Lectures on

International Macroeconomics

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Introduction:

- This course will study the fundamental theories of inter-national macroeconomics, and
- basic modern tools such as dynamic stochastic general equilibrium modeling,
- their application to issues of current interest in the academic literature,
- and their implications for macroeconomic stabilization and exchange rate policies

Examples of questions we will deal with:

- Are global financial imbalances like the large German trade surplus a problem?
- To what degree are global goods markets really integrated?
- To what degree are global financial markets integrated?
- How are recessions in one country transmitted to others?
- What caused the recent global recession?
- Do global recessions call for international coordination of macroeconomic policies?

Expectations for the Course:

Each day I will assign a main reading on theory or application.

Lectures will present basic theory, empirical tools, and class discussion of applications.

A few short problem sets will be assigned during the course, to check understanding of theory and tools.

Part 1.
Preliminaries: National Income Accounting and Data

Let's agree on some definitions:

- GDP: Gross Domestic Product: Total value of all final goods and services produced within a country's borders.

- This can be measured as the value added: sales minus payments for intermediate inputs of all firms.

- Can decompose this into expenditure categories:

$$GDP = C + I + G + TB$$

  - C: consumption
  - I: investment
  - G: government consumption
  - TB: trade balance = exports - imports

- <u>GNI: Gross national Income</u>: total value of all income earned by a country's factors of production (without regard to location). This implies:

$$GNI = GDP + NFIA$$

- <u>NFIA: net factor income from abroad</u> = (foreign income payments to domestic factors of production) – (domestic income payments to foreign factors of production).

Ireland has high output (GDP) per person, but much lower income (GNI almost 20% lower)

Rank	GDP per capita	GNI per capita
1	Luxembourg	Luxembourg
2	United States	United States
3	Norway	Norway
4	**Ireland**	Switzerland
5	Switzerland	Canada
6	Canada	Denmark
7	Denmark	United Kingdom
8	Netherlands	Netherlands
9	Austria	Belgium
10	Iceland	Iceland
11	Australia	Austria
12	United Kingdom	Australia
13	Belgium	Japan
14	France	France
15	Sweden	Sweden
16	Japan	Finland
17	Finland	**Ireland**
18	Germany	Germany
19	Italy	Italy
20	Spain	Spain

- Gross national disposable income (GNDI):

$$GNDI = GNI + NUT$$

  Includes net unilateral transfers (NUT) : international gifts, negative entry for giving country; positive for receiving country.
  (balances exports bought with foreign aid)

- When we include unilateral transfers on the right hand side of our accounting equation…

$$GNDI = C + I + G + \underbrace{\{TB + NFI + NUT\}}_{CA}$$

- CA: current account: consists of all international transaction of goods, services, and income.

Balance of Payments accounts (BOP): constructed to measure all international transactions.

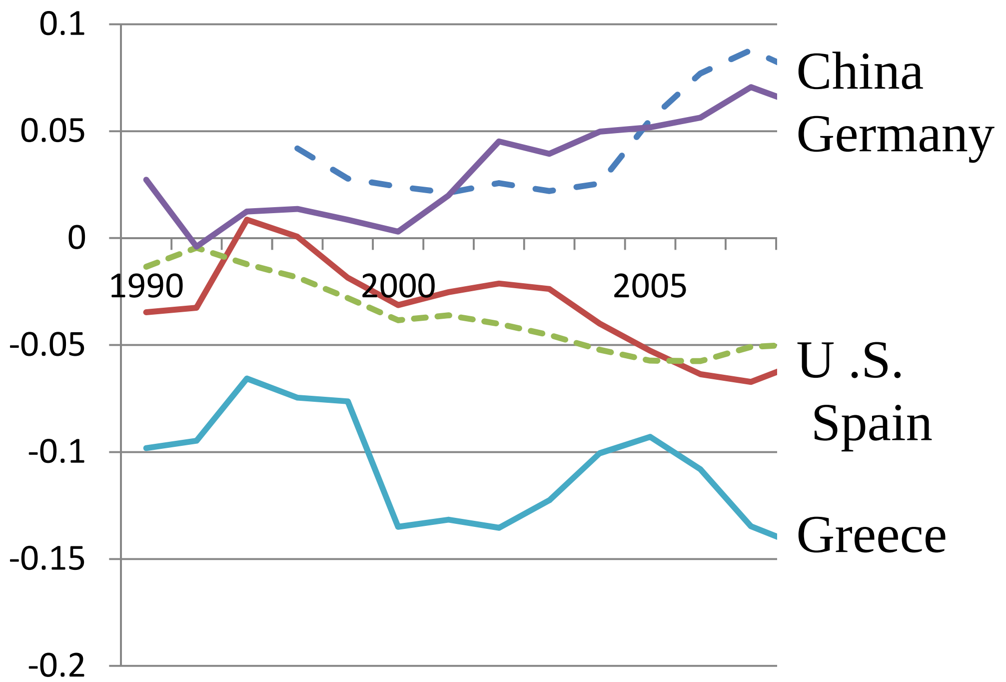
- Goods, services and income transactions measured by current account above.
- Asset transactions measured by Financial Account (FA): bonds, stocks, money, government foreign currency reserves, factories, land, ownership of bank accounts, etc.
- Debt write-offs and other special internat'l asset flows in Capital Account (KA): small category for US (ignore it here)

BOP rule: each international transaction implies two entries in BOP accounts, one positive and one negative.

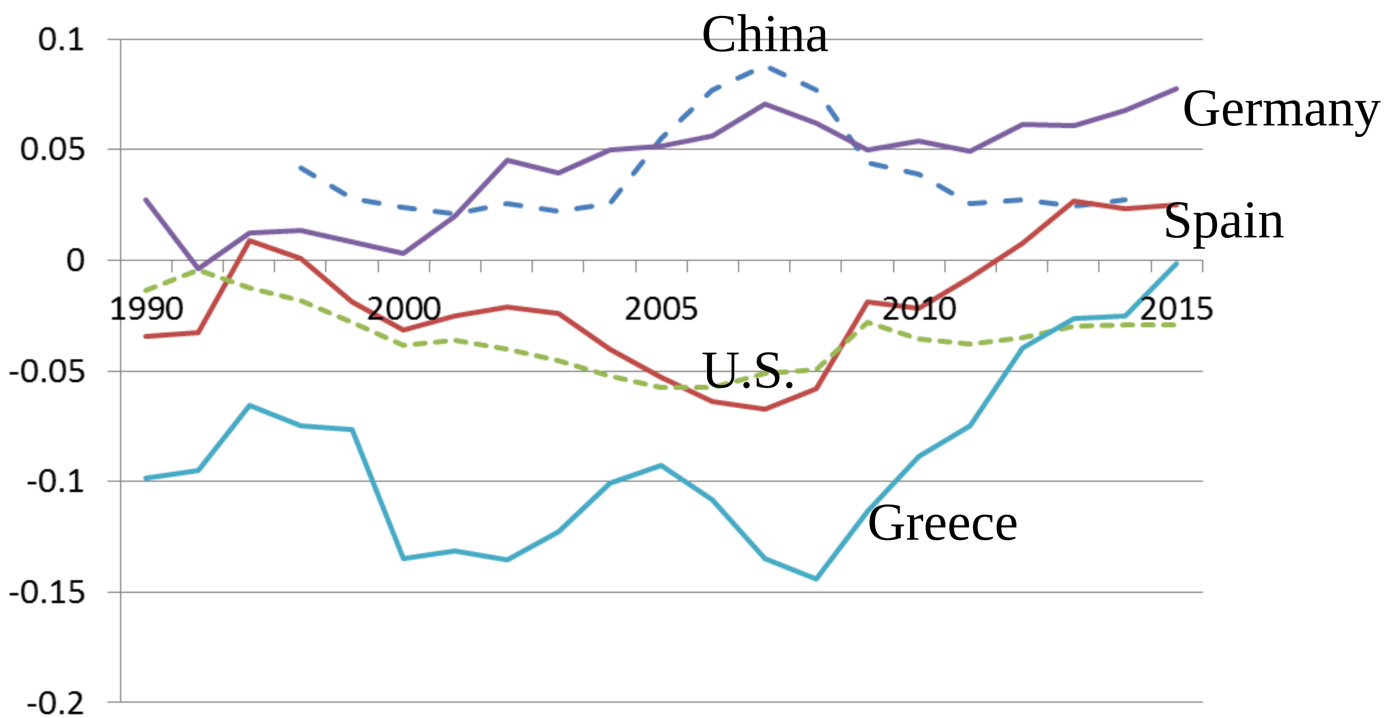
This implies the Balance of payments identity:

$$CA + FA = 0$$

CA / GNI ratios



CA / GNI ratios



Question: where are the large current account deficits/surpluses coming from? One possibility…

- Twin deficits hypothesis: tendency for government budget deficits to cause current account deficits.

