# The cost of excess reserves and inflation in the United States during the last century

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# The cost of excess reserves and inflation in the United States during the last century

*This paper proposes another factor explaining why the American banking sector accumulates reserves (the reserves-cost mechanism) and its consequences mainly on inflation (reserves-cost channel).*

*The mechanism claims that when banks are holding reserves more expensive than those available in the market, they obtain new reserves and accumulate those unused. In addition, the cost of the sources from where banks obtain their reserves determines banks' decisions about the loans rate. This originates the reserves-cost channel, whereby banks' decisions about the loans rate modify the impact of Fed's policies on final targets such as inflation. I test the validity of the mechanism and channel estimating an SVAR for the period 1922-2020. The results confirm both hypothesis and show that when banks set a loans rate lower in relation to the short-term rate of reference, there is higher demand for credit, output and inflation levels.*

- *JEL classification: E43, E51, E52, E58*

- *Keywords: monetary policy, Federal Reserve, SVARs, excess reserves, reserves cost*

# 1. Introduction

After the Great Recession comparisons arose between the causes and consequences of this episode and the Great Depression. One of them was the hoarding of excess reserves in the banking sector. Such level of excess reserves has often aroused fears about more credit and subsequently, inflation outbursts (Meltzer, 2009; Plosser, 2011). However, there is a strong opposition against that belief. Martin, McAndrews and Skeie (2016) showed that lending was not related to the amount of reserves, because the key determinant of lending is the expected profits between the return obtained on a loan and the opportunity cost of it. According to Bindseil (2004), the inflation fears have no foundation as they come from the erroneous "Reserve Position Doctrine". Under an interest rate target, banks do not need reserves to lend. Banks first lend if its profitable, and then, obtain the necessary reserves (Holmes, 1969; Carpenter and Demiralp, 2010; Jakab and Kumhof, 2015). Bindseil (2004) also stated: "whoever has worked in the credit department of a commercial bank, will confirm that the decision to grant a loan is never done on the basis of the bank's current level of excess reserves. Excess reserves can be traded in the money market, and what matters is their opportunity cost." Therefore, the result of an injection of reserves to make banks expand credit will result in a drop of interest rates to zero (if there is no deposit facility), and once this occurs, the money multiplier should fall with every further reserves injection, as the amount of reserves provided overcomes the demand for credit.

Although the Great Depression and Recession have been two remarkable and studied episodes, periods with normal levels of excess reserves seem to have fallen into oblivion. I consider all periods equally important because low levels may help to shed light on what consequences excess reserves can have on inflation. Similarly, during these periods that are not "contaminated" with the Fed flooding the market with reserves, it is possible to discover other factors that led banks to accumulate reserves. Comprehending these factors is politically relevant because the Federal Reserve could undertake policies aiming to control the way through which banks accumulate reserves and hence, its impact on inflation or another final target.

The literature claims (next section) that banks decide to accumulate reserves because low interest rates prevent banks from investing in alternative assets, financial shocks and oversupply of reserves under a low credit demand scenario. In this paper, I discover another factor. It is a mechanism based on the cost at which banks obtain and hold reserves, which also unveils the channel that links excess reserves and inflation.

This reserves-cost mechanism works as follow. Banks, as profit maximization agents, prefer to obtain their (required) reserves from the cheapest source. These sources can be excess reserves, borrowing at the discount window and nonborrowed reserves. When the Fed allows positive spreads between the short-term rate and the discount rate, banks prefer to borrow at the discount window. As a result, they can set a lower loans rate in relation to the short-term rate. When banks are holding reserves in excess with a cost higher than for nonborrowed and borrowed reserves, they will not use their excess reserves. They will fetch new reserves at the nonborrowed or borrowed cost, namely, the short-term rate of reference or the discount rate respectively, and set a higher loans rate in relation to the short-term rate to obtain the highest profit. Afterwards, they will accumulate the unused reserves.

How can the accumulation of reserves affect inflation? Through the reserves-cost channel. When the Federal Reserve provides reserves at a cost to achieve its intermediate targets, such as the federal funds rate (or another short-term rate), it influences banks' decisions on the loans rate. Thus, the reserves-cost channel states that when the loans rate increases more (less) than the short-term rate because of the cost of reserves, the demand for credit increases less (more). Consequently, inflation levels are lower (higher) than the Fed desired when raised the short-term rate.

This channel implies that what affects inflation is the price of excess reserves through banks' decision on the loans rate, not the amount. This channel is a contribution that has political implications. The Fed should control it through the reserves-cost mechanism to avoid transformations of its policies and gain more control over inflation or another final target.

I test the hypothesis of the mechanism estimating a structural vector autoregressive (SVAR) for the United States between 1922 and 2020. To evaluate banks' decisions about the level of excess reserves and the loans rate given the cost of reserves, I create a variable that measures the average cost of excess reserves. The results confirm that banks accumulate reserves when the cost of those held is above the price of the reserves available in the market. Also, when either they hold or can obtain cheaper reserves than the short-term interest rate of reference, they set a lower loans rate in relation to that short-term rate.

Last, I test the reserves-cost channel estimating a new SVAR that includes the spread between the loans rate and the short-term rate of reference. It represents the potential banks' transformations of Fed's policies. The results show that when banks set a higher loans rate in relation to the short-term rate, because of the higher cost of their excess reserves, loans, inflation and output decrease. Thus, this mechanism proves the relationship between the cost of excess reserves and inflation, and that banks can transform Fed's policies. I emphasize that this estimation is to evaluate the impact of banks' transformation of Fed's policies as a consequence of the cost of reserves held, but it does not evaluate Fed's policies per se.

These results have three implications. First, intermediate targets cannot be used to measure the impact of Fed's policies, as their impact on the loans rate change depending on the cost of reserves. Second, the reserves-cost channel may explain the price puzzle (Bernanke, Boivin and Eliasz, 2005; Uhlig, 2005) and the different characteristics of the Great Inflation and the Great Moderation. The reason is that during the Great Inflation, the loans rate increased less than the Fed rose the federal funds rate. Therefore, the demand for credit was not curtailed as much as the Fed intended. Last, the spread between the loans rate and the short-term rate between 1929 and 1933 was one of the largest of the sample. Therefore, it could have contributed to the deflation of that period.

This paper is structured as follows. Section 2 reviews the literature regarding the causes of the accumulation of excess reserves. Section 3 explains how the reserves-cost mechanism and channel operates. Section 4 offers some data supporting them. Section 5 describes the model used for estimation and section 6 displays the results. Section 7 considers the repercussions of the interest rates paid on reserves, the removal of required reserves and the role of the reserves-cost mechanism and channel under the current oversupply of reserves. Section 8 explains the implications of the reserves-cost channel for the literature. Last, section 9 summarizes the main results and their implications.

## 2. Literature review

The literature has proposed three reasons why banks accumulate reserves: low interest rates prevent banks from investing in alternative assets, financial shocks and oversupply of reserves under a low credit demand scenario.

Regarding the accumulation of reserves for the 1930s, Frost (1971) defended what he called the "adjustment-cost" hypothesis, whereby banks hold substantial amounts of excess reserves at low interest rates because brokerage costs, commissions, spreads…prevent them from adjusting their reserve position, as these costs are greater than the interest earned on short-term securities. Lindley, Clifford and Mounts (2001) and Dwyer (2010) claimed that there is a negative relationship between interest rates and excess reserves and that banks received reserves that were unable to convert into income-earning assets given the low demand for credit. Subsequently, they had to hold unintended reserves balance. Wilcox (1984) refuted Friedman and Schwartz's (1963) argument that excess reserves increased as a consequence of the increase in reserve requirements (or other shocks such as bank runs), because despite it may be able to explain the initial hoarding of excess reserves in the early 1930s, it cannot explain the greater pile up after 1934 and 1937. Instead, low interest rates were a more powerful factor in explaining those increases in excess reserves. Calomiris, Mason and Wheelock (2011) stated that excess reserves did not increase between June 1936 and June 1937 because banks curtailed credit as Friedman and Schwartz's (1963) stated. On the contrary, banks increased lending by 750 million dollars, but reduced their holding of government securities by 1,100 million dollars. They concluded, "as bank profits and loan opportunities increase, and as macroeconomic risk recedes, banks will reduce excess reserves to finance loan expansion." The increase in lending accompanied by the decline in government securities aforementioned could be explained by Cagan (1969)'s claim that when the spread between the short-term rate of the funds market and the discount rate was positive, banks preferred to borrow at the discount window. When the spread was zero or negative, as it was the case for the 1930s, banks sold securities to finance the expansion in loans. In general, he argued that the accumulation of excess reserves in the 1930s was due to the cost of investing in short-term securities, supplemented by the lack of demand for loans and the risk of investing in long-term securities. Todd (2013) stated that the accumulation of excess reserves in the 1930s went away only once banks were offered government-guaranteed lending alternatives, which funded defense production programs. Thus, in relation to the Great Recession, he argued that the quantitative easing (QE) aimed to encourage banks to ease the terms of credit was not accomplished given the low demand for credit and subsequently, excess reserves were hoarded. This author also claimed that the new policy tool, namely, the interest rate paid on reserves, is encouraging banks to retain excess reserves.

Dow (2001) estimated the demand for excess reserves for the 1990s and obtained that one percentage point increase in the federal funds rate decreased excess reserves in \$120 millions, while an increase in deposits of one billion dollars increased excess reserves in three million dollars. Regarding the years around the Great Recession, Chang, Contessi and Francis (2014) found that banks accumulated excess reserves when there was a deterioration between capital adequacy and loans loss provisions (what could be classified as precautionary motive due to weak balance sheet), when the opportunity cost of holding low-interest-bearing assets was low, and when the penalty for holding insufficient reserves increased. However, measuring economic uncertainty by the volatility index (VIX) and industrial production index (IPI) variance, the estimations showed that the uncertainty factor did not influence the level of excess reserves. Ennis and Wolman (2015) found that banks did not substitute reserves for liquid securities, but they complemented them contributing to increasing bank liquidity, partially, because the Fed is paying interest rates on reserves. He also added that the increase in reserves did not pressure insured banks' balance sheet capacity, because the Fed's purchase programs flooded with reserves mostly those banks with abundant capital. Therefore, banks could have lent without any pressure on their capital ratios. Ashcraft, McAndrews and Skeie (2011) analyzed the daily behavior of large and small banks in the federal funds market from 2002 to 2008. They observed that the reluctance to lend and the desperation to borrow for 2007 and 2008 triggered more volatility (extreme spikes and crashes) in the federal funds rate. Hence, banks held more precautionary reserves.

## 3. Theoretical framework

The reserves-cost mechanism and channel here proposed are based on the fact that banks do not need reserves before lending (Holmes, 1969; Bindseil, 2004; Carpenter and Demiralp, 2010; Jakab and Kumhof, 2015) and the demand for money is endogenous and dependent on the prime loans rate (Moore, 1983; Lombra, 1992; Goodhart, 2007). Under these two conditions, the debate about if the banking sector transmits monetary policy through the money channel (Romer and Romer 1990; Ramey, 1993; Oliner and Rudebusch, 1995 and 1996) or the credit channel (Bernanke and Blinder, 1992; Bernanke, 1993; Kashyap, Stein and Wilcox, 1993; Kashyap and Stein, 2000) would disappear, as they are based on the fact that banks need reserves before lending.

The interest rate, wealth, broad credit or monetarist channels are also some of the channels proposed to explain how monetary policy is transmitted to the real economy (Kuttner and Mosser, 2002). This paper does not intend to deny or confirm them (even though the results may reinforce some of them) but rather focuses on the intermediate agent standing between the Federal Reserve and the economy, namely, the banking sector. Most of the aforementioned channels are actually activated after banks have accommodated Fed's policies. Therefore, the new channel exposed here should be considered as a channel operating previously to the other ones.

### 3.2The reserves-cost mechanism

The reserves-cost mechanism states that banks as profit maximizing agents, choose the source of reserves depending on their cost to fulfill their levels of required or desired reserves. This factor determines the levels of excess reserves and also influences their decision about the loans rate.

The Federal Reserve uses its main instruments, namely, open market operations (OMO) and the discount rate (DR),[1] to control intermediate targets as the federal funds rate or another short-term rate of reference, some measure of reserves, monetary aggregates, exchange rate…. Through those intermediate targets, the Fed manages its final targets such as unemployment or inflation. I choose the federal funds rate (FR) as reference in this section given it is the main intermediate target during the most part of the period under analysis. Nonetheless, it can be considered as the short-term rate of reference (STR) of any period[2] or another intermediate target, such as borrowed reserves. The Fed manipulates it (directly or indirectly) providing banks with nonborrowed reserves (NBR) through OMO, and borrowed reserves (BR) at the discount window:

$$FR_t = \rho_1 NBR_t + \rho_2 BR_t \quad (1)$$

In both cases, the Fed provides reserves at a cost. Borrowed reserves are obtained at the discount window, where the cost is the discount rate. Regarding the reserves

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[1] The reserves requirement ratio is also a Fed's instrument, but it has hardly varied over the last decades and is irrelevant for this mechanism. Therefore, it is excluded. After 2008, another instrument was added: interest rates on required reserves (IORR) and excess reserves (IOER). They are discussed in section 7.

[2] Appendix A and C (variable STR)

obtained from the open market, when banks sell securities to obtain reserves, they renounce to the interest rate paid on those securities. The cost (or opportunity cost) of those reserves is the interest rate not received. The lowest price of reference for those reserves is the 3-months T-bill rate, which in general is around the federal funds rate[3]. If the term of those securities is longer, the cost will be higher.

