Discussion of "Reserve Requirements for Price and Financial Stability: When Are They Effective?"*

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Since the onset of the 2008 financial crisis, many economists have studied the effects of unconventional monetary policies such as credit-easing policies or actions aimed at altering the maturity structure of the private sector's asset holdings. But surprisingly, there has been relatively little work on one of the traditional policy tools of a central bank—required reserve ratios—and how required reserves might be used as a cyclical policy instrument. Christian Glocker and Peter Towbin fill this gap by employing a modern dynamic stochastic general equilibrium (DSGE) model of a small open economy to analyze the use of reserve requirements as a tool for cyclical stabilization.

At one time, we all learned that central banks had three policy instruments—the quantity of non-borrowed reserves, the interest rate charged on discount window borrowing, and the required reserve ratio. The first two instruments operated by affecting the supply of bank reserves; the third worked by affecting the demand for reserves. Then, many central banks adopted a short-term interbank rate as their primary policy instrument. Doing so made the quantity of non-borrowed reserves an endogenous variable, adjusting to ensure reserve supply and demand were consistent with the policy interest rate. Under such a policy regime, the discount rate and reserve requirement became irrelevant. Of course, this wasn't (and isn't) true of developing economies. There, central banks continued to

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employ reserve aggregates and reserve requirements as active instruments of monetary policy. However, most policy-related research offered little guidance to these economies, as standard DSGE models for policy analysis relied exclusively on interest rate rules to represent policy. So an investigation into the role of reserve requirements in a modern modeling framework is a useful addition to the study of monetary policy.

In my comments, I first give a brief overview of the paper and describe what the authors do. I then focus on a simplified version of the financial sector of their model to highlight how reserve requirements affect the economy and why using them, together with an interest rate instrument, can expand the set of outcomes achievable by monetary policy. Finally, I conclude by highlighting the parallels between monetary policy tools and tax instruments and offer some suggested extensions to the Glocker-Towbin analysis.

1. Overview of Paper

The core model used by Glocker and Towbin (henceforth, G-T) is a standard small open-economy DSGE model with nominal frictions. They add to this structure a banking sector and financial frictions. Since the real side of the model is similar to other small open-economy DSGE models, l will focus on the structure of the financial side of the model, as this structure is critical for the transmission of changes in reserve requirement to the real economy.

Three financial frictions characterize the economy. First, there is market segmentation; households—the ultimate savers in the model—cannot lend directly to entrepreneurs. Instead, households save by accumulating deposits with the banking sector or holding foreign bonds, and entrepreneurs are forced to obtain credit from banks. This market segmentation is important because it means the imposition of reserve requirements on banks—a form of tax on intermediated credit—cannot be avoided, as it could be if households were able to lend directly to entrepreneurs.

Second, G-T assume there is a direct real resource cost associated with deposit banking. This cost depends on the banking sector's holdings of excess reserves. Specifically, deposit-taking institutions face costs given by

$$G_t^{\varsigma} = \psi_1\left(\varsigma_t - \varsigma_t^{MP}\right) + \left(\frac{\psi_2}{2}\right)\left(\varsigma_t - \varsigma_t^{MP}\right)^2, \tag{1}$$

where ς_t is the ratio of reserve holdings to deposits and ς_t^{MP} is the required reserve ratio. The deposit-taking banks then lend at the interbank rate i_t^{IB} to loan-making banks who in turn lend directly to entrepreneurs.

Finally, a third financial friction arises due to the presence of agency costs associated with bank lending to entrepreneurs (Bernanke, Gertler, and Gilchrist 1999). These agency costs drive a wedge between the interest rate on loans and the loan-making banks' opportunity cost of funds. A final complication introduced into the model is to compare cases in which loans to entrepreneurs are denominated in foreign currency rather than in domestic currency.

Given this structure, there are three interest rates in the model: the rate paid to households on bank deposits, the rate deposit banks charge lending banks (the interbank rate), and the lending rate. The spreads between these rates will depend on the structure of competition for deposits, the costs associated with banking, and the agency costs associated with lending.

Various policy regimes are considered. These are (i) a standard regime in which only the interbank rate is used as a policy instrument; (ii) a regime in which both the interbank rate and reserve requirements adjust to inflation, output, and a financial variable (loan quantity); (iii) a regime in which the nominal exchange rate is fixed but reserve requirements adjust to inflation, output, and the quantity of loans; and (iv) a regime in which the policy rate adjusts to inflation and the output gap and reserve requirements adjust to the quantity of loans.

