A Portfolio Model of Quantitative Easing

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European Central Bank Workshop

Money Markets, Monetary Policy Implementation and Central Bank Balance Sheets

ECB, Frankfurt am Main, Germany
November 6, 2017

Motivation

- The transmission of QE to long rates is not well understood, conceptually and empirically.
- Notably, the existing literature lacks accounting for
  - The special features of central bank reserves;
  - The role of commercial banks for transmission.
- Transmission details matter for how to best design, calibrate, communicate, and exit QE programs.

Our Contribution

- We develop a portfolio model that contains the assets and liabilities of the central bank and of reserve-holding commercial banks.
- Two financial frictions, *imperfect substitutability* and *segmentation of the market for central bank reserves*, lead to two distinct portfolio balance effects:
  - Standard **supply-induced effects** due to lower available supply of the purchased assets;
  - Novel **reserve-induced effects** that are independent of the assets acquired.
- Key implication: Financial market structure and banking regulations may matter for transmission.

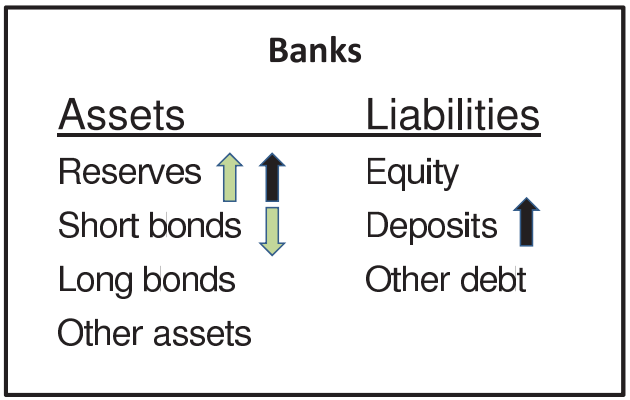
Outline

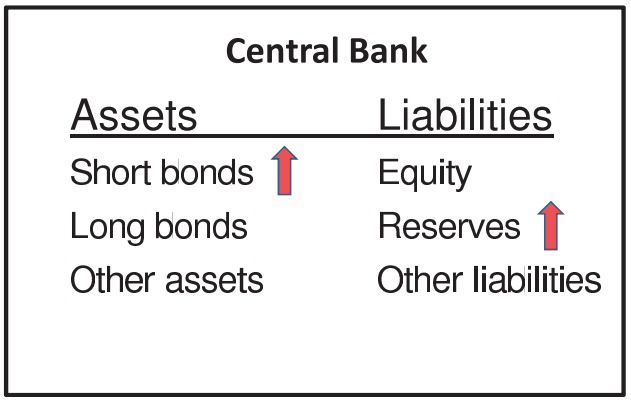
Existing Models Omit Important Aspects of QE

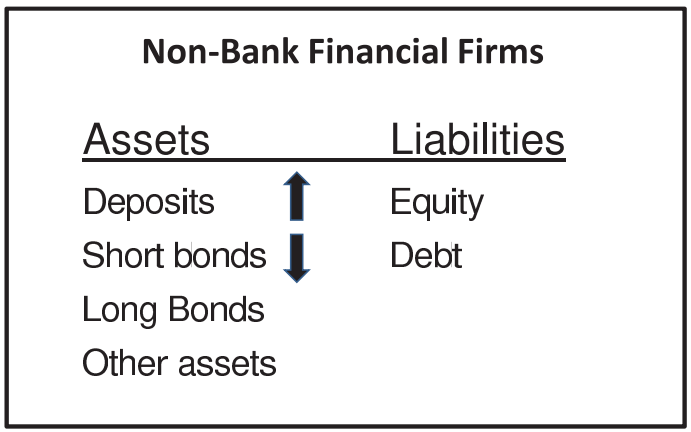
1. Signaling channel: Announcements of QE inform about future economic conditions or monetary policy intentions.
2. Supply-induced portfolio balance channel: CB purchases of long-term bonds reduce the supply of these in the market, thereby increasing their price.

- What about the role of reserves in QE?
  - Only banks can hold central bank reserves.
  - Bernanke and Reinhart (2004) argue that an expansion of reserves by itself can lead to portfolio balance effects.
  - Christensen and Krogstrup (2016) find empirical support for portfolio balance effects on long bond prices from reserve expansions.
  - Vayanos and Vila (2009) have no role for reserves or banks.

