INTRODUCTION

- These Lectures are something of a potpourri.
- The common thread is the growth process.
- What we have learned about it.
- How we can learn more about it.
- How we measure it.
- And the conceptual framework from which to view it.
- The soup will be salted by some gripes and grousings from this ancient mariner, mostly about the methods employed by some authors in their studies of economic growth.

- One of the threads that we will be following is the Two Deflator Method.
- For now, we will see how it is used with national aggregate data.
- The Traditional Method is often presented using an aggregate production function.

1. \( Y = \Lambda, \Phi(K, L) \)
2. \( \frac{dY}{dt} = \Phi_s \frac{dA}{dt} + \Phi_k \frac{dK}{dt} + \Phi_l \frac{dl}{dt} \)

Dividing by \( Y \), with a homogeneous of degree one production function, we get.

3. \( \delta_r = \delta_s + s_x \delta_s + s_t \delta_t \)

- Be forewarned. The presentation will not be very orderly.
- Different strands of ideas will weave in and out as the presentation proceeds.
- The lectures are demarcated not by conceptual or substantive results, but by areas of work.
- Today: Working with national aggregate data.
- Tomorrow: Working with data on industries and firms.
- Friday: Tasks and challenges for future work.

- Perpetual Inventory Approach:
  Traditional Method Capital Stock
  \( K_s = (1-\delta)K_{s-1} + \frac{l_s}{P_s} \)
  2-Deflator Capital Stock
  \( K^* = (1-\delta)K_{s-1}^* + \frac{l_s^*}{P_s^*} \)

- Basic differences – \( P_s \) is the investment deflator and \( P_s^* \) is the GDP deflator. Thus, for the 2-Deflator Method, \( K_s \) and \( Y \) are expressed in the same units.

- Why do we like that?
  Because we can attribute to increments of capital an increment of product equal to \( (\rho + \delta) \Delta K^* \).
- Focusing on the rate of return opens our eyes to many aspects of the growth process and of growth analysis that we did not see clearly using the Traditional Method.

- 2-Deflator Method is based on capital theory – pure and applied.

- Applied Capital Theory / Project Evaluation

  The Project Profile

![Graph showing output phase and investment phase]

One would never deflate investment phase flow by a different deflator than the output phase.

- Standard practice is to use the GDP deflator or the CPI in ex post cost-benefit analysis.

- We prefer the GDP deflator because it leaves Y the same, at the national level, for the Traditional Method and the 2-Deflator Method.

- So capital, for us, is measured in GDP baskets, instead of investment goods baskets.

- Capital's contribution to $\Delta Y$ is $(\rho + \delta)K_1 \Delta K^*.$

- Capital's contribution to $\frac{\Delta Y}{Y}$ is

\[
(6) \quad \frac{(\rho + \delta)K^* \Delta K^*}{Y K^*} = s_t g_t.
\]

- So, the GDP deflator is the first deflator of the 2-Deflator Method. It is used to convert all monetary flows to real terms.

- The second deflator is $w^*$, the real wage of a standard worker. This is a good way to correct for changes in the quality of labor.

- Analogy with residential construction in the national accounts.

- Total residential construction outlays are divided by the price of a standard house. Thus a mansion may work out to be 15 standard units and an upscale suburban house to be 5 standard units.

- So, for us, a successful surgeon may represent 20 labor units, a registered nurse 5, a medical technician 2, and maybe the medical orderly just one standard unit.

- The definition of $L^*$ is then

\[
(7) \quad L^* = \sum \frac{wL}{w^*} = \frac{\text{total labor earnings}}{w^*}
\]

- The contribution of labor to $\Delta Y$ is $w^* \Delta L^*.$

- Its contribution to $\frac{\Delta Y}{Y}$ is

\[
(8) \quad \frac{w^*L^* \Delta L^*}{Y L^*} = s_t g_t.
\]
• This labor contribution is an exact measure of \( \Sigma w_i \Delta L_i \) if the “multiples” \( (w_i / w^*) \) representing the relative skill premia of different classes and types of workers remain the same, or even if their changes average to zero, i.e. if \( \Sigma L_i \Delta \left( \frac{w_i}{w^*} \right) = 0 \).

