NBG Working Papers

WP 02/2020

Sterilized FX interventions may not be so sterilized

by Shalva Mkhatrishvili, Giorgi Tsutskiridze and Lasha Arevadze

საქართველოს ეროვნული ბანკი
National Bank of Georgia

Sterilized FX interventions may not be so sterilized[*]

Shalva Mkhatrishvili,[†‡] Giorgi Tsutskiridze[‡] and Lasha Arevadze[‡]

April 2020

Abstract

It is widely believed that sterilized interventions do not affect domestic currency interest rates. The reason is the word "sterilized". Yet we show in this paper that when collateral base for central bank operations isn't huge, sterilized interventions may still affect interest rates, loan extension and, hence, real economy (beyond the effects of altered exchange rate). The mechanism is simple: when banks make decisions about loan extension and, hence, deposit (money) creation, they take liquidity risk into account. When collateral base for central bank operations isn't big enough, even if collateral constraint isn't currently binding, banks may still fear (massive) withdrawals that, in principle, can get them to the constraint. This fear is reduced when they get permanent liquidity (from the central bank that buys FX) as opposed to getting the same amount of liquidity by borrowing from the central bank (that requires collateral). Reduction in this fear will then result in loan interest rate reduction and/or easier terms for loans. We demonstrate the importance of this mechanism through three different approaches: accounting, theoretical and empirical. The quantitative importance of this channel depends on the amount of unused collateral: the more the collateral the lower the liquidity risk and associated interest-rate-effects of FX interventions. In addition, the framework provides other interesting insights about the relationship between liquidity risk and reserve requirements.

JEL Codes: E43, E58, F31

Keywords: Sterilized FX interventions; Interest rates; Collateral constraint; Central bank operations

[*] We would like to thank Archil Imnaishvili, Zviad Zedginidze, Gaston Gelos and Umang Rawat as well as our colleagues at the Macroeconomics and Statistics Department at the NBG for their useful comments and feedback. All errors and omissions remain with the authors.

[†] *Corresponding author*: Shalva Mkhatrishvili, National Bank of Georgia, Head of Macroeconomic Research Division (e-mail: shalva.mkhatrishvili@nbg.gov.ge)

[‡] Macroeconomic Research Division; National Bank of Georgia

Contents

1 Introduction

The widely accepted view is that sterilized foreign exchange (FX) interventions, in principle, have no effect on interest rates. The reason is that when central banks sterilize their FX interventions they essentially undo any effect that interventions may have on monetary base. With demand for domestic currency liquidity being unchanged, if the supply of it also remains unchanged, it is natural to expect that the price (money market interest rates) will remain the same. Indeed, having no effect on domestic interest rates is the way sterilized interventions are defined as such (e.g. Abildgren, 2005 or Benes *et al*, 2013). Some have even argued that an FX intervention does not have any effect on any variable and, hence, isn't an independent instrument (e.g. Backus and Kehoe, 1989).

To be sure, the literature has identified mechanisms through which the above claim can be countered. For instance, Kumhof and Nieuwerburgh (2002) develop a general equilibrium model that shows how sterilized interventions may affect the real economy. Yet, what they (and other related papers) claim is that sterilized interventions affect UIP risk premium and that is the channel through which they affect exchange rates. The theory that we develop below, and provide some empirical support for it, argues that there is another different channel at work - a liquidity risk channel that may affect domestic loan interest rates and, hence, other variables, including deposit (money) creation and the exchange rate.

This domestic currency liquidity channel of sterilized FX interventions works in the following way: when banks make a decision about loan extension and, hence, deposit (money) creation, they take liquidity risk into account. The risk is that the newly created deposits may get converted into cash and/or transferred into other banks accounts. This necessitates central bank money (reserves). Banks may have some (precautionary) reserves above the reserve requirements but more importantly they rely on the ability to get the liquidity from other banks (e.g. repo market) or from the central bank (e.g. central bank refinancing operations). These operations require eligible collateral. But, even if collateral constraint isn't currently binding, when collateral base for central bank operations isn't big enough, banks may *still* fear (massive) withdrawals/transfers that, in principle, can make the constraint start binding in the future. This is especially true in countries that have fragile inflation expectations and large amounts of foreign currency borrowing, where central banks may not be able to do massive liquidity injections (see Mishkin, 2001). Banks internalizing this feature will set high enough interest rates on domestic currency loans to reflect the liquidity risk premium.

However, this fear is reduced when banks get permanent liquidity from the central bank that buys FX as opposed to getting the same amount of liquidity by borrowing from the central bank (that requires collateral). Reduction in this fear will then result in loan interest rate reduction and/or easier terms for loans. Lower loan rates will increase the demand for loans and, hence, loan extension. Newly extended loans create new purchasing power (deposits) that then puts some pressure on the exchange rate (among other prices). Hence, this novel channel, working through loan interest rates, may as well explain the exchange rate effects of sterilized interventions and this may work on top of the traditional portfolio balance channel (see e.g. Branson and Henderson, 1985). This also means that having sufficiently large collateral base not only minimizes interest-rate-effects of sterilized FX interventions, but also leads to low liquidity risk on average. However, this is difficult unless the amount of near risk-free securities is abundant-enough.[1] This means that, additionally as a liquidity management tool, FX interventions could be considered as an independent policy instrument.

In addition to the conclusion that sterilized FX interventions may affect liquidity risk premium and, therefore, loan interest rates, we arrive at a number of other interesting results. Namely, our modeling framework shows that the level of reserve requirements may still matter for loan interest rates even in financial systems that operate under interest rate targeting framework. Also, the public's propensity to use cash instead of bank deposits also affects the loan interest rate setting (both through direct impact from policy rate as well as indirect impact on liquidity risk premium). On the other hand, the size of government bond portfolio (or other near risk-free and liquid assets)

[1]In other words, taking risky assets as collateral for central bank operations is a tricky task, as it is a quasi-fiscal step.

also affects interest rates. Namely, more government bonds may reduce loan interest rates (through lower liquidity risk premium) - an opposite to the crowding out channel. Finally, our framework shows that in 100% reserve banking, liquidity risk would either be zero (when collateral constraint for central bank operations isn't binding) or infinite (when it is binding). This shows how switching from fractional banking to full reserve banking would turn commercial banks into traditional intermediaries (as described by loanable funds theory) instead of being the major creators of (deposit) money.

Section 2 discusses the related literature, while Section 3 develops the argument for our new channel linking sterilized interventions and domestic credit conditions. Namely, Subsection 3.1 sets the stage by discussing the above mentioned mechanism through the accounting view. Subsection 3.2 develops a theoretical model that shows how profit maximizing banks set interest rates and react to central bank interventions. The following subsection shows empirically how important this channel has been for interest rate setting in Georgia and quantifies the effects, while Section 4 concludes.

2 Literature review

Our work is related to a relatively small number of papers in the literature that discuss macroeconomic implications of sterilized FX interventions mainly through its impact on lending rates, loan extensions and aggregate demand. Despite the size of the work done in this area, the results are mixed, some claiming sterilized FX intervention (buying FX) having expansionary effects on the economy while others strongly doubting such an outcome. Here, we review both strands of the literature with the emphasis on key arguments (empirical as well as theoretical) through which they arrive at their corresponding conclusions and then highlight the original contribution of our paper.

Firstly, let's discuss the most recent finding about negative effects of sterilized FX purchases on domestic credit growth and then follow backwards chronologically. Hoffman *et al* (2019) propose a model similar to the banking model of Bruno and Shin (2015) which implies that the purchase of US dollars by the central bank accompanied with the sale of domestic bonds slows down the supply of domestic currency credit. The model arrives there through two different but mutually enforcing channels. The first one is "risk-taking channel" of the exchange rate, as the authors name it and the second one is widely known "crowding out" channel. The "risk-taking channel" arises from the fact that borrowers have legacy debt in foreign currency (in this case USD) and, hence, are subject to balance sheet effects of the exchange rate. When the central bank intervenes by purchasing US dollars, given that USD appreciates against local currency, borrowing firms bearing USD debts on their balances become more vulnerable as a result of higher debt service cost. This increased vulnerability of the borrowers directly translates into higher tail risk for a loan provider bank with diversified loan portfolio. And given that banks follow Value-at-Risk (VaR) rule, higher tail risk dampens the pace of credit extension. The "crowding out" works in the following way: when the central bank sterilizes the FX intervention by supplying domestic bonds to be absorbed by private banks it reduces their lending capacity. This result follows from the technical specification of the model. More specifically, the banking model in the paper has two units - a loan unit which lends in pesos to corporate borrowers and a bond unit which holds risk-free sovereign peso bonds. The bank has limited equity which it divides between these two branches to maximize its profit. The authors then make an assumption that the bank keeps the ratio of bond holdings to bond unit's equity constant. Further assuming that bonds market always clears (equivalent to claim that private banks always absorb any amount of the bond supplied by the central bank) we get that when the central bank increases the supply of domestic bonds for sterilization purposes of FX intervention, equity of the private bank devoted to bond unit increases as well. Given that the total equity of the private bank is constant, lending unit has smaller portion of it left to lend out. Hence, the loan extension to private sector in domestic currency decreases. The crucial point in establishing such "crowding out" channel is the assumption of constant leverage of bond unit, which authors do not fully justify in the paper. Another assumption subject to debate is the one about the effect of intervention on exchange rate. While the results of empirical research is inconclusive about this in the short-run (Schwartz, 2000) the view that in the long-run exchange rate is anchored to fundamentals is more or less established (Mark *et al*, 2001; Engel *et al*, 2008). These implications of the model are further tested against the rarely available high-frequency data and the test results are positive i.e. confirming the implication that through the above-mentioned two channels sterilized FX interventions dampen the growth rate of domestic currency credit.

