ECON 1550: International Finance

Money, Interest Rates, and Exchange Rates

A model of the money market

Exogenous variables

Variable	Description
Y	Real income
M^s	Money supply
P	Price level

Endogenous variables

Variable	Description	Equation	Type of equation
R	Domestic interest rate	$M^d/P = L(R, Y)$	Behavioral equation
M^d	Money demand	$M^d = M^s$	Equilibrium condition

Description of the Money Market

- There are only two assets: money and domestic bonds
- Money
  - Can be used for transactions
  - Pays no interest
- Bonds
  - Cannot be used for transactions
  - Pay interest $R \geq 0$

Money Demand

- Money demand is higher when:
  - Higher price level $P \rightarrow$ need more money to buy goods
  - Lower nominal interest rate $R \rightarrow$ bonds less attractive
  - Higher income $Y \rightarrow$ want more money to buy more

- Capture idea with a behavioral equation

$$M^d = P \times L(\underset{(-)}{R}, \underset{(+)}{Y})$$

Real money demand

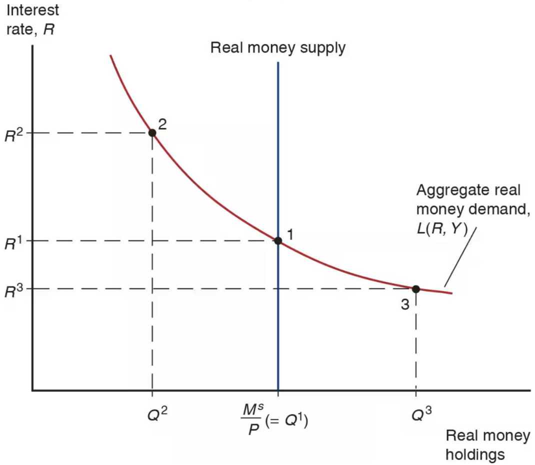
- Convenient to write in terms of real money demand

$$\frac{M^d}{P} = L(R, Y)$$

and real money supply

$$\frac{M^s}{P}$$

Equilibrium in money market



Money is defined by its function

- Medium of exchange
- Store of value
- Unit of account

Many types of money (1/2)

- Commodity money: a physical commodity (like gold) that is used as money
- Convertible paper money: a piece of paper that can be exchanged for a commodity

Many types of money (2/2)

- Fiat money: issued by a central bank, not backed by any commodity
- Digital currency: not backed by any commodity, privately issued, electronic payments

Fiat money

1. Central bank liabilities are special because they are the unit of account.
2. Currency is a promise to deliver future central bank liabilities.

Assets	Liabilities
\$0	\$0

$t = 0$

Assets	Liabilities
\$1 currency	\$1 money

$t = 1$

Assets	Liabilities
\$1 bonds	\$1 money

$t = 2$

Monetary policy

- Deposits at the Fed are called reserves
- “The” interest rate is just interest on reserves

Short-run FX and money market model

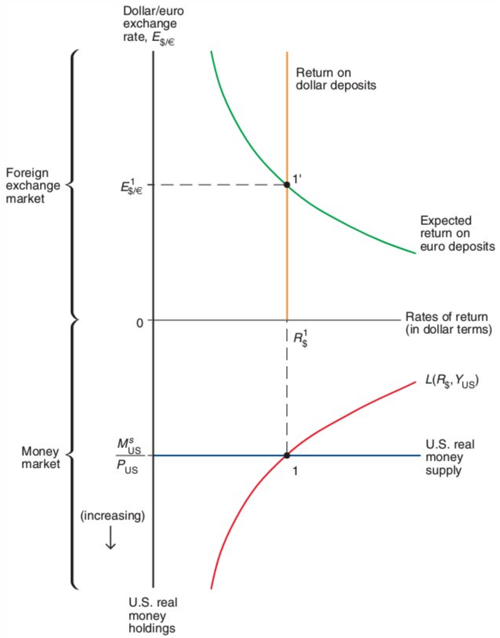
Exogenous variables

Variable	Description
R^*	Foreign interest rate
E^e	Expected exchange rate
Y	Real income
M^s	Money supply
P	Price level

