Open economy IS-LM-BP-AS model
International shock transmission
Anticipation effects

Foundations of Modern Macroeconomics
Second Edition
Chapter 10: The open economy

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Outline

1. Open economy IS-LM-BP-AS model
   - IS-LM-BP model
   - AS for the open economy
   - AD-AS for the open economy

2. International shock transmission

3. Anticipation effects
Aims of this lecture

- Opening up the IS-LM model (sequel to Chapter 1 material): Mundell-Fleming.
- Fiscal and monetary policy in the open economy.
  - Degree of capital mobility.
  - Exchange rate system (fixed, flexible, managed).
- Two-country IS-LM-AS models.
  - Shock transmission.
  - International policy coordination.
- Open economy perfect foresight models (sequel to Chapter 4 material).
  - Role of price stickiness.
  - Degree of capital mobility.
  - Monetary accommodation.
National income and monetary accounting (1)

For the open economy we have from the national accounts:

\[ Y \equiv C + I + G + (EX - IM) \]  \hspace{1cm} (S1)

- \( Y \) is aggregate output.
- \( C \) is private consumption.
- \( I \) is investment.
- \( G \) is government consumption.
- \( EX \) is exports (demand by RoW for our products).
- \( IM \) is imports (demand by us for RoW's products).

We often write:

\[ Y \equiv A + (EX - IM) \]

- \( A \) is absorption; \( EX - IM \) is net exports.
National income and monetary accounting (2)

- Remember output measurement:
  - Gross Domestic Product (GDP): output produced within the country ("produced where?").
  - Gross National Product (GNP): output produced by the country’s residents domestic ("produced by whom?").
  - Difference: net factor payments from abroad.

- We can add transfers ($TR$) and deduct taxes ($T$) from (S1) to get:

$$Y + TR - T \equiv C + I + (G - T) + (EX + TR - IM) \quad (S2)$$

- (a) Disposable income of residents.
- (b) Current account $CA$ (of the BoP).
National income and monetary accounting (3)

- Private sector saving:
  \[ S \equiv Y + TR - T - C \] \hspace{1cm} (S3)

- Combining (S2) and (S3):
  \[ (S - I) + (T - G) \equiv (EX + TR - IM) \equiv CA \]

- Current account surplus is sum of saving surpluses of private and public sectors.
- \( CA \) measures additions to net external assets (\( CA > 0 \) means that domestic country is lending to RoW):
  \[ \Delta NFA \equiv CA \]
  \[ \equiv (S - I) + (T - G) \]
Now some monetary accounting: how does $\Delta NFA$ affect the monetary side of the economy?

- Look at $\Delta NFA^{cb}$ ($cb$ stands for Central Bank).
- Stylized balance sheet:

```
Balance Sheet of the Central Bank

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
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<tbody>
<tr>
<td>Net foreign assets</td>
<td>$NFA^{cb}$</td>
</tr>
<tr>
<td>Domestic credit</td>
<td>$DC$</td>
</tr>
<tr>
<td></td>
<td>High powered money</td>
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<tr>
<td></td>
<td>$H$</td>
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</tbody>
</table>
```
Continued.

- $NFA^{cb}$: foreign exchange reserves less liabilities to foreign official holders.
- $DC$: securities held by CB (e.g. government bonds), loans, other credit.
- $H$: stock of high-powered money (“base money”):

$$H \equiv CP + RE$$

where $CP$ is currency and $RE$ is commercial bank deposits held at CB.

- by definition we get in first differences:

$$\Delta NFA^{cb} \equiv \Delta H - \Delta DC \quad \text{(S4)}$$
Expression (S4) yields important insights:

- If CB intervenes in foreign exchange market then, barring changes in $DC$, this will affect (base) money supply: $\Delta NFA^{cb} \equiv \Delta H$.
- But CB can break link between $NFA^{cb}$ and $H$ temporarily by sterilization: manipulate $DC$ to keep base money supply unchanged ($\Delta NFA^{cb} \equiv -\Delta DC$ so that $\Delta H = 0$). **Example:** sale of forex by CB $\Rightarrow \Delta NFA^{cb} < 0$, expansionary open market operation (purchase of domestic bonds) $\Rightarrow \Delta DC > 0$.

- Final remark: in fractional reserve system we have that money supply is proportional to base money, i.e. $M^S = \mu H$ and thus $\Delta M^S = \mu \Delta H$. 


The IS curve for the open economy can be written as follows:

$$Y = A(r, Y) + G + X(Y, Q),$$

$$Q = \frac{EP^*}{P}$$

- $A(r, Y)$ is part of domestic absorption depending on $r$ and $Y$; partial derivatives $A_r < 0$ (investment) and $0 < A_Y < 1$ (MPC).
- $X(Y, Q)$ is net exports; partial derivatives $X_Y < 0$ (import demand) and $X_Q > 0$ (Marshall-Lerner condition).
- $Q$ is the relative price of foreign goods:
  - $E$ is nominal exchange rate (dimension Euro/US$).
  - $P$ is domestic price level (dimension Euros).
  - $P^*$ is foreign price level (dimension US$).
The LM curve for the open economy is represented by:

\[ \frac{M^D}{P} = L(r, Y) \]

\[ M^S = \mu \left[ NFA^{cb} + DC \right] \]

\[ M^D = M^S = M \]

“Supply side.” Horizontal aggregate supply curves:

\[ P = P^* = 1 \]
Capital mobility and economic policy (1)

- Alternative assumptions regarding “financial openness” of an economy:
  - Capital immobility: no trade in financial assets at all (1940s, early 1950s).
  - Perfect capital mobility: no barriers; equalization of yields (1980s onward).
  - Imperfect capital mobility: intermediate case

- Balance of payments:

\[ B \equiv X(Y, Q) + KI(r - r^*) \equiv \Delta NFA^{cb} \]

- \( B \) is balance of payments.
- \( X \) is trade account (ignoring international transfers, \( TR \)).
- \( KI \) is net capital inflow’. For \( KI > 0 \) domestic agents sell more assets to RoW than they are buying from us; net borrowing from RoW.
- \( r^* \) is interest rate in RoW.
Cases mentioned above:

Capital immobility:
- \( KI(r - r^*) \equiv 0 \) regardless of \( r \) and \( r^* \).
- BoP equilibrium (\( B = 0 \)) identical to trade balance equilibrium (\( X(Y, Q) = 0 \)).

Perfect capital mobility:
- Arbitrage ensures that \( r = r^* \) (represented by \( KI_r \rightarrow +\infty \)).

Imperfect capital mobility:
- Differences in \( r \) and \( r^* \) can persist (represented by \( 0 < KI_r \ll +\infty \)).

Note: In latter two cases, BoP equilibrium is such that \( X(Y, Q) = -KI(r - r^*) \).

Three cases are drawn in Figure 10.1.
Figure 10.1: The degree of capital mobility and the balance of payments

(i) $B = X(Y, Q) = 0$

(ii) $B = 0, K_r \to \infty$

(iii) $B = 0, 0 < K_r < \infty$
Assumptions:

- Capital immobile: \( KI(r - r^*) = 0 \).
- Monetary authority maintains exchange rate at \( E_0 \).

Case is drawn in Figure 10.2.