"Crowding out" channel, though not clearly articulated under such name, is the main mechanism through which sterilized FX interventions have real effects when financial constraints bind according to Chang (2018) as well. The author develops a dynamic model of a small open economy with the aim to resolve the ever-existing dissonance on the recognition of foreign exchange intervention as an independent macroeconomic policy tool between academic research and policy practice. The main feature of the model is that all assets that the public holds (FX reserves as well as central bank sterilization bonds) are denominated in foreign currency hence, excluding the widely known portfolio balance effect of FX interventions on domestic credit conditions. Rather, the paper specifies the conditions under which FX sales increases the domestic credit. The logic here is the following: There are financial frictions in this model, namely banks who borrow from abroad in foreign currency in order to lend to either households or government domestically are subject to financial constraints. In particular, they can can borrow only a fraction of equity injected by the households. Furthermore, there is an additional constraint on the amount of equity households could inject into private banks in each period. Given these financial frictions sterilized FX interventions yield real effects when the debt constraints bind. For example, the sale of official reserves relaxes these constraints by reducing the central bank's debt to domestic banks (reduction in outstanding central bank's sterilization bonds), freeing resources for the latter to increase the supply of domestic credit.

In much of the same spirit, Cespedes *et al* (2017) establishes the idea that financial frictions are preconditions for the so called "crowding out" channel to work. The model structure is more or less similar to the one discussed previously. In particular, there is a representative household, firms, banks and two goods in the economy. Differently from Chang (2018), firms have their endowments which might even be negative meaning that they bear liabilities. Also, differently from the previous model there is no notion of nominal money. Instead everything is measured in terms of the tradable good. Furthermore, there is only two periods in the model: In the first period economic agents take debts, i.e. banks borrow from the world market and firms borrow from the banks in turn, while in the second period they settle their debts. The one distinctive feature of the model is the way collateral constraint is formulated. Formally, it states that the profit of the bank must be no less than the fraction of gross return from loans but intuitively it means that banks have no incentive to breach the promise to the rest of the world and do not default. Hence, collateral constraint is more like incentive compatibility constraint. In this set-up sterilized intervention takes form of spending foreign reserves on buying nontradables while providing them back through credit line or debt repurchase. Hence, such intervention is effectively equivalent to credit policy involving only tradables. Such perspective on sterilized interventions elucidates why they may have real effect on the economy. In other words, "monetary authority" is supplying tradable goods i.e. relaxing the friction when it binds and stimulate loans which are denominated in tradable goods. The technical formulation of the model and its implications allow the authors to suggest that neither portfolio balance view nor signaling view is necessary to claim that sterilized interventions can have real effects on the economy. As a result, the model suggests that sterilized intervention could be deemed as being equivalent to simpler credit policies.

In contrast to the theory presented above, Vargas *et al.* (2013) posits that FX intervention (buy), if effective through the portfolio balance channel, has expansionary effect on credit supply and aggregate demand. This result is the direct implication of a small open economy DSGE model with financial sector, comprising of private banks and the central bank. The real sector of the model is standard as is widely spread in the profession. As for the financial side, private banks maximize their cash flow subject to a technology constraint which describes the substitutability between central bank bonds and private loans. This constraint lies in the center of the result stated above. Since private loans and central bank bonds are not perfect substitutes and the respective returns differ, when the central bank purchases foreign reserves in exchange for domestic bonds, private banks optimal decision is to balance their asset composition by lowering the interest rates on commercial loans leading to the surge in domestic credit and aggregate demand.

Gadanecz *et al* (2014) carry out empirical test of the proposition that FX purchases by altering the composition of balance sheets of commercial banks in emerging market economies (EMEs) stimulate bank lending. The authors find that in a well capitalized banking systems, holdings of government and central bank papers over time lead to an expansion in their credit to the private sector. Such outcome is robust and is present at both country and bank level. While performing panel data analysis they are actually testing two hypothesis. First, the existence of "crowding out" effect of FX intervention (Bernanke and Blinder, 1988, Kuttner and Lown, 1988, and the three papers discussed above) meaning that FX purchase by the central bank and then sterilizing by supplying risk-free bonds leads to lower credit to the economy and, the second, the existence of credit expansion effect by providing liquidity buffers for private banks through the sterilization leg of the FX intervention (Kashyap and Stein, 1997). The authors find that when well capitalised banks' holdings of government and central bank securities, as a ratio of their credit stock, rise by one percentage point, their lending growth increases by 0.2 percentage points two years later. This estimates are statistically and economically significant and are further confirmed based on bank-level data.

Our theoretical model as well as its empirical investigation contributes to the second strand of the literature claiming that sterilized interventions (FX purchase) can have positive real effects on the economy through the impact on lending rates and the credit extension. In particular, we recognize the importance of liquidity constraint that private banks take into account when deciding their optimal portfolio allocations. Furthermore, under our set-up sterilization does not necessarily require the issuance or purchase of government securities. Instead, as it is the case for inflation targeting frameworks operating under structural liquidity shortage, sterilization happens automatically through central bank borrowing instruments (refinancing loans or some kind of standing facilities in the central bank). Building on this, in the next section we describe the theoretical model accompanied with accounting view for better exposition.

3 Interventions and interest rates

In this section we develop a theory of the liquidity risk channel of FX interventions and provide some empirical support for it for the case of Georgia. However, before we proceed directly to the theoretical model and estimations, for easier exposition it is useful to discuss the accounting implications of FX interventions. This is the topic of the next subsection.

3.1 Accounting view

For accounting the ultimate impact of the FX intervention in a simple way, let's consider how the FX purchase by the central bank affects its own as well as commercial bank balance sheets. Let's assume that prior to the FX intervention central bank and the commercial X bank[2] balance sheets have the following form[3]:

Figure 1: Initial central bank balance sheet

Liabilities	Assets
Commercial Banks' Reserves (GEL)	Refinancing Loans

Figure 2: Initial X bank balance sheet

Liabilities	Assets
Deposits (GEL)	Loans (GEL)
Refinancing Loans	Reserves (GEL)

In other words, at a given point in time, X bank has outstanding **GEL Loans**[4] and correspondingly, **GEL Deposits**. For managing liquidity risk or complying with reserve requirements it has outstanding **Refinancing Loans** on the liability side and, hence, **GEL Reserves** on the asset side.

[2]X bank, in this case, represents the whole banking sector.

[3]In reality, balance sheets are more complex and consist of more items, however for better exposition of the impact of the intervention we abstract from other details and include only the relevant items.

[4]Throughout this section GEL (Georgian lari) would represent domestic currency in general.

Now suppose that, having earned $1 from economic activity (e.g. exports), a person deposits this $1 on her account in X bank. This activity will be reflected on X bank balance sheet in the following way:

Figure 3: X bank balance sheet after depositing $1

Liabilities	Assets
Deposits (GEL)	Loans (GEL)
Refinancing Loans	Reserves (GEL)
Deposits (USD) ***$1***	***Foreign Currency*** ***$1***

The question is what happens if the central bank decides to intervene and purchase that $1 from the commercial bank (X bank). For this purchase, the central bank creates new reserve money which represent its liability towards society and then transfers it to the commercial bank in exchange for $1. Following this operation balance sheets of the corresponding banks will be:

Figure 4: Central bank balance sheet after intervention

Liabilities	Assets
Commercial Banks' Reserves (GEL)	Refinancing Loans
1 GEL/USD	***Foreign Reserves*** ***$1***

Figure 5: X bank balance sheet after intervention

Liabilities	Assets
Deposits (GEL)	Loans (GEL)
Refinancing Loans	Reserves (GEL)
Deposits (USD) ***$1***	*1 GEL/USD*

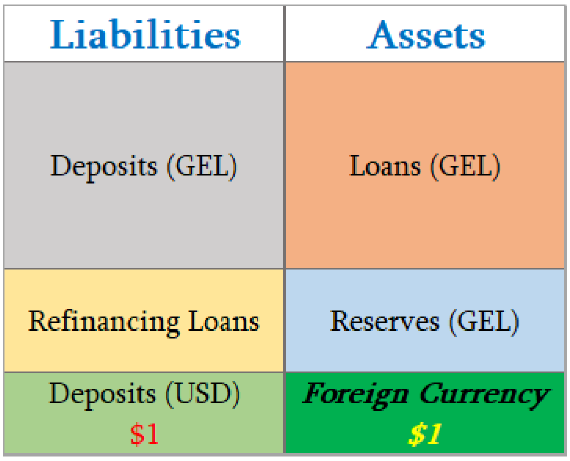
Following this intervention, X bank now has an open FX position (in particular, it has a dollar deposit on the liability side of the balance sheet, but has no corresponding dollar asset, since it has exchanged **$1** for **1GEL/USD**[5] Georgian laris). Maintaining an open FX position in sufficiently large amount is prohibited[6] due to banking regulations. There are three basic possibilities (or their combination) for X bank to close its FX position. Each of them is shown in yellow on the following diagrams:

1. **Acquisition of US dollars using GEL cash**[7], which shows up on X bank balance sheet as shown on Figure 6.