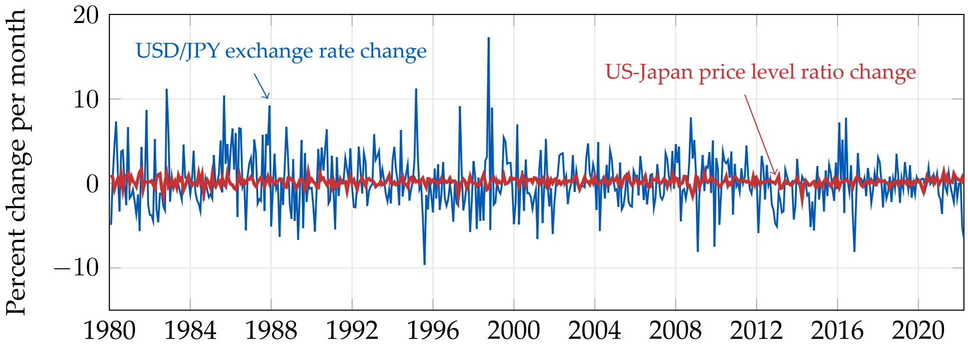
Endogenous variables

Variable	Description	Equation	Type of equation
E	Exchange rate	$R = R^* + \frac{E^e - E}{E}$	Equilibrium condition
R	Domestic interest rate	$M^d/P = L(R, Y)$	Behavioral equation
M^d	Money demand	$M^d = M^s$	Equilibrium condition

Short-run equilibrium in FX and money markets



Exchange rates are very volatile



Source: FRED/CPIAUCSL; FRED/CPALCY01JPM661N; FRED/DEXJPUS (end-of-month, inverted to USD/JPY).

Conceptual definition of long-run equilibrium

- Hypothetical equilibrium that would result if economy runs indefinitely with no shocks

- Equivalently, the hypothetical equilibrium that would occur if prices were perfectly flexible and always adjusted instantaneously and frictionlessly

Definition of the long run in the model

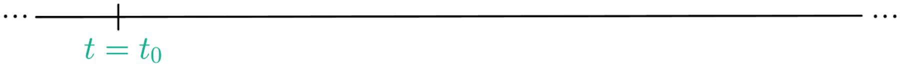
1. In the long run, $E = E^e$
   - By definition of the long run, all variables constant
   - By assumption of rational expectations, expectations must be correct in the long run
   - In the model, it means $E_{LR} = E^e_{LR}$

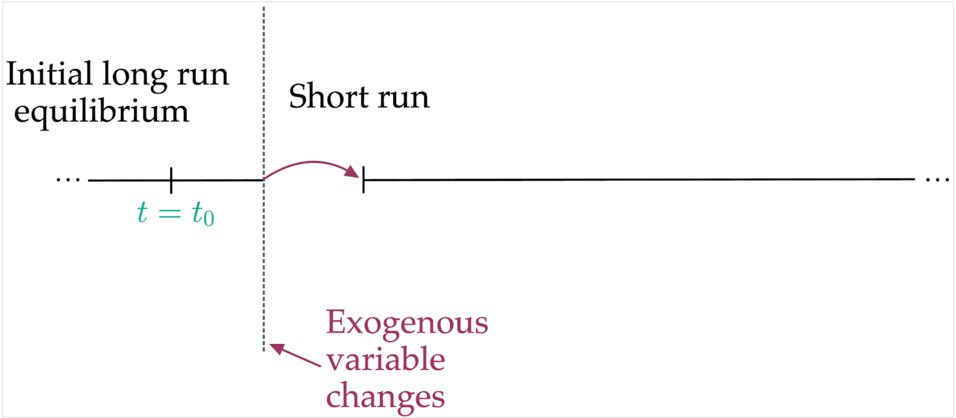
Assumptions about the short run

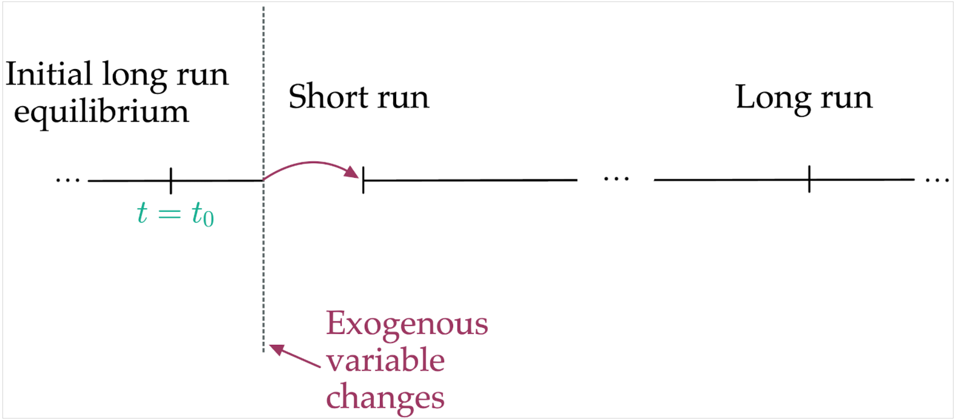
1. In the short run, P is fixed
   - Because prices are "sticky"
   - In the model, it means $P_0 = P_{SR}$

