14.02 AS-AD What Happens when MP

Maya's back

AS $P = (1 + \mu) W$

$W = P^e F(u, z)$

$Y = N$

$u = \frac{U}{L} = \frac{L - N}{L} = 1 - \frac{N}{L} = 1 - \frac{Y}{L}$

u is decreasing in Y

$W = P^e F(u, z) = P^e F(1 - \frac{Y}{L}, z)$

Wage is a function of price - since workers watch real wages

Unemployment rate is decreasing in output

↳ Causality is reversed

Output is decreasing in unemployment

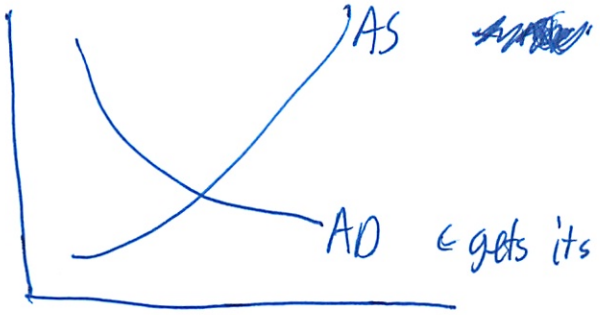
An increase in Y leads to an increase in P.

AD $Y = Y(\frac{M}{P}, G, T)$

For every level of P have equilibrium output in IS-LM model

Y is decreasing in P

(2)



← gets its name b/c decreasing relationship

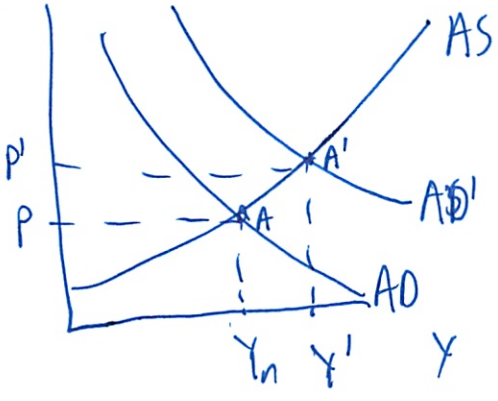
Its not really aggregating demand - how much would consumers demand (diff than we learned in HS?) at each P

↑ Money Supply

$$Y = Y\left(\frac{M}{P}, G, T\right)$$

So $Y \uparrow$

Shifts AD curve outward



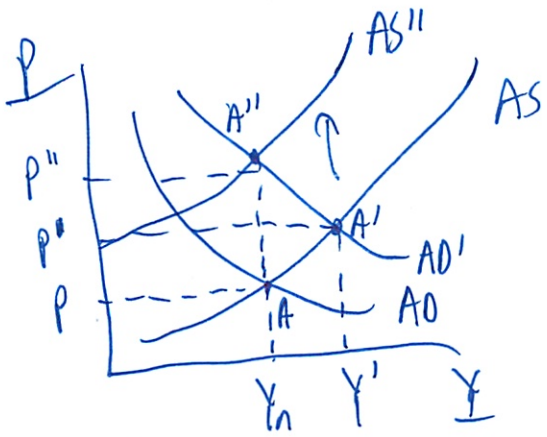
Price went up, but wages fixed

Will expect (P^e) higher prices, so expect higher wages in medium run

So then AS curve shifts up

For a given price, suppliers will be willing to supply less

(3)



At P'' price does not go up further since price level is where the wage setters expected

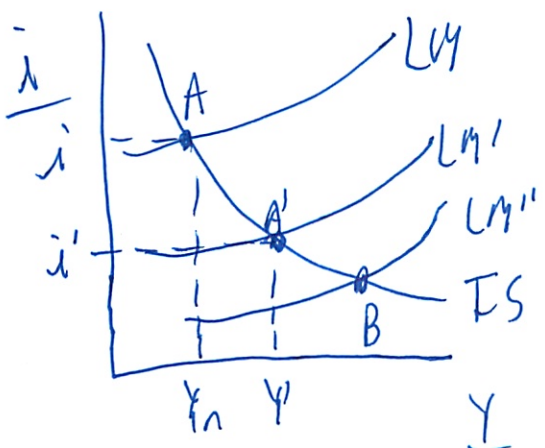
Behind the scenes

What happens when M↑:

- for every i, Y(i) is higher

So LM curve shifts down

Intersection w/ IS curve means lower i and Y is



↑ M, get a higher i for each level of output

(4)

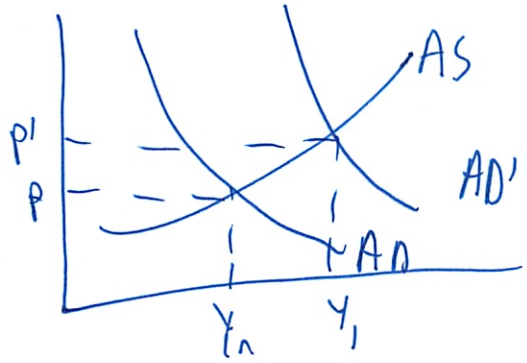
But holding price level constant

Asking what happens when ↑ M

So for every P, output will be higher

Even in SR, output ↑, prices ↑

Shifts AD curve outward



$$Y = \frac{M}{PL(i)}$$

So for every i an ↑ in P ↓ Y(i)

Over time P↑, so back at Y_n and i

* So LM'' was overestimate *

So ~~only~~ get equalibrium at LM' *

Is equalibrium before prices adjust

- which does not happen quickly

* Then wages adjust in medium run, so go back to A

(5)

B is not an equalibrium

A' = SR equalibrium

A'' = A = LR equalibrium

Money neutrality

A M expansion leads to

- ↑ in Y
- ↓ in i
- ↑ in P

Over time the PT, and the effects on Y, i disappear

The ↑ in money supply is completley reflected in the price

~~depends on shape of AS curve~~

Then ~~AD~~ does not i

did not follow about curve being flatter

So gov can use monetary policy for tempoary effects

Smooth long-run fluctiations

but can't cause a permanent ↑ in standards of living

Chap 8 Natural Rate Unemployment Phillips Curve

3/7

Reading

- negitive relation b/w inflation + unemployment
  - Phillips Curve
- much of discussion centered around where on curve to pick
  - <1970
- but 1970s: high inflation and high unemployment
- refined model to ~~inflation and the change~~
  - Unemployment and the change in inflation
- this was later expanded to AS model

8.1 Inflation, Expected Inflation, + Unemployment

Start w/ AS curve (chap 7)

$$P = P^e(1+\mu)F(u,z)$$

Assume a Function

$$F(u,z) = 1 - \alpha u + z$$

α = strenght of unemployment on wage

$$P = P^e(1+\mu)(1-\alpha u + z)$$

π = inflation rate

π^e = expected inflation rate

$$\pi = \pi^e + (\mu + z) - \alpha u$$

division is tedius

(I need to figure out how to write lower u - not μ)
(think best moving forward)

(2)

Appendix - deriving previous formula

P_t, P_t^e, U_t for each year t

$$P_t = P_t^e (1+\mu)(1-\alpha U_t + z)$$

Go from in terms of price level to in terms of inflation

$$\frac{P_t}{P_{t-1}} = \frac{P_t^e}{P_{t-1}} (1+\mu)(1-\alpha U_t + z)$$

Rewrite fraction

$$\frac{P_t}{P_{t-1}} = \frac{P_t - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t - P_{t-1}}{P_{t-1}} = 1 + \pi_t$$

(remember $\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$)

As well as for expected

$$\frac{P_t^e}{P_{t-1}} = \frac{P_t^e - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t^e - P_{t-1}}{P_{t-1}} = 1 + \pi_t^e$$