- To evaluate this claim, decompose total national saving (S) into two parts. Total saving (S) =

  - public saving by the government sector
    $S_g = T - G$, where T is taxes

  - private saving by households and firms
    $S_p = Y - T - C$

$$GNDI = C + I + G + CA$$

$$CA = GNDI - C - G - I$$

$$= (GNDI - T - C) + (T - G) - I$$

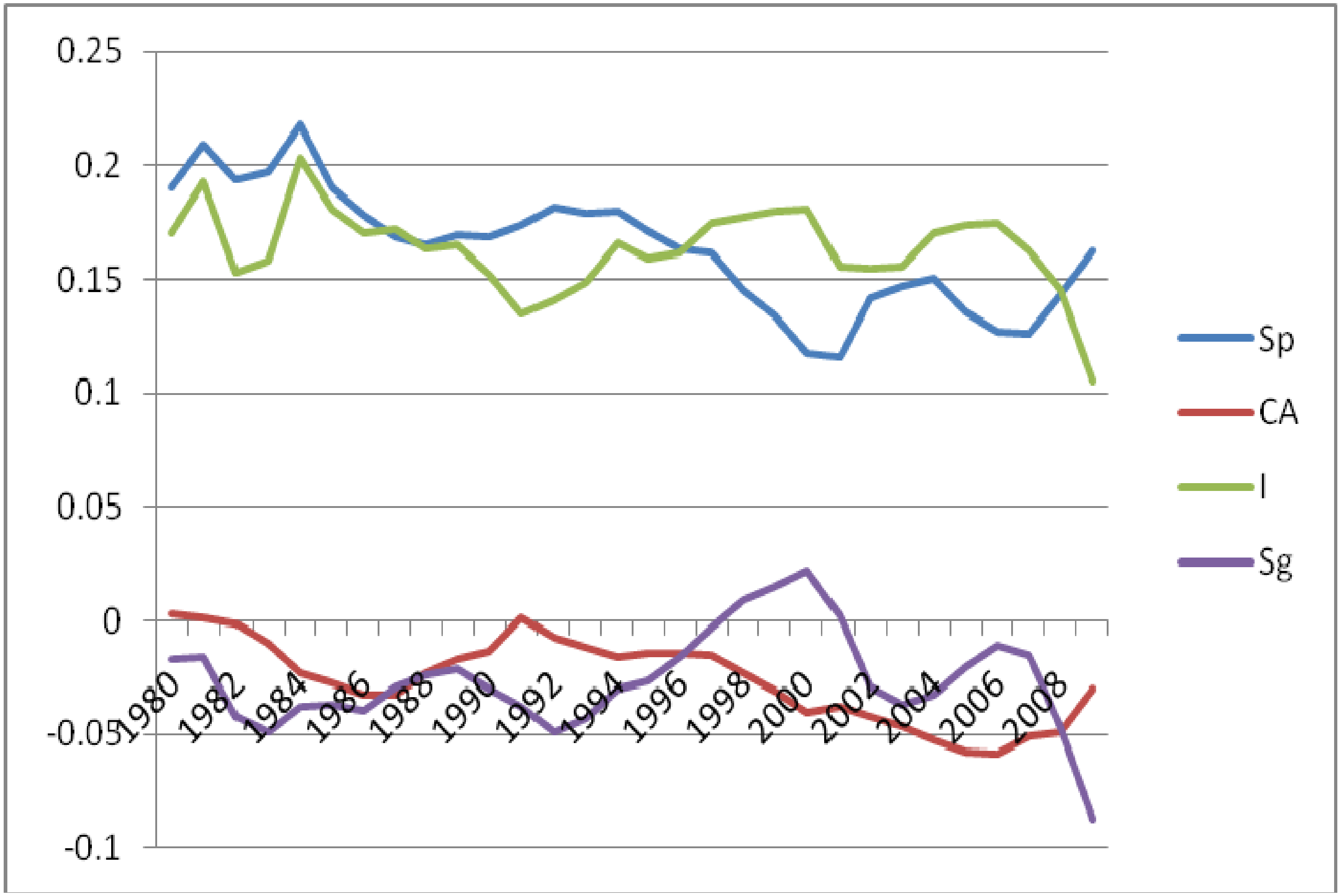
$$= s^p + s^g - I$$

$$= \text{private saving - government deficit - I}$$

- Implication: All else equal an increase in the government deficit causes an increase in the current account deficit. Is all else equal?

- In the US data below, which of these components contributes to the CA deficit?

U.S. CA and components as shares of GNDI



Souce: IFS

Questions:

- When is it justified to run a current account deficit?
- How large a deficit is too large?

The simple accounting exercises above cannot answer these questions. We need a formal model.

Part 2.
A Two-period model of the current account

Assumptions:

- **Open**: can borrow freely at the world real interest rate (*r*)
- **Small**: actions of domestic agents do not affect the world capital market. So the world interest rate is exogenous. We assume here it is fixed.
- **One world good used** for consumption (*C*).
- **Endowment economy**, with output levels (*Y*) exogenous.
- Government spending and investment also exogenous (No role for G in utility or I in production)
- **Riskless bond** is only asset (*B*)
- **Representative agent** lives two periods and chooses consumption for each period.
- Discounts future at rate β. Assume $\beta = 1/(1+r)$.
- **No uncertainty:** perfect foresight

Problem: maximize discounted sum of utility subject to the budget constraints.

$$\max_{C_1, C_2} \quad U(C_1) + \beta U(C_2)$$

$$s.t. \; Y_1 - I_1 - G_1 - C_1 = B \quad \text{period 1 budget constraint}$$

$$Y_2 + (1+r)B - I_2 - G_2 - C_2 = 0 \quad \text{period 2 budget constraint}$$

$$\text{where } \mathrm{U}(\mathrm{C}_{\mathrm{t}}) \equiv \frac{1}{1-\sigma} C_t^{1-\sigma}$$

Note that the budget constraints reflect the national income and balance of payments identities.

Period 2 budget constraint may be rewritten:

$$B = \frac{C_2 - NO_2}{1+r}$$

$$\text{where} \quad NO_t \equiv Y_t - I_t - G_t$$

Substitute this into the period 1 constraint to find the intertemporal budget constraint

$$C_1 + \frac{C_2}{1+r} = NO_1 + \frac{NO_2}{1+r}$$

An easy way to take the maximum is to use the intertemporal budget constraint to substitute out for period 2-consumption in the objective:

$$C_2 = -(1+r)C_1 + (1+r)NO_1 + NO_2$$

so

$$\max_{C_1} \quad \frac{1}{1-\sigma}(C_1)^{1-\sigma} + \beta\frac{1}{1-\sigma}\left[-(1+r)C_1 + (1+r)NO_1 + NO_2\right]^{1-\sigma}$$

Find the maximum by setting derivative equal to zero:

$$C_1^{-\sigma} + \beta\left[\left(1+r\right)C_1 - \left(1+r\right)NO_1 - NO_2\right]^{-\sigma}\left(1+r\right) = 0$$

$$C_1 + \left(\beta\left(1+r\right)\right)^{\frac{-1}{\sigma}}\left[\left(1+r\right)C_1 - \left(1+r\right)NO_1 - NO_2\right] = 0$$

Simplifies if impose our assumption that $\beta = 1/\left(1+r\right)$

$$\left(2+r\right)C_1 - \left(1+r\right)NO_1 - NO_2 = 0$$

$$\frac{2+r}{1+r}C_1 = NO_1 + \frac{NO_2}{1+r}$$

or

$$C_1 = \left(\frac{1+r}{2+r}\right)NO_1 + \left(\frac{1}{2+r}\right)NO_2$$

Note the Consumption smoothing behavior:

from above:

$$\frac{2+r}{1+r}C_1 = NO_1 + \frac{NO_2}{1+r}$$

If we substitute this back into the intertemporal budget constraint:

$$C_1 + \frac{C_2}{1+r} = NO_1 + \frac{NO_2}{1+r}$$

We get:

$$C_1 + \frac{C_2}{1+r} = \frac{2+r}{1+r}C_1$$

So $\frac{C_2}{1+r} = \frac{C_1}{1+r}$ or $C_1 = C_2$

Interpretation: household wishes to smooth consumption across time periods.

Deriving Current Account behavior:

In this context, the current account becomes:

$$CA_1 = NO_1 - C_1$$

Substitute in our solution for consumption above:

$$C_1 = \left(\frac{1+r}{2+r}\right) NO_1 + \left(\frac{1}{2+r}\right) NO_2$$

$$CA_1 = NO_1 - \left[\left(\frac{1+r}{2+r}\right) NO_1 + \left(\frac{1}{2+r}\right) NO_2\right]$$

To get:

$$CA_1 = \frac{1}{2+r}\left(NO_1 - NO_2\right)$$

Or equivalently

$$CA_1 = \frac{\beta}{1+\beta}\left(NO_1 - NO_2\right)$$

Interpretation of $CA_1 = \frac{\beta}{1+\beta}\left(NO_1 - NO_2\right)$

Current account depends on how output is expected to change over time.