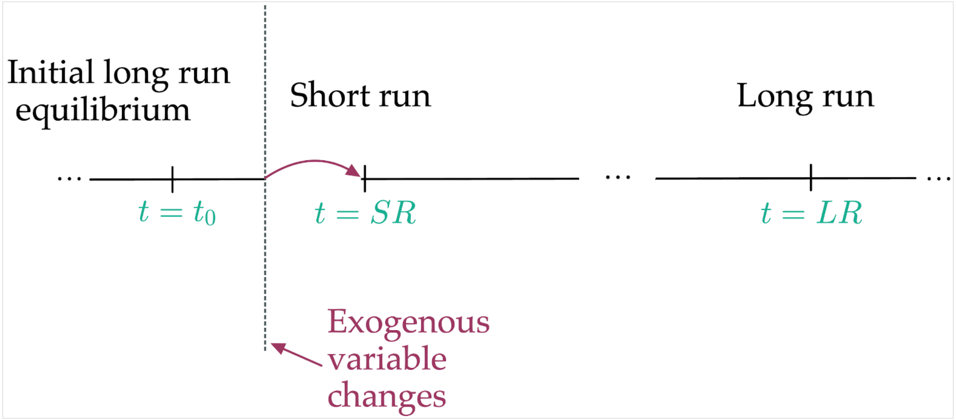
2. In the short run, E^e equals long-run E
   - By assumption of rational expectations
   - In the model, it means $E^e_{SR} = E_{LR}$

Initial long run equilibrium




Initial long run equilibrium
Short run
$t = t_0$
Exogenous variable changes


Initial long run equilibrium
Short run
Long run
$t = t_0$
Exogenous variable changes



Initial long run equilibrium
Short run
Long run
$t = t_0$
$t = SR$
$t = LR$
Exogenous variable changes

Results in the long run (1/3)

1. Long-run interest rate R_{LR} from FX market
   - Using $E_{LR} = E^e_{LR}$ and UIP:

$$R_{LR} = R^* + \frac{E^e_{LR}}{E_{LR}} - 1$$

$$\Rightarrow R_{LR} = R^*$$

Results in the long run (2/3)

2. Long-run price level P_{LR} from the money market
   - Using $R_{LR} = R^*$ and money market equilibrium condition:

$$\frac{M^s}{P_{LR}} = L(R_{LR}, Y) = L(R^*, Y)$$

$$\Rightarrow \quad P_{LR} = \frac{M^s}{L(R^*, Y)}$$

Results in the long run (3/3)

3. Long-run exchange rate E_{LR} from PPP (purchasing power parity)
   - Because E_{LR} is a nominal price, in the long run it moves proportionally to the price level:

$$E_{LR} \propto P_{LR}$$

Results in the short run (1/2)

1. Short-run exchange rate E_{SR} from UIP with $E^e = E_{LR}$
   – Using UIP and the short-run assumptions:

$$R = R^* + \frac{E_{LR} - E_{SR}}{E_{SR}} \quad \Rightarrow \quad E_{SR} = \frac{E_{LR}}{1 + R - R^*}$$

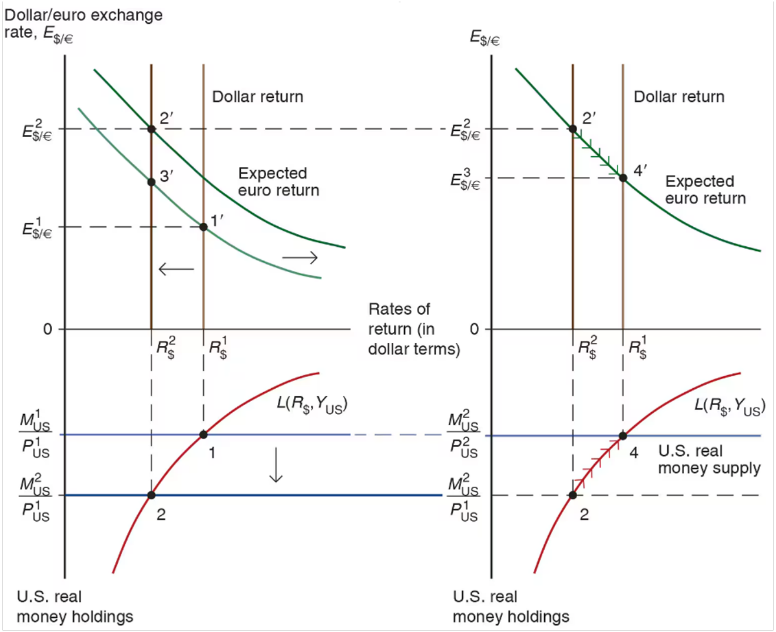
Results in the short run (2/2)

2. Short-run domestic interest rate R_{SR} from the money market
   - Using money market equilibrium condition and P fixed at P_0 in the short run:

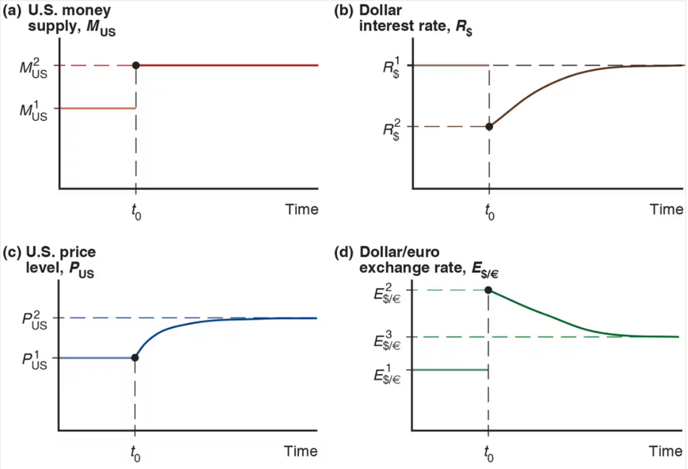
$$\frac{M^s}{P_{SR}} = L(R_{SR}, Y) \quad \Rightarrow \quad \frac{M^s}{P_0} \qquad = L(R_{SR}, Y),$$

which can be solved for R_{SR}

Permanent Money Supply Changes



Exchange Rate Overshooting



Long-run FX and money market model

Exogenous variables

Variable	Description
Y^n	Potential output
M^s	Money supply
R^*	Foreign interest rate

Endogenous variables

Variable	Description	Equation	Type of eq
E	Exchange rate	$R = R^* + \frac{E^e - E}{E}$	Eq. condition
M^d	Money demand	$M^d/P = M^s/P$	Eq. condition
E^e	Expected exchange rate	$E^e = E$	Behavioral
R	Domestic interest rate	$P = \frac{M^d}{L(R, Y^n)}$	Eq. condition
P	Price level	P fixed in the short run	Behavioral

Overshooting

1. Properties of initial, SR, LR equilibria
2. Dynamic FX and money market model
3. Example
   - Solve with equations
   - Solve graphically

Properties of initial, SR, and LR equilibria

Long run:

- $E^e = E$

  $\Rightarrow E_0^e = E_0$ and $E_{LR}^e = E_{LR}$

- E proportional to P and M^s

  $\Rightarrow E_0 = kM_0^s$ and $E_{LR} = kM_{LR}^s$ (k is a parameter)

Properties of initial, SR, and LR equilibria

Short run:

- Prices are fixed

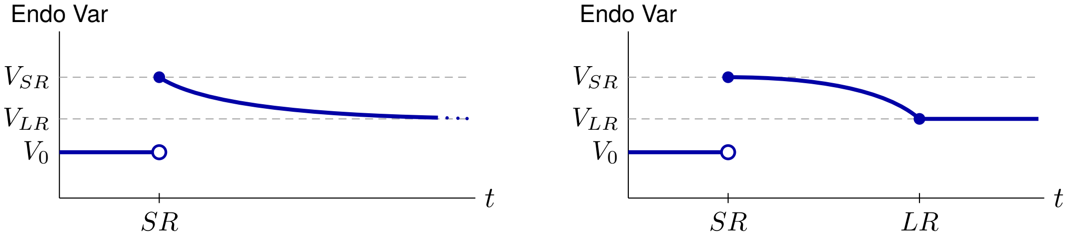
  $\Rightarrow P_{SR} = P_0$

- Rational expectations

  $\Rightarrow E^e_{SR} = E_{LR}$

Transition between SR and LR

- Slow monotonic transition between SR value and LR value
- No indication of shape



Dynamic FX and money market model

Exogenous variables

Variable	Description
M^s	Path of money supply
R^*	Path of foreign interest rate
Y	Path of income (GNP)
k	Long-run proportionality constant for E and M^s

Endogenous variables

Variable	Description
E	Exchange rate
E^e	Expected exchange rate
P	Price level
R	Domestic interest rate
M^d	Money demand

Equations that apply at all times

(UIP) : $R = R^* + \frac{E^e}{E} - 1$ (equilibrium condition)

(MD) : $\frac{M^d}{P} = L(\underset{(-)}{R},\ \underset{(+)}{Y})$ (behavioral)

(MS = MD) : $\frac{M^s}{P} = \frac{M^d}{P}$ (equilibrium condition)

Equations that apply in SR equilibria only

(Sticky P) : $P_{SR} = P_0$ (behavioral)

(RE) : $E^e_{SR} = E_{LR}$ (behavioral)

Equations that apply in LR equilibria only

(PPP) or (Flex P) : $E_0 = kM_0^s, \quad E_{LR} = kM_{LR}^s$ (behavioral)

(Defn LR) or (RE) : $E_0^e = E_0, \quad E_{LR}^e = E_{LR}$ (behavioral)

Example

Need to specify:

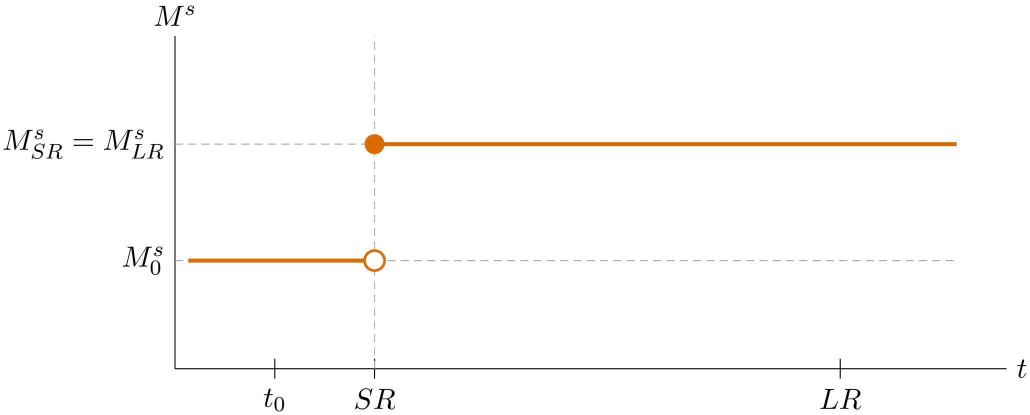
1. Function $L(R, Y)$
2. Path of exogenous variables

Assume:

1. $L(R, Y) = \dfrac{Y}{1+R}$
2. $R^* = 0.08, \ Y = 1, \ k = 1$

$$\{M_0^s, \ M_{SR}^s, \ M_{LR}^s\} = \{1, \ 1.05, \ 1.05\}$$

Example: Permanent increase in M^s



Solution steps

1. Solve initial LR equilibrium ($t = t_0$)

2. Solve LR equilibrium ($t = LR$)

3. Solve SR equilibrium ($t = SR$)

Solution sub-steps

LR (steps 1 and 2)			SR (step 3)		
(a) Flex P / PPP	$\longrightarrow$	E	(a) P fixed	$\longrightarrow$	P
(b) Defn LR / RE	$\longrightarrow$	E^e	(b) MS = MD	$\longrightarrow$	R
(c) UIP	$\longrightarrow$	R	(c) RE	$\longrightarrow$	E^e
(d) MS = MD	$\longrightarrow$	P	(d) UIP	$\longrightarrow$	E

Step 1: Solve initial LR equilibrium ($t = t_0$)

(a) Flex P / PPP $\rightarrow E$: $E_0 = kM_0^s = 1 \cdot 1 = 1$

(b) Defn LR / RE $\rightarrow E^e$: $E_0^e = E_0 = 1$

(c) UIP $\rightarrow R$:

$$R_0 = R^* + \frac{E_0^e}{E_0} - 1$$

$$= 0.08 + \frac{1}{1} - 1 = 0.08$$

Step 1: Solve initial LR equilibrium ($t = t_0$)

(d) MS = MD $\rightarrow P$:

$$\frac{M_0^s}{P_0} = \frac{Y_0}{1 + R_0}$$

$$\Rightarrow P_0 = M_0^s \cdot \frac{1 + R_0}{Y_0}$$

$$= 1 \times 1.08 = 1.08$$

Solution for t_0: $P_0 = 1.08,\ R_0 = 0.08,\ E_0^e = 1,\ E_0 = 1$

Step 2: Solve LR equilibrium ($t = LR$)

(a) Flex P / PPP $\rightarrow E$: $E_{LR} = kM^s_{LR} = 1 \cdot 1.05 = 1.05$

(b) Defn LR / RE $\rightarrow E^e$: $E^e_{LR} = E_{LR} = 1.05$

(c) UIP $\rightarrow R$:

$$R_{LR} = R^*_{LR} + \frac{E^e_{LR}}{E_{LR}} - 1$$

$$= 0.08 + \frac{1.05}{1.05} - 1 = 0.08$$

Step 2: Solve LR equilibrium ($t = LR$)

(d) MS = MD $\rightarrow P$:

$$\frac{M^s_{LR}}{P_{LR}} = \frac{Y_{LR}}{1 + R_{LR}}$$

$$\Rightarrow P_{LR} = M^s_{LR} \cdot \frac{1 + R_{LR}}{Y_{LR}}$$

$$= 1.05 \times 1.08 = 1.134$$

Solution for LR: $P_{LR} = 1.134, \; R_{LR} = 0.08, \; E^e_{LR} = 1.05, \; E_{LR} = 1.05$

Step 3: Solve SR equilibrium ($t = SR$)

(a) P fixed $\rightarrow P$: $P_{SR} = P_0 = 1.08$

(b) MS = MD $\rightarrow R$: $\dfrac{M^s_{SR}}{P_{SR}} = \dfrac{Y_{SR}}{1 + R_{SR}}$

$$\Rightarrow \frac{1.05}{1.08} = \frac{1}{1 + R_{SR}}$$

$$\Rightarrow 1 + R_{SR} = \frac{1.08}{1.05}$$

$$\Rightarrow R_{SR} = \frac{1.08}{1.05} - 1 \approx 0.02857$$

Step 3: Solve SR equilibrium ($t = SR$)