G-T conduct three primary experiments using a calibrated version of their model. First, they report impulse responses to an increase in the required reserve ratio for different degrees of nominal price rigidity, for different policy regimes, and with and without a financial accelerator mechanism. Second, they report optimal coefficients in policy rules for the interbank rate and the reserve ratio. Outcomes are evaluated using ad hoc quadratic loss functions involving inflation, output, and, in some cases, the quantity of loans as a proxy for financial stability objectives. Third, they show how the response of the economy to a technology shock differs under alternative policies.

The most interesting conclusions emerging from this analysis are, I believe, the insights it gives to the instrument assignment problem. G-T find that the optimal coefficients in a basic Taylor rule for the interbank rate are very little affected when the reserve requirement ς_t^{MP} is allowed to respond optimally to inflation and output (G-T's table 3). Nor is the loss function reduced very much by using ς_t^{MP} as an instrument. However, when policy also responds to the quantity of loans, G-T obtain some interesting new results. First, even when the interbank rate i_t^{IB} is the only instrument, reacting to loan quantities significantly reduces the loss function (G-T's table 4). This result is perhaps not surprising, as the model has five shocks (technology, cost push, government expenditures, foreign interest rate, and export demand), so responding to more than inflation and output should provide a better approximation to an optimal policy which would react to each of the five fundamental shocks. Second, for the case in which the financial accelerator is absent, essentially the same loss is achieved if the interbank rate reacts to inflation, output, and loans as when the interbank rate reacts *only* to inflation and output and the required reserve ratio reacts *only* to the quantity of loans (their regime IV). That is, there is a separation of policy instruments in that the reserve ratio can be moved in response to fluctuations in loans to achieve the central bank's financial stability objective while the interbank rate is employed to achieve inflation and output objectives.

This second result is strengthened when the financial accelerator is added back in. In this case, the lowest value for the loss function is achieved when both i_t^{IB} and ς_t^{MP} react to inflation, output, and loan quantity, but there is almost no deterioration in loss if i_t^{IB} responds only to inflation and output while ς_t^{MP} responds only to loan quantity. This is an interesting and novel result.

2. Reserve Requirements and Financial Equilibrium

In this section, I want to focus on the financial sector of the G-T model to highlight how reserve requirements work to affect the economy and why they can provide a useful supplement to an interest rate instrument, at least in principle.[1] Doing so helps one better understand Glocker and Towbin's results.

Deposit-taking banks earn i_t^R on their reserve holdings and i_t^{IB} on assets lent. Given the cost function G_t in (1), the equilibrium spread between the interbank rate and the rate paid on reserves must be such that the interest earned on reserve net of the marginal cost of additional reserve holding must equal the rate earning on lending:

$$i_t^R - \frac{\partial G_t^{\varsigma}}{\partial \varsigma_t} = i_t^R - \left[\psi_1 + \psi_2\left(\varsigma_t - \varsigma_t^{MP}\right)\right] = i_t^{IB}.$$

Thus, reserve demand is given by

$$\varsigma_t = \varsigma_t^{MP} + \left(\frac{i_t^R - i_t^{IB} - \psi_1}{\psi_2}\right).$$

Define Δ_t as the spread between the interbank rate and the rate paid on reserve balances: $\Delta_t \equiv i_t^{IB} - i_t^R$. G-T assume the central bank maintains Δ_t equal to a constant Δ, with $\Delta \geq 0$. Doing so requires that the central bank adjust reserve supply so that

$$\varsigma_t = \varsigma_t^{MP} - \left(\frac{\Delta + \psi_1}{\psi_2}\right), \tag{2}$$

where the second term on the right is a constant.

While the spread between the rate on reserves and the interbank rate is constant, the spread between the rate paid on deposits and the interbank rate is determined by the zero-profit condition for deposit-taking banks:

$$i_t^D = (1 - \varsigma_t)i_t^{IB} + \varsigma_t i_t^R - G^{\varsigma} = i_t^{IB} - \varsigma_t^{MP}\Delta - G^{\varsigma}, \tag{3}$$

where G^{ς} is the constant cost of servicing deposits. Using (2) in (1),

$$G^{\varsigma} = -\psi_1\left(\frac{\Delta + \psi_1}{\psi_2}\right) + \left(\frac{\psi_2}{2}\right)\left(\frac{\Delta + \psi_1}{\psi_2}\right)^2$$

is a constant (given Δ).