Consider:

If $NO_1 > NO_2$, run CA surplus in period 1 as save for future in order to smooth consumption.

If $NO_1 < NO_2$, run CA deficit in period 1 as borrow from future in order to smooth consumption.

This logic applies to all the components of NO: output, investment, and government consumption.

Implications for the Twin Deficits Hypothesis:

To show the role of government budget deficit explicitly, we must introduce lump-sum taxes and government debt.

Define: T lump-sum taxes

B^G government issue of bonds

Note: household holdings of bonds (B) may include governement issued bonds (B^G).

Household budget constraints become:

$$Y_1 - I_1 - T_1 - C_1 = B \quad \text{period 1 budget constraint}$$

$$Y_2 + (1+r)B - I_2 - T_2 - C_2 = 0 \quad \text{period 2 budget constraint}$$

$$C_1 + \frac{1}{1+r}C_2 = (Y_1 - I_1 - T_1) + \frac{1}{1+r}(Y_2 - I_2 - T_2) \text{ intertemporal constraint}$$

<u>Government</u> has its own budget constraints:

$$B^G = G_1 - T_1 \quad \text{period 1}$$

$$(1+r)B^G = T_2 - G_2 \quad \text{period 2}$$

$$G_1 - T_1 = -\frac{1}{1+r}(G_2 - T_2) \quad \text{intertemporal}$$

Combine household and government constraints:

$$C_1 + \frac{1}{1+r}C_2 = (Y_1 - I_1 - G_1) + \frac{1}{1+r}(Y_2 - I_2 - G_2)$$

This constraint is the same as for the case we solved above, hence the optimal consumption path is the same and current account is the same.

Interpretation:

- Solution for C and CA above still holds: high government spending implies current account deficit.
- Under the assumptions in this model, the timing of the taxes does not affect consumption or the current account (Ricardian model).

Does Twin deficits hypothesis hold? It depends:

- If the government deficit results from high government spending ($G_1>G_2$), then will imply a CA deficit.
- If it results just from low taxes ($T_1<T_2$) alone, then does not imply a current account deficit.

In homework you will demonstrate this to yourself in an example.

Part 3.
An infinite horizon intertemporal current account model

Now generalize model to a representative agent living more than two periods (infinite), and to stochastic endowment.

$$Max \;\; E_t \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_s\right)$$

$$s.t. \;\; B_{s+1} - B_s = Y_s + rB_s - C_s - I_s - G_s \equiv CA_s$$

- Where Y, I and G are subject to shocks that are independently and identically distributed (i.i.d.) in each period.
- Note the role of the expectations operator.
- The budget constraint implies the BOP identity: $-FA = CA$.
- And note that it coincides with our national income accounting, where Y is GDP, and $Y + rB$ *is* GNI in the context of this model ($= GNDI$ since no NUT).

The <u>intertemporal budget constraint</u> can be computed

- by recursively substituting the single-period budget constraint into itself (as we did in two-period model)
- and imposing the condition that the present value of wealth goes to zero in the long run (transversality condition): $\lim_{s\to\infty}\left(\frac{1}{1+r}\right)^{s-t}\left(B_s\right)=0$,
- which rules out Ponzi schemes, where borrower rolls over debt forever without repayment.

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}\left(C_s+I_s+G_s\right)=\left(1+r\right)B_t+\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}\left(Y_s\right)$$

Interpretation: present value of total expenditure equals present value of total income plus initial wealth.

We need to use the tools of dynamic programming to solve for infinite horizon case…

We make use of the recursive nature of the problem facing the consumer, where we maximize the current consumption choice, conditional on the assumption that we will face the same optimization decision in all future periods.

Define a value function: the maximized value of the objective function, the discounted sum of all future utilities, given some initial value of bond holdings.

$$V\left(B_t\right) = \max_{C_s, B_{s+1}} \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_t\right)$$

Then $V\left(B_{t+1}\right)$ is the value of utility that can be obtained with a beginning level of wealth in period $s = t+1$, and $\beta V\left(B_{t+1}\right)$ would be this discounted back to period $s=t$.

So rewrite the problem as:

$$V\left(B_t\right) = \max_{C_t, B_{t+1}} \left[U\left(C_t\right) + \max_{C_{t+1}, B_{t+2}} \sum_{s=t+1}^{\infty} \beta^{s-t} E_t U\left(C_s\right) \right]$$

$$= \max_{C_t, B_{t+1}} \left[U\left(C_t\right) + \beta E_t V\left(B_{t+1}\right) \right]$$

$$s.t.\ B_{s+1} - B_s = Y_s + rB_s - C_s - I_s - G_s \equiv CA_s$$

Incorporate the constraint by a Lagrangian. This is the <u>Bellman equation</u>.

$$V_t\left(B_t\right) = \max \left\{ U\left(C_t\right) + \beta E_t \left[V_{t+1}\left(B_{t+1}\right) \right] \right\} +$$

$$\lambda_t \left(Y_t + \left(1 + r\right) B_t - C_t - I_t - G_t - B_{t+1} \right)$$

Take derivatives to find the first order conditions:

$$C_t : U'(C_t) = \lambda_t$$

$$B_{t+1} : \beta E_t\left[\frac{\partial V_{t+1}}{\partial B_{t+1}}\right] = \lambda_t$$

So: $$U'(C_t) = \beta E_t\left[\frac{\partial V_{t+1}}{\partial B_{t+1}}\right]$$

This equates the marginal utility of consuming current output to the marginal utility of allocating it to bonds and enjoying augmented consumption next period.

Now, to find $\frac{\partial V_{t+1}}{\partial B_{t+1}}$, take the derivative of the original problem (Lagrangian) with respect to B_t.

Recall $$V_t\left(B_t\right) = \max \left\{U\left(C_t\right) + \beta E_t\left[V_{t+1}\left(B_{t+1}\right)\right]\right\} +$$
$$\lambda_t\left(Y_t + \left(1+r\right)B_t - C_t - I_t - G_t - B_{t+1}\right)$$

So the derivative is: $$\frac{\partial V_t}{\partial B_t} = \lambda_t\left(1+r\right)$$

Update this one period

$$\frac{\partial V_{t+1}}{\partial B_{t+1}} = \lambda_{t+1}\left(1+r\right)$$

Combining with the FOC $U'\left(C_t\right) = \lambda_t$ we find the envelope condition:

$$\frac{\partial V_{t+1}}{\partial B_{t+1}} = U'\left(C_{t+1}\right)\left(1+r\right)$$

Combine with FOC $U'\left(C_t\right) = \beta E_t\left[\frac{\partial V_{t+1}}{\partial B_{t+1}}\right]$ to get

$$U'\left(C_t\right) = \beta\left(1+r\right)E_t\left[U'\left(C_{t+1}\right)\right]$$

Or under our assumption $\beta = \dfrac{1}{1+r}$

$$U'(C_t) = E_t\left[U'(C_{t+1})\right]$$

The optimal behavior is to smooth marginal utility of consumption in expectation.

Under our assumed utility function: $U(C_t) = C_t - \dfrac{1}{2}C_t^2$

This is
$$1 - C_t = E_t\left[1 - C_{t+1}\right]$$
$$or \quad C_t = E_t\left[C_{t+1}\right]$$

This implies the same intertemporal consumption smoothing as found in the two-period model.

Next: we wish to derive the <u>current account implications</u>:

Recall that the intertemporal budget constraint states:

$$\sum_{s=t}^{\infty} \beta^{s-t} \left(C_s + I_s + G_s \right) = \left(1+r\right) B_t + \sum_{s=t}^{\infty} \beta^{s-t} \left(Y_s \right)$$

Regroup and impose expectations, since the constraint must hold ex-ante as well as ex-post:

$$\sum_{s=t}^{\infty} \beta^{s-t} E_t \left(C_s \right) = \left(1+r\right) B_t + \sum_{s=t}^{\infty} \beta^{s-t} E_t \left(Y_s - I_s - G_s \right)$$

Substitute the Euler equation $C_t = E_t \left[C_{t+1} \right]$ recursively for expected consumption, and rearrange:

$$\sum_{s=t}^{\infty} \beta^{s-t} C_t = \left(1+r\right) B_t + \sum_{s=t}^{\infty} \beta^{s-t} E_t \left(Y_s - I_s - G_s \right).$$

$$C_t = rB_t + (1-\beta)\sum_{s=t}^{\infty}\beta^{s-t}E_t\left(NO_s\right)$$

Substitute back into the single-period budget constraint:

$$CA_t = Y_t + rB_t - I_t - G_t - C_t = NO_t + rB_t - C_t$$

$$= \left(NO_t\right) - (1-\beta)\sum_{s=t}^{\infty}\beta^{s-t}E_t\left[NO_s\right]$$

or $$CA_t = \beta\left(NO_t\right) - (1-\beta)\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left[NO_s\right]$$

This indicates that most of a temporary rise in net output will be saved: country will run a positive current account.

