Central bank securities and FX market intervention in a developing economy

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ABSTRACT

The Bank of Papua New Guinea has maintained an active policy of foreign exchange market intervention. This monetary tool is associated with a depreciating currency and a worsening shortage of foreign currencies in the domestic market – suggesting that at most the policy instrument leans against existing FX market pressure. However, the one-sided sales of central bank securities (or bills) engender an appreciation of the rate and an easing of the shortage in the domestic FX market. Supported by empirical evidence, we demonstrate that the one-sided sales of central bank bills perform like an instrument of monetary policy for foreign exchange market stability in the presence of persistent non-remunerated excess bank reserves.

KEY WORDS: Papua New Guinea, central bank bills, one-sided sterilization, foreign exchange intervention

1. Introduction

Central bank bills (or securities) are usually adopted as tools for mopping up excess reserves and enabling the development of liquid money markets (Gray 2006, Gray and Pongsaparn 2015, Gevorkyan 2015, Nyawata, 2012). While the liability-side central bank bills (CBBs) might indeed be useful for fostering money markets, this paper demonstrates empirically that there is more to CBBs. Specifically, the paper proposes that the central bank's one-sided sale of CBBs to the private sector perform like an instrument of monetary policy by stabilizing the exchange rate through easing demand pressure in the domestic foreign exchange (FX) market. The central bank sells the securities to the private sector which then holds them until they mature. Hence, we

use the term one-sided sale when referring to CBBs. Moreover, the term demand pressure and FX constraint are used interchangeably throughout the paper[1].

As an instrument for managing the exchange rate, one-sided sales of CBBs have implications for whether a small open economy could maintain monetary policy space while managing the exchange rate and having de facto capital mobility. The latter is an aspect of the well-known impossible trinity. One way of circumventing the impossible trinity is to prevent a hierarchy of monetary tools – as is the case of the primacy of the benchmark interest rate instrument under inflation targeting – while also maintaining the exchange rate as an explicit goal of policy (Kaltenbrunner and Painceira 2017). We argue that the one-sided sales of CBBs (or one-sided sterilization) present the central bank with an instrument of monetary policy that is consistent with an exchange rate goal.

Figuring out the degree of monetary independence under an exchange rate target (or goal) and de facto capital account openness has been a struggle as well as a preoccupation of researchers from developing and emerging economies. For example, Worrell (1995) notes that a corridor policy space exists under a fixed exchange rate with de facto capital openness because of the cost of conversion from national currency assets to foreign currency assets. Moreover, observing the factors accounting for the buildup of excess non-remunerated bank reserves help us in determining whether fiscal and monetary policy space exist under the impossible trinity. As it relates to fiscal policy, Primus et al. (2014) show that excess reserves in Trinidad and Tobago are largely determined by government spending. Furthermore, banks are likely to hold these excess reserves, at least for some time before they are neutralized by the central bank, if they also have to provide foreign currency to long-established customers – implying that the banks themselves may not want to jeopardize their business loan portfolio by denying FX to their historical debtors. Hence, the banks mainly convert excess reserves into

[1] Demand pressure or FX constraint is measured as the gap between the total sales and purchases of foreign exchange inside the private sector (by licensed dealers). In this paper, sales by licensed FX traders indicate the use of foreign currency for imports and investments in foreign assets. Purchases by licensed dealers indicate source of foreign currency from remittances, exports and other sources. Therefore, FX constraint = Total Sales – Total Purchases of private sector entities. A higher value of FX constraint shows a tightening of the constraint (worsening of demand pressure), while a lower value indicates an easing.

foreign assets after they have satisfied the FX demand of their established loan customers (Khemraj 2009)[2]. Finally, Khemraj and Pasha (2012) estimate that several Caribbean economies possess dual monetary goals – namely fixed/managed exchange rates and a monetary target[3] – while also allowing for a high degree of capital mobility. They argue that the highly oligopolistic banking structure in the Caribbean enables a markup of domestic private interest rate over the equivalent foreign rate, thereby preventing the complete adjustment implied by uncovered interest parity theory.

This paper proposes that the central bank's one-sided sale of CBBs is consistent with an exchange rate goal, thereby availing an unappreciated monetary instrument that could enhance policy space. The Bank of Papua New Guinea (BPNG) introduced CBBs as a tool for mopping up excess reserves in 2004. In addition, this central bank actively intervenes in the domestic FX market for the purpose of stabilizing the exchange rate – particularly, the pre-emption of rapid depreciation[4]. Several researchers associated with the BPNG underscore the importance of stabilizing inflation in that country by maintaining a predictable exchange rate (Vellodi et al. 2012, Ofoi 2018, David and Nants 2006, Samson et al. 2006). We also show empirically that FX interventions by the BPNG do not achieve the goal of exchange rate stability.

We motivate the expanded role of one-sided CBB sales by drawing on the idea of inside-outside security and money. Ronald McKinnon was one of the early scholars to

[2] Of course, this all depends on whether the country maintains some degree of monetary sovereignty by not having a very high degree of dollarization.

[3] Note, the monetary target is not the classic constant money growth rate. Instead, it involves an institutional forecasting framework (not necessarily an econometric one) for excess reserves. The central bank in these economies then sell a monetary policy security or Treasury bills to mop up the excess reserves in line with the institutional forecast.

[4] New evidence points to a nuanced view of undervaluation of the exchange rate. Benefitting from an undervalued exchange rate depends on the structure of the economy and whether the country has a vibrant manufacturing base from which to export (Ribeiro et al. 2020). Bahmani-Oskooee and Gelan (2018) demonstrate that exchange rate volatility could be harmful to trade performance in some African economies. However, they explain that trade performance did not respond adversely to exchange rate volatility in all African cases, thus allowing those economies greater flexibility (Ibid.). Vernengo and Perry (2018) outline how depreciation contributed to inflation in Argentina. Moreover, when a country on the periphery – such as Papua New Guinea – invoices its exports and imports in a dominant currency, a rapid depreciation could result in high exchange rate passthrough to inflation while not improving the trade balance (Gopinath et al. 2020).

present the inside-outside metaphor to illustrate how government bond sales influence international adjustment in a portfolio-balance model. He notes that the government security – sold by the central government to private agents – is an interest-earning outside security (McKinnon 1969, p. 208). Tobin (1989) also discusses the notion of inside-outside money. He suggests that when applied to money, the inside-outside dichotomy must only be used for the most liquid forms of money. Neo-Chartalists refer to monetary efflux, which essentially involves government injection of outside money into the private sector. Always careful in identifying institutional mechanisms, Neo-Chartalists trace monetary efflux to government payments from its central bank account (Wray 1998, Bell 2000, Tymoigne 2014)[5]. However, our framework differs from the Neo-Chartalists in two primary ways: (i) the government does not need to drain (create reflux for) previously injected outside money by using taxation; and (ii) exchange rate management requires leaning against the FX constraint by selling an interest-earning security (denominated in the national currency) to the private sector for the purpose of creating an alternative for FX securities.

