ECON4033 Money and Finance in China

Week 9: Monetary Policy in China[1]

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[1] These lecture notes are largely based on the materials prepared by Prof. Siu Kee Wong for the same topic.

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I. Introduction

People's Bank of China began to function exclusively as a central bank in 1984. Since then, China's monetary policy framework has gradually moved away from a planned administrative system to a more market-based regime.

As part of this transition, interest rates have been liberalized, making them more responsive to market signals, and the tools of monetary policy have been modernized.

II. Objective of Monetary Policy

The official objective of China's monetary policy is "to maintain the stability of the value of the currency and thereby promote economic growth".

In practice, The People's Bank of China (PBC or PBOC) is supposed to maintain price stability, full employment, and financial stability. The central bank however is not independent and needs the permission of the State Council to change policy setting.

In the planned economy era, the government controlled the credit through credit plan.

In the 1990s, the PBC issued base money and implemented monetary policy through controls of lending and credit volume. The PBC provided liquidity to state-owned banks, which then lent the money to stated-owned enterprises.

III. Intermediate Targets: M2

More recently, money growth has replaced credit rationing as the main intermediate target of monetary policy. The PBC sets targets for the annual growth rates of money supply and bank credit that are deemed to be consistent with its policy objectives.

Over the course of the year, the PBC adjusts policy settings in line with developments in intermediate targets and other macroeconomic variables.

Figure: M2 in China and U.S.

Data source: https://fred.stlouisfed.org/.

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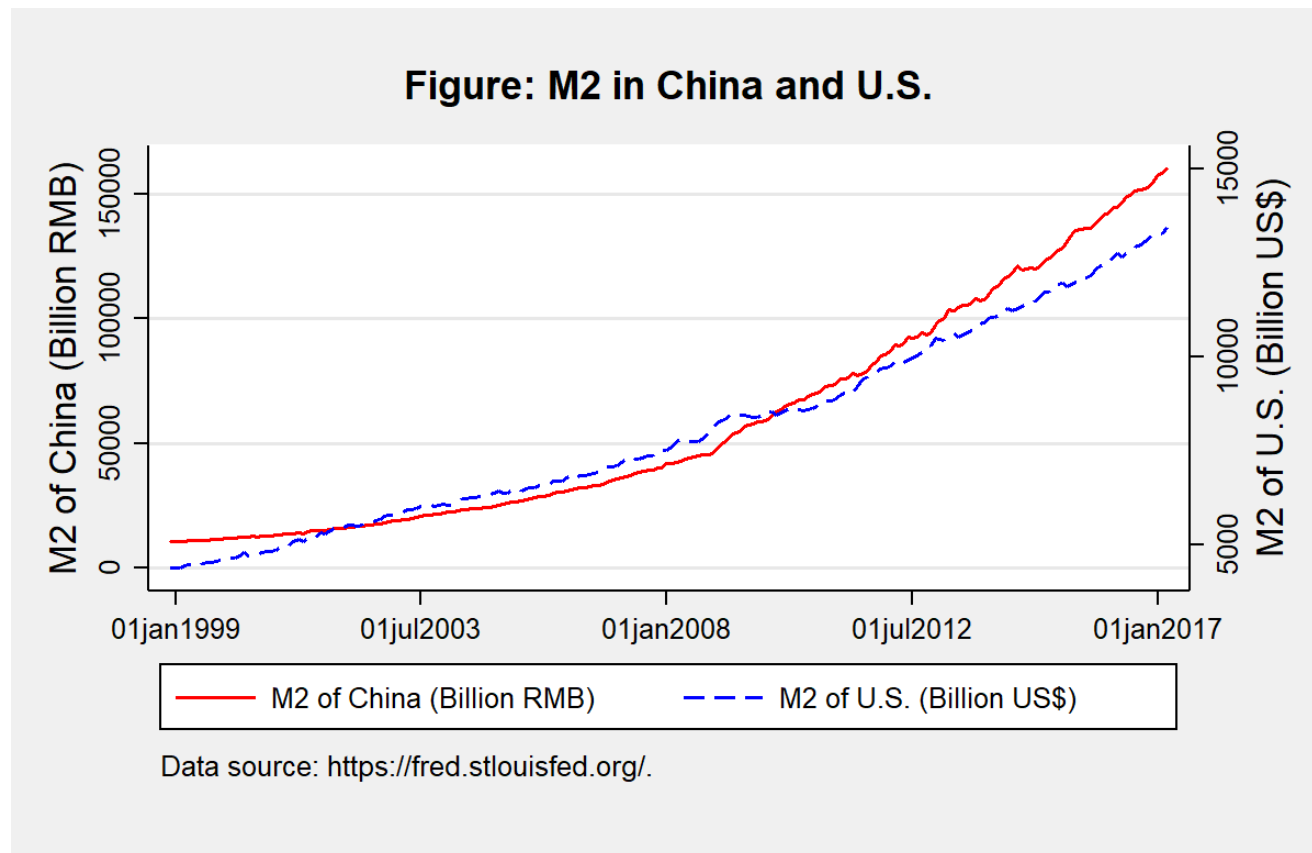
IV. Direct and Indirect Monetary Policy Transmission Mechanism

The transmission mechanism of China's monetary policy is switching from a direct one (i.e., the Central Bank skips the money market and manipulate money supply through financial institutions) to an indirect one (Central Bank manipulate the money market) with the development of the money market.

Transmission Mechanism						
中央銀行	⟹	貨幣市場	⟹	金融機構	⟹	企業和居民
Central bank		Money market		Financial institutions		Firms and residents

V. Money Supply Process

- Cash is created by central banks. Currency in circulation is called M0.

- The portion of the money supply that includes (1) currency in circulation, (2) currency held in vaults by banks, and (3) currency on reserve by banks at the central bank is the monetary base or high-powered money. It is the base from which all the other types of money-like accounts are created by the banking system.

- M1 includes cash and demand deposits.

- Most of money (M2) is demand deposits and other saving accounts. They are created by commercial banks and other financial institutions. While cash is deposited at these banks, that same currency is re-lent by banks many times over and re-deposited in checking and other deposits.

VI. Policy Instruments

- While the Fed (the U.S. central bank) relies primarily on open market operations to affect the federal funds rate, the PBC makes substantial use of other tools that we have described.

Compare and Contrast Monetary Policy Tools and Their Use by China and The United States

Monetary Policy Tools	China	United States
Open market operations	Active	Active
Adjusting reserve requirement	Active	Rare
Discount window lending	Active	Occasional
Window guidance	Active	Rare
Interest rate ceilings	Active	Not used
Directed credit	Active	Rare
Gov't. deposit management	Active	Rare

Source: Schramm (2015).

A. Window Guidance (窗口指導)

- Window guidance is a broad term describing how the central bank persuade financial institutions to follow stated monetary policies.

- Bank-specific credit ceilings were removed in 1998 but the PBC still gives administrative guidance to influence bank lending.

- The PBC holds monthly meetings with commercial banks to outline its concerns about credit conditions across sectors and provides more formal window guidance pronouncements on a quarterly basis.

B. Open Market Operation (OMO)

- Central banks buy or sell short-term securities and undertake repurchase agreements (repos) with financial institutions. A repo is an agreement to sell a security now and buy it back at fixed rate at a higher price, which yields an implicit interest rate. When the central bank buys a security, it pays the financial institution with high-powered money or reserves. This increases the money supply.

- In April 2003, the PBC converted all existing repurchase agreements into Central Bank bills to create a new instrument for OMO. The PBC uses these bills of various maturities to conduct open market operations aimed at achieving its liquidity targets.

- OMOs has become the main tool of monetary policy in China since 2012. OMOs are intended to affect the monetary base or the availability of reserves in the banking system and the interbank interest rate.

- The interbank market determines CHIBOR, the interbank interest rate (based on actual transactions for Chinese banks) and SHIBOR (based on a pool of 16 banks of the estimated cost of overnight funds in Shanghai). In the U.S., the interbank rate is called federal funds rate.

- OMOs in China also involves both sale or purchase of foreign exchange so as to maintain a targeted exchange rate under fixed exchange rate regime.