So update our original function

$$(1+\pi_t) = (1+\pi_t^e)(1+\mu)(1-\alpha U_t + z)$$

Divide by $(1+\pi^e_t)(1+\mu)$ to make more user friendly

$$\frac{(1+\pi_t)}{(1+\pi^e_t)(1+\mu)} = 1 - \alpha U_t + z$$

(3)

As long as inflation, π^e, μ not too large, a good approx is

(approx) $1 + \pi_t - \pi^e_t - \mu$

So

$$\pi_t = \pi^e_t + (\mu + z) - \alpha u_t$$

(end appendix)

An ↑ in expected inflation π^e, leads to ↑ in actual π
- same reason as price
- if wage setters expect a higher price, then will ask for higher wages, thus driving prices up

Given π^e, μ↑ or z↑ will cause π↑
- same argument as before, since higher wages

Given π^e, u↑ means π↓
- since at p^e, u↑ means w↓
- which ↓ p
- so ↓ in π

Look at the indexes

$$\pi_t = \pi^e_t + (\mu + z) - \alpha u_t$$

↑ ↑ think of as constant

(4) 8.2 Phillips Curve

Early Version - inflation was close to 0 when they were graphing

expect that 0 inflation last year = 0 inflation this year

$\pi^e_t = 0$

$\pi_t = (\mu + z) - \alpha u_t$

Given p^e (workers just use last years) $u \downarrow$ means $w \uparrow$

$\uparrow w = p \uparrow$

So **wage-price spiral**

So in 1960s gov targeted unemployment for a range for modest inflation

But broke in the 1970s

- large increase in non-labor costs (oil) meant $\uparrow \mu$
- but mostly wage setters changed how they form expectations
  - inflation was now never negitive
  - expected $p^e_t = p_{t-1}$ meant $\pi^e = 0$ which was foolish
  - so wage setters took this into account

$$\pi^e_t = \theta \pi_{t-1}$$

↑ the higher θ, the more wage setters consider inflation

- But as $\pi \uparrow$, more people plan for it, $\theta \uparrow$, so becomes persistant

(5)

$$\pi_t = \overbrace{\theta \pi_{t-1}}^{\pi e_t} + (\mu + z) - \alpha u_t$$

When $\theta = 0$ → its like original phillips curve

When $\theta > 0$ → then inflation depends on previous inflation

When $\theta = 1$ → then phillips curve about change in inflation

$$\pi_t - \pi_{t-1} = (\mu + z) - \alpha u_t$$

low U → $\Delta \pi$ (+)
high U → $\Delta \pi$ (−)

this is the modified / expectations-augmented / accelerationist Phillips curve

Back to Natural Rate of Unemployment

- Phillips curve closely related to natural unemployment rate
- original Phillips curve said no such thing as natural unemp rate
- some said unemployment could not be sustained below a certain rate
- natural rate of unemp = unemp rate such that $p_a = p_e$ or $\pi = \pi_e$

$$0 = (\mu + z) - \alpha u_n$$

$$u_n = \frac{\mu + z}{\alpha}$$

(e)

The higher the markup, or z, the higher u_n

So $$\pi_t - \pi_t^e = -\alpha\left(u_t - \frac{u+z}{\alpha}\right)$$

$$\pi_t - \pi_t^e = -\alpha\left(u_t - u_n\right)$$

If can approx π_t^e with π_{t-1} (like in US today)

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

- another way of thinking about the Phillips curve

* change in inflation rate depends on $u - u_n$

When $u > u_n$ $\pi \downarrow$

$u < u_n$ $\pi \uparrow$

u_n = rate of employment to keep inflation constant

non accelerating inflation rate of unemployment NAIRU

$\sim 6\%$ in US

8.3 Summary

- has held since 1970s well in US
- but u, α varies b/w countries
- like Japan w/ lifetime employment means lower α's
- u, z vary over time
  - monopolies, union wage bargining
- hard to see natural rate - only see avg rate
- if π falling fast, means $u_t > u_n$

  π constant $u_t \approx u_n$

(7)

Has the US seen a large ↓ in u_n 1994 → 2002?

