Intertemporal Macroeconomics

• Intertemporal Approach
  — Useful to start with an analogy for an individual household. Consider two cases:
    • Case 1: A debt that is serviced. Household makes interest payments on debt, but never pays down the principal amount borrowed. At the end of each period, the lender renews the loan (a rollover).
    • Case 2: A debt that is not serviced. Household pays neither interest owed nor the principal. In this case, the amount owed will grow over time.
  — Case 2 is not sustainable because all debts must be paid off eventually.
    • Case 2 is also known as a Ponzi scheme.
    • We will rule it out.

The Long Run Budget Constraint

• Assumptions for a simple model:
  — Prices are perfectly flexible. All quantities are real.
  — The country is a small open economy.
  — All debts carry a fixed real interest rate \( r^* \), the world real interest rate.
  — Net interest income = \( r^*W \)
    • Country pays \( r^* \) on start-of-period liabilities, \( L \), and receives interest \( r^* \) on start-of-period assets, \( A \).
    • Net interest income received is therefore \( r^*(A-L) = r^*W \), where \( W \) is external wealth.
  — No unilateral transfers (\( NUT = 0 \)), no capital gains earned on external wealth, no capital account, no other factor income from abroad (\( NFIA = 0 \)).

The Long Run Budget Constraint

• Calculating Change in Wealth Each Period
  — As we saw in the last chapter, the change in external wealth is here equal to the current account.
  — Consider change in wealth in a given period, \( N \):

\[
\Delta W_N = W_N - W_{N-1} = TB_N + r^*W_{N-1}\]

  — This expression says that external wealth will change from two sources.
    • Trade deficits/surpluses (\( TB \)).
    • Net interest income earned on external wealth (\( NFIA \)).
The Long Run Budget Constraint

• Calculating Future Wealth Levels
  – Subtracting \( W_{N-1} \) from both sides yields the following expression for external wealth in period \( N \):
  \[
  W_N = TB_N + (1 + r)W_{N-1}.
  \]
  External wealth at the end of this period
  Trade balance this period
  Last period's external wealth plus interest paid/received
  – This expression shows how to calculate future wealth based on the country's trade balance and initial wealth.

The Long Run Budget Constraint

• The Two Period Case
  – Suppose there are two periods in the economy. The current period denoted \( 0 (= N) \) and the previous period is denoted \( -1 (= N-1) \):
  \[
  W_0 = (1 + r)W_{-1} + TB_0
  \]
  – The next period is denoted \( 1 (= N + 1) \):
  \[
  W_1 = (1 + r)W_0 + TB_1
  \]
  Substituting in expression for current wealth, \( W_0 \):
  \[
  W_1 = (1 + r)^2W_{-1} + (1 + r)TB_0 + TB_1
  \]

The Long Run Budget Constraint

• Present Value Form of the LRBC
  \[
  -\frac{(1 + r^2)W_{-1}}{TB_0 + \frac{TB_1}{1 + r}}.
  \]
  Minus the present value of wealth from last period
  Present value of all present and future trade balances
  – Any payment at any time in the past, present of future can be expressed in present value terms.
  – Compute what payments are worth in today's dollars by adjusting for compound interest.
  • Payment of \( X \) in year \( N \) equivalent to \( X/(1+r)^N \) in year 0.
Example: The Perpetual Loan

- The perpetual loan
  - Country pays a fixed amount $X$ each period beginning in period $1$.
  \[ PV(X) = \frac{X}{1 + r} + \frac{X}{(1 + r)^2} + \frac{X}{(1 + r)^3} + \cdots \]
  - This expression simplifies to:
  \[ PV(X) = \frac{X}{r} \]
  - E.g., you owe a perpetual $\$2000$ at 5% interest, so you must pay the lender $X = 100$ interest every year forever.
  - $PV(X) = \frac{100}{0.05} = 2000$. You never pay off the principal.