Therefore, the empirical exercise involves estimating two vector-autoregressions (VARs) in order to assess the relative policy effectiveness of (i) foreign exchange interventions (hereafter FXI) and (ii) one-sided CBB sales. When the BPNG sells CBBs and foreign exchange to the domestic private sector, it produces a policy shock (intervention). The policy intervention causes an impact response and a dynamic adjustment over time in the key variables of interest: (i) exchange rate, (ii) FX constraint, (iii) excess reserves and (iv) government's account balance held at the BPNG.

The first key finding shows that FXI (a net sale) by the central bank, at best, leans against the FX constraint. More specifically, FXI is associated with a higher FX constraint (greater demand pressure) in the domestic market. Moreover, the same FXI is associated with a depreciation of the kina versus the dollar. This outcome is not surprising in light of a large body of literature observing the inconsistency of FX

[5] Also, see Lavoie (2013) for discussion of various institutional mechanisms pertaining to monetary efflux and reflux.

intervention in general and more specifically under inflation targeting (Kamil 2008, BIS 2013, Berganza and Broto 2012, Voltz 2015, Kaltenbrunner and Painceira 2017)[6].

On the other hand, a one-off CBB sale eases the FX constraint (reduces demand pressure) and appreciates the kina/dollar rate. We argue that the latter result occurs because the sale of CBBs offer the private sector an alternative interest-earning security instead of FX assets. In other words, the interest-earning outside security, emanating from the BPNG, replaces the non-remunerated outside money emanating from government spending.

The rest of the paper is set out as follows. Section 2 discusses the pertinent institutional features of Papua New Guinea. Section 3 spells out conceptually why one-sided sale of CBBs is a special monetary tool. Section 4 provides the empirical analysis and Section 5 concludes.

2. Some Stylized Facts

In 2001, the BPNG adopted a benchmark policy rate called the kina facility rate (KFR) to signal the monetary policy position of the central bank. In practice, adjustments in the KFR have been less frequent with the current rate maintained at 6.25 percent since its last change in 2012. Policymakers expected the KFR to affect market rates, particularly lending and deposit rates. To this end, the BPNG introduced a Repurchase Agreement Facility (RAF) and its interest rate is determined on a margin from the prevailing KFR.

One factor curtailing the use of the interest rate instrument, the KFR, is the persistence of excess reserves (Vellodi et al. 2012). Consequently, banks do not borrow from the BPNG or the interbank market – implying that the central bank does not need to inject liquidity for the purpose of shielding its benchmark interest rate target. In

[6] Another aspect of this literature looks at whether FXI could work effectively under inflation targeting Adler et al. 2019, Adler et al. 2020, Gosh et al. 2016, Ostry et al. 2012). Doubts remain, nevertheless; and in that context, compared with FX interventions, we feel that one-sided CBB sales could be more consistent with an inflation objective, particularly when the exchange rate is appreciating because of capital inflows. Here, as the central bank increases the monetary base from amassing international reserves, it simultaneously sells to private investors a security it creates (and denominated in the national currency) on the liability side of its balance sheet. The topic of inflation targeting, however, is beyond the scope of this paper.

fact, researchers from the BPNG find that the interest rate transmission mechanism does not work when there are excess reserves (Ofoi 2018, David and Nants 2006). However, these researchers contend that excess reserves do affect the exchange rate and by extension the rate of inflation.

Therefore, the BPNG introduced the use of CBBs in 2004 to sterilize or 'mop up' the excess reserves in the banking system. Several pieces of conventional wisdom motivate this action: (i) the contention that excess reserves stimulate credit expansion and excessively low interest rates (Saxegaard 2006); (ii) the need to nurture the development of money-market securities and manage excess reserves (Gray 2006, Gray and Pongsaparn 2015, Gevorkyan 2015, Nyawata, 2012); and (iii) the thesis that excess reserves induce agents to rebalance their portfolios, thereby causing spillover effects on the bond and foreign exchange markets (Dooley and Isard 1983, McKinnon 1969).

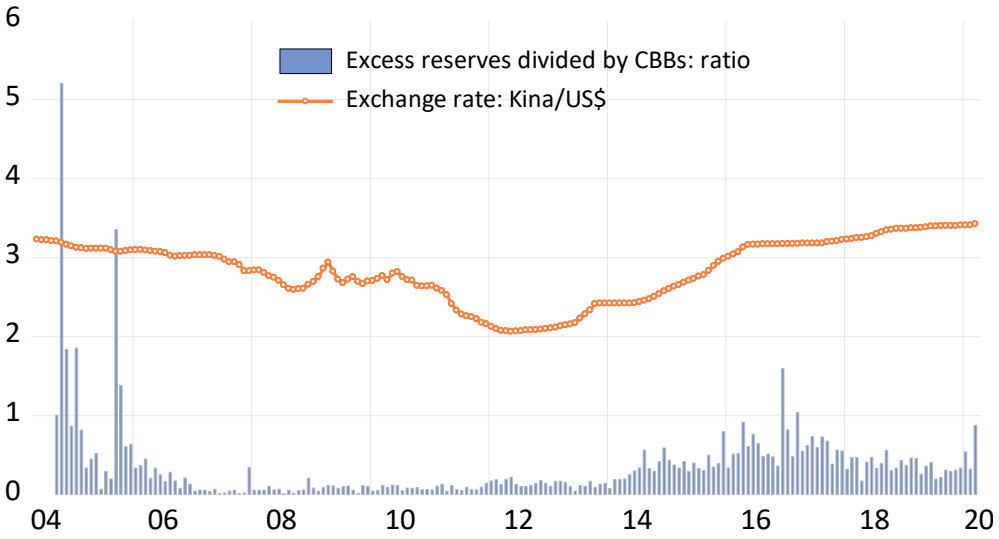
Figure 1 outlines the behavior of the exchange rate (Kina/US$) and the ratio of excess reserves to CBBs. The ratio of the stock of excess reserves to the stock of CBBs momentarily stood at over 5 for a few months prior to 2006, but subsequently declined to below one – indicating a high intensity of one-sided sterilization. By one-sided, we mean the BPNG sells CBBS, but never buys from a secondary market. The commercial banks demand the assets until they mature.

