

Inflation and Unemployment

①

from aggregate supply to unemployment.

- The AS curve defines a relationship between price and output:

$$y = \bar{y} + \alpha(p - p^e) \quad (1)$$

- Okun's law (which we saw in the section on the "data of macroeconomics") defines an empirical relationship between output and unemployment:

$$y - \bar{y} = -\beta(u - \bar{u}) \quad (2)$$

substitute this equation
into (1):

unemployment rate
corresponding to trend
output of $\bar{y}$.

$$-\beta(u - \bar{u}) = \alpha(p - p^e)$$

rearrange:

so if $p > p^e$, $u < \bar{u}$.

$$u = \bar{u} - \frac{\alpha}{\beta}(p - p^e)$$

we can now turn this into
a statement about inflation:

$$u = \bar{u} - \frac{\alpha}{\beta} (P - P_{-1} - (P^e - P_{-1}))$$

②

where P_{-1} is last year's price level.

$$\underline{u = \bar{u} - \frac{\alpha}{\beta} (\pi - \pi^e) P_{-1}},$$

It is convenient to choose units so that $P_{-1} = 1$. Then we can write

$$\text{where } \pi = \frac{P - P_{-1}}{P_{-1}}.$$

$$\underline{u = \bar{u} - \mu (\pi - \pi^e)},$$

$$\text{where } \mu = \alpha / \beta.$$

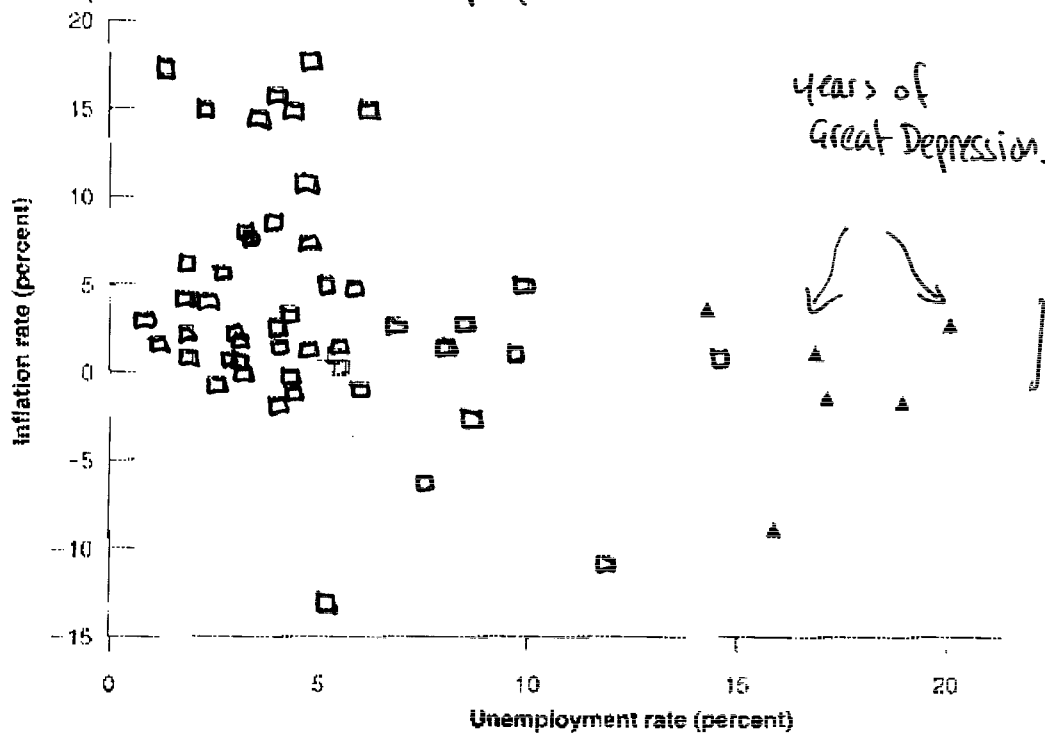
This equation is known as the expectations augmented Phillips curve. To understand how it got that name, we need to review the history of the perceived relationship between inflation and unemployment.

The Phillips Curve (1958-60).

- 1958, A.W. Phillips published an empirical study of the relationship between the rate of change in money wages and the unemployment rate in Britain from 1900-1957. He found clear evidence of a negative relationship.

- 1960, Paul Samuelson & Robert Solow replicated Phillips' work using U.S. data. They also found a negative relationship, with the exception of the unusual years around the Great Depression. ③

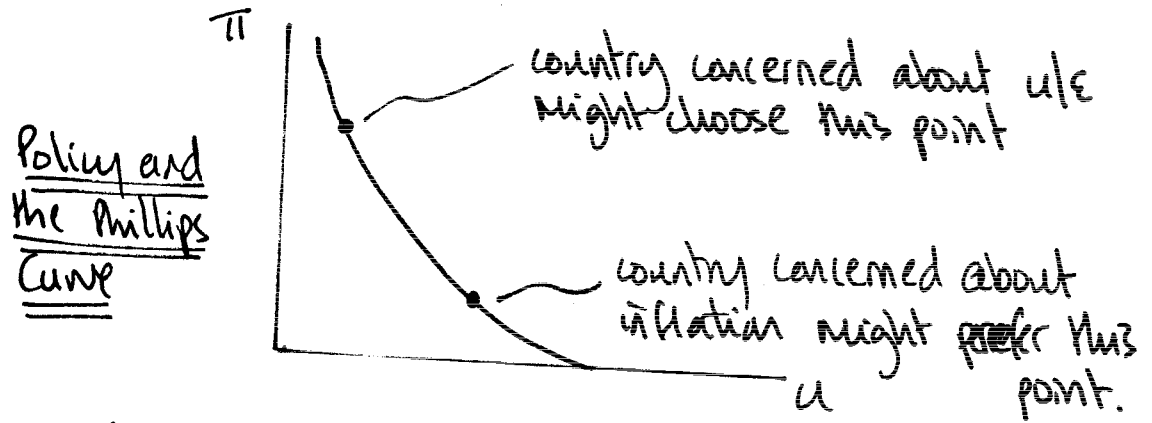
~~inflation~~ inflation + unemployment in the U.S. 1900-1960



Samuelson and Solow quickly dubbed this relationship the Phillips curve. It quickly became a centerpiece of macroeconomic thinking.

- Academics found the relationship very intuitive — wages and prices tend to get bid up when unemployment is low, because of the shortage of available workers.

- Policy makers liked it.
- It suggested that they could choose a pair of inflation and unemployment values according to preferences.



- The Phillips curve also explained why policy makers could not simultaneously attain low average inflation and low unemployment.

NOTE:

You should be suspicious that there is some loose thinking going on here. For example, what happened to the quantity theory as a statement about long-run inflation? Isn't the value of $\bar{y}$ obtained from the classical model where supply of labor equals the demand for labor, so that the long-run level of unemployment is zero?

- the empirical evidence of the relationship seemed so strong that it was overwhelming.
- the classical model as a long-run counterpart to Keynes' short run model was only just beginning to be the accepted model.

⑤

In 1968, Milton Friedman and Edmund Phelps, in independent work, each showed the fallacy in the loose thinking about the Phillips curve.

- recall from the AS curve

$$y = \bar{y} + \alpha(p - p^e),$$

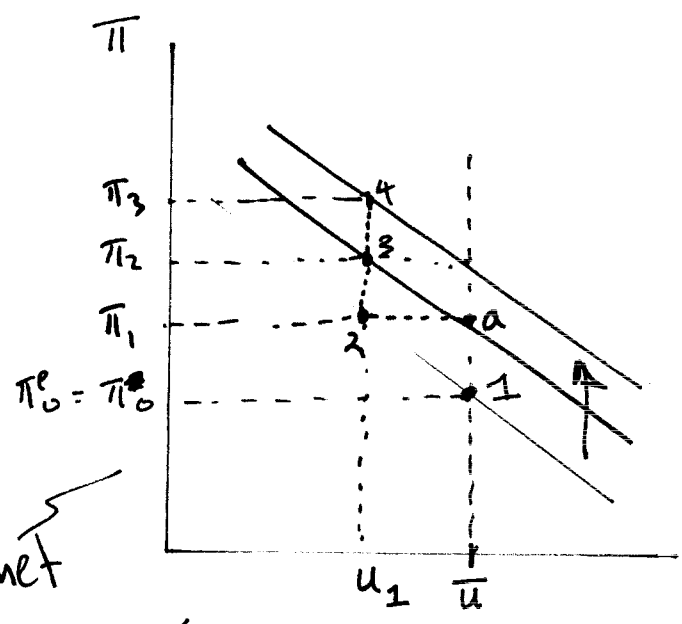
that the natural rate of output is the level of output obtained when $p = p^e$.

- By extension, define the natural rate of unemployment from the expectations augmented Phillips curve,

$$u = \bar{u} + \mu(\pi - \pi^e)$$

as the unemployment rate that obtains when $\pi = \pi^e$.