C. Interest Rate Ceilings and Floors

- Interest rates in the money market:

  o Rediscount Rate

    – The PBC rediscount facility allows banks to exchange commercial paper and other debt instruments with the central bank. Since 2004, PBC, has been allowed to set floating-rate rediscount rate independently.

  o Interbank Rates

    China Interbank Offered Rates (CHIBOR)

    – Since 1996, financial institutions have been allowed to fix interest rates for interbank loans. The CHIBOR system is based on actual traded rates on interbank deals, with the 7-day tenor as the benchmark.

    Shanghai Interbank Offered Rates (SHIBOR)

    – SHIBOR is set daily based on the average interbank rates of 16 banks.

  o Repurchase Rates

    – A repurchase (repo) agreement is a commitment by the seller (dealer) to buy back a security from the purchaser (customer) at a specified price at a designated future date. The seven-day repo is widely accepted as a benchmark rate for interbank transactions.

- The PBC has considerable leverage on the interest rate over short-term money market interest rates:

  o By setting the interest rate it pays on excess reserves, the PBC effectively imposes a floor in the interbank market: Decrease in interest rate discourage excess reserves, which triggers money creation process through bank loans.

  o In principle, the PBC base rate, at which it lends to banks, should impose a ceiling of the money market interest rates.

- Interest rate ceilings and floors are a form of "financial repression". The PBC set interest rate ceiling for saving deposit and interest rate floor for bank loans.

- They are also a means of subsidizing banks.

- The interest rate floor for bank loans was abolished in 2013. The ceiling for saving deposit rate was removed in 2015.

D. Reserve Requirements

- Reserve requirements represent how much cash banks are required to hold in their own vaults or on deposits at the central bank. They serve two purposes:

  1. As a precautionary amount providing the bank with adequate liquidity should depositors withdraw an abnormal amount from the bank (e.g., bank run).

  2. As a tool for controlling the money supply. When financial institutions have higher reserve requirements, they can lend out less.

- In recent years, China, among many economies in the world, use the reserve requirement ratio more to control the money supply. In contrast, the FED only change the ratio for long-term structural considerations rather than part of a targeted monetary policy.

- In the U.S., banks must maintain a marginal reserve requirement of 10 percent on checking accounts over US$79.5 million – a much narrower base for reserves than China's.

- China's extensive use of reserve requirements is consistent with its efforts at controlling monetary growth instead of overnight interest rates; this in turn is related to China's massive efforts to sterilize the foreign exchange inflows since 2007 in order to halt rapid monetary growth.

- It has been a less expensive alternative form of monetary control as the interest rate paid on reserves is low.

- A significant reduction in the amount of excess reserve held by the banking sector is one important reason why China's money market has become more sensitive to the actions of the PBC.

- In early 2002, excess reserves accounted for almost 8% of bank deposits. By 2009, it had fallen to under 2.5 %. Hence smaller banks are more likely to borrow in the money market to cover their requirements at PBC and are therefore more sensitive to money market rates.

- Money multiplier:

Let us derive the money multiplier, the ratio between money supply and the high-powered money:

$$M = C + D, \qquad H = C + R = D(c + r)$$

where M is the money supply, C is the currency in circulation and D is the total deposits, $r = R/D$ is the reserve ratio, and $c = C/D$ represents the fraction of deposits held in cash. Finally, H is the high-powered money. Given these, we have:

$$D = \frac{H}{c + r}, \qquad C = cD = \frac{cH}{c + r}$$

Therefore, the multiplier: $\frac{M}{H} = \frac{C+D}{D(c+r)} = \frac{1+c}{c + r}$. A decrease in r leads to a larger $\frac{M}{H}$.

- Despite the fall in excess reserve, it is still considered high by international standard. The high excess reserve ratio is partly due to the method used to calculate a bank's required reserves.

- In China, banks are penalized if their reserves at the end of a business day fall below the required level. In contrast, e.g., in Japan and the Euro area, banks could hold reserves below the required level on a given day provided the monthly average level of reserves meets the target. In the US, the averaging period is two weeks.

E. Discount Window Lending

- Discount window lending is targeted to specific banks that borrow short term on collateral in order to meet their reserve requirement. Borrowing banks are required to pay an interest rate (the discount rate) that is above the interbank market rate (i.e., a penalty).

- The discount rate also serves as a policy signal sent by the central bank to the market as an indicator of the upper bound of rates acceptable to the monetary authorities.

- China uses the discount window on regular basis whereas discount window leading in the U.S. tends to be for exceptional circumstances.

VII. Policy Objectives

- Macroeconomic Stability: low inflation, high employment, high growth rate, etc.

- Stability of RMB exchange rate.

- Compared to the U.S., China attempts to control both the money supply and interest rate, for the sake of controlling the exchange rate. That can result in shortages and surpluses of money and credit.
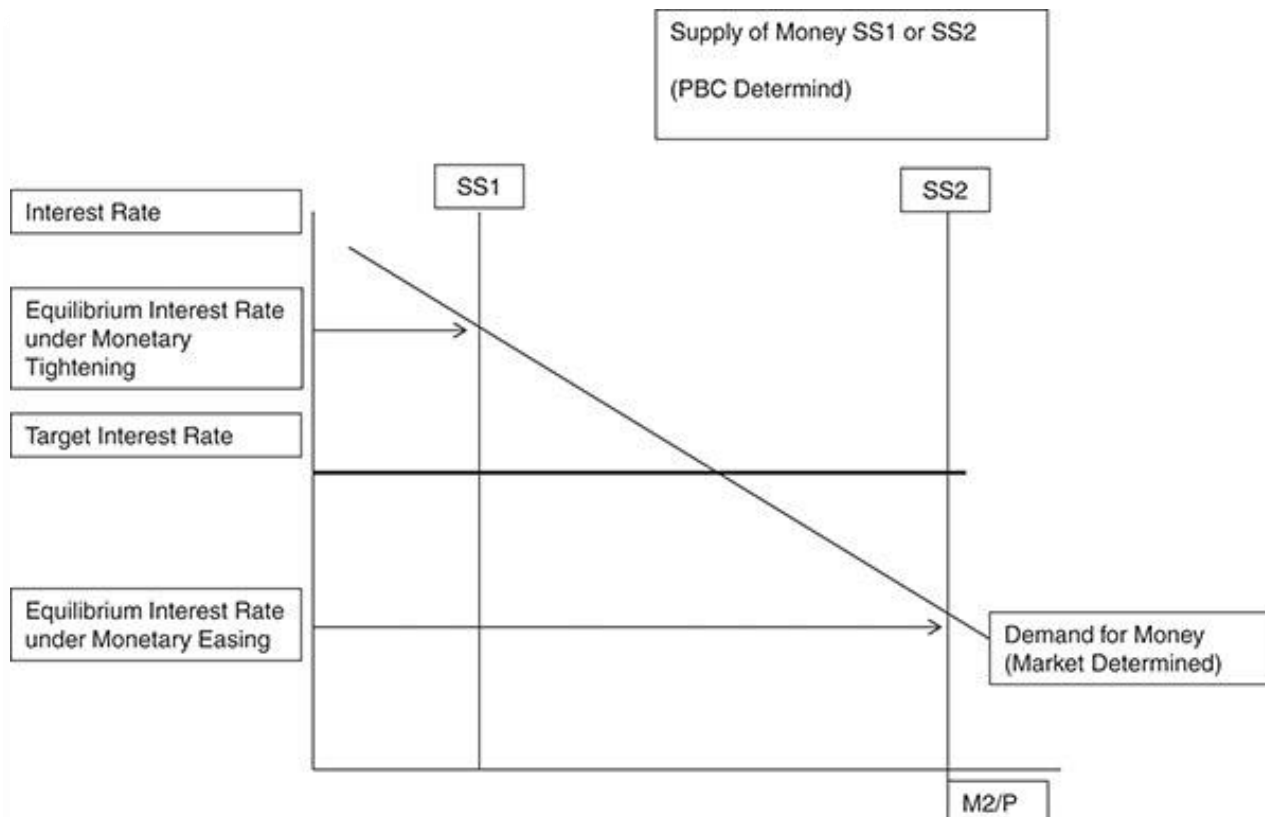
If the PBC reduces the supply of money, the supply curve will shift to the left and vice versa.

While the PBC may want to move the money supply to impact either output or inflation, it may prefer a different interest rate than the equilibrium rate because of China's desire to control the exchange rate.

The desire to control the money supply and the interest rate has led to the use of multiple policy tools. It can mean shortages and surpluses of money and credit. Most central banks only target the interbank interest rate; China targets both M2 and the interest rate.