- IS downward sloping, LM upward sloping, \( X(Y, E_0) = 0 \) line vertical.
- To right (left) of \( X(Y, E_0) = 0 \) imports too high (low) and \( B = X < 0 (> 0) \).
- Initial equilibrium at point e_0.
Figure 10.2: Monetary and fiscal policy with immobile capital and fixed exchange rates
Monetary policy:
- Open market operation: purchase of bonds by CB, $\Delta DC > 0$.
- Money supply goes up (from $M_0$ to $M_1$).
- LM to the right; economy to point $e'$.
- At $e'$ there is excess demand for forex.
- To keep exchange rate constant, CB must intervene (sell forex).
- Money supply *gradually* falls; LM shifts to left.
- Economy back to $e_0$.
- Conclusion: no long-run effect on $r$ and $Y$. 
Fiscal policy:

- Bond financed increase in government consumption.
- IS to the right; economy to point $e''$.
- At $e''$ there is excess demand for forex.
- To keep exchange rate constant, CB must intervene (sell forex).
- Money supply gradually falls; LM shifts to left.
- Economy moves to $e_1$.
- Conclusion: no long-run effect on $Y$ but $r$ higher.
- Crowding out of investment.
Perfectly mobile capital and fixed exchange rates (1)

- Assumptions:
  - Capital perfectly mobile: \( r = r^* \).
  - Monetary authority maintains exchange rate at \( E_0 \).
  - BP curve is horizontal in Figure 10.3.
  - Economy initially at \( e_0 \).

- Monetary policy:
  - OMO increases \( DC \) and money supply; LM to right.
  - At \( e' \) excess demand for forex (investors want to buy foreign assets).
  - CB intervenes and loses its foreign reserves; LM back.
  - Adjustment is *instantaneous*, so monetary policy ineffective even in short run.
Fiscal policy:
- Bond financed increase in government consumption.
- IS to the right; economy to point $e''$.
- At $e''$ there is excess supply of forex (investors dump foreign assets).
- To keep exchange rate constant, CB must intervene (buy forex).
- Money supply increases; LM to the right, economy moves to $e_1$.
- Adjustment is *instantaneous*: no effect on $r$ but $Y$ higher.
- Fiscal policy highly effective.
Figure 10.3: Monetary and fiscal policy with perfect capital mobility and fixed exchange rates
The flexible exchange rate ensures BoP equilibrium:

\[ B \equiv \Delta NFA^{cb} = 0 \iff X(Y, E) + KI(r - r^*) = 0 \]

- Imports: cause demand for forex.
- Exports: cause supply of forex.
- Capital imports: cause supply of forex.
- Recall: no exchange rate intervention by CB, so stock of forex in hands of CB constant. Change in DC affects money supply. Money supply can be controlled.

Focus on case with perfect capital mobility (PCM).
Perfect capital mobility and flexible exchange rates (2)

- PCM implies $r = r^*$ so model simplifies to:

\[
Y = A(r^*, Y) + G + X(Y, E) \quad \text{(YY)}
\]
\[
M = L(r^*, Y) \quad \text{(LL)}
\]

- Monetary policy:
  - See Figure 10.4.
  - OMO increases DC and money supply; LM to right.
  - At point $e'$ there is excess demand for forex.
  - Domestic currency depreciates; IS to right.
  - Hence: *instantaneous* adjustment from $e_0$ to $e_1$.
  - Monetary policy highly effective!
Figure 10.4: Monetary policy with perfect capital mobility and flexible exchange rates
Fiscal policy:

- See Figure 10.5.
- Bond financed increase in government consumption; IS to right.
- At point $e'$ there is excess supply of forex.
- Domestic currency appreciates; IS to left.
- Hence: in panel (a) the economy stays at $e_0$; in panel (b) it moves from $e_0$ to $e_1$.
- Fiscal policy completely ineffective at influencing output!
Figure 10.5: Fiscal policy with perfect capital mobility and flexible exchange rates
Insulation property:
- Flexible exchange rates insulate small open economy from foreign shocks (provided $r^*$ is unaffected).
- Example: RoW spending boom. Our exports rise, YY curve to the right, exchange rate appreciates, no effect on output. Shock not transmitted to quantities.

For global shocks no insulation property:
- Example: boost in RoW driving up world interest rate, $r^*$
- See Figure 10.6.
- LL to right; YY up; domestic currency depreciates; output increases.
Figure 10.6: Foreign interest rate shocks with perfect capital mobility and flexible exchange rates
Summary open economy IS-LM-BP model

- Exchange rate regime matters a lot.
  - Completely fixed exchange rates.
  - Completely flexible exchange rates.
  - Intermediate case: managed float (see below).

- Mobility of financial capital matters a lot.
  - No mobility.
  - Perfect mobility.
  - Intermediate case: imperfect capital mobility (see Figure 10.7 and Table 10.1).
Figure 10.7: Monetary policy with imperfect capital mobility and flexible exchange rates
### Table 10.1: Imperfect capital mobility under fixed and flexible exchange rates

<table>
<thead>
<tr>
<th>Flexible exchange rates</th>
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</table>
| $dY$                    | $dM$                    | $dr^*
### Table 10.1: Imperfect capital mobility under fixed and flexible exchange rates (continued)

<table>
<thead>
<tr>
<th></th>
<th>$dG$</th>
<th>$dE$</th>
<th>$dr^*$</th>
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<tbody>
<tr>
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<td>} &gt; 0$</td>
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<tr>
<td>$dr$</td>
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<td>\Gamma</td>
<td>} \geq 0$</td>
</tr>
<tr>
<td>$dM$</td>
<td>$\frac{L_Y - L_T X_Y / K_I r}{</td>
<td>\Gamma</td>
<td>} \geq 0$</td>
</tr>
</tbody>
</table>
Assumed so far: horizontal AS curves in the domestic economy and in the RoW: $P = P^* = 1$ (constant).

Adding the supply side important because:

- “Microeconomic” foundation behind demand/supply curves.
- Consistent treatment of cost-of-living indexes.
- Used later to study international shock transmission.
Macroeconomic relations:

\[ C = C(Y) \]
\[ I = I(r) \]

- MPC between 0 and 1 (\( 0 < C_Y < 1 \)).
- Investment depends negatively on cost of capital (interest rate) (\( I_r < 0 \)).
- Note: Part of \( C \) and \( I \) produced domestically, part imported.

Armington approach to model components. Example: consumption.
- \( C \) “constructed” out of \( C_d \) (domestic) and \( C_f \) (foreign) according to:

\[ C = C_d^\alpha C_f^{1-\alpha}, \quad 0 < \alpha < 1 \]

- Household faces prices \( P \) (domestic) and \( EP^* \) (foreign).
Continued.

Choose \( C_d \) and \( C_f \) to minimize expenditure for given \( C \).

Solutions:

\[
C_d = \alpha \Omega_0 \left( \frac{EP^*}{P} \right)^{1-\alpha} C(Y)
\]

\[
C_f = (1 - \alpha) \Omega_0 \left( \frac{EP^*}{P} \right)^{-\alpha} C(Y)
\]

\[
P_C \equiv \Omega_0 P^\alpha (EP^*)^{1-\alpha}
\]

where \( \Omega_0 \equiv [\alpha^\alpha (1 - \alpha)^{1-\alpha}]^{-1} > 0 \).