- Thus, to lower unemployment, the Fed can stimulate the economy with monetary growth, ~~by~~ raising π .
Then, for a given π^e , u must fall below $\bar{u}$.
- But, if $\pi > \pi^e$, the theory of adaptive expectations tells us that π^e will rise next year.
- In the next year, to keep unemployment at its target level below $\bar{u}$, inflation must be raised even higher. Any attempt to sustain $u < \bar{u}$ must induce an ever increasing inflation rate.



Beginning at 1 with $\pi^e = \pi$, $u = \bar{u}$. The Fed raises M^s growth, moving up the Phillips curve to 2, with inflation π_1 . The Fed attains unemployment $u_1 < \bar{u}$. If the Fed maintains inflation at π_1 , unemployment rises back to $\bar{u}$ at a. So to maintain u_1 , Fed must raise inflation to π_2 ... and so on.

"The Ratchet Effect"

Note: This diagram assumes that in the adaptive expectations equation,

$$\pi_t^e = \pi_{t-1}^e + \alpha (\pi_{t-1} - \pi_{t-1}^e),$$

$\alpha = 1$, so

$$\pi_t^e = \pi_{t-1}.$$

you should be able to work out the diagram for some $\alpha < 1$.

So why did there appear to be a Phillips curve?

- Because expectations didn't move around too much, and because $\bar{u}$ was pretty constant.

Then,

$$u_t = \bar{u} + \mu(\pi_t - \pi_t^e)$$

$$= k + \mu\pi_t$$

$$, (k = \bar{u} - \mu\pi_t^e)$$

so it looks like a stable relationship between u_t and π_t .

"Implicitly, Phillips wrote his article for a world in which everyone anticipated that nominal prices would be stable and in which this anticipation remained unshaken and immutable whatever happened to actual prices and wages."

Friedman (1968) "The Role of Monetary Policy." American Economic Review, 58:1-17.

Friedman is most famous for his contributions to monetarism, but this article got him his Nobel prize.

Theory Ahead of Facts.

Friedman and Phelps found logical flaws in a theory that seemed to have worked empirically for a long time. It is therefore doubly remarkable that the stable empirical Phillips curve fell apart only a few years after Friedman and Phelps published their papers.

why? The first-oil price shock.

The Phillips Curve: 49-57 data with time lag

Close fit
of 50s UK
data to
curve

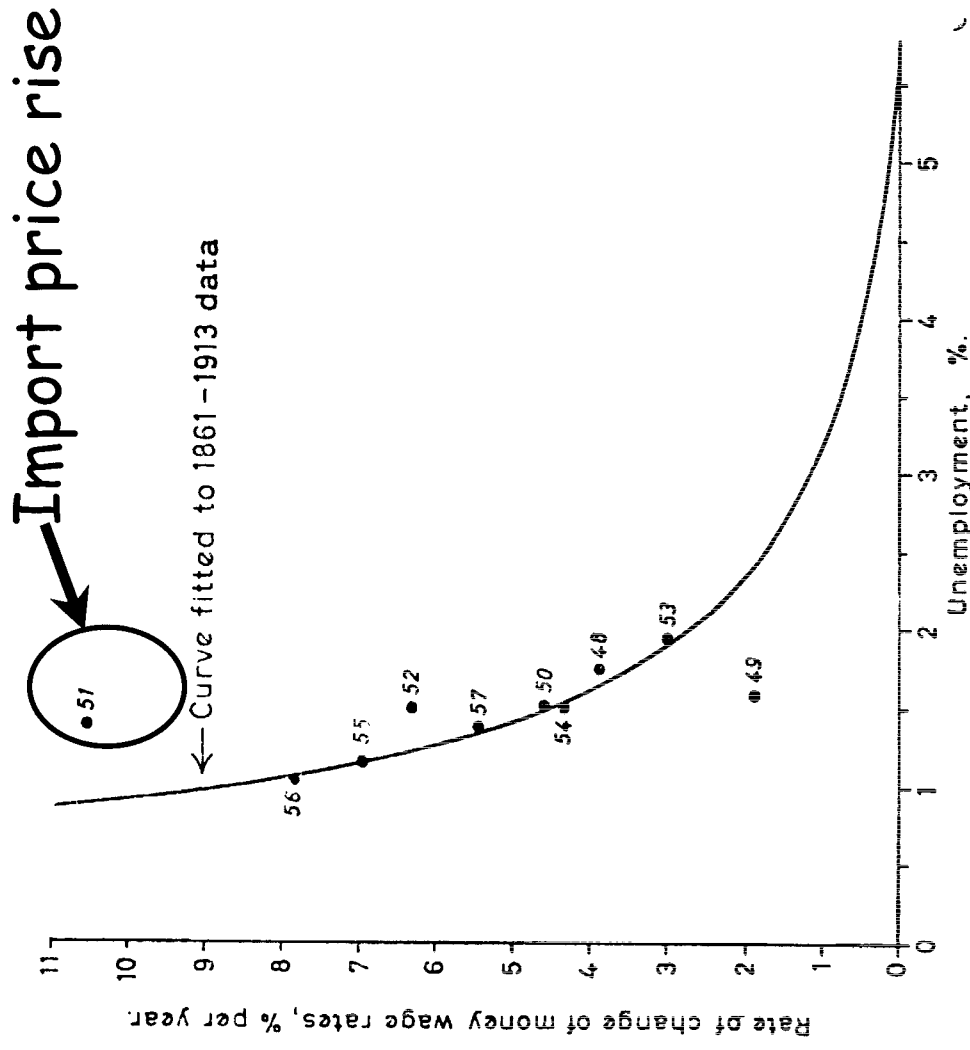


Fig. 11. 1948-1957, with unemployment lagged 7 months

The Phillips Curve: Breakdown...?