2. **Acquisition of US dollars in exchange for GEL deposit** which shows up on X banks balance sheet as shown on Figure 7.

3. **Incentivize US dollar deposit owner (clearly, using the price mechanism) to swap her US dollar deposit for GEL one**, which shows up on X bank balance sheet as shown on Figure 8.

Figure 6: X bank balance sheet after purchasing US dollars using GEL cash on the FX market



Since each of the above mentioned possibilities increases demand for US dollars, exchange rate will temporarily depreciate (compared to **no-intervention case**) while X

[5]**1GEL/USD** denotes the amount of Georgian lari X bank receives from the central bank in exchange for 1 US dollar. For example, if X bank sells 1 US dollar for 2.8 Georgian laris, then **1GEL/USD** = 2.8.

[6]At the same time, X bank must satisfy minimum reserve requirements which will automatically be met after closing its FX position.

[7]X bank can withdraw its reserves from the cash center of the central bank and purchase US dollars from the private (non-bank) sector on the FX market.

Figure 7: X bank balance sheet after purchasing US dollars using GEL deposit

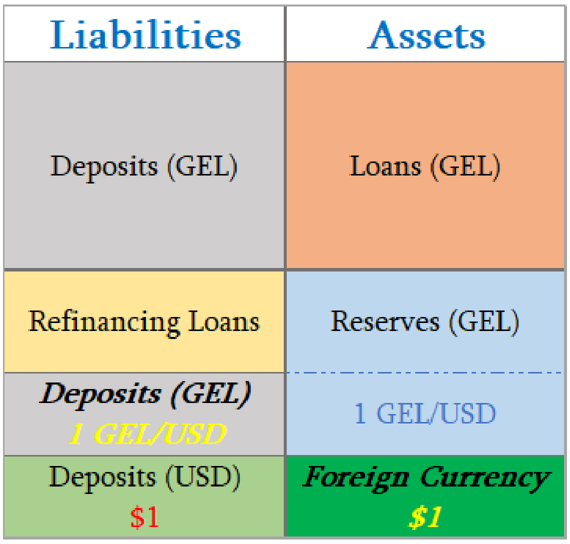
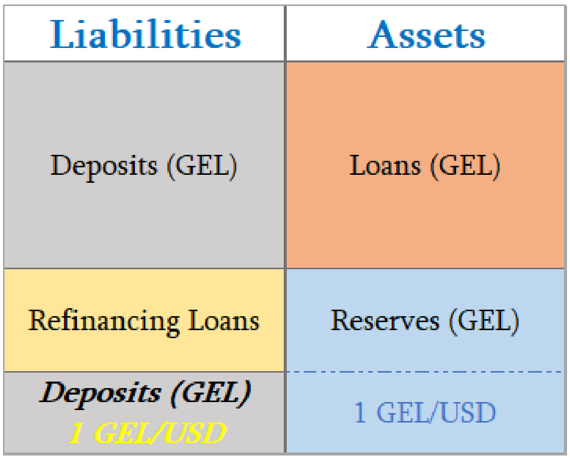


Figure 8: X bank balance sheet after "larization" of the dollar deposit



bank closes its FX position. This mechanism so far (of affecting the exchange rate) has been traditional portfolio balance effect. Since USD and GEL are not perfect substitutes in portfolio holdings of the private sector, trying to switch between this two would result in price (i.e. exchange rate) changes[8].

Now let's consider what happens afterwards. And this is where our novel mechanism starts playing, which, as mentioned above, works on top of the traditional portfolio

[8]Note also that, while the first and third options for closing an open FX position do not change the size of X bank balance sheet, the second option does - it stretches it by the amount of $1. Hence, capital adequacy regulations (something we don't consider here) may disincentivize X bank in following the second option.

balance channel. In the first case (Figure 6), when X bank buys 1 USD using GEL cash, it accrues excess liquidity in FX (but *not* in GEL, at least not yet). Seeking profit maximization, the bank's optimal decision would be lending out in USD, hence creating new USD deposits (X bank can do this because it has excess US dollar cash[9] and, hence, its liquidity risk is low enough). As a result, similar to no-intervention case, USD loans will increase[10] and this concludes the first-round effects of the intervention. However, after the non-bank sector realizes that now it has more GEL cash (domestic currency liquidity), if the demand for cash is the same, this excess amount of cash will move from non-banks to banks (i.e. deposits). This will then eventually create excess GEL liquidity for X bank. In short, given demand for liquidity isn't changed, FX purchase by the central bank will create an excess of liquidity in the private sector, at least until sterilization happens (discussed below).

In the second (Figure 7) and third (Figure 8) cases, on the other hand, X bank has excess liquidity in GEL right away[11]. In our example, X bank has **0.95 GEL/USD** GEL in surplus[12] (given reserve requirements for GEL stands at 5%), that can be used for:

1. Purchasing collateralizable (mostly government) securities[13]
2. Reducing demand for refinancing loans (i.e. automatic sterilization)
3. Issuing new GEL loans

However, as shown below only the combination of the 2nd and 3rd options are plausible. To show this, let's discuss each of them separately:

1. **Purchasing government securities**

[9]Here, we assume that reserve requirements for USD are lower than 100%.

[10]Note that, compared to no-intervention case the quantity of USD in real economy will be lower (since the central bank bought it and took out of the economy). In other words, cash dollarization (currency substitution) will probably decrease, while financial dollarization (asset substitution) will be the same as in the absence of intervention.

[11]In the second case, liquidity is in surplus for both USD as well as GEL, while in the third case, only for GEL.

[12]For supervisory purpose, liquidity requirements might be more stringent, however this doesn't change qualitative results; only the amount of surplus will be lower.

[13]We call collateralizable securities the ones that are included in the collateral base of central bank operations.

We might think that X bank would use existing excess liquidity to buy some high quality near-risk-free (e.g. government) securities. Why not put excess reserves into use in such a way that has no risk? If done so, it would have **0.95 GEL/USD** worth of government securities on the asset side of the balance sheet while depleting GEL reserves by the same amount. As a result, X bank will hold less reserves (**-0.95 GEL/USD**) at the central bank, but at the same time, net position of the government deposits will increase on the liability side of the central bank balance sheet (**0.95 GEL/USD**).

Figure 9: X bank balance sheet after purchasing the securities

Liabilities	Assets
Deposits (GEL)	Loans (GEL)
Refinancing Loans	***Reserves (GEL)*** 1 GEL/USD *-0.95 GEL/USD*
Deposits (GEL) 1 GEL/USD	***Government Securities*** *0.95 GEL/USD*

Figure 10: Central bank balance sheet after the purchase of securities

Liabilities	Assets
Commercial Banks' Reserves (GEL) 1 GEL/USD *-0.95 GEL/USD*	Refinancing Loans
Government Deposits *0.95 GEL/USD*	Foreign Reserves $1

Though, there appears a rhetorical question: if the commercial bank wanted to buy government securities why had not it done so before and why had it been waiting for the FX intervention? Since government securities are the most liquid assets (near equivalent to reserves), X bank did not even need the liquidity provided through the intervention operation to purchase such assets[14]. For example, even in the absence of sufficient liquidity to purchase government bonds, it could borrow the money from some other commercial bank, buy government bonds, then take a refinancing loan from the central bank by collateralizing the bonds (haircut on such securities is usually almost 0%[15]) and return the original loan to the other commercial bank. There is another way as well: a commercial

[14]Here, we assume that providing excess liquidity does not change inter-bank lending rates as commercial banks can always deposit excess money to the central bank standing facility and, hence, earn interest. The width of the interest rate corridor set by the central bank is assumed to be narrow enough.

[15]Clearly, if haircuts are large, then the story changes.

bank could have used required reserves to buy government securities (since it can temporarily breach reserve requirements without violating, in our case, 2 weeks average) and then meet the reserve requirements again using refinancing loans from the central bank obtained by collateralizing the government bonds.