The ratio increased after 2012 and exceeded one on two occasions in early to mid-2017. Interestingly, the exchange rate tended to appreciate as excess reserves declined relative to the stock of CBBs. The exchange rate, on the other hand, displayed a long-term trend towards depreciation over the period coinciding with an increasing ratio of excess reserves to CBBs. This started to occur from around 2014. Nevertheless, even after 2014 the ratio mainly stayed below one.

The ratio fell below one for a substantial part of the review period, meaning the stock of CBBs exceeded the stock of excess reserves. The latter can only occur if the rate of change of CBBs exceeded the rate of change of excess reserves for many prior periods. This presents an interesting stylized fact of over-sterilization. However, as outlined later in the paper, we do not think of sterilization in conventional sense of two-sided open market operations. It should be noted, furthermore, that the BPNG undertook average monthly net FXI (net sale of foreign currencies) of US$76 million

over 2000: Jan to 2020: March. This implies that there will be a withdrawal of excess money balances in addition to the drain created by CBB sales.

Figure 1 Central bank bills, exchange rate and excess reserves – 2004: June to 2020: March



Years: 2004 to 2020: March

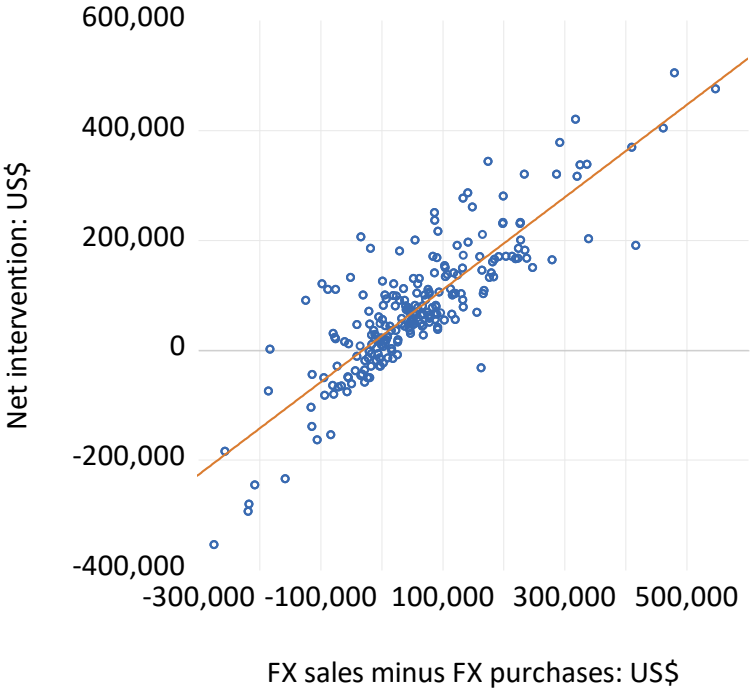
The phenomenon of one-sided sales, although known to policy makers, is unexplored as a tool of exchange rate management. This is a quantity-based instrument that not only mops up excess reserves, but also provides an investment alternative in the national currency. The mechanism has two unappreciated benefits: (i) it stabilizes the exchange rate; and (ii) by providing an alternative investment security, it frees up hoarding of foreign exchange and increases the stock traded in the local market. In other words, it eases the FX constraint or demand pressure – at least in the short run.

The central bank has been keen to sell foreign exchange when there is a shortfall (greater demand pressure) in the domestic market, an important stylized fact illustrated by Figure 2. This can be seen as an attempt to lean against the FX market pressure of constraint[7]. The FX constraint can be measured by the stock sold by banks

[7] Another measure of FX market pressure can be found in Aizenman and Hutchison (2012) and Gevorkyan (2019). Our measure of FX constraint uses sales and purchases by licensed dealers. The latter has a parallel in the literature on FX market microstructure focusing on order flow (Rime et al. 2010). However,

and licensed traders (use of foreign currencies for imports and foreign assets) minus the total stock purchases by same agents (source of hard currencies from exports, remittances, foreign grants and others) in a given month.

Figure 2 FX Sales – FX Purchases and net FX-market intervention



If the quantity sold in a month is greater than that purchased, then there is a binding constraint in the given period. On the other hand, when the purchases are greater than the sales, the market is in a temporary surplus. Therefore, in Figure 2, positive values on the horizontal axis indicate a binding constraint, while negative numbers a contemporaneous surplus. The net intervention by the BPNG is graphed on the vertical axis. Positive values indicate sales and negative ones show purchases from the local market.

our measure of FX constraint can only be interpreted as order flow if ex ante sales-purchases equal ex post sales-purchases. The fact that our data are ex post means that it better to interpret the measure as an FX constraint.

It is clear from Figure 2 that the central bank sells foreign currency when the private traders' sales are greater than the purchases – a binding constraint. In other words, the BPNG – on average – intervenes in the local FX market when there are more uses than sources of foreign exchange in a given month (increased demand pressure). We take this as evidence that the monetary authority leans against market pressure. Over the abovementioned review period, the average constraint is US$56.1 million. The central bank has a positive net sales average of US$76 million. The scatter plot is particularly tight indicating that it is less likely to be a spurious relationship. The unit root rest results presented in Appendix 1 show that both FXI and FX constraint are stationary variables, thereby making a spurious relationship less likely.

3. Conceptual Notes

This section introduces the operation of one-sided sterilization as a new instrument of monetary policy. The one-sided mechanism is different from traditional sterilization that is triggered by an increase or decrease in net foreign assets (NFAs) of the central bank. Here the central bank must possess enough domestic assets which it previously acquired from the secondary markets to neutralize the money injected when there is a change in its NFAs. Therefore, classic sterilization in the Mundell-Fleming world represents a rearrangement of the net wealth of the private sector. On the other hand, one-sided CBB sales indicate that the monetary authority is replacing the net injection of outside money with an outside security created for neutralizing the potentially disruptive effects of surplus money. Central bank bills, therefore, rearranges and expands the net asset position of the private sector.