Implications of LRBC for GNE and GDP

- GDP = C + I + G + TB (NFIA = 0 by assumption).
- TB = GDP - GNE.

\[
\frac{(1 + r)W_1 + GDP_0}{1 + r} + \frac{GDP_1}{(1 + r)^2} + \frac{GDP_2}{(1 + r)^3} + \cdots
\]

\[
= \frac{GNE_0}{1 + r} + \frac{GNE_1}{(1 + r)^2} + \frac{GNE_2}{(1 + r)^3} + \cdots
\]

Implications of LRBC for GNE and GDP

- Implications:
  - LRBC says, in the long run, in present value terms, a country’s expenditures (GNE) must equal its production (GDP) plus any initial wealth.
  - Shows how the country is able to finance differences between its production and spending through borrowing/lending over time.
The Favorable Situation of the United States

• “Exorbitant Privilege”
  – U.S. a net debtor, W < 0, since 1980s, yet factor income from abroad has been positive.
  • Can a net debtor earn positive interest income?
  • Yes. U.S. pays a low rate of interest on external liabilities relative to rate of interest on external assets, \( r^* - r \).
  • Roughly 1.5–2 percentage points difference.

• “Manna from Heaven”
  – U.S. also had capital gains on external wealth.
  • Rate of capital gains also higher on external assets than on external liabilities.
  • Another roughly 2 percentage point difference.

The Difficult Situation of the Emerging Markets

• Assumptions revisited
  – No risk premium: same interest rate paid on assets and liabilities.
  – No debt limit: countries are able to borrow and lend freely, as long as they satisfy the LRBC.

• Risk premiums and debt limits are a reality

The Difficult Situation of the Emerging Markets

• Risk Premiums
  • Investors require a risk premium in order to be willing to buy your assets.
  • Creditworthiness measured by credit rating, and this is correlated with interest rate charged (e.g. junk bonds).
  • As a country’s debt increases, this increases risk of default, so the bond rating typically declines.
  • Advanced countries barely affected by this problem.
The Difficult Situation of the Emerging Markets

- Debt limits—nobody willing to buy your assets
  - Lead to sudden stops in the flow of external finance.
    - financial account surplus rapidly shrinks,
    - requiring a decrease in current account deficit,
    - requiring a sudden cut in expenditures (GNE) relative to production (GDP).

![Graph showing the number of countries experiencing a "sudden stop" over time.]

Consumption Smoothing: Example

- Closed versus Open, No Shocks

  - Closed economy
    - $Q = 100 = C$ in each period; $TB=0$
    - $PV(Q) = 100 + 100/0.05 = 2100 = PV(C)$

  - Open economy
    - $Q = 100 = C$ in each period; $TB=0$
    - $PV(Q) = 100 + 100/0.05 = 2100 = PV(C)$

Consumption Smoothing: Example

- Closed versus Open, No Shocks.
  - In an open economy with no shocks, there is no reason to borrow or lend.
  - The household is able to maintain smooth consumption every period.

<table>
<thead>
<tr>
<th>Period</th>
<th>Output GDP</th>
<th>Expenditure GDP</th>
<th>Trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
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<tr>
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<td>0</td>
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<tr>
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<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Present Value</th>
<th>$e^{-0.05}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>2</td>
<td>0.90</td>
</tr>
<tr>
<td>3</td>
<td>0.85</td>
</tr>
<tr>
<td>4</td>
<td>0.80</td>
</tr>
<tr>
<td>5</td>
<td>0.76</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Consumption Smoothing: Example

- Closed versus Open, Shocks.
  - Temporary, negative shock to output (of –21 units) in year 0, so output is 79. Output is equal to 100 units in every period thereafter.
  - What happens?

<table>
<thead>
<tr>
<th>Period</th>
<th>Present Value</th>
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<tbody>
<tr>
<td>0</td>
<td>79 100 100 100 100 100 ...</td>
</tr>
<tr>
<td>1</td>
<td>79 100 100 100 100 100 ...</td>
</tr>
<tr>
<td>2</td>
<td>79 100 100 100 100 100 ...</td>
</tr>
<tr>
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<td>79 100 100 100 100 100 ...</td>
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<td>4</td>
<td>79 100 100 100 100 100 ...</td>
</tr>
<tr>
<td>5</td>
<td>79 100 100 100 100 100 ...</td>
</tr>
</tbody>
</table>

Consumption Smoothing: Computation

- How can the open economy do better?
  - Use the LRBC:
    - Figure out change in resources (fall in PV of GDP)
    - Figure out required change in consumption (fall in PV of C)
  - Compute the present value of GDP:
    \[ PV(Q) = Q_0 + \frac{Q}{r} \]
    - Since \( Q_0 = 79 \) and output is equal to 100 thereafter:
    \[ PV(Q) = 79 + \frac{100}{0.05} = 2079 \]

