• Final exam will be Sat March 18, 11:30 a.m. to 2:30 p.m. in Peterson 108 (11:00 class) and Peterson 110 (12:30 class)
• Will again use assigned seats (see course webpage to find yours; not same as Exam 2)
• Exam with your name will be at your desk before you sit down; do not turn exam over until instructed to do so
• 2/3 on material since second midterm, 1/3 on material covered on first two exams
• Please complete evaluations of professor and TAs at
  https://academicaffairs.ucsd.edu/Modules/Evals/?e1570229

Outline of Chapter 20 lectures
20.1. Introduction
20.2. Exchange rates in the long run
20.3. Exchange rates in the short run
20.4. Using the short-run open-economy model
20.5. Exchange rate regimes

20.1. Introduction
• In the U.S. you would buy things with the U.S. currency (dollars)
• In Mexico you would buy things with the Mexican currency (pesos)
• Nominal exchange rate (denoted $E$) is the rate at which one currency trades for another

Example: one U.S. dollar today will buy you about 20 Mexican pesos

\[ E = \frac{20 \text{ pesos}}{\text{dollar}} \]

You could buy a gallon of gasoline in Mexico today for 57 pesos.
To convert this to dollars, divide by the exchange rate $E$:

\[ \frac{57 \text{ pesos}}{\text{gallon}} \times \frac{1 \text{ dollar}}{20 \text{ pesos}} = \frac{2.85 \text{ dollars}}{\text{gallon}} \]

Gas sells for $3.03/gallon in San Diego right now.
### Prices of different goods in U.S. and Mexico

<table>
<thead>
<tr>
<th></th>
<th>Price in Mexico</th>
<th>U.S. equivalent</th>
<th>Price in U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>57 pesos/gallon</td>
<td>57/20 = $3.03/gallon</td>
<td>$3.03/gallon</td>
</tr>
<tr>
<td>Corn</td>
<td>3429 pesos/ton</td>
<td>3429/20 = $171/ton</td>
<td>$159/ton</td>
</tr>
<tr>
<td>Big Mac</td>
<td>49 pesos/Mac</td>
<td>49/20 = $2.45/Mac</td>
<td>$5.06/Mac</td>
</tr>
</tbody>
</table>

- The nominal exchange rate measures how many Mexican pesos we could get for one U.S. dollar.
- We could also think about the exchange rate in real terms, for example, how many Mexican gallons of gasoline we could get for one U.S. gallon of gasoline.

• Sell one gallon of gasoline in U.S. for 3.03 dollars
  
  \[ P_{US} = \frac{3.03 \text{ dollars}}{\text{gallon in U.S.}} \]

• Use this to buy 60.6 pesos
  
  \[ P_{US} \times E = \frac{3.03 \text{ dollars}}{\text{gallon in U.S.}} \times \frac{20 \text{ pesos}}{\text{dollar}} = \frac{60.6 \text{ pesos}}{\text{gallon in U.S.}} \]

• Use this to buy 1.06 gallons in Mexico
  
  \[ P_{US} \times E = P_{Mex} \]
  
  \[ = \frac{3.03 \text{ dollars}}{\text{gallon in U.S.}} \times \frac{20 \text{ pesos}}{\text{dollar}} \times \frac{1 \text{ gallon in Mex}}{57 \text{ pesos}} \]
  
  \[ = \frac{1.06 \text{ gallon in Mexico}}{\text{gallon in U.S.}} \]

### Real exchange rate calculated in terms of different goods

<table>
<thead>
<tr>
<th></th>
<th>Price in Mexico</th>
<th>Price in U.S.</th>
<th>Real exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>57 pesos/gallon</td>
<td>$3.03/gallon</td>
<td>20 x 3.03 = 57 = \frac{57}{1.06}</td>
</tr>
<tr>
<td>Corn</td>
<td>3429 pesos/ton</td>
<td>$159/ton</td>
<td>20 x 159 = 3429 = \frac{3429}{1.93}</td>
</tr>
<tr>
<td>Big Mac</td>
<td>49 pesos/Mac</td>
<td>$5.06/Mac</td>
<td>20 x 5.06 = 49 = \frac{49}{2.05}</td>
</tr>
</tbody>
</table>

- A “gasoline” exchange rate greater than one means that gasoline is more expensive in the U.S.
- A “gasoline” exchange rate less than one means that gasoline is less expensive in the U.S.
• Which good (gasoline, corn, Big Mac) should we use?
• Answer: use overall price level

Definition: real exchange rate $\frac{E_{US}}{P_{Mex}}$

$E =$ nominal exchange rate (pesos/$)
$P_{US} =$ overall U.S. price level as measured by the U.S. consumer price index
$P_{Mex} =$ overall Mexican price level as measured by the Mexican CPI

• If real exchange rate is greater than one it means goods overall are more expensive in the U.S. than in Mexico

• Today, one dollar will buy you 20 pesos
• 25 years ago, one dollar would only buy you 3 pesos
• The dollar has appreciated against the peso over the last 25 years (that is, the dollar has become worth more)
• Equivalently, the peso has depreciated against the dollar over the last 25 years (that is, the peso has become worth less)