A permanent rise in net output, however, will lead to no increased saving, and no change in the current account.

Writing this in terms of "permanent net output":

- Define permanent value of a net output $\tilde{N}O_t$:

- Want present value of this constant value at t to be equal to the present value of the real variable (*NOs*):

$$\sum_{s=t}^{\infty} \beta^{s-t} \tilde{N}O_t = \sum_{s=t}^{\infty} \beta^{s-t} NO_s$$

- This means that the term on the RHS of equation on previous page equals $\tilde{N}O_t$

$$(1-\beta) \sum_{s=t}^{\infty} \beta^{s-t} E_t \left[NO_s \right] = \tilde{N}O_t$$

- So write current account equation:

$$CA_t = NO_t - \tilde{N}O_t$$

- Interpret: if net output rises above its permanent level, the extra income will be saved, raising the CA.

Conclusions:

So effect of shock to net output on consumption and hence CA depends on if shock is temporary or permanent:

If **temporary**: just affect NO_t, then C rises by (1-beta) times this, and rest is saved and raises CA.

$$\Delta C_t = \left(1-\beta\right)\Delta NO_t$$

$$\Delta CA_t = \beta \Delta NO_t$$

If **permanent**, NO rises for current and all future periods, then:

$$\Delta C_t = \Delta NO_t$$

$$\Delta CA_t = 0$$

Consider an <u>intermediate degree of permanence</u>.

Say: $NO_t - \overline{NO} = \rho\left(NO_{t-1} - \overline{NO}\right) + \varepsilon_t$

Where shock is serially uncorrelated disturbance,

$E_t\left[\varepsilon_s\right] = 0,\ 0 \le \rho \le 1$

Means: $E_t\left[NO_s - \overline{NO}\right] = \rho^{s-t}\left(NO_t - \overline{NO}\right)$

Derivation: can skip in class:

$$CA_t = \beta\left(NO_t\right) - \left(1-\beta\right)\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left[NO_s\right]$$

$$= \beta\left(NO_t - \overline{NO}\right) - \left(1-\beta\right)\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left(NO_s - \overline{NO}\right)$$

$$= \beta\rho\left(NO_{t-1} - \overline{NO}\right) + \beta\varepsilon_t - \left(1-\beta\right)\sum_{s=t+1}^{\infty}\beta^{s-t}\rho^{s-t}\left[\rho\left(NO_{t-1} - \overline{NO}\right) + \varepsilon_t\right]$$

$$= \beta\rho\left(NO_{t-1} - \overline{NO}\right) + \beta\varepsilon_t$$

$$-\left(1-\beta\right)\rho\frac{\beta\rho}{1-\beta\rho}\left(NO_{t-1} - \overline{NO}\right) - \left(1-\beta\right)\frac{\beta\rho}{1-\beta\rho}\varepsilon_t$$

$$= \frac{\beta\rho\left(1-\rho\right)}{1-\beta\rho}\left(NO_{t-1} - \overline{NO}\right) + \frac{\beta\left(1-\rho\right)}{1-\beta\rho}\varepsilon_t$$

result:

$$CA_t = \frac{\beta\rho\left(1-\rho\right)}{1-\beta\rho}\left(NO_{t-1} - \overline{NO}\right) + \frac{\beta\left(1-\rho\right)}{1-\beta\rho}\varepsilon_t$$

So there is a predictable component to CA, which disappears if rho equals 1 or zero: either extreme. But in middle range, a shock leads to predictable deviations in current account in future periods.

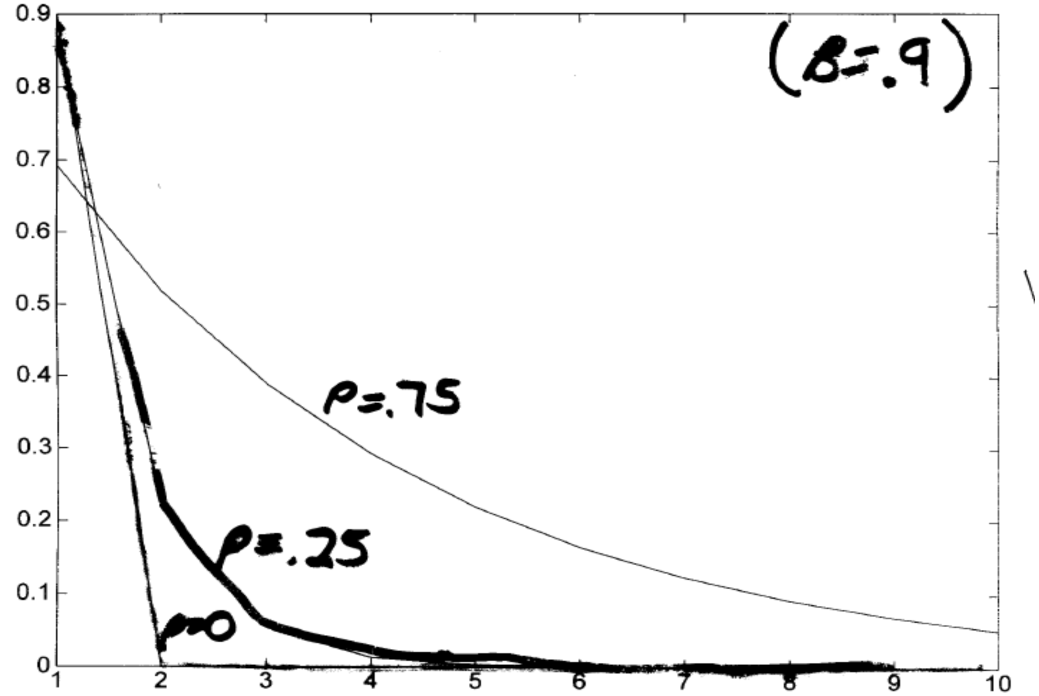
In case of rho=0: get same result as before: CA rises by Beta*shock & no effect in future periods.

In case of rho=1: get same result as before: no change in CA & no effect in future periods.

In between: shock has partial effect on CA in t, and has some effect to raise CA in future periods as well.

Simulations:

CA



Where is $\rho=1$?

Part 4: Empirical Tests

How useful is this theory? Is it true?

- Sheffrin and Woo (JIE 1990) were first to adapt for the intertemporal theory of the CA an estimation strategy used by Campbell to test consumption theory.
- Idea: Present value test: take basic prediction of the intertemporal model and superimpose over a VAR.

- Recall basic prediction (Present-value restriction):

$$CA_t = \beta\left(NO_t\right) - \left(1-\beta\right)\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left[NO_s\right]$$

$$= -\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left[NO_s - NO_{s-1}\right]$$

- To make operational, need proxy for expectations of change in net output. One way is use lags of net output.

- But households have more information at date t. So regress change in net output on current CA as well, which contains information on what households expect for NO.

- So run a VAR to determine what households best forecast is for change in net output.

$$\begin{bmatrix} \Delta NO_s \\ CA_s \end{bmatrix} = \begin{bmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{bmatrix} \begin{bmatrix} \Delta NO_{s-1} \\ CA_{s-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1s} \\ \varepsilon_{2s} \end{bmatrix}$$

- Get consumers' forecasts:

$$E_t \begin{bmatrix} \Delta NO_s \\ CA_s \end{bmatrix} = \begin{bmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{bmatrix}^{s-t} \begin{bmatrix} \Delta NO_t \\ CA_t \end{bmatrix}$$

- Can get forecast of CA alone by premultiplying rhs by vector [0 1], or forecast of NO by premultiplying by [1 0]. Represent coefficient matrix with: Ψ.

