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The Evolving Role of Reserve Requirements in Monetary Policy

César Carrera

Central Reserve Bank of Peru, Lima, Peru

Abstract

The design of monetary policy has been a subject of debate in the specialized literature. Over the last three decades, this literature has moved from questioning the very existence of reserve requirements (RRs) to analyzing and discussing their role as a tool for monetary policy. The large variation in how central banks implement RRs around the world suggests that a consensus has yet to emerge on what constitutes an optimal reserve requirement strategy. I survey the main modeling strategies which incorporate RRs in the design of monetary policy. Furthermore, I discuss different modeling approaches in which RRs can affect the banking system, improve monetary policy decisions, and help achieve a central bank's macroeconomic objectives.

Keywords: Reserve requirements, monetary policy

JEL Classification codes: E31, O42

The recent literature on reserve requirements (RRs) highlights their role as a defense mechanism against crises or negative aggregate shocks, especially for developing countries. From a macroprudential perspective, RRs can serve as a preventive measure against potential distortions in the financial system. In fact, RRs can complement and strengthen the monetary policy schemes of central banks that use a short-term interest rate as the operating target. In this context, the objective of this paper is to review RR policies in the literature of the last 30 years.[1]

Currently, setting RRs seems to be a common practice among central banks around the world. Gray (2011) illustrated the current practices on RRs by pointing out that out of 121 central banks, only nine do not use RRs. Gray used the 2010 International Monetary Fund (IMF) survey and reported that central banks that do have a RR system have different operating practices (see Table 1).[2]

RRs are an amount of money and/or liquid assets that commercial banks must hold in cash or on deposit with the central bank (as part of its reserves). Usually, central banks require commercial banks to hold a specific percentage of deposits from the public. There is a large variation across countries as to how much to have as reserves (percentage of deposits), how much to remunerate, and the length and structure of the maintenance period.[3] Friedman and Kuttner (2010) illustrated the following operating practices: (a) reserve averaging (banks hold reserves on average over a fixed number of days or weeks), (b) lagged reserves (the amount of reserves is predetermined when the period begins), and (c) standing facilities (central banks lend reserves or pay interest on the excess reserves). There are also nonconventional uses of RRs, especially for capital control reasons, for example, nonremunerated RRs to different types of agents who are not residents of a country.

Table 1
Survey of Central Banks on RRs (Conducted by the IMF)

	Number of central banks		Percent (%)	
	2008	2010	2008	2010
RR Rate limit				
No RR	9	9	9.6	7.4
One RR rate:				
between 0 and 5%	24	29	25.5	24.0
between 6 and 15%	39	28	41.5	23.1
greater or equal to 16%	5	8	5.3	6.6
A range:				
between 0 and 5%	2	17	2.1	14.0
between 6 and 15%	10	23	10.6	19.0
greater or equal to 16%	5	7	5.3	5.8
Total	94	121	100.0	100.0
Remuneration rate				
At the interest policy rate		7		5.8
Fixed margin, below the policy rate		3		2.5
Below the policy rate		25		20.7
No remuneration		86		71.1
Total		121		100.0
Maintenance periods				
No maintenance period	8	8	8.5	6.6
Between 1 and 7 days	25	25	26.6	20.7
Between 8 and 14 days	16	27	17.0	22.3
Greater than 15 days	41	57	43.6	47.1
Varies	4	4	4.3	3.3
Total	94	121	100.0	100.0

Note. The table is from Carrera and Condor (2011).

Similar to a tax, RRs can increase fiscal revenues at the cost of reducing the rate of return on deposits. In fact, the literature during the 1970s and 1980s focused on the similarities between regulated and unregulated banking systems in terms of the tax effects of imposing RRs.

More recent analysts (Betancourt & Vargas, 2009; Di Giorgio, 1999) have argued that as the short-term interest rate becomes the standard operating target for monetary policy, RRs lose ground as a monetary policy tool. On the other hand, Terrier et al. (2011) suggested that central banks use RRs for monetary or financial stability.

The nature of the debate about RR policies has evolved over time. Therefore, it is possible to identify the main issues that have motivated the different types of work during different periods of time. In the late 1980s and 1990s, the literature focused on the use of RRs as a monetary policy instrument to stabilize the money supply. This group of papers used overlapping generation models in which RRs are a temporal mechanism that ensures liquidity between periods.

Moreover, the wave of literature that followed used partial equilibrium models in which a representative bank has to decide the optimal quantity of reserves and when to enforce RRs. In this process, banks have to decide the optimal amount of reserves to allocate for the next period and whether they should maintain excess reserves. The main conclusion is that the policy rate and RRs can complement each other.

The most recent literature is characterized by dynamic stochastic general equilibrium (DSGE) models, which give an active role to RRs. The potential effects of RRs are associated with financial frictions and the financial accelerator of Bernanke, Gertler, and Gilchrist (1999).

The rest of this paper provides a comprehensive review and analysis of the policy use of RRs. In the next section, RRs are defined and their roles are outlined. I then present the benefits and costs of RRs in the next

section. In the following two sections, I discuss the prudential role of RRs and what role RRs play when a short-term interest rate is the operating target. Furthermore, I extend the analysis to unconventional uses of RRs as capital controls and their role in structural models for macroprudential purposes in subsequent two sections. Last, I present my conclusions.