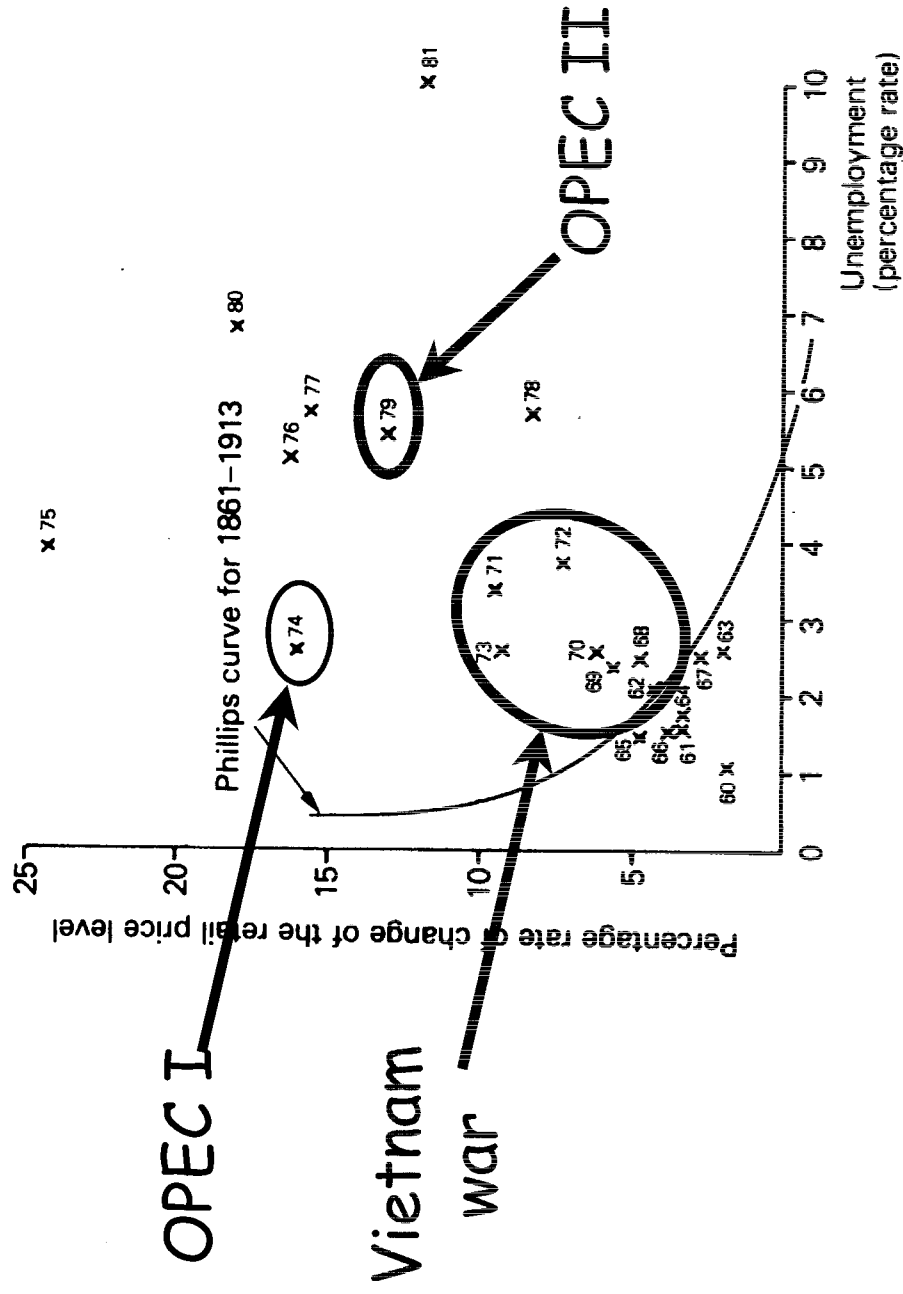
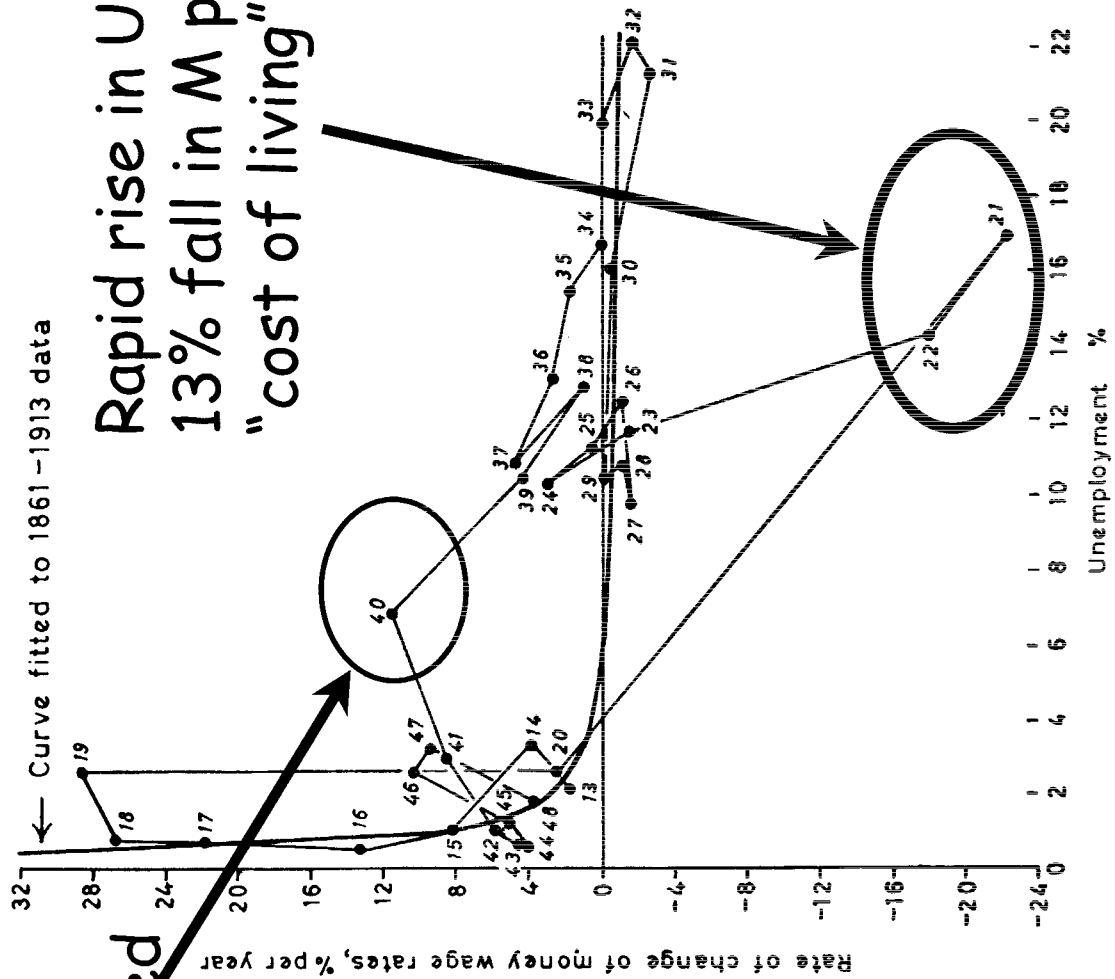


FIGURE 18.3 The Phillips relation in the United Kingdom, 1960–81

Note: data up to 1981 are up to the second quarter

Source: *Economic Trends*.

The Phillips Curve fitted to 1913-1948 data



-in retrospect, the relationship always moved around.

source: Atkeson & Ohanian (2001):
"Are Phillips Curves Useful for
Forecasting Inflation." Federal Reserve
Bank of Minneapolis Quarterly Review.

Charts 1-2

The Breakdown in an Early Phillips Curve

Quarterly Unemployment as a Percentage of the U.S. Labor Force vs.
Changes in the Implicit Price Deflator for U.S. GDP Over the Next Four Quarters,
1st Quarter 1959-1st Quarter 1999

Chart 1 A Negative Relationship in 1959-69 . . .

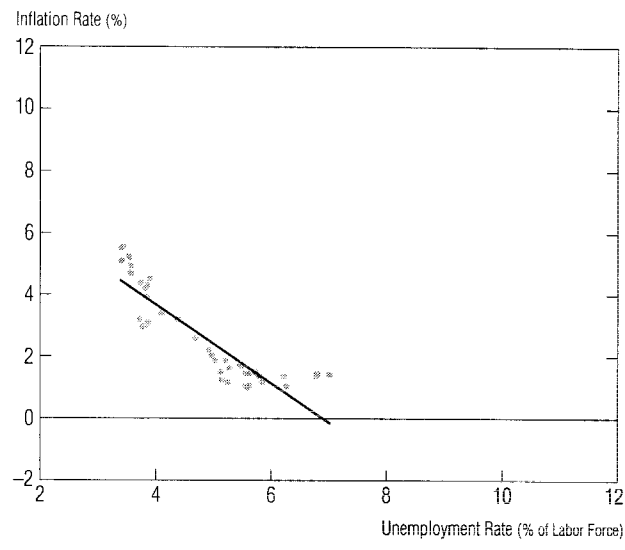
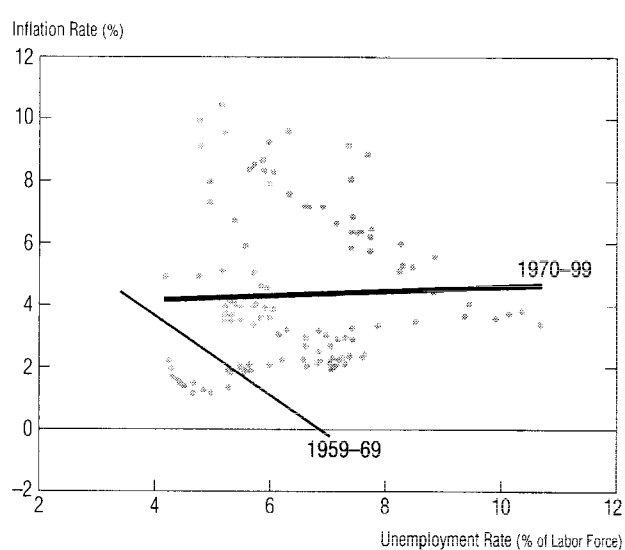


Chart 2 . . . Disappeared in 1970-1999



Sources: U.S. Departments of Labor and Commerce

Charts 3-4

A Shift in the Textbook NAIRU Phillips Curve

Quarterly Unemployment as a Percentage of the U.S. Labor Force vs.
Difference Between Change in the Implicit Price Deflator for U.S. GDP
Over the Next Four Quarters and Its Change Over the Previous Four Quarters,
1st Quarter 1960-1st Quarter 1999

Chart 3 The Steep Negative Relationship in 1960-83 . . .

Change in Inflation Rate (% Points)

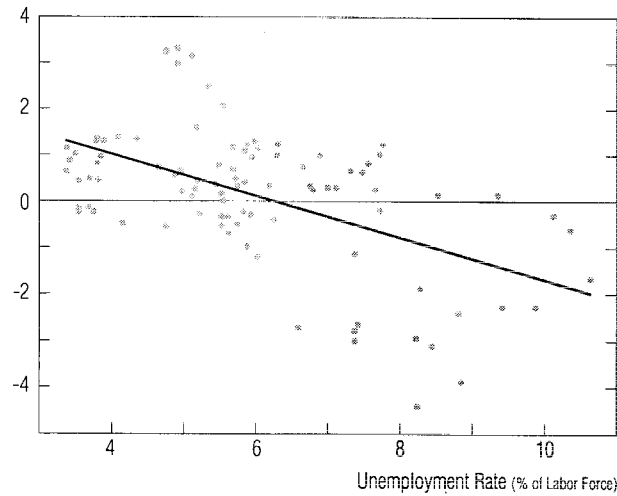
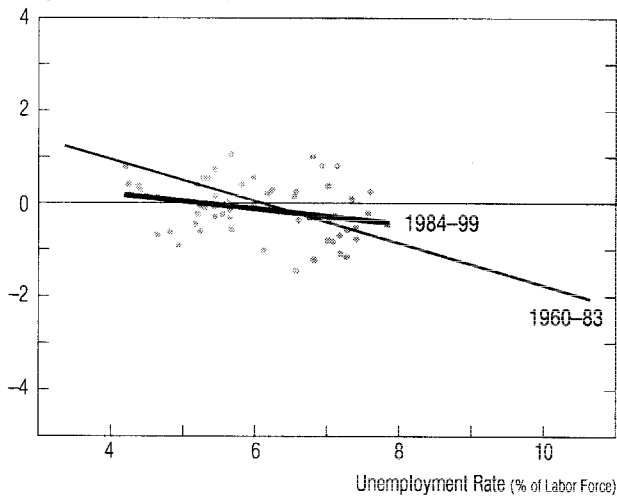


