Business Cycle Facts

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Macroeconomic Analysis I

Introduction to Business Cycles

- We start by identifying some key business cycle facts
- Throughout, we will focus on the US and in the post-WWII/pre-financial crisis era.
- Not very different if you look at the typical OECD country

Useful References

- Stock and Watson (1998), "Business Cycle Fluctuations in U.S. Macroeconomic Series"
- King and Rebelo (2000), "Resuscitating Real Business Cycles"

Questions

- How do we define and measure the business cycle?
- What kind of regularities do we see in the data?
- How do real quantities move over the business cycle?

  real quantities: aggregate output, consumption, investment, employment, etc.
- How do nominal variables move over the business cycle?

  nominal variables: nominal price index, nominal wages, and nominal interest rates

Real Output

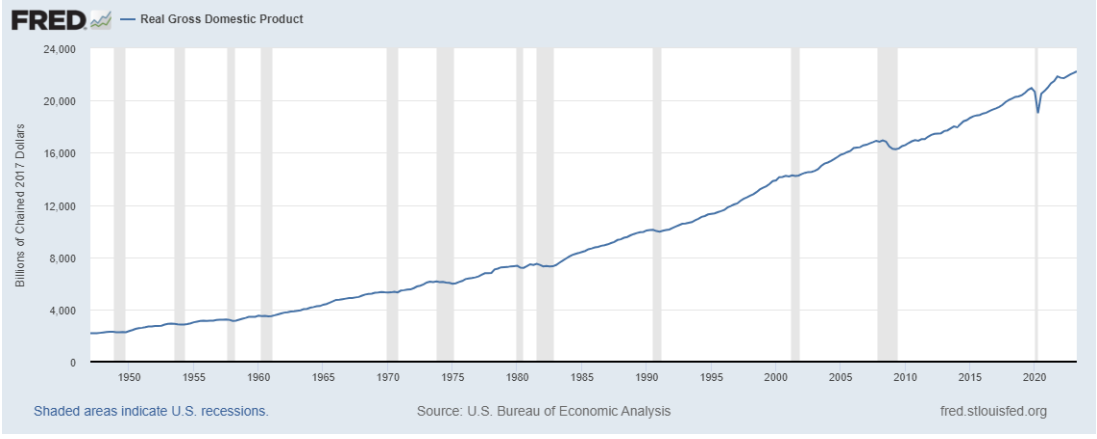


Figure: Time Series of Real GDP in the US

Real Output Since 2000

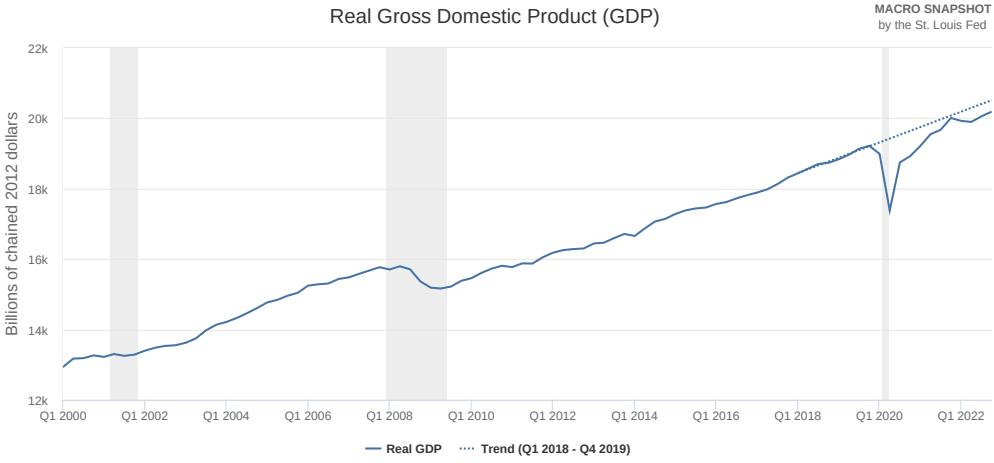


Figure: Time Series of Real GDP in the US

Unemployment

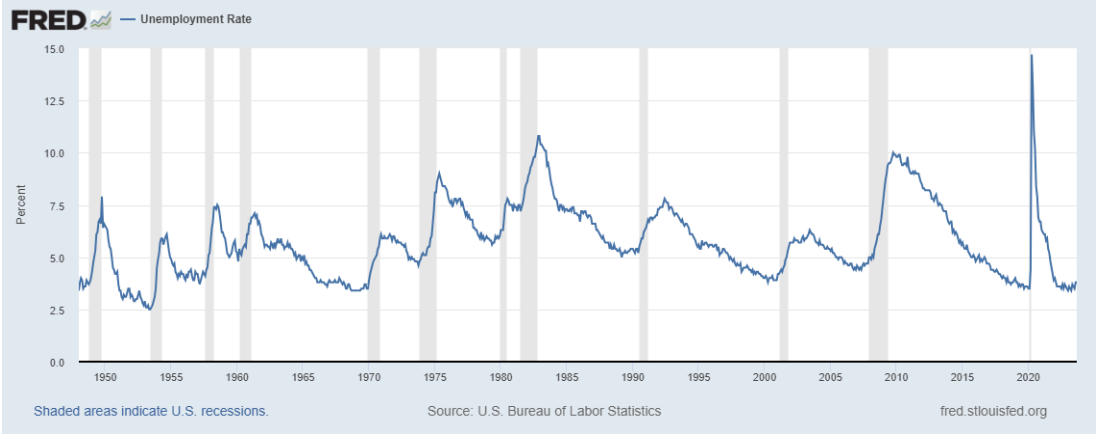


Figure: Time Series of Unemployment in the US

Inflation

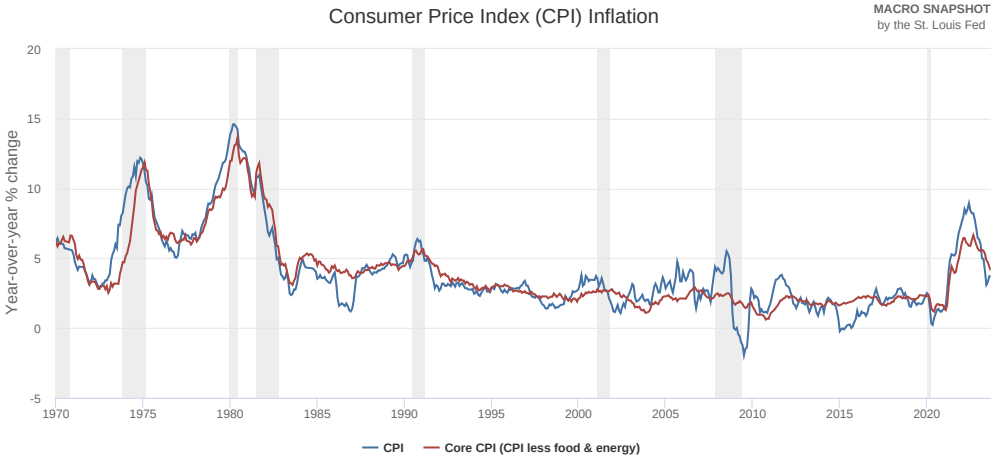


Figure: Time Series of Inflation in the US

What are Business Cycles?

- Clearly, output has grown on average, but it has also exhibited fluctuations around its trend
- In the data, business cycles are loosely defined as:
  - short run fluctuations of macro variables around a smoother long-run (growth) trend
- What macroeconomic variables are we interested in?
- And how can we separate the cycle from the trend?

We focus on real quantities

- The business cycle framework that we study next is concerned exclusively with real quantities
- We postpone a discussion of nominal variables (inflation, interest rates) for later in the first-year macro sequence

Key Macroeconomic Variables of Interest

- GDP and its components: $Y = C + I + G$
  - think of a closed economy (for simplicity)
- Consumption (C):
  - Nondurables + Services
  - Durables
- Investment (I):
  - Investment in capital
  - Changes in inventories
- Labor: total hours worked = employment $\times$ hours per worker
- Relative prices:
  - real wage
  - real Interest rate

Separating the Cycle from the Trend

- We need a "filter" that will remove the trend and give us the cycle
- Some commonly used filters:
  - Linear trend
  - HP (Hodrick-Prescott) filter
  - Bandpass filter