VIII. Policy Trilemma

- There is a proposition in international monetary economics known as the policy trilemma (impossible trinity) which states that it is impossible in the long run to simultaneously (1) maintain a fixed exchange rate, (2) conduct an independent monetary policy, and (3) allow unrestricted capital flows.

- A fixed exchange rate means that a country's central bank can act as a market maker in its own currency – buying and selling at a fixed rate.

- Independent monetary policy means achieving a target interest rate via the monetary policy tools discussed earlier.

- Free capital mobility means the permission of movement of funds into and out of the country for purposes of financial investment.

- To fully understand policy trilemma, note that (see the Appendix):

$$\underbrace{R_{RMB}}_{\substack{\text{Deposit Returns in China} \\ \text{(Home Return)}}} = \underbrace{R_{USD} + \text{Expected USD appreciation}}_{\substack{\text{Deposit Returns in US} \\ \text{(Foreign Return)}}}$$

  o Capital mobility implies the equation above (Uncovered Interest Parity approximation).

  o Fixed exchange rate gives zero expected appreciation of USD, where $R_{RMB} = R_{USD}$.

  o The domestic interest rate must follow the foreign interest rate at equilibrium.

- Impossible trinity:

  o If a country adopts fixed exchange rate, it loses its monetary autonomy (i.e., no independent monetary policy). Any attempts to increase or decrease money supply will result in a change of exchange rate so monetary autonomy could not be achieved.

  o If a country allows free capital mobility, it could not adopt fixed exchange rate regime as free capital mobility keep changing the relative amount of home and foreign currencies in the exchange rate market resulting in exchange rate appreciation or depreciation based on the market force (i.e., floating exchange rate regime rather than fixed exchange rate).

  o Free capital mobility leads to constant changes in the money supply in the market; hence, no monetary autonomy.

- In principle, China has accommodated the impossible trinity by restricting international capital mobility.

- While foreign direct investment (FDI) is encouraged, non-FDI capital flows (Foreign Portfolio Investment, FPI) have been largely prohibited.

- Despite the restrictions, significant amount of capital flows occurs in both directions.

- As China moves toward greater capital account liberalization (more capital mobility), it must allow greater flexibility in its exchange rate.

IX. Sterilization

- Sterilization: The central bank carries out equal foreign and domestic asset transaction to nullify the impact of capital flow on money supply.

- Continuous capital flows would affect the money supply, independent monetary policy or a fixed exchange rate might have to be abandoned.

- The central bank, however, can sterilize foreign exchange accumulation in the short run.

- Example: Central Bank's Balance Sheet

Asset		Liabilities	
Time 0:			
Foreign assets	1000	Deposits held by private banks	500
Domestic assets	1500	Currency in circulation	2000
Time 1: 100 Capital inflow			
Foreign assets	1100	Deposits held by private banks	500
Domestic assets	1500	Currency in circulation	2100

- Example: Central Bank's Balance Sheet (cont.)

Asset			Liabilities	
Time 0:				
Foreign assets	1000		Deposits held by private banks	500
Domestic assets	1500		Currency in circulation	2000
Time 1: 100 Capital inflow				
Foreign assets	1100		Deposits held by private banks	500
Domestic assets	1500		Currency in circulation	2100
Time 2: To sterilize, the central bank sells 100 worth of domestic bond				
Foreign assets	1100		Deposits held by private banks	500
Domestic assets	1400		Currency in circulation	2000

Result: Money supply stays constant and the impact of capital flow on money supply is nullified.

Figure 16. PBoC sterilisation and base money

CNY Bn | PBoC bonds | Required reserves | Foreign reserves | CNY Bn
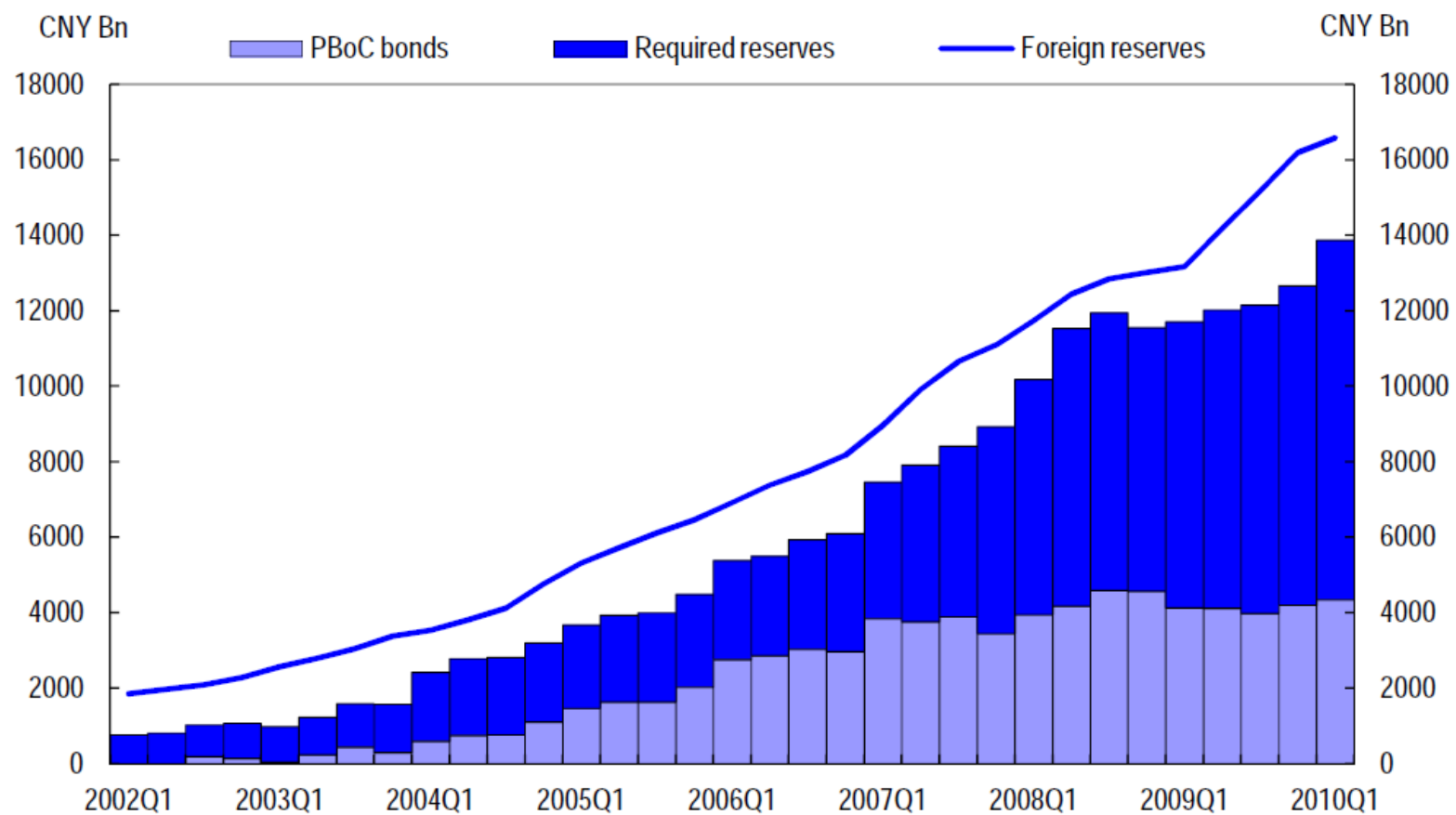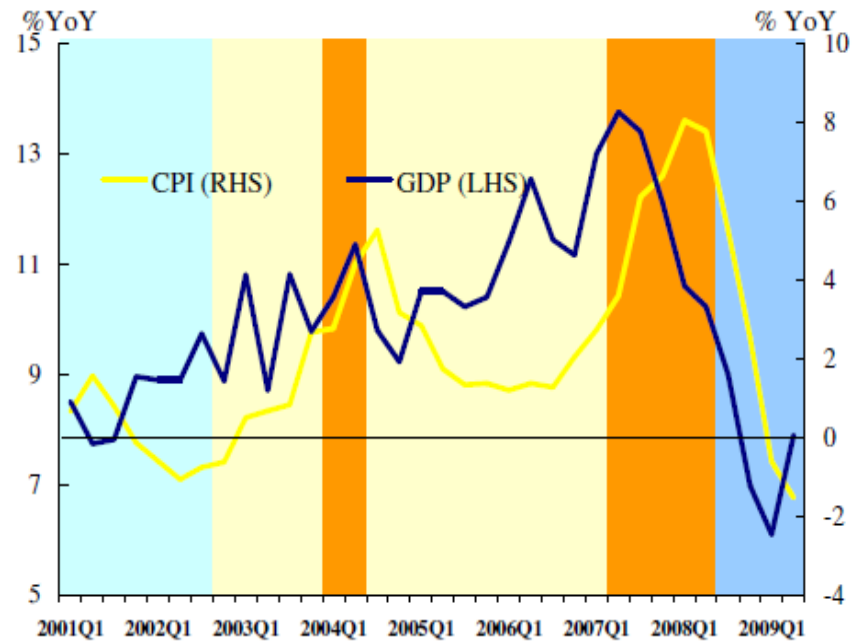
Source: CEIC

