Topic 3: Price Surprises

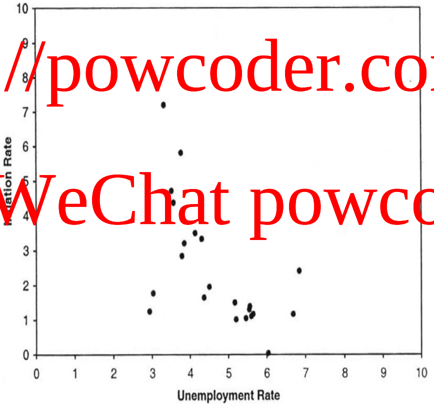
Monetary Economics

ECOS3010

Introduction

- The relationship between inflation and unemployment – the Phillips curve
- Cross country evidence on the relationship between inflation and output.
- In this chapter, we develop a theory to rationalize the empirical observations?
  - **Unanticipated** changes in money supply. In previous sections, we consider **anticipated** increases in money supply.
  - How do unanticipated fluctuations in money supply affect output?
  - Can the government exploit such a relationship?
- The Lucas (1972) model and the Lucas critique.

- In 1958, Phillips discovered a significant statistical link between inflation and unemployment of the United Kingdom over a century. For example, the Phillips curve 1948-1969 in US.



- The original Phillips curve suggests that there is a negative relationship between inflation and unemployment, or there is a positive relationship between inflation and output.
- Does it imply that there maybe an exploitable trade-off between inflation and unemployment? Can the government reduce unemployment and increase output by increasing inflation?
- In the following decades, many governments tried to use monetary policy to stimulate the economy. Suddenly, the Phillips curve, a stable relationship for more than a century, disappeared. Inflation occurs with no gains in output or employment.

- Inflation and unemployment in U.S. from 1970 to present.

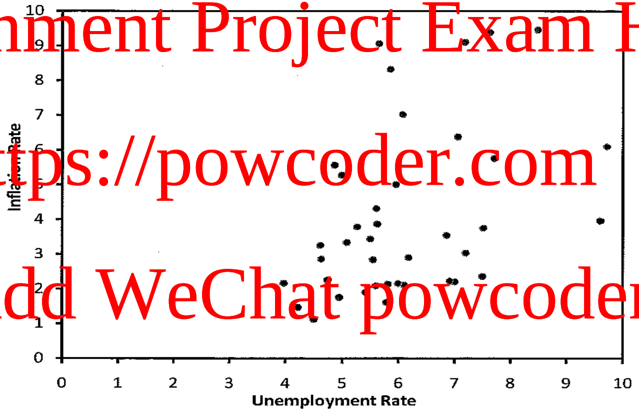
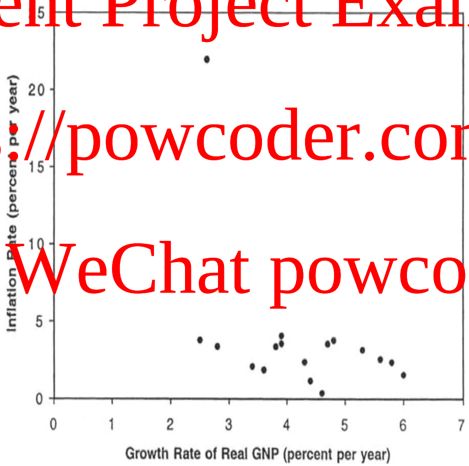


Figure 5.2. The Phillips curve (1970–present). Data on the unemployment rate and the inflation rate from the period after the 1960s display no apparent relationship between these two variables. *Source:* The Federal Reserve Bank of St. Louis FRED database, (http:www.stls.frb.org/fred/index.html).

- The Phillips curve is a **time series** correlation between inflation and unemployment in different periods of the **same** country.

- If we compare across countries, inflation rates are on average higher in countries with lower average real GDP growth rates. Note: its a **cross-section** comparison here.
- How can there exist seemingly contradictory correlations
  - Time series of the same country: **-ve** correlation between inflation and unemployment, that is, **+ve** correlation between inflation and output.
  - Cross-country comparisons: **-ve** correlation between inflation and output.

