Monetary Policy Implementation in a Negative Rate Environment

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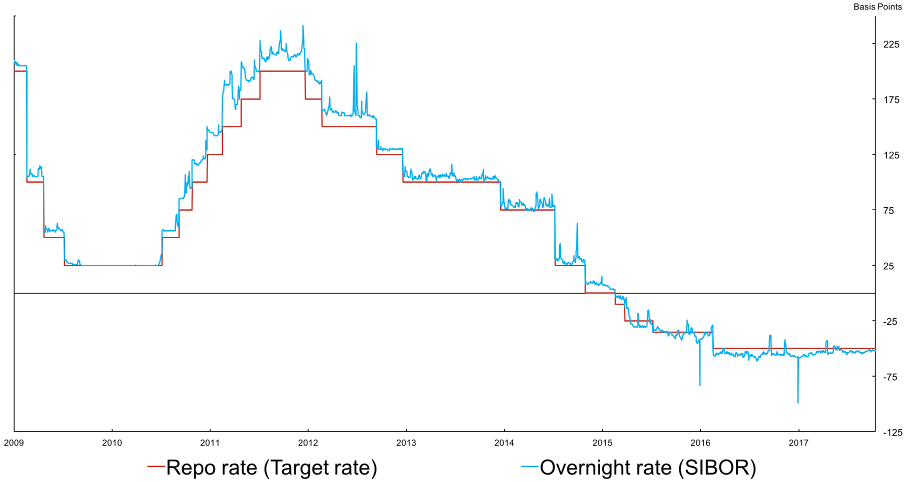
The views expressed herein are those of the authors and do not necessarily reflect the views of the Bank of Canada.

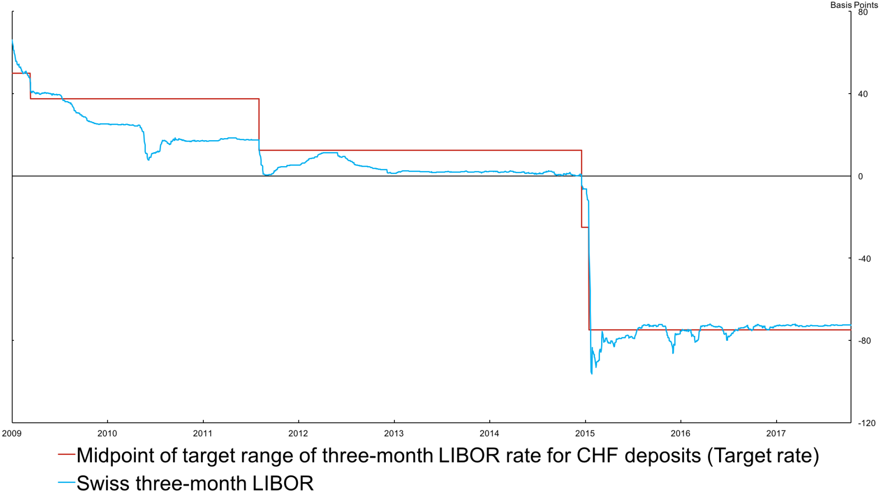
Context

- Crucial aspect of monetary policy is effective implementation of interest rate target.
  - Interbank lending rate $=$ central bank target rate
- Negative rates could induce cash withdrawals and hinder effective implementation of monetary policy.
  - Optimal behaviour in light of negative deposit rate is to convert reserves to “vault cash” with zero return.
  - Return on cash is actually slightly negative, around -0.5% in Canada (Witmer and Yang, 2016).
- Negative rates have been introduced in several countries but monetary policy implementation seems to be working.

Example #1: Sweden



Example #2: Switzerland



Many unanswered questions...

- Which central bank rate matters?
  - borrowing rate? deposit rate? return on required reserves?
- Can it work with large excess reserves (ie. during QE)?
- What are the effects of tiers of policy rates? What other policy levers can we adjust to implement negative rates?