The peso had a long-term trend of depreciation as well as rapid depreciations in 1994, 2008, and last 3 years

Two questions
(1) What accounts for ongoing gradual depreciation of the peso over last 25 years?
   – Answer: use long-run model
(2) What accounts for sudden episodes of rapid depreciation in 1994, 2008, and last 3 years?
   – Answer: use short-run model
20.2. Exchange rates in the long run

- **Law of one price** says that in the long run, goods must sell for the same price in different countries.
- Law of one price implies that in the long run, the real exchange rate should equal 1

If \( \frac{P_{EX}}{P_{MEX}} = 1 \) it means that if prices in Mexico go up 10% with U.S. prices fixed, exchange rate will go up 10% (dollar will appreciate 10% relative to peso).

Law of one price means the primary factor driving long-term changes in the exchange rate is differences in inflation.

The peso depreciated against the dollar by 7.9% per year on average over 1993-2016

\[ 8.2 - 2.2 = 6.0\%/year \] inflation difference accounts for much of the observed 7.9% depreciation per year

- The long-run model would explain the long-run depreciation of the peso in terms of the long-run higher inflation rate in Mexico.
- This is a reasonable first approximation.
- The long-run model would in turn attribute long-run differences in inflation to long-run differences in money growth.
- 14.5 – 5.6 = 8.9% difference in money growth per year is again similar to the 7.9% depreciation of the peso per year
- Conclusion: long-run model and the law of one price explain much (but not all) of the long-run trend in the nominal exchange rate over this period

<table>
<thead>
<tr>
<th>Country</th>
<th>local_price per Mac</th>
<th>exchange rate per Mac</th>
<th>dollar equivalent per Mac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>6.5 francs</td>
<td>1.02 francs/$</td>
<td>$6.55</td>
</tr>
<tr>
<td>Norway</td>
<td>60 kroner</td>
<td>6.64 kroner/$</td>
<td>$55.97</td>
</tr>
<tr>
<td>Brazil</td>
<td>10.8 real</td>
<td>2.32 real/$</td>
<td>$25.12</td>
</tr>
<tr>
<td>U.S.</td>
<td>1.95 USD</td>
<td>1.00</td>
<td>$1.95</td>
</tr>
<tr>
<td>Canada</td>
<td>1.39 CAD</td>
<td>1.33 CAD/$USD</td>
<td>$1.41</td>
</tr>
<tr>
<td>Denmark</td>
<td>50 kroner</td>
<td>7.10 kroner/$</td>
<td>$54.22</td>
</tr>
<tr>
<td>Euro area</td>
<td>8.88 euros</td>
<td>0.96 euros/$</td>
<td>$54.06</td>
</tr>
<tr>
<td>S. Korea</td>
<td>1400 won</td>
<td>1196 won/$</td>
<td>$53.68</td>
</tr>
<tr>
<td>Mexico</td>
<td>40 pesos</td>
<td>10 pesos/$</td>
<td>$52.45</td>
</tr>
<tr>
<td>Thailand</td>
<td>119 baht</td>
<td>35 baht/$</td>
<td>$53.35</td>
</tr>
<tr>
<td>Poland</td>
<td>9.6 zloty</td>
<td>4.57 zloty/$</td>
<td>$52.30</td>
</tr>
<tr>
<td>India</td>
<td>170 rupee</td>
<td>68 rupee/$</td>
<td>$52.49</td>
</tr>
</tbody>
</table>

- You can’t really “trade” a Big Mac in San Diego for a Big Mac in Mexico City
- If you buy a Big Mac in San Diego, part of what you are paying for is service and location of restaurant
- Labor and land are cheaper in poor countries, so a Big Mac is as well
- Called the Balassa-Samuelson effect

20.3. Exchange rates in the short run
- In the short run, the exchange rate depends on how many people want to hold dollars instead of pesos
- Suppose the Federal Reserve raises the short-run U.S. interest rate $i_{US}$ but other countries do not raise their interest rates
- Then investors would find U.S. assets offer better return than foreign
- The would want to trade their currency for dollars in order to buy U.S. assets
• In June 2014 the ECB went to negative interest rates and has been going more negative since
• In December 2015 the U.S. began raising interest rates
• The result was higher interest rates in the U.S. than in Europe and a big appreciation of the dollar against the euro.