General Views of RRs

According to Gray (2011), the purpose of RRs is related to prudential management of deposits, monetary policy, and liquidity management. With respect to prudential management, banks hold reserves in order to meet demand for short-term liquidity. Regarding monetary policy, RRs allow the central bank to control the money supply through the money multiplier and also to control the interest rate and the availability of credit.[4] Finally, liquidity management refers to a situation in which banks have to satisfy RRs and have to decide the optimal amount of reserves to hold.

Regarding the general view of RRs, the literature of the 1970s and 1980s focused mainly on RRs as a monetary policy instrument. In this regard, Horrigan (1988) pointed out that the early literature focused on the role of RRs in affecting the money supply by using the money base multiplier[5] or directly through the money base:[6]

$$Money\ supply = \left(\frac{1}{RR\ rate} \right) Money\ base . \tag{1}$$

The initial discussions of the 1970s and 1980s triggered a debate about the deregulation of the banking system. In particular, the benefits and problems of the regulated banking system raised research questions about the optimality of banking restrictions, such as questions regarding the restrictions imposed by RRs over banks' deposits.

Benefits and Problems of RRs

RRs are considered taxes that *distort financial intermediation*, specifically the rate of return on deposits (see Figure 1).[7] Fama (1980) proposed that RRs are taxes on the return on deposits because other assets that have similar returns and risks do not have required reserves. In a RR regime, the proportion of deposits that are on reserve generates an opportunity cost (alternative use of RRs). Then, banks pay a lower interest rate on deposits relative to the unregulated case (see panel a. in Figure 2).
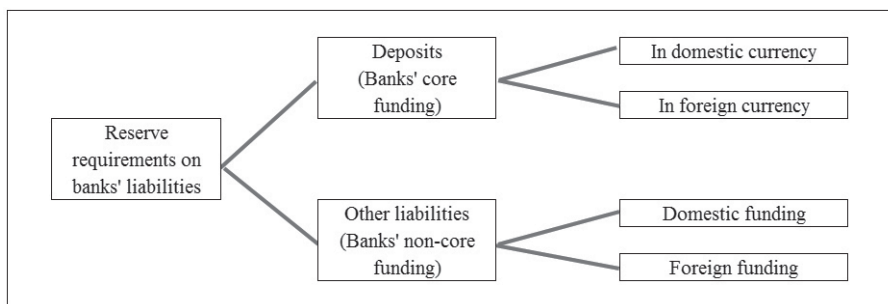

Note. RRs can apply to either domestic or foreign (deposit or non-deposit) liabilities of a bank's balance sheet. The graph is from Terrier et al. (2011).

Figure 1. RRs on banks' liabilities.

Once we have accepted that RRs are taxes on financial intermediation, the following focuses on understanding the effects of those RRs on banks' decisions.

For example, Freixas and Rochet (1997) noted that a bank's decision concerning the allocation of its funds is a portfolio decision because banks can decide among different alternatives such as credit, certificates of deposit, and interbank borrowing. That assertion would explain why RRs affect the interest rate of both deposits and credits (see panels a. and b. in Figure 2).
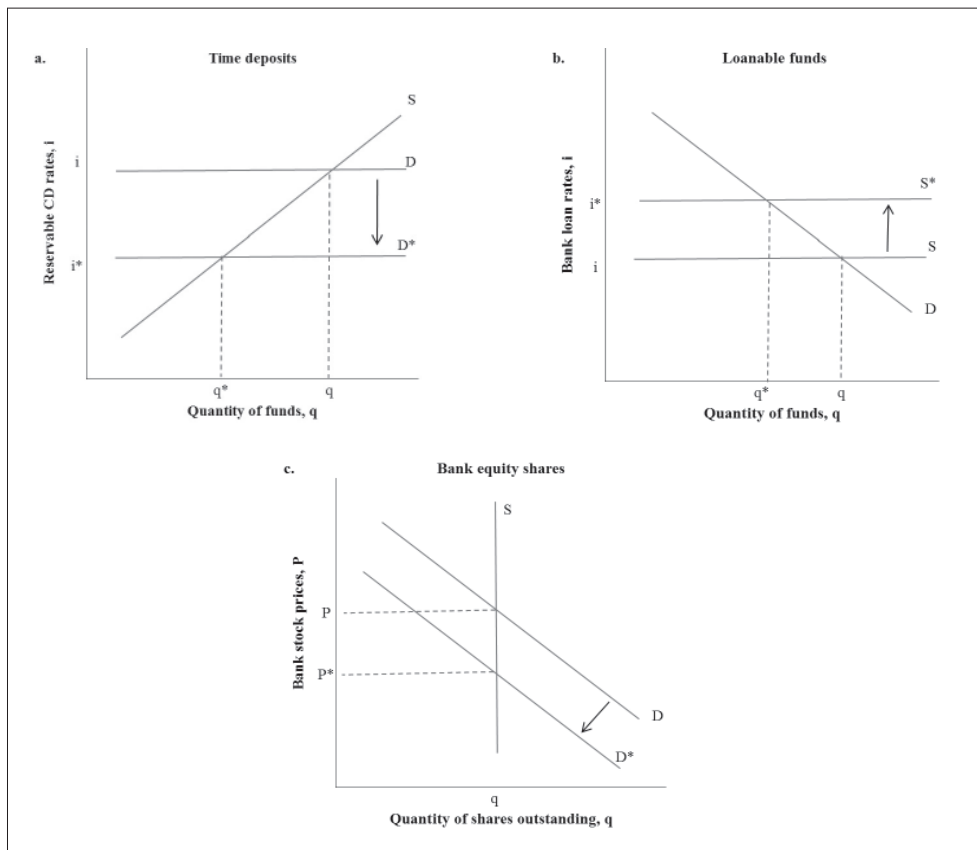
Note. (a) The increase in RRs can be seen as an increase in taxes on financial intermediation. The cost of an increase in RRs would be borne by: a. depositors (lower yields on reservable instruments because those returns should be equal to the market-determined rate on identical nonreservable instruments multiplied by one minus the required reserve ratio); b. borrowers (banks contract the supply of credit in order to pass on the higher cost of funding through deposits); and/or c. banks' owners (reduction in profits as a result of the high level of competition in the deposit and loan market, which is reflected in the lower stock prices of banks). (b) The graph is from Hein and Stewart (2002).