Our Setup

A model helps crystallize intuition around the equilibrium interbank rate. We:

1. Use the workhorse model of monetary policy implementation with interbank loans (Poole (1968), Bech and Keister (2013)),
2. add the option to exchange reserves for cash,
3. add tiers of policy rates,
4. and add varying reserve requirements.

Equilibrium Interbank Rate in Poole (1968)

Poole (1968) showed the equilibrium interbank rate depends on the:

1. borrowing and deposit rates
2. level of central bank excess reserves (MP framework)
3. distribution of commercial bank deposit shocks

In a corridor monetary policy framework (no excess reserves):

$$r_{interbank} \approx \frac{\text{deposit rate} + \text{borrowing rate}}{2}$$

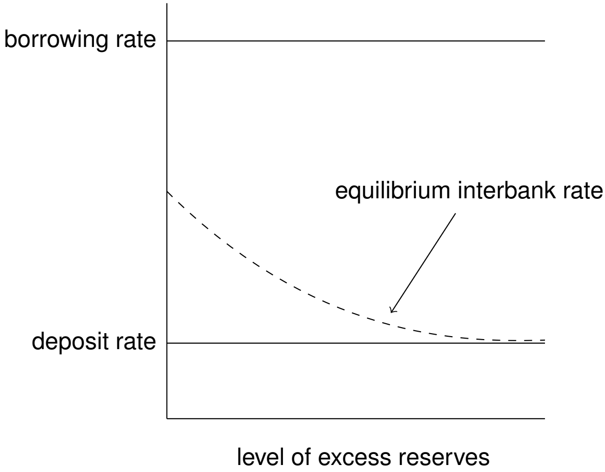
In a floor framework (high excess reserves):

$$r_{interbank} \approx \text{deposit rate}$$

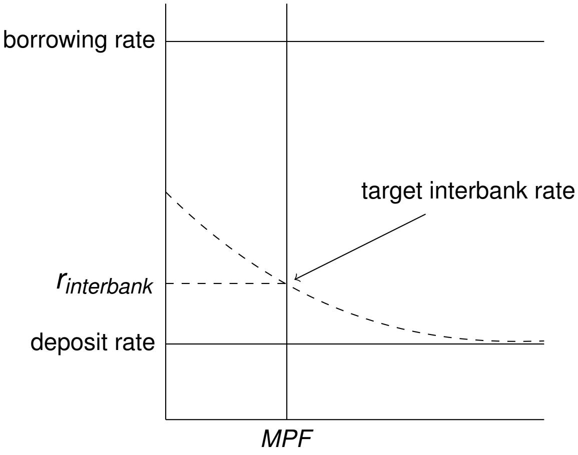
The central bank decides on r_{target} and sets policy such that:

$$r_{interbank} \approx r_{target}$$

Equilibrium Interbank Rate

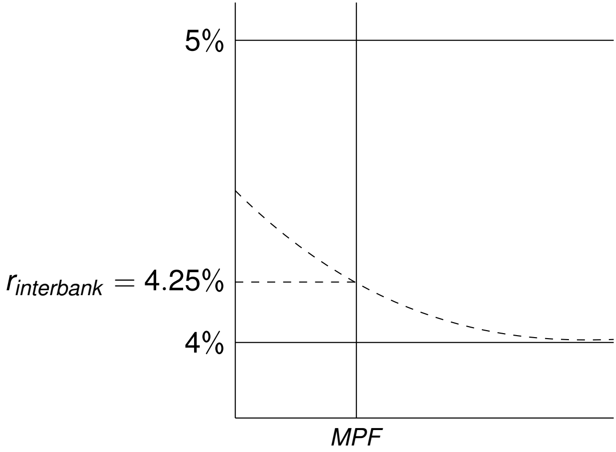


Equilibrium Interbank Rate



- $r_{interbank}$ = target interbank rate is the equilibrium outcome

Equilibrium Interbank Rate in Normal Times



- the "return on cash" is irrelevant during normal times

What we get:

- MP implementation works as expected only when:

$$r_{interbank} > r_C$$

  the target/interbank rate is above the return on cash (ie. ZLB/ELB).