Intuition for Reserve-Induced Effects (1)

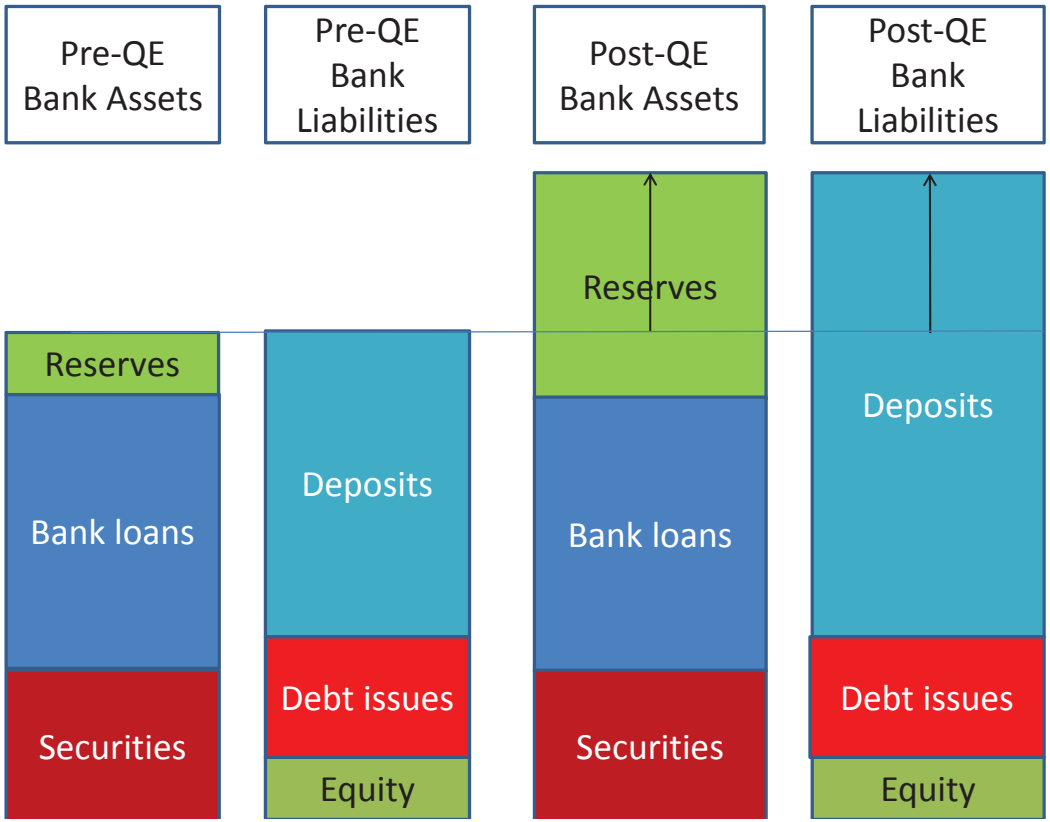






- Example where central bank purchases short bonds in exchange for reserves.
- Traditional view: No effect at ZLB because short bonds and money are perfect substitutes.

Intuition for Reserve-Induced Effects (2)



- Initial impact of QE: Bank asset duration is shortened.
- The extra reserves must stay in banks: Hot potato effect....
- ... until longer-duration yields decline (prices increase) enough to make banks content to hold the extra reserves.

Model with One Traded Security

One-period portfolio model of asset market equilibrium.

- Three types of actors:
  - A central bank (CB);
  - A continuum of reserve holding commercial banks (B);
  - A continuum of nonbank financial firms (NB).
- Three types of assets:
  - Long bonds, L, with the price of P_L and $TP = 1 - P_L > 0$;
  - Central bank reserves, R, with the price of one (numeraire);
  - Bank deposits, D, with the price of one.

Model - The Central Bank

Central bank balance sheet:

- $P_L L_{CB} = E_{CB} + R$.
  - L_{CB} is the central bank's holdings of the long bond;
  - E_{CB} is the value of the central bank's initial equity;
  - R is the amount of outstanding reserves.

Policy tool:

Bond purchases, $P_L dL_{CB}$, paid for with reserves, dR, while equity is determined as a residual from bond price changes

- $dE_{CB} = dP_L L_{CB} + P_L dL_{CB} - dR$.

Model - Nonbank financial firms

Nonbank financial firm j's balance sheet:

- $P_L L^j_{NB} + D^j_{NB} = E^j_{NB}$.
  - L^j_{NB} is firm j's holdings of the long bond;
  - D^j_{NB} is its holdings of bank deposits;
  - E^j_{NB} is its initial equity value.

Nonbank financial firms balance their liquid portfolio and demand positive amounts of both deposits and bonds:

- $L^j_{NB} = f_{NB}(P_L, E^j_{NB})$;
- $\frac{\partial f_{NB}}{\partial P_L} < 0$, i.e., normal downward sloping bond demand;
- $\frac{\partial f_{NB}}{\partial E_{NB}} = 0$, no immediate reaction to changes in equity value.