- In China, large current account surplus and rising capital inflows have resulted in appreciation pressure of RMB. In response, the State Administration of Foreign Exchange (国家外汇管理局) has sold RMB, leading to a large increase in foreign exchange reserve.

- This may spill over into the domestic money market. To limit such effects, the PBC used open market operation and changed the reserve requirement of commercial banks.

- Since 2002, the value of the PBC sterilization instruments outstanding has risen roughly in line with the stock of foreign exchange reserves, indicating that the central bank has been largely successful in offsetting the domestic monetary impact of capital flows.

- The cost of sterilization can be high as most of the foreign assets are held as low-interest US Treasury bonds and the USD had been depreciating against RMB throughout the 2000s.
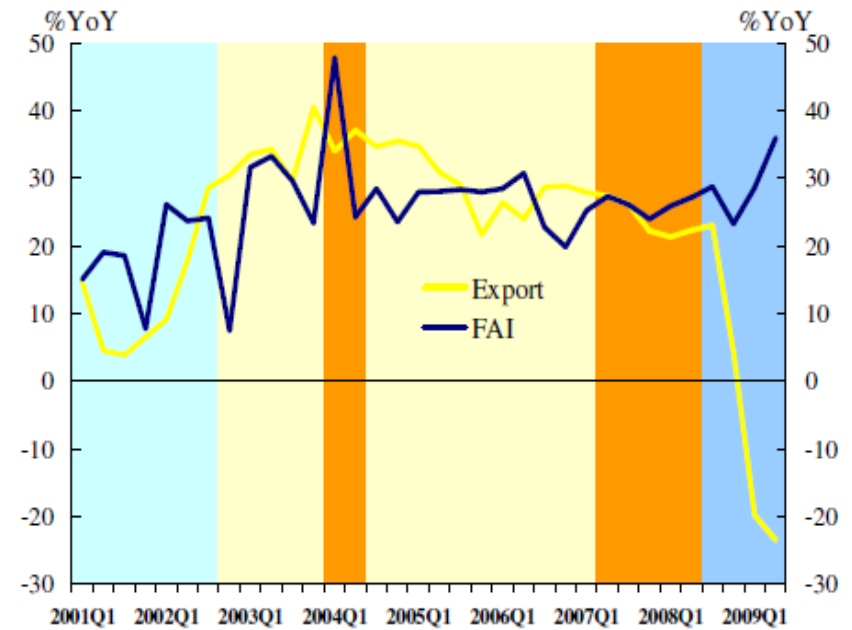
X. Implementation of Monetary Policy

- Shu and Ng (2010) take a "narrative approach" by examining quarterly reports and press announcements from the PBC. They come with a broad spectrum of measures ranging from "strong tightening" to "strong loosening".

- Most scholars find that monetary policy in China responds more to growth and external economic factors (e.g. the 2008 financial crisis) rather than inflation targets. Control of inflation is given a low priority.

- Monetary policy became more expansionary in 2003 because of the outbreak of SARs.

- Fear of economic slowdown led China's continuing to carry out expansionary monetary policy throughout the mid-2000s.

- Credit expansion resulted in deterioration of loan quality and threaten further reform of the financial sector.

Chart 1. Major macroeconomic indicators

a. GDP growth and inflation

b. Investment and exports

Chart 2. Selective policy changes

a. OMO and RRR

- Open market operations (RHS)
- Required reserve ratio (LHS)

withdrawal / injection

Legend:
- Strong tightening (orange)
- Strong loosening (blue)
- Tightening (pale yellow)
- Loosening (pale cyan)

b. Interest rates

- 1-year lending rate (LHS)
- 3-month central bank bill issuance rate (RHS)

Legend:
- Strong tightening (orange)
- Strong loosening (blue)
- Tightening (pale yellow)
- Loosening (pale cyan)

Sources: CEIC and authors' estimates.

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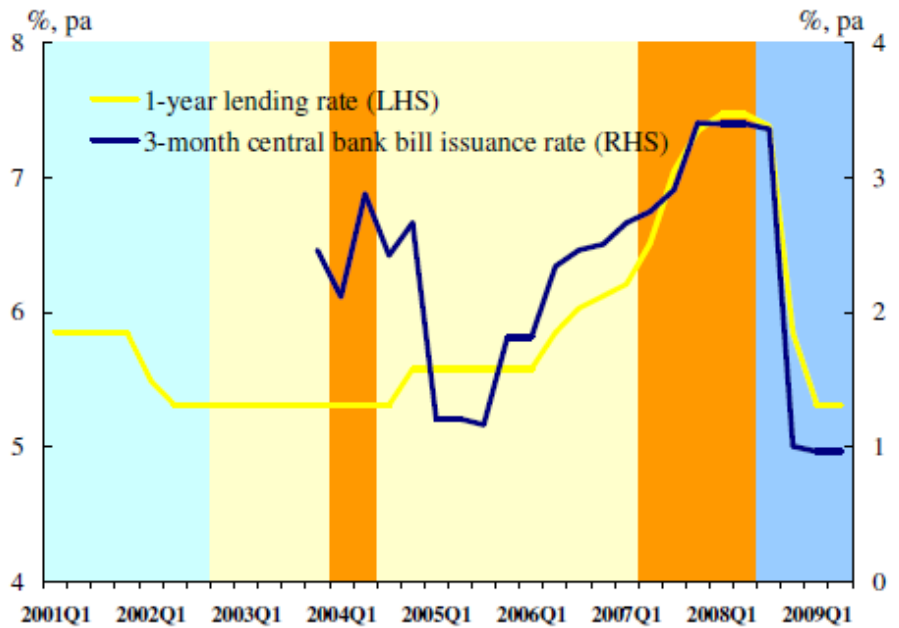
Table: PBC targets and Outcomes

	M1	*M1*	*M2*	*M2*	%ΔCPI	%ΔCPI	%ΔGDP	%ΔGDP
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
1998	17	12	16-18	15.8	5	-0.8	8	7.8
1999	14	14.5	14-15	16	2	-1.4	8	7.6
2000	15-17	19.7	15-16	16.1	1	0.4	8	8.4
2001	13-14	14	13	16.2	1-2	0.7	7	8.3
2002	13	16	16	14.2	1-2	-0.8	7	9.1
2003	16	19.1	17	15.2	1	1.2	7	10.0
2004	17	16.4	15	20	3	3.0	7	10.1
2005	15	11.7	16	16.2	4	1.8	8	10.4
2006	14	14.5	16	14.8	3	1.5	8	11.6
2007	Nil	21	16	18.1	3	4.8	8	13.0
2008	Nil	13.6	16	17.5	4.8	5.9	8	9.6
2009	Nil		17	16.6	3-4.8	-0.7	8	8.7
2010			17	26.5	3		8	

Table: PBC targets and Outcomes (cont.)

	M2 growth rate	M2 growth rate	%ΔCPI	%ΔCPI
	Target	Actual	Target	Actual
2010	17%	19.7%	3%	3.3%
2011	16%	13.6%	4%	5.4%
2012	14%	13.8%	4%	2.6%
2013	13%	13.6%	3.5%	2.6%
2014	13%	12.2%		2.0%
2015	12%	13.3%		1.4%
2016	13%	11.3%		2.0%

XI. Effectiveness of Monetary Policy

- Market interest rates including interbank rates and rediscount rate are fully liberalized and move flexibly to clear markets for liquidity in China.