Figure 2. RRs and financial intermediation.

Furthermore, even if RRs do affect deposit and loan interest rates and banks' decisions are portfolio oriented, for Betancourt and Vargas (2009), what really matters is to understand how effective RRs are in an environment in which the money supply is endogenous to the behavior of a short-term interest rate, which is the rate most central banks aim to stabilize. Betancourt and Vargas analyzed the case of costly financial intermediation when higher RRs increase the banks' demand for reserves. The final effect depends on the degree of substitution for deposits as a source for funding loans and the expectations about the reference interest rate announcement made by the central bank.[8]

Some economists have argued in favor of eliminating RRs because they are the source of inefficiencies in the banking sector.[9] Fama (1983) believed RRs were the source of unnecessary costs for providing banking services. Moreover, the objective of price stability through movements in RRs may affect banks' marginal benefits by reducing the availability of loans that finance economic activity, as shown in panel b. in Figure 2.[10]

The RR discussion implies that part of the cost of having a distorting tax is that prices do not adequately reflect the cost of providing services. On the other hand, one of the benefits of having RRs is that they generate resources for *seigniorage* to the government.[11]

Romer (1985) formalized the effects of RRs on government income and on the welfare of a representative agent. For Romer, RRs and a tax on deposits were not equivalent.[12] Romer's definition of equivalence was criticized by Freeman (1987) and Mourmouras and Russell (1992) because an increase in RRs distorts financial intermediaries' portfolio decisions, which, in turn, affects deposits and loans.

Bhattacharya and Haslag (2003) modeled the role of RRs as a source of seigniorage income and its use to fund public deficits. In this case, the government determines open market operations and has two ways of paying its additional debt: by a change in the growth rate of emissions (rate) or RRs (base).[13] The first measure causes long-run inflation, while the second measure permits the payment of interest on the debt.[14]

Freixas and Rochet (1997) and Horrigan (1988) discussed the *stabilizing* role of RRs in economic activities. This view is based on the hypothesis that the stability of the money supply is a determinant of production. In the particular case of Horrigan, if firms could set salaries and use the current interest rate to set their price expectations, this mechanism was irrelevant.[15]

Gomis-Porqueras (2002) and Freixas and Rochet (1997) agreed that RRs distort banks' portfolio decisions, and that may have an effect on the nominal interest rate. A decrease in RRs has the potential to increase loans that may fund more investment projects and that may have a final positive effect on higher levels of production.

Chowdhury and Schabert (2008) and Friedman and Kuttner (2010) suggested that, under certain conditions, there is a relationship between the money supply and economic activity. These authors implied that instruments that have effects on the money supply would have an effect on economic activity as well. Friedman and Kuttner found evidence that during the 2007-2009 financial crisis, the policy interest rate and the money emission of the Federal Reserve (Fed) operated as independent instruments. One of the conclusions of this paper is that the Fed can choose the level of the interest rate and the size of its balance sheet in a way that the two are independent of each other, for periods that are long enough to matter for the evolution of macroeconomic variables.

One additional advantage of RRs suggested in the literature is lowering the risk of higher *agency costs*. This view is related to the part of financial intermediation that involves costly state verification of loans. Di Giorgio (1999) negatively correlated the level of required reserves with the development of financial markets. This view is related to the fact that financial intermediation is affected by asymmetries in information (costly state verification). That is why stronger financial regulation is the result of higher inefficiencies in the financial sector, and that would explain the decrease in RRs in developing countries (see Table 2).[16]

Table 2
Central Banks and RRs (Conducted by the IMF)

No RRs	RRs over 15%
Autralia	Bhutan
Canada	Cape Verde
Denmark	Comoros
Mexico	Iraq
New Zealand	Liberia
Norway	Malawi
Sweden	Maldives
Timor Leste	Sao Tome & Principe
United Kingdom	Angola
	Brazil
	Kuwait
	Lebanon
	Paraguay
	Serbia
	Suriname

Note. Gray (2011).

Prudential Role of RRs

The existence of a free banking system (unregulated) goes back to the beginning of the 19th century, when holding RRs was voluntary. Gray (2011) discussed this prudential role and pointed out that RRs ensured that a fixed proportion of liquid and high-quality assets was held; i.e., banks held enough gold to guarantee the deposits received or the credit notes issued by other banks (safety net). These voluntary reserves were important in case banks decided to fund their lending activities with deposits.[17]

After this first stage, reserves were held in a central bank (after passage of the National Bank Act in the United States of America) that imposed minimum RRs. This can be justified on the grounds that it is optimum for the whole banking system, but not for individual banks, to hold reserves; therefore, a central authority that can enforce RRs is necessary (Cothren & Waud, 1994).[18]

The benefits of using RRs for prudential purposes are more relevant when RRs are implemented in combination with supervision, regulation (capital adequacy and liquidity requirements), and standing credit facilities because banking regulation and supervision are not necessarily central bank duties.