Following the logic above, if commercial bank wanted to purchase government bond, it could have done so without the intervention. Consequently, if X bank did not buy such securities before the intervention, it would not buy them after either (*ceteris paribus*), even if it has excess liquidity now. This conclusion is partly based on the assumption that operational framework of the central bank is credible and market participants do not expect any quantitative restrictions on liquidity supply. As this assumption is realistic (see IMF, 2017), hence, we can finally conclude that X bank will use the existing excess liquidity for other purposes and the intervention will not bear on interest rates of government securities per se.

2. **Reducing demand for refinancing loans**

   A much more realistic path for X bank to follow is that it might use excess GEL liquidity to reduce the demand for refinancing loans. As borrowing from the central bank is costly, it can reduce the amount of refinancing loans, since this amount of liquidity is not necessary given the amount of GEL deposits at X bank. If X bank does so, following this operation, X bank balance sheet shrinks on both asset (reduction in reserves) as well as liability side (reduction in refinancing loans). Central banks balance sheet shortens correspondingly (both compared to immediate post-intervention condition).

   Now the critical point here is whether X bank will reduce refinancing loans one-for-one (i.e. by the amount of **0.95 GEL/USD**). The answer depends on the amount of unused collateralizable assets[16] X bank holds. If this amount is big enough (as is usually assumed), then X bank will reduce refinancing loans one-for-one and easily solve the excess liquidity issue. In other words, if X bank wanted

[16] I.e. those assets that can be used for collateral in central bank operations but has not yet been used.

Figure 11: X bank balance sheet after reduction in refinancing loans.

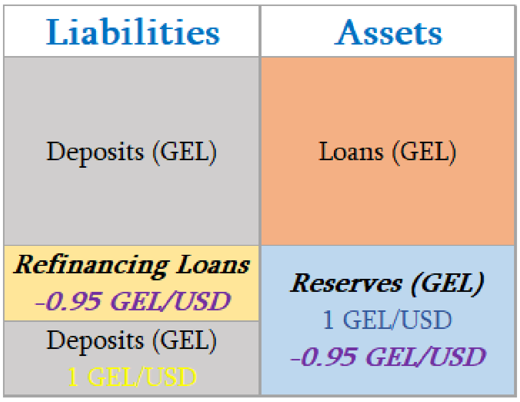
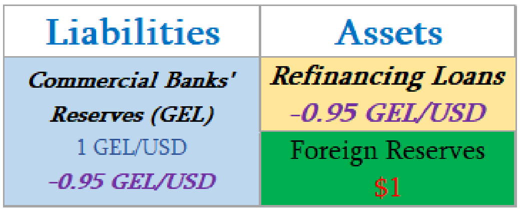


Figure 12: Central bank balance sheet after reduction in refinancing loans.



this liquidity (for issuing new loans and, hence, creating new deposits) it could have also got it through borrowing from the central bank (using its collateral).

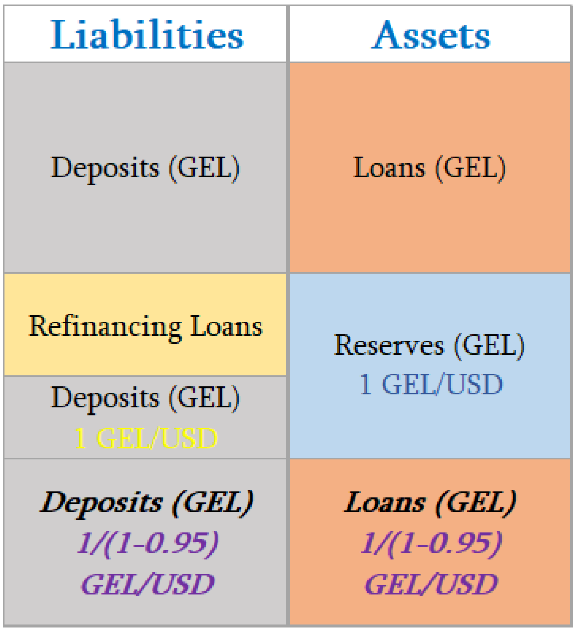
But, in some developing economies where financial sector is in its early stages, commercial banks might not have that much collateralizable assets. In our example, this means that X bank may had been wanting additional liquidity before, but it wasn't able to borrow from the central bank (because of collateral constraint). Whats more important, even if X bank had enough liquidity for *current* market conditions, it may still had been refraining from extending new loans. The reason is that new deposits created by new loans may at some point in the future get converted into cash or transferred in other commercial banks and this would had necessitated additional liquidity in the future, for which X bank may already not have sufficient collateral.

3. **Issuing new GEL loans**

In other words, this *fear* of future deposit withdrawals or transfers and, hence, future possibility of hitting the collateral constraint may had been a constraining factor for X bank in extending new loans. But as X bank now has additional GEL liquidity *without* borrowing it from the central bank (and, hence, without employing the scarce collateral), it may now be more confident in its ability to meet future liquidity needs, so that it may be more inclined to issue new loans by incorporating lower liquidity risk premium in loan interest rates (i.e. lower probability of hitting the collateral constraint). In that case, X bank will issue new loans, consequently create new deposits and meet the reserve requirements using the currently-excess liquidity. The reason why X bank will follow this path is that it increases profitability from additional financial intermediation (that's what commercial banks do for a living - making money from maturity and liquidity transformation).

Graphically, this situation will be depicted in the following way: By issuing new loan X bank creates new deposit of equal size. As a result its balance sheet stretches in size. In our simple example, the rate of increase depends on the reserve requirements[17] and is equal to $\frac{1}{1-0.95} = 20$. As a result X bank balance sheet will take the form:

Figure 13: X bank balance sheet after issuing new GEL Loans



Differently from purchasing government securities, here we cannot argue that X bank could have issued these loans before central bank FX intervention. The reason is that haircut on such assets (private loans) is extremely high and usually

[17] In reality issuing new loans is restricted not only by reserve requirements but, more importantly, capital requirements and many other factors (e.g. Liquidity Coverage Ratio, etc., that can be more binding than reserve requirements). We can ignore them without loss of generality.

it equals to 100% (when it is not included in the collateral base). For example, if X bank issues new consumer loan and creates new deposit, it will need additional liquidity (for reserve requirements and daily operations). And since consumer loans cannot be used as collateral for refinancing loans from the central bank, X bank might find it difficult to get new liquidity (given that most of government securities have already been used as a collateral in the central bank operations).

As a result, if we have a situation where collateral base is binding (meaning that all appropriate assets have already been collateralized) or, more realistically, where there is a meaningful probability that it may become binding in the future (think of a probability of a bank run), by supplying additional liquidity through FX intervention, commercial bank has an opportunity for issuing new loans and earning additional profit. Consequently, it will be willing to reduce interest rates on these new loans (compared to no-intervention case) in order to create additional demand for loans. Thus, we have a situation where while FX intervention does not affect risk-free interest rates (e.g. government bond yields), market interest rates on risky assets (loans), that are not included in collateral base of the central bank, will fall. In other words, we get that intervention might influence not only the exchange rate but domestic currency loan interest rates as well. This is equivalent to monetary policy rate cut with all of its consequences for aggregate demand, exchange rate and inflation.

Clearly, if we consider intervention the other way around (selling USD and withdrawing GEL liquidity), then the result will be a mirror image of what we described above. More specifically, in response to FX intervention, exchange rate will appreciate, X bank will reduce the issuance of new loans and at the same time, increase interest rates on new loans (again, given collateral constraint is a possible threat). To conclude our analyses of central bank interventions from accounting point of view, when collateral base is either already binding or, more realistically, when there is a probability of collateral constraint being binding in the future, even sterilized FX intervention (defined as making sure short-term risk-free interest rates do not change) might still mimic monetary policy tightening/loosening.

3.2 Theoretical view

After setting the stage by the above accounting exercises, here we obtain analytic representation of the dependence of loan interest rates on FX interventions. In other words, in this subsection we develop a theoretical model that shows how a profit-maximizing bank would take the collateral constraint for central bank operations into account when setting interest rates on loans and deposits. Although the model we consider here can easily be made part of a general equilibrium framework, here we consider only the banks' optimization problem (i.e. taking demand for loans and deposits as given - something that will probably come out of households' or other agents' optimization problem). Looking at the banks' problem is sufficient, for our purposes, to see how interest rates would depend on the collateral base and central bank liquidity injections or withdrawals (e.g. through FX interventions). In our model the central bank has the following balance sheet:

Central bank

Assets	Liabilities
(R) Refinancing loans	Reserve balances (Q)
($\bar{R}^{fx}$) FX reserves	Cash in circulation (C)

While each commercial bank's balance sheet is the following[18]:

Commercial bank

Assets	Liabilities
(L) Loans	Deposits (D)
(Q) Reserve balances	Refinancing loans (R)
($\bar{S}$) Securities	

The variables with bars over them indicate that they aren't modeled here endogenously - their values are determined outside our framework (something that could be relaxed while applying the approach to a general equilibrium model).