- is globalization ↓ u and ↓ α (bargining strength of employees)
- aging of US pop.
  - young workers have higher unemp. rates
- ↑ prision pop, 3% → 1%
  - many would have be, unemp. otherwise
- ↑ workers on disability since weaker standards
  3.1% → 5.3%
- ↑ temp employment
  - allows workers to look for jobs while emp
- higher rate of productivity growth
  - means costs grew slower than expected
  - so less inflation, despite low unemployment

When inflation is high, is more variable

So shorter contracts better

Or <u>wage indexation</u> (a COLA)

Lead to a stronger response of inflation to unemployment

λ = proportion of labor contracts indexed to inflation

Nominal wages move 1 for 1 w/ changes in price level

$$\pi_t = [\lambda \pi_t + (1-\lambda)\pi_t^e] - \alpha(u_t - u_n)$$

Assume this years inflation same as last years $\pi_t^e = \pi_{t-1}$

$$\pi_t = [\lambda \pi_t + (1-\lambda)\pi_{t-1}] - \alpha(u_t - u_n)$$

(8)

When $\lambda = 0 \rightarrow$ all inflation set to expectations

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

When $\lambda > 0 \rightarrow$

$$\pi_t - \pi_{t-1} = \frac{-\alpha}{(1-\lambda)}(u_t - u_n)$$

w/o indexation wages lag price increases

w/ indexation wages respond faster so effect of unemp on inflation within the year is higher

When $\lambda \rightarrow 1$ approaches
- Small changes in unemp can lead to large change in unemp.

Or large changes in inflation w/o changes in unemp
- like in countries where inflation is high

Deflation + Phillips Curve

Why was inflation high during the Great Depression?
- also saw ↑ u_n?
  - since large shifts in AD
- or Phillips Curve does not apply
  - workers reluctant to accept wage "cuts"
  - but don't notice inflation eating down real wages
  - so Phillips curve weaker at close to 0 inflation

Phillips Curve – relation b/w inflation + unemployment

Just AS rewritten

In AS (review)

$$P = P^e (1+\mu) F(u, z)$$

From wagesetting vs pricesetting curve

WS $W = P^e F(u, z)$

PS $P = (1+\mu) W$

Inflation

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$ Rate of change of position

Put in t

$$P_t = P_t^e (1+\mu) F(u_t, z)$$

↑ change much slower over time

Phillips Curve

$$\pi_t = \pi_t^e + (\mu + z) - \alpha u_t$$

To go from AS to Phillips – a few assumptions

1. $F(u_t, z) = 1 + z - \alpha u_t$ ← linear
2. π_t is not too large

Need to bound
$\alpha > 0$
$\alpha < \bar{\alpha}$ such that $p > 0$

(2) (Normally in this class no calculus)

Trick to Derive w/ Calculus

$$P_t = P^e_t (1+\mu)(1+z - \alpha u_t)$$

$$\ln(P_t) = \ln(P^e_t (1+\mu)(1+z-\alpha u_t))$$

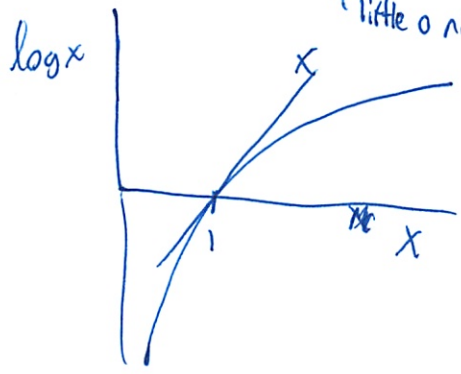
Use properties of log to write as sum

$$\ln(P_t) = \ln(P^e_t) + \ln(1+\mu) + \ln(1+z-\alpha u_t)$$

Use Taylor expansion for ln

$$\log(1+x) \approx x + o(x^2)$$

↑ little o notation - error is of order x^2



$$\log(x) \approx 1 + x + o(x^2)$$

$$\frac{d(\log P_t)}{dt} = \frac{1}{P_t} \cdot \frac{dP_t}{dt} = \frac{P_{t+1} - P_t}{P_t} = \pi_{t+1}$$