• Conclusion: when $i_{US}$ goes up, dollar will appreciate ($E^\uparrow$)
• Since prices don’t adjust fully in the short run, this will mean a real appreciation as well

\[ i_{US} \uparrow \Rightarrow E \uparrow \Rightarrow \frac{EP_{US}}{P_{world}} \uparrow \]

• In other words, if monetary policy in the U.S. becomes tighter than in the rest of the world, U.S. goods will become more expensive than foreign goods
• That will tend to discourage U.S. exports and encourage U.S. imports

\[ EX_t = \text{U.S. exports} \]
\[ IM_t = \text{U.S. imports} \]
\[ NX_t = EX_t - IM_t = \text{U.S. net exports} \]
\[ R_t = \text{U.S. real interest rate} \]
\[ \bar{R}^w = \text{real interest rate in rest of world} \]
\[ \frac{NX_t}{Y_t} = \tilde{a}_{nx} - \tilde{b}_{nx}(R_t - \bar{R}^w) \]

• This identifies an additional channel by which U.S. monetary policy affects the economy
• Chapter 12: If Fed raises interest rate it reduces investment which means less demand for U.S.-produced goods
• Chapter 20: If Fed raises interest rate it reduces net exports which also means less demand for U.S.-produced goods
\[
\frac{nx_t}{y_t} = \ddot{a}_{nx} - \ddot{b}_{nx}(R_t - \ddot{R}^w)
\]
Recall \(\ddot{r}\) = long-run real rate

\[
\frac{nx_t}{y_t} = \ddot{a}_{nx} - \ddot{b}_{nx}(R_t - \ddot{r}) + \ddot{b}_{nx}(\dddot{R}^w - \ddot{r})
\]

\[
\tilde{Y}_t = \ddot{a} - \ddot{b}(R_t - \ddot{r})
\]
This is identical equation as that for our IS curve in Chapter 11, but with some new interpretations

(1) An increase in foreign interest rates is a new factor that increases \(\ddot{a}\) (shifts IS to right)
(2) An increase in net exports is another thing that happens as move along IS to the right

20.4. Using the short-run open-economy model

\(\tilde{Y}_t\) = level of output predicted by long-run model (also called potential output)
\(\ddot{r}\) = real interest rate predicted by long-run model (also called marginal product of capital)
\(Y_t\) = real GDP (also called actual output)
\(\ddot{Y}_t\) = \(\frac{y_t - \ddot{Y}_t}{\ddot{Y}_t}\) = difference between actual GDP and potential GDP expressed as a fraction of potential (also called short-run output)
IS curve:
\[ \tilde{Y}_t = \tilde{a} - \tilde{b}(R_t - \tilde{r}) \]
passes through \( \tilde{Y}_t = \tilde{a}, \ R_t = \tilde{r} \)

\[ \tilde{a} = \tilde{a}_c + \tilde{a}_g + \tilde{a}_i + \tilde{a}_{nx} + \tilde{b}_{nx}(\tilde{R}^w - \tilde{r}) - 1 \]

IS shifts right if:
- exogenous increase in consumption, government spending, investment demand, or net export demand (\( \tilde{a}_c \uparrow, \tilde{a}_g \uparrow, \tilde{a}_i \uparrow, \tilde{a}_{nx} \uparrow \))
- increase in foreign interest rate (\( \tilde{R}^w \uparrow \))

Reason: \( \tilde{R}^w \uparrow \)
\[ \Rightarrow \text{real exchange rate depreciates} \]
\[ \Rightarrow NX \uparrow \]

In Chapter 13 we assumed that Fed follows a simple rule to achieve a target inflation rate of \( \tilde{\pi}_t \), raising real rate whenever \( \pi_t > \tilde{\pi} \)
\[ R_t - \tilde{r} = \tilde{m}(\pi_t - \tilde{\pi}) \]

Since the open-economy equation for the IS curve has identical form as before, the open-economy AD curve will have the identical form as before.

AD:
\[ \tilde{Y}_t = \tilde{a} - \tilde{b}\tilde{m}(\pi_t - \tilde{\pi}) \]
slopes down
passes through \( \tilde{Y}_t = \tilde{a}, \ \pi_t = \tilde{\pi} \)
AD shifts right if
- exogenous increase in consumption, government spending, investment demand, or net export demand
- increase in foreign interest rate
- increase in Fed’s inflation target

AD becomes flatter ($\bar{Y}$, more responsive to $\pi_t$) if
- $\bar{b}_i$ bigger
  (investment more responsive to $R_t$)
- $\bar{b}_{nx}$ bigger
  (real exchange rate more responsive to $R_t$ or $NX$ more response to exchange rate)
- $\bar{m}$ bigger
  (Fed more responsive to inflation)

AS identical as before:
$$\pi_t = \pi_{t-1} + \bar{\alpha} + \bar{p}\bar{Y}_t$$
slopes up
passes through $\bar{Y}_t = 0$, $\pi_t = \pi_{t-1} + \bar{\alpha}$

Example 1
- Suppose as in the MP model of Chapter 12 the Fed just chooses an interest rate and holds it fixed
- Consider an economy that initially started out in long-run equilibrium
- Describe the effects on the economy if the Fed then lowers the U.S. interest rate

Effects in Example 1
- Dollar depreciates
  - Reason: U.S. assets now less attractive, foreigners want fewer dollars
- U.S. net exports increase
  - Reason: U.S. exports now look cheaper to foreign buyers, U.S. imports now look more expensive to U.S. buyers
Effects in Example 1

• U.S. investment increases
  – Reason: lower U.S. interest rates stimulate investment demand

• U.S. GDP increases
  – Reason: higher exports, higher investment and lower imports