[18] We abstract from capital adequacy issues, since this is a different topic and, while introducing more complexity, would not alter our qualitative results.

Within our model, when the central bank conducts an FX intervention, even if through commercial banks, it eventually buys (sells) FX from (to) non-banks, since our assumption is that the banks have closed FX position[19]. Hence, from the central bank balance sheet above we can see that the only way for the central bank to provide permanent liquidity to the economy is through FX interventions[20].

We also assume that the central bank remunerates reserve balances with the policy rate ($\bar{i}$). Refinancing loan rate and yield on securities both equal policy rate (i.e. we abstract from term premium for simplicity). Loan rate (i^L) and deposit rate (i^D), in turn, come from banks optimization problem. Hence, given these decisions in our model, monopolistically competitive commercial bank's profit reads:

$$\Pi = (i^L L + \bar{i}Q + \bar{i}\bar{S}) - (i^D D + \bar{i}R) - \alpha Prob(R > \bar{S}) \tag{1}$$

Here all interest rate parts are standard interest revenues and costs. The crucial new term here is α which, in our model, will be nonzero (weight given to the probability of $R > \bar{S}$). This would mean that each commercial bank, to some extent (depending of the value of α), fears the possibility of refinancing needs (R) exceeding the available collateral for central bank operations ($\bar{S}$). The interpretation of α can be both from market as well as regulatory perspective. In terms of the former, the bank may fear a bank run (liquidity crisis) and, hence, bankruptcy excluding this particular bank from future profits (given re-entry into banking sector would, as in real world, be costly - e.g. attracting a customer base once again is difficult). In terms of the regulatory perspective, the bank may fear a liquidity crisis, because the supervisory authority may impose large regulatory burden in that case (which could also reduce future profits). Even if central bank widens the collateral base and accepts other assets (like loans), the terms would still be more costly. In any case, running out of liquidity (obtaining which

[19]Even if we relax this assumption, results wouldn't change much.

[20]We could have easily included central bank operations with government bonds, but it would not have changed the final results. Buying government bonds does not relax the collateral constraint, as the bond owner becomes the central bank.

requires collateral) is costly and the higher α higher is this cost in our model. Given that in real world bank runs are something that everybody in the banking system tries to protect themselves from, it only makes sense to assume nonzero α.

In addition to this new term (that creates a constraint for optimization problem), the banks face additional constraints, like demand for loans and deposits or reserve requirements and balance sheet identities. More specifically, how much loans can each bank extend depends on overall loan demand ($\bar{L}$), how different is this bank's loan interest rate relative to the market average ($\bar{i}^L$) and how high is the elasticity of substitution (ε) - standard result of CES aggregation. Then, each bank must maintain reserve balances that at least satisfy reserve requirements (rr). Deposit demand also restricts the banks from setting interest rates below the policy rate (by more than a markdown $\frac{\varepsilon-1}{\varepsilon}$). Balance sheet identity requires that banks assets and liabilities be always equal. Finally, the demand for refinancing loans from central bank depends on a number of things: how high is the reserve requirement (rr), how much does the public cash out their deposits on average (c), stochastic component of public's demand for cash ($\hat{e}$)[21], for which banks need central bank liquidity, and how much permanent (non-borrowed) liquidity did the central bank provided ($\bar{R}^{fx}$), in our case through FX interventions[22]. Hence, bank's profit maximization problem reads[23]:

[21] Here profit means the next-period profit, since the banks decide on interest rates and the profits realize afterwards. Hence, given the stochastic component $\hat{e}$, there is some uncertainty surrounding profits that the banks are trying to maximize. This is the reason why we have $Prob(\cdot)$ in the model.

[22] Note that cash in circulation $C = cD + \hat{e}$.

[23] In effect, we are considering such banking systems which do not incentivize holding excess reserves and, hence, commercial banks only obtain the central bank money when they need it for either reserve requirements or satisfying the demand for cash.

$$
\begin{aligned}
\max_{i^L, L, Q, i^D, D, R} \quad & \Pi = \left(i^L L + \bar{i} Q + \bar{i}\bar{S}\right) - \left(i^D D + \bar{i} R\right) - \alpha Prob(R > \bar{S}) \\
\text{subject to} \quad & (i) \quad L \leq \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon} \bar{L} \\
& (ii) \quad Q \geq rrD \\
& (iii) \quad i^D \geq \frac{\varepsilon - 1}{\varepsilon}\bar{i} \\
& (iv) \quad L + Q + \bar{S} = D + R \\
& (v) \quad R = Q + cD + \hat{e} - \bar{R}^{fx}
\end{aligned}
$$

First order conditions of this optimization problem, after some manipulations, yield the following equation for setting the loan interest rate[24]:

$$
\boldsymbol{i^L} = \frac{\varepsilon}{\varepsilon - 1}\left[\frac{1}{1+c}\boldsymbol{i^D} + \frac{c}{1+c}\bar{\boldsymbol{i}} + \alpha\frac{rr + c}{1 - rr}\boldsymbol{f}\left(\bar{S} + \bar{R}^{fx} - \frac{rr + c}{1 - rr}L\right)\right] \tag{2}
$$

where $i^D = \frac{\varepsilon-1}{\varepsilon}\bar{i}$ and $L = \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon}\bar{L}$, while f (a probability density function)[25] represents liquidity risk premium. This premium, usually absent in DSGE models that feature banking systems, is the central part in our analysis.

The most important result here, for the purposes of this paper, is the dependence of liquidity risk premium on central bank FX interventions. Namely, whenever central bank buys FX reserves, it swaps borrowed reserves into non-borrowed reserves. Hence, even if the total amount of reserve money is unchanged (i.e. intervention is sterilized), the refinancing needs decline. The latter in turn increases the amount of free (unused) collateral and, hence, lowers the probability of reaching the collateral constraint in the (low-probability) event of bank run in the future. This, in turn, reduces the liquidity

[24] The detailed derivation is shown in the appendix.

[25] We remain agnostic about the functional form. We just do not consider cases when refinancing needs are already above the collateral base, in which case liquidity risk premium would be infinite (banks will just have to de-leverage right away or default). For positive values of its argument x, $f(x)$ will be a decreasing function.

risk premium and, therefore, loan interest rates. Lower loan rates induce more borrowing, which, on its own, creates new purchasing power (deposits). This new money will then temporarily stimulate the real economy (including through exchange rate depreciation). Clearly, the channel works in the opposite direction, when the central bank sells FX reserves. What's crucial for the quantitative importance of this non-linear channel is the distance between the amount borrowed from the central bank and the available collateral. The smaller this distance the more elastic could the liquidity risk premium be to changes in FX reserves. In other words, the process is non-linear: if the need for borrowing from the central bank declines from a large value, liquidity risk also declines significantly, but if this need declines by the same amount from a small value, liquidity risk may not change much (and remain close to zero).

In addition to the main result above, the following interesting insights (some of them trivial, some of them usually overlooked) can also be extracted from the above optimization problem. According to our loan interest rate setting equation:

- Liquidity risk premium, in addition to FX reserves, depends on reserve requirements. This may be a surprise result to standard analysis of interest rate targeting frameworks. Whenever short-term interest rate is the operational target of the central bank, the level of reserve requirement, the argument goes, should not matter, because if it is high or low the required reserves will always be provided by the central bank so that short-term interest rates do not change. This argument, however, misses the point we described above: the distance between refinancing loans and collateral base. Indeed, whenever reserve requirements increase, for instance, banks would need to borrow more from the central bank (given non-borrowed reserves aren't changed). This would reduce the amount of free collateral and, hence, increase the probability of reaching the collateral constraint in the future. The result would be higher liquidity risk premium and loan interest rate. Therefore, in financial systems where the collateral base isn't big enough, reserve requirements still matter, even in interest rate targeting frameworks.

- As also mentioned above, making sure that the collateral base for central bank operations is sufficiently large not only minimizes interest-rate-effects of sterilized FX interventions, but it also leads to low liquidity risk on average. This may, in principle, be related to increased efficiency in the financial sector. However, this is a difficult task unless the amount of near risk-free (e.g. government) securities is abundant-enough. Put differently, taking risky assets as a collateral for central bank operations, even if it reduces liquidity risk, is difficult for central banks as it is a quasi-fiscal step.

- As would have been expected, weighted average of the deposit rate and the policy rate is the major component of the loan rate. The weights depend on the public's demand for cash relative to deposits (i.e. cash to deposit ratio - c). The higher the cash to deposit ratio the more the commercial banks need to borrow from the central bank (to satisfy deposit withdrawals) and, hence, the more their costs depend on the policy rate. On the other hand, in cashless societies, banks would no longer need central bank borrowing for loan extension and, hence, the sole determinant of the loan rate (in addition to liquidity risk premium) becomes the deposit rate[26].