Regarding banks, when they lend, they create a deposit (D) in the process and obtain the required reserves afterwards (Moore, 1998; Jakab and Kumhof, 2015). Thus,

$$RR_t = \kappa D_t \quad (2)$$

where κ is the reserves requirement ratio.

Banks will also consider other factors (previous section) to determine the levels of excess reserves apart from the cost of reserves. Thus, the banking sector sets the federal funds rate (the price at which banks are willing to lend their reserves) conditioned on the amount of required reserves (RR) and the desired level of excess reserves (ER). The desired level of ER may include expectations about Fed's policies, for instance, federal funds rate targets. That is, if banks expect that the Fed raises the FR, they will assume that it will be more expensive to obtain reserves in the federal funds market. Therefore, either they will use their ER if needed (lowering their amount of reserves and putting upward pressure on their price), or they will offer those reserves at a higher cost in the federal funds market (the expected FR).

$$FR_t = \varsigma_1 RR_t + \varsigma_2 ER_t \quad (3)$$

[3] Figure 1 shows that the 3-months T-Bill rate tracks the federal funds rate, except for those periods when the spread between the federal funds rate and the discount rate was larger. Yet, the 3-months T-Bill rate remained above the discount rate and hence, banks preferred to borrow at the discount window (Figure 2).

Consequently, the reserves market must be in equilibrium for the targeted federal funds rate:

$$\rho_1 NBR_t + \rho_2 BR_t = \varsigma_1 RR_t + \varsigma_2 ER_t \qquad (4)$$

The four coefficients could vary with time, depending on expectations regarding Fed's policies or possible events affecting the economy.

The new required or desired reserves have associated a cost depending on the source. It was commented above that borrowed reserves have the cost of the discount rate. However, in the case of nonborrowed reserves, there are more sources than OMO. They are the federal funds market (FF), where the cost is the federal funds rate and new deposits created from the currency held by depositors ($D^C$).

$$NBR_t = OMO_t + FF_t + D^C{}_t \qquad (5)$$

For the cost of reserves obtained from new depositors, I take as reference the rate paid on the 3-months Eurodollar deposits. This rate has been either the same as the federal funds rate or slightly higher[4] (Figure 1)[5]. Hence, it can be considered that the cost of borrowed reserves is the discount rate and the cost of nonborrowed reserves is the federal

[4] Until the late 1980s, for some periods, a cheaper source of reserves was time and saving deposits. Under regulation Q banks could not offer an interest rate above the ceiling rate established, and several times short-term rates were above that ceiling. Therefore, those reserves were cheaper than the different costs of reserves displayed in Figure 1. Nonetheless, given the alternatives yields, depositors looked for better interest rates in Eurodollar deposits or loans and saving associations. Thus, it is not expected that banks obtained a significant amount of new reserves from time and saving deposits.

[5] Data for the 3-months Eurodollar deposits is only available since 1960.

funds rate (or another short-term rate of reference). Although these measures are not accurate, they are a good approximation.

Substituting (2) and (5) into (4), and for simplicity, removing the coefficients ρ and ς,

$$OMO_t + FF_t + D^C_t + BR_t = \kappa D_t + ER_t \quad (6)$$

Expressing equation (6) in growth rates (denoted by the dot over the variables),

$$\dot{OMO} + \dot{FF} + \dot{D}^C + \dot{BR} = \kappa\dot{D} + \dot{ER} \qquad (7)$$

Equation (7) shows that new deposits need reserves from any of the sources on the left hand side of the equation or excess reserves. The growth of ER would be the result of obtaining more reserves than needed for new deposits. It would decrease the federal funds rate of equilibrium, unless banks, for other reasons, need to hold excess reserves. If it were the case, the direction of the federal funds rate would be unknown. Those excess reserves have associated the costs of the sources from where they were obtained in the past.

Deposits grow when there are depositors carrying their currencies and banknotes to banks or new loans. Therefore,

$$\dot{D} = \dot{D}^C + \dot{L} \quad (8)$$

Substituting (8) into (7) and rearranging,

$$\dot{L} = \frac{\dot{OMO} + \dot{FF} + \dot{D}^C(1-\kappa) + \dot{BR} - \dot{ER}}{\kappa} \quad (9)$$

Equation (9) shows the sources from where banks can obtain reserves to fulfil their new level of required reserves after lending[6]. As profit maximization agents, they will choose the cheapest source. Therefore, if they are holding excess reserves but their cost is more expensive than the other sources, they would prefer to obtain new reserves. This situation can lead to a higher level of excess reserves, as bank may obtain unintended reserves.

To sum up, if the cost of the reserves in the market is cheaper than the cost of the reserves held, banks will obtain more reserves from the market. The new unintended reserves will pile up as excess reserves. Their cost, along with the cost of reserves available in the market, will determine banks' decisions about the prime loans rate as explained below.

### *3.3 The reserves-cost channel*

The reserves-cost channel works as follows. Banks set the loans rate according to the cost of reserves available in the market or excess reserves. As the Federal Reserve uses the federal funds rate as intermediate target to influence its final targets, when banks obtain reserves at a different cost than the federal funds rate, this rate has a varying impact on the loans rate. This varying impact is transmitted to lending and inflation. Therefore, banks can modify Fed's policies when they set the loans rate given the cost of their reserves. That is the link between inflation and excess reserves.

[6] An increase in the reserves requirement ratio does not necessarily mean a decrease in loans. In equation (9), increasing the amount of reserves can compensate a higher reserves requirement ratio. It will influence, however, banks' profits. But, as long as there is demand for credit, banks have no reason to decrease lending, as more loans would increase their profits. In the case of a lower reserves requirement ratio, loans will increase only if their demand is also raising. Otherwise, the demand for reserves will decrease and banks will use their excess reserves for new loans when that is the cheapest alternative.

The support to the claim that banks set the loans rate conditioned on the cost of reserves is that I asked the Federal Reserve by email: "what does determine the (prime) loans rate?"

They answered: "The prime rate is a rate established by commercial banks as a lending rate or base off which their commercial loans are priced. In other words, the banks set their own rates based on the demand for various kinds of loans, on the cost of money to the banks, and on the administrative costs of making loans…" The cost of money to banks is the price of reserves and the cornerstone of this channel. It confirms that before lending, banks know the cost of the reserves needed or desired and set the loans rate accordingly[7].

As the cost of reserves varies depending on the source and banks will try to obtain most of their reserves from the cheapest one, they will set the loans rate (LR) according to that source to maximize their profits or avoid any potential solvency problem. Apart from that, banks also consider the state of the economy to set the loans rate. Assuming that banks gather information about inflation, output and lending, they set the loans rate as follows:

$$LR_t = \delta LR_{t-1} + Y_t^{LR} + \Psi_1 (FR - DR)_t + \Psi_2 (RC - FR)_t + \Psi_3 FR_t + u_t^{LR} \quad (10)$$

where

$$Y_t^{LR} = (\Sigma_{i=-1}^{1} \lambda^{LR} y_i)_t + (\Sigma_{i=-1}^{1} \phi^{LR} \pi_i)_t + (\Sigma_{i=-1}^{1} \alpha^{LR} L_i)_t \quad (11)$$

[7] Risk, liquidity, required capital ratios, the amount of credit already extended …are also factor influencing the loans rate. However, the case under study uses the prime loans rate, which is the rate that commercial banks charge to their most credit-worthy customers. Thus, the aforementioned factors potentially influencing the loans rate either do not apply to this case, or they are significantly diminished.

Therefore, it is supposed that banks set the loans rate depending on lagged (i=-1), current (i=0) and forecasted (i=1) data about output (y), inflation (π) and the amount of lending (L), the spread between the federal funds rate and the discount rate, the spread between the cost of excess reserves held by banks until period t and the federal funds rate, and last, the federal funds rate.

$\Psi_3$ represents how banks set the loans rate according to the interest rate of reference for reserves in the federal funds market. The spread FR-DR ($\Psi_1$) signals when banks can obtain cheaper reserves at the discount window. If the spread is positive, banks will obtain as many reserves as possible at the discount rate cost. When both rates are similar, the source will be indifferent. When the spread is negative, banks will avoid the discount window, unless it is necessary. Thus, the expected sign for $\Psi_1$ is,

$$\begin{cases} \Psi_1 < 0 \quad if \quad FR - DR > 0 \\ \Psi_1 = 0 \quad if \quad FR - DR = 0 \\ \Psi_1 \geq 0 \quad if \quad FR - DR < 0 \end{cases}$$

That is, if the federal funds rate increases but this spread is positive, banks will borrow reserves at the discount window and set the loans rate considering the discount rate rather than the federal funds rate. Consequently, the impact of the federal funds rate on the loans rate $\Psi_3$ will be diminished, as $\Psi_1$ will be negative.

The relationship between positive spreads FR-DR and borrowing has been widely reviewed in the literature[8]. In summary, when the Fed allowed a positive spread, banks increased their borrowing at the discount window. This fact is easily visualized in Figure 2 (it has a ceiling for the sake of the presentation), where I display borrowed reserves as percentage of required reserves and the spread between the short-term rate of reference

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[8] Appendix B

(STR) and the discount rate. Even when the spread was negative, its reduction led to more borrowing. However, after 1990 banks reacted differently to that spread because of factors explained in section 4.

Thornton (1982) visualized part of this mechanism when analyzing the effect of the discount rate on market interest rates: "It is not simply the level of the discount rate that influences a depositary institution's decision to borrow, but the level of the discount rate relative to rates on alternative adjustment asset. […] Thus, the important variable in the decision to borrow is the so-called least-cost spread between the rate on the next best reserve adjustment asset and the discount rate" (p.2).

Last, $\Psi_2$ captures how banks set the loans rate depending on the spread between the cost of the excess reserves they are holding at time t (RC)[9] and the federal funds rate. The higher is that cost in relation to market rates, the higher banks will set the loans rate to maximize profits from lending.

Thus, the expected sign for $\Psi_2$ is,

$$\begin{cases} \Psi_2 > 0 & if \quad RC - FR > 0 \\ \Psi_2 = 0 & if \quad RC - FR = 0 \\ \Psi_2 \leq 0 & if \quad RC - FR < 0 \end{cases}$$

Equation (10) implies that unless the spreads FR-DR and RC-FR are zero, the banking sector is able to transform Fed's policies, because the impact of the federal funds rate on the loans rate will vary with those spreads.[10] Therefore, credit and inflation will also react

[9] Appendix C (Variable Reserves Cost)

[10] Under another intermediate target, the short-term rate would adjust. Those adjustments would have also a different impact on the loans rate depending on the cost of reserves obtained.

differently to the same movements in the federal funds rate. Thus, the spread $LR_t$-$FR_t$ represents the higher or lower level of tightening that the banking sector applies when setting the loans rate, in relation to Fed's policies, when it sets the federal funds rate (or other intermediate targets). When a movement in the federal funds rate is equally reflected on the loans rate, Fed's policies are not transformed in that period. On the contrary, when a movement in the federal funds rate has an impact ratio on the loans rate different from one, banks are transforming Fed's policies.

While the impact ratio is useful to capture potential transformations for a specific period, the magnitude of the spread is more relevant. The aggregation of the different impact ratios over time determines that magnitude. The larger the spread, the more the banking sector is tightening the demand for money in relation to Fed's policies. Thus, even if the impact ratio is below one for a specific period, for instance, FR is raised one percentage point but LR only increases 0.8 percentage points, a positive spread as result of the accumulation of impact ratios above one would counteract the transformation for that specific period. That is, if for example the spread LR-FR was three percentage points, although LR is increasing less than FR, the spread would be 2.8 percentage points. Thus, the banking sector would tighten the economy more than the Fed desires, even though in that moment, LR has increased less then FR (0.8 vs 1 percentage points). In the same way, when the impact ratio is one, the accumulation of ratios above (below) one would tighten (loosen) the Fed's policies of that period, despite the lack of transformations in that specific period.

According to this channel, the Federal Reserve could have greater control over monetary policy if it aims for a zero spread FR-DR and manipulates the cost at which banks obtain reserves or accumulate excess reserves, given it is the main provider. This implies that the relation between excess reserves and inflation is not about the amount of reserves accumulated, but the price at which they were obtained.

### *3.4 Regime changes*

The reserves-cost channel is not affected by changes of monetary regimes[11], financial regulation (Regulation Q, for instance), variations in the level of required reserves or legal modifications for borrowing at the discount window. The reason is that while banks may have had to change among the sources available to obtain reserves, in any case, they had to obtain reserves from somewhere at a cost. This cost determines the loans rate, what in turn, governs the demand for credit.

However, the mechanism can be altered. For example, after 1990 banks hardly used the discount window, even though it was the cheapest source for some periods. Thus, banks used the cheapest reserves source only after discarding the discount window. This fact modified the mechanism as the discount rate cost cannot be considered during those periods when it was below the federal funds rate. In terms of equation 10, $\Psi_1 = 0$. Appendix D discusses whether changes in the way that the discount window operated and Regulation Q, may have affected the reserves-cost mechanism.

## 4. Empirical Evidence

In this section, I support with some data the reserves-cost mechanism (Figure 3-6) and channel (Figures 7-8).

[11] A monetary regime implies an intermediate target. To achieve such target, the Federal Reserve has to use its instruments. Those instruments provide reserves at a cost.

Figure 3 displays the average cost at which banks hold reserves (RC), the logarithm of excess reserves as percentage of required reserves (ER)[12] and the spread between RC and the short-term rate of reference (STR). The figure is cut above given the high excess reserves levels after 2008.