Interest Rate and RRs

Most models consider the nominal money supply, the nominal interest rate, or even the inflation rate as variables that the central bank directly controls. Bindseil (2004) pointed out that methods of conducting monetary policy that involved directly controlling the money supply were popular until the early 1980s. Walsh (2010), however, pointed out that these first approximations ignored actual problems that surrounded the implementation of policy, given the fact that central banks cannot directly control variables that determine aggregate expenditure. For Walsh (2010), the central bank has more control over certain variables such as reserves, the money base, or a short-term interest rate. If so, the interaction between RR policies and interest rate policies can be classified as follows:

1. Monetary policies with direct control over monetary aggregates. These were common practice for most central banks until the early 1980s. During that period, the interest rate was not a key component in formulating monetary policy.

2. Complementary role between the interest rate and RR policies. The RRs management combined with the interest rate strengthens the effects of monetary policy over key macroeconomic variables such as inflation and output (this role is described in the following subsections).

3. The interest rate and the primary emission of money work as independent instruments. This is possible under special conditions such as a financial crisis or low effectiveness of the interest rate to achieve macroeconomic objectives. Friedman and Kuttner (2010) affirmed that during the last financial crisis, the Fed used interest rate policies and money emission as independent instruments (zero lower bound and quantitative easing).

One way to analyze the relationship between RRs and the interest rate is the existence of a relationship between the money supply and variables like inflation and the output gap. Chowdhury and Schabert (2008) studied this relationship and found that the policy stance of the Fed could be identified through the use of nonborrowed reserves that were under the direct control of the Fed.[19] Chowdhury and Schabert showed that this measure of the money supply allowed analysts to identify the response of monetary policy to changes in prices and production. In other words, the Fed reacts to changes in inflation or the output gap through changes in the money supply, which, in turn, affects the interest rate.

In the following subsection, I present modeling strategies when a central bank has an interest rate operating target. These models are restricted to a representative bank and partial equilibrium. Friedman and Kuttner (2010) and Whitesell (2006) provided examples of this approach.

Interest Rate and Short-Term Liquidity

The short-term interest rate may not be related to the reserve supply. Because financial intermediaries that participate in the reserve market react to the central bank's announcements by modifying their demand for reserves, they validate the central bank's information without any need on the central bank's part to modify its reserve supply. The strength of this channel lies in the fact that the operating process that a central bank follows in the market for reserves is on a day-by-day basis in order to achieve an interest rate target. In this short period, there is no relationship between the interest rate and the amount of reserves.[20]

Friedman and Kuttner (2010) argued that the relatively greater effect of interest rate movements is observed during the maintenance period in which a bank holds a minimum required reserve. Then, movements in the interest rate have no effect on the supply of reserves because the effect is distributed over the number of days that the reserves have to stay in the central bank's account.

Since RRs are not applied every day (they are applied, on average, over a period of time), the demand for reserves for period t depends on the actual value of the interest rate and the expected rate for borrowing and lending reserves. The reserve supply is given by the quantity base and the central bank's response to any deviations of the short-term interest rate, which is the operating target. In equilibrium:

$$r_t^F = \frac{\beta^{RF} + \lambda\gamma}{\beta^{RF} + \gamma}\bar{r}_t^F + \frac{(1-\lambda)\gamma}{\beta^{RF} + \gamma}E_t r_t^F + \frac{1}{\beta^{RF} + \gamma}(e_t^R - u_t^R), \tag{2}$$

where r_t^F is the rate that results in equilibrium in the reserve market; $E_t r_t^F$ is the expected rate (within the maintenance period); $\bar{r}_t^F$ is the objective rate; e_t^R is a demand shock for reserves; u_t^R is a supply shock for reserves; β^{RF} is the reaction of the reserve demand in the presence of an increase in returns in the reserve market; γ is the degree of substitution for holding reserves among the maintenance days; and λ is the degree of how active the central bank is in the reserve market for a given value of γ.

Equation 2 implies that if the demand for reserves does not move in response to movements in the current interest rate ($\beta^{RF} = 0$), decisions about the management of reserves only take into account the distribution of those reserves during periods when those reserves have to be held (otherwise excess RRs have to be considered).

If $\beta^{RF} = 0$ and $E_t r_{t+1}^F = \bar{r}^F$ then $r_t = E_t r_{t+1}^F = \bar{r}^F$ (in the absence of demand and supply shocks). In this case, the central bank can impose its interest rate target with only credible announcements and without any change in the supply of reserves.

In Friedman and Kuttner's (2010) model, the demand for reserves depends on the difference between the actual interest rate and the expected interest rate. In this case, the central bank can modify the equilibrium short-term interest rate without altering the supply of reserves. The announcement of a change in the target rate is the source of changes in the liquidity of the market.

Whitesell (2006) found a similar result. Whitesell concluded that a combined policy of an interest rate corridor and RRs results in a better outcome than a design with a single monetary policy instrument. Whitesell argued that a bank has to decide the amount of reserves to hold in the central bank's account (required reserves), taking into consideration the central bank's target interest rate. In the case of RRs, the threat of not having enough liquid assets offers sufficient incentive to control the demand for reserves and achieve smooth behavior in the interest rate.[21]

Preliminary Conclusions

The policy interest rate and the RRs complement each other, if short-term evidence is considered. In this section, the effectiveness of the RRs is based on the operating method in which banks have to hold reserves; i.e., banks must satisfy a minimum amount of reserves, either averaging or lagged, during a period of time.