- Example: inflation and output across countries 1952-1967



The Lucas Model

Basic Environment

- Consider the standard OLG model with money. Now assume that individuals live on two spatially separated islands.
- N_t individuals are born in each period. N_t is constant. In each period,
  - half of the old live on each of the islands;
  - 1/3 of the young live on one island and 2/3 live on the other island;
  - the allocation of the young and the old is random.
    - the old are randomly distributed across the two islands, regardless of where they lived when young
    - in any single period, each island has an equal chance of having the large population of young.

- Money supply grows at a rate z_t in period t, $M_t = z_t M_{t-1}$. The new money is distributed to each **old** person as a lump-sum transfer in every period t worth a_t units of the consumption good:

$$a_t = \left(1 - \frac{1}{z_t}\right) \frac{v_t M_t}{N}.$$

- Informational assumptions: in any period,
  - the young cannot observe the number of young individuals on their island;
  - the young cannot observe the size of the transfers to the old;
  - the nominal stock of money supply is known with a delay of one period; e.g., in period t, individuals know M_{t-1}, but not M_t;
  - the price of goods on an island is observed but only by the individuals on that island;
  - no communication between islands within a period.

- We assume that individuals are rational.
  - They may not have complete information, but they can infer whatever they can from the information they have and they make the most correct inference possible given the explicitly specified limits on what they can observe.
  - The assumption of "rational expectation", first introduced by Muth (1961): people understand the probabilities of outcomes important to their welfare.
  - In our model, individuals do not observe z_t and the population of the young on each island, but they know the prices. They know 1/3 of the young are on one island and the rest 2/3 are on the other island. They will try to infer z_t and the distribution of the young population.

- A reinterpretation of an individual's problem:
  - y : individuals are endowed when young with y units of **time** (instead of goods): think of y as 24 hours;
  - c_1 : consumption of **leisure** (instead of consumption of goods); $y - c_1$ is spent working;
  - c_2 : consumption of goods;
  - $l = y - c_1$: labor supply by the individual when young; $l_t^i = l(p_t^i)$: the choice of labor by an individual born in period t for a given price of goods, p_t^i, on island i;
  - production function: 1 unit of l can be used to produce 1 unit of the consumption goods

- Consumption

Generation	$t=1$	$t=2$	$t=3$	$t=4$	$\rightarrow$
0	c_2				
1	c_1	c_2			
2		c_1	c_2		
3			c_1	c_2	
$\downarrow$				$\ldots$	$\ldots$

- In our model, the young are endowed with time and the old are endowed with nothing.
- In period t, a young individual on island i
  - chooses between working l_t^i and **leisure** $c_{1,t}^i$

$$c_{1,t}^i + l_t^i \leq y,$$

where l_t^i units of goods are produced and sold to the old to acquire m_t^i units of money,

$$l_t^i = v_t^i m_t^i.$$

Here $v_t^i m_t^i$ still represents the individual's real demand for money.

- In period $t+1$, the young individual born in period t becomes old and could be on island j, where j may or may not be the same island as i. His consumption $c^{i,j}_{2,t+1}$ comes from his own saving and government transfers,

$$\begin{aligned} c^{i,j}_{2,t+1} &= v^j_{t+1} m^i_t + a_{t+1} \\ &= \frac{v^j_{t+1}}{v^i_t} l^i_t + a_{t+1} \\ &= \frac{p^i_t}{p^j_{t+1}} l^i_t + a_{t+1} \end{aligned}$$

- Note that when the young individual decides to supply 1 more unit of labor by increasing l_t^i by 1, he will be able to produce 1 more unit of good and acquire $1/v_t^i$ more units of money. Then he can use the $1/v_t^i$ units of money to buy v_{t+1}^j/v_t^i units of goods when old. This implies that the rate of return to labor is

$$\frac{v_{t+1}^j}{v_t^i} = \frac{p_t^i}{p_{t+1}^j}$$

- We assume that an increase in the current price of goods p_t^i, other things being equal, will induce the young to work more, that is, l_t^i increases.

  - When p_t^i increases, the rate of return to labor increases.
    - Substitution effect: work more because working is more profitable.
    - Wealth effect: work less because the higher return from labor means higher income and less need to work.

  - We are assuming that the substitution effect of an increase in price **dominates** the wealth effect.