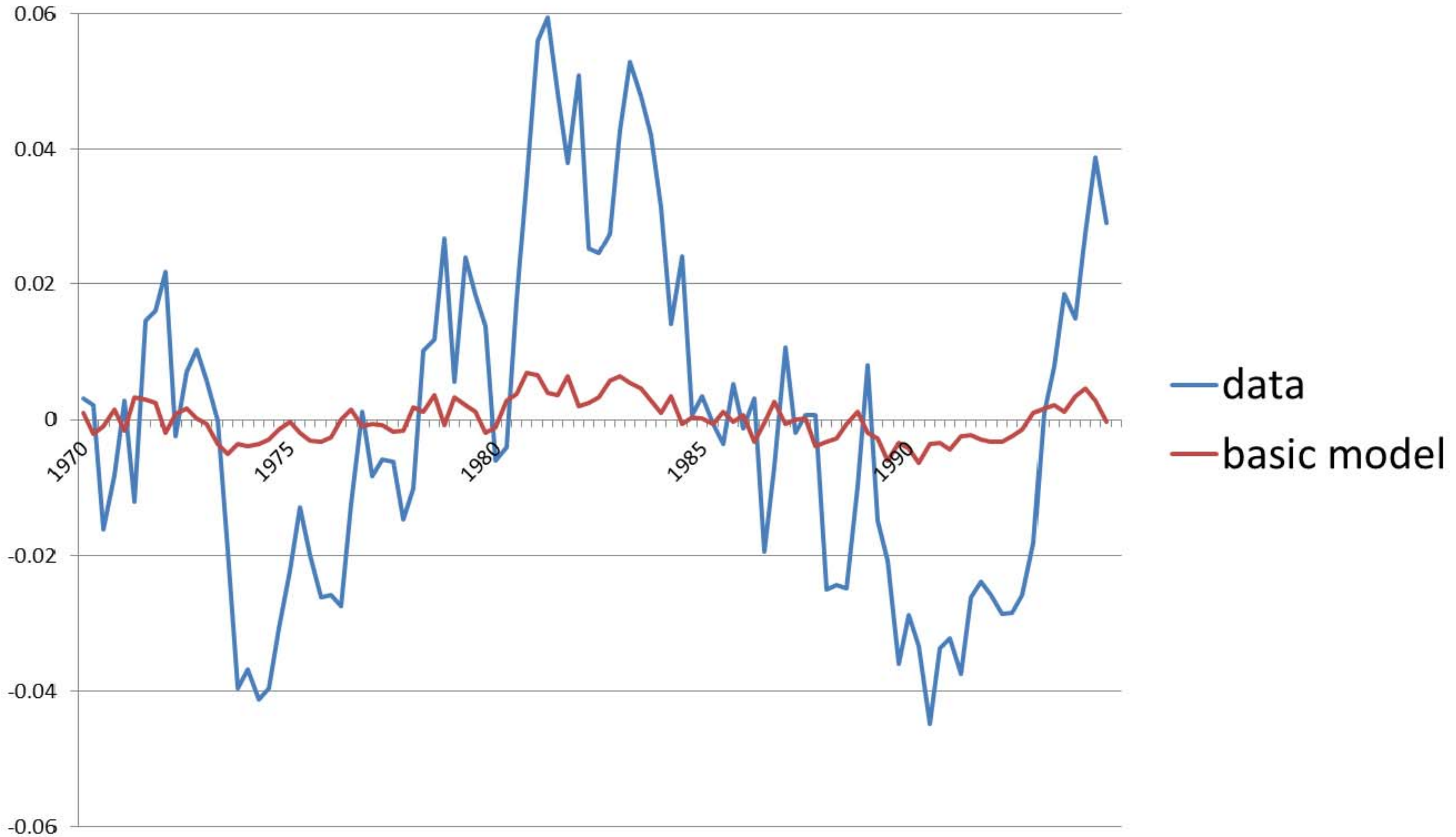
  And get rhs of present-value condition using this VAR:

$$\hat{C}A_t = -\begin{bmatrix}1 & 0\end{bmatrix}\beta\Psi\left(I-\beta\Psi\right)^{-1}\begin{bmatrix}\Delta NO_t \\ CA_t\end{bmatrix}$$

$$\equiv\begin{bmatrix}\Phi_{\Delta NO} & \Phi_{CA}\end{bmatrix}\begin{bmatrix}\Delta NO_t \\ CA_t\end{bmatrix} = K\begin{bmatrix}\Delta NO_t \\ CA_t\end{bmatrix}$$

- Note that CA in t is in info set we use to test present value condition. So test is whether the CA hat produced using condition is close to data on CA at t.

Basic PV model fit to data for Canada:



Model captures sign of CA changes; under-predicts volatility.

Part 5: Extensions to the intertemporal model

- Can also improve empirical performance by augmenting shocks: interest rates and relative prices.
- Theory from Dornbusch (JPE 1983); made empirical by Bergin and Sheffrin (2000); extended in Campa (2006) and Hoffmann (2010).

Problem: retain assumptions of simple model, plus:

- household consumes two types of goods, one tradable (T) and the other nontradable (N).
- Price of N in terms of T is p_t.
- Return on bonds (r_t).
- Assume perfect foresight for simplicity.

$$Max \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_{T,s}, C_{N,s}\right)$$

$$s.t. \;\; NO_s + r_s B_s - \left(C_{T,s} + p_s C_{N,s}\right) = B_{s+1} - B_s$$

$$where \;\; U\left(C_{T,s}, C_{N,s}\right) = \frac{\sigma}{\sigma - 1}\left(C^{\theta}{}_{T,s} C^{1-\theta}{}_{N,s}\right)^{\frac{\sigma-1}{\sigma}}$$

- Where everything is measured in units of traded goods.

- The <u>inter</u>temporal elasticity of substitution is σ.

- What is the <u>intra</u>temporal elasticity between traded and nontraded goods? (Hint: Cobb-Douglas functional form).

FOCs give intertemporal and intratemporal condition.

- Intratemporal tradeoff between two goods within period

$$\frac{U'_{Nt}}{U'_{Tt}} = p_t$$

- Intertemporal tradeoff between periods, either in terms of traded goods:

$$\frac{U'_{Tt}}{U'_{Tt+1}} = \beta\left(1 + r_{t+1}\right)$$

Solve for CA using budget constraint:

$$CA_t = NO_{T,t} + p_t NO_{N,t} + r_t B_t - \left(C_{T,t} + p_t C_{N,t}\right)$$

and market clearing for nontradeds: $NO_{N,t} = C_{N,t}$

So: $CA_t = NO_{T,t} + r_t B_t - C_{T,t}$

We want to understand the determination of $C_{T,t}$.

Use intertemporal FOC for tradeds:

$$\frac{U'_{Tt}}{U'_{Tt+1}} = \beta\left(1+r_{t+1}\right) \text{ where } U'_{T,t} = \theta\left(C_{T,t}{}^{\theta} C_{N,t}{}^{1-\theta}\right)^{-\frac{1}{\sigma}} \left(\frac{C_{T,t}}{C_{N,t}}\right)^{\theta-1}$$

with intratemporal FOC: $C_{N,t} = \frac{1-\theta}{\theta}\frac{C_{T,t}}{p_t}$, to compute:

$$\left(\frac{C_{T,t}}{C_{T,t+1}}\right) = \beta^{-\sigma}\left(1+r_{t+1}\right)^{-\sigma}\left(\frac{p_t}{p_{t+1}}\right)^{-(\sigma-1)(1-\theta)} = \beta^{-\sigma}\left(1+r^{c}{}_{t+1}\right)^{-\sigma}$$

where define a “consumption-based real interest rate”:

$$1+r^{c}_{t+1} = \left(1+r_{t+1}\right)\left(\frac{p_t}{p_{t+1}}\right)^{\frac{(\sigma-1)}{\sigma}(1-\theta)}$$

combining effect of interest rate in terms of T goods, and changes over time in the relative price of N to T goods.

Interpret this intertemporal condition:

$$\left(\frac{C_{T,t}}{C_{T,t+1}}\right) = \beta^{-\sigma}\left(1+r_{t+1}\right)^{-\sigma}\left(\frac{p_t}{p_{t+1}}\right)^{-(\sigma-1)(1-\theta)} = \beta^{-\sigma}\left(1+r^{c}{}_{t+1}\right)^{-\sigma}$$

1) A rise in the conventional interest rate (r):

- borrowing to finance extra consumption more expensive,
- so traded consumption today will fall relative to the future
- by elasticity σ.
- This raises the current account.

Interpret this intertemporal condition, cont:

$$\left(\frac{C_{T,t}}{C_{T,t+1}}\right) = \beta^{-\sigma}\left(1+r_{t+1}\right)^{-\sigma}\left(\frac{p_t}{p_{t+1}}\right)^{-(\sigma-1)(1-\theta)} = \beta^{-\sigma}\left(1+r^{c}{}_{t+1}\right)^{-\sigma}$$

2) <u>A rise in current p relative to future (rise in p_t / p_{t+1}).</u>

- implies a fall in the price of N goods in future, that is, a rise in the price of T goods in future

- Similar to rise in r, since debt repaid in terms of traded goods, which become more expensive when bonds due.

- Lowers current traded consumption relative to future by elasticity $(\sigma-1)(1-\theta)$.

- Which raises the current account by that amount.

- Note: sign could be reversed if $\sigma < 1$. (tricky).

Empirical tests of the extended model:

- Idea:Test equation with consumption based real interest rate: use world real interest rate data and real exchange rate as proxy for relative prices of goods.