[1]A reduced-form version of the G-T financial sector is similar in many ways to the framework employed by Romer (1985) to study reserve requirements.

The equilibrium relationship (3) is key to understanding the way in which the reserve ratio affects the economy. With $\Delta \geq 0$, a rise in ς_t^{MP} forces banks to hold more reserves and acts as a tax on deposits, reducing the interest rate households receive on bank deposits. The deposit interest rate appears in the household sector's Euler condition, so as i_t^D falls, the demand for deposits by households falls as households increase current consumption.

Deposit-taking banks lend to loan-making banks at the interbank rate. Thus, the opportunity cost of funds to lenders is i_t^{IB} in nominal terms. Let i_t^L denote the nominal interest rate on loans to entrepreneurs. Then the Bernanke, Gertler, and Gilchrist (1999) model delivers an equilibrium relationship between the spread between these two rates as a function of entrepreneur net worth, the supply price of capital, and the demand for loans by entrepreneurs. Writing loan demand as $L^d(i_t^L, i_t^{IB}, Z_t)$, where Z_t is a vector of these other variables (including expected inflation), and letting $D(i_t^D)$, $D' > 0$ denote the reduced-form household demand for deposits, the supply of loans will equal deposits net of reserves $(1 - \varsigma_t)D(i_t^D)$, and equilibrium in the loan market can be summarized by

$$(1 - \varsigma_t)D\left(i_t^D\right) = L^d\left(i_t^L, i_t^{IB}, Z_t\right). \tag{4}$$

Finally, reserve demand is $\varsigma_t D(i_t^D)$, so if H_t denotes reserve supply, equilibrium in the reserve market requires that

$$H_t = \varsigma_t D\left(i_t^D\right). \tag{5}$$

Equations (2)–(5) constitute a stylized representation of the financial market in a closed-economy version of Glocker and Towbin's model. These equations consist of four equilibrium conditions involving i^D, i^{IB}, i^L, Δ, H, ς_t, and ς_t^{MP}, implying that there are choices that can be made with respect to which variables the central bank uses as instruments. There are four potential instruments: the interbank rate i^{IB}, the required reserve ratio ς_t^{MP}, the spread between the interbank rate and the rate charged on reserve borrowing Δ, and the quantity of reserves H. Combining (2), (3), and (5) yields

$$H_t = \left[\varsigma_t^{MP} - \left(\frac{\Delta + \psi_1}{\psi_2}\right)\right] D\left(i_t^{IB} - \varsigma_t^{MP}\Delta - G^{\varsigma}\right),$$

which illustrates how, in the traditional analysis with ς_t^{MP} and Δ fixed, H_t must adjust endogenously, once the central bank has set i_t^{IB}, to ensure reserve supply (the left side) equals reserve demand (the right side). However, an alternative would be to fix H_t and let the reserve requirement adjust to be consistent with the chosen values of the interbank rate and the spread Δ. In the open economy, the nominal exchange rate becomes an additional potential instrument (combined with a new equilibrium condition given by uncovered interest parity).

Equations (3) and (4) are key to understanding the transmission of reserve requirements to the real economy under an interest rate policy that determines i_t^{IB}. From (3),

$$i_t^D = i_t^{IB} - \varsigma_t^{MP}\Delta - G^{\varsigma},$$

and so with Δ fixed,

$$\frac{\partial i_t^D}{\partial \varsigma_t^{MP}} = -\Delta \leq 0.$$

A rise in ς_t^{MP} acts as a tax on the banking sector when the interest paid on reserves is less than the interbank rate (i.e., when $\Delta > 0$). This tax is passed on to households in the form of lower interest on bank deposits. A rise in ς_t^{MP} lowers the return available to households and, from the household's Euler equation, increases current consumption. Thus, one channel through which reserve requirements affect the economy is via the return earned by households on their holdings of bank deposits.

How big is this consumption channel likely to be? In the calibration exercise performed by Glocker and Towbin, $\Delta = 0.015$ (150 basis points). Thus, a 50 percent rise in the reserve requirement rate—from 10 percent to 15 percent, for example—would decrease the deposit interest rate by $\Delta(.15 - .10) = 0.00075$, or 7.5 basis points. Hence, a fairly large change in ς_t^{MP} produces a very small change in the deposit rate and, correspondingly, is likely to have a small effect on consumption. Even this small effect would disappear under a Friedman-rule policy which would set $\Delta = 0$ to eliminate the tax on reserves.