The announcement of changes in the policy interest rate and the banks' expectations when they have to satisfy a minimum amount of required reserves over a determined period of time affects the banks' demand for reserves. This effect would change the interbank interest rate for reserves without any need for changes in the supply of reserves. Banks have to incorporate the announced change into the interest rate in their demand for reserves because they have to borrow reserves from the central bank when they cannot meet their RRs.[22]

Capital Flows and RRs

The use of RRs as an instrument for capital control is based on interest-rate parity conditions and unremunerated required reserves to foreign capital. Reinhart and Reinhart (2008) set the following interest-rate parity condition for an investor who has to decide between a domestic and a foreign financial asset:

$$i - t^D - \delta = \rho + i^* - t^F - \frac{\dot{s}}{s}, \tag{3}$$

where i is the nominal return on a domestic asset, t^D is unremunerated RRs, δ is the expropriation risk, i^* is the nominal return on a foreign asset, t^F is a tax paid to the foreign government, $\frac{\dot{s}}{s}$ is the expected change in the exchange rate and ρ is a risk premium.[23]

The definition of unremunerated required reserves is open because they can be defined in terms of a type of instrument, terms, or currency. De Gregorio, Edwards, and Valdés (2000) and Ocampo, and Tovar (2003) described the evolution of this instrument for the case of Chile and Colombia, respectively.

In order to evaluate the effects of the unremunerated RRs, it is necessary to estimate an implicit cost for holding reserves.[24] For the case of Chile, De Gregorio et al. (2000) found that unremunerated RRs affected composition of capital flows, which moved to longer maturities. For Colombia, Ocampo, and Tovar (2003) found similar results but also reported a reduction in the net volume of foreign capital.

Ostry et al. (2010) pointed out that, in practice, capital controls have been more effective in countries in which there is an extensive system of restrictions and in countries that have largely open capital accounts and then re-impose their controls. On the other hand, Gray (2011) mentioned that Peru is a successful example of capital control with an unremunerated and marginal RR that is high enough, in domestic currency, and that applies to nonresidents (i.e., it works as an effective capital control). It is important to mention that such RRs apply only to domestic financial institutions, so that it is difficult to consider them as a capital control.[25]

Structural Macroeconomic Models with RRs

The financial crisis of 2007-2009 in the United States of America presented the challenge of incorporating financial frictions into a general equilibrium model, taking into account models with bank loans that were written in the 1990s and unconventional mechanisms of transmission.[26] In this regard, micro-founded DSGE models can help us understand the trade-offs (incentives and restrictions) that are present in the monetary policy mechanism of transmission based on the interest rate channel (the conventional method of setting monetary policy) and on monetary policy based on changes in RRs.[27]

The Modigliani-Miller (M-M) theorem states that financial and nonfinancial institutions do not differ in the ways they raise funds, for example, by issuing stocks or bonds or borrowing from banks. That is the main reason why several macro models ignore the source of funding and financial intermediaries and focus only on the relationship between households' savings and the need for resources on the part of firms. Therefore, the M-M theorem has been superseded by financial frictions.[28]

Most models of this type either depart from or extend the model of Bernanke et al. (1999) or model the amplification mechanism through the banking system. In the financial accelerator of Bernanke et al., the relevant friction arises from information asymmetries between entrepreneurs and borrowers and between banks and lenders. Due to the monitoring cost that arises from the information asymmetry, firms face more expensive funding from banks and in capital markets. Another friction that nullifies the M-M theorem is costly intermediation, as described by Fischer (1983), Bernanke and Gertler (1995), or Edwards and Vegh (1997).

Regarding the use of RRs in this type of modeling, there is no clear indication of what friction is best to introduce. For that reason, in this section, I will discuss, first, the rigidity that emerges from asymmetric information (credit channel), then I will present models with RRs where financial intermediation is costly, and last, I will expand the use of RRs from a macroprudential point of view. This section ends with the comparison of the effects of changes in RRs under different modeling strategies.

Asymmetric Information and Credit Channel

In the context of models with asymmetric information, firms' balance sheets play an important role in the business cycle. In other words, the model structure is based on an optimal debt contract under a costly state verification of the debt.

The asymmetric information between borrowers and lenders endogenously amplifies the effects of, for instance, monetary policy shocks on the credit market and generates an external finance premium that inversely depends on the rate of debt to the net worth of the firm. The log-linear version can be represented as follows:

$$E_t\left\{r_{t+1}^k\right\} - r_{t+1} = -v\left[n_{t+1} - (q_t + k_{t+1})\right],$$

(4)

where: $E_t\left\{r_{t+1}^k\right\}$ is the expected return on capital, r_{t+1} is the return on a risk-free asset, n_{t+1} is the entrepreneur's net worth, q_t is the price of capital, and k_{t+1} is the capital used by the entrepreneur. Equation 4 in Bernanke et al. (1999) characterizes the influence of net worth on investment in the absence of financial frictions $E_t\left\{r_{t+1}^k\right\} - r_{t+1} = 0$. With frictions in the financial market, the cost of external funding depends on the entrepreneur's net worth with respect to the value of the capital: $n_{t+1} - (q_t + k_{t+1})$. According to Bernanke et al. (1999), an increase in this ratio reduces the cost of external funding.