- Higher cash to deposit ratio could also mean higher need for central bank liquidity and, hence, may exacerbate the problem of collateral constraint. Therefore, the higher c the higher is the liquidity risk premium (clearly, once other factors are held constant).

- Increasing the amount of (near) risk-free securities ($\bar{S}$) would reduce the liquidity risk premium, per the mechanism described above. This means that bigger government bond portfolio supports lower loan interest rates and, hence, more private borrowing. This is in contrast to classic crowding out argument. To be sure, we do not rule out the possibility of crowding out. Instead, what we argue is that, while the bigger size of the government bond portfolio may lower the liquidity risk premium, crowding out may still happens as a result of deliberate

[26]Deposit rate could still depend on the policy rate (due to competition from government bonds, money market mutual funds or alike). Hence, while higher cash to deposit ratio implies the direct impact of the policy rate on the loan rate, in cashless societies, all central banks can hope for is to affect loan interest rates solely through deposit rates.

central bank reaction to fiscal expansion (i.e. central banks increasing policy rates in response to higher government deficits).

- Here we assumed that $\bar{S}$ is exogenous. But if this problem is incorporated into general equilibrium model, one could easily see that monetary policy transmission would also be working through liquidity risk premium channel, on top of more traditional channels. For instance, increase in policy rate would reduce the price of securities and, hence, the size of their portfolio. Lower amount of $\bar{S}$ would then mean less distance until the collateral constraint and, therefore, higher liquidity risk premium.

- Last but not least, the bank optimization problem above shows what would happen to the liquidity risk premium and, hence, interest rates in case of 100% reserve requirements (full reserve backing). In this case the stochastic component in our model vanishes and liquidity risk premium becomes zero when collateral constraint isn't binding and infinity when it is binding. In other words, the bank would no longer include any liquidity risk premium in its loan rate if it has enough liquidity to cover 100% of newly created deposit, or if it doesn't it will just not extend the credit (which, in principle, is equivalent to imposing infinitely high loan rate). As expected, switching from fractional banking to full reserve banking would seem to turn commercial banks into traditional intermediaries (as described by loanable funds theory) instead of being the major creators of (deposit) money. For a related discussion see Jakab and Kumhof (2019).

Incorporating this liquidity risk channel into general equilibrium (e.g. DSGE) models shouldn't be far from trivial. What's challenging is the solution of the resulting model, since the liquidity risk premium in our model is strongly non-linear. Yet there is some work, including our own, that tries to deal with the issue of solving non-linear dynamic models (see Fernandez-Villaverde *et al*, 2016 or Mkhatrishvili *et al*, 2019).

3.3 Empirical view

The empirical literature, as discussed above, is somewhat limited on the effects of FX interventions on lending rates. According to our theoretical discussions, FX interventions (on the purchase side) could relax collateral constraint and reduce liquidity risk and, hence, lending rates. Relatedly, a few empirical researches do suggest that sterilized interventions could be channeled into credit markets through increased risk-taking behaviour on the side of the financial system. This could drive credit expansion, something related to lower interest rate (e.g. see Gadanecz *et al*, 2014). However, as shown in our analytic exercise, the channel through which FX interventions affect interest rates is different from those discussed in other papers. We show that this channel depends on the amount of collateral.

With this question in mind, we estimate a possible link between lending rates and freely available collateral in the banking system. To identify the channel, our empirical strategy is closely related to the literature on estimation of the determinants of lending rates (e.g. Almarzoqi and Naceur, 2015). However, we further extend those empirical models by introducing freely available collateral (total amount of collateral minus borrowing from the central bank) in bank balance sheets as an additional determinant of lending rates. To the best of our knowledge, the channel is not quantified in other empirical researches yet. Hence, we try to assess whether the amount of freely available collateral makes financial institutions less anxious about future liquidity risks, consequently changing rates on their loans. In other words, e.g. in case of FX purchase by the central bank, we test "leveraging-up" effect of FX interventions.

To estimate the empirical relationship between collateral base and loan interest rates, we include other control variables which could contribute to variation in loan interest rates of local currency loans in Georgia. In any case, as said above, the equation estimated here is close to empirical models on interest rate determinants (see also Ho and Saunders, 1981 or Saunders and Schumacher, 2000). The estimated equation has the following form:

$$\lambda(a)i_t = \lambda(p)col_t + \lambda(q)x_t + \epsilon_t \tag{3}$$

where i_t is interest rates on loans in GEL, while col_t is a measure of the distance until the collateral constraint. We estimate two specifications of the equation 3: in the first specification we test whether the log of the ratio of freely available collateral (difference between collateral base and borrowings from the central bank) to loans in GEL affects lending rates. Hence, we estimate constant elasticity of interest rate with respect to free collateral in the first specification. In the second one, we included the inverse of that ratio to estimate non-linear effects of the free collateral-to-loan ratio on interest rates. On the other hand, $\lambda(a)$, $\lambda(p)$ and $\lambda(q)$ are lag polynomials, while x_t represents the set of control variables.

As regards the control variables, to account for *the cost of funding* and *liquidity* we included deposit and monetary policy rates in the equation; in addition, loan loss provisions are applied to control for *credit risk*[27]. Also, The ratio of non-interest income over assets in banking system is used as the proxy of diversification of banks' activities; theoretically, that may contribute to lower lending rates. GDP growth, sovereign spread, and inflation are included to control for *macroeconomic risks* in our model. Share of non-interest expenses is applied to account for the contribution of *overheads* in interest rates. To account for the effect of *market structure* on interest rate margins, proxies of competition are included, such as HH and Lerner indexes[28]. The equity over assets ratio as well as the index of risk appetite from the survey on lending conditions are used to measure banks *risk aversion* and its effects[29]. The average maturity of credit, also included in the estimation, has an increasing trend in our case, which, cetaries paribus, could have an upward pressure on interest rate due to higher *term premium.* It seems reasonable to assume that all those controls would be sufficient to capture the real net effects of collateral on interest rates[30].

We estimate equation (3) with distributed lag model, most of the variables are stationary processes, at least around deterministic trend. We fail to show that lending rate and free collateral are co-integrated - those variables are stationary processes around

[27]Non-performing loans to total loans ratio was also tried as well, but the shortcoming of the indicator is its backward-lookingness in representing the credit risk.

[28]Based on our own calculations.

[29]However, it is questionable whether the former index measures change in banks' risk preference or it reflects variation in perceived risks. But even if we fail to account for the change in risk appetite (that moves interest rates and the amount of riskless assets in the same direction), the results would only underestimate the linkage we hope to prove, making our claim even more convincing.

[30]As a control, in the estimation we also tried accounting for the active de-dollarization policy that started in 2017, however it didn't significantly change the results.

deterministic trend. Hence, we include trend in the estimated equation, while the variables which failed to be stationary around deterministic trend are included in the equation in the form of first order difference. Lag order are selected based on SC information criteria[31]. The equation (3) is estimated based on aggregated data on banking system with monthly frequency from 2010 to 2019.

Table 1: Results of estimated distributed lag models

	Specification 1		Specification 2	
	Coefficient	P-value	Coefficient	P-value
Lending rate (-1)	0,288	0,001	0,305	0,001
Lending rate (-2)	0,130	0,144	0,145	0,105
Lending rate (-3)	-0,110	0,211	-0,114	0,200
Lending rate (-4)	0,230	0,006	0,245	0,003
Lending rate (-12)	-0,158	0,010	-0,147	0,018
Free collateral to loan ratio(-1)	-1,367	0,004		
Inverse free collateral ratio(-1)			0,366	0,012
Policy rate	0,154	0,058	0,201	0,003
Deposit rate	0,103	0,211		
Reserve requirement	0,146	0,119	0,171	0,069
d(maturity)	2,549	0,149	2,914	0,098
d(maturity(-1))	-4,317	0,011	-4,149	0,014
Loan loss provision ratio	-0,136	0,120	-0,157	0,053
Diversification	-2,718	0,082	-2,834	0,072
Non interest expense ratio	0,960	0,435	0,840	0,497
d(HH index)	0,205	0,044	0,207	0,044
GDP growth	-0,130	0,000	-0,121	0,001
Sovereign risk premium	0,004	0,000	0,004	0,000
Time dummy	-1,427	0,000	-0,147	0,018
Trend	-0,024	0,051	-0,024	0,058
Constant	10,438	0,001	10,324	0,002

Note: Definitions: Lending rate is the weighted average interest rate on GEL loans; Free collateral to loan ratio is the total amount of collateral adjusted with refinancing loans divided by total amount of lending in GEL by commercial banks; policy rate is monetary policy rate, while deposit rate is interest rate on deposits in GEL; reserve requirement is the minimum reserve requirement set by the NBG for GEL funding; maturity measures average maturity of loans in GEL; loan loss provision is the ratio of loan loss provisions to gross loans; diversification is the ratio of non-interest income to total assets; while non-interest expense ratio is measure of non-interest expenses to total assets. HH index is the Herfindahl-Hirschman index calculated based on loan portfolios. GDP growth is YoY percentage change in GDP; Sovereign risk premium is in bps.