Method:

- Log linearize IBC and impose linearized version of condition above: gives condition to test:

$$CA*_t = -E\sum_{i=1}^{\infty} \beta^i \left[\Delta no_{t+i} - \sigma r^c{}_{t+i} \right]$$

  where CA* is a log-linearized version of CA components, and r^c is consumption based real interest rate from before.

- Similar to Sheffrin-Woo, where CA was function just of expected change in NO, now includes also r^c

- Do VAR on the three variables: Z is vector: CA*, ΔNO, and r^c.

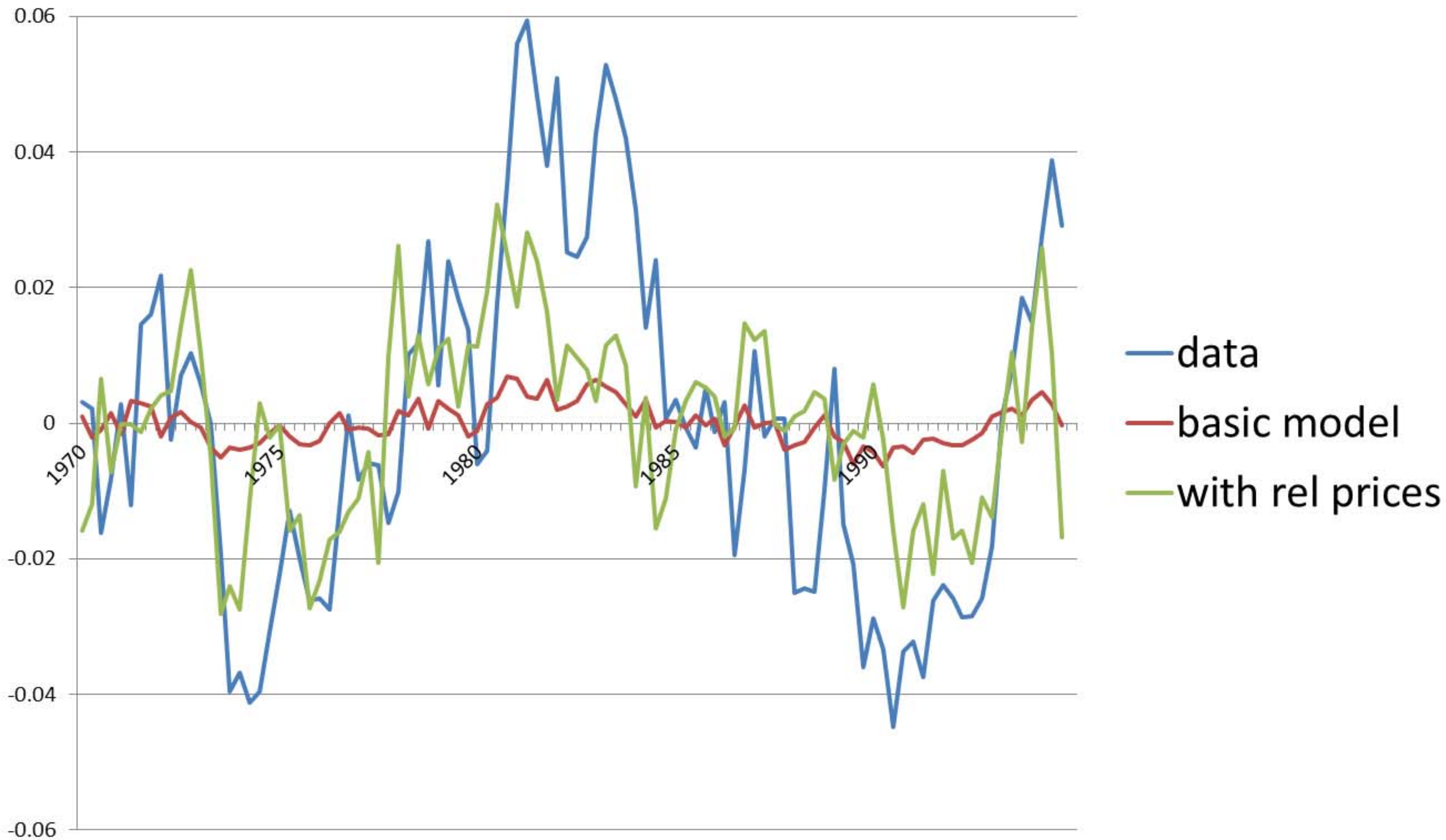
- Again use CA condition to compute CA prediction using forecast of variables from VAR

$$\hat{C}A_t^* = KZ_t$$

where

$$K = -\left(\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} - \sigma \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \right) \beta A \left[I - \beta A \right]^{-1}$$

PV model with relative prices fit to data for Canada:



Better matches CA volatility.

<u>A useful extension: Habits</u>

- Empirical results become very good if the underlying preferences are extended to be non-time separable.

- Consider a specification of preferences with habits:

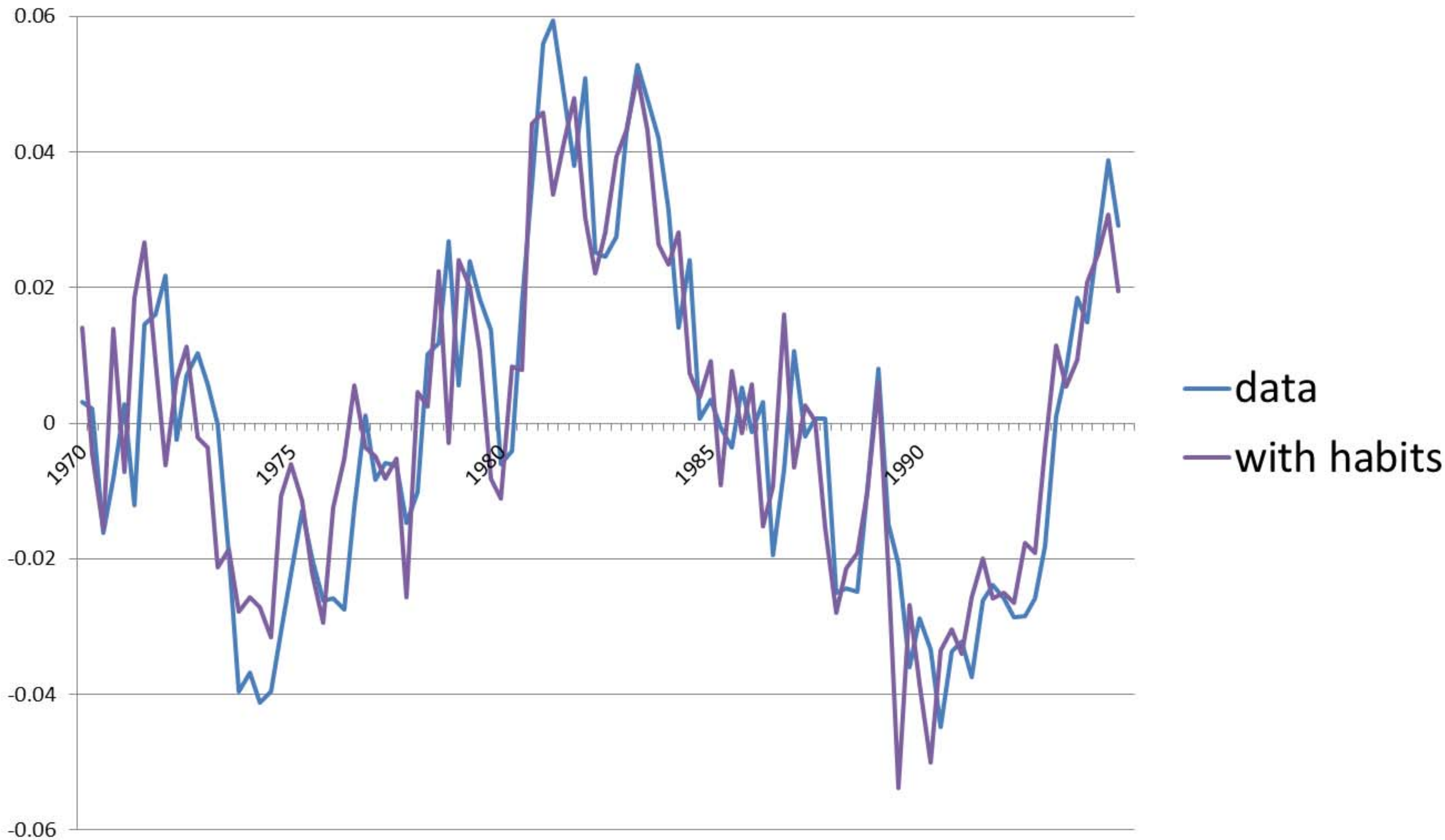
$$U_s = u\left(C_s - \gamma C_{s-1}\right) = u\left(\left(1-\gamma\right)C_s + \gamma\left(\Delta C_s\right)\right)$$

  where γ shows the role of habits.