(c) RE $\rightarrow E^e$: $E^e_{SR} = E_{LR} = 1.05$

(d) UIP $\rightarrow E$: $R_{SR} = R^*_{SR} + \dfrac{E^e_{SR}}{E_{SR}} - 1$

$$\Rightarrow\ 0.02857 = 0.08 + \frac{1.05}{E_{SR}} - 1$$

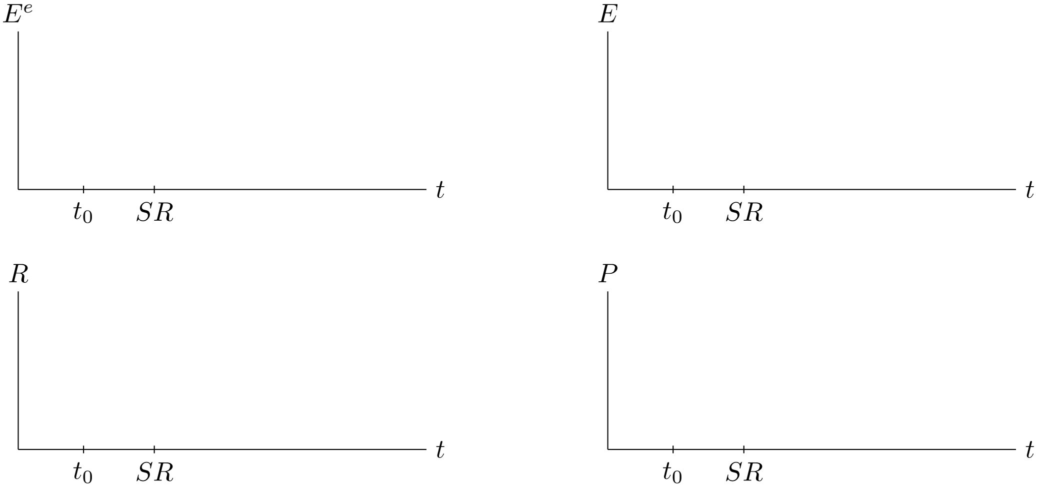
$$\Rightarrow\ E_{SR} = \frac{1.05}{0.02857 - 0.08 + 1} = \frac{1.05}{0.94857} \approx 1.1069$$

Solution for SR: $P_{SR} = 1.08,\ R_{SR} \approx 0.029,\ E^e_{SR} = 1.05,\ E_{SR} \approx 1.107$