[31] The AIC criteria suggested longer lag structure, but we ended up with the problem of autocorrelation in this case (probably, due to model misspecification).

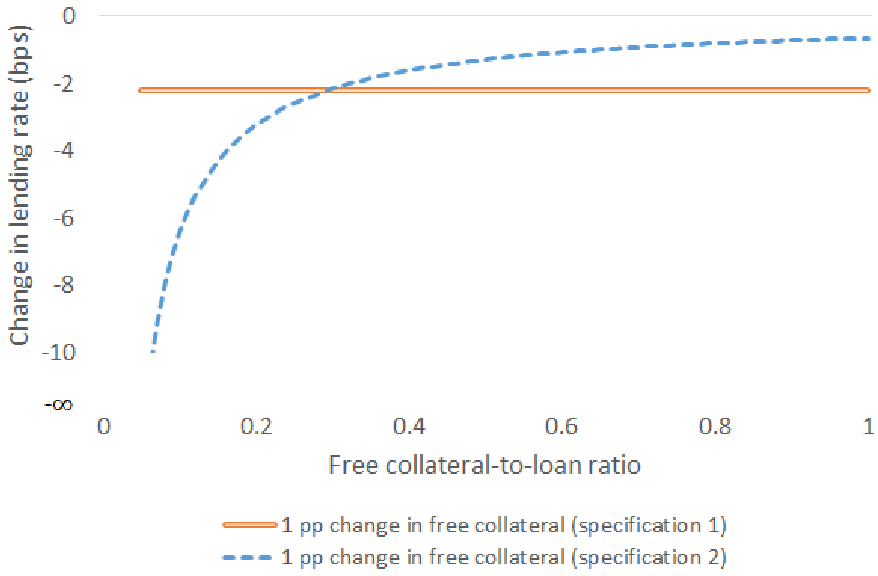


Figure 14: Change in lending rate due to 1 pp change in free collateral

The estimation results are shown in Table 1. As it shows 1 percentage point (pp) change in free collateral decreases lending rate by 1.4 basis points (bps) on impact and by 2.2 bps in the long run, in case of specification 1. In specification 2, the marginal effect of 1 pp change in free collateral depends on the size of this ratio at the moment of change (see Figure 14). For example, if the ratio is 0.22 (as it was at the end of 2019), then lending rate decreases by 1.6 bps on impact and by 2.9 bps in the long run. These estimates are non-negligible and in line with our theory. As mentioned, since the impact of FX intervention on lending rate depends on the amount of free collateral for the first specification, we plot this relationship (between the effect of FX intervention on lending rate, on the one hand, and the amount of free collateral, on the other) in Figure 14. Apart from the main result, in some cases, the estimated coefficients of the banking system-related variables are against the prior beliefs: loan loss provision ratio, for example, is estimated to have a negative contribution to interest rates, while overheads have positive but insignificant effect. On the other hand, index of industry concentration has positive impact on interest rate as expected. Proxies of macroeconomic risks play an important role in determination of interest rates as well. For instance, an increase in GDP growth by 1 pp reduces lending rates by 13 bps on impact, while 1 pp shock to sovereign risk premium pushes lending rates up by 0.38 pp on impact and 0.62 pp in the long run.

Endogeneity may arise in the estimated equation if risk aversion is not properly treated, as higher risk aversion pushes both lending rate and investments in risk free assets up (Gadanecz *et al*, 2014). We have applied several alternative proxies of risk aversion to fix the problem. Firstly, we included equity to assets ratio and deviation of capital adequacy ratio from regulatory requirements. However, both of them were highly insignificant and made statistical properties of the estimated equation worse, while the estimates of the rest of the coefficients were not effected at all. Also, we applied risk appetite indicator from the survey of lending conditions conducted by the NBG, but the results are not much different than in the former case. In addition, the sample size further shrank. Therefore, those proxies of risk aversion are not included in the final stage of estimation. If those proxy variables are appropriate measures of unobserved risk aversion then we can conclude that it doesn't have a significant simultaneous effect on lending rate and the amount of risk free asset holdings. However, even if the above mentioned indicators fail to adequately measure unobserved risk aversion, we can show that it could be a source of underestimation (not overestimation) of the linkage we try to prove (i.e. negative impact of free collateral on lending rates).

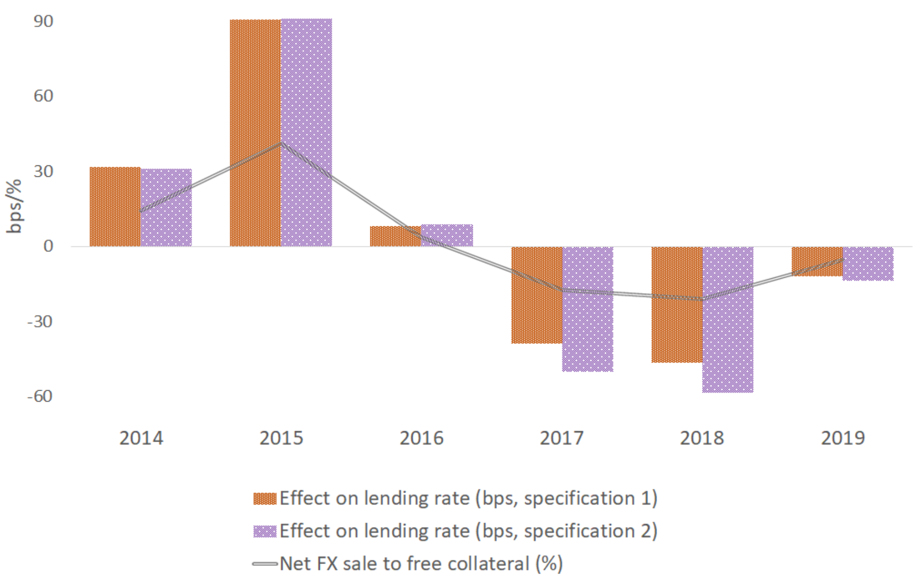


Figure 15: Simulated change in lending rate from FX interventions

As the historical analysis of the effects of actual FX interventions shows (see Figure

15), the National Bank of Georgia's FX interventions on the FX market could had have tangible effects on lending rates. Those findings mean that it would have required higher policy rates in 2017-2019 (by about 50 bps) to neutralize the implications of lower liquidity risk premium on credit growth, real economy and, hence, inflation. On the other hand, in 2015 when the NBG was selling FX instead, this interventions could have meant an equivalent of policy rate tightening by 90 bps. Going forward, these estimates may become an useful input in monetary policy deliberations if FX interventions would turn out to be significant enough in size in the future.

4 Conclusion

The literature has identified mechanisms through which the sterilized FX interventions may affect the exchange rate and the real economy. Yet, what it usually claims is that sterilized interventions work through currency or country risk premia. The theory that we developed above, and provided some empirical support for it, demonstrates a different mechanism at work - a liquidity risk channel. This is tightly related to the available collateral that can be used for central bank operations: even when the collateral constraint isn't currently binding, if the collateral isn't sufficiently abundant banks may still fear (massive) deposit withdrawals that, in principle, can make the constraint start binding in the future. This fear, however, is reduced when banks get permanent liquidity from the central bank that buys FX as opposed to getting the same amount of liquidity by borrowing from the central bank (that requires collateral). Reduction in this fear will then result in loan interest rate reduction and, hence, more loan extension. This novel channel, working through loan interest rates, may as well explain the exchange rate effects of sterilized intervention. In addition, the theory above arrives at a number of other interesting results, e.g. related to reserve requirements. For future research it would be very interesting to see how important this channel would be if estimated based on cross-country panel data.

Finally, despite a theoretical rigor and significant empirical evidence, there's one important caveat. It is very difficult to estimate the true size of the amount of unused collateral. Namely, whenever commercial banks know that the central bank will find ways to expand the collateral base *if needed*, the banks may not have much liquidity risk fears even if the current collateral base is small. However, it is politically difficult for the central bank to take risky assets as collateral (since in that case it will essentially be conducting quasi-fiscal operation). That's why we still think that our approach of calculating the liquidity risk based only on near risk-less securities should be sufficiently accurate, at least in normal times.

References

[1] Almarzoqi, R. and Naceur, S.B., 2015. Determinants of Bank Interest Margins in the Caucasus and Central Asia. International Monetary Fund.

[2] Abildgren, K., 2005. Sterilised and Non-Sterilised Intervention in the Foreign-Exchange Market. Danmarks Nationalbank Monetary Review, pp.61-71.

[3] Backus, D.K. and Kehoe, P.J., 1989. On the denomination of government debt: a critique of the portfolio balance approach. Journal of Monetary Economics, 23(3), pp.359-376.

