</td>
</tr>
</tbody>
</table>

Note: *, ** and *** denotes that a variable is stationary at 1%, 5% and 10% level of significance, respectively. The values in parenthesis denote the probabilities (P-values)
### Annex Table IV.3: Results of Simultaneous Estimation of Monetary Policy Reaction Function and Capital Flow Equation – Estimated using two-stage least squares and ordinary least squares in R-Studio (variables in natural logs)

#### MFR Equation: Dependent variable, ΔNFA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full Sample</th>
<th>Pre-Crisis Sample</th>
<th>Post-Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sample observations 57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Net Foreign Assets (sterilization coefficient)</td>
<td>IV (TSLS)</td>
<td>OLS</td>
<td>IV (TSLS)</td>
</tr>
<tr>
<td>Coefficient</td>
<td>T-statistic</td>
<td>Coefficient</td>
<td>T-statistic</td>
</tr>
<tr>
<td>-1.1</td>
<td>-23.9**</td>
<td>-1.1</td>
<td>-34.0***</td>
</tr>
</tbody>
</table>

Output growth, inflation, constant and dummy are all insignificant.

**Instrument:** Δ SDR/Pula exchange rate

#### Diagnostics

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Pre-Crisis Sample</th>
<th>Post-Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.943</td>
<td>0.983</td>
<td>0.808</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.942</td>
<td>0.982</td>
<td>0.801</td>
</tr>
<tr>
<td>Equation standard error</td>
<td>0.018</td>
<td>0.012</td>
<td>0.028</td>
</tr>
<tr>
<td>Wald / F-statistic</td>
<td>570.2 F(1,56)</td>
<td>1159 F(1.27)</td>
<td>42 F(1.27)</td>
</tr>
<tr>
<td>Probability (F-statistic)</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Weak instrument (H₀) test (J-statistic)</td>
<td>30.4***</td>
<td>29.4***</td>
<td>3.45</td>
</tr>
<tr>
<td>Wu-Hausman (H₀: exogenous ΔNFA)</td>
<td>7.396</td>
<td>11.921</td>
<td>3.961</td>
</tr>
<tr>
<td>Sargan (H₀: exogenous instrument)</td>
<td>0.116</td>
<td>0.176</td>
<td>0.041</td>
</tr>
<tr>
<td>Correlation (instrument and residuals)</td>
<td>0.045</td>
<td>0.079</td>
<td>0.038</td>
</tr>
</tbody>
</table>

#### Capital Flow Equation: Dependent variable, ΔNFA

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Pre-Crisis Sample</th>
<th>Post-Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sample observations 57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Net Domestic Assets (offset coefficient)</td>
<td>IV (TSLS)</td>
<td>OLS</td>
<td>IV (TSLS)</td>
</tr>
<tr>
<td>Coefficient</td>
<td>T-statistic</td>
<td>Coefficient</td>
<td>T-statistic</td>
</tr>
<tr>
<td>-0.84</td>
<td>-23.8***</td>
<td>-0.86</td>
<td>-34.8***</td>
</tr>
<tr>
<td>-0.86</td>
<td>-32.2***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Current account balance</td>
<td>--</td>
<td>insignificant</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Interest rate differential, output growth, constant and dummy are all insignificant.

**Instrument:** Δ SDR/Pula exchange rate

#### Diagnostics

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Pre-Crisis Sample</th>
<th>Post-Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.948</td>
<td>0.949</td>
<td>0.986</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.947</td>
<td>0.948</td>
<td>0.985</td>
</tr>
<tr>
<td>Equation standard error</td>
<td>0.01574</td>
<td>0.01567</td>
<td>0.01005</td>
</tr>
<tr>
<td>Wald / F-statistic</td>
<td>568 F(1,56)</td>
<td>1038 F(2,26)</td>
<td>40 F(1.27)</td>
</tr>
<tr>
<td>Probability (F-statistic)</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Weak instrument (H₀) test (J-statistic)</td>
<td>37.7**</td>
<td>24.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Wu-Hausman (H₀: exogenous ΔNDA)</td>
<td>0.741</td>
<td>8.301</td>
<td>0.892</td>
</tr>
<tr>
<td>Sargan (H₀: exogenous instrument)</td>
<td>0.081</td>
<td>0.8197</td>
<td>0.017</td>
</tr>
<tr>
<td>Correlation (instrument and residuals)</td>
<td>0.038</td>
<td>0.062</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Note:  *denotes significant at 0.1 percent, **denotes significant at 1 percent, ***at 5 percent.