In addition to the tax channel affecting consumption, changes in the reserve ratio also affect the real economy through the loan market. Here, there is both a direct and an indirect effect of ς_t^{MP} on loan supply. Since the supply of loans is $(1 - \varsigma_t)D(i_t^D)$, for a given level of deposits a rise in ς_t^{MP} increases ς_t (see (2)) and reduces lending by the banking system. This is the direct effect on loan supply. The indirect effect occurs via the fall in i_t^D caused by a rise in ς_t^{MP}. This reduces the demand for deposits, shrinking the banking sector and further reducing loan supply. As previously argued, the direct effect on i_t^D is small, so this indirect effect on loan supply is also likely to be small. Both direct and indirect effects work in the same direction, reducing loan supply. For a given policy rate i_t^{IB}, the rate on loans must rise and the quantity of loans must fall to maintain equilibrium in the loan market (4). This translates into a decline in investment spending.

This discussion of the channels through which changes in ς_t^{MP} affect the economy serves to illustrate why ς_t^{MP} has effects that differ from those of the policy rate. A rise in i_t^{IB} reduces both consumption and investment; a rise in ς_t^{MP} reduces investment but increases consumption. Because ς_t^{MP} and i_t^{IB} affect consumption differently, using them in combination expands the effective number of instruments available to the central bank.

My discussion of the G-T financial sector ignored open-economy consideration. The effects of ς_t^{MP} on the exchange rate and net exports will depend on the policy regime adopted by the central bank. Under a flexible exchange rate system, with i_t^{IB} as the primary policy instrument, the fall in i_t^D produced by a rise in the reserve ratio leads to a depreciation of the exchange rate and a rise in net exports. Under a fixed exchange rate regime, i_t^{IB} would have to rise to prevent a depreciation.

Table 1 summarizes how macro variables are affected by a change in the reserve requirement.[2] As a baseline, column 1 gives the effects of a rise in the interbank rate, holding the reserve ratio and the spread Δ fixed. Columns 2 and 3 show the effects of a rise in the

[2]In the table, S is the local currency price of foreign currency, so a rise denotes a depreciation. The effects are for the baseline calibration; figure 1 of G-T shows that the output response to ς^{MP} under an i^{IB} policy can change signs if prices are relatively flexible.

Table 1. Impact Effects

Variable	**(1)**	**(2)**	**(3)**
	$\boldsymbol{i^{IB}} \uparrow$	$\varsigma^{MP} \uparrow$	
		Policy Regime	
		$\boldsymbol{i^{IB}}$	$\boldsymbol{S}$
Deposit Rate: i^D	↑	↓	↓
Loan Rate: i^L	↑	↑	↑
Consumption: C	↓	↑	↑
Investment: I	↓	↓	↓
Exchange Rate: S	↓	↑	—
Net Exports: NE	↓	↑	
Output: Y	↓	↑	↓

required reserve ratio under different policy regimes. Outcomes when i^{IB} is the policy instrument and the exchange rate is flexible are shown in column 2. The case of a fixed exchange rate policy is shown in column 3. ς^{MP} expands the feasible allocations achievable by the central bank because it affects consumption and investment differentially.

Having an extra policy instrument should improve the trade-offs the central bank faces. To gain some intuition for how using ς^{MP} can improve policy trade-offs, it is useful to consider the expression for real marginal cost common to basic New Keynesian models. With flexible wages, real marginal cost is proportional to the marginal rate of substitution between leisure and consumption and the marginal product of labor. When log-linearized around the steady state, this yields an expression of the form

$$\ln mc_t = \sigma \ln c_t + \eta \ln y_t - (1+\eta) z_t + \mu_t,$$

where mc_t is real marginal cost, c_t is real consumption, y_t is output, z_t is a productivity shock, and μ_t is a markup (cost) shock. The coefficient of relative risk aversion is denoted by σ, and η is the inverse Frisch elasticity of labor supply with respect to the real wage. In the face of a positive markup shock μ_t, the central bank can moderate the rise in inflation by raising i^{IB}, thereby lowering c and y. A reduction in ς^{MP} reduces consumption relative to output.