- Explore two alternatives to eliminate this constraint:
  1. tiered renumeration of reserves
  2. varying reserve requirements

Commercial Banks

Continuum of commercial banks that maximize expected profit. Each day is divided into five stages:

1. Start of Day
2. Interbank Borrowing and Cash/Reserve Conversion
3. Deposits Shock
4. Central Bank Borrowing (End of Day)
5. End of Day

Commercial Bank Balance Sheet

1. Start of Day

Assets	Liabilities
C^i Vault Cash	D^i Deposits
R^i Reserves	

2. Interbank Borrowing and Cash/Reserve Conversion
3. Deposits Shock
4. Central Bank Borrowing
5. End of Day

Commercial Bank Balance Sheet

1. Start of Day
2. Interbank Borrowing and Cash/Reserve Conversion

Assets	Liabilities
$C^i + T^i$ Vault Cash	D^i Deposits
$R^i + \Delta^i - T^i$ Reserves	Δ^i Interbank Borrowing

   T^i is new vault cash converted from reserves.

3. Deposits Shock
4. Central Bank Borrowing
5. End of Day

Commercial Bank Balance Sheet

1. Start of Day
2. Interbank Borrowing and Cash/Reserve Conversion
3. Deposits Shock

Assets	Liabilities
$C^i + T^i$ Vault Cash	$D^i - \epsilon^i$ Deposits
$R^i + \Delta^i - T^i - \epsilon^i$ Reserves	Δ^i Interbank Borrowing

$\epsilon^i \sim G$ is a symmetric random variable with $E(\epsilon^i) = 0$.

4. Central Bank Borrowing (End of Day)

Commercial Bank Balance Sheet

1. Start of Day
2. Interbank Borrowing and Cash/Reserve Conversion
3. Deposits Shock
4. Central Bank Borrowing

Assets	Liabilities
$C^i + T^i$ Vault Cash	$D^i - \epsilon^i$ Deposits
$R^i + \Delta^i - T^i - \epsilon^i + X^i$ Reserves	Δ^i Interbank Borrowing
X^i Central Bank Borrowing	

5. End of Day

Central Bank Borrowing

Central bank sets required reserves and three interest rates:

1. Required reserves earn r_K

$$K^i \equiv \text{required reserves for commercial bank } i$$

2. Excess reserves earn the deposit rate r_R

$$\epsilon_K^i \equiv \text{excess reserves for } i = \underbrace{(R^i - K^i)}_{\text{starting excess reserves}} + \underbrace{(\Delta^i - T^i)}_{\text{net change}}$$

3. Borrowing from the central bank costs $r_X > r_R$

Commercial Bank Decision

Commercial bank i chooses Δ^i and T^i to maximize expected profit *before* the deposit shock is realized.

Deposit shock is drawn from commercial bank's excess reserves.

1. Insufficient excess reserves: borrowing rate r_X if

$$\epsilon^i \geq \underbrace{(R^i - K^i)}_{\text{starting excess reserves}} + \underbrace{(\Delta^i - T^i)}_{\text{net change}} \equiv \epsilon^i_K$$

2. Sufficient/extra excess reserves: deposit rate r_R.

Interaction between cash conversions and interbank borrowing implies that cash conversions may affect implementation of monetary policy.

Equilibrium Interbank Rate

Monetary policy framework: all banks face an exogenous, constant reserve requirement:

$$K^i = \overline{k} \geq 0 \text{ and } K \equiv \int_i K^i = \overline{K}$$

Since all banks are identical, the equilibrium interbank rate is determined by aggregate balance sheet statistics:

$$\begin{aligned} MPF &= R - K \\ r_\Delta &= G(MPF - T) \cdot r_R + (1 - G(MPF - T)) \cdot r_X \\ &= r_R + (r_X - r_R)[1 - G(MPF - T)] \end{aligned}$$

The equilibrium interbank rate r_Δ:

1. **decreases** in the monetary policy framework *MPF*.
2. **increases** in cash transfers T.