- Before we examine a random z_t, we begin with a constant growth rate of money supply $z_t = z$ in all periods. In this case, can rational individuals infer the current stock of money?
  - Yes, they know M_{t-1} and z. So they can infer $M_t = zM_{t-1}$.
- In period t money market clearing condition on on island i with N^i young individuals is:

$$N^i\left(y - c_{t,t}^i\right) = v_t^i \frac{M_t}{2}$$

or equivalently

$$N^i l_t^i = v_t^i \frac{M_t}{2} = \frac{1}{p_t^i} \frac{M_t}{2}.$$

- We label the island with 1/3 young individuals as island A and the other island as island B. We have

$$p_t^A = \frac{\frac{M_t}{2}}{N^A l_t^A} = \frac{M_t/2}{\frac{1}{3} N l_t^A}, \tag{1}$$

$$p_t^B = \frac{\frac{M_t}{2}}{N^B l_t^B} = \frac{M_t/2}{\frac{2}{3} N l_t^B}. \tag{2}$$

Claim: $p_t^A > p_t^B$ – the price level is higher on the island with less young individuals.

Why? By contradiction. If $p_t^A \leq p_t^B$, then the rate of return to labor is lower on island A which implies that $l_t^A \leq l_t^B$. However, from (1) and (2), $l_t^A \leq l_t^B$ implies that $p_t^A > p_t^B$, which is a contradiction to the assumption of $p_t^A \leq p_t^B$. So it is only possible that $p_t^A > p_t^B$.

- We find that the price of goods is high on the island with relatively **less** young individuals and is low on the island with relatively **more** young individuals.
  - Intuition: when there are less young people, there are less people supplying labor to produce the good. With the same number of old individuals, the demand for goods is relatively high on the island with less young individuals. Therefore, the price is high on the island with less young individuals.
  - Further implication: since we know that $p_t^A > p_t^B$ (and *all else equal*), the rate of return to labor is high on island A, young individuals work more on island A with less young individuals. That is, $l_t^A > l_t^B$.
  - These implications depend critically on the assumption that the substitution effect dominates the wealth effect.

- Prices here signal the true state of the economy: the young can infer that
  - they are on the island with a smaller population if they observe the high price;
  - they are on the island with a larger population if they observe the low price.
- What else can affect the price level? A revisit of the prices:

$$p_t^A = \frac{M_t/2}{\frac{1}{3}NI_t^A} \text{ and } p_t^B = \frac{M_t/2}{\frac{2}{3}NI_t^B}.$$

Money supply can also affect the price level.

  - When money supply increases, the price level increases.
  - When money supply decreases, the price level decreases.

- Suppose $z = 1$. What if there is a permanent (once-and-for-all) increase in the money stock? That is, M increases permanently.

Recall that
$$p_t^i = \frac{M_t/2}{N^i l_t^i}.$$

Once M increases permanently, p_t^i will increase but p_{t+1}^j will also increase. Overall, the rate of return to labor
$$\frac{v_{t+1}^j}{v_t^i} = \frac{p_t^i}{p_{t+1}^j} = \frac{\frac{M_t/2}{N^i l_t^i}}{\frac{M_{t+1}/2}{N^j l_{t+1}^j}} = \frac{N^j l_{t+1}^j}{N^i l_t^i}\frac{M_t}{M_{t+1}},$$

is not affected by the level of money supply. Therefore, a permanent increase in money supply does not affect employment and output in this economy.

- Money is **neutral** in this economy: a permanent change in M does not affect the real economic variables.

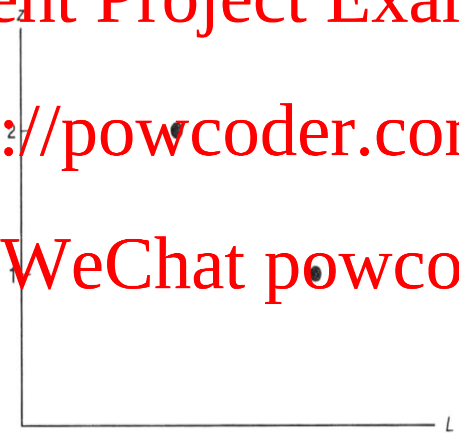
- What if there is a permanent increase in z? Now the rate of return to labor is

$$\frac{v^j_{t+1}}{v^i_t} = \frac{p^i_t}{p^j_{t+1}} = \frac{\frac{M_t/2}{N^i l^i_t}}{\frac{M_{t+1}/2}{N^j l^j_{t+1}}} = \frac{N^j l^j_{t+1}}{N^i l^i_t} \frac{M_t}{M_{t+1}} = \frac{N^j l^j_{t+1}}{N^i l^i_t} \frac{1}{z}.$$