Figure 4 displays the level of nonborrowed reserves as percentage of loans. This variable explains the increases in excess reserves corresponding to the Great Depression and the Great Recession. It represents when the Fed oversupplied reserves given the demand for loans. Back to Figure 3, the spread RC-STR seems to be related to the behavior of ER. Except for the periods when the Fed flooded banks with nonborrowed reserves and between 1970 and 1973, a higher spread RC-STR is accompanied by higher levels of excess reserves. This would mean that when banks held more expensive reserves than those available in the market, they preferred to obtain new reserves for lending. Subsequently, the unused reserves led to higher level of excess reserves. The RC variable can be slightly misleading for the Great Depression and Great Recession. The Fed provided large amounts of nonborrowed reserves at low cost and hence, the average cost of reserves is dragged down, even though banks held reserves at higher prices.

Figure 5 displays the spread LR-STR and STR-DR. The negative relationship between both spreads is clear. When the Fed allowed positive spreads STR-DR and banks could borrow cheaper reserves at the discount window (Figure 2), they set a lower loans rate in relation to the short-term rate of reference. However, after 1990 the spread LR-STR was practically constant. There are two reasons. First, banks were reluctant to borrow because of the active involvement of the discount window during the 1980s to

[12] This series is multiplied by ten so that it can be better compared with the other variables in all the figures where it appears.

avoid bank failures. Therefore, borrowing at the discount window sent a signal of weakness. Second, although the Fed set a fixed 0.25-0.5% spread to incentivize institutions to borrow, they must have exhausted before other available funds sources. Consequently, banks obtained most of their reserves as nonborrowed, which have the cost of the short-term rate of reference. Thus, it seems that banks pegged the loans rate to the federal funds rate and the discount rate no longer influenced the loans rate. Yet, it is unknown (to the best of knowledge) why they have maintained that approximately three percentage points spread. It seems to be a ceiling except between 1980 and 1982, when the spread was occasionally over that number.

In Figure 6 I also display the spread RC-STR and ER, but this time along with the spread LR-STR. The higher the spread RC-STR, the larger the spread LR-STR is. The 1970s is the exception because the loans rate movements are slightly smoother than those of RC, although the correlation is still positive. RC is more volatile because of the low levels of ER. That is, the cost of the few reserves in excess changed quickly as they were used almost immediately. Further, those reserves were priced at two different costs as the spread between the federal funds rate and the discount rate was positive. Regarding the ceiling commented previously, it seems that it coincides with the highest spreads RC-STR, except during the period of low excess reserves levels and after 2007. As commented before, the RC variable can be misleading once the Fed oversupplies nonborrowed reserves. Thus, banks set a higher loans rate when they were trapped with more expensive reserves than those available in the market.

Last, Figure 7[13] and 8 shows that the banking sector's transformation of the Federal Reserve's policies could have contributed to the evolution of inflation and credit.

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[13] The series LOANS% YoY is divided by ten so that it can be better compared with the other variable.

That is, lower spreads LR-STR contributed to a higher demand for loans and higher inflation levels. The relationship was weaker between the 1930s and 1950s, and after 1990. For the last case, however, when the spread was almost the largest of the entire period despite being constant, inflation and credit growth rates were lower and less volatile. As commented in the previous section, the magnitude of the spread is more relevant than how the spread evolves from t-1 to t.

## 5. Methodology and variables[14]

The model set-up is as follows. Consider the VAR standard form

$$y_t = c + \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} \dots + u_t \quad (10)$$

where $y_t$ is an *n x 1* vector of endogenous variables at time t, c is an *n x 1* vector of constant terms, $\Gamma_t := ß_t A^{-1}$, are *n x n* matrices of coefficients and $u_t := \varepsilon_t A^{-1} B$ is an *n x 1* vector of error terms, with $u_t$ having variance covariance matrix $\Sigma_u = B\ A^{-1} \Sigma_\varepsilon\ A^{-1}{'} B'$. Normalizing the variances of the structural innovations to one, i.e., assuming $\varepsilon_t \sim (0, I_n)$, $\Sigma_u = B\ A^{-1}\ A^{-1}{'} B'$. Therefore, the model can be rewritten as

$$y_t = c + \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} \dots + BA^{-1}\varepsilon_t \quad (11)$$

However, to recover the parameters of the structural form, at least $2n^2 - ½n(n+1)$ restrictions are to be imposed in B and A to identify all $2n^2$ elements of these matrices. In this way, the structure of the model follows the AB-model described in Lutkepohl (2005).

[14] Appendix C.

Setting equation 11 as $A(I_k + ß_1L + ß_2L^2\ldots)y_t = B\varepsilon_t$ where L is the lag operator, the order of the variables and the restrictions are set as follows:

$$\begin{pmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ b_{ij} & \cdots & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ . \\ . \\ . \\ x_n \end{pmatrix}_t (I_k+ß_1L+ß_2L^2\ldots)= \begin{pmatrix} \sigma_{11} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma_{nn} \end{pmatrix} \varepsilon_t \quad (3)$$

That is, the coefficient matrix is lower triangular with ones in the main diagonal. The standard deviations matrix is diagonal containing the elements $\sigma_{ij}$.

The aim of this model is twofold. First, to shed light on the influence of the reserves cost on the amount of excess reserves and the loans rate. Second, to unveil how banks' decisions about the loans rate modify the impact of Fed's policies.

For the first case, I estimate three models. The first model consists of (model 1.1, n=3) NBR ($x_1$), followed by ER($x_2$), and RC-STR($x_3$). For the second model (model 1.2, n=3) $x_1$ is ER, followed by RC-STR($x_2$), and LR-STR($x_3$). Last, for the third model (model 1.3, n=3) $x_1$ is ER, followed by STR-DR($x_2$), and LR-STR($x_3$).

ER and NBR are the growth rate of excess reserves and nonborrowed reserves respectively, as percentage of required reserves, RC-STR is the spread between the new variable measuring the reserves cost and the short-term rate of reference, STR-DR is the spread between the short-term rate and the discount rate and last, the spread between the prime loans rate and STR (LR-STR). The identification scheme for model 1.1 assumes that RC-STR determines banks' decision about excess reserves for the next period, (apart from the fact that the amount of nonborrowed reserves and banks' decision about excess reserves affect immediately the cost of reserves held), while banks respond contemporaneously to the amount of nonborrowed reserves received when considering their levels of ER. For the model 1.2 and 1.3, LR-STR is set last, as banks set the loans rate immediately after they know the cost of reserves available as excess reserves or in the market, and the level of excess reserves. The difference between the two models is that for model 1.2 banks set the loans rate according to the cost of reserves accumulated over time, while for model 1.3 banks set the loans rate depending on whether the Fed is providing cheaper reserves through the discount window.

Regarding the model for the transmission channel (model 2), $x_1$ is IPI, followed by CPI($x_2$), LOANS ($x_3$), STR-DR($x_4$) and LR-STR($x_5$). IPI is the growth rate of the industrial index production, CPI is the growth rate of the consumer price index and LOANS is the growth rate of total loans. The two spreads are set last, as the three interest rates involved are set depending on the other three variables.

Last, the period under analysis is 1919:III-2020:III (monthly data, 1209 observations) for models type 1 and 1922:IV-2020:III (quarterly data, 392 observations) for models type 2. The different periodicity is because of the data available for the variable LOANS. According to BIC criteria, the models type 1 are estimated with one lag and the type 2 with two lags.

## 6. Results

In this section, I analyse the impulse response functions and the forecast error variance decomposition for the models described above.

For the model 1.1, Figure 9 displays the response of the ER after a positive RC-STR and NBR shock. When the spread RC-STR increase one percentage point, banks increase their ER 0,4% for the first months and then, it decays slowly to zero for the next months. In addition, one percentage point shock to NBR increases ER by 9% immediately, although the impact is zero and not significant after one month. Looking at Table 1, the forecast error variance decomposition shows that ER is mostly explained by itself, followed by NBR. The spread RC-STR explains between 0,2% and 0,6% of the ER variation.

For the model 1.2, Figure 10 displays three panels. The first one shows that banks set the loans rate around 0,13 percentage points higher in relation to the short-term rate when there is a positive shock to RC-STR. This positive and significant response decreases smoothly, being no significant after 16 months. The second panel displays that a positive shock to ER leads to a significant increase of 0.02 percentage points of LR-STR after 2 months. In the last panel, a positive shock to RC-STR leads banks to increase ER by 0,6% after one month. Table 2 shows again that ER accounts for the most part of its forecast error variance, but the percentages are higher than in Table 1, once NBR has been removed. This time the spread RC-STR explains between 0,3% and 1,4% of the ER variation. Further, the spread RC-STR accounts between 15% and 20% of the LR-STR forecast error variance.

Figure 11 shows the results for the model 1.3. Apparently, the spread STR-DR does not influence banks' decisions about excess reserves (Panel 1). However, a positive shock to the spread STR-DR triggers that banks set immediately the loans rate 0.2 percentage points lower in relation to the short-term rate (Panel 2). The response smoothly goes to zero and is not significant after eight months. After 13 months, the response is positive and significant. Given the characteristics of both spreads, that positive response may be capturing random relationships, as banks react contemporaneously as seen in Figure 5. Last, a positive shock to ER triggers the same LR-STR response as in model 1.2 (Panel 3). This time, the variation of ER is mostly explained by itself, specifically 99,9% after 20 months (results not presented).

As the Great Depression and Great Recession are exceptional episodes (along with the COVID) in relation to excess reserves levels, I estimate the same models for the period 1946-2007. While the response of ER to an RC-STR shock is similar, the ER response to an NBR shock varies (Model 1.1). ER increases immediately by 6%, then it goes to -3% after one month, 2% after two months, -1% after three months and then, the response is no longer significant (Figure 12).

For the model 1.2, the responses of LR-STR to an RC-STR and ER shock are similar. This time banks set the loans rate 0,17 percentage points higher for the former, and 0,03 for the latter. The response of ER to a RC-STR shock is equal. Last, the results remain the same for model 1.3.

Regarding model 2, Figure 13 shows credit, inflation and output responses to a positive LR-STR shock. The first panel shows that LOANS decreases significantly around 0,18% after 2 quarters, when the loans rate is set one percentage point higher than the short-term rate. After and before that, it is not significant. To the same shock, CPI decreases around 0,1% for the first quarter and around 0,05% for the second and third quarter. After the third quarter the response is not significant. The last panel shows that the same shock decreases IPI significantly around 0,7%, although only for the first quarter.

Figure 14 displays the results when the shock is to the spread STR-DR. Panel 1 and 2 shows that the LOANS and CPI responses are not significant. In Panel 3, however, the IPI response is negative and significant between the second and ninth quarter. It goes from -0,4% to -0,1%. The last panel shows that banks set the loans rate around 0.2 percentage points lower in relation to the short-term rate, when the Fed increases the spread STR-DR one percentage point. This response disappears after three quarters and becomes positive and significant after 7 quarters. Again, that positive response after so many quarters is not reasonable, as banks react contemporaneously.

If the spread STR-DR is removed from the model, the results for LR-STR are similar. This confirms what was commented in section 3.2. Even if the mechanism is modified, the reserves-cost channel remains unaltered. Hence, banks reluctance to borrow after 1990 is not relevant for the results about the channel. Apart from that, I restricted the sample from 1922 to 1990, but the LR-STR response to STR-DR remained equal (results not presented).

Table 3 shows the forecast error variance decomposition for this model. Both spreads account for around 2% of the forecast error variance of IPI, between 1% and 2% for CPI, and between 0,1% and 0,5% for LOANS. Last, STR-DR explains 25% of LR-STR after one quarter and decrease to 14,5% after 20 quarters. Substituting RC-STR for STR-DR I obtain similar results for LR-STR. The only variation is in the forecast error variance decomposition, where LR-STR gains relevance in explaining the other three variables, while RC-STR has low explanatory power. In fact, a shock to this variable does not produce any significant response from the other variables (results not presented).

I estimate alternative models with further lags and new variables measuring factors such as risk or uncertainty in Appendix E.

To sum up, the results supports that when the Fed provides banks with excessive nonborrowed reserves in relation to the demand for loans, they have to hold unintended reserves (in line with Lindley, Clifford and Mounts, 2001; Dwyer 2010; Todd, 2013) and excess reserves increases. Under that scenario, the cost of reserves contributes to the accumulation of excess reserves but it is dwarfed by the provision of nonborrowed reserves. However, the nonborrowed reserves factor loses relevance and has an ambiguous impact when the periods of the Great Depression and the Great Recession are removed from the sample, while the cost of reserves remains significant. Likewise, while banks consider risk and uncertainty factors to decide the level of excess reserves, those factors are not significant once the sample is restricted[15]. Therefore, the reserves-cost mechanism, while always significant, has a more relevant impact on excess reserves for periods of standard monetary policies.

This mechanism would explain the negative relationship between interest rates and excess reserves found in the literature review. As interest rates rises, more reserves held in excess become cheaper than those reserves available in the market. Therefore, banks can maximize profits using them.

Beside the evolution of excess reserves, the cost of the reserves held by banks and of those available in the market, determines banks' decisions about the loans rate. According to the results, the higher is the cost of reserves held in relation to the short-term interest rate, the higher banks set the loans rate. In addition, when the Fed allowed a positive spread between the short-term rate and the discount rate, bank borrowings at the discount window increased as those reserves were cheaper. Consequently, banks set a lower loans rate in relation to the short-term interest rate. The amount of excess reserves also contributes to a larger spread LR-STR, but in this case, the influence is rather small. All of this means that banks can modify the impact of Fed's policies. Thus, when the Fed increased, for instance, the federal funds rate, but allowed a positive spread STR-DR, or banks held cheaper reserves than those available in the market, the loans rate increased relatively less. Consequently, the demand for money was not tightened as much as the Fed intended and the levels of credit, inflation and output increased (Figure 13).