Costly Financial Intermediation

Financial intermediation is costly due to, for example, the managing of deposits and credits, the evaluation of clients, credit monitoring, rental payments for buildings, and the maintenance costs of ATMs. Banks with intermediation costs are the source of imperfect substitution between uses and sources of available funds, as Bernanke and Gertler (1995) and Bernanke et al. (1999) argued.[29]

RRs can be used as a countercyclical measure in the presence of shocks that affect the banking system or adverse external business cycles. A banking system with high operating costs is enough to modify the results of conventional open-economy models. If it is assumed that deposits affect the cost of providing credit, negative shocks to consumption or to deposits are transmitted to the supply side through an increase in the interest rate on loans or a contraction of credit. Edwards and Vegh (1997) solved the problem of a representative bank that has operating costs for the managing of credits and deposits and found that the interest rates for deposits and loans were as follows:

$$i_t^l = i_t + \xi_t \eta_z\left(\frac{z_t}{d_t}, 1\right),$$

(5)

$$i_t^d = (1 - \delta_t)i_t + \xi_t \eta_d\left(1, \frac{z_t}{d_t}\right),$$

(6)

where i_t^d is the interest rate for deposits, i_t^l is the interest rate for loans, i_t is the return on an international traded bond, d_t is the demand for deposits, z_t is the value of loans provided by the banking system, ξ_t is a shock to banks' cost for either taking deposits, $\eta_z(.)$, or for making loans, $\eta_d(.)$, and δ_t are the RRs.

Edwards and Vegh (1997) said that RRs can be effective in the presence of an external shock. If this shock affects the demand side only (which would affect deposits), a decrease in RRs can be very effective as a precaution against a contraction in credit and, thus, may avoid effects on output. When the negative shock strikes the banking system directly and spreads to both the demand and the supply side, changes in RRs can help to keep constant either consumption or production, but not both at the same time.

There is a possibility that banks can finance their activities or even take on external debt in order to satisfy their needs for funding. An increase in RRs turns deposits into an expensive source of funding, so that the interest rate on deposits would decrease. For Prada (2008), the decrease in demand for deposits reduces credit as well, because, in his model, deposits and credit are complements.

A decrease in deposits in Prada's model implies an increase in transaction costs; this increase reduces the purchasing power of households and affects firms' capacity to pay back loans. The central bank can react by lowering the interest rate, but because banking activities are costly, efforts have to be greater in order to avoid effects on output.[30]

There is also the case where regulatory restrictions can be imposed on reserves and on a bank's capital. Cohen and Martinez (2010) added a financial sector that further amplifies the business cycle modeled in Bernanke et al. (1999) because, in their model, banks offer credit and intermediate households' savings and firms' investment.

If banks' balance sheets are added to the amplification process of Bernanke et al. (1999), banking regulation alters banks' portfolio decisions, in which case the transmission mechanism is modified. In this model, the premium for external financing can be characterized as a function of the leverage of banks and the aggregate systemic risk associated with banks' revenues:

$$\begin{matrix} External\ finance \\ premium \end{matrix} = f\left(\begin{matrix} Aggregate \\ shocks \end{matrix}, \begin{matrix} Agency\ cost \\ channel \end{matrix}, \begin{matrix} Balance\ sheet \\ channel \end{matrix} \right). \tag{7}$$

Macroprudential Role of RRs

Banks' use of leverage constraints is also present in Carrera and Vega (2012) and Glocker and Towbin (2012) who modeled an interbank market for funding that is subject to financial frictions in the form of collateral and leverage constraints and RRs on deposits. The contracts and constraints endogenously generate an interest-rate differential and an intermediation of credit.

In this block of the literature, banks finance the activities of entrepreneurs. The key factor is the interaction in the interbank market; while Glocker and Towbin's (2012) banks can be specialized in either taking deposits or lending, Carrera and Vega's (2012) interbank market is composed for narrow and retail banks. Then banks take into account the difference between the interest rate on loans and the interbank interest rate.[31]

Glocker and Towbin (2012) analyzed the case of an optimal RR rule. Carrera and Vega (2012) considered the interbank market structure in the use of RR policies. In both papers, RRs complemented the measures of monetary policy based on an interest rate.

Strategies of DSGE Models with RRs

Cohen and Martinez (2010) compared a situation with RRs and without RRs and then documented their effects on banks' balance sheets.[32] This strategy contrasts with those found in Prada (2008), Glocker and Towbin (2012), and Carrera and Vega (2012) in which the role of RRs is more active. In Prada (2008) and Carrera and Vega (2012), an exogenous increase in RRs has effects similar to those of a tax on deposits, which makes funding through deposits more expensive. Banks reduce their demand for deposits and, therefore, reduce the quantity of credit because credit and deposits are complements, and banking activities are costly. In the case of Glocker and Towbin (2012) and Carrera and Vega (2012), an exogenous increase in RRs increases the interest rate on credit, which reduces the availability of credit. The effectiveness of the RRs is given by a bank's borrowing capacity in the interbank market (leverage constraint).

With respect to the macroprudential role of RRs, the objective is the moderation of financial cycles. Moderate financial cycles decrease the probability of financial stress. Contrary to Prada (2008) and Cohen and Martinez (2010), for whom RRs are exogenous, Glocker and Towbin (2012) noted a policy rule regarding RRs, and, thus, RRs reacted to deviations in credit with respect to its steady state. In this sense, Glocker and Towbin highlighted the macroprudential role of RRs. Walsh (2012) argued that it is not clear what type of distortions RRs are correcting in Glocker and Towbin's (2012) model if, after all, RRs can be viewed as a tax. Carrera and Vega (2012) argued that RRs help to diminish financial frictions that arise from the interbank market structure, so the macroprudential role works through those monitoring costs between narrow banks and retail banks.