An increase in z lowers the rate of return to labor, which discourages working because the money earned from labor is now taxed by the government through inflation. Lower l_t leads to lower output.

- Money is **not superneutral** in this economy: a permanent change in z affects the real economic variables.

- We can construct a graph plotting output as a function of z.



- So far we find that inflation reduces employment and output in our economy.
- Now consider the following random monetary policy.

$$
\begin{aligned}
M_t &= M_{t-1} && \text{with probability } \theta \quad (z_t = 1) \\
&= 2M_{t-1} && \text{with probability } 1-\theta \quad (z_t = 2)
\end{aligned}
$$

The realization of z_t is kept secrete from the young until the end of period t.

Can the young still infer the current money supply? **Maybe not.**

- As before, we will focus on how the young's labor supply decisions depend on monetary policy.

- Again, using the equation that determines the price level on island i

$$p_t^i = \frac{M_t/2}{N^i l_t^i}.$$

Notice that individuals do not know M_t and N^i, but they know M_{t-1}. We can rearrange the price equation as

$$p_t^i = \frac{z_t M_{t-1}/2}{N^i l_t^i}.$$

Individuals know that with probability θ, $z_t = 1$ and with probability $1-\theta$, $z_t = 2$.

- Let's think about the potential prices. Depending on the values of z_t and N^i,

	$\frac{2}{3}N$	$\frac{1}{3}N$
$z_t = 1$	$p_t^a =$	$p_t^b =$
$z_t = 2$	$p_t^c =$	$p_t^d =$

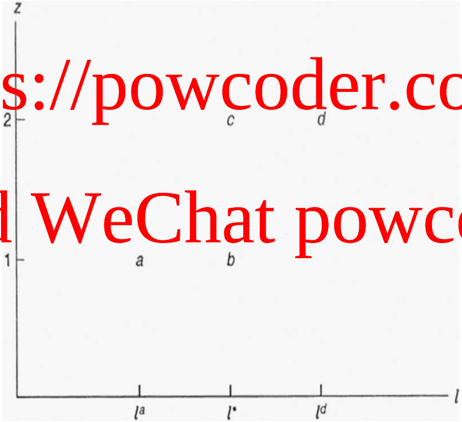
- For any young individual, he does not know the population of the young on his island. He also does not know the current money supply in the economy. Can he still infer z_t and N^i from the prices?

  - If the young individual observes p_t^a, he will know that he is on the island with $N^i = 2N/3$ and $z_t = 1$.
  - If the young individual observes p_t^d, he will know that he is on the island with $N^i = N/3$ and $z_t = 2$.
  - If the young individual observes p_t^b, what can he infer?
  - If the young individual observes p_t^c, what can he infer?

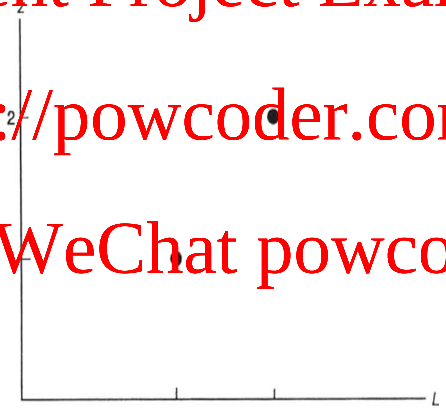
- There are two factors that affect the price level: N^i and z_t.
  - If $N^i = N/3$ (island with less young individuals), it contributes to a higher p_t^i. If $N^i = 2N/3$ (island with more young individuals), it contributes to a lower p_t^i.
  - If $z_t = 1$, it contributes to a lower p_t^i. If $z_t = 2$, it contributes to a higher p_t^i.
- Two of the four possible prices are unique: $\left(p_t^a, p_t^d\right)$. Each can have occurred in only one particular combination of events.
  - If observing the low price p_t^a, the young would supply labor l_t^a (a low level).
  - If observing the high price p_t^d, the young would supply labor l_t^d (a high level).