[15] Appendix E

Therefore, a more efficient monetary policy would imply to aim for an impact ratio of one between the federal funds rate and the prime loans rate, minding also the spread between both. Thereby, if the impact ratio were below one, the Fed should increase further the federal funds rate (keeping the discount rate at the same level or above it), so that the loans rate has the desired impact on the real economy. Moreover, the Federal Reserve should pay attention to how banks accumulate excess reserves, mainly their prices. As the main provider of reserves, the Fed could manipulate the cost at which banks are holding reserves, so that the impact ratio of the federal funds rate on the loans rate remains equal over time.

I emphasize that the results of model 2 are measuring the impact of the banks' transformations of Fed's policies on the economy, when they set the loans rate in relation to the short-term rate. They do not measure the impact of the Fed's policies per se. That is, while an increase in the federal funds rate may have curtailed credit and decreased inflation, those transformations could have reduced (and sometimes even avoid) the effectiveness of that increase.

## 7. Interest on reserves and the removal of required reserves

This paper has unveiled another factor that contributes to the accumulation of excess reserves and its consequences on credit, inflation and output. However, during the last years the rules of the game have changed. Nowadays, the Federal Reserve pays interest rates on required reserves (IORR) and excess reserves (IOER) and recently, the reserves requirements have been eliminated. How does it affect the reserves-cost mechanism and channel?

Regarding the interest rates paid on reserves, central banks use this tool to control separately interest rates and excess reserves, either by building floors or corridors

(Goodfriend, 2005; Keister, Martin and McAndrews, 2008; Bernanke, 2010; Bowmman, Gagnon and Leahy, 2010). In that way, the Fed can inject liquidity into the market when there are liquidity problems like in September 2001, without altering the policy about interest rates. It also helps the Fed to control the level of excess reserves as banks are receiving interests on those reserves and they will not look for alternative assets unless they offer a higher return (Todd, 2013; Ennis and Wolman, 2015).

Despite the relevance of this new instrument, there are several reasons why it was not included in the models estimated. First, the interest paid on reserves would appear only in the last part of the sample, coinciding with the QE and COVID. During that period, excess reserves have mostly increased, except from 2016 to 2019. There are not data for interest rates paid on reserves during “ordinary” periods. Hence, avoiding sample selection bias I decided to not use a variable capturing this new tool. That does not imply that those interest did not contribute to the increase in excess reserves. Actually, banks have had incentives to not buy securities, as they paid less than the interest on reserves. However, it was already said that the oversupply of reserves dwarfed the reserves-cost mechanism, which is proposed only as another factor contributing to the accumulation of reserves and works mainly, when the Fed undertakes “standard” policies. Therefore, the inclusion of that instrument would not modify the results.

Second, if there is demand for credit and banks can profit from it, the levels of excess reserves will decrease despite the interest rate paid on reserves, as the prime loans rate is way above those rates[16]. This will happen as long as excess reserves are the cheapest source available and the Fed doesn’t supply more reserves than necessary.

[16] This supports the argument exposed previously by Moore (1998), Lindley, Clifford and Mounts (2001), Dwyer (2010), Calomiris, Mason and Wheelock (2011) among others, that banks lend when there is demand for credit and is profitable.

Last, it was shown that for the reserves-cost channel, it is not the amount of reserves what matters, but their price. Thus, while banks can get rid or accumulate excess reserves depending on the interest paid on them, on short-term securities or the demand for credit, that change in the amount of reserves will not affect the reserves-cost channel, as banks set the prime loans rate depending on the cost of reserves.

The reserves requirements were reduced to zero per cent on March 2020. Therefore, the measure of excess reserves is obsolete. Regarding the reserves-cost mechanism, total reserves can now be considered as excess reserves because they actually are. However, banks need them to comply with their depositors despite the Fed doesn't require them to hold reserves. Hence, banks still obtain new reserves, use those accumulated or decide to accumulate more according to the reserve-cost mechanism. Consequently, the reserves-cost channel and mechanism are unaffected by the removal of required reserves.

Last, the empirical evidence and results have shown that during periods of oversupply of reserves as a consequence of extraordinary Fed's policies, the reserves-cost mechanism is less relevant and the channel has a constant impact regardless of the movements in the federal funds rate. The reason is that the Fed has been providing banks with a huge amount of reserves at a very low cost. In addition, the federal funds rate has been around zero after 2008. Thus, banks increased their excess reserves not only because the Fed provided them with unintended reserves, but also because they preferred to use reserves at almost zero cost and accumulate cheaper reserves given the federal funds rate. Once the federal funds rate increased from 2016 to 2019 from zero to 2.5 percentage points, banks could use excess reserves below that cost and their levels decreased. In the future, when the federal funds rate increases along with other costs of reserves, banks will be able to use more of their cheap reserves and their holdings of reserves should decrease. Therefore, once the Fed starts to increase the federal funds rate, the reserves-cost mechanism will gain relevance again. However, this effect will be hard to isolate, as the Fed's lower provision of reserves will still remain the main factor until banks reserves reach the levels seen between the 1960s and 1980s. Regarding the reserves-cost channel, Figures 6 shows that the spread LR-FR was fixed about 1992, when the federal funds rate was between three and four percentage points (Figure 1). As banks were trapped with more expensive reserves after the federal funds rate peaked in 1980, the spread LR-FR increased until it reached the roughly three percentage points ceiling. While the federal funds rate is below four percentage points, even if banks hold reserves below that rate, it seems that they will not set a smaller LR-FR spread, as they would still be trapped with expensive reserves. Therefore, the channel will have a constant impact until then, because a movement in the federal funds rate will be equally reflected on the prime loans rate. Once that the federal funds rate overcomes four percentage points, the channel may behave as before 1992. If banks are still holding cheaper reserves when that happens, they may be able to increase the loans rate less in relation to the federal funds rate. The consequences of that were already analysed.

## 8. Broader implications for the literature

The reserves-cost channel has three implications for the literature.

### 8.1 The measurement of Fed's policies

The first implication relates to the literature that uses the federal funds rate to measure how Fed's policies affect the economy (Christiano, Eichenbaum and Evans, 1998; Romer and Romer, 2004; Bernanke, Boivin and Eliasz, 2005, among many others). Their omission of the banking sector as a transmission channel can be problematic. Using the federal funds rate during periods of positive spreads STR-DR or when the cost of excess reserves held by banks is different from the short-term interest rate, introduce bias into the model. The reason is that for those cases, banks use as reference mostly the discount rate and consider the cost of their reserves to set the loans rate. Thus, the same movements in the federal funds rate or other intermediate target will have a different impact on the economy during those periods, as their impact on the loans rate will also be different.

### 8.2 The 1929-1933 deflation

The sterilization of gold inflows through open market sales and increases in the discount rate are broadly accepted as the main causes of deflation between 1929 and 1933 (Friedman and Schwartz's 1963; Eichengreen, 1988; Temin, 1989; Meltzer, 2003). Trade tariffs, lack of coordination between France, Britain and the US or people hoarding currency are also some of the factors proposed. The reserves-cost channel does not invalidate them, but it could contribute to explain that period of deflation. The 1929-1933 period coincides with the highest LR-STR spread of the interwar period. It restrained the demand for loans (Figure 8), what led to lower inflation levels (Figure 7).

### 8.3 The price puzzle and the Great Inflation

The theoretical framework and the models estimated show how the banking sector's transformations of Fed's policies influence the evolution of credit, inflation and output. However, they do not address how the Fed's policies per se or the evolution of the loans rate alone affect those variables. The standard approach in the literature for that purpose uses the federal funds rate. However, even if the reserves-cost channel variable (LR-STR) was included in such models to solve its omission, it would not eliminate another issue: endogeneity. It affects the federal funds rate, the discount rate and the loans rate. When the Fed sets the federal funds rate or the discount rate, it is responding to forecasts (Romer and Romer, 2004) or simply, to the trends of the targeted variables. This phenomenon is what Kuttner and Mosser (2002) call simultaneity: “the Federal Reserve loosen policy when economy weakens and tightens when the economy strengthens” (p. 17). This originates puzzles, such as the price puzzle (Barth and Ramey, 2001; Boivin and Giannoni, 2003; Bernanke, Boivin and Eliasz, 2005; Uhlig, 2005; Hanson, 2006). That is, while an increase in interest rates should decrease inflation, the results show the opposite. The inclusion of forecasted data in the model (Barth and Ramey, 2001), a filtered federal funds rate (Romer and Romer, 2004) or even more information using a FAVAR (Bernanke, Boivin and Eliasz, 2005) are unable to eliminate the price puzzle.

Thus, the analysis about the impact of Fed’s policies on the economy seems a difficult task. However, the contrast of the results obtained here along with the empirical evidences suggest that the reserves-cost channel could potentially explain how the Fed’s policies affected the evolution of inflation and output. In fact, it may be a cause or the cause of the price puzzle, and the Great Inflation and Great Moderation.

In Figure 15 two regimes are distinguishable. They coincide with the periods known as the Great Inflation (1965-1982) and the Great Moderation (1990-2007) (McConnell and Perez-Quiros, 2000; Stock and Watson, 2003; Moreno, 2004; Gali and Gambetti, 2009). The Great Inflation is characterized by high volatility in inflation and output, and high inflation levels. During this period the spread LR-STR underwent the greatest instability and was negative or near zero four times (1965-66, 1969-70, 1973-74 and 1979-1982), coinciding with spikes on inflation. Banks faced positive spreads STR-DR during these four subperiods. That is, the tightening exerted by the loans rate was lower during the Great Inflation than during the Great Moderation. For example, a federal funds rate of seven percentage points in 1969 had associated a loans rate of seven percentage points or lower. On the other hand, the same federal funds rate in 1995 had associated a loans rate of ten percentage points. This could be the reason why inflation was difficult to control during the Great Inflation and the explanation for the price puzzle. Inflation kept raising because banks were modifying Fed's policies and the economy was facing a relatively lower interest rate, even though the Fed was raising the federal funds rate. This would explain why Barth and Ramey (2001) observed a more pronounced price puzzle for the pre-Volcker era. Therefore, the puzzle may not be a puzzle, but the consequence of inefficient policies, as the Fed did not identify this channel. In the same line, if this channel was a factor determining the Great Moderation (understood as a period of good policies), it could be argued that the Fed was lucky. The fact that banks pegged the loans rate three percentage points above the federal funds rate, that spread being one of the largest ever seen, could be the cause or an important contributor of the low volatility and inflation levels.

Regarding the volatility witnessed during both periods, the explanation may be related to the fact that when the Fed raised the federal funds rate during the Great Inflation, its impact on the loans rate was constantly varying. Subsequently, that variation was transmitted into the economy for two reasons. First, the demand side of the second submarket was unable to learn from movements in the federal funds rate given the uncertain evolution of the loans rate. Second, the Federal Reserve could not obtain a regular feedback about the impact of its policies because of the varying impact ratio of the federal funds rate on the loans rate. Consequently, it applied more abrupt policies. In comparison, after 1990 federal funds rate raises were equally reflected on the loans rate. Thus, the Federal Reserve obtained a regular feedback about the impact of its policies and could apply them more efficiently. At the same time, the other agents of the economy recognized patterns in its behavior and acted accordingly. Those adaptations may have caused lower volatility. Figures 15 shows that IPI and CPI inflation were less volatile just after LR-STR was constant.

# 9. Conclusions

Periods of accumulation of excess reserves as during the Great Depression and the Great Recession have attracted the interest of researchers, who have tried to unveil the reasons behind that hoarding and its consequences. The literature has found low interest rates, financial shocks and oversupply of reserves as the main reasons behind the increase of excess reserves. For some authors, high levels of excess reserves can trigger inflation outbursts in the future as a consequence of an expansion of credit once those reserves are used to lend. Nonetheless, there is a body of literature which argues that banks lend regardless of their excess reserves, as long as it is profitable and there is demand. However, periods with normal levels of excess reserves seem to have fallen into oblivion. In this paper, I consider all periods equally important. As a consequence, I unveil the reserves-cost mechanism as another factor contributing to the accumulation of reserves. The hypothesis of this mechanism is that banks consider the different costs of reserves available to them, either as excess reserves or in the market, before lending. If they are holding reserves with a cost above markets rates, they will obtain new reserves from the other sources to maximize profits and the unused reserves will be accumulated. This mechanism also originates the reserves-cost channel, whereby banks' decisions about the loans rate conditioned on the cost of the reserves obtained, modify the impact that Fed's policies have on credit, inflation and output.

To test these hypotheses, I estimate a SVAR for the American economy between 1922 and 2020. The results confirm that when the cost of banks' reserves is above the cost of other sources of reserves, banks accumulate more reserves and set the loans rate higher in relation to the short-term rate. Also, when the spread between the short-term rate and the discount rate is positive, banks obtain cheaper reserves at the discount window and set the loans rate lower in relation to the short-term rate. This means that banks can transform how Fed's policies affect credit, inflation and output. That is, when banks set the loans rate lower in relation to short-term rate and the Fed is raising it, credit and inflation will not be curtailed as much as the Fed aimed with its policies. Thus, the relation between excess reserves and inflation is subtler. It is not the amount of reserves what affects inflation, but the influence of the price of those reserves on the loans rate.

These results imply that the use of the federal funds rate to analyse the impact of Fed's policies on the economy is not the right choice. The same increase in that rate can have a different impact on the loans rate, depending on the cost of reserves available to banks. In line with this, the different impact of the federal funds rate on the loans rate may be a factor that could help to explain the period of the Great Inflation, the price puzzle and the deflation between 1929 and 1933.

Last, it was shown that the spread between the loans rate and the federal funds rate has been constant since 1992. I claim that once the federal funds rate is again over four percentage points, banks will be able get rid of their expensive reserves accumulated when that rate was higher. Then, the spread may vary again and hence, its impact on inflation.