Chart 4 . . . Flattened in 1984-99

Change in Inflation Rate (% Points)



Sources: U.S. Departments of Labor and Commerce

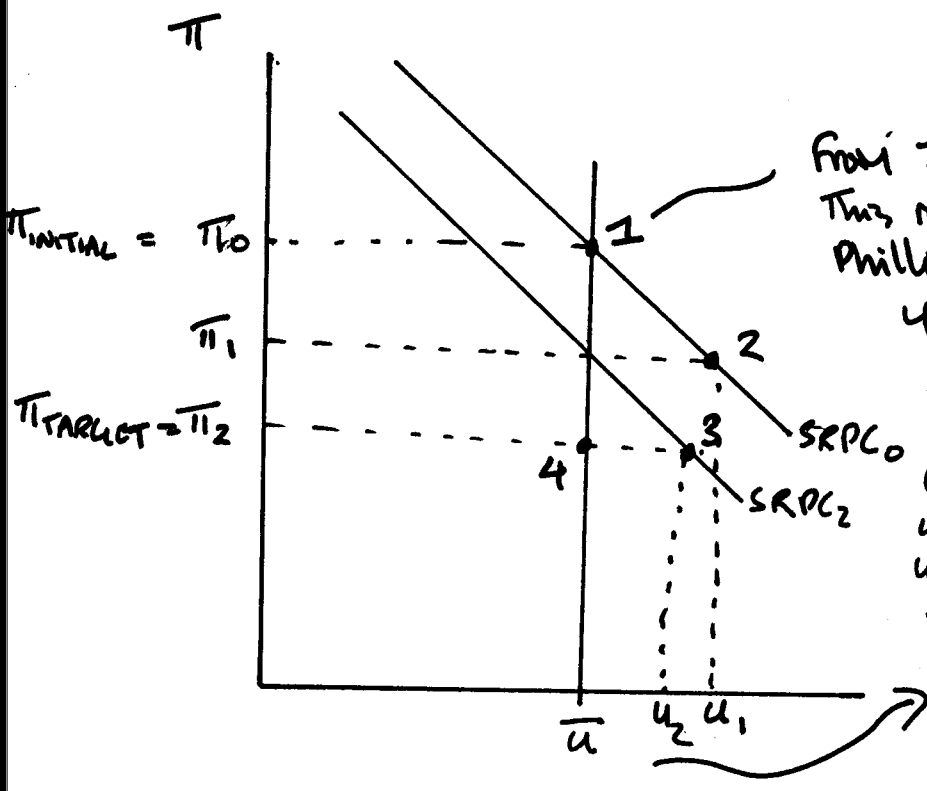
The Sacrifice Ratio.

- If the central bank wants to maintain unemployment below the natural rate, it can do so only by allowing ever-increasing inflation.
- The same framework can be used to address an important question: how big is the sacrifice ratio?

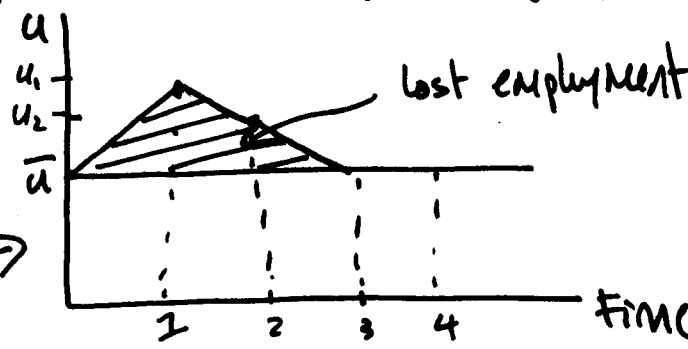
$$\text{SACRIFICE RATIO} = \frac{\text{TOTAL \% -YEARS OF EXTRA U/E}}{\text{\% DECLINE IN TREND \pi.}}$$

Sometimes it is defined in output terms:

$$\text{SACRIFICE RATIO} = \frac{\text{TOTAL \% LOST CUMULATIVE GDP}}{\text{\% DECLINE IN TREND \pi.}}$$



From 1, Fed reduces inflation to π_1 . This raises u to u_1 , but shifts down Phillips curve to $SRPC_2$ for following year. Fed then chooses π_2 + holds inflation there. u is u_2 in the next year, + $\bar{u}$ after.



How big is the sacrifice ratio?

- Consider the special case:

$$u_t = \bar{u} + \beta (\pi_t - \pi_t^e)$$

$$\pi_t^e = \pi_{t-1}$$

~ case of adaptive expectations with $\alpha = 1$.

Then we have:

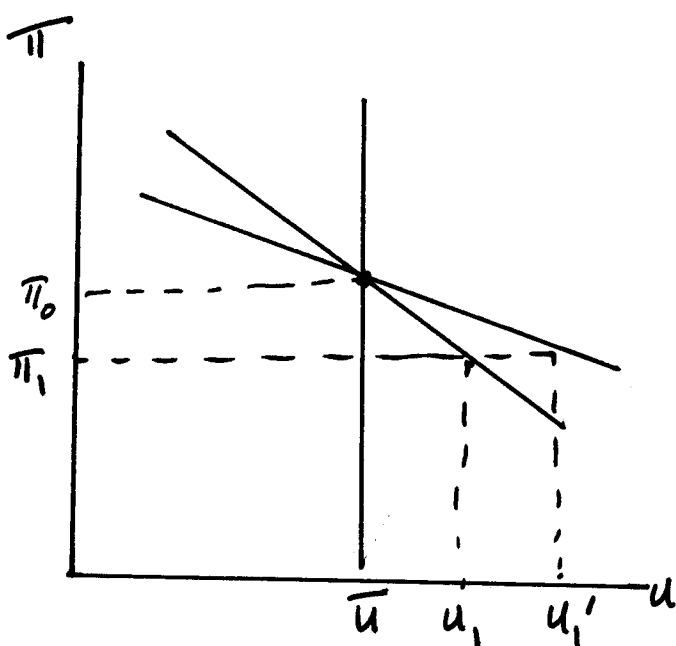
$$u_t = \bar{u} + \beta (\pi_t - \pi_{t-1})$$

Imagine we start out with $\pi_t = \pi_{t-1} = \pi_t^e = 10\%$, and the Fed wants to reduce π to 4% . It could choose gradual or rapid adjustment.

Assume $\beta = 1$.

YEAR	Gradual		Intermediate		Rapid	
	π_t	$u_t - \bar{u}$	π_t	$u_t - \bar{u}$	π_t	$u_t - \bar{u}$
0	10%	0	10%	0%	10%	0
1	9%	1	8%	2%	7%	3
2	8%	1	6%	2%	4%	3
3	7%	1	4%	2%	4%	0
4	6%	1	4%	0%	.	.
5	5%	1	.	.		.
6	4%	1	.	.		.
7	4%	0	.	.	.	.
TOTAL		6%		8%		6%

- So, the sacrifice ratio = $6\% / 6\% = 1$, is the same whether the Fed chooses a rapid or a slow adjustment — it does not depend on the policy choice.
- In general, given $\pi_t^e = \pi_{t-1}$
 - the sacrifice ratio = β .
 - the sacrifice ratio is larger, the flatter the expectations-augmented Phillips curve.



A given reduction in inflation requires more unemployment when the Phillips curve is flatter.

Estimated Sacrifice Ratios

Canada	1.50
Germany	2.92
Japan	0.93
UK	0.79
US	2.39

These are very tentative statistical estimates.

Ball, L. (1993): "What Determines the Sacrifice Ratio." FRBP working paper.