- The flows in the interbank money market are greatly influenced by the big four banks, which have a structural surplus of deposits and consistently supply money to the interbank market.

- The depth of market is restricted by regulations limiting foreign banks to borrow only 1.5 times their capital in the interbank market.

- The macro-based evidence of a significant negative relationship between interest rate change and capital formation in China is not strong, see e.g. the results in Conway, P., R. Herd and T. Chalaux (2010).

- Most of the studies found that the impact of interest rate changes on GDP growth is extremely small.

- State-owned commercial banks are often obliged to lend to SOEs (many of which are owned by local authorities) that enjoy soft budget constraints, may have their debts forgiven and are therefore insensitive to changes in interest rates.

- Moving forward, economic reforms over recent years would have increased the elasticities of capital formation to its user cost. Since 1980s, the government has been progressively separating government functions from business operations across sectors, including banks.

- SOEs are now held more accountable for their performance and access to finance at interest rates that are below market levels has become more limited.

- The rapid development of the private sector should increase the sensitivity of investment to the user cost of capital.

- Listed Chinese firms have been relying more on debt funding over recent years, which also heighten their sensitivity to interest rate changes.

XII. Alternative Transmission Mechanism

- Another channel by which monetary policy can influence economic activity is through the asset prices. Monetary policy that increase liquidity will cause asset prices to rise. As investors move towards less-liquid assets, the prices of longer-term securities and then other assets such as stocks and real estate would rise.

- This channel appears quite strong in China. Stock market prices are affected rapidly by changes in monetary policy.

- China's consumer credit market is relatively small but is developing quickly.

- Banks have rapidly expanded mortgage lending, which has increased by over 20% annually between 2006 and 2008. In the twelve months to mid-2010, residential mortgage rose by almost half, reaching almost 13% of total bank lending.

- At current interest rates and assuming a 15-year mortgage, a two-percentage point increase in interest rates would increase mortgage payments by an amount equivalent to 3.5% of consumer spending.

XIII. Change of the Monetary Policy Framework

- "At present, the focus of China's monetary policy is gradually shifting from quantity control to price control … we are in a transition from quantity to price control, and both tools are employed during this process."

  Yi Gang, Govenor of PBOC (2018), https://www.bis.org/review/r190130b.htm.

- Financial innovation made M2 a weak indicator of the financial activities in the economy. Comparing the M2 targets and its actual growth rates, we can see that it had been hard to achieve those targets.

- In 2018, the PBOC reformed the monetary policy framework and dropped the M2 targets. China has since targeted the interest rate by setting an "interest rate corridor".

- An interest rate corridor or a policy corridor refers to the range within which the operating target of the monetary policy – a short term interest rate – moves around the policy rate announced by the central bank.

- The floor of the corridor is the interest rate paid on excess reserves. In 2013, the PBOC set up the standing lending facility (SLF). It provides reserves on demand to financial institutions with collateral. The interest rate under this arrangement is thus the ceiling of the corridor.

Figure 2. Interest Rate Corridor
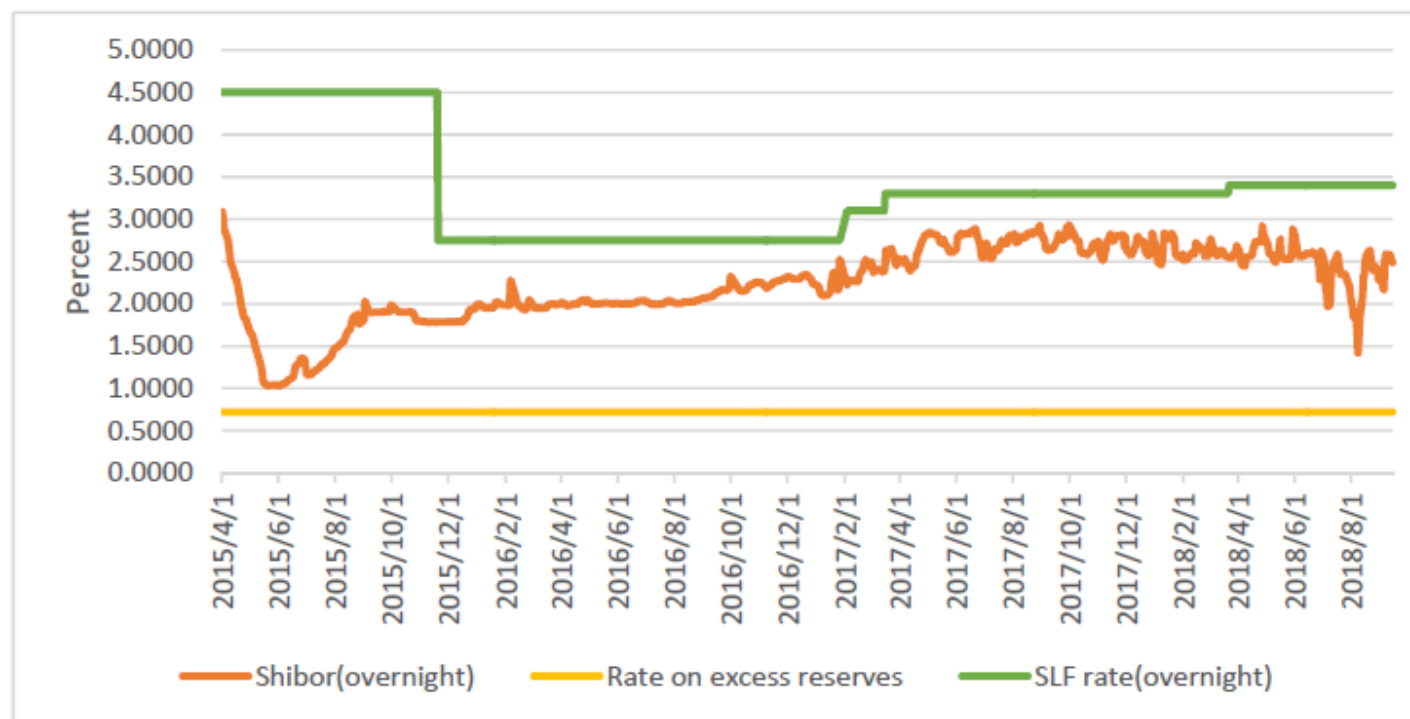
Source: China Foreign Exchange Trade System & National Interbank Funding Center's website (www.chinamoney.com.cn) and the People's Bank of China's website (www.pbc.gov.cn)

From He and Jia (2019), "An Institutional Reform of China's Reform of their Monetary Policy Framework", Levy Institute of Economics of Bard College, working paper 925.

XIV. Further Reforms?

- Although a range of factors are in play, the PBC's policy actions do reflect balance of payments concerns at the expense of domestic policy objectives.

- The exchange rate regime imposes a constraint on the PBC's ability to tailor monetary policy to domestic objectives.

- While the exchange rate of RMB has been rather stable, the inflation rate remains highly volatile.

- Currently the exchange rate of RMB is neither fixed nor floating. A policy of gradually increasing exchange rate flexibility is likely to be adopted in future.

- Greater exchange rate flexibility would enhance the exchange rate's role as automatic stabilizer that helps smooth business cycle volatility.

- Greater exchange rate flexibility raises the question of the most appropriate nominal anchor for Chinese monetary policy.

- The PBC's reliance on the stock of money as an intermediate policy target is problematic.

- Simple quantity-based frameworks do not handle shocks very well and are susceptible to errors in forecasting money demand.

- The PBC reaction function should place greater weight on forward-looking indicators of inflation and just react when inflation breaches the targets.

- A more independent PBC:

  o Currently, decision to adjust the PBC monetary policy instruments are made by the State Council (国务院). It requires modernizing the framework require granting PBC instrument independence so it can react promptly to changing economic circumstances without being swayed by political concerns.

  o Operational independence would allow the PBC to generate and sustain the credibility it needs to effectively influence inflation expectation.

  o Borrowers typically use treasury bonds or central bank bills as collateral to secure their loans, with an agreement to repurchase the collateralized bonds at maturity.

  o Interbank repo market, trading is dominated by the 7-day maturity, which accounts for nearly 80% of the total turnover. For longer maturities, market depth is limited.