The Cycle vs. the Trend

- let y_t be the log of actual GDP (or any other variable of interest)

$$y_t = \log GDP$$

- we decompose log GDP in the following way:

$$y_t = \hat{y}_t + \tilde{y}_t$$

  - where $\hat{y}_t$ is the trend (or growth) component
  - and$\tilde{y}_t$ is the cyclical (or detrended) component

$$\tilde{y}_t \equiv y_t - \hat{y}_t$$

The Cycle vs. the Trend

$$y_t = \hat{y}_t + \tilde{y}_t$$

- we'd like to measure $\tilde{y}_t$, the log deviation from trend
  - expansions/recessions: output above/below trend
- but how do you define $\tilde{y}_t$ vs. $\hat{y}_t$?
  - multiple plausible answers

Linear Trend

- simplest answer: assume a linear trend
- let g be the average growth rate

$$\hat{y}_t \equiv gt$$

- equivalently, $\tilde{y}_t$ is the residual from regressing y_t on time t.

Linear Trend at work: US GDP

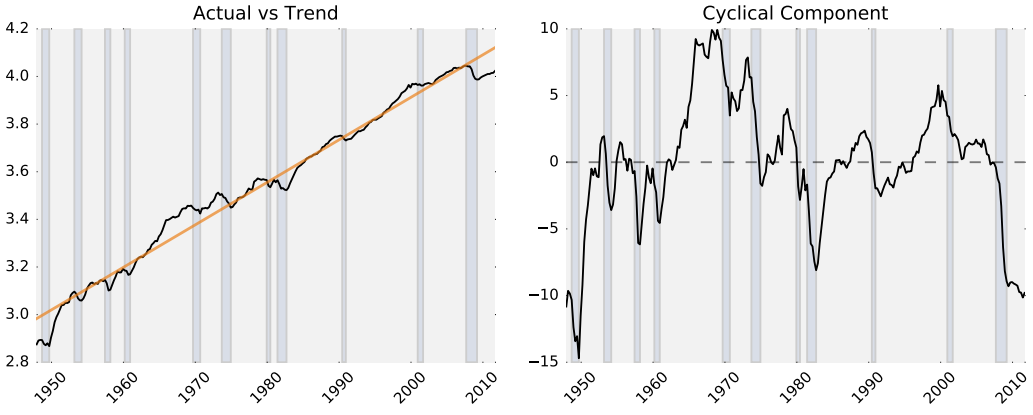


Figure: GDP

Issues with a Linear Trend

- conceptually simple
- but not that useful if low-frequency movements are not a deterministic linear trend
  - e.g. productivity slowdown, changes in demographics
- needed: filter that eliminates medium- to low-frequency variation

The Hodrick-Prescott (HP) Filter

- HP filter: $\hat{y}_t$ is defined by minimizing the following loss function:

$$L = \sum_t (\hat{y}_t - y_t)^2 + \lambda \sum_t [(\hat{y}_{t+1} - \hat{y}_t) - (\hat{y}_t - \hat{y}_{t-1})]^2 .$$

- parameter $\lambda > 0$ governs how much we punish variations in the growth component
- $\hat{y}_t$ converges to a linear trend when $\lambda \to \infty$ and to the actual data as $\lambda \to 0$
- the standard practice is to set $\lambda = 1600$ (for quarterly data).

HP Filter at work: US GDP

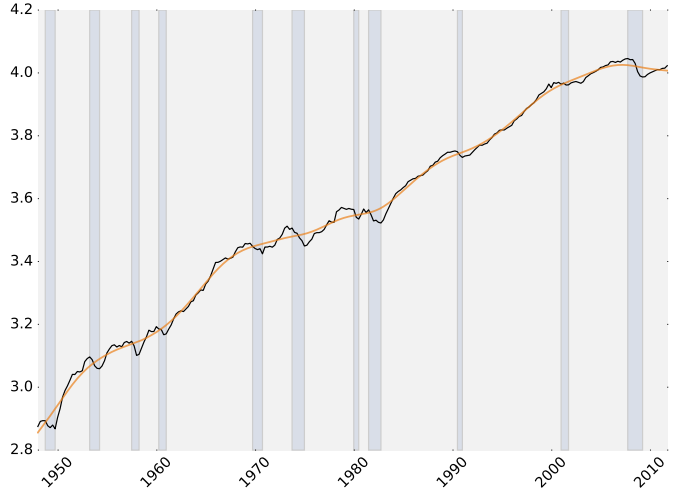


Figure: black line: actual GDP data, red line: trend (smooth but not linear)