- In general, we have:

$$u_t = \bar{u} - \beta(\pi_t - \pi_t^e)$$

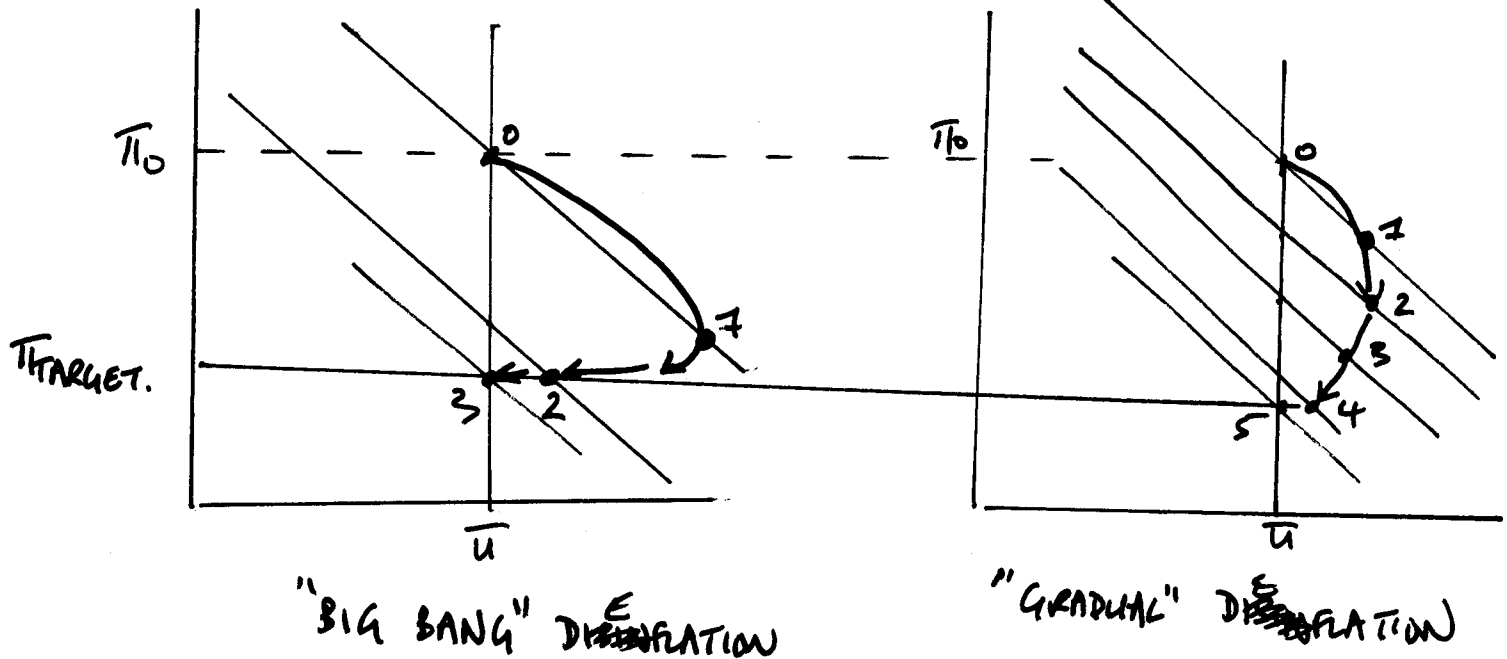
$$\pi_t^e = \pi_{t-1}^e + \alpha(\pi_{t-1} - \pi_{t-1}^e)$$

we set $\alpha=1$ above.

we have found that the sacrifice ratio depends on β , and the speed of adjustment does not matter.

- what do you expect is the effect on the sacrifice ratio of a smaller α ?

Policy implication: gradualism or big bang?



Choice between the two depends as much on politics as it does on economics.

The Volcker Deflation. (U.S.)

(17)

- 1981 Inflation was 9.7%
- Paul Volcker (Greenspan's predecessor) initiated a tight monetary policy to reduce inflation over the next three years.
- By 1985, inflation had fallen to 3%, a reduction of 6.7% over three years.

	1982	1983	1984	1985	Total
unemployment (%)	9.5	9.5	7.4	7.1	
Natural rate (%)	6.0	6.0	6.0	6.0	
Excess unemployment	3.5	3.5	1.4	1.1	9.5
Output lost (% of Trend)*	8.75	8.75	3.50	2.75	23.75
Output lost (\$ bn)**	437	437	175	137	1,186

* Calculated via Okuns law assuming a 1% excess u/e equals 2.5% lost GDP.

** Trend equal to about \$5,000 bn in 1996 dollars.

u/e Sacrifice ratio : $\frac{9.5}{6.7} \approx 1.4$

output sacrifice ratio : $\frac{23.75}{6.7} \approx 3.5$

cost per % drop in π : $\frac{\$1,186 \text{ bn}}{6.7} \approx \177 bn.

The Thatcher Deflation

18

- 1979-80, inflation was 18%
- During 7 years of tight monetary policy, it was brought down to 4.0%.

	1980	1981	1982	1983	1984	1985	1986	1987	Total
u/e	7.0	11.0	11.2	11.4	11.2	10.8	11.0	9.6	
N.R.	7	7	7	7	7	7	7	7	
Excess u/e	0.0	4.0	4.2	4.4	4.2	3.8	4.0	2.6	27.2
output lost (%) [*]	0.0	8.0	8.4	8.8	8.4	7.6	8.0	5.2	54.4

* assumes each excess 1% of u/e $\rightarrow$ 2.0% lost GDP.

$$\text{u/e sacrifice ratio} = \frac{27.2}{14} \approx 1.9$$

$$\text{output sacrifice ratio} = \frac{54.4}{14} \approx 3.9$$

The Natural Rate of Unemployment.

(19)

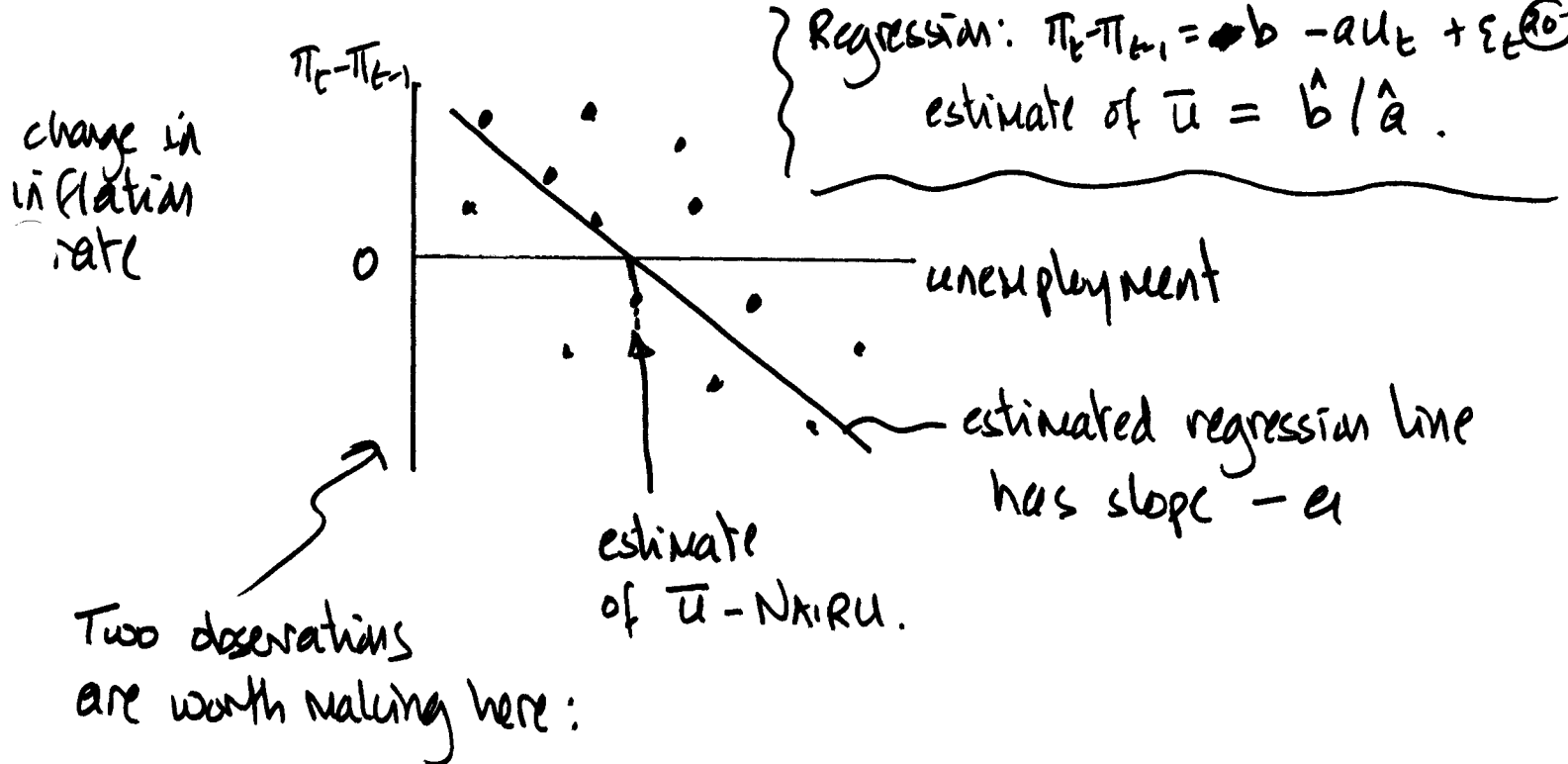
① What is the natural rate of unemployment?

A. One interpretation is that it is the unemployment rate to which the economy tends in its adjustment process.

B. It is perhaps more useful to think in terms of the expectations augmented Phillips curve:

- it is the rate at which the inflation rate is — in the absence of monetary policy changes — neither rising nor falling.
- this definition has received the misnomer — the non-accelerating inflation rate of unemployment (NAIRU).
- to identify the NAIRU requires statistical analysis:

$$\underbrace{\pi_t - \pi_{t-1}}_{\text{change in inflation rate...}} = -\alpha \underbrace{(u_t - \bar{u})}_{\text{.. depends negatively on } u/\bar{u}...} + \underbrace{\varepsilon_t}_{\text{...? and a random error term.}}$$



1. In any one year, the relationship can be quite noisy, (the variance of ε is quite large), so we cannot estimate $\bar{u}$ very precisely.