Consumption Smoothing: Computation

- Compute \( C \) each period
  - Consumption smoothing \( C_0 = C_1 = C_2 = \ldots = C \):
    \[ PV(C) = C + \frac{C}{r} \]
    - From above, we know \( PV(Q) = 2079 = PV(C) \):
    \[ 2079 = C + \frac{C}{0.05} \]
    - Therefore, \( C = 99 \) in every period if it is smooth
  - Hint: \( PV(Q) \) has fallen by 1%, from 2100 to 2079, so \( C \) must fall by 1% in all periods to still be smooth and satisfy LRBC.
Consumption Smoothing: Computation

- Closed versus Open, Shocks.
  - In the open economy, the present value of output is the same, yet the household is able to smooth consumption through running a trade deficit in period when the negative shock reduces output.

<table>
<thead>
<tr>
<th>Period</th>
<th>Present Value</th>
<th>Output GDP</th>
<th>Expenditure GDP</th>
<th>Trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.479</td>
<td>99</td>
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<tr>
<td>5</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>6</td>
</tr>
</tbody>
</table>

Consumption Smoothing: Permanent Shocks

- Permanent Shocks?
  - If a country faces a permanent shock to output, then it will be forced to FULLY adjust its consumption, regardless of whether it is a closed or open economy.
    - Trade balance cannot be used to make up the difference between consumption and output because the change is permanent—remember we assumed no Ponzi games.
    - An important result from the model: consumers can smooth out temporary shocks, but they must adjust to permanent shocks.

Consumption Volatility and Financial Openness

- Data
  - Ratio far from zero, even for open countries.
  - In many cases, the ratio is greater than one.
Precautionary Saving, Reserves, and Sovereign Wealth Funds

- How can poor countries better smooth their consumption? **Precautionary saving.**
  - Government saving in a “rainy day” fund in case of a sudden stop. Keeps high level of external wealth which for use as a buffer against shocks.

- Two common forms of precautionary saving:
  - **Foreign reserves:** usually safe assets, e.g. U.S. Treasuries, owned by central bank.
  - **Sovereign wealth funds:** state-owned companies that invest in safe assets (foreign reserves) and riskier high-return assets (equity and FDI.)

Efficient Investment: Example

- Open economy can borrow to finance investment, without having to reduce consumption today.

<table>
<thead>
<tr>
<th>Period</th>
<th>Output (GDP)</th>
<th>Expenditure</th>
<th>Trade Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>105</td>
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<tr>
<td>4</td>
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<td>105</td>
<td>105</td>
<td>-20</td>
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<tr>
<td>...</td>
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<td>...</td>
</tr>
</tbody>
</table>

Efficient Investment: Generalizing

- **Generalizing**
  - Objective is to maximize \( PV(C) \).
  - Investment worthwhile if \( PV(Q) \) increases more than \( PV(I) \):
    \[
    \Delta Q \geq r^* \Delta K
    \]
  - \( \Delta Q / \Delta K \) is the **marginal product of capital (MPK)**
  - \( r^* \) is the interest rate paid on each unit of borrowed.

- **Bottom line**
  - Undertake any project if MPK exceeds \( r^* \).
  - Because this will increase \( PV(C) = PV(Q) - PV(I) \).
Summary: Efficient Investment

• Make Hay While the Sun Shines
  – Open economy
    • Country able to separate consumption and investment decisions. Borrow/save through the world capital market.
    • Efficient level of investment where MPK = r*
  – Closed economy
    • Country must be self-sufficient and is unable to borrow from the world capital market.
    • Will choose a lower level of investment versus open economy, because it finances projects with consumption.
    – Key lesson—"make hay while the sun shines"
      • Take advantage of good investment opportunities (those with MPK ≥ r*), without sacrificing current consumption.

Can Poor Countries Gain from Globalization?

• What can be gained? Must ask: What is MPK?
• Production Function Approach
  – Simple production function (0 < θ < 1):
    $$q = A \times k^\theta$$
    where q = Q/L and k = K/L, and A measures productivity. (Cobb-Douglas form.)
  – To determine efficient level of investment, find the MPK, the slope of the production function:
    $$MPK = \frac{\Delta q}{\Delta k} = \theta A \times k^{\theta - 1} = \frac{q}{k}$$

Can Poor Countries Gain from Globalization?