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# Tables

| *Forecast error* | *forecast horizon* | *proportion of forecast error variance accounted by innovations in* | | |
|---|---|---|---|---|
| *in* | *h* | **NBR** | **ER** | **RC-STR** |
| **NBR** | 1 | 1 | 0 | 0 |
| | 2 | 0,9764 | 0,0236 | 0 |
| | 3 | 0,9756 | 0,0243 | 0 |
| | 4 | 0,975 | 0,025 | 0 |
| | 8 | 0,975 | 0,025 | 0,0001 |
| | 12 | 0,9748 | 0,025 | 0,0001 |
| | 20 | 0,9748 | 0,025 | 0,0001 |
| **ER** | | | | |
| | 1 | 0,167 | 0,8329 | 0 |
| | 2 | 0,1354 | 0,8627 | 0,0018 |
| | 3 | 0,133 | 0,8648 | 0,0021 |
| | 4 | 0,1318 | 0,8654 | 0,0028 |
| | 8 | 0,1314 | 0,8644 | 0,0042 |
| | 12 | 0,1313 | 0,8637 | 0,005 |
| | 20 | 0,1312 | 0,8631 | 0,0056 |
| **RC-STR** | | | | |
| | 1 | 0,0053 | 0,1831 | 0,8115 |
| | 2 | 0,0077 | 0,114 | 0,8782 |
| | 3 | 0,0069 | 0,1048 | 0,8882 |
| | 4 | 0,0068 | 0,093 | 0,9 |
| | 8 | 0,0064 | 0,0799 | 0,9137 |
| | 12 | 0,0063 | 0,0757 | 0,918 |
| | 20 | 0,0062 | 0,0731 | 0,9207 |

**Table 1**

| *Forecast error* | *forecast horizon* | *proportion of forecast error variance accounted by innovations in* | | |
|---|---|---|---|---|
| *in* | *h* | **ER** | **RC-STR** | **LR-STR** |
| **ER** | 1 | 1 | 0 | 0 |
| | 2 | 0,9966 | 0,0034 | 0 |
| | 3 | 0,9948 | 0,0051 | 0 |
| | 4 | 0,9931 | 0,0067 | 0,0001 |
| | 8 | 0,988 | 0,0109 | 0,0002 |
| | 12 | 0,9866 | 0,0129 | 0,0005 |
| | 20 | 0,9849 | 0,0143 | 0,0008 |
| **RC-STR** | | | | |
| | 1 | 0,2258 | 0,7741 | 0 |
| | 2 | 0,161 | 0,8387 | 0,0003 |
| | 3 | 0,1424 | 0,8566 | 0,001 |
| | 4 | 0,1311 | 0,867 | 0,0019 |
| | 8 | 0,1116 | 0,88 | 0,008 |
| | 12 | 0,1035 | 0,8808 | 0,0156 |
| | 20 | 0,0967 | 0,8748 | 0,0285 |
| **LR-STR** | | | | |
| | 1 | 0,0171 | 0,2054 | 0,7773 |
| | 2 | 0,0147 | 0,1999 | 0,7854 |
| | 3 | 0,0147 | 0,1939 | 0,7913 |
| | 4 | 0,015 | 0,1884 | 0,7965 |
| | 8 | 0,017 | 0,1706 | 0,8124 |
| | 12 | 0,0188 | 0,1588 | 0,8223 |
| | 20 | 0,0212 | 0,1472 | 0,8316 |

**Table 2**

| *Forecast error* | *forecast horizon* | *proportion of forecast error variance accounted by innovations in* | | | | |
|---|---|---|---|---|---|---|
| *in* | *h* | **IPI** | **CPI** | **LOANS** | **STR-DR** | **LR-STR** |
| **IPI** | 1 | 1 | 0 | 0 | 0 | 0 |
| | 2 | 0,9742 | 0,0002 | 0,0003 | 0 | 0,0252 |
| | 3 | 0,9616 | 0,0008 | 0,0025 | 0,01 | 0,0249 |
| | 4 | 0,9565 | 0,0009 | 0,0025 | 0,0135 | 0,0263 |
| | 8 | 0,9462 | 0,001 | 0,0027 | 0,022 | 0,0275 |
| | 12 | 0,9432 | 0,001 | 0,0029 | 0,0247 | 0,0282 |
| | 20 | 0,9423 | 0,001 | 0,0029 | 0,0253 | 0,0282 |
| **CPI** | | | | | | |
| | 1 | 0,0986 | 0,9013 | 0 | 0 | 0 |
| | 2 | 0,1292 | 0,8379 | 0,0158 | 0,0071 | 0,0098 |
| | 3 | 0,1403 | 0,8191 | 0,0186 | 0,008 | 0,0138 |
| | 4 | 0,1521 | 0,7997 | 0,0229 | 0,0098 | 0,0153 |
| | 8 | 0,166 | 0,7755 | 0,0271 | 0,013 | 0,0182 |
| | 12 | 0,1674 | 0,7726 | 0,0276 | 0,0137 | 0,0185 |
| | 20 | 0,1675 | 0,7721 | 0,0277 | 0,014 | 0,0185 |
| **LOANS** | | | | | | |
| | 1 | 0,007 | 0,0102 | 0,9827 | 0 | 0 |
| | 2 | 0,0551 | 0,0178 | 0,9251 | 0,0006 | 0,0012 |
| | 3 | 0,0784 | 0,0411 | 0,8757 | 0,0005 | 0,0041 |
| | 4 | 0,0866 | 0,0482 | 0,8593 | 0,0006 | 0,0052 |
| | 8 | 0,0942 | 0,0574 | 0,8416 | 0,001 | 0,0057 |
| | 12 | 0,0945 | 0,058 | 0,8404 | 0,0012 | 0,0057 |
| | 20 | 0,0945 | 0,058 | 0,8403 | 0,0013 | 0,0057 |
| **STR-DR** | | | | | | |
| | 1 | 0,0028 | 0,0035 | 0,01 | 0,9836 | 0 |
| | 2 | 0,0089 | 0,0027 | 0,0102 | 0,8734 | 0,1045 |
| | 3 | 0,0129 | 0,0034 | 0,0149 | 0,8615 | 0,107 |
| | 4 | 0,0295 | 0,0041 | 0,0179 | 0,8387 | 0,1095 |
| | 8 | 0,0521 | 0,007 | 0,0239 | 0,7996 | 0,1172 |
| | 12 | 0,0583 | 0,0085 | 0,0257 | 0,7898 | 0,1175 |
| | 20 | 0,0601 | 0,0093 | 0,0263 | 0,7871 | 0,117 |
| **LR-STR** | | | | | | |
| | 1 | 0,0156 | 0,003 | 0,0045 | 0,2517 | 0,7251 |
| | 2 | 0,0184 | 0,0073 | 0,0038 | 0,1492 | 0,8212 |
| | 3 | 0,0554 | 0,0097 | 0,0054 | 0,1168 | 0,8125 |
| | 4 | 0,0838 | 0,0119 | 0,0054 | 0,0936 | 0,8051 |
| | 8 | 0,1101 | 0,0208 | 0,005 | 0,072 | 0,792 |
| | 12 | 0,1075 | 0,0283 | 0,0042 | 0,0937 | 0,7661 |
| | 20 | 0,0958 | 0,0383 | 0,0044 | 0,145 | 0,7163 |