2. To estimate $\bar{u}$ we need to use historical data. So our estimated $\bar{u}$ represents the average behaviour over the (historical) sample period.

? what if $\bar{u}$ has recently changed?

We can try to get more precise estimates by adding control variables to the regression:

$$\pi_t - \pi_{t-1} = -a(u_t - \bar{u}) + b(m_t - m_{t-1}) + c(g_t - g_{t-1}) + \dots + \varepsilon_t$$

other controls such as changes in money supply, government expenditure, etc.

Frictional unemployment.

(21)

- unemployment is a necessary feature of the labor market.
 - without it it would be difficult for new & expanding firms to find workers.
 - Finding work after losing a job takes time.
- The unemployment caused by this labor turnover is called frictional unemployment.

What determines the amount of frictional unemployment?

Define:

U = the number of people unemployed

E = the number of people employed

$L = U + E$, total size of labor force.

s = rate of job separation: the fraction of employed people who lose their jobs in a given period of time.

f = rate of job finding: the fraction of unemployed people who find a new job in a given period of time.

we are ignoring discouraged people here

There is a precise relationship between these variables (22) which must hold if the unemployment rate is to stay the same from one period to the next.

• we require that

$$\underbrace{fU}_{\substack{\text{number of unemployed} \\ \text{people who find jobs} \\ \text{in a given period of} \\ \text{time}}} = \underbrace{sE}_{\substack{\text{number of employed} \\ \text{people who lose their} \\ \text{jobs in the same time frame.}}$$

Rearrange this:

$$fU = s(L - U)$$

or

$$(f+s)U = sL$$

$$\text{or } \underline{\underline{\bar{u} = \frac{U}{L} = \frac{s}{s+f}}}$$

Numerical example:

- average duration of a job is 7 years (84 months), so on average $1/84$ workers lose their jobs each month: $s = 1/84$
- average duration of a spell of unemployment is 5 months, so $f = 1/5$.

$$\text{Then } \bar{u} = \frac{1/84}{1/84 + 1/5} = \underline{\underline{0.056}}$$

Note:

$$\frac{d\bar{u}}{ds} = \frac{(s+f) - s}{(s+f)^2} = \frac{f}{(s+f)^2} > 0$$

$$\frac{d\bar{u}}{df} = \frac{-s}{(s+f)^2} < 0.$$

↓ The natural rate of unemployment is increasing in the rate of job separation and decreasing in the rate of job finding.

Determinants of the rate of job finding.

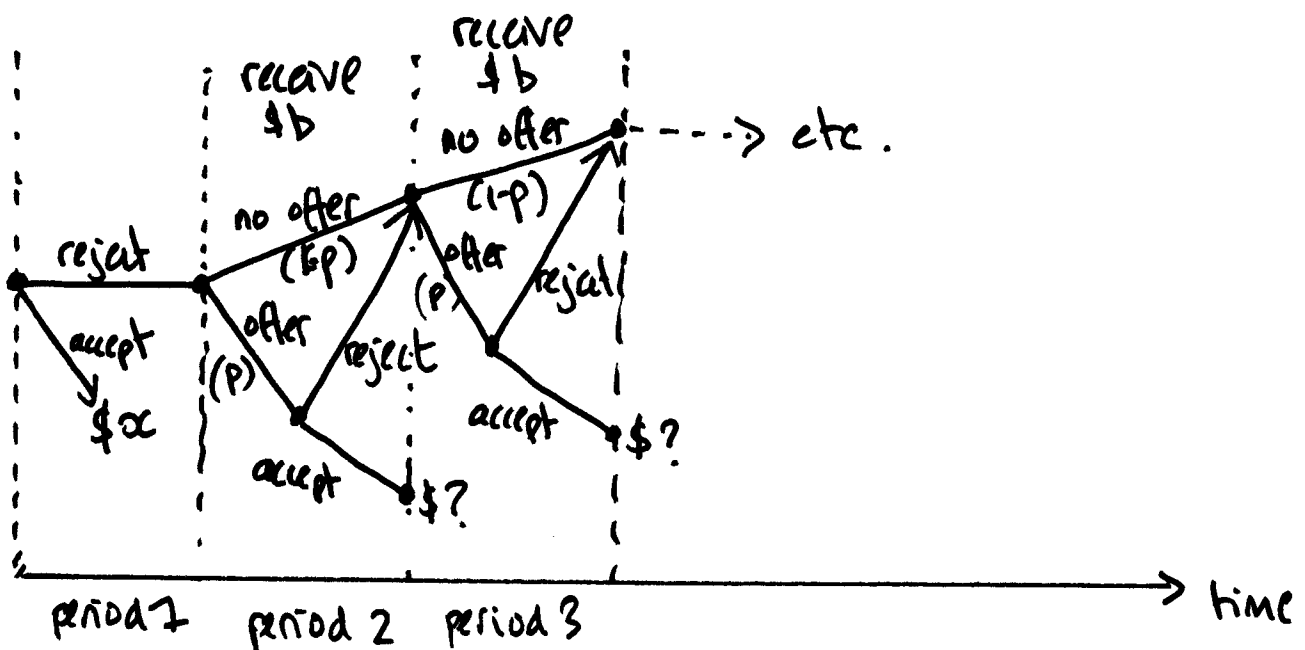
- Simple models of supply and demand assume that every unit of a product is identical. If we extend this idea to the labor market - all firms/jobs are the same and all workers are the same - then every firm would hire the first worker that came along and every worker would take the first job that came along.
- In reality, firms & workers face a search problem.

A simple model of search:

Assume

- In each time-period, an unemployed person can find 0 or 1 job offers.
- The offer pay $\$x$, but x varies from firm to firm, with a mean over all firms of $\bar{x}$.
- In each period, the person receives $\$b$ of welfare or unemployment benefits.
- Let p be the probability an offer of a job is received in each time period.

Consider an individual that has just received an offer of $\$x$. The possible futures for this individual can be drawn in a tree diagram:



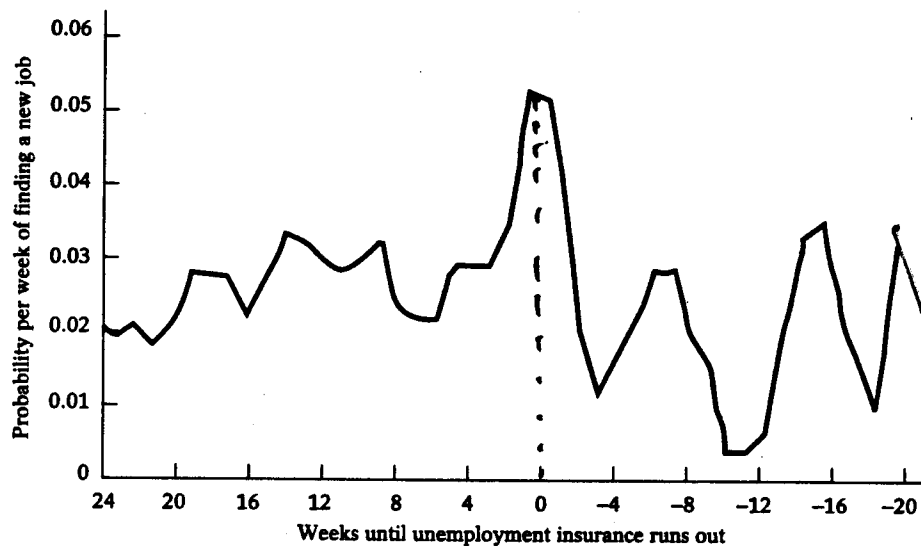
One can solve a model such as this formally. But there is no need to (and it is not easy) for us to think about what is going on.

what increases the probability, p , that an offer is made?

- Make it easier for workers to find out about appropriate jobs.
- Raise the qualifications of the least skilled so a firm is less likely to wait in the hope of finding a better worker. This will reduce the variation in worker quality.
- Make it easier for firms to fire workers if times get bad in the future.

what increases the likelihood that the worker accepts an offer?

- Reduce unemployment benefit, b , either by reducing the payment or putting a time limit on eligibility.
- Make being unemployed more onerous by requiring some form of work in exchange for benefits.



The end of insurance benefits produces a spike in the rate of job finding.

Source: Mankiw "Macroeconomics"

- Make it less likely that waiting will yield a better offer. For example, similar wages, working conditions and benefits for similar skills can be encouraged by legislation. One can also encourage similar wages by simply providing more information about wages across firms: the better information potential employees have, the less likely a firm is to deviate from the norm.

Summary: The rate of job finding is enhanced by: greater homogeneity among firms and workers; more onerous conditions in unemployment; better information and greater labor market flexibility.

Determinants of the rate of job loss.