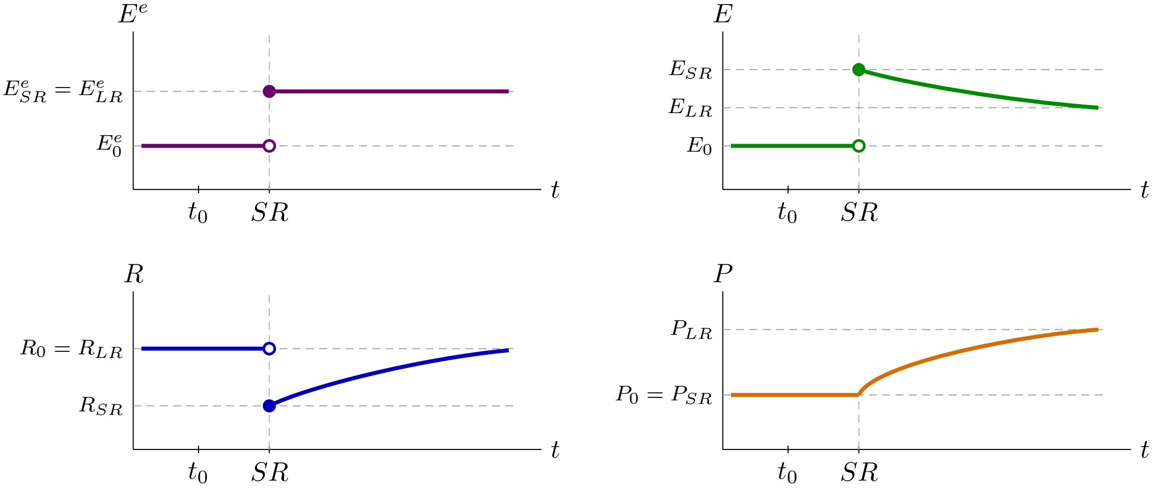
Example: solution summary

	t_0	SR	LR
P	1.08	1.08	1.134
R	0.08	0.029	0.08
E^e	1	1.05	1.05
E	1	1.107	1.05

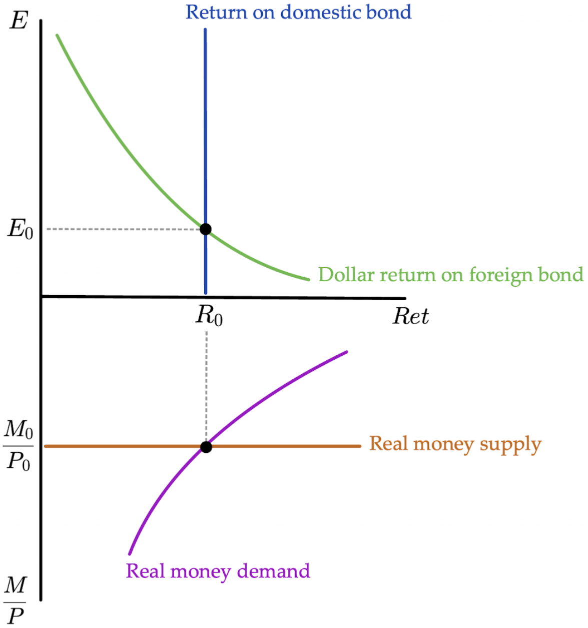
Paths of solution



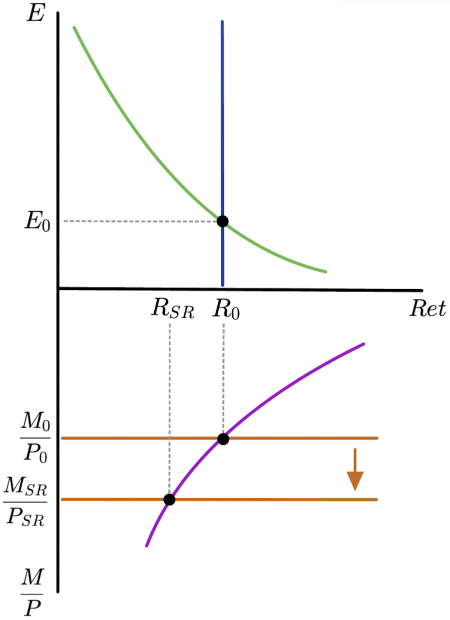
Paths of solution



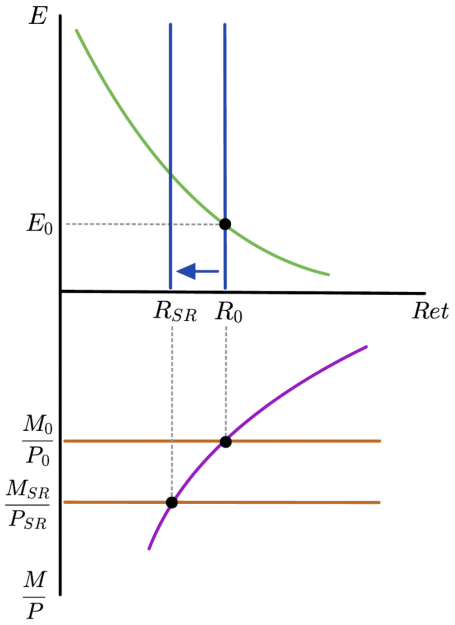
Solve with plots: Initial LR equilibrium