• A Naïve Model: When Counties Have Identical Productivity Levels.
  – Assume: A = 1, θ = 1/3
    • Suppose poor country has 1/2 the level of output per worker as enjoyed in the rich country.
    • Poor country has capital per worker k equal to 1/8 that of rich country.
    • And poor country has MPK 4 times that of rich country!
  – The poorer the country, the lower its capital per worker, and therefore, the higher its MPK.
    • Capital should flow from rich into the poor countries.
    • Poor country’s capital per worker rises, and therefore output per worker rises relative to output in rich country.
    • Convergence between poor and rich countries.
Can Poor Countries Gain from Globalization?

- Naïve Model with $A_P = A_R$

The “Lucas Paradox”: Why Doesn’t Capital Flow from Rich to Poor?

- Robert E. Lucas Jr. (Nobel Laureate)
- Implication from naïve model: capital should flow from rich to poor countries.
- This is not the case, indicating the assumptions used in the model are “drastically wrong”.
- There is a great deal of investment in wealthier countries.

An Augmented Model: When Countries Have Different Productivity Levels.

- Relax a key assumption: allow productivity levels $A$ to differ across countries ($P =$ poor; $R =$ rich country): $q_P = A_P \times k_P^\theta$, $q_R = A_R \times k_R^\theta$
- Based on the production functions above, we can find the relative MPK of the two countries: $MFK_P = q_P/k_P$, $MFK_R = q_R/k_R$
Can Poor Countries Gain from Globalization?

• An Augmented Model: When Countries Have Different Productivity Levels.
  – We can use the MPK ratio to understand how differences in productivity levels affects convergence.
    \[
    \frac{MPK_P}{MPK_R} = \frac{q_P/k_P}{q_R/k_R}
    \]
  – Naïve model: \(MPK_P > MPK_R\)
    • Lower \(q\) could only be a result of lower \(k\).
  – Augmented model—this need not be the case.
    • If productivity levels are lower in poor countries, we could see \(MPK_P = MPK_R = r^*\) with \(q_P < q_R\). How?...

Can Poor Countries Gain from Globalization?

• Augmented Model with \(A_P < A_R\)
  – Example: \(A\) in Mexico about 50% of \(A\) in U.S.
  – For a given \(k\), \(q\) and MPK are at 1/2 the US level.

A versus \(k\)

• Productivity Levels
  – Compare output per worker and capital per worker in selected countries to those in the U.S.
    • Compute difference in the productivity levels \(A\) and in the MPK levels in poor countries relative to the U.S.
  – What the data say:
    • A large part of the reason why poor countries are poor is low productivity \(A\).
    • This causes them to have low MPK, despite low levels of capital per worker \(k\).
    • As a result, little capital can be expected to flow to them, with little gain from financial globalization.
A versus k

- **Divergence?**
  - If naïve model were true, poor countries ought to take in huge capital flows, enjoy big gains in GDP.
    - Even if true, credit limits and risk likely to hinder the size of the flows. GNI gains smaller due to interest costs.
  - But naïve model isn’t right. Augmented model is. It predicts tiny capital flows, small gains.
    - Countries with low productivity levels may have no mechanism to converge to richer countries (through borrowing capital from abroad).
    - Result: divergence between rich and poor countries.
    - Unless poor countries can increase their productivity levels, their output per worker will continue to lag behind.

A versus k

- More Bad News?
  - Model makes no allowance for risk premiums.
    - Poor country may need to pay a premium above \( r^* \) in order to borrow: \( r_p > r^* \) and \( MPK_P = r_p > r^* = MPK_R \).

A versus k

- More Bad News?
  - Risk premiums may be large enough to cause capital to flow “uphill” from poor to rich countries.
    - If risk premiums are large enough, investors attracted to lower-risk opportunities in “safe haven” rich countries. Even if the return is higher in a poor country, the risk is greater, making the investment potentially less attractive.
  - Model assumes investment can be acquired at the same relative price in output terms.
    - In poor countries, imported capital goods can be expensive (e.g. due to trade costs or protectionism).
Gains from Diversification: Generalizing

- Countries can only reduce volatility if output shocks are negatively correlated across countries (asymmetric).
- If both countries suffer a negative shock at the same time, they are unable to use diversification to reduce volatility in income. These shocks are known as common shocks (identical or symmetric).
- If output shocks become increasingly common across countries, then the gains from diversification are diminished.