Red coefficients show where the null hypothesis of an exogenous explanatory variable was not rejected, indicating the absence of endogeneity and confirming that OLS estimates are more efficient.

**IV (TSLS)**
In the diagnostics for the full-period analysis, the high and significant Wu-Hausman statistic in the monetary reaction function indicates that the null hypothesis that $\Delta NFA$ is exogenous in the equation (and IV-TSLS estimates are as consistent as OLS) is rejected. This confirms endogeneity of the explanatory variable $\Delta NFA$. Thus OLS estimates are inefficient and can’t be used. The valid estimates are therefore the two-stage IV estimates shown. The “weak instruments” F-test rejects the null of a weak instrument and confirms that the SDR/pula is a strong instrument, while the Sargan test cannot reject the null that the instrument is exogenous to the system, and this is confirmed by the near-zero correlation coefficient for the instrument and equation residuals. We can therefore conclude the SDR/pula instrument used is an efficient one.

The low and insignificant Wu-Hausman statistic in the full-period capital flow equation however, indicates that the null hypothesis that $\Delta NDA$ is exogenous in the equation (IV-TSLS estimates are as consistent as OLS) cannot be rejected. This means the OLS and two-stage IV estimates are similar and endogeneity may not be a big problem. Thus the more efficient OLS estimates should be used. Instrument tests are no longer needed since OLS estimates are used.

For the pre-crisis period, the diagnostics confirm the endogeneity of the explanatory $\Delta NFA$ variable in the monetary reaction function, and of the explanatory $\Delta NDA$ variable in the capital flow equation. Therefore the IV-TSLS estimates are the more efficient, valid estimates for the pre-crisis period. The diagnostics show the SDR/Pula instrument to be strong, exogenous and uncorrelated with the residuals of the regressions in the pre-crisis period. In the post-crisis period however, the exogeneity of the $\Delta NFA$ and $\Delta NDA$ explanatory variables cannot be rejected, and the OLS regression estimates are therefore the more efficient estimates in both the monetary reaction and capital flow regressions for the post-crisis period.

For the MFR regression therefore, diagnostics confirm that in the pre-crisis period, the exchange rate peg (peg to a basket roughly half of which is comprised of SDR) served as a nominal anchor, and the SDR/Pula exchange rate was correlated with changes in net foreign assets. After the crisis however, the new crawling peg regime weakened the exchange rate’s correlation with changes in net domestic assets (and the significance of the exchange rate instrument in the monetary reaction regression). Also in this latter period, $\Delta NFA$ is no longer endogenous to the system. With the exchange rate determined to a significant extent by market forces under the crawling peg regime and the need for and significance of sterilization reduced, $\Delta NFA$ which was endogenously determined prior to the crisis, is exogenous after the crisis.

In the case of the capital flow equation prior to the global crisis, while foreign currency transactions determined the level of the exchange rate peg and impacted foreign reserves, the extent of reserve accumulation in turn influenced the extent of offsetting sterilization requirements; hence the correlation of the SDR/Pula exchange rate instrument with changes in net domestic assets. In the post crisis period, however, the new crawling peg regime weakened the influence of the exchange rate peg on reserve accumulation and therefore weakened the SDR/Pula exchange rate’s correlation with changes in net domestic assets. At the same time, the
crawling mechanism took away some of the influence of changes in net foreign assets on sterilization decisions; as a result, ∆NDA which was endogenously determined prior to the crisis, is exogenous after the crisis.