Interpretation:

- Ceteris paribus \( C(Y) \), an increase in the relative price of foreign goods leads to an increase in \( C_d \) and a decrease in \( C_f \) (substitute to domestic goods).
- \( P_C \) is the cost-of-living index, i.e. the unit cost of composite consumption.
Armington approach (3)

- We can use the same trick for investment and for government consumption:
  
  Assume same $\alpha$ (as for $C$) for simplicity:
  
  $$I = I_d I_f^{1-\alpha}$$
  $$G = G_d G_f^{1-\alpha}$$

- Solutions:
  
  $$I_d = \alpha \Omega_0 \left( \frac{EP^*}{P} \right)^{1-\alpha} I(r)$$
  $$I_f = (1 - \alpha) \Omega_0 \left( \frac{EP^*}{P} \right)^{-\alpha} I(r)$$
  $$G_d = \alpha \Omega_0 \left( \frac{EP^*}{P} \right)^{1-\alpha} G$$
  $$G_f = (1 - \alpha) \Omega_0 \left( \frac{EP^*}{P} \right)^{-\alpha} G$$
Armington approach (4)

Assume that export demand also depends on relative price (modelled later):

$$EX = EX_0 \left( \frac{EP^*}{P} \right)^\beta, \quad \beta \geq 0$$

- $EX_0$ is exogenous component of export demand (e.g. income in RoW, etcetera).
- The higher is $EP^*/P$ the cheaper are domestic goods for customers in RoW and the higher are exports.
Re-do national income accounting:

\[ PY \equiv P_C C + P_C I + P_C G + PEX - EP^* [C_f + I_f + G_f] \]

\[ = P_C d + P I_d + P G_d + PEX \quad \Rightarrow \]

\[ Y \equiv C_d + I_d + G_d + EX \]  

\( (S5) \)

Used in second line:

\[ P_C C = P_C d + EP^* C_f \]

\[ P_C I = P I_d + EP^* I_f \]

\[ P_C G = P G_d + EP^* G_f \]

\( \rightarrow \) (S5) shows quite clearly that only domestic goods enter GDP.
The Armington approach is very popular in applied modelling. Here are some exercises.

- Show the derivations leading to the expressions for $C_d, C_f,$ and $P_C$.
- Assume composite consumption is a CES aggregate of $C_d$ and $C_f$. Rederive the expressions for $C_d, C_f, and P_C$ and interpret (difficult).
**** Self Test ****

Define net exports in real terms as:

\[ X \equiv EX - \left( \frac{EP^*}{P} \right) [C_f + I_f + G_f] \]

Derive the Marshall-Lerner condition and show how \( \alpha \) and \( \beta \) affect it.
Extended Mundell-Fleming model (1)

- Perfect capital mobility.
- Flexible exchange rates.
- Fixed capital stock $\bar{K}$ (short-run model).
- Demand side goods market:

$$Y = \alpha \Omega_0 Q^{1-\alpha} [A(r, Y) + G] + EX_0 Q^\beta$$

- $Q \equiv EP^*/P$ is the relative price of foreign goods. (Note that $Q \downarrow$ is real appreciation of domestic currency!)
- $A(r, Y) \equiv C(Y) + I(r)$. 

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Extended Mundell-Fleming model (2)

- Supply side goods market:

\[
W = PF_N (N, \bar{K}) \quad \text{(S6)}
\]
\[
W = W_0 P_C^\lambda, \quad 0 \leq \lambda \leq 1 \quad \text{(S7)}
\]
\[
Y = F (N, \bar{K}) \quad \text{(S8)}
\]

(S6) is short-run labour demand, wage equals value of MP of labour.
(S7) is a wage-setting rule (\(W_0\) is exogenous). Special cases:
- \(\lambda = 1\) real wage target: hold \(W/P_C\) constant.
- \(\lambda = 0\) nominal wage target: hold \(W\) constant.
- \(0 < \lambda < 1\) incomplete wage indexing: changes in cost of living not fully incorporated in wage claims.
Extended Mundell-Fleming model (3)

- Money market equilibrium:
  \[ \frac{M}{P} = L(r, Y) \]

- Perfect capital mobility:
  \[ r = r^* \]

- The model can be analyzed.
  - Mathematically by loglinearizing it—see Table 10.2 for the key expressions.
  - ...Graphically by means of Figure 10.8.
Table 10.2: The extended Mundell-Fleming model

\[ \tilde{Y} = \frac{(1 - \omega_X) \left[ -\omega_I \epsilon_I R \epsilon^* + (1 - \omega_C - \omega_I) \tilde{G} \right] + \omega_X \tilde{E} X_0}{1 - (1 - \omega_X) \omega_C \epsilon_C Y} \]  

\[ \tilde{M} - \tilde{P} = -\epsilon_{MR} \epsilon^* + \epsilon_{MY} \tilde{Y} \]  

\[ \tilde{Y} = -\epsilon_{YW} \left[ \tilde{W}_0 + \lambda (1 - \alpha) \tilde{Q} - (1 - \lambda) \tilde{P} \right] \]
On the AS curve (1)

- See Figure 10.8.
- Labour demand downward sloping:
  \[ \tilde{N} = -\varepsilon_{NW} \cdot [\tilde{W} - \tilde{P}] \]
- Labour supply horizontal:
  \[ \tilde{W} = \tilde{W}_0 + \lambda \tilde{P}_C \]
  \[ = \tilde{W}_0 + \lambda \cdot \left[ \tilde{P} + (1 - \alpha) \tilde{Q} \right] \]
  \[ \tilde{W} - \tilde{P} = \tilde{W}_0 - (1 - \lambda) \cdot \tilde{P} + \lambda (1 - \alpha) \cdot \tilde{Q} \]
- Initial equilibrium at e₀
On the AS curve (2)

- Nominal wage rigidity case: $\lambda = 0$
  - no effect of real exchange rate
  - an increase (decrease) in $P$ results in downward (upward) shift of labour supply and moves equilibrium to $e_1$ (to $e_2$), so that employment and output increase (decrease)

- Real wage rigidity case: $\lambda = 1$
  - no effect of price level
  - an decrease (increase) in $Q$ results in downward (upward) shift of labour supply and moves equilibrium to $e_1$ (to $e_2$), so that employment and output increase (decrease)

- Money illusion: $0 < \lambda < 1$
  - AS depends positively on $P$
  - AS depends negatively on $Q$
Figure 10.8: Aggregate supply curve for the open economy
Comparative static effects

- Interpretation of Table 10.2 & Figure 10.9:
  - \( \tilde{Y} \equiv dY/Y, \ \tilde{P} \equiv dP/P, \ \tilde{Q} \equiv dQ/Q \) etcetera.
  - Endogenous: \( Y, P, \) and \( Q. \)
  - Exogenous: \( r^*, G, EX_0, W_0. \)
  - Eqn. (T2.1) is the IS curve for the open economy: negative effect on \( Y \) of \( r^*; \) positive effects of \( G, EX_0, \) and \( Q. \)
  - Equation (T2.2) is the LM curve with PCM substituted.
  - Equation (T2.3) is the AS curve: negative effects on \( Y \) of \( W_0 \) and \( Q \) (if \( \lambda > 0 \)); positive effect of \( P \) (if \( 0 < \lambda < 1 \)). Why?
Figure 10.9: Aggregate demand shocks under wage rigidity