**Table 3**

# Figures

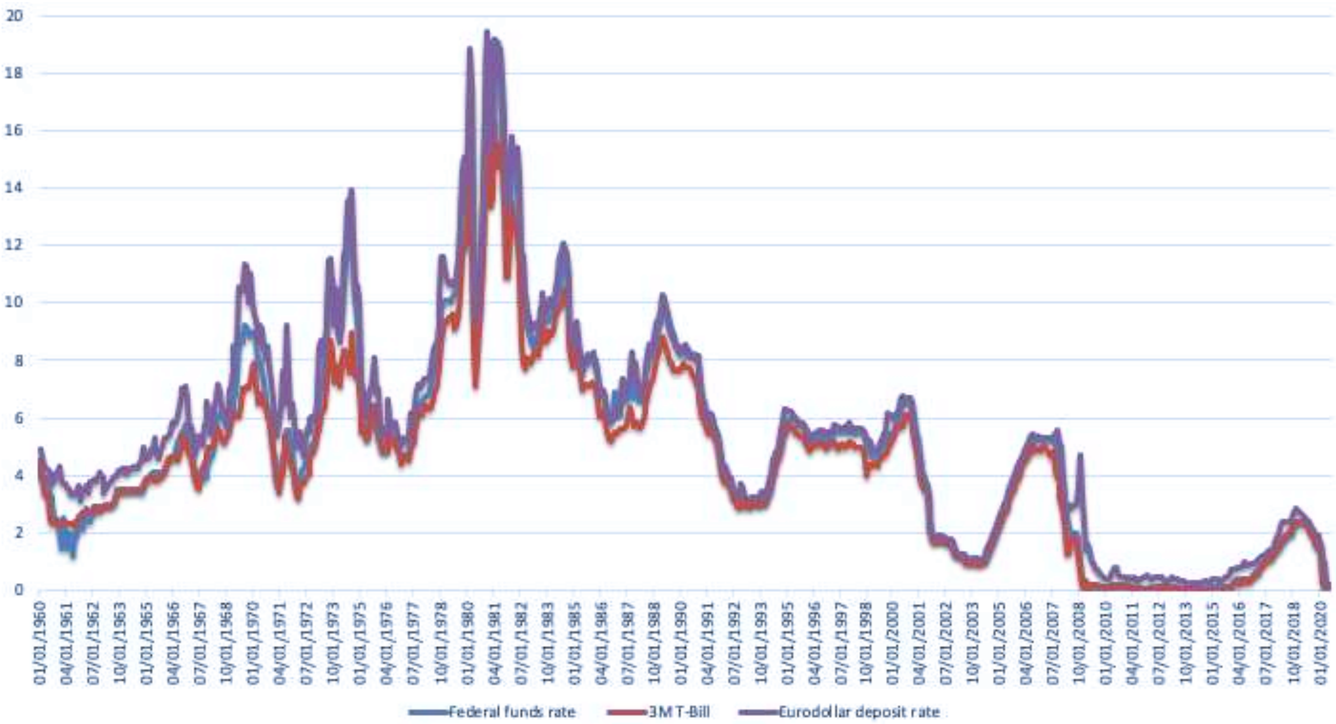


**Figure 1- Data source: FRED**

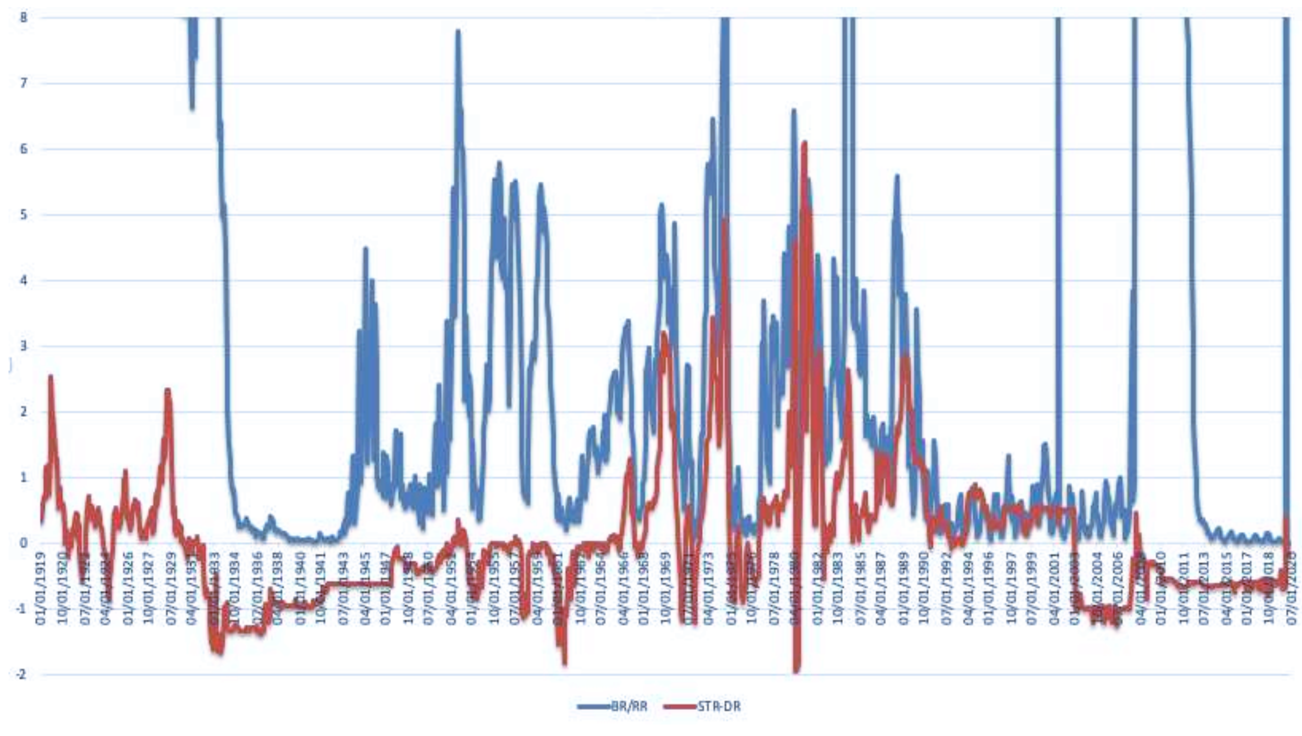


**Figure 2-Data source: FRED**

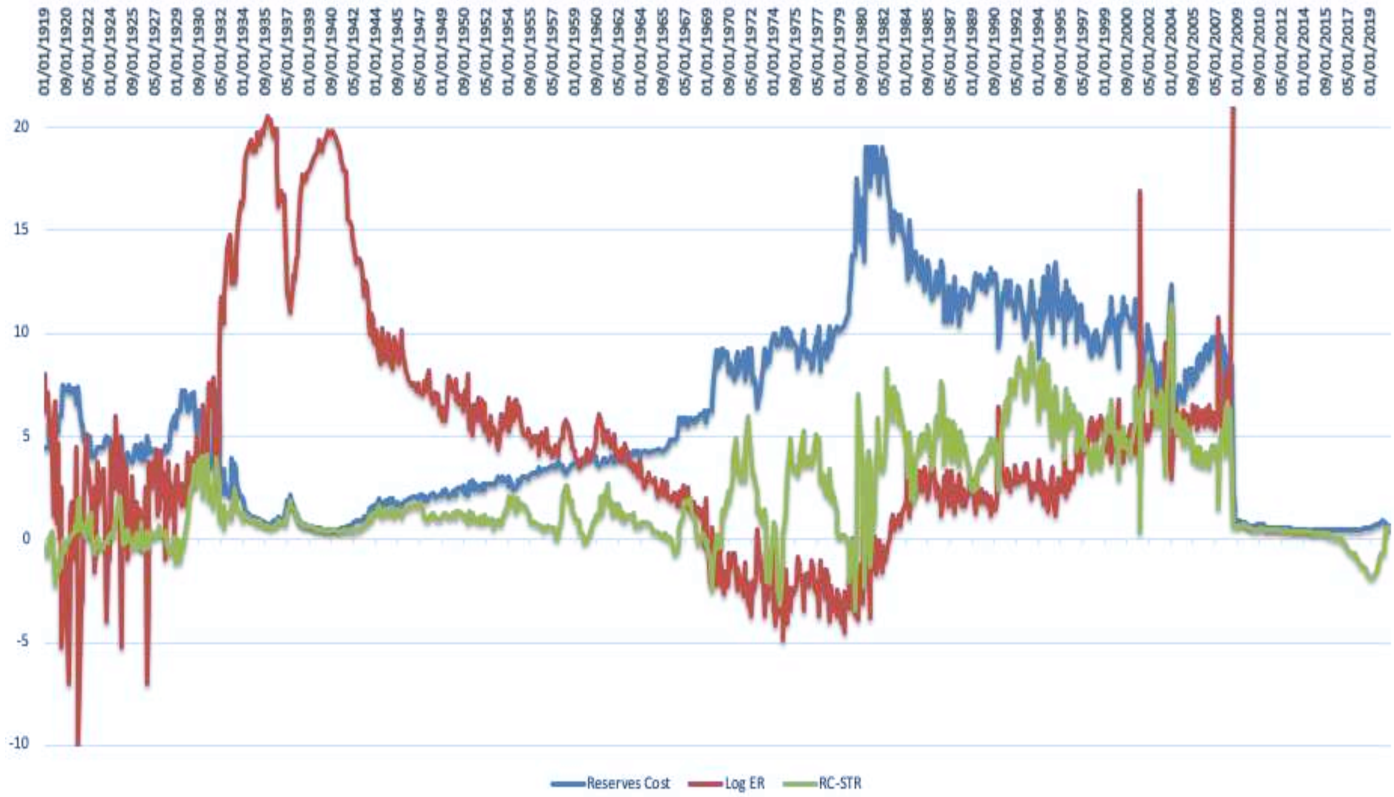


**Figure 4- Data source: FRED**

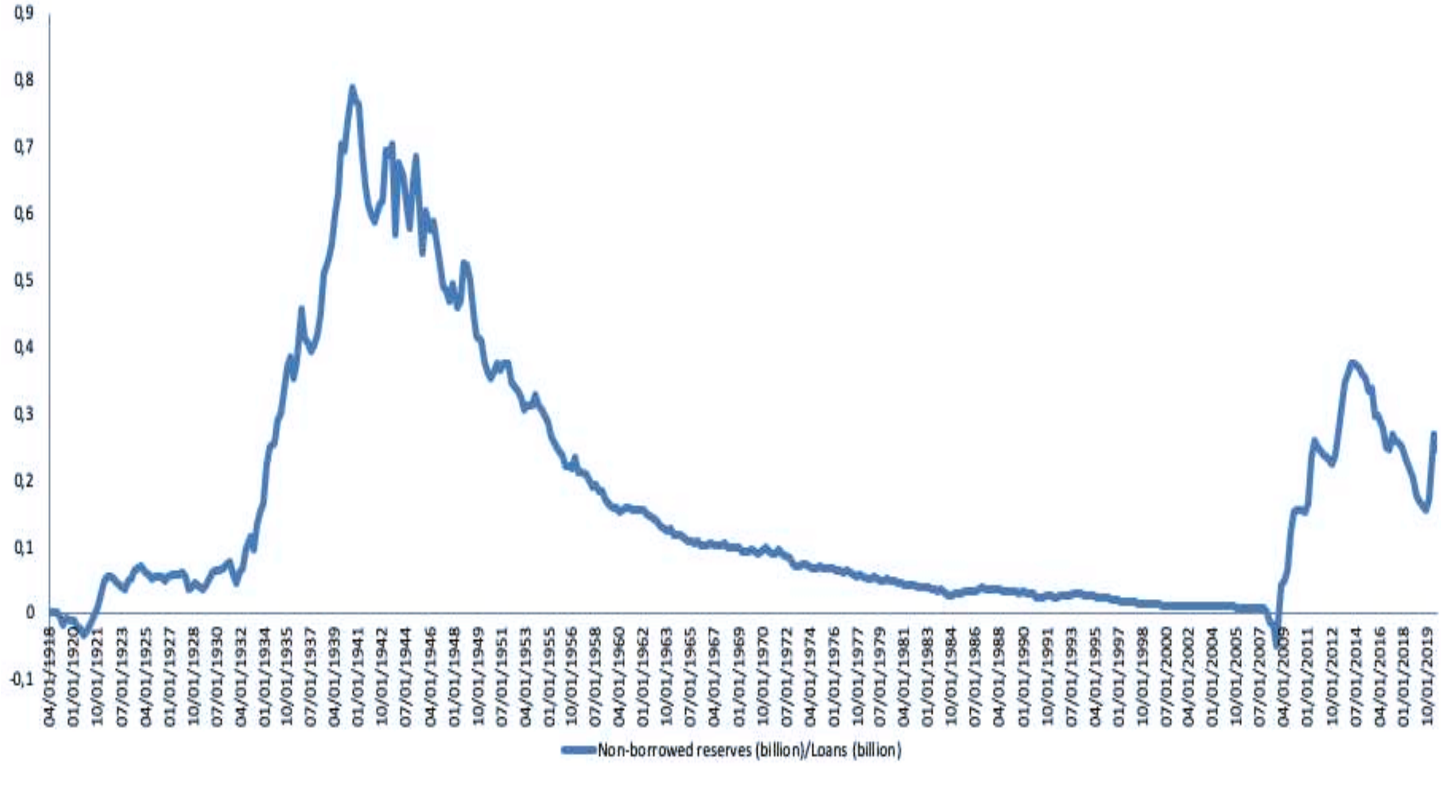


**Figure 3- Data source: FRED and FRASER**

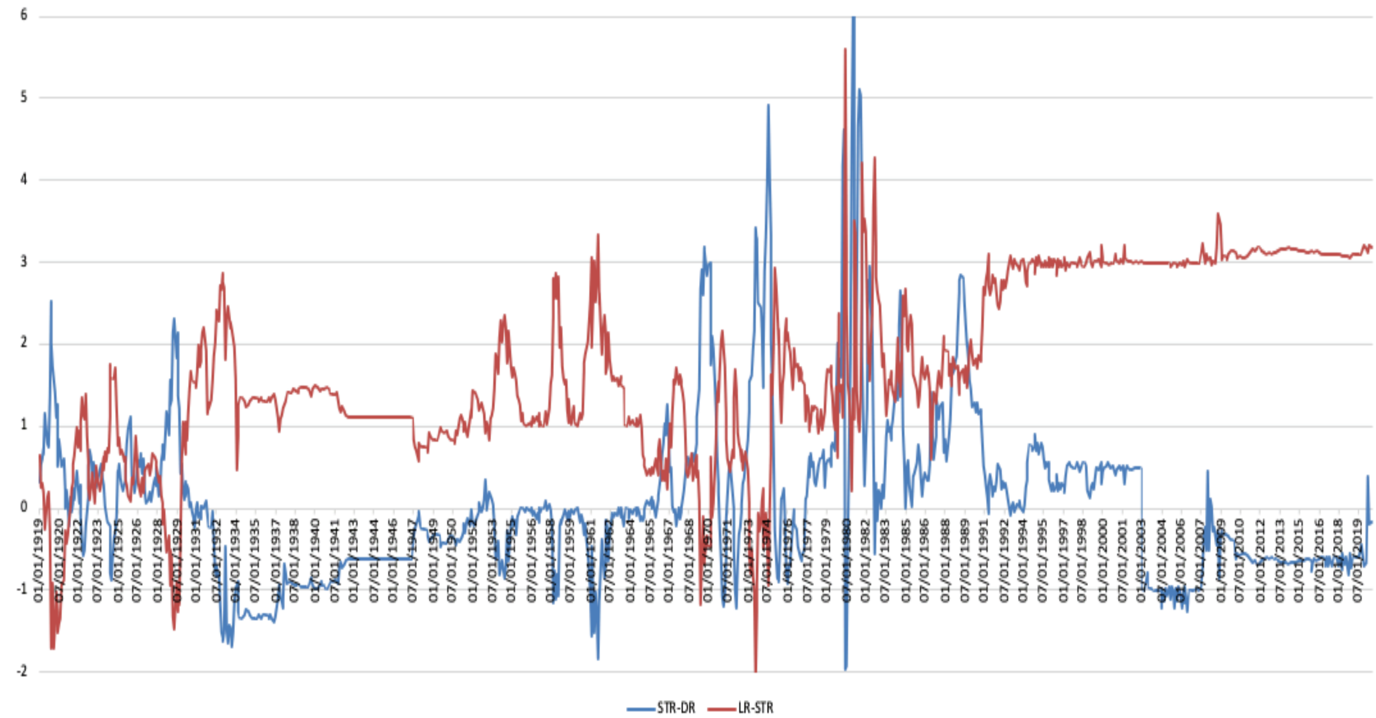


**Figure 6-Data source: FRED**

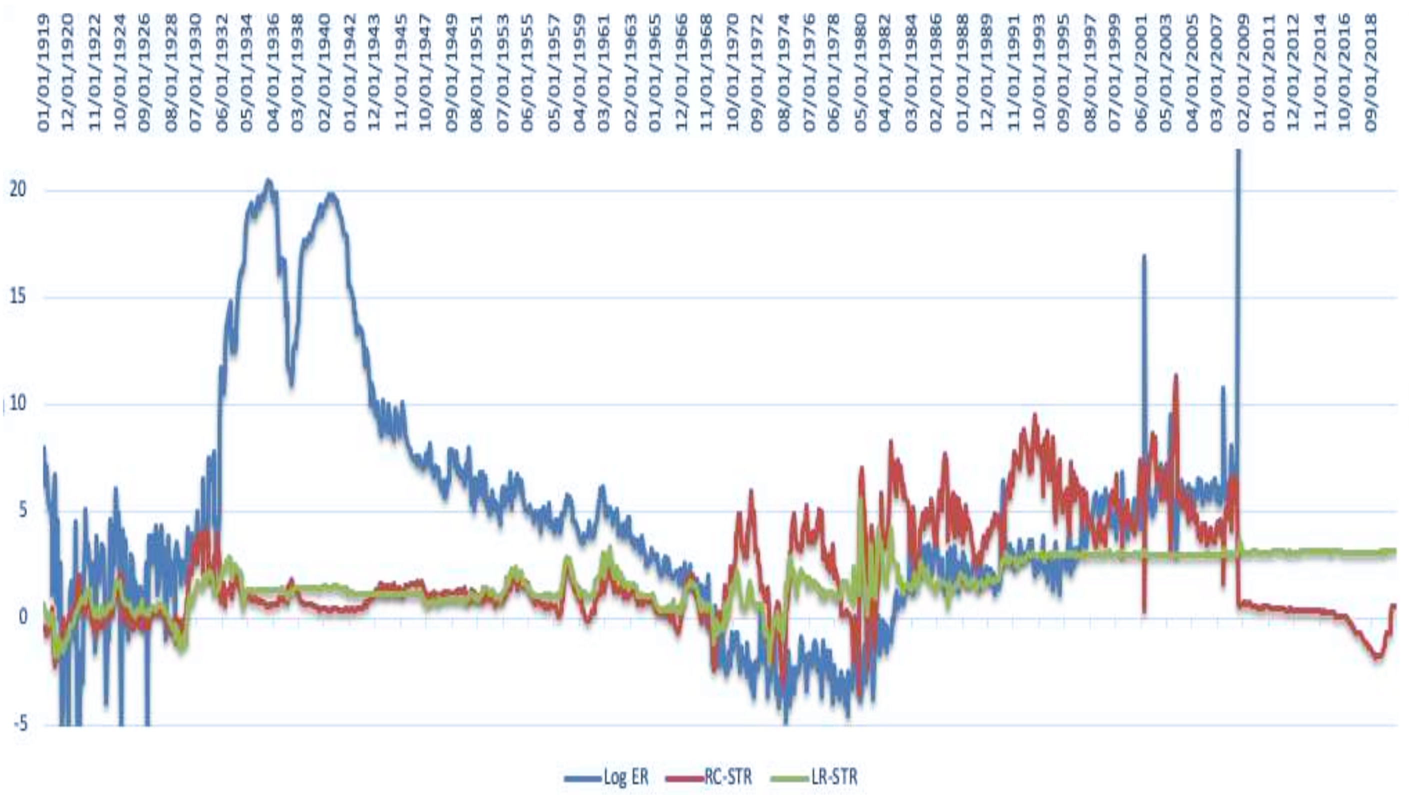


**Figure 5 - Data source: FRED**

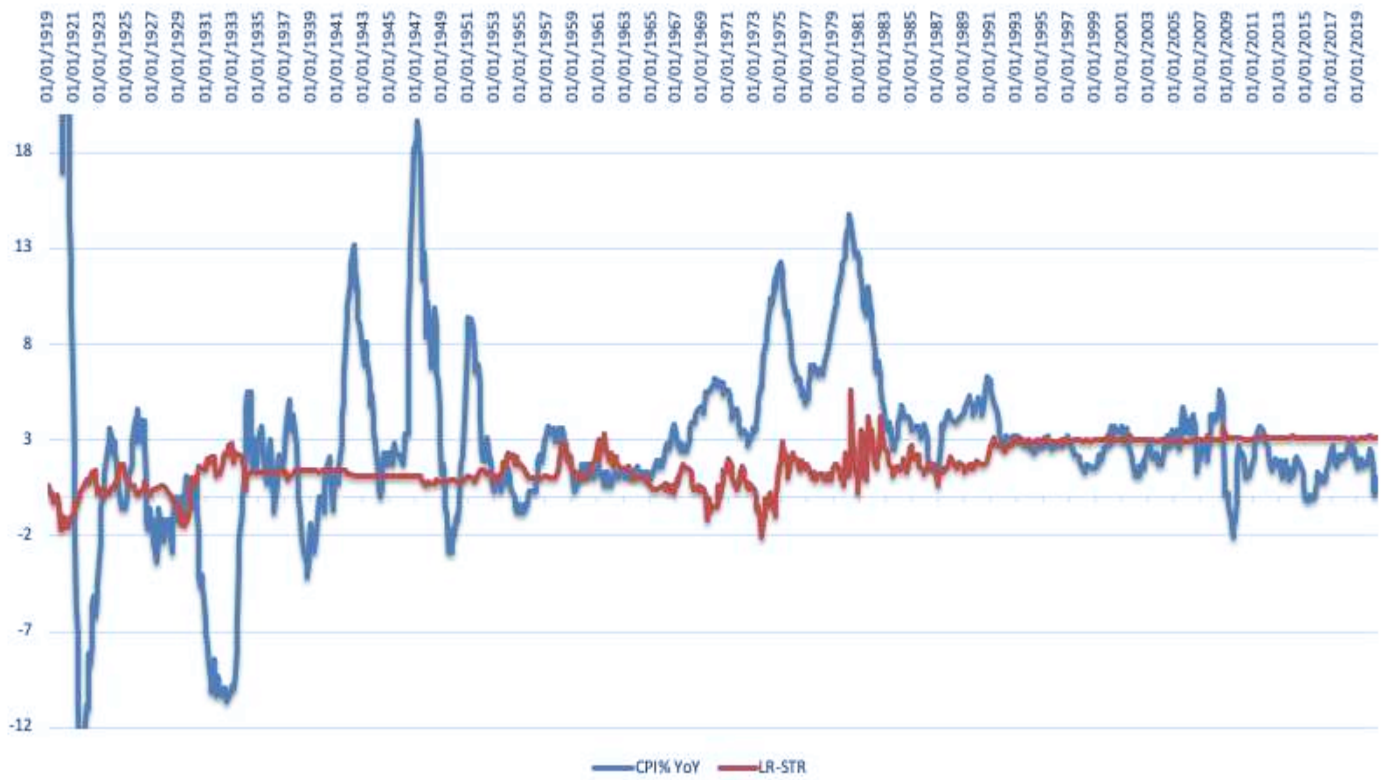


**Figure 7- Data sources: FRED and Bureau of Labor Statistics**

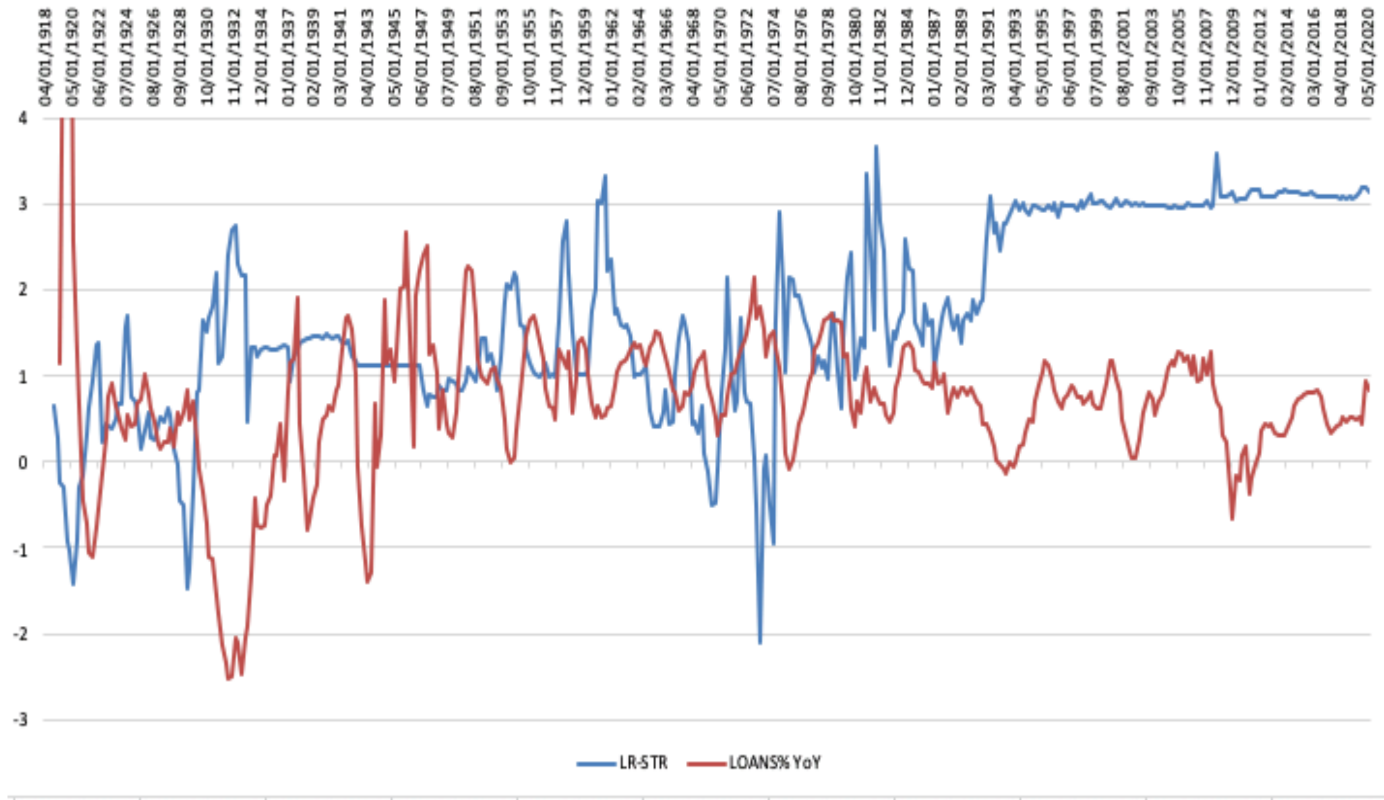