Monetary Policy Implementation

The equilibrium interbank rate is given by:

$$r_{\Delta} = r_R + (r_X - r_R)[1 - G(MPF - T)]$$

In our model, the Poole/target rate is defined as:

$$r_{target} = r_R + (r_X - r_R)[1 - G(MPF)]$$

Monetary policy implementation works normally when

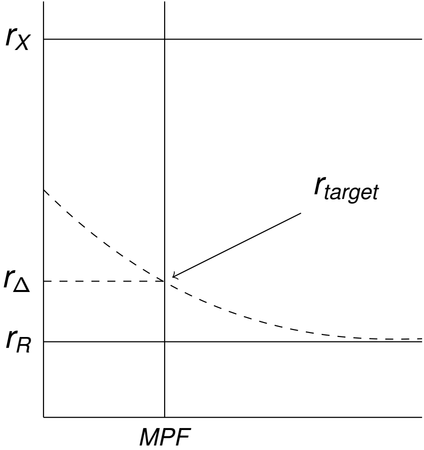
$$r_{\Delta} = r_{target}$$

which requires that

$$T = 0$$

Monetary Policy Implementation

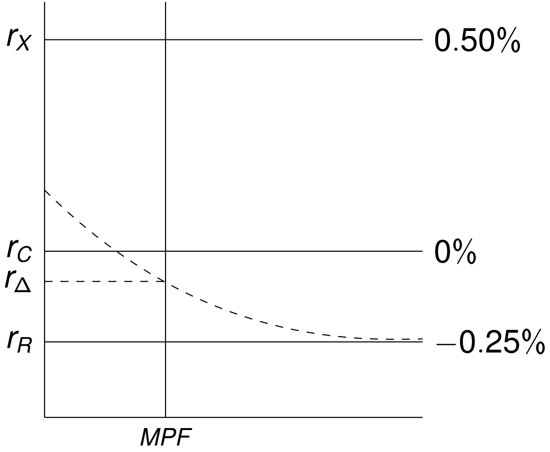
$$r_{target} = r_R + (r_X - r_R)[1 - G(MPF)]$$
$$r_\Delta = r_R + (r_X - r_R)[1 - G(MPF - T)] \text{ w/ } T = 0$$



Key Question: When is $T = 0$?