The figure illustrates the IS-LM-BP-AS model for an open economy, focusing on the effects of aggregate demand shocks under wage rigidity. The graph shows the interaction of the IS, LM, and AS curves under different conditions:

- **IS Curve**: Represented as IS($G_0$) and IS($G_1$)
- **LM Curve**: Represents the market for money
- **AS Curve**: Represented as AS(LM) with two conditions: ($\lambda = 0$) and ($\lambda > 0$)

The figure highlights the shifts in Y and P under different shocks, with points $e_0$, $e_1$, and $e_2$ indicating equilibrium points before and after the shocks.
In Figure 10.9, AS(LM) is the combination of the LM curve and the AS curve:

\[
\tilde{Y} = \frac{-\varepsilon_{YW} \left[ \tilde{W}_0 + \lambda(1-\alpha)\tilde{Q} - (1-\lambda) \left( \tilde{M} + \varepsilon_{MR}dr^* \right) \right]}{1 + (1-\lambda)\varepsilon_{MY}\varepsilon_{YW}}
\]

- Horizontal in \((Y, Q)\)-space if \(\lambda = 0\) (NWR).
- Downward sloping in \((Y, Q)\)-space if \(\lambda > 0\) (IWI or even RWR).
- Independent of \(M\) and \(r^*\) if \(\lambda = 1\) (RWR).
Fiscal policy (2)

- Increase in government consumption.
  - In standard MF model: no effect on $N$ and $Y$ (insulation property of flexible exchange rates).
  - In extended MF model: IS shifts up, from IS($G_0$) to IS($G_1$).
    - If $\lambda = 0$, $Q$ appreciates (from $Q_0$ to $Q_2$) and $P$ stays the same. No effect on $N$, $P$, and $Y$ (insulation again).
    - If $\lambda > 0$, $Q$ appreciates (from $Q_0$ to $Q_1$), $P$ falls (from $P_0$ to $P_1$), $W/P$ falls, $N$ and $Y$ increase.

- Conclusion: depending on wage-setting regime, the supply side can matter a lot! See Table 10.3 for monetary and wage-setting shocks.
### Table 10.3: Wage rigidity and demand and supply shocks

<table>
<thead>
<tr>
<th>( \omega_G (1 - \omega_X) \tilde{G} )</th>
<th>( \omega_X \tilde{E} X_0 )</th>
<th>( \varepsilon_{YW} \tilde{W}_0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \dot{Y} )</td>
<td>( \frac{\lambda(1-\alpha)\varepsilon_{YW}}{</td>
<td>\Delta</td>
</tr>
<tr>
<td>( \dot{Q} )</td>
<td>( -\frac{1+(1-\lambda)\varepsilon_{MY} \varepsilon_{YW}}{</td>
<td>\Delta</td>
</tr>
<tr>
<td>( \dot{P} )</td>
<td>( -\frac{\lambda(1-\alpha)\varepsilon_{MY} \varepsilon_{YW}}{</td>
<td>\Delta</td>
</tr>
<tr>
<td>( \dot{E} )</td>
<td>( -\frac{1+(1-\alpha\lambda)\varepsilon_{MY} \varepsilon_{YW}}{</td>
<td>\Delta</td>
</tr>
<tr>
<td>( \tilde{P}_C )</td>
<td>( -\frac{(1-\alpha)(1+\varepsilon_{MY} \varepsilon_{YW})}{</td>
<td>\Delta</td>
</tr>
</tbody>
</table>
Shock transmission in a two-country world (1)

Assumptions:
- The world consists of two identical countries (symmetric case).
- Perfect capital mobility.
- World interest rate endogenous.

Model modification: one country’s exports are the other country’s imports.

Imports by domestic economy (country 1):

\[ EX^* \equiv C_f + I_f + G_f = (1 - \alpha) \Omega_0 \left( \frac{EP^*}{P} \right)^{-\alpha} [A(r, Y) + G] \]

Imports by foreign economy (country 2) by symmetry:

\[ EX \equiv C_f^* + I_f^* + G_f^* = (1 - \alpha) \Omega_0 \left( \frac{EP^*}{P} \right)^{\alpha} [A(r^*, Y^*) + G^*] \]

where stars refer to foreign variables.
Shock transmission in a two-country world (2)

- Look at IS and IS* curves:

\[ Y = \alpha \Omega_0 Q^{1-\alpha} [A(r, Y) + G] + (1 - \alpha) \Omega_0 \left( \frac{E P^*}{P} \right)^\alpha [A(r^*, Y^*) + G^*] \]  

(S9)

\[ Y^* = \alpha \Omega_0 Q^{-(1-\alpha)} [A(r^*, Y^*) + G^*] + (1 - \alpha) \Omega_0 \left( \frac{E P^*}{P} \right)^{-\alpha} [A(r, Y) + G] \]  

(S10)

- Both own and foreign spending enters both IS curves.
- Note sign of real exchange rate effects.
- Since PCM implies \( r = r^* \), (S9) and (S10) can be combined into quasi-reduced form expressions (details in text):
Continued.

\[ Y = \Psi[r^*, G, G^*, Q] \]

\[ Y^* = \Phi[r^*, G, G^*, Q] \]

- Own fiscal policy effect greater than spillover effect (assumed).
- Interest rate effect same in both countries (via investment).
- Real exchange rate effect different sign (for obvious reasons).

From here on we work with logarithmic version of the two-country model. See Table 10.4.
Table 10.4: A two-country extended Mundell-Fleming model

\[
y = -\varepsilon_{YY}r^* + \varepsilon_{YQ}q + \varepsilon_{YG} \left[ g + \eta g^* \right] \quad (T3.1)
\]

\[
y^* = -\varepsilon_{YY}r^* - \varepsilon_{YQ}q + \varepsilon_{YG} \left[ g^* + \eta g \right] \quad (T3.2)
\]

\[
m - p = \varepsilon_{MY}y - \varepsilon_{Mr}r^* \quad (T3.3)
\]

\[
m^* - p^* = \varepsilon_{MY}y^* - \varepsilon_{Mr}r^* \quad (T3.4)
\]

\[
y = -\varepsilon_{YW} \left[ w - p \right] \quad (T3.5)
\]

\[
y^* = -\varepsilon_{YW} \left[ w^* - p^* \right] \quad (T3.6)
\]

\[
w = w_0 + \lambda p_C \quad (T3.7)
\]

\[
w^* = w_0^* + \lambda^* p_C^* \quad (T3.8)
\]

\[
p_C = \omega_0 + p + (1 - \alpha)q \quad (T3.9)
\]

\[
p_C^* = \omega_0 + p^* - (1 - \alpha)q \quad (T3.10)
\]
To build intuition we first look at some symmetric cases:
- Nominal wage rigidity (NWR) in both countries.
- Real wage rigidity (RWR) in both countries.

Next, we look at asymmetric case:
- NWR in foreign country (say the United States).
- RWR in domestic country (say Europe).
Nominal wage rigidity and economic policy (1)

- Assumptions: $\lambda = \lambda^* = 0$ in Table 10.4.