- This will imply intertemporal smoothing of consumption <u>changes</u> rather than of consumption <u>levels</u>.

- So that permanent shocks will not translate fully into immediate consumption change; they will pass in part into saving, and greater current account fluctuations.

PV model with habits fit to data for Canada:



Model fits sign of CA changes and volatility.

Part 6: Class discussion:

Hoffmann (2013): What Drives China’s Current Account?

or

Campa and Gavilan (2011): Current accounts in the euro area: An intertemporal approach

Questions for Discussion for Hoffmann (2013)

1) What find most interesting about the paper?

2) What is the question paper is trying to answer?

3) How is the methodology similar to what studied in lecture; how extended it?

4) Discuss data: what are difficulties with dataset?

5) What are main results?
a) Model fit:
b) Decomposition into PV components: what component is most important? Explain theory of how works.

6) Offer critiques of methods and findings. Offer other explanations for high saving and CA surplus in China?

Questions for further discussion for Campa-Gavilan (2011):

1) Do you think the CA deficits of Spain and Portugal reflect greater financial integration in the EU?

2) Are the CA deficits justified?

3) Are they beneficial to people in Spain? How about for people in Germany?

4) The US is also running historically high CA deficits. What might be the cause or justification there?

5) Consider the role of world interest rates and savings.

Part 7: Investment in an intertemporal CA model

a) Motivation:

- Investment is volatile and is the cause of much of the short-run fluctuations in the CA. It is important to include in our intertemporal CA model a theory of investment.

Some stylized facts:

- cor(CA,I) = -0.4 on average for G7 in post '75 period
- cor(S,I) = 0.6 on average for G7 (about 0.9 for US)
- Note that our simple model of the previous lecture suggests the latter correlation would be zero.

Cross-sectional evidence: Feldstein and Horioka (1980)

- This was the first paper to document and popularize the saving-investment correlation puzzle: a high cor(S,I).

- This is often taken as evidence of lack of capital mobility. It appears that changes in national saving pass through almost completely to investment in the country.

Data:

- Compute the saving rate and investment rate for each country, averaged over a 15 year period.

- The saving rate in each country is very close to the investment rate in that country.

Examples:

country	S/Y	I/Y	(average rates over 1960-74)
USA	0.186	0.186	(lowest in sample)
Japan	0.372	0.368	(highest)
Germany	0.271	0.264	

Test: Run cross-sectional regressions, using the 15-year averages for 16 OECD countries.

$$(I/Y)_i = \alpha + \beta(S/Y)_i + u_i \quad \text{for country } i$$

- If capital is mobile (and other assumptions) then beta should be close to zero.
- If no capital mobility, then beta would be close to unity.

Results: estimate of beta:
Full sample (60-74): 0.887 (std error = 0.074)

b) Theoretical Explanations

Basic Explanation 1: Global shocks

- If the shock driving investment is global, the country cannot borrow because all countries would like to borrow.
- With no country willing to lend, interest rates rise and no one borrows.

Basic Explanation 2: Technology shocks:

- Consider a temporary rise in productivity that raises the marginal product of capital:
- Temporary rise in output raises saving
- Rise in marginal product of capital raises investment
- So saving and investment may move together.

Illustrate explanation 2: Small open economy with Invest.

features:

- As before: fixed world interest rate, real bond is only asset
- New: output is a function of capital and technology, (no depreciation or adjustment cost on investment)
- Abstract away from government spending.

Problem:

$$Max \quad E_t \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_s\right)$$

$$s.t. \quad B_{t+1} - B_t = Y_t + rB_t - C_t - I_t \equiv CA_t$$

$$Y_t = A_t F\left(K_{t-1}\right)$$

$$I_t = K_t - K_{t-1}$$

Implications:

- Consumption smoothing under quadratic utility (as before)

$$U'_t = (1+r)\beta E_t\left[U'_{t+1}\right]$$

$$C_t = E_t\left[C_{t+1}\right]$$

- Implies usual current account equation:

$$CA_t = Y_t - I_t - C_t$$

$$= \beta(Y_t - I_t) - (1-\beta)\sum_{s=t+1}^{\infty}\beta^{s-t}E_t\left[Y_s - I_s\right]$$

- We will focus on two cases: completely temporary shocks or completely permanent shocks.

- In these two extremes, all future periods will be the same as each other, so we can simplify the condition above:

$$CA_t = \beta(Y_t - I_t) - \beta E_t\left(Y_{t+1} - I_{t+1}\right)$$

- So to find current account, we need to trace out what happens to output and investment now and in the future:

What determines investment and output:
- First order condition governing capital accumulation:

$$1 = E_t\left[\left(1 + A_{t+1}F'(K_t)\right)\beta\frac{U'_{t+1}}{U'_t}\right]$$

$$= E_t\left[\left(1 + A_{t+1}F'(K_t)\right)\right]E_t\left[\beta\frac{U'_{t+1}}{U'_t}\right] + \mathrm{cov}\left[\left(1 + A_{t+1}F'(K_t)\right), \beta\frac{U'_{t+1}}{U'_t}\right]$$

- Use consumption smoothing equation, and abstract from covariance term for now:

$$E_t\left[A_{t+1}F'(K_t)\right] = r$$

= So accumulate capital until the *expected future* marginal product equals world real interest rate.

- Under a Cobb-Douglas production function, $F\left(K_{t-1}\right) = K^{\alpha}{}_{t-1}$

  This says: $K_t = \left(\dfrac{\alpha}{r} E_t\left[A_{t+1}\right]\right)^{\frac{1}{1-\alpha}}$

  So $Y_t = A_t\left(\dfrac{\alpha}{r} E_{t-1}\left[A_t\right]\right)^{\frac{\alpha}{1-\alpha}}$ This depends on last period's expectations.

- So investment is:

$$I_t = K_t - K_{t-1} = \left(\frac{\alpha}{r} E_t\left[A_{t+1}\right]\right)^{\frac{1}{1-\alpha}} - \left(\frac{\alpha}{r} E_{t-1}\left[A_t\right]\right)^{\frac{1}{1-\alpha}}$$

Specify the shock process:

Shock: $A_s - \overline{A} = \rho\left(A_{s-1} - \overline{A}\right) + \varepsilon_s$

Where $0 \le \rho \le 1$ indicates persistence.
ε_s is a serially uncorrelated shock with $E_{s-1}\left[\varepsilon_s\right] = 0$

We begin by studying the two extreme cases, where analytical solution is possible: $\rho = 0$ and $\rho = 1$.

Consider case 1: <u>Temporary shock to productivity:</u>

Shock: $A_s - \overline{A} = \rho\left(A_{s-1} - \overline{A}\right) + \varepsilon_s$

$\rho = 0, \quad \varepsilon_t > 0 \quad so \quad A_t > \overline{A}$ in period t

Steady state: $\overline{CA} = 0,\ \overline{I} = 0, \quad \overline{K} = \left(\frac{\alpha}{r}\overline{A}\right)^{\frac{1}{1-\alpha}},\ \overline{Y} = \overline{A}\overline{K}^{\alpha}$

Use equations above to find investment and output:

$$I_t = K_t - K_{t-1} = \left(\frac{\alpha}{r}E_t\left[A_{t+1}\right]\right)^{\frac{1}{1-\alpha}} - \left(\frac{\alpha}{r}E_{t-1}\left[A_t\right]\right)^{\frac{1}{1-\alpha}} = \left(\frac{\alpha}{r}\overline{A}\right)^{\frac{1}{1-\alpha}} - \left(\frac{\alpha}{r}\overline{A}\right)^{\frac{1}{1-\alpha}}$$

= 0

$$E_t\left[I_{t+1}\right] = E_t\left[K_{t+1}\right] - K_t = \left(\frac{\alpha}{r}E_{t+1}\left[A_{t+2}\right]\right)^{\frac{1}{1-\alpha}} - \left(\frac{\alpha}{r}E_t\left[A_{t+1}\right]\right)^{\frac{1}{1-\alpha}} = \overline{K} - \overline{K} = 0$$

$$Y_t = A_t \overline{K}^{\alpha} > \overline{Y}$$

$$E_t\left[Y_{t+1}\right] = \overline{A}\overline{K}^{\alpha} = \overline{Y}$$

Note that the capital stock is unaffected in period t.

Plug into current account equation from above:

$$CA_t = \beta\left(Y_t - E_t Y_{t+1} - I_t + E_t I_{t+1}\right) = \beta(Y_t - \overline{Y})$$

This is just like the effect of a temporary endowment shock in previous models.