Figure 3 Stylized balance sheets

Central Bank

Assets	Liabilities
Foreign Assets (F^{cb})	Monetary base (M0) (includes bank reserves R^b)
	Government deposit (D^g)
Domestic Assets (D^{cb})	Quarantined money from CBB sales

Aggregate Balance Sheet of Commercial Banks

Assets	Liabilities
Bank Reserves (R^b)	Broad Money (M1)
CBBs & Govt bonds	Net Worth (V^b)
Foreign Assets (F^b)	
Loans (L)	

Let us further consider the two interconnected stylized balance sheets expressed by Figure 3. First, we discuss the conventional sterilization and its accompanying symmetric or two-sided open market operations. An increase or decrease in F^{cb} must be reflected in M0, everything else constant. However, sheltering M0 from any change in F^{cb} requires open market operations by changing domestic assets (D^{cb}) in the opposite direction of the change in F^{cb}. Moreover, classic sterilization is motivated by the need to insulate the interest rate instrument from changes in M0 that occur owing to changes in F^{cb}. In this institutional set up, the central bank can sell domestic assets (which it previously bought from the secondary markets) to mop up bank liquidity associated with an increase in F^{cb}. On the other hand, it could buy securities to add to its stock of domestic assets when there is a decrease in F^{cb}.

Second, there is also the situation in which an increase in F^{cb} results in a corresponding increase in government deposit at the central bank (D^g) if banks use the excess money to purchase government bonds in primary auctions. The latter point is the market-driven or automatic compensation (sterilization) mechanism described by Ragnar Nurkse (Lavoie and Wang 2012, Korner and Ehnts 2013). This compensating sterilization also shields the interest rate instrument from FX-market interventions, according to Lavoie and Wang. These authors tested the compensating sterilization in

the case of China and found a cointegrating positive relationship between F^{cb} and government bonds. The positive cointegrating relationship was weaker between F^{cb} and D^{g}, as one can expect given the numerous factors affecting these deposits.

Third, the one-sided sterilization is not triggered by the change in F^{cb}, but by central government's injection of base money by writing cheques drawn on D^{g} and paying salaries of public workers by directly depositing funds into commercial banks. This aspect of money that finances government expenditure is *outside* money because it was not created endogenously *inside* the private sector. The government writes cheques on its deposit at the central bank after it has been replenished when the BPNG buys Treasury bills directly from the central government[8].

These government expenses emitted via D^{g} often result in non-remunerated excess reserves. Various frictions and demand-deposit volatility often result in these funds being stored as non-remunerated excess reserves by the banks before they can find an investment outlet in foreign assets[9]. The frictions do not last forever, causing the monetary authority to be particularly concerned with adverse adjustments in quantity and price of the FX market.

Hence, the need to create a liability-side security which quarantines the reserves on the liability side of the central bank's balance sheet. Therefore, the chain of events is as follows: (i) increase money expenses via D^{g} and salary payments will expand excess reserves that are a subset of M0; (ii) the central bank purchases T-bills directly from government to replenish D^{g}; and (iii) one-sided sale of CBBs by the central bank to compensate the private sector for switching from non-interest money to the interest-

[8] This can be seen by looking at the assets and liabilities of the central bank (BPNG, various years). The table shows that T-bills and inscribed stocks were bought by the BPNG from the central government. Also, a glance at the asset side of the balance sheet would indicate that the BPNG does not lend to commercial banks. The latter supports our contention that excess reserves are determined by outside central government injections. The task of the BPNG is to compensate the private sector with a central bank security in order to circumvent disruptions to the FX market.

[9] One friction is a risk-adjusted marginal transaction cost, according to Khemraj (2010). The author notes that when the risk-adjusted marginal cost is equal to the market loan rate, the commercial banks hold non-remunerated excess reserves as a perfect substitute. Khemraj (2009) also explains that an FX constraint (akin to a short-term shortage) restricts the demand for foreign assets – hence a demand for non-remunerated excess reserves. Saxegaard (2006) presents the deposit volatility thesis of excess liquidity.

earning security. Essentially, the CBBs complete the circle and swap out the non-remunerated excess reserves. This process creates a new profit center for the private sector in place of foreign-currency assets. One possibility is to make the interest payment commensurate with the bid-ask spread in the local foreign exchange market (Khemraj 2014).

One might be tempted to ask why is it necessary to sell a liability-based security. Would the same profit center be created if the BPNG just pay interest on excess reserves? There are two rejoinders to this. The first is the CBBs serve as a process of interest rate discovery considering the ineffective benchmark rate, the kina facility rate. Second, by offering an interest-earning national asset, the quantity of hard currencies traded in the local market will likely increase as market participants dishoard, thus releasing foreign exchange into the domestic market.

4. Empirical Analysis

This section explores the dynamic relationships among the two purported instruments and the goal of FX-market stability. In other words, we are interested in finding out whether a positive shock to CBBs (akin to a one-sided sale) and a same shock to FXI (similar to a net sales) result in stabilizing the FX market. FX market stability is illustrated by a slight appreciation of the kina/dollar rate and easing of the short-term FX constraint (market pressure). We are also interested in finding out how the intermediate target of excess reserves respond to a shock in CBBs and FXI. Given that excess reserves comprise the intermediate target for BPNG, we also want to know how a shock to this variable will affect exchange rate and the FX constraint.

It is obvious that these variables are endogenous to each other over certain lags in the variables. A VAR methodology is particularly useful for studying the impact response and dynamic adjustment of endogenous variables given an exogenous shock. The shocks to the policy instruments are exogenous in the VAR system once an identification methodology is utilized.

The first VAR we estimate is a stationary one. As can be seen from Appendix 1, CBBs and exchange rate are I (1) variables; while FXI, excess reserves and the FX constraint are I (0) variables. Therefore, we enter the first difference of CBBs and

exchange rate, the level of excess reserves, level of FXI, and level of the FX constraint (shortage). The usual conventions associated with estimating VARs are followed (Enders 2004, Pesaran 2015).