⋮ skipped

(3)

Phillips Curve Endogenizing π_t^e

Original $\pi_t^e = 0$ ← good approx till 1960s

↳ $\pi_t = (\mu + z) - \alpha u_t$

tradeoff b/w unemployment and inflation

But after that, was not very accurate anymore

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

↑ not rational

just rule of thumb

about last year

Lucas $\pi_t^e = \pi_{t+1} + \varepsilon_t$ ← error term

↑ if have perfect foresight — no one does this — but people right on avg

makes it harder to predict

Inflation expectations are important

key part of what central bank does - set expectations

Predictability is difficult

By nature - most things unpredictable

If could predict, then you would change the outcome

Predict stock will go ↑, if you knew that price will shoot up

Taken care of

4

Plug each in

Original $\pi_t = (\mu + z) - \alpha u_t$

Friedman/Phillips $\pi_t = \theta \pi_{t-1} + (\mu + z) - \alpha u_t$

Lucas $\pi_t = \pi_{t+1} + (\mu + z) - \alpha u_t + \varepsilon_t$

(not in both)

$\theta = 1$

$\pi_t - \pi_{t-1} = (\mu + z) - \alpha u_t$ – buying employment ↑ cost inflation

– policy can't have unemp. that high

natural rate of unemployment

u_n when $P_t = P_t^e$

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

$u_n = \frac{\mu + z}{\alpha}$ plug in for

↑ determined just by fixed parameters

lets you know when it changes

(5)

Diff countries have diff tradeoffs b/w inflation and unemployment

u, z, α are different

$\pi_t - \pi_{t-1} = [\text{redacted}] - \alpha(u_t - [\text{redacted}]\, u_n)$ ← backwards looking

↑ How most economies think about the natural rate

Lucas

$\pi_t - \pi_{t+1} = (u+z) - \alpha [\text{redacted}]\, u_t + \varepsilon_t$

$u_n = \frac{u+z}{\alpha} - \varepsilon_t$

Phillips curve similar ↓

$\pi_t - \pi_{t+1} = -\alpha(u_t - u_N)$

↑ forward looking

$Y_t = A(1-u_t)$

Chap 9 Inflation, Activity, Nominal Money Growth

How can inflation be controlled?

9.1 Output, Unemp, Inflation

Last Chap 7: output, P level, AS-AD

Okun's Law

We assumed $Y = N$, L constant

If output ↑ 1%, employment ↑ 1% if they move together

g_{Yt} = growth from $t-1$ to t

So $U_t - U_{t-1} = -g_{Yt}$ ← if

But not so simple in real life: Okun's Law

$$U_t - U_{t-1} = -.4(g_{Yt} - 3\%)$$

is best fit regression on emperical data

- annual g_Y must be at least 3% to prevent unemployment from rising due to labor-force and productivity growth

  3% = normal growth rate = labor-force g + productivity g

- A 1% growth in output only leads to ~.4% ↓ in U
  - some base workers needed no matter the output
  - firms don't lay off immeditly in bad times labor hoarding
- .6% ↑ in employment only = a .4% ↓ in unemp
  since discaraged workers come back

(2)

$\bar{g}_y$ = normal growth rate (~3%)

β = effect of output growth above normal on change in unemployment (~.4%)

$$u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y)$$

* Output growth above normal makes unemp rate Fall *

below rise

$g_{yt} > \bar{g}_y \rightarrow u_t < u_{t-1}$

$g_{yt} < \bar{g}_y \rightarrow u_t > u_{t-1}$

Phillips Curve

$$\pi_t = \pi_t^e - \alpha(u_t - u_n)$$

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

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

↑effect of unemp on inflation

~1% in USA so $u_t - u_n$ of 1 for 1 year = ↓1% drop π

AD

$$Y_t = Y\left[\frac{M_t}{P_t}, G_t, T_t\right]$$

- ignore changes in other than real M here, so simplify

$$Y_t = Y\frac{M_t}{P_t}$$

↑ ↑

behind this is IS-LM!