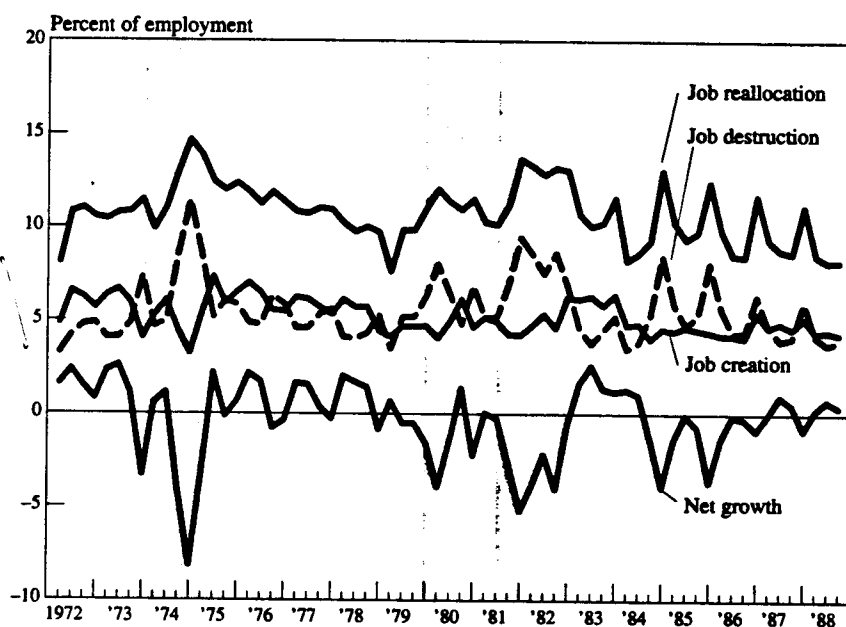
(27)

- People leave jobs for a number of reasons
 - to find a better job
 - because they were fired.
- Jobs are also destroyed as part of the process of business turnover.

2 higher than most people think:

$\frac{1}{3}$ of new businesses close in 5 years.

3% - 10% of all jobs destroyed each year.
job creation is less volatile, fluctuating between 4% + 7% per year.



Source: Davis, Haltiwanger + Schuh: "Job Creation & Destruction."

- There is little one can do to prevent bankruptcies unless the government is prepared to subsidize loss-making firms.
- One can reduce job loss by imposing costs on firms that stay in business who dismiss workers
 - minimum terms on redundancy
 - notice of dismissal, etc.

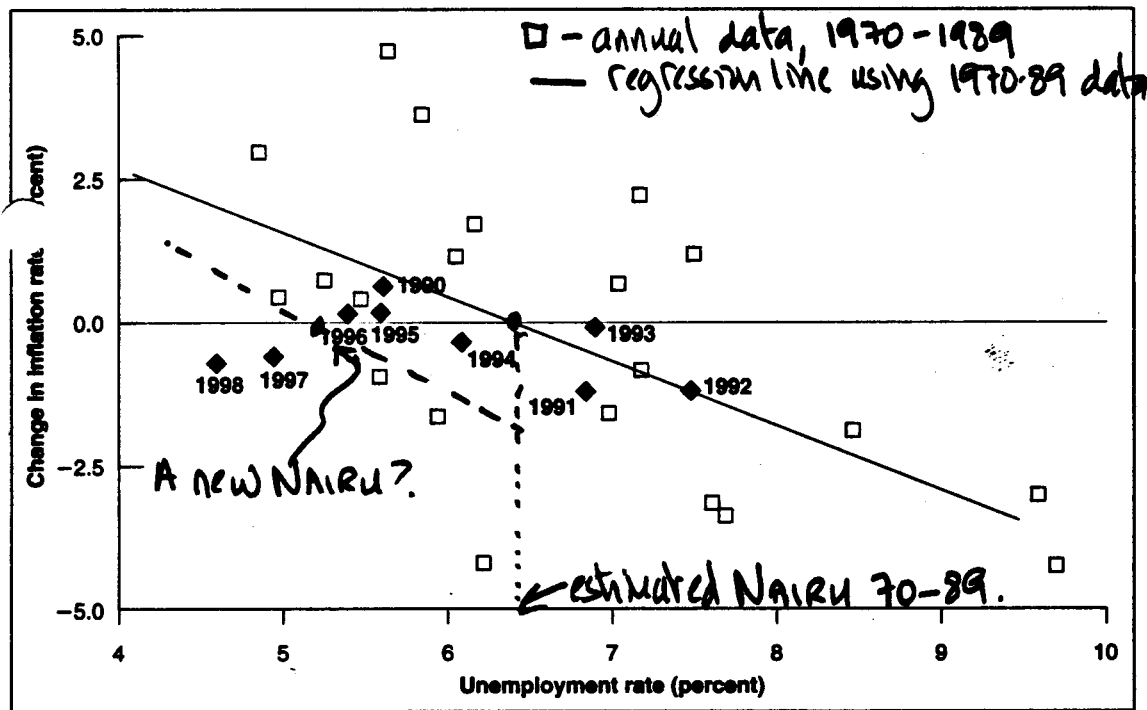
But these might make firms reluctant to hire in good time, ~~raising~~ lowering the rate of job finding.

Has the US Natural Rate Declined?

(29)

1998: unemployment was 4.6%, lowest in 3 decades
inflation was lower in '98 (1.6%) than '97 (2.3%)

- This has led some economists to proclaim "a new labor market" — unemployment can be kept very low without needing higher inflation
- Business Week asked "Is the business cycle dead?"



Check these claims with the NAIRU concept.

Most observations in 1990s lie below the regression line.

Is this just luck? or has the NAIRU moved?

In fact, the data for the 1990s

do not even suggest a negative relationship between inflation changes and unemployment at all.

Has the relationship broken down?

But see this table

(30)

	1995	1996	1997	1998
u/e	5.6	5.4	4.9	4.6
Δ in wage infl:	0.0	+0.6	+0.5	+0.4
Δ in price infl:	+0.2	+0.2	-0.7	-0.7

... while price
inflation fell.

Money wage
inflation was
rising with low
unemployment...

what appears to have broken down is not the concept of the
NAIRU, but the relationship between wage + price inflation.

- Benefits (e.g. health) grew more slowly than wages in the late 1990s.
- Dollar has appreciated → cheaper imports → reduction in CPI (imports account for about 10% of the CPI).
- Prices of many raw materials, including oil, has declined.

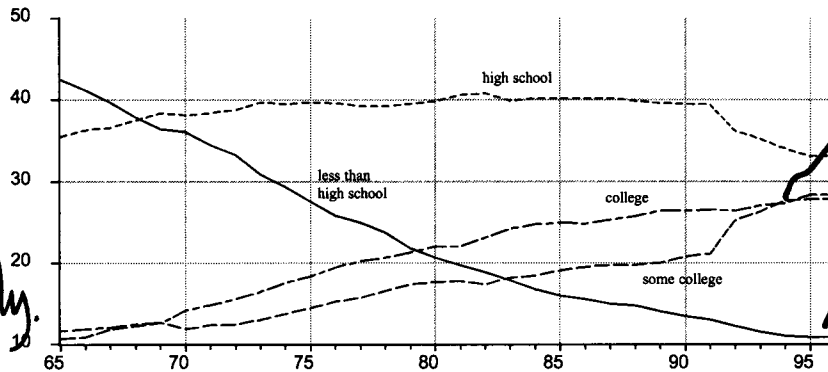
So, low u/e still leads to wage pressure. The failure for the pressure to show up as rising price inflation is due to factors that must be temporary. The natural rate of unemployment may have declined in the US, but not by as much as is suggested by basic data on price inflation.

Education and The Natural Rate.

(31)

Chart 1

The Educational Composition of the Labour Force in the United States

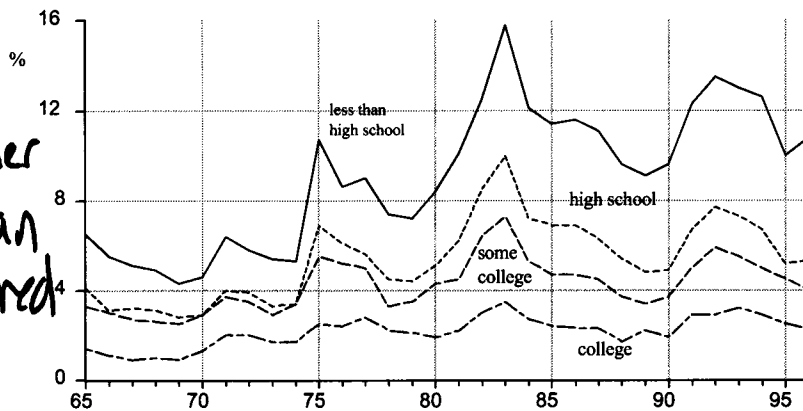


big rise in college-level education.

enormous decline in high school dropouts

Chart 2

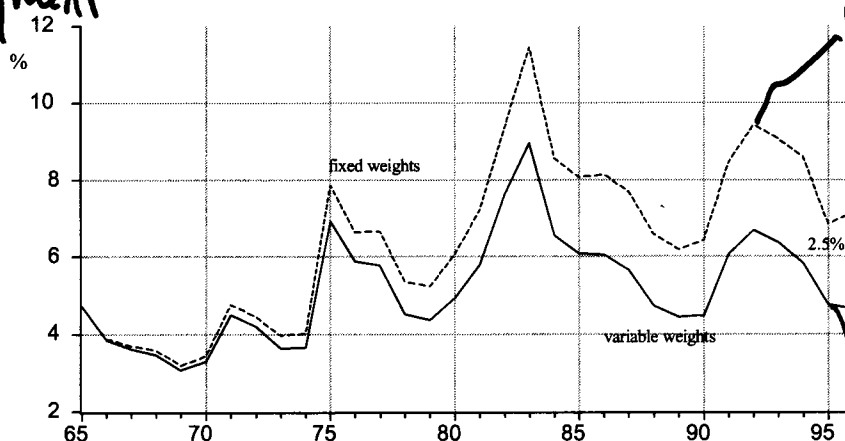
The Rate of Unemployment by Education in the United States



college graduates have 50-70% lower unemployment than high-school drop-outs.