We do not make a commitment to the ordering of the variables and instead report the generalized impulse response functions (IRFs). We will justify a specific ordering of the variables for a theory-based or institutional-based VECM later in the analysis. Of particular importance is the lag length of the VAR. The final model has two lags in order to satisfy the Akaike information criterion (AIC), Schwarz information criterion (SIC) and no autocorrelation. Finally, all the roots of VAR lie inside the unit circle. The three highest roots are: 0.925, 0.654 and 0.520.

Figure 4 presents the first set of results, which we will describe by rows. The first two charts in the first row show the response in the exchange rate to a shock to our two policy variables: FXI and CBB. The first chart in the second row shows the response of the exchange rate given the shock to the intermediate target: excess reserves. To be precise, these three charts show the response in the first-difference of the exchange rate. It should be noted when reading the IRFs that the mean of the level of the exchange rate from Jan: 2000 to March: 2020 is 2.96 and 0.0024 for the first difference. Finally, the exchange rate is quoted indirectly (kina/US$), implying that a higher value indicates a depreciation of the kina and a lower value an appreciation.

The first chart shows that a positive shock to FXI (a net sale) produces a depreciation of the kina. This signals that the central bank's FXI is done mainly to lean against FX market pressure that already exists. Therefore, the net sales are merely signaling that the central bank is worried about the shortage or constraint in the FX market – hence the rate depreciates given a positive shock to FXI.

FIGURE 4 HERE: see end of manuscript

The second chart shows that the one-sided sale or positive shock to the first-difference of CBBs brings about an appreciating or stabilizing kina. The impact response of the kina in period t = 1 is around -0.005. As an aside, note that the software uses t = 1 for the impact period, which mathematically has to be t = 0 when calculating the impact response. This means for that t = 12 on the horizontal axis of the chart is actually t = 11 in the derivation, t = 11 in the chart is mathematically t = 10 when deriving the

IRFs, and so on[10]. For the rest of the paper, we will use the forecast time periods illustrated by the charts. The appreciating adjustment rose in period t = 2 to almost -0.01 and subsequently damped out until period t = 12. These numbers are quite substantial given that the sample average is 0.0024 for the first difference of the exchange rate.

A positive shock to excess reserves (an increase) produces a depreciation of the kina in period t = 1 and in subsequent periods. The impact effect is substantial and amounts to approximately 0.005 in period t = 1. In subsequent forecast periods, the depreciation persists given the same shock to excess reserves. The result underscores why this variable is an intermediate target – leaving excess reserves unsterilized could depreciate the currency. The one-sided sale of CBBs is meant to influence the FX market via the intermediate target. This fact is confirmed by the very last chart (bottom right). Here the first-differenced CBB shock elicits a -100 million kina decline in excess reserves in period t = 1. Excess reserves transition to a new stationary state by period t = 5 of approximately -30 million kinas – implying that CBB sterilization has a permanent effect on excess reserves.

Interestingly, the positive shock to FXI did not result in a decline in excess reserves – as we expect in the canonical sterilization story. This can be seen in the left chart of the bottom row. The impact response of excess reserves is around 20 million kinas. One reason for this apparent puzzle is the central bank might be selling foreign exchange to the government sector in larger amounts compared with the private actors. In this case, the positive injection into the FX market is followed by payments from government deposit that increase the monetary base (excess reserves being a subset).

Next, we discuss the dynamics of the FX constraint or market shortage. The second chart of the second row shows the response of the FX-constraint given the one standard deviation shock in FXI. The impact response is large and amounts to approximately US$90 million. This means that the FX shortage in the local FX market worsens when the central bank conducts net sales of foreign currency. There are two possible explanations for this unanticipated result. First, some of the net sales might

[10] Enders (2004) provides an excellent explanation of how to derive IRFs using first- and second-order difference equations.

be going to the government sector at a greater level compared to the private market. Hence, the intervention does not ease the shortage in the private sector. Second, a sale of foreign exchange by BPNG is a signal of market pressure and therefore agents are busy withdrawing foreign exchange from the market into hoarding and converting into foreign assets.

However, a one standard deviation shock to first-differenced CBBs produces an easing of the of the FX-market shortage. The initial-period impact response is around -30 million dollars. The shortage is further eased in period t = 2 by an amount of almost -40 million dollars. This further supports our argument that CBBs can stabilize the market price and quantity. It should be noted that the average monthly amount of foreign currencies bought and sold amounts to approximately US$1.04 billion.

The reasons for the positive quantity effect of CBBs are as follows. First, CBBs replace non-remunerated excess reserves with an interest-earning domestic security. Second, this produces a new domestic profit opportunity for banks instead of trying to convert excess money balances into foreign assets. Therefore, they are willing to dishoard and release more foreign currencies to the domestic market.

A second VAR model

This section estimates a second stationary VAR for the purpose of emphasizing a few key nuances. First, further evidence explaining the notion of one-sided sterilization is provided. Second, the government's deposit account at the central bank enters the VAR. Third, instead of using the FXI data, we use the change in the central bank's net foreign assets (ΔNFA). Using the latter variable makes the study consistent with many others who studied classic sterilization that is typically premised on two-sided open market operations (Aizenman and Glick 2008, Moosa and Bhatti 2010).

The usual protocols for estimating a stationary VAR are followed (Pesaran 2015, Enders 2004). Relating to the best lag length, the AIC suggested two lags and SIC one. However, two lags are needed in order to not reject the null hypothesis of no autocorrelation in the residuals. All the roots fall within the unit circle, with the four largest roots equaling: 0.896, 0.895, 0.650 and 0.456. Unit root tests on government deposit are mixed. The ADF test suggests marginal stationarity in the level while the Phillips-Perron test indicates stronger stationarity. In such a situation the series is likely

stationary but has long memory (Pesaran 2015). The level of NFA was found to be non-stationary while ΔNFA is stationary. Therefore, the VAR has the following variables: ΔCBB, ΔNFA, FX constraint, government deposit, excess reserves, and exchange rate (first difference).

Figure 5 reports the generalized IRFs with two standard error bands. The first two charts, top row, indicate the feedback relationship between CBB and NFA. Under classic sterilization, the central bank would hold a quantity of domestic financial assets which it uses to offset the effect a change in NFA would have on the monetary base. There is a short period of domestic assets, namely Treasury bills, which the BPNG bought from government (see: BPNG, various years). The series showing T-bills owned by BPNG starts from August 2012 is not long enough to be included in the second VAR. However, an error correction model is estimated and reported in Table 2A of the Appendix[11].