• It is possible to break this labor contribution into
  1) A part \( w^* \Delta N \) due to “raw labor” (i.e. what labor would have contributed if all the increments of labor were of standard quality).
  2) A part \( w^*(\Delta L^* - \Delta N) \) due to the increment of human capital being used.

• Where does \( w^* \) come from?
  Best answer: where does the “standard house” come from for residential construction accounts.

• We have experimented with:
  - average wage of textile or apparel workers.
  - median wage from a broader class of low-end manufacturing industries.

• Here, we use \( 2/3 \) of \( 1 \) per capita GDP.
  Why?
  - Because it is easy to get.
  - Because it is easy to explain.
  - Because if the 2-Deflator Method works reasonably well using \( w^* = 2/3 \) (GDP / POP) that is a very good sign for the method. It should work even better with a more refined definition of \( w^* \).

• The human capital contribution can in turn be broken into a maintenance component \( \frac{L^* \Delta N}{N} \), endowing new workers with the previous average human capital, and the rest (due to improved average quality of the labor force).

• Enough of conceptual matters (for now).
  Now, we will compare the 2-Deflator Method with the Traditional Method for 23 countries.

• These were countries for which U.N. National Accounts gave “compensation to workers”. Where these accounts also gave “income of unincorporated enterprises”, half of which was assigned to labor and half to owners of capital.

• Otherwise the following formula was used:

\[
S_\text{c} = \frac{\text{comp. to workers} + 0.3(Y - "IndirectTaxes" - "comp. to workers")}{Y - "IndirectTaxes"}
\]
• First, we compare graphs of
  K and K* (capital stock time series)
  L and L* (labor force time series)
  for the 23 countries.
• Then, we plot against each other
  -the two capital contributions to growth
    (Traditional and 2-Deflator)
  -the two labor contributions to growth
    (Traditional and 2-Deflator)
• This is done for growth measured:
  a) in annual steps
  b) in non-overlapping 5-year steps
• Then, f.y.i., we plot our raw labor contribution
  against the Traditional labor contribution.
Finally, we plot a scatter of the TFP contribution to the changes in output, measured by the two methods.

In annual steps, $R^2 = .77$

In 5 year steps, $R^2 = .85$
In this case the stories told by the two methods are virtually identical.

Then differences are taken between the averages of the two sets.

One easy and familiar story concerns accounting for the differences between high-growth and low-growth episodes. For this purpose, averages are taken of the top set (20 of 144) of growth experiences and a bottom set (also 20 of 144) of growth experiences and a bottom set (also 20 of 144).
### COMPARISON OF HIGH AND LOW GROWTH PERIODS (TOP AND BOTTOM 20)

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP Growth Rate (%)</th>
<th>Real GDP Growth Rate (%)</th>
<th>Net Rate of Growth (%)</th>
<th>Long-Run Capital's Contributions to GDP (%)</th>
<th>Long-Run Labor's Contributions to GDP (%)</th>
<th>Differences in Average</th>
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<tbody>
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### SUMMARY OF 20 HIGH AND 20 LOW GROWTH PERIODS

<table>
<thead>
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<th>Periods</th>
<th>2-Deftor Method</th>
<th>Traditional Method</th>
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<td>Growth Periods</td>
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<td>Periods</td>
<td>2-Deftor Method</td>
<td>Traditional Method</td>
<td>Differences in Average</td>
</tr>
<tr>
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<td>2.55%</td>
<td>6.51%</td>
</tr>
<tr>
<td>Differences in</td>
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<td>2.55%</td>
<td>6.51%</td>
</tr>
</tbody>
</table>

Data Source: U.N. National Accounts and World Bank Development Indicators
• It is, of course possible that these stories would mainly reflect "country effects", with a few countries accounting for most of the high-growth episodes, and a different few countries for most of the low-growth episodes.