Consider case 2: Permanent shock to technology:

Shock: $\rho = 1, \quad \varepsilon_t > 0 \quad so \quad A_t > \overline{A}$ in period t

and $\mathrm{E}_t \left[A_{t+1} \right] = A_t > \overline{A}$ in period t+1

Use equations above to find investment and output:

$$I_t = K_t - K_{t-1} = \left(\frac{\alpha}{r} A_t \right)^{\frac{1}{1-\alpha}} - \left(\frac{\alpha}{r} \overline{A} \right)^{\frac{1}{1-\alpha}} > 0$$

$$E_t \left[I_{t+1} \right] = 0$$

$$Y_t = A_t \overline{K}^{\alpha} > \overline{Y} \quad (Same \; value \; as \; in \; temporary \; case)$$

$$E_t \left[Y_{t+1} \right] = A_t \left(\frac{\alpha}{r} A_t \right)^{\frac{\alpha}{1-\alpha}} > Y_t > \overline{Y}$$

Plug into current account equation from above:

$$CA_t = \beta\left(Y_t - E_t\left[Y_{t+1}\right] - I_t + E_t\left[I_{t+1}\right]\right) < 0$$

The current account now falls. This is for two reasons:

- First output in future periods is higher than the current period, so consumption smoothing makes consumption higher than current income, so saving falls.

- Second, this is compounded by the fact that there is a rise in investment, dragging the current account down further.

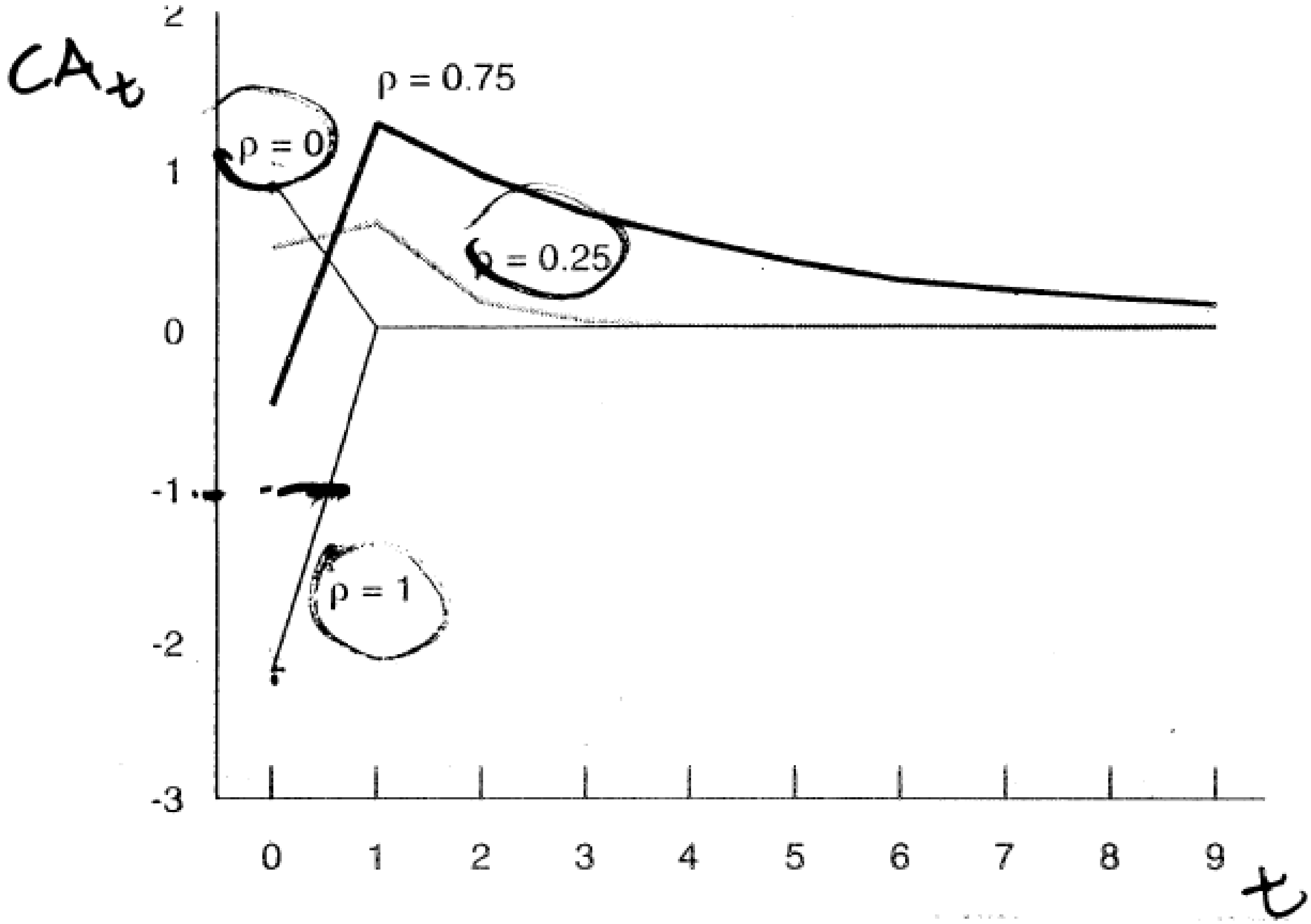
- Note that since $\Delta CA_t = \Delta S_t - \Delta I_t$ and saving is falling while investment is rising, this implies that the **fall in the current account is larger than the change in investment:** $\left|\Delta CA_t\right| > \left|\Delta I_t\right|$

To summarize: A temporary positive technology shock leads to a current account surplus; a permanent positive technology shock leads to a large deficit.

We can consider cases between these two extremes, where

$$\left(A_s - \overline{A}\right) = \rho\left(A_{s-1} - \overline{A}\right) + \varepsilon_s \qquad 0< \rho <1$$

These intermediate cases lead to current account balances closer to zero, with saving and investment moving more closely together. See figure.



CA_t
ρ = 0.75
ρ = 0
ρ = 0.25
ρ = 1
2
1
0
-1
-2
-3
0
1
2
3
4
5
6
7
8
9
t

c) Empirical Test (Glick and Rogoff, JME 1995)

idea: Try some simple tests of the predictions of the theoretical models discussed above.

- Get estimates of technology by computing a Solow residual

$$\log(A) = \log(Y) - \alpha \log(L)$$

(Note that this measure ignores changes in capital input.)

The labor share parameter is calibrated based on the OECD database, min 0.48 for Italy, max 0.68 for U.K.

- Theory distinguishes between the effects of world technology shocks (A^w) and country-specific shocks (A^c).

- Measure the global shock as the average over the G7.

- Measure the country-specific as difference between Solow residual of a country with the G7 average.

- These technology shocks are very persistent. Dickey-Fuller tests show we cannot reject nonstationarity.

- So the analysis of the "fully permanent" case of the model earlier in the lecture may apply here.

- The form of their regressions is as follows:

$$\Delta I_t = a_0 + a_1 \Delta A^c_t + a_2 \Delta A^w_t + a_3 I_{t-1}$$

$$\Delta CA_t = b_0 + b_1 \Delta A^c_t + b_2 \Delta A^w_t + b_3 I_{t-1}$$

- Note: These regression equations presume that technology shocks follow a random walk. Otherwise they would involve some additional lagged terms representing dynamics.

Intertemporal theory predicts:

- $a_1>0$, $b_1<0$ $\uparrow A^c \rightarrow \uparrow$ I and $\downarrow$ CA
- abs(b_1)> a_1 because S falls if Ac is permanent (and data can't reject that techno shocks are permanent)
- $a_2>0$, $b_2=0$ $\uparrow A^w \rightarrow \uparrow$ I, can't borrow, so no change in CA

Results:

For the pooled regressions over all countries: (See table 4)

- a1 = 0.35, b1 = -0.17, a2>0 and significant
- b2 not signif dif from zero
- But reject abs(b1) > a1: saving not fall in Ac shock.

- The regression results for each country are generally very consistent with main hypotheses.

- For the investment equation: the coefficients all the right sign, and significantly so in 80% of the cases.

- For the CA equation: right sign for persistent shocks: country-specific shocks lower the current account, world shocks have small effects not significantly different from zero (true for all countries except UK)

Conclusions:

- Generally supportive of main predictions of the theory.

- Why reject last one: perhaps techno shock is not totally permanent. Data cannot reject unit root, but also cannot reject other values little below it.

- Show by simulation that if rho lowered a bit (0.97), it counterbalances effect of lagged output rise with capital.

- So income is higher on impact than pdv of future income, so saving rises and CA falls less than I rises. (See table 9)

Table 9
Rho is the AR coefficient,
Beta2 is the change in investment
Gamma2 is the change in current account

ρ	β_2	γ_2	$\lvert\gamma_2\rvert/\beta_2$
1.00	0.35	−0.97	2.76
0.99	0.35	−0.60	1.72
0.98	0.34	−0.35	1.04
0.97	0.32	−0.21	0.64
0.96	0.31	−0.04	0.13
0.95	0.30	0.05	0.18