Returning to the IRFs, a positive shock to NFA (an increase) results in a positive response in CBBs amounting to about 60 million kinas. The left chart in the bottom row indicates that the same increase in NFAs is partly reflected in the monetary base given the positive impact on excess reserves as well as positive adjustment in excess reserves. Although economically important, the latter result comes with relatively wider standard error bands.

However, the same positive NFA shock engenders a positive impact effect on the government's deposit at the BPNG, as indicated by the left chart in the third row. The dynamic adjustment in this variable is also positive. The response in government deposit implies that the central bank is purchasing hard currencies from government-owned FX earners. The latter purchase increases the government's deposit just as the purchase of Treasury bills directly from government would. The positive deposit balance enables the government to write cheques from this account and in the process inject outside money into the private sector. A similar result was observed for the People's Bank of China by Lavoie and Wang (2012). In other words, the change in NFA is not always

[11] NFA and T-bills are not cointegrated in levels. They are both I (1) variables and the error correction model indicates a small sterilization intensity of around −0.082. The latter cautionary result appears, on the surface, to support the notion of classic two-sided open market operations-based sterilization (Moosa and Bhatti 2010).

reflected in the monetary base; hence, the sterilization mechanism is much more nuanced. Once the government's account balance is positive in the present period, it can then make payments to the private sector in future periods[12].

There is another important possibility relating to the positive impact response and adjustment of government deposit following the exogenous shock to ΔNFA. If state-owned enterprises that earns foreign exchange are not selling all hard currencies in the local FX market, but significant quantities to the central bank, then the market will perceive the amount of international reserves the BPNG holds as a source of confidence in the value of the kina relative to the dollar and other hegemonic currencies. This might account for the counterintuitive finding that net FX interventions by the central bank are associated with depreciation in the kina, and vice versa.

FIGURE 5 HERE: see end of manuscript

Furthermore, the positive response of CBBs in t = 1 and its adjustment up to t = 3 outline the mechanism of one-sided sterilization for the purpose of stabilizing the foreign exchange market. The increase in NFAs quarantines foreign exchange from the private sector, especially if state-owned enterprises are not able to unload all hard currencies into the private sector. This opens the possibility for private agents to bid up the price of the scarce hard currencies. Therefore, creating and selling a liability-side security, CBBs, just like creating outside base money, would enable the banks to earn interest income, even though not all the money injected from increasing NFAs is reflected as bank reserves. This mechanism, of course, raises interesting and perhaps major implications in the realm of political economy – a topic on which a tentative assessment is given in the Conclusion.

The exogenous increase in NFAs produces an appreciating response in the exchange rate, a result that corroborates the previous finding in Figure 4. Recall that in Figure 4, FXI measures the net intervention in which a positive shock indicates a net sale by the BPNG. Here a positive ΔNFA implies a net purchase (negative shock to FXI). The net purchase or positive shock to ΔNFA appreciates the exchange rate. It is likely,

[12] In some countries the government can have an overdraft or negative balance on this account. Guyana and Trinidad and Tobago are two examples. There was a period in the mid-1990s when the Barbadian government held an overdraft on its central bank account.

as noted above, that economic participants perceive a positive ΔNFA or negative FXI to be one of confidence. On the other hand, a negative shock to ΔNFA would be perceived as increasing FX market pressure.

In addition, the positive shock to ΔNFA produces a neutral or zero impact response on the FX constraint. This result is consistent with the idea that the BPNG is purchasing hard currencies from other government-based FX earners. As noted earlier, the FX constraint is a private sector variable of Sales minus Purchases of licensed foreign exchange traders (bank and non-bank) – a measure that should not be confused with the FXI of the central bank. At period t = 2, the positive NFA shock eases the FX constraint by about US$15 million. The delayed response and dynamic adjustment suggest that economic participants in the private sector are more likely to unload foreign exchange into the local market when there is confidence given the positive increase in NFA. Otherwise, when there is a negative ΔNFA, they may hoard some hard currencies in the hope of a depreciation that results in a capital gain in terms of kinas.

The positive shock to CBBs produces results that are largely consistent with findings from the first VAR model. We would therefore not repeat them here. An important new finding, however, is the negative impact response of approximately 58 million kinas in government deposit given the one-sided sale. The likely reason for the negative impact response has to do with whether the one-sided sales are meant for the next period fiscal spending or for monetary policy in the form of exchange rate management. If the one-sided sales are for replenishing the government's deposit for emitting future payments, then government deposit should increase following the positive ΔCBB shock. On the other hand, if monetary policy is of primary concern then the monies mopped up from the private sector enters a sterilization account not connected to the government's deposit account. The latter is indeed the case as the proceeds from CBBs are on the liability side of the balance sheet of the Bank of Papua New Guinea (see: BPNG, various years). Finally, the interaction between CBBs and government deposit is a topic that has been emphasized in the literature recently as it

pertains to the coordination between Ministry of Finance (or Treasury) and central bank – a topic beyond the scope of this paper[13].

5. Conclusion

The Bank of Papua New Guinea is known to intervene in the foreign exchange market. It aims to stabilize the exchange rate given its potential for adverse consequences. This paper demonstrated that interventions in the FX market are associated with existing pressure in the FX market – namely a depreciation of the rate and a tightening of availability for hard currencies. Therefore, this tool of monetary policy at best enables the central bank to lean against the existing market pressure. We uncovered a possible explanation for the counterintuitive result relating to FX market interventions. A positive change in net foreign assets of the Bank of Papua New Guinea might be associated with greater market perception of confidence. Therefore, a net intervention – a negative change in NFA – is seen as a sign of FX market shortage; therefore, the depreciation. We believe this might be related to the intra-governmental purchases of foreign exchange.

The established view holds that central bank securities are a tool for mopping up surplus money balances and for enabling the development of market-based financial instruments. True as that may be, we ascribe another important role for one-sided CBB sales: engendering a stable FX market. A stable FX market is defined as one with an appreciation in the rate and higher quantity of traded hard currencies (lower FX demand pressure) following a shock to the policy variable. We are not aware that this point has been made before in the literature.