- Model can be summarized graphically Figure 10.11.

- $AS_N$ and $AS^*_N$ curves are:

  $y = -\varepsilon_{YW} [w_0 - p] \quad (AS_N)$

  $y^* = -\varepsilon_{YW} [w^*_0 - p^*] \quad (AS^*_N)$

- Combining with relevant LM curves gives:

  $y = \frac{\varepsilon_{YW} [m + \varepsilon_{MRR} r^* - w_0]}{1 + \varepsilon_{YW} \varepsilon_{MY}} \quad (LM(AS_N))$

  $y^* = \frac{\varepsilon_{YW} [m^* + \varepsilon_{MRR} r^* - w^*_0]}{1 + \varepsilon_{YW} \varepsilon_{MY}} \quad (LM^*(AS^*_N))$
Nominal wage rigidity and economic policy (2)

Continued.

and:

\[ p = \frac{m + \varepsilon_M r^* + \varepsilon_Y W \varepsilon_M Y w_0}{1 + \varepsilon_Y W \varepsilon_M Y} \]

\[ p^* = \frac{m^* + \varepsilon_M r^* + \varepsilon_Y W \varepsilon_M W w_0^*}{1 + \varepsilon_Y W \varepsilon_M Y} \]

In view of symmetry assumptions \((m = m^* \text{and } w_0 = w_0^*)\), \(LM^*(AS^*_N)\) and \(LM(AS_N)\) coincide in Figure 10.11.
Nominal wage rigidity and economic policy (3)

Continued.

Combining LM\((AS_N)\) with IS and LM\(^*\)(AS\(^*_N\)) with IS\(^*\) yields:

\[
\begin{align*}
\rho^* &= \frac{(1 + \varepsilon YW\varepsilon_{MY}) [\varepsilon YQq + \varepsilon YG(g + \eta g^*)]}{\varepsilon YR(1 + \varepsilon YW\varepsilon_{MY}) + \varepsilon YW\varepsilon_{MR}} \\
&+ \frac{\varepsilon YW [w_0 - m]}{\varepsilon YR(1 + \varepsilon YW\varepsilon_{MY}) + \varepsilon YW\varepsilon_{MR}} \\
\rho^* &= \frac{(1 + \varepsilon YW\varepsilon_{MY}) [-\varepsilon YQq + \varepsilon YG(g^* + \eta g)]}{\varepsilon YR(1 + \varepsilon YW\varepsilon_{MY}) + \varepsilon YW\varepsilon_{MR}} \\
&+ \frac{\varepsilon YW [w_0^* - m^*]}{\varepsilon YR(1 + \varepsilon YW\varepsilon_{MY}) + \varepsilon YW\varepsilon_{MR}}
\end{align*}
\]

In Figure 10.11 these curves are drawn (notice slopes).
Nominal wage rigidity and economic policy (4)

- Fiscal policy in domestic economy ($g$ up).
  - $\text{GME}_N$ and $\text{GME}^*_N$ shift up (former by more if $\eta < 1$ “dominant own effect”).
  - Equilibrium from $e_0$ to $e_1$.
  - Real exchange rate domestic economy appreciates.
  - Output in both countries rises! **Locomotive policy**: one country drags itself and the other country out of a recession (real wages fall).

- Fiscal policy in foreign economy ($g^*$ up): exercise.
  - $r^*$ up; $y$ and $y^*$ up by same amount.
  - Used below: $\zeta = \zeta^* = 1$. 
Figure 10.11: Fiscal policy with nominal wage rigidity in both countries
Monetary policy in domestic economy \((m \text{ up})\).
- See **Figure 10.12**.
- \(GME_N\) goes down.
- \(LM(AS_N)\) to the left.
- Equilibrium from \(e_0\) to \(e_1\) in right-hand panel.
- In left-hand panel, domestic economy from \(e_0\) to \(e_1\); foreign economy from \(e_0\) to \(e_1^*\).
- Domestic economy gains at expense of foreign country: **beggar-thy-neighbour policy**.

Monetary policy in foreign economy \((m^* \text{ up})\): exercise.
Figure 10.12: Monetary policy with nominal wage rigidity in both countries
Real wage rigidity and economic policy (1)

- Assumptions: $\lambda = \lambda^* = 1$ in Table 10.4.
- Model can be summarized graphically Figure 10.13.
  - $AS_R$ and $AS_R^*$ curves are:
    \[
    y = -\varepsilon_Y W \left[ \omega_0 + w_0 + (1 - \alpha)q \right] \quad (AS_R)
    \]
    \[
    y^* = -\varepsilon_Y W \left[ \omega_0 + w_0^* - (1 - \alpha)q \right] \quad (AS_R^*)
    \]
  - Combining with relevant IS curves gives:
    \[
    r^* = \frac{\varepsilon_Y W \left[ \omega_0 + w_0 \right] + (\varepsilon_Y Q + \varepsilon_Y W)q + \varepsilon_Y G \left[ g + \eta g^* \right]}{\varepsilon_Y R} \quad (GME_R)
    \]
    \[
    r^* = \frac{\varepsilon_Y W \left[ \omega_0 + w_0^* \right] - (\varepsilon_Y Q + \varepsilon_Y W)q + \varepsilon_Y G \left[ g^* + \eta g \right]}{\varepsilon_Y R} \quad (GME_R^*)
    \]
Real wage rigidity and economic policy (2)

- Fiscal policy in domestic economy ($g$ up).
  - $\text{GME}_R$ and $\text{GME}_R^*$ shift up (former by more if $\eta < 1$ “dominant own effect”).
  - Equilibrium from $e_0$ to $e_1$.
  - Real exchange rate domestic economy appreciates; interest rate rises.
  - Output rises in domestic economy but falls in foreign economy! **Beggar-thy-neighbour policy**: the domestic expansion hurts the other country (producer real wage falls domestically but rises abroad).
- Fiscal policy in foreign economy ($g^*$ up): exercise.
  - $y^*$ up, $y$ down.
  - Used below: $\zeta = \zeta^* = -1$.
- Monetary policy has no real effects: exercise.
Figure 10.13: Fiscal policy with real wage rigidity in both countries
Mixed case studied by Branson & Rotemberg (1980):

- **RWR in domestic economy, say Europe ($\lambda = 1$):**

  \begin{align*}
  y &= -\varepsilon_{YW} \left[ \omega_0 + w_0 + (1 - \alpha)q \right] \\
  r^* &= \frac{\varepsilon_{YW} [\omega_0 + w_0] + (\varepsilon_{YQ} + \varepsilon_{YW})q + \varepsilon_{YG} [g + \eta g^*]}{\varepsilon_{YR}}
  \end{align*}

  \hspace{1cm} \text{(AS}_R\text{)} \quad \text{(GME}_R\text{)}

- **NWR in foreign economy, say the United States ($\lambda^* = 0$):**

  \begin{align*}
  y^* &= \frac{\varepsilon_{YW} [m^* + \varepsilon_{MR} r^* - w_0^*]}{1 + \varepsilon_{YW} \varepsilon_{MY}} \\
  r^* &= \frac{(1 + \varepsilon_{YW} \varepsilon_{MY}) [-\varepsilon_{YQ}q + \varepsilon_{YG} (g^* + \eta g)]}{\varepsilon_{YR}(1 + \varepsilon_{YW} \varepsilon_{MY}) + \varepsilon_{YW} \varepsilon_{MR}} \\
  &\quad + \frac{\varepsilon_{YW} [w_0^* - m^*]}{\varepsilon_{YR}(1 + \varepsilon_{YW} \varepsilon_{MY}) + \varepsilon_{YW} \varepsilon_{MR}}
  \end{align*}

  \hspace{1cm} \text{(LM}^*(\text{AS}_N^*)) \quad \text{(GME}_N^*\text{)}
Fiscal policy in domestic economy ($g$ up): see Figure 10.14.