**Figure 8 - Data sources: FRED and FRASER**

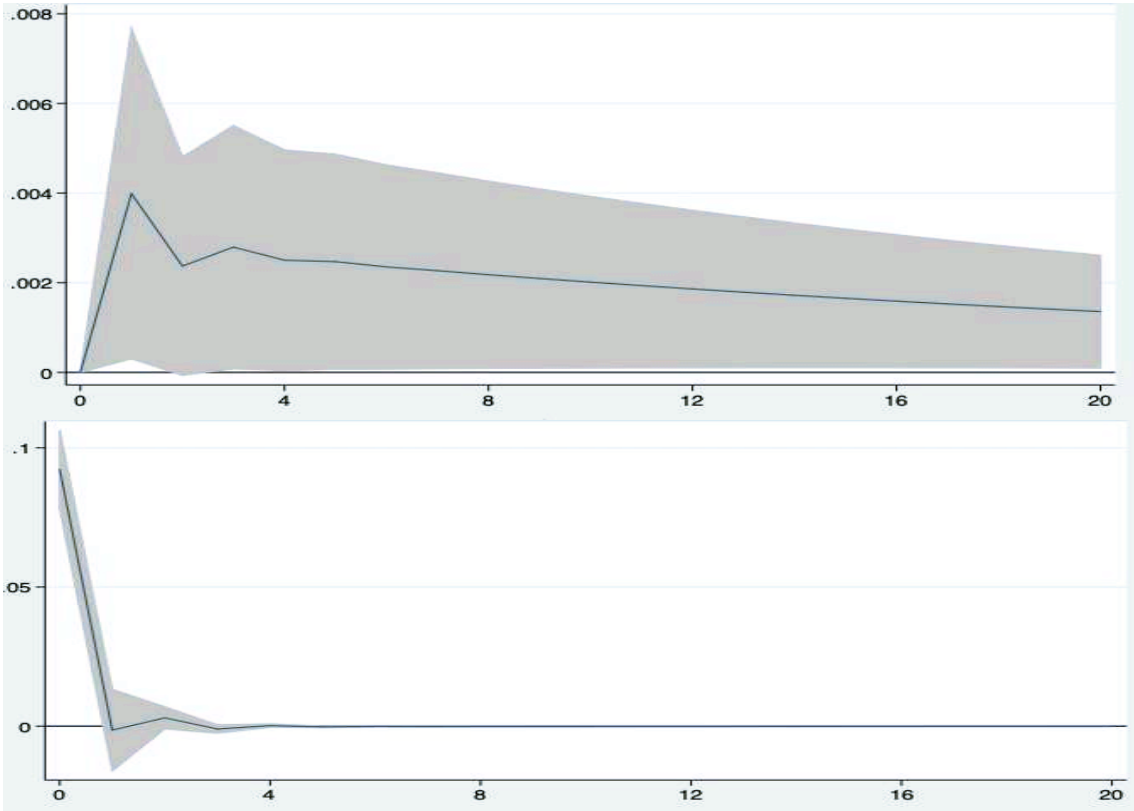


**Figure 9 – ER impulse responses (blue line) to an RC-STR (Panel 1) and NBR shock (Panel 2). Confidence interval 95%**

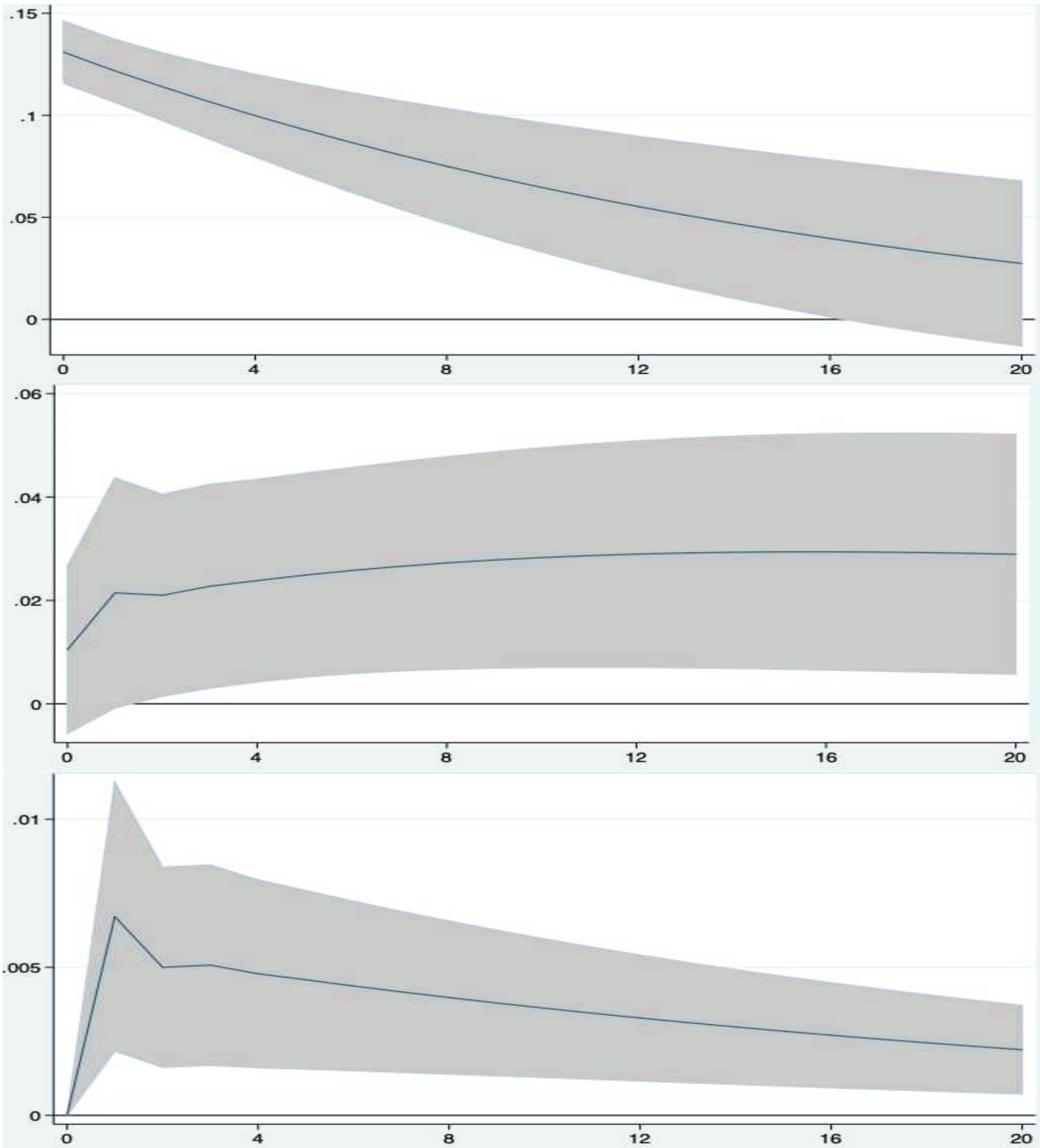


**Figure 10 – LR-STR impulse responses (blue line) to an RC-STR (Panel 1) and ER shock (Panel 2). ER impulse response to an RC-STR (Panel 3). Confidence interval 95%**

## Appendix A – Short-term interest rates of reference

For the interwar period, the call loans rate was the most similar rate to the federal funds rate.