• To guard against this possibility, we made another set of tables. In this case the "high-growth" observations were the single highest 5-year GDP growth period for each country. The "low-growth" observations were similarly composed of each country’s lowest-growth quinquennium.
<table>
<thead>
<tr>
<th>Country</th>
<th>Growth Rate</th>
<th>Control</th>
<th>Education</th>
<th>Real GDP</th>
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### Summary of Country by Country High and Low Growth Periods

<table>
<thead>
<tr>
<th>Country</th>
<th>Growth Rate</th>
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</tbody>
</table>

#### Notes
- The data was sourced from "National Accounts and World Bank Development Indicators."
This syndrome pervades the data we have dealt
higher output growth
higher rates of investment
higher rates of return
plays the leading role, simultaneously
It is a syndrome in which real cost reduction
store of the growth process.
This is our first glimpse of what I think of as "my
evils. Now, we turn to ATP as a predictor of future
not empirical predictions.
The preceding results were substantial, but did

(high-growth and 7.81% for the low-growth
average rates of return) 2(d) are 11.05% for the
periods are taken country by country, the
Method does not. When high and low growth
growth process in a way the Traditional
difference, which less us see inside of the
episodes. Clearly, this is an enormous
(high-growth) and the low-growth (5.38%)
average rates of return (d) for the high-growth
the 2-Determinant Method. So we can isolate the
The capital contribution consists of (6) in

One important footnote, however:
Our procedure is to correlate future values with base period values. The base period value is the average over the year in which the real cost reduction takes place (is measured).

Thus, we look at

\[ \rho_{x_1} = \frac{\rho_1 + \rho_{x_2}}{2}, \quad \rho_{x_2} = \frac{\rho_1 + \rho_{x_3}}{2}, \quad \rho_{x_3} = \frac{\rho_1 + \rho_{x_4}}{2}, \ldots \]

Similarly,

\[ \left( \frac{\Delta K^*}{K^*} \right)_{x_1} = \frac{\left( \frac{\Delta K^*}{K^*} \right)_{x_2} + \left( \frac{\Delta K^*}{K^*} \right)_{x_3}}{2} \]

and

\[ \left( \frac{Y_{x_1}}{Y_{x_2} + Y_{x_3}} \right) = \frac{\left( \frac{Y_{x_2}}{Y_{x_2} + Y_{x_3}} \right)_{x_1} + \left( \frac{Y_{x_3}}{Y_{x_2} + Y_{x_3}} \right)_{x_2}}{2} \]

Conclusion:

1. The syndrome is real.
2. The syndrome is revealed equally well using the Traditional Method and the 2-Deflator Method.
• Now, to some of my gripes.
• First and foremost is the recent fascination of our profession with cross-country and panel regressions.
• What serious inferences can we draw from comparing:
  Bangladesh with Belgium?
  Senegal with Switzerland?
  Nepal with New Zealand?
  Cameroon with Canada?
• Are they part of the same population in any relevant statistical sense?
• If these regressions reveal something, what lessons can we draw?

• Not much help here for the Finance Minister or the economic team in India or Uruguay. Most of the variables (X1, X2, X3, X4, X5, X7, and probably X9 and X10) are typically the fruits of a long period of economic development. The terms of trade are also beyond any small country’s (and most big countries’) control. So we are left with the inflation rate and government consumption as amenable to prompt policy action, and male secondary schooling as a long-term policy goal.