- $GME_R$ and $GME^*_N$ shift up (former by more if $\eta < 1$ “dominant own effect”).
- Equilibrium from $e_0$ to $e_1$.
- Real exchange rate domestic economy appreciates; interest rate rises.
- Output rises in both economies. **Locomotive policy:** the domestic expansion benefits the other country (producer real wage falls domestically but rises abroad).
- Used below: $0 < \zeta^* < 1$. 
Figure 10.14: European fiscal policy with real wage rigidity in Europe and nominal wage rigidity in the United States
Fiscal policy in foreign economy ($g^*$ up): see Figure 10.15.

- $GME_R$ and $GME^*_N$ shift up (latter by more if $\eta < 1$ “dominant own effect”).
- Equilibrium from $e_0$ to $e_2$.
- Real exchange rate domestic economy depreciates; interest rate rises.
- Output falls in domestic economy but rises in the foreign economy! **Beggar-thy-neighbour policy**: the foreign expansion hurts the domestic economy (real wage rises domestically but falls abroad).
- Used below: $\zeta < 0$. 
Figure 10.15: US fiscal policy with real wage rigidity in Europe and nominal wage rigidity in the United States
RWR-NWR* and economic policy (4)

- Monetary policy in domestic economy ($m$ up) has no real effects.
- Monetary policy in foreign economy ($m^*$ up): see Figure 10.14.
  - $\text{GME}^*_N$ down and $\text{LM}^*(\text{AS}^*_N)$ to the left.
  - Equilibrium from $e_0$ to $e_1$.
  - Real exchange rate domestic economy appreciates; interest rate falls.
  - Output rises in both economies (largest increase in domestic economy)! **Locomotive policy**: the foreign monetary expansion benefits the other country (producer real wage falls in both countries).
Figure 10.16: US monetary policy with real wage rigidity in Europe and nominal wage rigidity in the United States
International policy coordination (1)

- Policy question: is international coordination of policy welfare enhancing or not?
  - International spillovers.
  - Quantitative theory of economic policy (cf. Chapter 9).

- Summarize the insights from symmetric two-country model as follows:

\[
\begin{align*}
  y &= g + \zeta g^* \\
  y^* &= g^* + \zeta^* g
\end{align*}
\]

(S11)  
(S12)

- \(g\) and \(g^*\) are indexes of fiscal policy.
- NWR in both countries: \(\zeta = \zeta^* = 1\).
- RWR in both countries: \(\zeta = \zeta^* = -1\).
- RWR in home country, NWR in foreign country: \(\zeta < 0\) and \(0 < \zeta^* < 1\).
International policy coordination (2)

- Objective function domestic policy maker:

\[ L_G = \frac{1}{2} (y - \bar{y})^2 + \frac{\theta}{2} g^2 \]  

(S13)

- \( L_G \) is the loss function (to be minimized s.t. trade-off (S11)).
- \( \bar{y} \) is the target output level.
- Small government sector desired.

- Objective function foreign policy maker:

\[ L_G^* = \frac{1}{2} (y^* - \bar{y})^2 + \frac{\theta}{2} (g^*)^2 \]  

(S14)

- \( L_G^* \) is the loss function (to be minimized s.t. trade-off (S12)).
- \( \bar{y} \) is the target output level (same as home country).
- Small government sector desired.
Policy makers choose own fiscal policy, ignoring international spill-overs.

Domestic policy maker chooses $g$ to minimize $L_G$ subject to (S11). FONC:

$$\frac{\partial L_G}{\partial g} = (g + \zeta g^* - \bar{y}) + \theta g = 0 \quad \Rightarrow$$

$$g = \frac{\bar{y} - \zeta g^*}{1 + \theta}$$

(RR)

Foreign policy maker chooses $g^*$ to minimize $L_G^*$ subject to (S12). FONC:

$$\frac{\partial L_G^*}{\partial g^*} = (g^* + \zeta^* g - \bar{y}) + \theta g^* = 0 \quad \Rightarrow$$

$$g^* = \frac{\bar{y} - \zeta^* g}{1 + \theta}$$

(RR*)
Continued.

(RR) and (RR*) are so-called reaction functions: a country’s best response, given what the other country does.

See Figures 10.17-10.18 for the two pure cases. Non-cooperative Nash equilibrium is at the intersection of RR and RR*.

For symmetric case ($\zeta = \zeta^*$) we have:

\[ g_N = g_N^* = \frac{\bar{y}}{1 + \zeta + \theta} \quad \text{(Symmetric)} \]
Uncoordinated fiscal policy (3)

- NWR in both countries: $\zeta = \zeta^* = 1$.
  - **Figure 10.17**: reaction functions downward sloping.
  - Unique non-cooperative Nash equilibrium at point N.
  - Stable: possible sequence is $g_0^* \rightarrow g_1 \rightarrow g_1^* \rightarrow g_2 \rightarrow \cdots \rightarrow g_{N-1}^* \rightarrow g_N$.

- RWR in both countries: $\zeta = \zeta^* < 0$.
  - **Figure 10.18**: reaction functions upward sloping
  - unique stable non-cooperative Nash equilibrium at point N.
Figure 10.17: International coordination of fiscal policy under nominal wage rigidity in both countries

Graphical representation of the IS-LM-BP-AS model with emphasis on international shock transmission and anticipation effects.
Figure 10.18: International coordination of fiscal policy under real wage rigidity in both countries
Coordinated fiscal policy (1)

- Is fiscal policy too expansionary?
- What would a coordinated fiscal policy look like?
- National policy makers give control over fiscal policy to international agency which sets $g$ and $g^*$ in order to minimize $L_G + L_G^*$ subject to the trade-offs (S11)–(S12).
  
  Formally:

  $\min_{\{g^*,g\}} L_G + L_G^* \equiv \frac{1}{2} (g + \zeta g^* - \bar{y})^2 + \frac{1}{2} (g^* + \zeta^* g - \bar{y})^2
  + \frac{\theta}{2} g^2 + \frac{\theta}{2} (g^*)^2$
Coordinated fiscal policy (2)

Continued.