The reason for this outcome has to do with the creation of an alternative interest-earning security in the national currency. In the terminology of inside-outside

[13] The institutional mechanism of coordination varies from country to country. For example, the United States Treasury regularly moves funds from the private commercial banks into the federal government's Treasury General Account at the Federal Reserve for the purpose of preventing a negative balance (Tymoigne 2014, 2020). In previous years there was greater connection between the Consolidated Fund and the Ways and Means account in the United Kingdom (Pantelopoulos and Watts 2021). In the case of Guyana, a developing economy, the central bank auctions Treasury bills for the Treasury. Most of the funds enter into the government's Consolidated Fund and are used for government payments in the next period. Only a small fraction enters the sterilization account, unlike Papua New Guinea. The Guyana case study of coordination between Treasury and central bank is the subject of an unpublished working paper which is not cited here.

money and financial assets, central bank bills – when sold to the private sector – are an outside asset, unlike the classic sterilization that uses two-sided open market operations to rearrange the existing financial assets inside the private sector. The outside interest-bearing security subsidizes the private sector for not investing previously injected non-interest surplus money balances (outside money) into foreign assets. In other words, the liability-based central bank security incentivizes the private traders to dishoard and release foreign currencies to the domestic market.

While beyond the scope of this paper, the mechanism of one-sided sales raises very important, and some might argue troubling, political economy questions. Instead of paying private agents interest income – which is an implicit subsidy – why not raise the required reserve ratio? On the one hand, an increase in reserve requirements would act as an implicit tax on bank revenue. If banks possess enough market power to make up the loss revenues in the FX market by increasing the bid-ask spread, that would adversely affect the exchange rate and perhaps quantity of FX traded in local market.

On the other hand, changing reserve requirements does not rearrange the composition or expand the stock of assets held inside the private sector. Instead, it quarantines a higher level of liquid reserves that implicitly levy a tax on revenues, as noted earlier. Preventing banks from trying to make up the revenues through hoarding foreign currency, and waiting for a currency depreciation, may require a domestic outside security that rearranges and expands the portfolio composition of the private sector. An implicit subsidy instead of a tax might be needed under a dominant fiscal framework[14]. Nevertheless, such a portfolio rearrangement will depend on the demand for the national security and currency.

Ultimately, however, these are tentative notes on political economy and a deeper assessment will depend on theory and empirics. In particular, one would need a clear identification of the winners and losers from a permanent currency devaluation or depreciation versus CBB-based interest income. Wage earners, banks and owners of capital will gain or lose income shares depending on the structure of production and

[14] Even under persistent fiscal surpluses these types of securities could be issued as the Australian example shows (Tymoigne 2020, p. 54).

the degree of dollarization given a devaluation (or depreciation) shock versus interest income.

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APPENDIX 1

TABLE 1A HERE

TABLE 2A HERE

Figure 4 IRFs from first VAR model testing FX intervention versus one-sided CBB sales

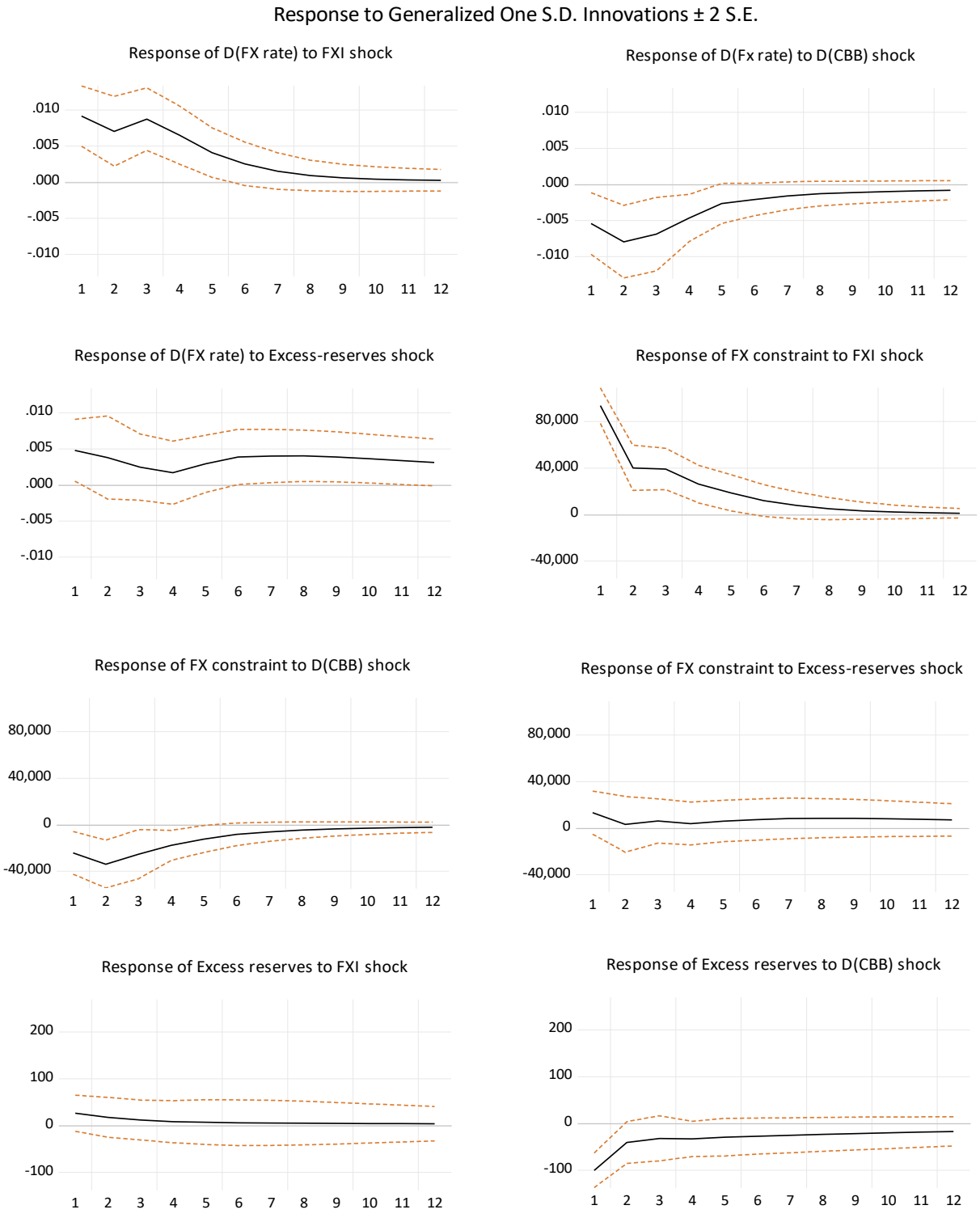
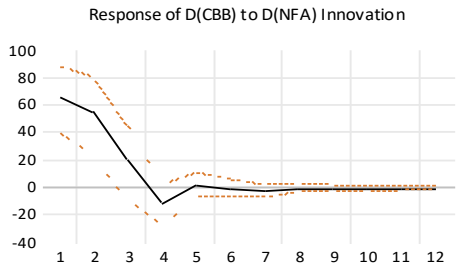
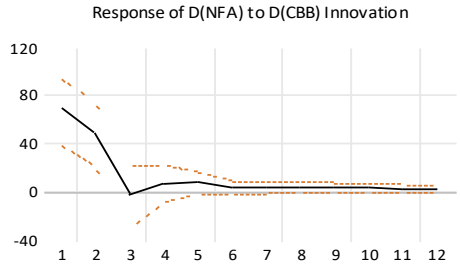
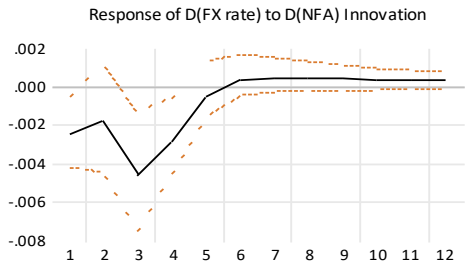
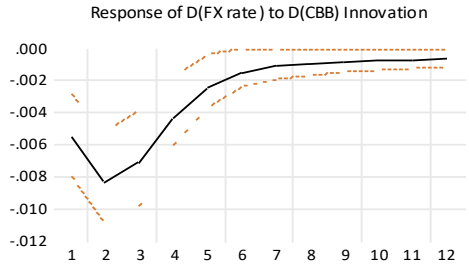