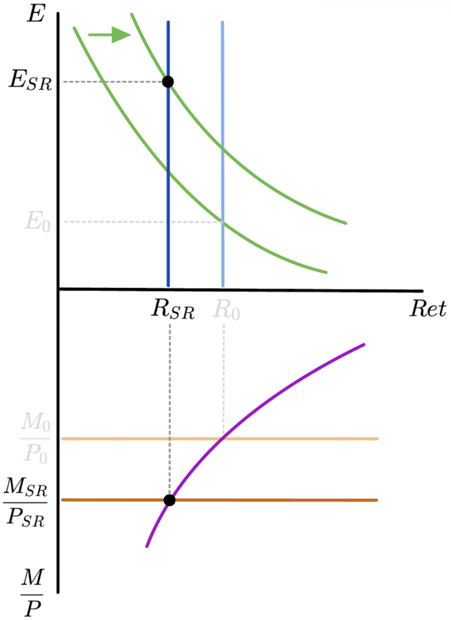
Higher M^s lowers R



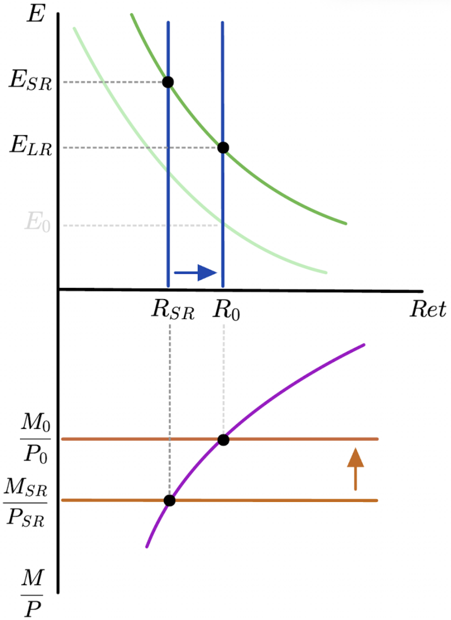
Lower R causes depreciation



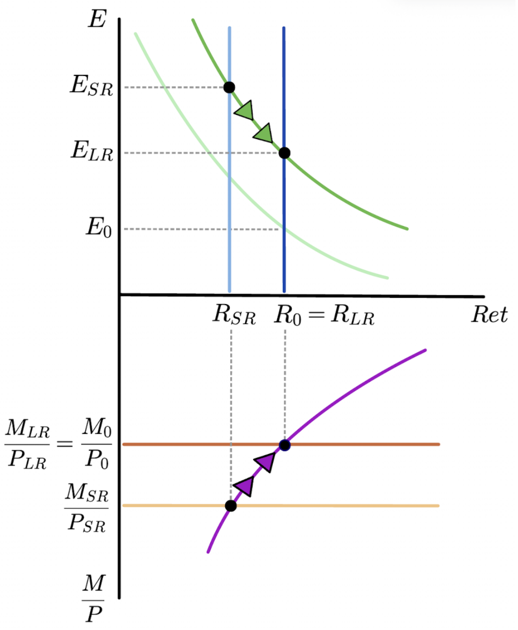
Higher E^e shifts dollar return on foreign bond



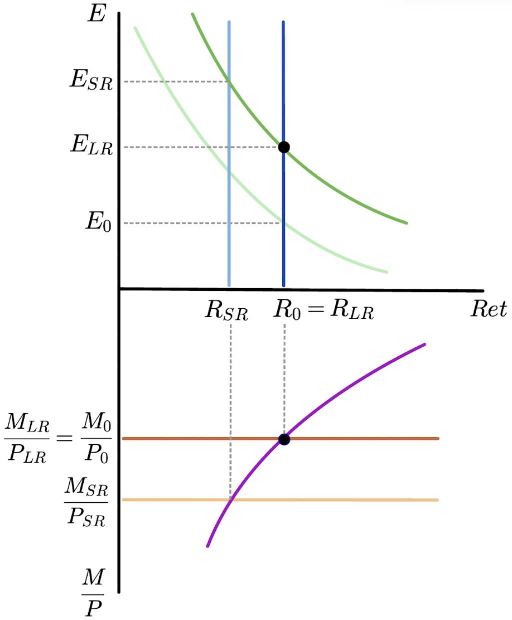
SR equilibrium



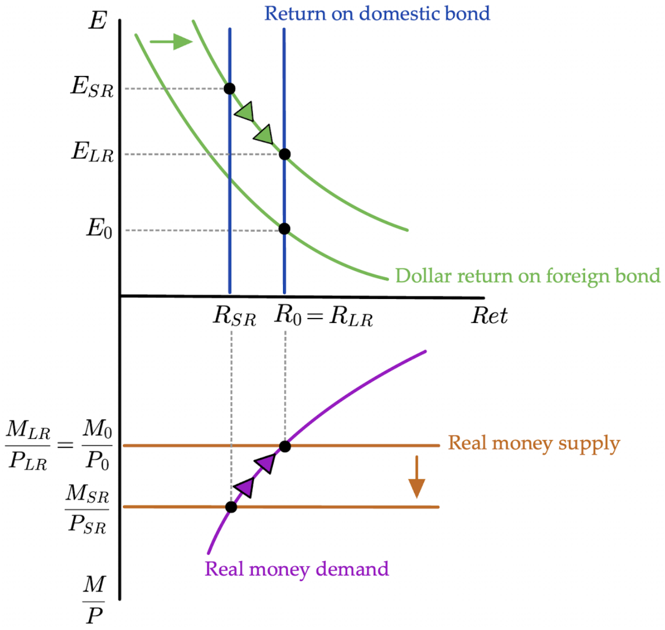
Transition between SR and LR



Final LR equilibrium



Solve with plots: All steps together



Equilibrium Determination Map

	Initial	SR	LR
E	flex P / PPP	FX mkt	flex P / PPP
E^e	defn LR	RE	defn LR
R	FX mkt	money mkt	FX mkt
P	money mkt	fixed P	money mkt

PPP = purchasing power parity $\Rightarrow E \propto P \propto M^s$

defn LR = definition of the long run $\Rightarrow E_0^e = E_0$ and $E_{LR}^e = E_{LR}$

RE = rational expectations $\Rightarrow \begin{cases} E_{SR}^e = E_{LR} \\ E_0^e = E_0 \text{ and } E_{LR}^e = E_{LR} \end{cases}$