- ↑ in M means i↓
- ↓ in i → ↑ demand goods = ↑ Y

(3)

- relation b/w levels
  - output level
  - level of money
  - price level
- need relation b/w growth rates
  - for each of above

g_{Yt} = growth rate of output

π_t = growth rate of price level (aka inflation)

$g_{Yt} = g_{mt} - \pi_t$

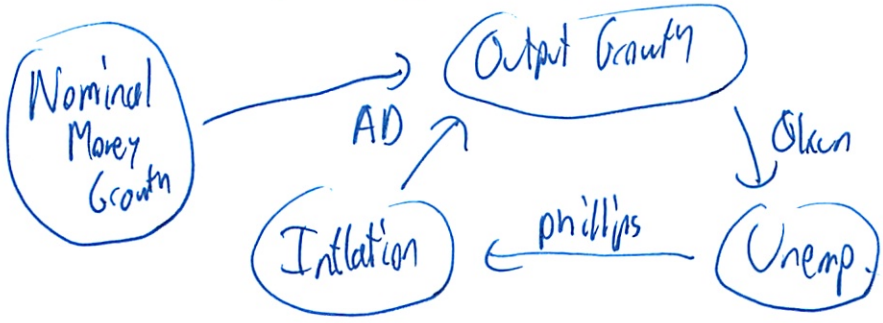
If nominal money growth > inflation, real money growth is positive and so is output growth

(What is driving this?)

Given inflation → expansionary monetary policy leads to high output growth

9.2 Effects of Money Growth

- Okun's law $u_t - u_{t-1} = -\beta(g_{Yt} - \bar{g}_Y)$
- Phillips Curve/AS $\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$
- AD $g_{Yt} = g_{mt} - \pi_t$



(9)

So how do these work?

Look at the medium run

Assume central bank keeps constant growth of nominal money $\bar{g}_m$

- Unemp will be constant since can not ↑ or ↓ forever (??? what?)
  $U_t = U_{t-1}$ into Okun → $g_{Y*} = \bar{g}_Y$
  * In medium run, output must grow at natural rate of growth $\bar{g}_Y$
- When this
  $\bar{g}_Y = \bar{g}_m - \bar{\pi}$
  $\bar{\pi} = \bar{g}_m - \bar{g}_Y$
  ↑ So in medium run inflation = nominal money growth − nominal output growth
  = adjusted nominal money growth

If inflation constant $\pi_t = \pi_{t-1} \rightarrow U_t = U_n$
└ Unemp should = natural unemp.

So Nominal money growth affects only inflation
Same as Chap 7 − money supply (nominal) only affects prices in mid run
└ neutrality of money

Review
- inflation = nominal money growth − output growth
- real money growth = nominal money growth − inflation
- so real money growth = output growth

(5) Short run / dynamics

Suppose at equalibrium (previous page)
Central bank ↓ money growth

- AD: ↓ M growth = ↓ real nominal growth = ↓ Y growth
  ↺ ? how can have both
- Okun: Y growth below normal = U ↑
- Phillips: U above normal = ↓ inflation

So initally a recession and lower inflation

A temp ↑ in U buys a perm ↓ inflation

9.3 Disinflation (decrease in inflation)

Fed in 1979: very high inflation

First pass $\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$

We need u_t to > u_n

But can alter speed
- total amt of inflation is still the same

Define a first point-year of excess unemployment
where $u_t - u_n = 1\%$ for 1 year

Say central bank wants to drop inflation from 14 → 4%
that is 10 point years

(6)