    – Interbank market: A market banks and other financial institution use short-term repurchase agreement (回购交易, repo) to manage their liquidity (流动性) positions. Participants in the money market with an excess supply of liquidity can lend short term (usually with a maturity from overnight to seven days) to other participants that have an excess demand for liquidity.

  o The market for uncollateralized loans, which are traded between large banks, is not large and around 90% of the short-term money market turnover takes place in the repo market.

Reference:

Ronald M. Schramm (2015), *The Chinese Macroeconomy and Financial System: A U.S. Perspective*, Taylor and Francis, London.

Conway, P., R. Herd and T. Chalaux (2010), "Reforming China's Monetary Policy Framework to Meet Domestic Objectives", *OECD Economics Department Working Papers*, No. 822, OECD Publishing. http://dx.doi.org/10.1787/5km32vmsq6f2-en

Appendix A: Short-Run Asset Pricing Approach to Exchange Rates (CIP and UIP)

- **Notation**

  - Home country: $\qquad$ H

  - Foreign country: $\qquad$ F

  - Nominal exchange rate:

    - European terms: F/H – foreign currency price of one unit of home currency
    - American terms: H/F – home currency price of one unit of foreign currency

  - We will be using American terms. So, in uppercase, denote

    - Spot rate: $S_{H/F,\ t}$ – exchange rate in the market for spot transaction at time t

    - Forward rate: $F_{H/F,\ t}$ – exchange rate in a forward contract at time t

  - Home interest rate: $\qquad$ i_H

  - Foreign interest rate: $\qquad$ i_F

- **Question:**

For 1-unit home currency deposit of 1 period, will the returns from the home country and foreign country be the same? If not, what drives the difference?

Let's work out these two returns denominated in home currency:

Deposit Returns in Home Currency	
Domestic Return	Foreign Return
$(1 + i_H)$	$\dfrac{1}{S_{H/F,\ t}} \times (1 + i_F) \times ?_{H/F}$

where

- $\dfrac{1}{S_{H/F,\ t}}$ coverts 1 unit of home currency to foreign currency (as normally will be required by a foreign bank);

- $\dfrac{1}{S_{H/F,\ t}} \times (1 + i_F)$ gives the deposit return in foreign currency.

- We need $?_{H/F}$ (an exchange rate) to convert the foreign return back to home currency for comparison.

- **What could be the candidates for $?_{H/F}$:**

(1) We could use a forward contract at time t to hedge currency risk, i.e., using riskless arbitrage. Consequently, we have

Deposit Returns in Home Currency	
Domestic Return	Foreign Return
$(1 + i_H)$	$\dfrac{1}{S_{H/F,\,t}} \times (1 + i_F) \times F_{H/F,\,t}$

Since there is no risk involved (i.e., no ambiguity about the value of returns) and these are all returns for the same asset (1-unit home currency deposit), in principle they are supposed to both equal to each other. If not, one could buy low and sell high to earn profit until the difference disappears (i.e., use arbitrage to gain profit until market clears):

$$(1 + i_H) = \frac{1}{S_{H/F,\,t}} \times (1 + i_F) \times F_{H/F,\,t}$$

Taking logarithm on both sides gives

$$\log(1 + i_H) = \log\left(\frac{1}{S_{H/F,\ t}}\right) + \log(1 + i_F) + \log\left(F_{H/F,\ t}\right)$$

$$\therefore\ i_H = -s_{H/F,\ t} + i_F + f_{H/F,\ t}$$

Where we have used the fact that:

$$\log(a \times b) = \log(a) + \log(b)$$
$$\log\left(\frac{1}{a}\right) = -\log(a)$$

$$\log(1 + r) \approx r \ \text{ if } \ r \ \text{ is } \ \text{very} \ \text{small.}$$

We have also used lowercase to denote values in log, i.e.,

$$s_{H/F,\ t} = \log\left(S_{H/F,\ t}\right)$$
$$f_{H/F,\ t} = \log\left(F_{H/F,\ t}\right).$$

Consequently, we have $i_H = -s_{H/F,\ t} + i_F + f_{H/F,\ t}$

$$\therefore\ i_H - i_F = f_{H/F,\ t} - s_{H/F,\ t}$$

(CIP, Covered Interest Rate Parity 有拋補利率平價)

where $\left(f_{H/F,\ t} - s_{H/F,\ t}\right)$ is called forward premia or negative of the forward discount. $\left(s_{H/F,\ t} - f_{H/F,\ t}\right)$ is called forward discount.

(2) Alternatively, we could choose to do nothing at time t and choose to accept whatever spot rate offered in the market at time $t + 1$, i.e., choose speculation. Since at time t we do not know what spot rate $(S_{H/F,\ t+1})$ we will have at time $t + 1$, when calculating the returns at time t, we use expected value $S^e_{H/F,\ t+1}$ (i.e., do a forecast):

Deposit Returns in Home Currency	
Domestic Return	Foreign Return
$(1 + i_H)$	$\dfrac{1}{S_{H/F,\ t}} \times (1 + i_F) \times S^e_{H/F,\ t+1}$

Again, these two returns should both equal to each other in the equilibrium:

$$(1 + i_H) = \frac{1}{S_{H/F,\ t}} \times (1 + i_F) \times S^e_{H/F,\ t+1}$$

$$\therefore\ i_H = -s_{H/F,\ t} + i_F + s^e_{H/F,\ t+1}$$

$$\therefore\ i_H - i_F = s^e_{H/F,\ t+1} - s_{H/F,\ t} \qquad \text{(UIP, Uncovered Interest Rate Parity 無拋補利率平價)}$$

- We now have:

$$\text{(1)} \quad i_H - i_F = f_{H/F,\ t} - s_{H/F,\ t} \qquad \text{(CIP, Covered Interest Rate Parity)}$$

$$\text{(2)} \quad i_H - i_F = s^e_{H/F,\ t+1} - s_{H/F,\ t} \qquad \text{(UIP, Uncovered Interest Rate Parity)}$$

Note that,

at time t (*ex ante*) we could fix $(f_{H/F,\ t} - s_{H/F,\ t})$

at time $t+1$ (*ex post*) we know $(s_{H/F,\ t+1} - s_{H/F,\ t})$

these two will be the same if we forecast the future spot rate $s_{H/F,\ t+1}$ correctly and put it down in a forward contract, i.e., when $f_{H/F,\ t} = s^e_{H/F,\ t+1} = s_{H/F,\ t+1}$, where $s^e_{H/F,\ t+1}$ is the expected (forecasted) value of future spot rate.

- Implications:

  o In a world without transaction cost and asymmetric information, according to UIP condition, changes in the nominal exchange rate depends on the interest rate gap between two countries.

  o Forward exchange rate depends on investors' expectation of the future spot rate, which depends on expected future interest rate gap between two countries.

- UIP approximation:

This is a useful formula that later will help us to understand governments' exchange rate policy during the Asian Financial Crisis. Recall from UIP and CIP conditions, supressing time subscripts, we obtain:

$$(1 + i_H) = \frac{1}{S_{H/F}} \times (1 + i_F) \times F_{H/F} \quad \Rightarrow \quad (1 + i_H) = (1 + i_F)\frac{F_{H/F}}{S_{H/F}}$$

$$(1 + i_H) = \frac{1}{S_{H/F}} \times (1 + i_F) \times S^e_{H/F} \quad \Rightarrow \quad (1 + i_H) = (1 + i_F)\frac{S^e_{H/F}}{S_{H/F}}$$

When both UIP and CIP hold, we have forward rate equals to the expected future spot rate $F_{H/F} = S^e_{H/F}$.

From $(1 + i_H) = (1 + i_F)\dfrac{S^e_{H/F}}{S_{H/F}}$, note that $\dfrac{S^e_{H/F}}{S_{H/F}} = 1 + \dfrac{S^e_{H/F} - S_{H/F}}{S_{H/F}} = 1 + \dfrac{\Delta S^e_{H/F}}{S_{H/F}}$, we have

$$(1 + i_H) = (1 + i_F)\frac{S^e_{H/F}}{S_{H/F}} = (1 + i_F)\left(1 + \frac{\Delta S^e_{H/F}}{S_{H/F}}\right) = 1 + i_F + \frac{\Delta S^e_{H/F}}{S_{H/F}} + \left(i_F \frac{\Delta S^e_{H/F}}{S_{H/F}}\right)$$

when the euro interest rate and the expected rate of depreciation are small, the last term in bracket is very small and may be neglected in an approximation.