The demand for deposits is determined as a residual:

- $D^j_{NB} = E^j_{NB} - P_L f_{NB}(P_L, E^j_{NB})$.

Model - Depository Banks

Depository bank i's balance sheet:

- $R^i + P_L L_B^i = E_B^i + D_B^i$.
  - L_B^i is bank i's holdings of the long bond;
  - R^i is its holdings of central bank reserves;
  - D_B^i is the bank's deposit funding;
  - E_B^j is its initial equity value.

Depository banks' demand for bonds:

- $L_B^i = f_B(P_L, E_B^i + D_B^i)$.

Central assumptions:

- $\frac{\partial f_B}{\partial P_L} < 0 \Rightarrow$ bond is a normal good, imperfect substitutability;
- $0 < \frac{\partial f_B}{\partial D_B^i} < 1 \Rightarrow$ "Maturity transformation" assumption.

The demand for reserves is determined as a residual:

- $R_B^i = E_B^i + D_B^i - P_L f_B(P_L, E_B^i + D_B^i)$.

Model Equilibrium

- We assume a continuum of identical banks and nonbanks normalized to 1 $\Rightarrow$ We can drop superscripts.
- Equilibrium: The bond price that ensures aggregate demand for bonds from banks and nonbanks equals total supply of bonds net of central bank holdings.
- Comparative statics: We analyze the change in the equilibrium bond price associated with a QE transaction

$$dL_{CB} = -dL_B - dL_{NB} > 0.$$

- What happens?

Model Solution with One Traded Security

Change in the equilibrium bond price due to a QE transaction:

- $$\frac{dP_L}{dL_{CB}} = \frac{-1}{\frac{\partial f_B}{\partial P_L} + \frac{\partial f_{NB}}{\partial P_L}\left(1 - P_L \frac{\partial f_B}{\partial D_B}\right)} > 0.$$

Deposits respond to central bank purchases as follows

- $$\frac{dD_B}{dL_{CB}} = -P_L \frac{\partial f_{NB}}{\partial P_L} \times \frac{dP_L}{dL_{CB}} \geq 0.$$

Impact depends on:

- The asset price sensitivity of the bond demand;
- Banks' propensity to engage in maturity transformation.

Corner Solution with only Banks Selling Bonds

- For intuition, consider the special case where nonbanks have inelastic demand for bonds: $\frac{\partial f_{NB}}{\partial P_L} = 0$.
- $\frac{dP_L}{dL_{CB}} = \frac{-1}{\frac{\partial f_B}{\partial P_L}} > 0.$
- $\frac{dD_B}{dL_{CB}} = 0.$

The reserve-induced effect shuts down, but supply-induced effects continue to exist.

Corner Solution with only Nonbanks Selling Bonds

- Now, consider the other extreme where banks have inelastic demand for bonds: $\frac{\partial f_B}{\partial P_L} = 0$.
- $$\frac{dP_L}{dL_{CB}} = \frac{-1}{\frac{\partial f_{NB}}{\partial P_L}\left(1 - P_L \frac{\partial f_B}{\partial D_B}\right)} > 0.$$
- $$\frac{dD_B}{dL_{CB}} = \frac{P_L}{1 - P_L \frac{\partial f_B}{\partial D_B}} > 0.$$

The reserve-induced effect arises, amplifying the supply-induced effect.

Summary of Model Findings

- When nonbanks' demand for bonds is sensitive to bond prices, reserve-induced portfolio balance effects arise and amplify the transmission of QE.
- Model with two traded securities in addition to reserves and deposits confirm findings, but is less tractable (see paper).
- Reserve-induced effects on long bond yields or other asset prices are independent of the assets purchased.