HP Filter at work: US GDP

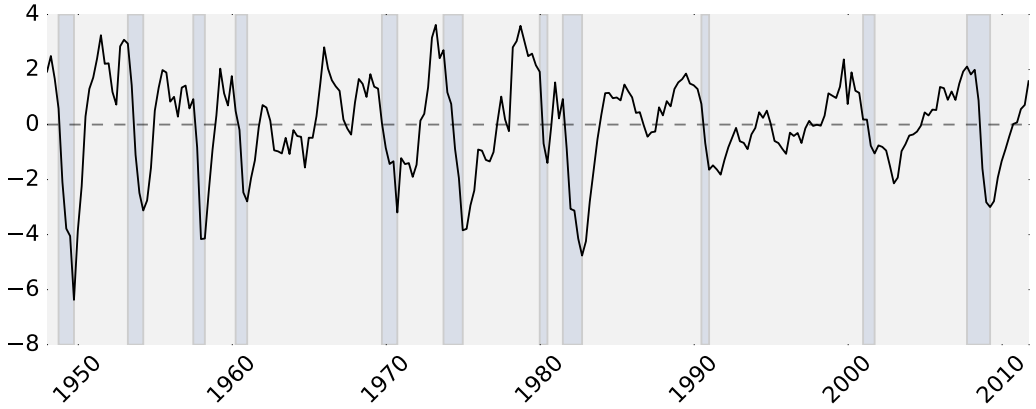


Figure: cyclical component of GDP (using HP filter)

The Bandpass Filter

- Bandpass filter: a bit more sophisticated, but also more kosher
- isolates the sources of variation that operate at particular frequencies. common practice to look at the BP filter that keeps frequencies between 6 and 32 quarters (8 years)
- like HP, this removes low-frequency movements.
- but in contrast to HP, the BP filter has the advantage that it also removes high-frequency "noise"
- it thus leaves us with only the interesting, regular business-cycle movements.
- [see Stock and Watson (1998) for further discussion]

In Practice

- common practice: use either HP or BP filter
- fortunately, both filters give very similar picture for most macro variables
- implies that business cycle facts are robust to different ways of inspecting the data
- the next figure illustrates the similarity of the cyclical components of GDP that we obtain if we apply either the HP or the BP filter.

HP vs BP

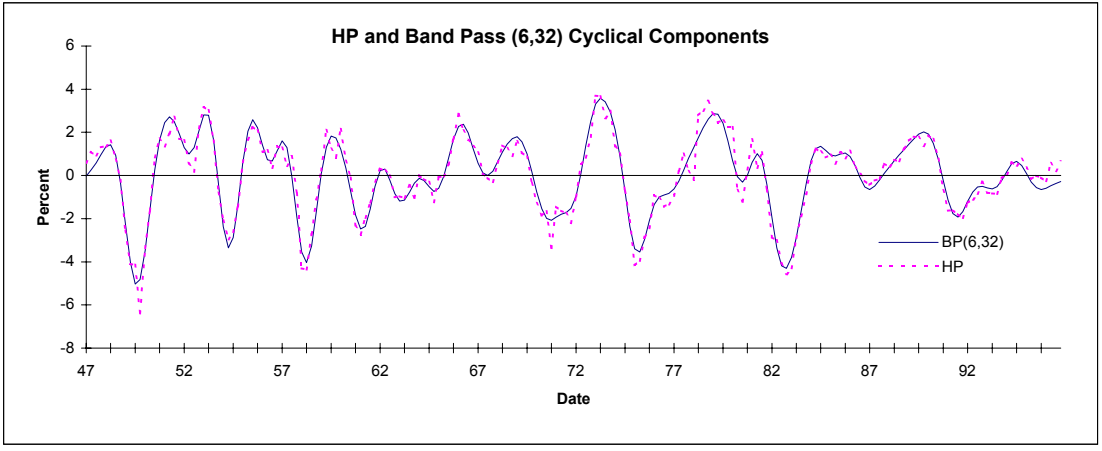


Figure: cyclical components of real output

HP vs BP

- clearly, there isn't much difference in the case of output.
- note, however, that there could be more noticeable differences for other variables.
  - think, e.g., of stock prices.
- with the preceding points in mind, we use interchangeably the two filters.