- UIP approximation (cont.):

Consequently,

$$(1 + i_H) = (1 + i_F) \frac{S^e_{H/F}}{S_{H/F}} \approx 1 + i_F + \frac{\Delta S^e_{H/F}}{S_{H/F}}$$

$$\therefore \quad \underbrace{i_H}_{\text{Domestic Return}} = \underbrace{i_F + \frac{\Delta S^e_{H/F}}{S_{H/F}}}_{\text{Foreign Return}} .$$

Appendix B: Long-Run Monetary Approach to Exchange Rates

- Just as arbitrage occurs in the international market for financial assets, it also occurs in the international markets for goods. An arbitrage is present when there is the opportunity to instantaneously buy low and sell high. The result of goods market arbitrage is that the prices of goods in different countries expressed in a common currency tend to be equalized.

- Applied to a single good, this idea is referred to as the law of one price; applied to an entire basket of goods, it is called the theory of purchasing power parity.

- Our goal is to develop a simple yet useful theory based on an idealized world of frictionless trade where transaction costs can be neglected. We start at the microeconomic level with single goods and the law of one price. We then move to the macroeconomic level to consider baskets of goods and purchasing power parity.

- The law of one price states that in the absence of trade frictions, and under conditions of free competition and price flexibility, identical goods sold in different locations must sell for the same price when prices are expressed in a common currency.

- By definition, in a market equilibrium there are no arbitrage opportunities. If diamonds can be freely moved between New York and Amsterdam, both markets must offer the same price. Economists refer to this situation in the two locations as an integrated market.

- We can mathematically state the law of one price as follows, for the case of any good g sold in two locations:

$$\underbrace{q_{US/EUR}^{g}}_{\substack{\text{Relative price of good g} \\ \text{in Europe versus U.S.}}} = (\ \underbrace{E_{\$/€}P_{EUR}^{g}}_{\substack{\text{European price} \\ \text{of good } g \text{ in } \$}}\ )/\ \underbrace{P_{US}^{g}}_{\substack{\text{U.S.price} \\ \text{of good g in } \$}} \tag{1}$$

  - $q_{US/EUR}^{g}$ expresses the rate at which goods can be exchanged: it tells us how many units of the U.S. good are needed to purchase one unit of the same good in Europe, i.e., real exchange rate.

  - $E_{\$/€}$ expresses the rate at which currencies can be exchanged ($\$/€$).

- Given law of one price holds, i.e., $q_{US/EUR}^{g} = 1$, we have:

$$E_{\$/€}P_{EUR}^{g} = P_{US}^{g} \quad \Longrightarrow \quad \underbrace{E_{\$/€}}_{\substack{\text{Norminal} \\ \text{exchange rate}}} = \underbrace{P_{US}^{g}/P_{EUR}^{g}}_{\substack{\text{Ratio of} \\ \text{goods' prices}}} \tag{2}$$

- The principle of purchasing power parity (PPP) is the macroeconomic counterpart to the microeconomic law of one price (LOOP). To express PPP algebraically, we can compute the relative price of the two baskets of goods in each location: $q_{US/EUR} = (E_{\$/€}P_{EUR})/P_{US}$

- There is no arbitrage when the basket is the same price in both locations, i.e., $q_{US/EUR} = 1$. PPP holds when price levels in two countries are equal when expressed in a common currency. This statement about equality of price levels is also called **absolute PPP**:

$$E_{\$/€} = P_{US}/P_{EUR} \qquad (3)$$

or more generally, when PPP holds, we have

$$P_H = E_{H/F}P_F \quad \text{or simply} \quad P = eP^*$$

where e is nominal exchange rate in American terms, and P and P^* are home and foreign price levels respectively.

- Given this framework, we are now able to examine the implications of PPP for the study of inflation to predict the relationships between relative PPP, inflation, and exchange rate depreciation.

- The rate of change of the price level is known as the rate of inflation, or simply inflation. Given $E_{\$/€} = P_{US}/P_{EUR}$ from equation (3) and assume that PPP holds, let's work out the change of variables on both left- and right-hand sides of the equation.

- We have from the left-hand side of equation (3): the rate of change of the exchange rate in Home (US) is the rate of exchange rate depreciation in Home given by:

$$\frac{\Delta E_{\$/\text{€}, \, t}}{E_{\$/\text{€}, \, t}} = \underbrace{\frac{E_{\$/\text{€}, \, t+1} - E_{\$/\text{€}, \, t}}{E_{\$/\text{€}, \, t}}}_{\substack{\text{Rate of depreciation of the} \\ \text{nominal exchange rate}}} \tag{4}$$

- The rate of change of the ratio of two price levels mathematically equals the rate of change of the numerator minus the rate of change of the denominator, hence from the right-hand side of equation (3) we have:

$$\frac{\mathsf{D}(P_{US} / P_{EUR})}{(P_{US} / P_{EUR})} \approx \frac{\mathsf{D}P_{US,t}}{P_{US,t}} - \frac{\mathsf{D}P_{EUR,t}}{P_{EUR,t}}$$

$$= \underbrace{\left(\frac{P_{US,t+1} - P_{US,t}}{P_{US,t}} \right)}_{\substack{\text{Rate of inflation in U.S.} \\ \rho_{US,t}}} - \underbrace{\left(\frac{P_{EUR,t+1} - P_{EUR,t}}{P_{EUR,t}} \right)}_{\substack{\text{Rate of inflation in Europe} \\ \rho_{EUR,t}}} = \rho_{US} - \rho_{EUR} \tag{5}$$

where the terms in brackets are the inflation rates in each location, denoted π_{US} and π_{EUR}, respectively.

- By combining equation (4) and (5), we obtain relative PPP:

$$\underbrace{\frac{DE_{\$/€,t}}{E_{\$/€,t}}}_{\substack{\text{Rate of depreciation} \\ \text{of the nominal exchange rate}}} = \underbrace{\rho_{US,t} - \rho_{EUR,t}}_{\text{Inflation differential}} \quad (6)$$

- Relative PPP implies that the rate of depreciation of the nominal exchange rate equals the difference between the inflation rates of two countries (the inflation differential).

- Now we know in the long run the exchange rate is determined by the ratio of the price levels in two countries. But this prompts a question: What determines those price levels?

- Monetary theory supplies an answer: in the long run, price levels are determined in each country by the relative demand and supply of money.

- How is the supply of money determined? In practice, a country's central bank controls the money supply.

- A simple theory of household money demand (the need of holding cash or cash equivalent) is motivated by the assumption that the need to conduct transactions is in proportion to an individual's income. We can infer that the aggregate money demand will behave similarly. All else equal, a rise in national dollar income (nominal income) will cause a proportional increase in transactions and, hence, in aggregate money demand.

- A simple model in which the demand for money is proportional to dollar income is known as the quantity theory of money:

$$\underbrace{M^d}_{\substack{\text{Demand} \\ \text{for money (\$)}}} = \underbrace{L(i)}_{\substack{\text{A decreasing} \\ \text{function of nominal} \\ \text{interest rate}}} \times \underbrace{PY}_{\substack{\text{Nominal} \\ \text{income (\$)}}} \tag{7}$$

$$\underbrace{\frac{M^d}{P}}_{\substack{\text{Demand} \\ \text{for real money (\$)}}} = \underbrace{L(i)}_{\substack{\text{A decreasing} \\ \text{function of nominal} \\ \text{interest rate}}} \times \underbrace{Y}_{\text{Real income}} \tag{8}$$