- If the young observe p_t^b or p_t^c, the young cannot infer whether they are on the island with $N/3$ young and $z_t = 1$ or they are on the island with $2N/3$ young and $z_t = 2$. Therefore, the young decide to supply labor l^*.

- What is the relationship between inflation and output in this economy? If we graph output and inflation on two islands separately,



- If we graph aggregate output and inflation, we have



- Imagine that an economy's time series plot of inflation and output resembles our previous figure. What can you infer?
  - Does the historical correlation suggest that the government can control aggregate output through its control of the money supply?
  - If the government wants to achieve a higher level of output, should the government print money to stimulate output in every period?
  - Will such a policy work?
  - What happens to output if money supply increases at a constant rate in every period?

The Lucas Model

The Lucas Critique

- Imagine that an economy's time series plot of inflation and output shows a positive correlation. What can you infer?
  - Does the historical correlation suggest that the government can control aggregate output through its control of the money supply?
    No.
  - If the government wants to achieve a higher level of output, should the government print money to stimulate output in every period?
    No.
  - Will such a policy work?
    No.
  - What happens to output if money supply increases at a constant speed in every period?
    When the growth rate of money supply becomes constant, people can perfectly infer current money supply. A higher growth rate of money supply leads to lower labor supply and lower output. The positive correlation between inflation and output disappears!

The Lucas Model

The Lucas Critique

- The correlation of money and output or any set of variables results from the reaction of decision makers to the environment they face. An important feature of this environment is government policies.
  - In our example, the relation between inflation and output depends on the monetary policy being followed.
    - Random inflation: positive correlation between inflation and output.
    - Steady inflation (nonrandom inflation): negative correlation between inflation and output.
    - When monetary policy changes from random to nonrandom, the labor supply decisions by the young change as well.
- A correlation between variables that is the result of equilibrium interactions of an economy can be called a **reduced-form** correlation.
  - In our example, it is the correlation between inflation and output.

The Lucas Model

The Lucas Critique

- The Lucas Critique: these reduced form correlations are subject to change when the government changes its policies.
  - In our example, the positive correlation between inflation and output disappears when the government changes from random inflation to non random inflation because young individuals change their labor supply decisions.
- How can we evaluate policies?
  - Econometric policy evaluation is useful.
  - But we also need a theory to help us understand people's motives (preferences) and constraints (physical limitations, informational restrictions, and government policies).
  - It is not sufficient just to look at the data.

For a simple example, consider the question of how much Fort Knox should spend on protection. The United States Bullion Depository, often known as Fort Knox, is a fortified vault building located within the United States Army post of Fort Knox, Kentucky, used to store a large portion of United States official gold reserves and occasionally other precious items belonging or entrusted to the federal government. It is estimated to have roughly **2.3%** of all the gold ever refined throughout human history.

Fort Knox has never been robbed. Statistical analysis using high-level, aggregated data would therefore indicate that the probability of a robbery is independent of the resources spent on guards. The policy implication from such analysis would be to eliminate the guards and save those resources. This analysis would, however, be subject to the Lucas Critique, and the conclusion would be misleading. In order to properly analyze the trade-off between the probability of a robbery and resources spent on guards, the "deep parameters" (preferences, technology and resource constraints) that govern individual behaviour must be taken explicitly into account. In particular, criminals' incentives to attempt to rob Fort Knox depends on the presence of the guards. In other words, with the heavy security that exists at the fort today, criminals are unlikely to attempt a robbery because they know they are unlikely to succeed.

However, a change in security policy, such as eliminating the guards, would lead criminals to reappraise the costs and benefits of robbing the fort. So just because there are no robberies under the current policy does not mean this should be expected to continue under all possible policies. In order to answer the question of how much resources Fort Knox should spend on protection, the analyst must model the "deep parameters" and strive to predict what individuals will do conditional on the change in policy.