Business Cycle Facts

- We are now ready to explore the empirical regularities of business cycles
- For convenience, I report some figures from King and Rebello (2000)
  - they use the HP filter and concentrate on real quantities
- Similar figures can be found in Stock and Watson (1998), who use the BP filter.

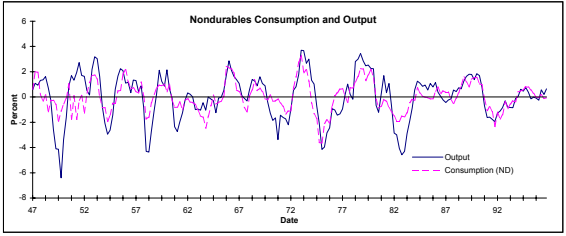
Business Cycle Facts

- The following series of figures illustrate the cyclical components of various macroeconomic variables (in pink) against the cyclical component of GDP (in blue).
- Terminology:
  - procyclical = movements are positively correlated with movements in output
  - countercyclical = movements are negatively correlated with movements in output
  - acyclical = movements have zero correlation with movements in output
- These figures help guide the construction and evaluation of the theoretical business-cycle framework that we will study next

Consumption

- Consumption is procyclical (positively correlated with output)
- Spending on durables is more volatile than output
- Spending on non-durables is less volatile than output

Durable vs Non-Durables



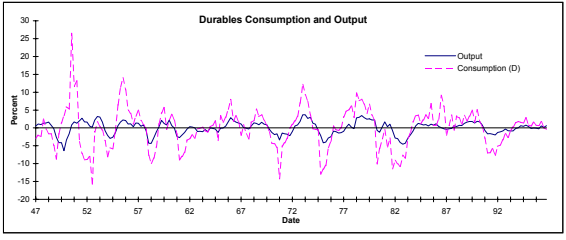


Figure: Consumption and Output

Investment is strongly procyclical and more volatile than output

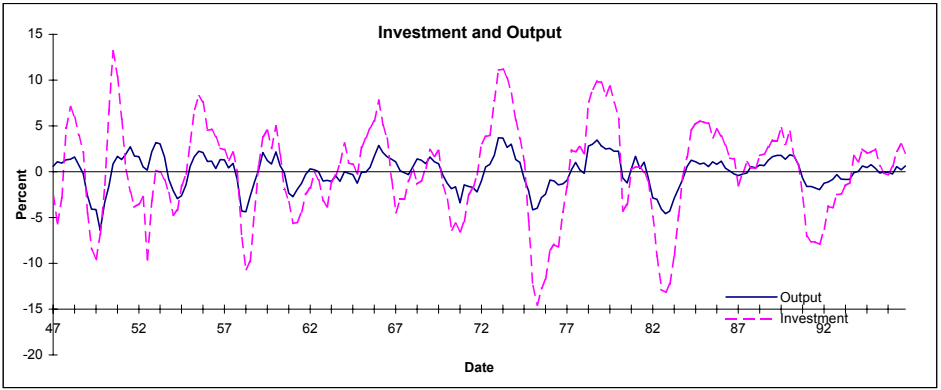


Figure: Investment and Output

Labor (Total Hours) is procyclical and as volatile as output

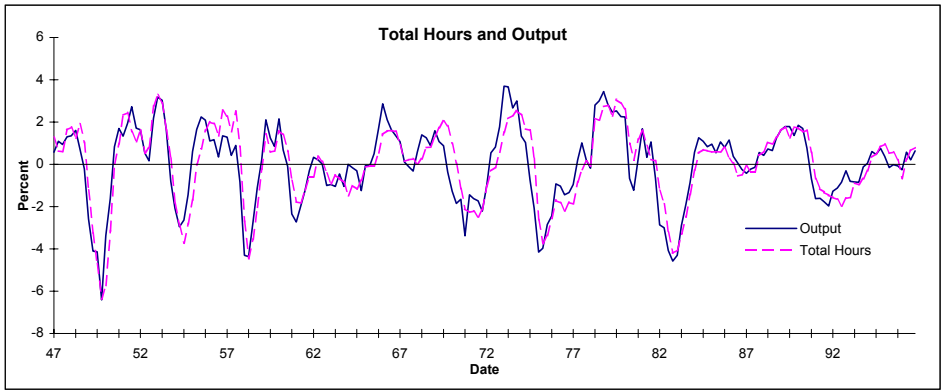
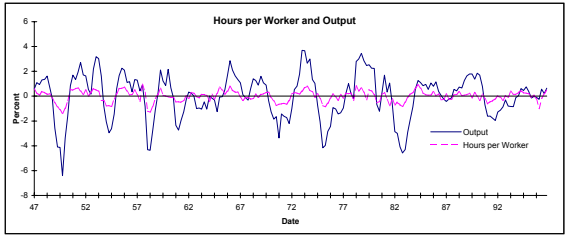