Chart 3

The Rate of Unemployment in the United States



ule that would prevail with 1965 education levels

unemployment actually observed using the ever-changing education balance.

① Since the 1960s, the educational balance of the US labor force has changed dramatically.

② And the less educated have always had higher unemployment than more educated

③ So the unemployment rate is brought down.

Source: M. Francesconi et. al. (1999): "Education and The Natural Rate of Unemployment," Institute for Social and Economic Research, University of Essex. Unpublished paper.

Efficiency Wage Models.

(32)

- Frictional unemployment results from the mechanics of the labor market. As such it has little to do with the private choices made by firms or individuals. In contrast, a second class of explanations focuses specifically on firms' optimizing behavior. This class of explanations, collectively called efficiency wage models, suggest that it is optimal in a private profit-maximizing sense for firms not to try and pay market clearing wages.

3 main models:

- shirking models
- labor turnover models
- adverse selection models.

Firms pay higher wages to induce effort

we will look at one of these - the shirking model.

Firms pay higher wages to induce ~~firms~~ workers to stay.

Firms pay higher wages to induce better qualified applicants to apply for jobs.

The Labor shirking model.

(33)

The basic intuition

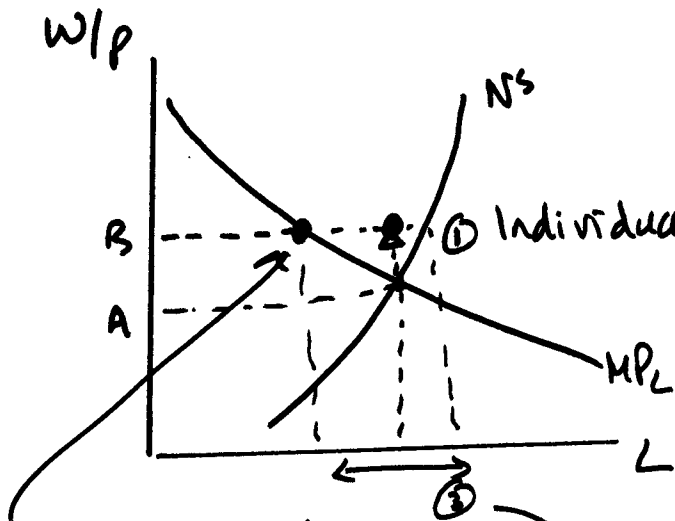
- Most people do not like expending effort. If they can get away with it, they will shirk.
- A firm tries to monitor worker effort, firing those not working up to standard. But monitoring is costly, imperfect, and the best a firm can do is impose a possibility on shirking workers that they will get caught.
- This possibility may be insufficient to deter shirking.
If I can go get another job at the same wage, the threat of being fired is no threat at all!
- So each firm decides to pay a higher wage. Then, the expected cost of shirking is:

$$[\text{current wage} - \text{future wage}] \times [\text{probability of getting caught}].$$

⚡
Firm raises wage sufficiently that the cost of shirking is so high that workers will put in effort.

- The problem is, all firms try to do this, and of course every firm cannot be paying a higher wage than other firms.

- Surprisingly, this does not mean that firms cannot provide the requisite incentive. As every firm raises its wage, firms also decide to employ less labor, and this creates unemployment. (34)



① Individual firms try to pay more than the usual wage to encourage more effort.

② But all firms do this, so the average wage rises and total employment falls...

... thus creating persistent involuntary unemployment.

The expected cost of shirking is now given by

$$C = [\text{current wage} - \text{u/s benefits}] \times \left[\begin{array}{c} \text{probability of not getting} \\ \text{a replacement job} \end{array} \right] \times \left[\begin{array}{c} \text{probability of getting} \\ \text{caught} \end{array} \right].$$

Note: a) No one shirks in equilibrium.

b) No firm has an incentive to lower the wage even though there is a pool of unemployed.

c) unemployment will be lower if the monitoring technology is better.

Let us try this a little more formally:

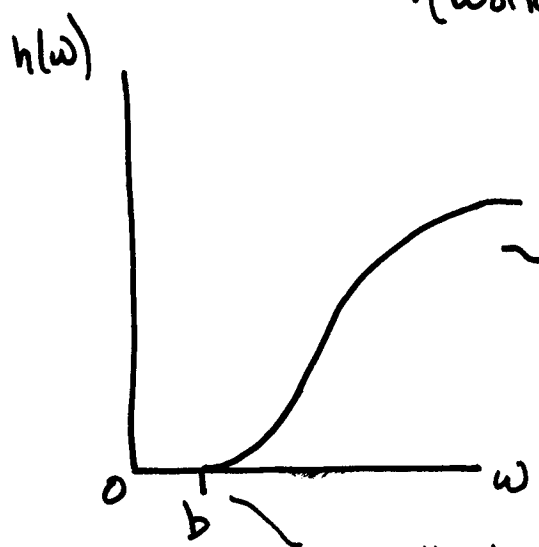
- Assume that at low wages individuals are less productive.
- There is a fixed (given) value to the individual of being unemployed (e.g. benefits), equal to b .

We now consider the firm's optimization problem.

Define: $h(w)$ - efficiency units per worker (the amount of effort the worker puts in).

$f(nh(w))$ - the production function

output = $f(\underbrace{\text{no. of workers}}_{nh(w)} \times \underbrace{\text{amount of effort each one exerts}}_{h(w)})$.



~ effort function $h(w)$ is assumed to have this form - convex at first, then concave.

no effort is put in at all unless $w > b$.

The firm maximizes profits:

max
 ω, n

$$\pi = pf(nh(\omega)) - \omega n$$

revenues - wage costs.

maximize profits
by choosing $\omega + n$.

The optimality conditions are:

$$\frac{\partial \pi}{\partial n} = pf' h(\omega) - \omega = 0$$

$$\left[= p \cdot \frac{df}{dnh(\omega)} \cdot \frac{dnh(\omega)}{dn} \right]$$

$$\frac{\partial \pi}{\partial \omega} = pf' h'(\omega) n - n = 0$$

$$\left[= p \cdot \frac{df}{dnh(\omega)} \cdot \frac{dnh(\omega)}{dh(\omega)} \cdot \frac{dh(\omega)}{d\omega} \right]$$

So, we have:

$$pf' h(\omega) = \omega \quad (1)$$

$$pf' h'(\omega) = 1 \quad (2)$$

and taking ratios (dividing (2) by (1)):

$$\frac{h'(\omega)}{h(\omega)} = \frac{1}{\omega}$$

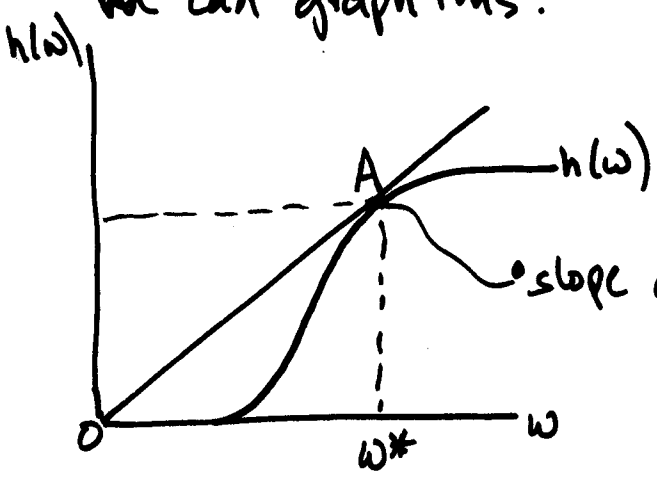
or

$$\underline{\underline{\frac{\omega h'(\omega)}{h(\omega)} = 1}}$$

Note: $\frac{\omega h'(\omega)}{h(\omega)} = \frac{dh}{d\omega} \cdot \frac{\omega}{h} = \frac{dh/h}{d\omega/\omega}$

$= \frac{\% \text{ change in effort}}{\% \text{ change in wage}}$
 $= \underline{\text{elasticity of effort}}$

We can graph this:



- slope at this point is $h'(\omega)$
- slope of straight line OA is $\frac{h(\omega)}{\omega}$, and our optimality condition says $\frac{h(\omega)}{\omega} = h'(\omega)$

So point A pins down ω absolutely.

So what is interesting about this?

- Note that the wage is fixed entirely by the effort function $h(\omega)$. Changes in technology, $f(\cdot)$, in the price level, p , and changes in the labor supply function, do not alter the nominal wage.