• To illustrate, I take as my text R. J. Barro’s Determinants of Economic Growth: A Cross-Country Empirical Study. In doing so, I recognize that Barro ranks among the most thoughtful and careful users of cross-country data.
• First of all, the variables explaining the per capita growth rate are:
  X1. Log per Capita Real GDP
  X2. Male Secondary and Higher Schooling
  X3. Log Life Expectancy
  X4. Interaction (X1*X2)
  X5. Log Fertility rate
  X6. Government Consumption / GDP
  X7. Rule of Law
  X8. Terms of Trade
  X9. Democracy Index
  X10. Democracy Index squared
  X11. Inflation Rate

• Barro’s most important education variable is male “secondary and higher schooling”. Once this variable is in, both male primary schooling and female secondary schooling are insignificant. Barro does mention that male primary is a necessary predecessor of male secondary and higher education, and that female education in general has a strong effect via fertility.
• But let us simply pursue Barro’s positive results – a coefficient that says that every extra year of male secondary and higher schooling tends to augment a country’s growth rate by 1.2 percentage point per annum.
• When I first saw this result, I practically fell off my chair. How could it be true?
- Careful reading of Barro reduced the shock somewhat. His variable measures total years of secondary and higher education among males 25 years or older, divided by the population of such males. It is not, for example, just adding one year to the average level achieved by the current cohorts.

- But still, it is an enormous effect. Israel’s reward for an extra year, thus measured, is a growth rate 1.2 percentage higher per year than Argentina’s. Canada’s reward is a growth rate 2.4 percentage point per year higher than Spain’s. And the U.S.’s reward is a growth rate over three points per year higher than that of the U.K.

- These figures do not incorporate Barro’s interaction term (male secondary and higher education per capita real GDP), mainly because I do not see the mechanism by which this works, and because I believe that many alternative variables interacting with per capita GDP would probably yield similar results, with interpretations that would not be connected with education.

- But just to satisfy skeptics, we can note that Barro’s interaction term has an estimated impact on the growth rate of less than one percentage point per annum for the great bulk of his sample of countries.

- How should we try to analyze the effect of education on the growth rate? Well, in the first place, by assigning to each category its corresponding wage or earnings level. This is how we have for more than half a century estimated social (gross of tax and counting government costs) and private (net of tax and not counting government costs) rates of return to education. This, too, is the approach employed by Griliches, Jorgenson and many followers in the empirical analysis of growth.

- The expression $\sum w_i \Delta t_i$ captures it all, provided we have good enough data and sufficient detail. Obviously, this expression can be positive in sign and important in magnitude even when $\sum \lambda L_i = 0$. 
This emphasizes that it fully captures any direct effects on growth of an upgrading of the labor force. By direct effects, I mean those that are reflected in the market earnings (gross of taxes and fringe benefits) of the various categories of labor.

- As was already shown, the 2-Deflator Method seeks to do the same kind of job that Jorgenson does, by expressing each worker’s contribution in standard units. Suppose, then, a very extreme case, in which from quality improvement via education alone the labor force was increasing at 2 percent per year. This would double the effective labor force in some 36 years. Over that span, the contribution of quality of education to education contribution building up to this over the 36 year period.

- You may feel that I have been unfair because I have not mentioned externalities. I believe there are real externalities to education, some of which probably have an impact on the growth rate. But the way to proceed is to try to identify these externalities and measure them. To do this one should not throw away the imputation of the direct effects of education. Rather, we should use it and build on it. Make an imputation of direct effect using $\Sigma m_{x,t}$, and $\Sigma (\rho + \delta)A_t$, and then test to see how different variables representing possible sources of externalities succeed in accounting for the as yet unexplained residual, $R$ and $R^*$.

- If the externality works in a geographical area, what is the area -- the village or the town, the country, the state or the province, etc.? Maybe the education externality works across a metropolitan area or across an industry within a nation. These are things that we can investigate empirically, so long as we can measure the growth residual across sufficiently disaggregated units. There is plenty of serious work to be done here, for those who are willing to pay the price.
Inflation is an area where Barro’s treatment gives me less of a problem. Though Barro uses a single inflation variable in his regressions explaining growth, he goes beyond this in the text. In particular, he presents scatters showing that the relationship between the rates of inflation and the rates of growth is strongly negative and significant for annual inflation rates above 20 percent, and much less negative and not significant for rates below for rates below 20 percent. He also notes the important association between higher average rates of inflation and higher variability of these same rates.