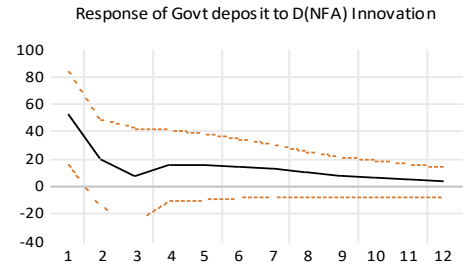
Figure 5 IRFs from second VAR model that includes government deposit and NFAs

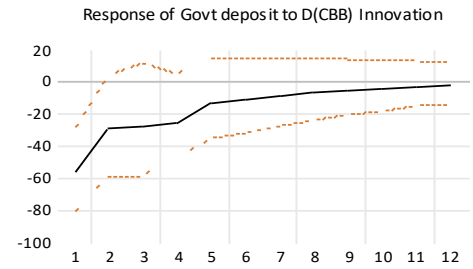


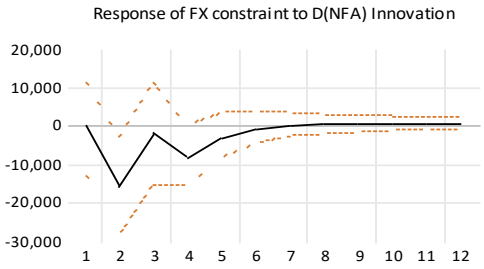


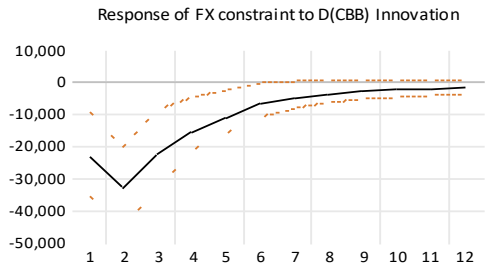


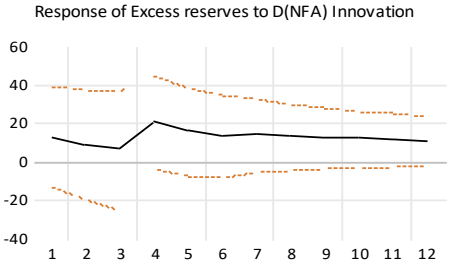












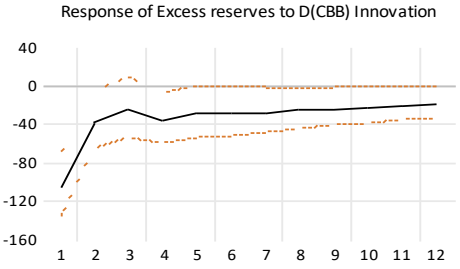


Table 1A Unit root test results

VARIABLES	ADF	Phillips-Perron	Features	OIG
Excess reserves	-4.25*	-8.83*	(C, T)	I(0)
FX Purchases	-0.89	-1.45	(C, T)	
D(FX Purchases)	-6.33*	-9.23*	(C, T)	I (1)
FX Sales	-1.26	-1.95	(C, T)	
D(FX Sales)	-7.62*	-10.95*	(C, T)	I (1)
FX Constraint	-6.88*	-10.30*	(C, T)	I (0)
Exchange rate	-2.11	-1.22	(C, NT)	
D(Exchange rate	-7.65*	-14.68*	(C,NT)	I (1)
CBBs	-1.55	-1.50	(C, T)	
D(CBBs)	-14.96*	-14.96*	(C, T)	I (1)
FX intervention	-5.00*	-8.33*	(C,NT)	I (0)
Interest rate	-2.10	-2.93	(C, T)	
D(Interest rate)	-4.92*	-10.59*	(C, T)	I(1)

* 1% significance
** 5% significance
D = first difference
OIG = order of integration
C, T = constant and trend
C, NT = constant and no trend

Table 2A Estimate of classical sterilization coefficient from an ECM

Dependent Variable: D(T-Bills)
Sample (adjusted): 2012M10 2020M12
Included observations: 99 after adjustments
HAC standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	P-value
Constant	0.353	15.312	0.023	0.982
D(NFA)	-0.082	0.036	-2.284	0.025
D(T-bills(-1))	0.305	0.095	3.195	0.002
R-squared	0.125			
Durbin-Watson stat.	1.977			
F-statistic	6.828338 (p-value = 0.001)			

D = first difference