Gains from Diversification: Limitations

- Limits to Diversification: Capital versus Labor Income
  - Country is unable to eliminate volatility associated with shocks to labor income. It is not possible to trade ownership of labor across countries (or even within countries!).
  - Often shocks to affect capital and labor in the same way, so countries experiencing low capital income (home) likely experience low labor income at the same time.
  - Solution, in theory: buy even more of the foreign portfolio.

The Home Bias Puzzle

- Home Bias
  - The tendency for investors to own a disproportionate share of their wealth in home assets, versus foreign assets.
  - Home bias identified by comparing risk and return for sample portfolios available to U.S. investors.
    - They could have increased their return without increasing risk.
    - A share of 40–60% in foreign assets would have increased the return while reducing risk.
The Home Bias Puzzle

- Home Bias—sample portfolios

![Graph showing home bias and standard deviation of total portfolio return](image)

The Home Bias Puzzle

- Disappearing home bias?

<table>
<thead>
<tr>
<th>Country</th>
<th>All Investments</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>1980</td>
<td>2.2%</td>
<td>3.5%</td>
</tr>
<tr>
<td>1990</td>
<td>3.1%</td>
<td>4.2%</td>
</tr>
<tr>
<td>2000</td>
<td>3.7%</td>
<td>4.9%</td>
</tr>
<tr>
<td>2005</td>
<td>3.6%</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

The Home Bias Puzzle

- Exaggerated home bias?
  - Data understate the true level of diversification
    - Some diversification can be achieved without purchasing foreign assets.
    - Large multinational firms have capital income streams from many different countries.
    - When an American investor purchases stock in one of these companies based in the U.S., she is effectively buying the rights to a capital income stream from abroad.

![Graph showing mean and standard deviation of total portfolio return](image)
Gains from Diversification

• Don’t Put All Your Eggs in One Basket
  – Diversification allows a country to reduce volatility in income, without borrowing or lending.
    • Useful in a world of risk premiums, credit limits, and limited access to world capital markets.
    • Through ownership of capital income streams from several different sources, the likelihood of suffering dramatic shocks to income is reduced.
  – Risk sharing may be limited in practice because
    • The number of assets is limited.
    • The market for claims to capital is incomplete because not all equity is publicly traded on stock exchanges.
    • Trade in claims to labor income is impossible/illegal.
    • Investors averse to investing abroad (home bias puzzle).

A Simple Intertemporal Trade Model

• Two period model: \( 0 = \text{Now} ; 1 = \text{Later} \).
• No government, so \( \text{GNE} = C + I, \text{GDP} = C + I + TB, \) and \( S_D = GDP - C \).
• \( TB + N F I A + FA = 0 \).
• No past external wealth, so \( W_{-1} = 0 \).
• No future, so \( C_1 = \text{GNE}_1, I_1 = 0, \) and \( W_1 = 0 \).
• Indifference curves based on consumption smoothing, some willingness to substitute between now and future.
• PPF represents domestic investment opportunities, with diminishing marginal returns:
  – \( \text{GDP}_0 \) predetermined (= \( A k_0^0 \)).
  – \( k_1 = k_0 (1-\delta) + I_0 \).
  – \( \text{GDP}_1 = A k_1^0 \).

Intertemporal Trade Predictions

• In closed economy, domestic \( r_A \) is determined by tangency, so \( \text{GNE} = \text{GDP} \) and \( S_D = I \).
• In an open economy, country borrows or lends at \( r^* \).
  – If borrowing, \( r^* < r_A, TB < 0 \) and \( \text{GNE}_0 > \text{GDP}_0 \).
    \( S_0 \) falls, \( I \) rises, \( \text{GDP}_1 \) rises.
    \( FA_0 = -TB_0, FA_1 = -FA_0 \).
    \( N F I A_1 = -TB_0(r^*), TB_1 = -TB_0(1+r^*) > 0 \).
  – If lending, \( r^* > r, TB > 0 \) and \( \text{GNE}_0 < \text{GDP} \).
    \( S_D < 0, I \) falls, \( \text{GDP}_1 \) falls, \( \text{GNE}_1 \) rises, \( TB_1 < 0 \).
  - Whether a borrower or a lender, country’s welfare is enhanced by intertemporal trade.