Equilibrium* Interbank Rate near Zero

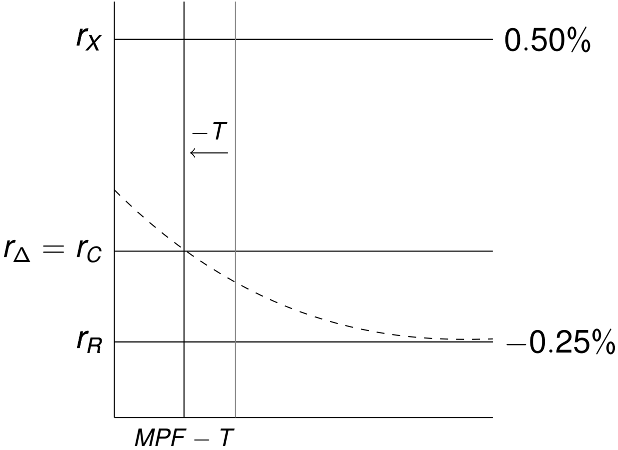
Case 1: $r_{target} < r_C$



- arbitrage: convert reserves to cash, borrow on interbank

Equilibrium Outcome

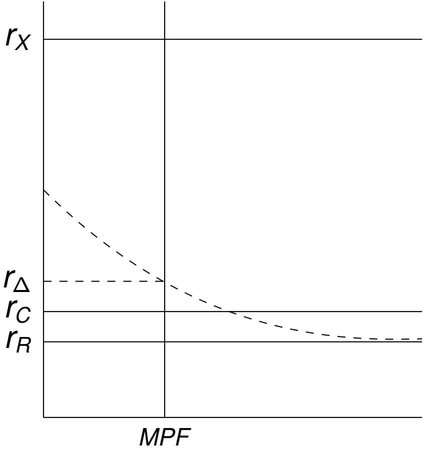
Case 1: $r_{target} < r_C$



- increasing $T > 0$ decreases r_Δ until in equilibrium $r_\Delta = r_C$

Equilibrium Interbank Rate near Zero

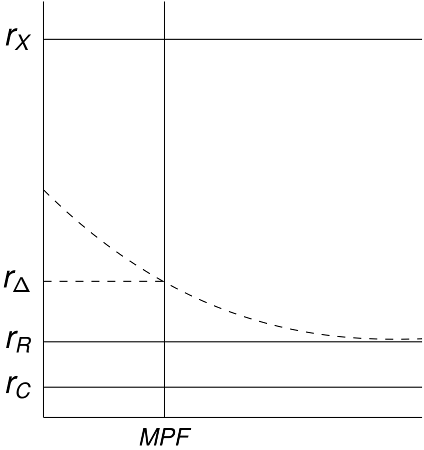
Case 2: $r_{target} > r_C$



- equilibrium outcome: $T = 0, r_\Delta = r_{target}$

Equilibrium Interbank Rate near Zero

Case 2: $r_{target} > r_C$



- equilibrium outcome: $T = 0, r_\Delta = r_{target}$

Summary of Equilibrium Outcomes

When $r_{target} \geq r_C$, monetary policy implementation works normally:

$$r_{interbank} = r_{target}$$

When $r_{target} < r_C$, monetary policy is constrained because

$$r_{interbank} = r_C \neq r_{target}$$

1. Equilibrium level of cash conversions is greater than zero.
2. Equilibrium interbank rate is equal to the return on cash.

Which central bank instruments matter? The deposit rate, the borrowing rate, and the monetary policy framework.

Alt. #1: Tiered Policy Rates

The central bank pays r_M on the first M reserves and r_R afterwards, with $r_R < r_M < r_X$.

The central bank target rate now depends on all three rates, the MPF, and the threshold M.

When $r_{target,M} < r_C$, an arbitrage opportunity exists in the interbank market.

Summary: When $r_{target,M} < r_C$, the interbank equilibrium rate is r_C and monetary policy implementation is constrained.

Alt. #2: Required Reserves with Varying Threshold

Each commercial bank's required reserves depends on its cash withdrawals:

$$K^i = \overline{K} - T^i$$

Central bank borrowing threshold:

$$\begin{aligned} \epsilon_K^i &\equiv (R^i - K^i) + (\Delta^i - T^i) \\ &= R^i + \Delta^i - \overline{K} \end{aligned}$$

Broken the link between cash conversions and excess reserves and, by extension, between cash conversions and interbank borrowing.

Varying Required Reserves Equilibrium Outcome

1. Before: cash conversion lowers reserves, need to borrow on interbank market
2. Now: cash conversion lowers reserve requirement, no need to borrow on interbank market

No uncertainty when choosing cash conversions T^i:

$$E[\pi^i] = \cdots + r_C(C^i + T^i) + r_K(\overline{K} - T^i)$$

In equilibrium, whenever return on required reserves $r_K \geq r_C$:

1. The equilibrium level of cash transfers is zero.
2. The equilibrium interbank rate is the target rate.

Main Conclusions

1. The relevant rate is the target rate given the central bank rates and framework (excess reserves, threshold, etc.).
2. Regular and tiered monetary policy implementations are constrained when the target rate is below the return on cash.
3. A cash-adjusted required reserves implementation operates normally as long as the return on required reserves is above the return on cash but may present other problems.

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