So if ς^{MP} is cut as i^{IB} is increased, a given decline in $\sigma \ln c_t + \eta \ln y_t$ can be achieved with a smaller fall in output. That is, using the reserve ratio allows the central bank to gain the same movement of real marginal cost with a smaller decline in y. Thus, given that G-T evaluate outcomes using a quadratic loss function in inflation and output volatility, the trade-off between inflation stabilization and output stabilization is improved when ς^{MP} is used. But, at least in the calibrated version of the G-T model, this effect is small, so the gains from using reserve requirements actively are generally small, and the optimal coefficients in the simple Taylor-type rule for i_t^{IB} are little changed if reserve requirements become an active tool of monetary policy (see table 3 of G-T).

While G-T consider a standard quadratic loss function involving output and inflation, they also consider one expanded to include a loan stabilization objective so that loss is given by

$$L_t = \pi_t^2 + \lambda_Y \hat{Y}_t^2 + \lambda_L \hat{L}_t^2, \tag{6}$$

where inflation, output, and the quantity of loans are expressed as deviations from their steady-state values. The fact that using ς^{MP} helps very little in achieving inflation and output goals implies that it can instead focus on stabilizing loans. Hence, G-T obtain the result that i^{IB} should respond to inflation and output while ς^{MP} should respond solely to loans.

3. Central Bank and Tax Policies

Glocker and Towbin's analysis is a useful reminder that the tools of monetary policy can have tax-like effects by altering the allocation of resources among competing uses. Of course, taxes give rise to tax-avoidance behavior, and the effects of changing a tax will be muted if agents are able to shift out of the taxed activities. This is a concern of particular relevance in thinking about reserve requirements. By taxing deposits at one class of financial institutions, funds will flow out of the banking sector into other financial institutions not subject to reserve requirements. In Glocker and Towbin's model, this type of action is ruled out by assumption—bank deposits are the only source of funds that can be lent to entrepreneurs. While this is fine in a theoretical exercise, it does suggest that the quantitative magnitude of G-T's findings may provide an upper bound for the actual effects of changing the required reserve ratio.

If non-reservable assets were also available to households, the effects of the required reserve ratio on consumption would be smaller than G-T find. However, the impact of a rise in the reserve ratio in reducing bank loan supply would be larger as funds move into assets not subject to the reserve tax. Whether this also increases the impact on investment would depend on the extent to which bank lending is special. If borrowers can access other sources of funds, a rise in the tax on banking would have little net effect on either consumption or investment. However, the issue of whether bank lending is special is the subject of an old and inconclusive debate.

The analogy with taxes is helpful in thinking about monetary policy in general (Walsh 1984). We are trained to think of steady-state inflation as a tax, but in New Keynesian models, deviations from price stability affect markups in ways that are similar to what would occur with a cyclical tax (or subsidy) on the inputs used to produce final goods (Ravenna and Walsh, forthcoming). Thus, deviations from price stability have tax-like effects.

Taxes create distortions; their usefulness as tools to improve allocations arises in the context of the second best. There must be some other distortion in the economy without taxes that can be reduced if a tax is introduced. The financial frictions and nominal rigidities in the G-T model suggest the allocation without taxes is not optimal. The question then is: How can reserve requirements offset existing distortions? Unfortunately, this is where the limitations of the ad hoc objective functions G-T use become clear, as a loss function such as (6) is not adequate for assessing welfare. For example, not all fluctuations in output should be stabilized in the presence of technology shocks. And presumably not all fluctuations in the quantity of loans should be stabilized, as some will reflect the efficient movement of loans in the face of productivity shocks. In general, the quantity of loans should rise in the face of technology shocks, so a policy that acts to stabilize the level of loans would be misguided. And in the face of financial frictions, it could even be the case that loans are too stable and optimal policy should increase the volatility of loans. For example, Faia and Monacelli (2007) find that financial frictions prevent asset prices from moving sufficiently in response to productivity shocks, and optimal policy calls for interest rates to be cut as asset prices rise. Thus, while the ad hoc loss functions employed by G-T provide a useful starting point for analyzing the role of reserve requirements, it would be interesting to see this policy instrument integrated into a welfare-based analysis of optimal policy.

To conclude, Glocker and Towbin have provided an important extension to the existing literature by integrating reserve requirements into a DSGE framework. In building on their work, it will be important to expand the financial sector of the model to allow for non-bank sources of credit. This extension may reduce the effects reserve requirements can have on the economy. Another extension would be to link the analysis of Glocker and Towbin to the discussion of procyclical bank capital requirements, as these would seem to have similar effects to a procyclical reserve requirement. And finally, it will be interesting to see what role reserve requirements might play in a welfare-based evaluation of policy.

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