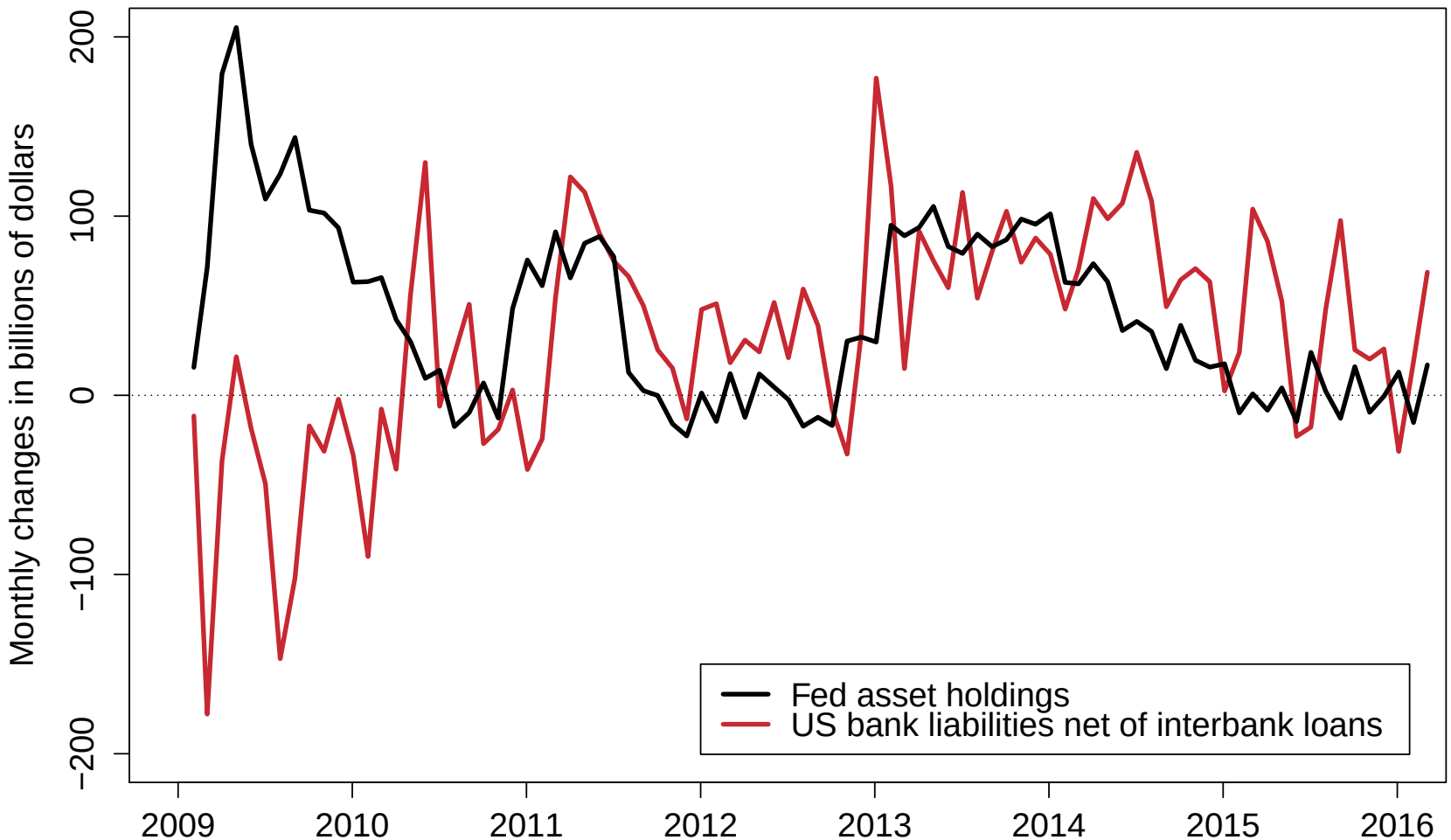
Empirical Relevance of Reserve-Induced Effects (1)

Have reserve-induced effects been empirically relevant in QE programs?

- For identification of reserve effects independently of supply effects, we need QE-style central bank reserve expansions in the absence of long-term bond purchases.
- The Swiss reserve expansion program of August 2011 represents a unique natural experiment.
- Christensen and Krogstrup (2016) analyze the announcement responses and present supporting evidence.
- Event studies of U.S. and U.K. QE programs cannot separately identify reserve effects, but circumstances make them likely.

Empirical Relevance of Reserve-Induced Effects (2)

- Data on bank total liabilities - except for QE1, U.S. banks have tended to see an expansion of their balance sheets in tandem with Fed asset purchases.



Conclusion

- We develop a portfolio model of the transmission of QE to asset prices that takes the roles of central bank reserves and depository banks into account.
- PB effects come in two forms, supply- and reserve-induced.
- Characteristics of reserve-induced effects:
  - Independent of the assets the central bank is purchasing.
  - Importance depends on financial market structure, banks' preferences, and their portfolio constraints (regulation).
  - Empirically relevant, likely to have played a role in the transmission of QE2 and QE3.

Some Tentative Policy Implications

- Implications for design and transmission of QE programs
  - Which assets to buy? Not necessary to buy long-dated securities to affect long-term yields.
  - Financial institutional framework and counterparties matter. Who has access to reserves?
  - Role of regulation in transmission: banks' leverage constraints and portfolio risk management tools are both likely to matter.
- Implications for the exit
  - A "naive" exit from QE through absorption of reserves without asset sales could still affect long-term bond markets.