Figure: Equilibrium in the Money Market

At equilibrium we have $M = M^s = M^d = L(i) \times PY$

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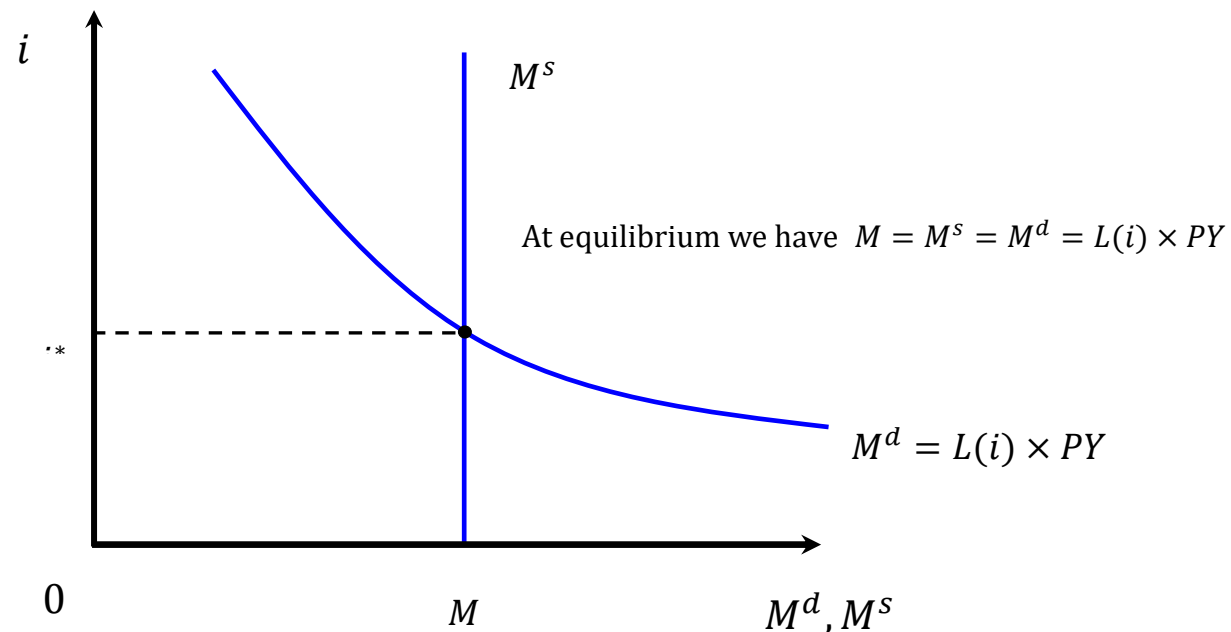
- Given this framework, we have price levels in the U.S. and Europe are:

$$P_{US} = \frac{M_{US}}{L_{US}Y_{US}} \qquad\qquad P_{EUR} = \frac{M_{EUR}}{L_{EUR}Y_{EUR}} \qquad (9)$$

- These two equations are examples of the fundamental equation of the monetary model of the price level. In the long run, we assume prices are flexible and will adjust to put the money market in equilibrium.

- Building Block of The Monetary Theory of the Price Level According to the Long-Run Monetary Model: In these models, the money supply and real income are treated as known exogenous variables (in the green boxes).

- The models use these variables to predict the unknown endogenous variables (in the red boxes), which are the price levels in each country.
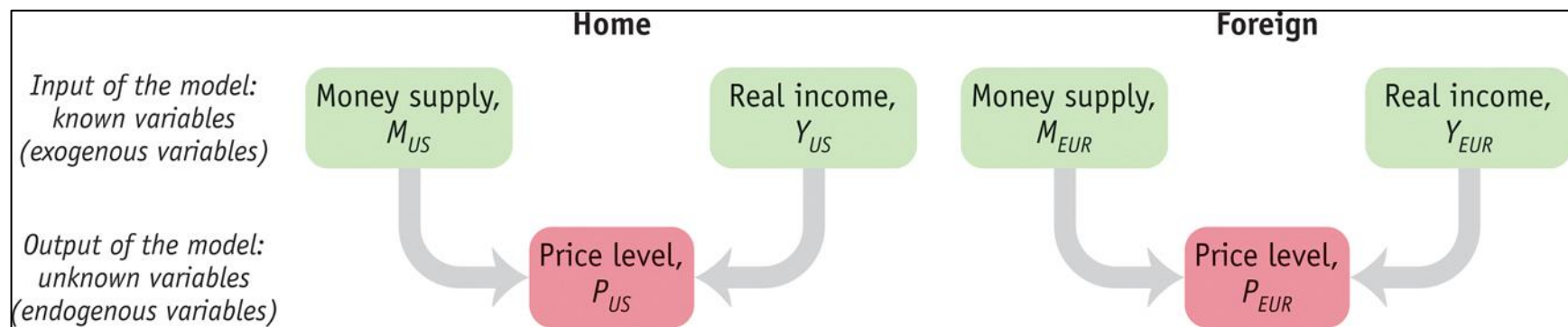
Source: Feenstra and Taylor (2011), p476.

- Equations (3) and (7) to (9) give us fundamental equation of the monetary approach to exchange rates:

$$\underbrace{E_{\$/EUR}}_{\text{Exchange rate}} = \underbrace{\frac{P_{US}}{P_{EUR}}}_{\text{Ratio of price levels}} = \frac{\left(\dfrac{M_{US}}{L_{US}Y_{US}}\right)}{\left(\dfrac{M_{EUR}}{L_{EUR}Y_{EUR}}\right)} = \frac{\left(M_{US}/M_{EUR}\right)}{\underbrace{\left(L_{US}Y_{US}/L_{EUR}Y_{EUR}\right)}_{\substack{\text{Relative nominal money supplies} \\ \text{divided by} \\ \text{relative real money demands}}}} \qquad (10)$$

- The implications of the fundamental equation of the monetary approach to exchange rates are intuitive:

  o Suppose the U.S. money supply increases, all else equal. The right-hand side increases (the U.S. nominal money supply increases relative to Europe), causing the exchange rate to increase (the U.S. dollar depreciates against the euro).

  o Now suppose the U.S. real income level increases, all else equal. Then the right-hand side decreases (the U.S. real money demand increases relative to Europe), causing the exchange rate to decrease (the U.S. dollar appreciates against the euro).

  A bit further math on the next page help us to see this.

- Denote U.S. money supply as M_{US}, and its growth rate as μ_{US}:

$$\mu_{US} = \underbrace{\frac{M_{US,t+1} - M_{US,t}}{M_{US,t}}}_{\text{Rate of money supply growth in U.S.}} \qquad (11)$$

- Also denote the growth rate of real income in the U.S. as g_{US}:

$$g_{US} = \underbrace{\frac{Y_{US,t+1} - Y_{US,t}}{Y_{US,t}}}_{\text{Rate of real income growth in U.S.}} \qquad (12)$$

- Assume that there is no change in real nominal interest rate, so that $L(i)$ is a constant $\bar{L}$ for now. Putting all the pieces together, mathematically, the growth rate of $P_{US} = M_{US}/(\bar{L}_{US}Y_{US})$ equals the money supply growth rate μ_{US} minus the real income growth rate g_{US}. The growth rate of P_{US} is the inflation rate π_{US}.

$$\pi_{US,t} = \mu_{US,t} - g_{US,t} \qquad (13)$$

Similarly, we have

$$\pi_{EUR,t} = \mu_{EUR,t} - g_{EUR,t} \qquad (14)$$

i.e., when money growth is higher than income growth, we have "more money chasing fewer goods" and this leads to inflation.

- From equation (6), relative PPP, we now have

$$\underbrace{\frac{\mathrm{D}E_{\$/€t}}{E_{\$/€,t}}}_{\substack{\text{Rate of depreciation} \\ \text{of the nominal exchange rate}}} = \underbrace{p_{US,t} - p_{EUR,t}}_{\text{Inflation differential}} = \left(m_{US,t} - g_{US,t} \right) - \left(m_{EUR,t} - g_{EUR,t} \right)$$

$$= \underbrace{\left(m_{US,t} - m_{EUR,t} \right)}_{\substack{\text{Differential in} \\ \text{nominal money supply} \\ \text{growth rates}}} - \underbrace{\left(g_{US,t} - g_{EUR,t} \right)}_{\substack{\text{Differential in} \\ \text{real output} \\ \text{growth rates}}}.$$

(15)

or in general form:

$$\underbrace{\frac{\Delta E_{H/F}}{E_{H/F}}}_{\substack{\text{Rate of depreciation of} \\ \text{the nominal exchange rate}}} = \underbrace{(\mu_H - \mu_F)}_{\substack{\text{Differential in nominal} \\ \text{money growth rates} \\ \text{between Home } (H) \text{ and} \\ \text{Foreign } (F) \text{ countries}}} - \underbrace{(g_H - g_F)}_{\substack{\text{Differential in real} \\ \text{output growth rates} \\ \text{between Home } (H) \text{ and} \\ \text{Foreign } (F) \text{ countries}}}.$$