"The market for brokers' loans, as it is generally conceived, is centered around the New York Stock Exchange. […] the majority are made in the open market on a strictly impersonal basis. The market in which these loans are made was until recent years the most active and the most sensitive of the money markets of the country."

Further: "It was the market where surplus funds of banks, and sometimes of other lenders, could generally be readily placed or from which funds could be quickly withdrawn when needed. Because of the dominance of call loans, the branch of the money market dealing in brokers' loans has been designated as the call money market" (Board of Governors of the Federal Reserve System (U.S.), 1935–. Banking and Monetary Statistics, 1914-1941, 1943, https://fraser.stlouisfed.org/title/38, p. 434).

The Federal Reserve tried to control the call loans rate since 1919, when governor Benjamin Strong, chairman of the Fed of New York, realized that the spread between the discount rate and short-term rates would avoid a decline in inflation, as it was profitable for banks to borrow at lower rates and lend. In several occasion, the discount rate was increased to reduce that spread. This concern increased over the 1920s.

After 1933, the Treasury took the main role in managing monetary policy, while the Fed was relegated to the backseat. Marriner S. Eccles, who became governor of the Board in 1934 believed that the Fed should keep market rates low, in order to facilitate private spending and government finance. Therefore, the 3-Months Treasury Bill was the short-term rate of reference. Last, in 1954 the federal funds market emerged, although it did not become relevant until the early 1960s. Yet, the 3-Months Treasury Bill and the federal funds rate were similar during those years.

## Appendix B – Spread federal funds rate - discount rate

Several authors studied the dynamics between this spread and borrowed reserves. In Meltzer (2003 and 2009), there are several references to the Fed's member commenting on how banks borrowed more reserves when the spread between the short-term rate of reference and the discount rate was positive. For instance, for the interwar period:

"…[O]n December 31, 1928, the Board adopted a resolution that blamed the spread between discount rates and rates for stock exchange loans for the temptation to borrow from the Fed and lend to help buy or carry securities" (Meltzer 2003, p. 237).

Pierce (1993) claimed that the changes in the Fed's operating procedures from 1975 to 1991 transformed the relationship between the spread and the borrowing function. According to the author, the period from 1975 to 1979 was a period of a federal funds rate target, from 1979 to 1982, of a nonborrowed reserves target and lagged reserve accounting. Last, from 1982 to 1991, the period was characterized by a borrowed reserves target with lagged reserve accounting, which changed to contemporaneous reserve accounting after 1984. He showed that for the first period there was a strong non-linear relationship between positive spreads and borrowing. Thus, the higher the spread, the more borrowed reserves were demanded. For the second period the relationship was looser and for the last period, the relationship became weak. Also, he pointed out that during the contemporaneous reserve accounting period, the excess reserves ratio increased and borrowing fell to its lowest level despite the higher spreads. Peristiani (1991) identified a nonlinear relationship between the spread and borrowing (for the period 1959-1988) with an inverted S-shape. The number of banks going to the discount window increased when the spread was higher, but borrowing decreased at the highest levels of the spread due to restrictions, further costs and the collateral required to back the amount of borrowing. In the same line, Hamdani and Peristani (1991) with a disaggregated approach differentiating between small and large banks, observed the same non-linear relationship and found that borrowing was positively autocorrelated for small banks but not for large banks. Kasriel and Merris (1982) claimed that borrowing also depended on expectations about the spread. That is, if banks expected a larger spread, they would borrow less at that moment. They also added that before 1979, under the federal funds target, the Fed was careless about the relation between the spread and borrowing. Later, under the nonborrowing reserves target and lagged reserves accounting, the relationship weakened because of the greater uncertainty and volatility of the spread, as also stated by Goodfriend (1981).

For the 1990s, Clouse (1994) mentioned that banks were reluctant to borrow because of the active involvement of the discount window during the 1980s and 1990s to avoid bank failures. As explained by the New York Fed (Fedpoint, 2015), institutions that borrowed at the discount window expressed their concern about the signal of weakness that it represented. Thus, in 1999 more facilities were provided to avoid this situation. After 1990 the discount rate was fixed 0.25-05% below the federal funds rate, what incentivized institutions to borrow. Nonetheless, they must have exhausted previously other available funds sources.

# Appendix C – Variables and sources

The data sources for the variables of this section are "Banking and Monetary Statistics 1914-1941", "Banking and Monetary Statistics 1941-1970" available in FRASER, and last, the FRED database.

Reserves-cost (RC): In order to visualize how the cost of reserves held by banks evolves over time, I recorded the cost of reserves as follows. Starting from 1919, when the level of excess reserves was near zero, I calculated the difference between the quantity of borrowed reserves held in period t and t-1. The same procedure was applied to the nonborrowed reserves that belong to non-required reserves (free reserves). When the difference for borrowed reserves was positive, that quantity was registered at its cost, namely, the discount rate of that period, by way of inventory. The same process was carried out for nonborrowed reserves, but the interest rate applied was the short-term rate of reference (see short-term rate (STR) below). When the difference between periods for any type of reserves was negative, that quantity was removed from the lowest interest rate at which reserves were registered in the inventory. In that way, banks maximize profits by using the largest difference between the reserves cost and the loans rate. Once reserves were added or removed from the inventory at each period, the quantity of reserves remaining and registered until that period is multiplied by its cost. Thereafter, I calculate the average cost. As result, I obtain the average cost that banks have paid until period t for one dollar of the reserves they hold. This procedure has to be repeated for every period. This is a simple method and therefore, far from accurate. Therefore, this variable has to be understood as a general indicator of the cost of reserves held. This indicator signals the higher or lower probability, when compared to market rates, that banks use their excess reserves or obtain new ones from other sources. The further is RC from, for instance the federal funds rate, the lower is the probability that banks use their excess reserves, as most of them would be above the federal funds rate. However, if RC is above the federal funds rate, it does not necessarily mean that banks are not going to use their excess reserves. Banks could still be holding some reserves with a cost below or equal to the federal funds rate.

The prime loans rate (LR) is the base rate used by banks to price short-term business loans, posted by a majority of 25 insured U.S.-chartered commercial banks. The prime loans rate appeared officially in 1934 defined as "the rate that banks charge their most creditworthy business customers on short-term loans. It is the base from which rates charged on loans to other business customers are scaled upward. Generally speaking, the prime rate has not been considered a sensitive rate that fluctuates daily in response to short-terms changes in demand and supply as measured by a national market." Further, "Prime rates are "formally" posted only by largest banks. A nationally publicized and uniform prime rate did not emerge until the depression of the 1930's. The rate in that period -1.5 per cent- represented a floor below which banks were said to regard lending as unprofitable" (Banking and Monetary Statistics 1941-1970, p. 642). Thus, from 1934 to 1949, the data for this variable is collected from the source just mentioned. Since 1949, I use the data from FRED. For the periods 1919-1929 and 1930-1933, I collected the rates on customers' loans and commercial loans respectively, in New York. These rates are the most similar to the prime loans rate once there are data available for it.

The short-term rate of reference (STR) has been changing through the period under analysis, depending on the sources from which banks obtained funds. For the period 1919-1933 I use an average of the most important short-term open-market instruments.

These instruments are: 4- to 6-month commercial paper and prime 90-day bankers' acceptances (loans based on commercial transactions) and 90-day Stock Exchange time loans and Stock Exchange call loans, new and renewal (loans based on security collateral). Given that after 1931 there is a decline in commercial and bankers' acceptances holding and an increase in short-term Treasury bills, for the period 1934-1954 I use the rates on 3-months T-bills. Last, I consider the federal funds rate as the short-term rate of reference after 1954.

The LOANS variable is not homogenously available for the entire sample and different data needed to be plugged and extrapolated. First, I collected the quarterly amount of loans from "member banks" from 1919 to 1947. In some cases, some quarters are missing. To fill those quarters, I have calculated the average of loans between t-1 and t+1. However, "member banks" does not represent all commercial banks, for which there are only semi-annual data. Thus, for those periods when data is available for both series, I have calculated the proportion of commercial banks' loans in relation to member banks' loans. The resulting number is multiplied for the amount of member banks' loans for the quarters missing in the commercial banks' loans series, until the next datum in the semi-annual series for commercial banks is found, when the proportion is calculated again. This series comprises loans on securities, real state, banks and other loans. Since 1948, the data has been collected from FRED "Loans and Leases" series, which includes commercial, industrial, consumer and real estate loans and other loans and leases. It is measured in billions of dollars.

## Appendix D – The discount window and regulation Q

Regarding the discount window, there were two changes in regulation that could have affected the mechanism. First, in 1955, the Board issued regulation A, where the Federal Reserve orthodoxy was that banks did not borrow for profit but only reluctantly for need. Thus, the discount window formed a ceiling on the federal funds rate. Later, the discount rate stopped being a ceiling and borrowing increased as seen in Figure 2. The Federal Reserve needed a long time until it changed its mind and accepted that banks also borrowed for profits. Therefore, the supposed stigma for borrowing for that period is false, unlike after 1990. Second, the Depository Institution Deregulation and Monetary Act of 1980 allowed more institutions access to the discount window. Despite this fact, the analysis undertaken here is in aggregate level. That is, before some institutions could have access to the discount window, they were likely to borrow from the banking sector, which in turn, would borrow at the discount window if more reserves were necessary. Hence, it is not expected that the mechanism underwent any modification from such deregulation act.

Regulation Q could be considered as another Fed's instrument, as it imposed interest rate ceilings on deposits rates. This regulation was active from 1933 to 1986 but was binding only when market rates reached ceiling levels around the 1960s. That meant that banks could not offer enough yields to attract depositors. Consequently, saving and loans associations enticed them. According to Koch (2015), interest rate ceilings contracted banks' credit growth and affected the lending channel, because without more deposits banks could not increase lending. However, it has been already explained that banks first lend and afterwards, they obtain the necessary reserves (Moore, 1983; Bindseil, 2004; Jakab and Kumhof, 2015). This fact is also supported by some data. In

Koch (2015, Figure 1), he displayed when markets rates were above ceiling rates. The periods of higher rates, except for 1960, coincides with those periods when the spread between the federal funds rate and the discount rate was positive (Figure 2). During those periods borrowing increased. Therefore, the lower amount of reserves from deposits could have been counteracted with borrowing and credit would have not been restrained. However, Koch's conclusion that when the interest rate ceiling was binding, credit decreased is not surprising. As expected, for periods of rising interest rates, at some point, lending levels will decrease. In relation to the reserves-cost mechanism, during those periods banks could obtain the cheapest reserves from depositors, as the interest rates on those deposits was the ceiling set by the Federal Reserve, which was below market rates. However, as many depositors sought better yields in saving and loans associations, along with the fact that during those periods the level of borrowing was high, I would not expect a significant impact of this cost on the loans rate. On top of that, there are also references in Meltzer (2009a, p.470, 608 and 648) regarding how banks evaded that regulation by offering different kinds of deposits or services.

## Appendix E – Alternative models

I have also introduced two variables in model 1.1 as proxies for risk and uncertainty (two different models, n=4), ordered before ER and NBR. That is, the new variables are $x_1$. For the former, I have used the growth rate of public debt (DEBT, quarterly data), while for the latter I have calculated the IPI standard deviation for an interval of four years (48 observations) and rolling it one period ahead (GDPD).

The impact of a GDPD shock on ER is significant for alternating periods (Figure E.1, Panel 1). Thus, a positive shock to GDPD makes banks to increase ER significantly around 1,5% initially and around 0,25% after two months. The ER responses to NBR and

RC-STR are similar to model 1.1. Substituting GDPD for the growth rate of DEBT (Figure E.1, Panel 2), ER responds positively to a DEBT shock. It increases significantly around 4% initially and 1% for the second quarter. Regarding the responses of ER to a positive shock to NBR and RC-STR, they are similar to model 1.1 but the ER responses are larger. It is reasonable as the periodicity has changed from monthly to quarterly. If the sample is restricted as before (1946-2007), the ER responses to a DEBT and GDPD shock are not significant.

Last, estimating model 1.1 with up to five lags (results no presented), while the response of ER to an NBR shock hardly changes, it does for RC-STR. It is mostly not significant, except for isolated months. This is expected as it is supposed that banks take their decisions just after they know the cost of their excess reserves. Likewise, the ER response to the spreads LR-STR and RC-STR in model 1.2 estimated with more lags, are similar to the RC-STR shock in model 1.1.

Model 2 was also estimated with up to five lags and the results hardly vary for three and four, but after five lags, many of the previous results become not significant.