Conclusions

The first academic papers regarding RRs from the 1970s and early 1980s sparked the discussion of regulated versus unregulated banking systems. Part of the discussion includes the elimination of RRs, because they distort taxes that generate resources only for the government.

In a world without RRs, banks have to maintain a stock of liquid assets that allow a quick response to short-term demand from their depositors. At the beginning of the 19th century, the banking system created a safety net among banks, so banks could provide guarantees to each other if they experienced liquidity problems. However, this resulted in an incentive to hold few reserves, which, in turn, resulted in the creation of a central bank. Recent evidence regarding RR policies is diverse, and this diverse evidence continues to motivate the discussion of their effectiveness.

The costs of having a RR system include a distortion of the return on deposits with respect to assets with similar risk and making banking services more expensive. On the other hand, the benefits include income from seigniorage, the use of RRs as a countercyclical policy, and, in the presence of high agency costs, a restraint on the inefficiencies of the banking system.

RRs that are part of the monetary policy instrument used by a central bank are linked to the short-term policy interest rate. Some of the literature focused on an operating relationship, basically partial equilibrium models in which a representative bank faces a shortage of required reserves. Models based on short-term evidence favor the use of RRs as a complement to the policy interest rate, which is also the central bank's operating target.

RRs may serve as capital controls. Studies in this area use interest-rate parity conditions and unremunerated RRs to foreign capital. This literature agrees that this type of RR is not effective in the long run and the final effect is on the change in the composition of foreign capital to longer maturity terms. Peru is mentioned as an example of a successful case, even though this particular RR is not a traditional tool of capital control (it is even debatable whether it is a capital control or a macroprudential measure).

Recent efforts focus on structural models, specifically DSGE models that incorporate RRs as an unconventional monetary policy instrument. Those papers use RRs in models with financial frictions and then proceed to analyze the effects on banks' balance sheets. In cases where there are effects on the credit supply, RRs may have a stabilizing role in the economy.

Ongoing research gives a macroprudential role to RRs as a way to control systemic risk. Macroprudential policies have the capacity to reduce systemic risk, strengthen the financial system against external shocks, and allow a fluid financial intermediation process. The greater control of the money supply and the fact that financial cycles do not necessarily coincide with business cycles contribute to the debate about the role of RRs in smoothing the behavior of the interest rate in financial markets, which is desirable from a macroprudential point of view.

What is still on the agenda for future research is the role of other instruments the central bank has at its disposal (as highlighted in Walsh, 2012). For example, the central bank could provide loans directly to banks with the same effect in terms of liquidity in the financial system. In such a case, a new group of problems would arise, for example, heterogeneous banks and collateral constraints. The use of conventional versus unconventional instruments that affect the liquidity in the financial system has not yet been studied. These topics seem ambitious, but they also promise a better understanding of monetary policy.

Endnotes

[1]   For a review of the previous literature on RRs, see Frodin (1980), who presents the costs and benefits of being a member of the Federal Reserve (Fed) System between 1923 and 1976; Luckett (1982), who documents the effectiveness of the Fed's marginal requirements; and Toma (1999), who gives a historical review of the Fed as a clearinghouse. Each one of these papers provides an operating mechanism of RRs.

[2]   See Glocker and Towbin (2012) for specific examples.

[3]   See Meltzer (2012) for a discussion between lagged RRs and meet reserve shortfalls. Some other aspects in which RRs differ across countries are as follows: the financial product that is subject to RRs, the currency type of the financial product, and how to calculate those reserves (average RRs, marginal RRs, or a combination of both).

[4]   See Gray (2011, pp. 10-13) for a discussion of the channels in which RRs operate.

[5]   For the United States of America, "The banking system plays a critical role in the economy because demand deposits are an important component of the money stock, representing over 50 percent of M1 in 2000" (Stiglitz & Walsh, 2002, p. 171). Moreover, "the currency manufactured by the Treasury is a relatively small part of the money supply. Who creates the rest of the money? Banks" (Stiglitz & Walsh, 2002, p. 173).

[6]   The money base is equal to the sum of money that is held in the banks and the amount of currency held by other agents (Walsh, 2010, p. 531). Some authors believe that the multiplier should include the public's preference for money; however, the general definition of the multiplier is the maximum amount of money that banks can legally create for a given amount of RRs.

[7]   See Black (1970), Fama (1980), Calvo and Fernandez (1983), and Romer (1985), who did the pioneering work in this line of research.

[8]   Gomis-Porqueras (2002) added to this discussion with the idea of having multiple RRs for all funding options in which the expected return can be in equilibrium.

[9]   This group is led by Fama (1983), Friedman (1984), and Hall (1984).

[10] This literature is criticized on the grounds of not having a formal model to test the results.

[11] The first papers along these lines are Black (1970), Fama (1980), and Calvo and Fernandez (1983).

[12] Romer took the argument of Fama (1980) and proposed the following exercise: Compare a scenario in which there are RRs of x percent against a scenario in which there is a tax of x percent on deposit rates. Romer concluded that RRs have the same effects as a tax on the interest rate on deposits plus a government bond emission. This research line assumes that only depositors absorb the additional cost of the tax, and the analysis takes into account the demand for a financial asset that is a substitute for deposits (see panel a. in Figure 2).