FONCs:

\[ \frac{\partial (L_G + L_G^*)}{\partial g} = (g + \zeta g^* - \bar{y}) + \zeta^* (g^* + \zeta^* g - \bar{y}) + \theta g = 0 \]

\[ \frac{\partial (L_G + L_G^*)}{\partial g^*} = \zeta (g + \zeta g^* - \bar{y}) + (g^* + \zeta^* g - \bar{y}) + \theta g^* = 0 \]

Rewritten FONCs:

\[ g = \frac{(1 + \zeta^*) \bar{y} - (\zeta + \zeta^*) g^*}{1 + \theta + (\zeta^*)^2} \quad (CC) \]

\[ g^* = \frac{(1 + \zeta) \bar{y} - (\zeta + \zeta^*) g}{1 + \theta + \zeta^2} \quad (CC^*) \]

Symmetric solution:

\[ g_C = g_C^* = \frac{\bar{y}}{1 + \zeta + \frac{\theta}{1+\zeta}} \quad (symmetric) \]
Coordinated fiscal policy (3)

- By comparing \((g_C, g_C^*)\) to \((g_N, g_N^*)\) we can answer the question posed.
- NWR in both countries: \(\zeta = \zeta^* = 1\).
  - \(g_N < g_C\) and \(g_N^* < g_C^*\) (see Figure 10.17).
  - Too little spending in non-cooperative equilibrium.
  - Fiscal policy is a locomotive policy; positive spill-over effect only taken into account in coordinated policy.
- RWR in both countries: \(\zeta = \zeta^* = -1\).
  - \(g_N > g_C\) and \(g_N^* > g_C^*\) (see Figure 10.18).
  - Too much spending in non-cooperative equilibrium.
  - Fiscal policy is a beggar-thy-neighbour policy; negative spill-over effect only taken into account in coordinated policy.
Coordinated fiscal policy (4)

- RWR in Europe / NWR in United States.
  - Non-symmetric case.
  - $\zeta < 0$, $0 < \zeta^* < 1$.
  - (RR), (RR*), and FOCs unchanged. See Figure D (not in book).
  - Non-cooperative Nash equilibrium:

$$g_N = \frac{(1 + \theta - \zeta) \bar{y}}{(1 + \theta)^2 - \zeta \zeta^*} = \frac{\bar{y}}{1 + \zeta + \theta + \left[ \frac{\zeta (\zeta - \zeta^*)}{1 + \theta - \zeta} \right]}$$

$$g_N^* = \frac{(1 + \theta - \zeta^*) \bar{y}}{(1 + \theta)^2 - \zeta \zeta^*} = \frac{\bar{y}}{1 + \zeta + \theta - \left[ \frac{(1 + \theta) (\zeta - \zeta^*)}{1 + \theta - \zeta} \right]}$$
Coordinated fiscal policy (5)

Continued.

Comparison:

\[ g_C > g_N \]
\[ g_C^* < g_N^* \]

Intuition:

- In absence of coordination, Europe spends too little (locomotive) and the US spends too much (beggar-thy-neighbour).
- Interest rate too high, dollar too strong, unemployment in Europe too high (conclusion not relevant in 2005 but was deemed relevant in early 1980s).
Figure D: Asymmetric case (RWR, NWR*)
Forward-looking behaviour in international financial markets

- Look at yields on two types of portfolio investment:

$$\text{yield gap } \equiv (1 + r) - (1 + r^*) \frac{E_1^e}{E_0} = (1 + r) - (1 + r^*) \left(1 + \frac{\Delta E^e}{E_0}\right)$$

$$= (1 + r) - \left(1 + r^* + \frac{\Delta E^e}{E_0} + r^* \frac{\Delta E^e}{E_0}\right)$$

$$\approx r - \left(r^* + \frac{\Delta E^e}{E_0}\right)$$  \hspace{1cm} (YG)

- $r$ is yield on domestic bonds (denominated, say, in Euros).
- $r^*$ is yield on foreign bonds (denominated, say, in US dollars).
- $E$ is the (spot) exchange rate (Euros per US dollar).

- In continuous time we can write (YG) as:

$$\text{yield gap } = r - (r^* + \dot{e}^e)$$

where $e \equiv \ln E$, and $\dot{e}^e \equiv de^e/dt \equiv \dot{E}^e/E$. 
Arbitrage in world financial markets will ensure that like assets will earn like yields, i.e. uncovered interest parity holds:

\[ r = r^* + \dot{e} \]  

(UIP)

Under flexible exchange rates the agents must form an expectation regarding future exchange rates:

- So far we have used the assumption of inelastic expectations:

\[ \dot{e} = 0 \]  

(SEH)

- From here on we will use the perfect foresight hypothesis:

\[ \dot{e} = \dot{e} \]  

(PFH)

Rudiger Dornbusch (1942-2002) added (UIP) and (PFH) to the IS-LM model and investigated the effects of monetary and fiscal policy.
The Dornbusch model (1)

- **Table 10.5** describes the Dornbush model. Key features:
  - All variables (except $r$ and $r^*$) measured in logarithms.
    - Endogenous: $y$, $r$, $e$, and $p$.
    - Exogenous: $p^*$, $g$, $m$, and $\bar{y}$.
  - UIP and PFH assumed.
  - Prices are sticky.
  - Foreign and domestic goods imperfect substitutes.
  - The phase diagram for the model is given in **Figure 10.19**.
Table 10.5: The Dornbusch model

\[ y = -\varepsilon_{YR}r + \varepsilon_{YQ} [p^* + e - p] + \varepsilon_{YG}g \]  \hspace{1cm} (T5.1)

\[ m - p = -\varepsilon_{MR}r + \varepsilon_{MY}y \]  \hspace{1cm} (T5.2)

\[ r = r^* + \dot{e} \]  \hspace{1cm} (T5.3)

\[ \dot{p} = \phi [y - \bar{y}] \]  \hspace{1cm} (T5.4)

\[ \dot{e}^e = \dot{e} \]  \hspace{1cm} (T5.5)
The Dornbusch model (2)

- Derivation
  - Quasi-reduced form expressions for $r$ and $y$:
    $$
y = \frac{\varepsilon_{MR}\varepsilon_{YQ} [p^* + e - p] + \varepsilon_{MR}\varepsilon_{YG}g + \varepsilon_{YR}(m - p)}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} \tag{S15}
    $$
    $$
r = \frac{\varepsilon_{MY}\varepsilon_{YQ} [p^* + e - p] + \varepsilon_{MY}\varepsilon_{YG}g - (m - p)}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} \tag{S16}
    $$
  - Derive dynamic system for $e$ and $p$:
    $$
    \begin{bmatrix}
    \dot{e} \\
    \dot{p}
    \end{bmatrix} = \begin{bmatrix}
    \frac{\varepsilon_{MY}\varepsilon_{YQ}}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} & \frac{1-\varepsilon_{MY}\varepsilon_{YQ}}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} \\
    \phi \frac{\varepsilon_{MR}\varepsilon_{YQ}}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} & -\phi \left(\varepsilon_{YR} + \varepsilon_{MR}\varepsilon_{YQ}\right)
    \end{bmatrix}
    \begin{bmatrix}
    e \\
    p
    \end{bmatrix}
    + \begin{bmatrix}
    \frac{\varepsilon_{MY}\varepsilon_{YQ}p^* + \varepsilon_{MY}\varepsilon_{YG}g - m}{\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR}} \\
    \phi \left[\varepsilon_{MR}\varepsilon_{YQ}p^* + \varepsilon_{MR}\varepsilon_{YG}g + \varepsilon_{YR}m\right]
    \end{bmatrix}
    \begin{bmatrix}
    1 \\
    \phi \bar{y}
    \end{bmatrix} \tag{S17}
    $$
The Dornbusch model (3)

Continued.