Figure: Total Hours and Output

Employment vs. Hours

- Most of the labor-input fluctuations are in total employment (number of workers employed)
- rather than in hours per worker

Employment fluctuates more than hours per worker



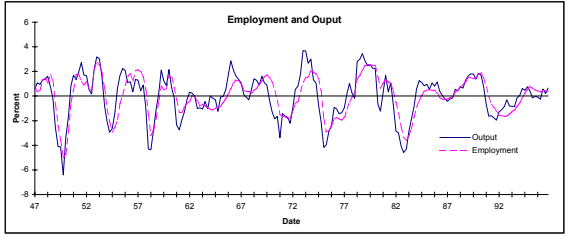


Figure: Hours, Employment, and Output

Capital

- The capital stock moves very slowly
- But capital utilization is highly procyclical
- As a result, effective capital input is highly procyclical

Capital Utilization is highly procyclical

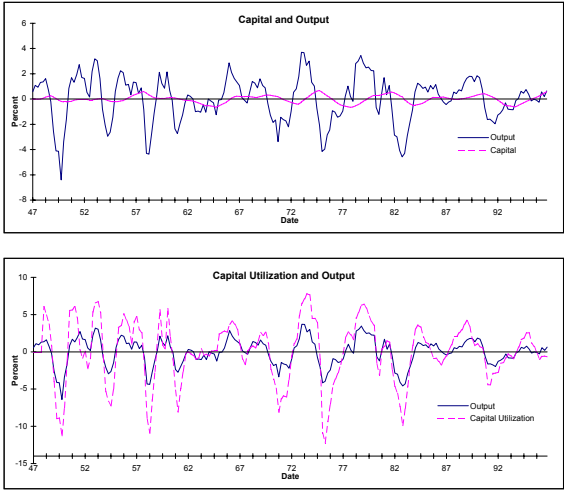


Figure: Capital and Output

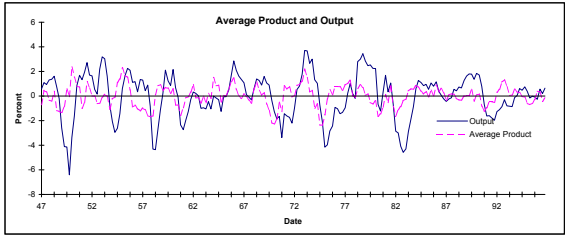
Labor Productivity and Real Wages

- Define labor productivity as output per worker-hour

$$\frac{Y_t}{L_t}$$

- Labor productivity is moderately procyclical
- But real wages are only mildly procyclical

Labor Productivity and Real Wages



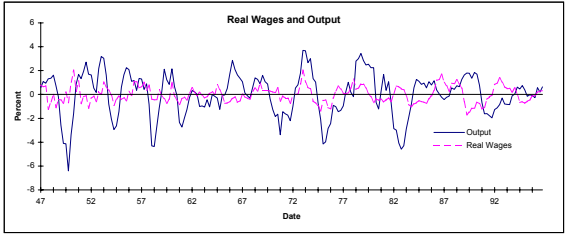


Figure: Labor productivity, real wages, and output

Productivity

- We would like a measure of "productivity"
- Suppose that output is produced using a Neoclassical Production Function

$$Y_t = A_t F(K_t, L_t).$$

- We call A_t "Total Factor Productivity"
  - this is also sometimes called *Hicks-neutral* productivity
  - this is clearly an unobserved variable

The Solow Residual

- We would like a measure of Total Factor Productivity (TFP)
- Suppose that production is in particular Cobb-Douglas