I like this degree of subtlety in discussing the relationship between inflation and growth.

My own summary on this subject emphasizes the confusion about relative prices that seems to be the inevitable counterpart of high inflation rates.

I like to note that, quite contrary to the feeling that once prevailed, that inflation was the painless way and that we always had to pay a huge price for disinflation, the evidence on high inflation episodes is quite to the contrary.

Obviously, we are not here “measuring” the effect of inflation on growth. Without doubt the episodes of high inflation were not sought by policymakers, but came as a result of their inability to control the situation.

Typically this inability was mirrored in poor policy management in many different directions such as futile efforts at price control, devaluation crises, multiple exchange rates, enormous tariffs, widespread import prohibitions. In almost every case black markets flourished, often dominating activity in many sectors. Negative interest rates were common, at least in “official” arenas.

We really have no case with which to establish how a textbook “pure” inflation would affect the growth rate.

What we can say is that the high inflation syndrome has in fact entailed worse growth experiences on the upside, and better on the downside, in nearly every case.

What can we learn looking at within-country evidence? I have for many years used a classification system in which inflation episodes were broken down in to cases of

- Acute inflation
- Chronic inflation / devaluation crisis
- Stable exchange rate

Here we see a clear pattern

- A very strong negative relation for the acute inflation cases
- A reasonably strong negative relation for he middle group
- Essentially no relation for the stable exchange rate group
• This is what we should expect. In Central America in the 50's, 60's and 70's (up to about 1978), the inflation was essentially the world inflation (in $). High growth was a year of good coffee prices. Low growth was an earthquake or a coffee bust.
• What does the one have to do with the other?
• This is why the relation between inflation and growth is so inconclusive for the stable-exchange-rate countries.

• Good rules to follow in growth analysis are
  - look at all the evidence you can find
  - try to understand what you see
  - try to state clearly what conclusions you draw
    (without shame but also without exaggeration)
  - try to reach a level of understanding that encompasses some element of texture of what you see.
• I think our story of inflation and growth meets these conditions.

• My other complaint concerns, in a sense, two topics in one: a) more on cross-country and panel-type regression analysis, and b) analyzing growth by fitting production functions. The context is in an article by Larry Lau and J. I. Kim which in turn was brought to my attention by Paul Krugman in his blockbuster article in Foreign Affairs. In that paper Krugman asserted that the performance of the East Asian Tigers represented no miracle at all. Their growth was simply due to more labor and more capital. Of real cost reduction (TFP improvements), they had experienced little or none.

• Krugman's support for these assertions came from just two sources -- a paper by Alwyn Young, and the one by Lau and Kim. I was puzzled from the beginning when I read the Lau-Kim paper, because they went at the measurement of growth by fitting a common production function to panel data from nine countries. My obvious question was why would anybody ever do a thing like that? Why would countries differ only in the constant term of a common production function and in its rate of shift over time?
This led me to experiment with measuring a Cobb-Douglas production function (the form fitted by K-L) with time series data for a number of countries. I was absolutely stunned by the results. The estimates that emerged made practically no sense at all. Instead of elaborating, let me show you the results.

### Fitting Cobb-Douglas Production Functions

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Data source: U.N. National Accounts and World Bank Development Indicators.

### Fitting Cobb-Douglas Production Functions (d-log Y = C + B₁ d-log L + B₂ d-log K)

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Data source: U.N. National Accounts and World Bank Development Indicators.
### Fitting Cobb-Douglas Production Functions

\( \log Y = C_1 + B_L \log L + B_K \log K \)

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<th>( B_K )</th>
<th>( R^2 )</th>
<th>Adj. ( R^2 )</th>
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### Fitted Effect Regressions

\( \log Y = C_1 + B_L \log L + B_K \log K + A_T \times \text{TIME} \)

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<th>( B_K )</th>
<th>( A_T \times \text{TIME} )</th>
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### Graphs

Graphs showing the fitted Cobb-Douglas production functions, with lines indicating the relationship between variables and time.