[4] Benes, J., Berg, M.A., Portillo, M.R.A. and Vavra, M.D., 2013. Modeling sterilized interventions and balance sheet effects of monetary policy in a New-Keynesian framework. International Monetary Fund.

[5] Bernanke., B. and A Blinder., 1988. "Credit, money and aggregate demand", American Economic Review, May, pp 435-439.

[6] Branson, W.H. and Henderson, D.W., 1985. The specification and influence of asset markets. Handbook of International Economics, 2, pp.749-805.

[7] Bruno, V. and H.S. Shin, 2015. Capital flows and the risk-taking channel of monetary policy.

[8] Chang, R. 2018. Foreign Exchange Intervention Redux. NBER Working Paper no. 24463

[9] Engel, Charles, Nelson C. Mark, and Kenneth D. West. 2007. Exchange Rate Models Are Not As Bad As You Think. In NBER Macroeconomics Annual, Vol. 22, edited by Daron Acemoglu, Kenneth Rogoff, and Michael Woodford, 381441. Chicago: University of Chicago Press.

[10] Fernandez-Villaverde, J., Rubio-Ramrez, J.F. and Schorfheide, F., 2016. Solution and estimation methods for DSGE models. In Handbook of Macroeconomics (Vol. 2, pp. 527-724). Elsevier.

[11] Gadanecz, B., Mehrotra, A., Mohanty, M.S., 2014. Foreign exchange intervention and the banking system balance sheet in emerging market economies. Bank of International Settlements.

[12] Ho, T.S.Y. and Saunders, A., 1981. The Determinants of Bank Interest Margins: Theory and Empirical Evidence. Journal of Financial and Quantitative Analysis, 16(4), pp.581-600.

[13] Hofmann, B., Shin H.S., Villamizar-Villegas. M., 2019. BIS Working Paper No. 774. FX intervention and domestic credit: evidence from high-frequency micro data.

[14] International Monetary Fund, 2017. Georgia Technical Assistance Report - Liquidity Management Operations. IMF Country Report No. 17/107

[15] Jakab, Z. and Kumhof, M., 2019. Staff Working Paper No. 761 Banks are not intermediaries of loanable fundsfacts, theory and evidence.

[16] Kashyap, A, J Stein 1997. "The role of banks in monetary policy": a survey with implications for the European monetary union.", Economic Perspectives, Federal Reserve Bank of Chicago, 2-18.

[17] Kumhof, M. and Nieuwerburgh, S., 2002. A Fiscal Theory of the Currency Risk Premium and of Sterilized Intervention (No. 2002-2029). International Monetary Fund.

[18] Kuttner, K and C Lown 1988. "Government debt, the composition of bank portfolios, and transmission of monetary policy" in A Christal(ed), Government debt structure and monetary conditions, Banks of England.

[19] Mark, Nelson C., and Donggyu Sul. 2001. Nominal Exchange Rates and Monetary Fundamentals: Evidence from a Small Post-Bretton Woods Panel. Journal of International Economics 53 (1): 2952.

[20] Mkhatrishvili, S., Laxton, D., Tutberidze, D., Sopromadze, T., Metreveli, S., Arevadze, L., Mdivnishvili, T. and Tsutskiridze, G., 2019. Solving non-linear

dynamic models (more) efficiently: application to a simple monetary policy model. National Bank of Georgia Working Paper 01/2019.

[21] Mishkin, F.S., 2001. Financial policies and the prevention of financial crises in emerging market economies. The World Bank.

[22] Saunders, A. and Schumacher, L., 2000. The determinants of bank interest rate margins: an international study. Journal of International Money and Finance, 19(6), pp.813-832.

[23] Schwartz, Anna J. 2000. The rise and fall of foreign exchange market intervention as a policy tool. Journal of Financial Services Research 18 (23): 31939.

[24] Vargas, H., Gonzalez, A., Rodriguez, D., 2013. Foreign exchange intervention in Colombia.

A Appendix: deriving loan interest rate equation

Before showing the detailed derivations, let's reiterate the optimization problem:

$$\max_{i^L,L,Q,i^D,D,R} \quad \Pi = \left(i^L L + \bar{i}Q + \bar{i}\bar{S}\right) - \left(i^D D + \bar{i}R\right) - \alpha Prob(R > \bar{S})$$

subject to

$$(i) \quad L \leq \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon} \bar{L}$$

$$(ii) \quad Q \geq rrD$$

$$(iii) \quad i^D \geq \frac{\varepsilon - 1}{\varepsilon}\bar{i}$$

$$(iv) \quad L + Q + \bar{S} = D + R$$

$$(v) \quad R = Q + cD + \hat{e} - \bar{R}^{fx}$$

with all the variables as defined in the main text. We next form the Lagrangian function in the following way[32]:

$$\begin{aligned}\mathcal{L} = &\left(i^L L + \bar{i}Q + \bar{i}\bar{S}\right) - \left(i^D D + \bar{i}R\right) - \alpha(1 - \Phi(\bar{S} + \bar{R}^{fx} - \frac{rr + c}{1 - rr}L)) \\ &-\lambda_1(L - \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon} \bar{L}) + \lambda_2(Q - rrD) + \lambda_3(i^D - \frac{\varepsilon - 1}{\varepsilon}\bar{i}) \\ &-\lambda_4(L + Q + \bar{S} - D - R) - \lambda_5(R - Q - cD - \hat{e} + \bar{R}^{fx})\end{aligned} \tag{4}$$

FOCs:

$$L - \lambda_1 \varepsilon \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon} \bar{L}\frac{1}{i^L} = 0 \tag{5}$$

$$i^L - \alpha\frac{rr + c}{1 - rr}f(\bar{S} + \bar{R}^{fx} - \frac{rr + c}{1 - rr}L) - \lambda_1 - \lambda_4 = 0 \tag{6}$$

$$\bar{i} + \lambda_2 - \lambda_4 + \lambda_5 = 0 \tag{7}$$

$$- D + \lambda_3 = 0 \tag{8}$$

$$- i^D - \lambda_2 rr + \lambda_4 + \lambda_5 c = 0 \tag{9}$$

$$- \bar{i} + \lambda_4 - \lambda_5 = 0 \tag{10}$$

[32] By combining (binding as discussed below) constraints (ii), (iv) and (v) and using the definition of cumulative distribution function (CDF) we can write: $Prob(R > \bar{S})$=$Prob(\hat{e} > \bar{S} + \bar{R}^{fx} - \frac{rr+c}{1-rr}L)$ $= 1 - \Phi(\bar{S} + \bar{R}^{fx} - \frac{rr+c}{1-rr}L)$

Also,

$$\lambda_1(L - \left(\frac{i^L}{\bar{i}^L}\right)^{-\varepsilon}\bar{L}) = 0 \tag{11}$$

$$\lambda_2(Q - rrD) = 0 \tag{12}$$

$$\lambda_3(i^D - \frac{\varepsilon - 1}{\varepsilon}\bar{i}) = 0 \tag{13}$$

And, $\lambda_1 \geq 0$, $\lambda_2 \geq 0$, $\lambda_3 \geq 0$.

We can note that constraints (i) and (iii) should be binding, otherwise λ_1=0 and λ_3=0 to satisfy FOCs. With that (11) and (13) imply $L = 0$ and $D = 0$, which we exclude as possibilities in our model and set $\lambda_1 > 0$ and $\lambda_3 > 0$. Therefore, constraints (i) and (ii) become automatically binding. Also, as holding excess reserves has no additional benefit for banks in our framework, the constraint (iii) should be binding too.

From equation (5) :

$$\lambda_1 = \frac{1}{\varepsilon}i^L \tag{14}$$

The equation (14) together with (6) implies:

$$i^L = \frac{\varepsilon}{\varepsilon - 1}\Big(\lambda_4 + \frac{rr + c}{1 - rr}\alpha f(\bar{S} + \bar{R}^{fx} - \frac{rr + c}{1 - rr}L)\Big) \tag{15}$$

By combining (7) and (9) we get :

$$\lambda_4 = \frac{1}{1+c}\bar{i}^D + \frac{c}{1+c}\bar{i} + \frac{c + rr}{1+c}\lambda_2 \tag{16}$$

and

$$\lambda_5 = \frac{1}{1+c}(\bar{i}^D - \bar{i}) - \frac{1 - rr}{1+c}\lambda_2 \tag{17}$$

By putting (16) and (17) in the equation (10), implies that $\lambda_2 = 0$. Then by combining equations (15) and (16), we get optimality condition for the lending rate given by the equation shown in the main text.

Distributed by the National Bank of Georgia.

Available at www.nbg.gov.ge

National Bank of Georgia
Macroeconomic Research Division
Sanapiro st. #2, 0114, Tbilisi, Georgia
Phone: +995 32 2406531
www.nbg.gov.ge
Email: research@nbg.gov.ge

საქართველოს ეროვნული ბანკი
National Bank of Georgia