- Draw equilibrium loci $\dot{e} = 0$ and $\dot{p} = 0$.

\[
e + p^* = \frac{-(1 - \varepsilon_{MY}\varepsilon_{YQ})p - \varepsilon_{MY}\varepsilon_{YG}g}{\varepsilon_{MY}\varepsilon_{YQ}}
+ \frac{m + (\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR})r^*}{\varepsilon_{MY}\varepsilon_{YQ}}
\] (Edot)

\[
e + p^* = \frac{(\varepsilon_{YR} + \varepsilon_{MR}\varepsilon_{YQ})p - \varepsilon_{MR}\varepsilon_{YG}g}{\varepsilon_{MR}\varepsilon_{YQ}}
+ \frac{-\varepsilon_{YR}m + (\varepsilon_{MR} + \varepsilon_{MY}\varepsilon_{YR})\bar{y}}{\varepsilon_{MR}\varepsilon_{YQ}}
\] (Pdot)

- Derive disequilibrium dynamics.
- Verify that the unique equilibrium is a saddle point: $e$ is a non-predetermined (jumping) variable; $p$ is a predetermined (sticky) variable.
Figure 10.19: Phase diagram for the Dornbusch model

The diagram illustrates the phase diagram for the Dornbusch model, showing the relationships between the exchange rate ($e$) and the domestic price level ($p$). The points A, B, C, and D represent different equilibrium states, with arrows indicating the direction of movement. The lines $e = 0$, $p = 0$, and $\dot{e} = 0$ are also shown, indicating the null conditions for the exchange rate and price levels.
Economic policy in the Dornbusch model (1)

- Under PFH timing of policy is crucial (as in perfect foresight models of Chapter 4).
- **Fiscal policy: unanticipated / permanent increase in** $g$
  - See **Figure 10.20**
  - $\dot{e} = 0$ and $\dot{p} = 0$ shift down.
  - Equilibrium from $a_0$ to $a_1$; immediate appreciation of currency.
  - No price change and no transitional dynamics.
  - Conclusion same as standard Mundell-Fleming model.
- **Fiscal policy: anticipated / permanent increase in** $g$
  - Heuristic solution principle of Chapter 4.
  - Adjustment path jump from $a_0$ to $a'$, gradual move from $a'$ to $a''$ and then to $a_1$.
  - Intuition: self-test.
Figure 10.20: Fiscal policy in the Dornbusch model
Economic policy in the Dornbusch model (2)

- Monetary policy: unanticipated / permanent increase in $m$.
  - See Figure 10.21.
  - $\dot{e} = 0$ and $\dot{p} = 0$ to the right.
  - Long-run equilibrium from $a_0$ to $a_1$ (real exchange rate unaffected in long run).
  - Transitional dynamics: impact jump from $a_0$ to $a'$; thereafter gradual move from $a'$ to $a_1$.
  - Conclusion: the nominal exchange rate overshoots its long-run value in the short run! Intuition for overshooting:
    - Agents expect long-run depreciation of currency ($e$ from $e_0$ to $e_1$).
    - Domestic assets less attractive, at impact $r \downarrow$ (net capital outflow) and $e \uparrow$.
    - During transition investors must be compensated for $r < r^*$ by appreciating exchange rate ($\dot{e} < 0$).

- Monetary policy: anticipated / permanent increase in $m$: self-test.
Figure 10.21: Monetary policy in the Dornbusch model
Overshooting: sensitivity analysis (1)

- What are the key assumptions leading to the overshooting result?
  - Role of price stickiness?
  - Role of imperfect capital mobility?
  - Role of monetary accommodation?

- Perfectly flexible prices in the Dornbush model.
  - $\phi \rightarrow \infty$, so $y = \bar{y}$ always.
  - Domestic interest rate:

$$
r = \frac{(\varepsilon_{YQ}\varepsilon_{MY} - 1)\bar{y} + \varepsilon_{YQ}(p^* + e) + \varepsilon_{YG}g - \varepsilon_{YQ}m}{\varepsilon_{YR} + \varepsilon_{YQ}\varepsilon_{MR}}
$$
Continued.

(Unstable) differential equation for $e$:

$$\dot{e} = \frac{(\varepsilon YQ\varepsilon M - 1)\bar{y} + \varepsilon YQ(p^* + e) + \varepsilon YGg - \varepsilon YQm}{\varepsilon YR + \varepsilon YQ\varepsilon MR} - r^*$$

Unanticipated / permanent increase in $m$ results in a once-off increase in $e$ (depreciation): no overshooting!

See Figure 10.22.
Figure 10.22: Exchange rate dynamics with perfectly flexible prices
Overshooting: sensitivity analysis (3)

- Imperfect Capital Mobility in the Dornbusch model.
  - Frenkel & Rodriguez (1982).
  - Model given in Table 10.6.
  - Phase diagram with low capital mobility in Figure 10.23: no overshooting.
  - Phase diagram with high capital mobility in Figure 10.24: overshooting.
  - Lesson: sticky prices necessary but not sufficient condition for overshooting result to occur.
### Table 10.6: The Frenkel-Rodriquez model

\[
y^d = \bar{y} + \varepsilon_{DQ} \left( p^* + e - p \right) \quad (T6.1)
\]
\[
r = \varepsilon_{RY} \bar{y} - \varepsilon_{RM} \left( m - p \right) \quad (T6.2)
\]
\[
\dot{p} = \phi \left[ y^d - \bar{y} \right] \quad (T6.3)
\]
\[
X = \varepsilon_{XQ} \left[ p^* + e - p \right] \quad (T6.4)
\]
\[
KI = \xi \left[ r - (r^* + \dot{e}) \right] \quad (T6.5)
\]
\[
KI + X = 0 \quad (T6.6)
\]
Figure 10.23: Exchange rate dynamics with low capital mobility
Figure 20.24: Exchange rate dynamics with high capital mobility
Monetary accommodation in the Dornbusch model.

Policy maker may accommodate price shocks:

\[ m = \tilde{m} + \delta p \]

- \( \delta = 0 \) in Dornbush model ("pure float" of the exchange rate).
- \( 0 < \delta < 1 \) here ("dirty float").

Phase diagram with no accommodation in Figure 10.21: overshooting.
Phase diagram with strong accommodation (\( \delta \) high) in Figure 10.25: no overshooting.

Lesson: by engaging in monetary accommodation, the policy maker can prevent overshooting to occur.
Figure 10.25: Monetary accommodation and undershooting
Open economy IS-LM-BP-AS model
International shock transmission
Anticipation effects

Punchlines

- Crucial aspects open economy:
  - Financial openness.
  - Type of exchange rate system.
- Effects of fiscal and monetary policy depend on both aspects.
- From the supply side another aspect is highlighted: the wage setting rule.
- In a two-country setting, shocks generally spill over across countries.
- Coordinated policy is generally different from uncoordinated policy.
  - Direction of change depends on wage setting rule in place.
  - (Positive or negative) spill-overs internalized.
Punchlines

- Forward-looking sticky-price model with perfect capital mobility.
  - Overshooting: financial shocks cause volatility.
  - Determinants of overshooting.