[13] The definition of rate and/or base comes from the decomposition of seigniorage between the expansion rate of the money base (rate) and the real balance stocks of money (base) such as: $s = (\Delta M / M) M / P$, where s is seigniorage, M is the money base, and P is the price level.

[14] With a multiple RR system, à la Gomis-Porqueras (2002), RRs for government bonds can finance the public deficit at a lower cost.

[15] According to Stein (2012), the fact that financial intermediaries like to fund themselves with short-term debt which, in turn, can be made into riskless money represents a cheap source of finance for banks. The externality associated with excessive private money creation justifies financial stability regulation.

[16] An economy is financially developed when the monitoring costs associated with a loan are low. In this model, a bank and an entrepreneur sign a contract that sets the borrowed amount and its costs. The benevolent regulator aims to maximize the social utility of depositors and entrepreneurs through the management of RRs (taxes on the financial intermediation).

[17] This view is related to the greater trust in the use of banking products. The prudential role and the safety net mechanism among banks are covered by a combination of regulation and supervision, deposit insurance, and standing credit facilities provided by the central bank.

[18] Individual banks' decisions as to how much to hold in reserves when holding reserves is voluntary is affected by the return and risk associated with the banks' investment, which affects the exchange between households and banks. If each bank takes this aggregate relationship as given and each bank's incentive is to optimize the level of intermediation, then banks would reduce their individual level of reserves as much as possible.

[19] Nonborrowed reserves are the difference between total reserves and reserves from the Fed's discount window. The supply of nonborrowed reserves can be interpreted as changes in the money supply.

[20] Friedman and Kuttner (2010) presented evidence for the United States of America, the European Union, and Japan about the absence of this relationship. Ogawa (2007) presented similar results for Japan and argued that the absence of such a relationship is due to the zero interest rate policy implemented by the Bank of Japan.

[21] In terms of modeling, the interest rate corridor can be represented in a one-day model in which the central bank relies on reserves borrowing and lending facilities and creates symmetric opportunity costs around the short-term interest rate operating target. In this case, the bank takes into account the central bank's decision in order to determine the balance of reserves at the end of the day. The use of a corridor and RRs requires a two-day model (for the maintenance period), and in this case, the bank takes into account the penalty for not holding enough reserves. Such a penalty favors the smoothing of the policy interest rate.

[22] Whitesell (2006) mentioned the case of the European Central Bank, which lends funds to banks to cover an overdraft and can be used to meet RRs.

[23] Reinhart and Reinhart (2008) focused on the potential sources of pressure on the exchange rate and reviewed various policy efforts that are employed to control capital inflows. One of those instruments is the unremunerated required reserves. See Selaive and Tuesta (2008) for the case in which the net foreign assets position of a country affects the UIP.

[24] The cost is estimated with an interest rate that the funds in reserve would not receive from an alternative financial product.

[25] In the Peruvian case, this type of RR makes it expensive for financial institutions to carry out trade operations; i.e., any person can open a deposit account, but financial institutions have to pay an additional tax. In that sense, RRs in Peru do not limit nor make expensive capital inflows that are generated by the financial system, have a prudential role, and do not control capital.

[26] Carpenter and Demiralp (2012) pointed out that the level of reserve balances has risen in the United States of America from roughly US\$ 20 billion before the financial crisis to well past US\$ 1 trillion with the use of nontraditional policy tools.

[27] Even though measuring the effectiveness of RRs is debatable, Tovar, García-Escribano, & Vera (2012) showed that RRs have a moderate and transitory effect and mainly play a complementary role to monetary policy in Latin American countries. See Glocker and Towbin (2012) for an empirical review of the cases of China, Malaysia, Turkey, and Brazil. In all cases, RRs were used during the 2007-2009 financial crisis.

[28] See Kashyap and Stein (2000) for a discussion of the M-M theorem and models with banks.

[29] According to Edwards and Vegh (1997), the provision of banking services is costly because banks have to use resources for managing and monitoring a given level of loans and deposits. Prada (2008) extended Edwards and Vegh's (1997) argument and pointed out that the cost function of banks has to take into account the amount of resources (in terms of production) that are needed to provide financial services (deposits and credits). Edwards and Vegh quoted Fischer (1983), Diaz-Gimenez, Prescott, Fitzgerald, and Alvarez (1992), and Bernanke and Gertler (1995) as previous works using models with banks that have intermediation costs.

[30] Prada's (2008) calibration of his model shows that for the Colombian case, RRs are not effective, which differs from Edwards and Vegh's (1997) estimation in which RRs have significant effects for the Mexican and Chilean economies. Bustamante (2011) took elements from Edwards and Vegh (1997) and Prada (2008) but considered the case of a closed economy in which there are heterogeneous households, financial intermediates that are risk averse, and a central bank that follows countercyclical rules. Bustamante's (2011) conclusion is that RRs and the interest rate are complementary.

[31] Collateral restraints amplify the credit cycle through the value of the banks' assets (financial leverage position). This assumption generates a demand for liquid assets. The financing problem, in this case, applies to banks.

[32] The authors found that the amplification effect that was higher than in Bernanke et al. (1999) was still there because of the capital requirements.

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Author Note

César Carrera, Research Department, Banco Central de Reserva del Perú, Jr. Miroquesada 441, Lima, Peru.

Correspondence concerning this article should be addressed to César Carrera, Email: cesar.carrera@bcrp.gob.pe