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

- TFP can be computed from data on output Y_t, capital K_t, and total hours L_t as follows:

$$\log A_t = SR_t \equiv \log Y_t - \alpha \log K_t - (1-\alpha) \log L_t$$

  where α is the income share of capital.
- We call this the Solow residual; it is simply a "residual"

The Solow Residual is strongly procyclical

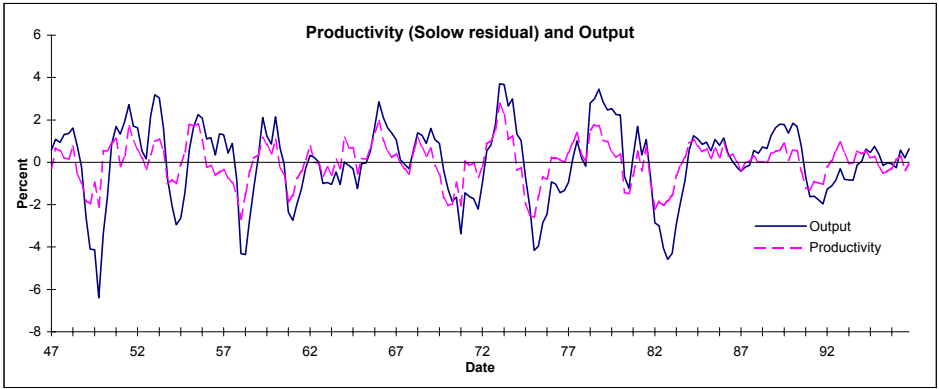


Figure: The Solow Residual and Output

Moments

- Although the previous figures are illuminating, eye-balling is not enough.
- To be more methodical, we look at the following moments:
  - standard deviations of variables of interest
  - contemporaneous correlations with output (or other cross-variable correlations)

Business Cycle Statistics for the US Economy

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.81	1.00	0.84	1.00
C	1.35	0.74	0.80	0.88
I	5.30	2.93	0.87	0.80
N	1.79	0.99	0.88	0.88
Y/N	1.02	0.56	0.74	0.55
w	0.68	0.38	0.66	0.12
r	0.30	0.16	0.60	-0.35
A	0.98	0.54	0.74	0.78

Figure: Table 1 of King and Rebelo, 2000

The Strong Comovement of Y, C, and I

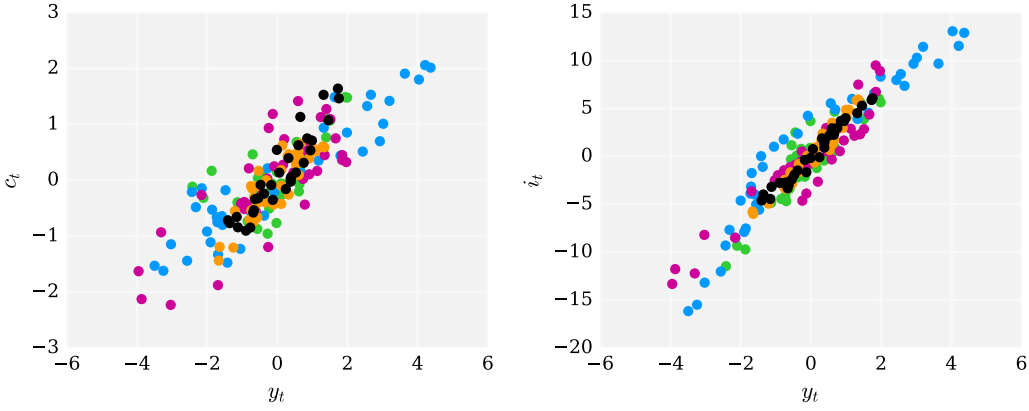


Figure: Scatterplots. Left: output and consumption. Right: output and investment.

Summary

- We have discussed how to measure and define the cyclical component of macroeconomic time series
- With this tool, we have established some key business cycle stylized facts

Business Cycle Facts

- Consumption, investment, and labor are all strongly procyclical
  - durables are more procyclical than non-durable consumption
  - employment fluctuates more than hours
  - although capital moves slowly, capital utilization is highly procyclical
- Labor productivity is moderately procyclical
- Real wages are only mildly procyclical
- The Solow residual (a proxy for TFP) is strongly pro-cyclical

Conclusion

- These empirical regularities are all I'm going to say about the data
- We will use these facts to help guide the construction and evaluation of the theoretical business-cycle framework that we study next