Could do 1 year unemp 10% above natural
2 5%
5 2%
both years

Sacrifice ratio = $\frac{\text{point-years of excess unemp}}{\text{decrease in inflation}}$

Equals $\frac{1}{\alpha}$, nothing to do w/ policy

But remember our relation is not one-for-one

$$\begin{cases} 6\% - 6\% = -.4(g_{yt} - 3\%) \\ U_t - U_{t-1} = -\beta(g_{yt} - \bar{g}_y) \end{cases}$$

So output growth is not one for one

The traditional approach said just could change timings not point-years

Lucas Critique

- said can't use old relation estimates
- model assumed wage setters would not notice in Phillips curve
- but they would notice!
- would change π^e_{t+1}
- Could get inflation to fall at same unemp.
- if could convince wage setters inflation would be lower
- needed credibility
- quick would be better
- would not remove all unemp.

(7)

Nominal Rigities & Contracts

Some disagreed

Wages are set/fixed for some time

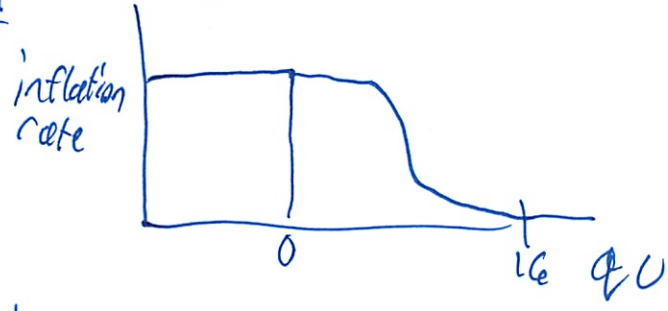
even if credible, inflation expectations could not be reduced overnight

Should be announced in advanced

wage contracts signed over time - staggering of wage decisions

no one wants to be the first to leep

so go slowly



Go slow in beginning

Announce will go faster soon

But credibility lost when saying will do in 2 years

Actual

- no credibility gains
- Traditional model : 12 point-years

Other countries - go fast
- better when short contracts

14.02

3/11

Exam - lots of stuff in book, that was not gone over in class

1. Explain links in wage-price spiral

low unemp → higher nominal wage

higher nom wage → bigger PL

higher PL → higher wage

; Wouldn't this lead to more unemp since higher wage?

Original Phillips curve ; negitive correlation

~~Also more eager~~ have more $ → forced to purchase more

Or can say wage ↑ is cost ↑ for firms, so have to ↑ prices

workers want ↑ wage to maintain purchasing power

2. Explain why says low unemp → high inflation

Since it drives the prices up

Unemp low when wages low

Firms competing, rising wages - also more eager to retain workers

; ~~correct~~ ✓

Needs to be paid for

Or some AS-AD argument

inflation = sustained higher price levels (first deriv)

higher inflation (2nd order) └ continuing to ↑ not just a one-off jump

Above is accelerating

(2)

3. Explain why has wrong assumption

- well wage setters actually predict inflation
Since the 1970s
Actually for above argument
(3rd step never happened
Could be already in steady state → Step 1, 3 rely on people working for wrong wage
- Wrong expectations

(2) → Could have already taken inflation into account → so don't need to ?wages

4. Explain why this is a good way to take into accout expected inflation: $\pi_t = \pi^e_t + (\mu + z) - \alpha u_t$

- ?Thats what is in book
- follow derivation → that long divation in appendix
Can explain each if it ? what happens → what we expect
Adds expectation to normal Phillips Curve

5. What is natural rate of u_n
When inflation = expected inflation $\pi_t = \pi^e_t$ ✓

$$u_n = \frac{\mu + z}{\alpha}$$

(3)

6. Equation to show this
from book

$$\pi_t - \pi_t^e = (\mu + z) - \alpha u_t$$

$$0 = (\mu + z) - \alpha u_t$$

$$\pi_t - \pi_t^e = -\alpha \left(u_t - \frac{\mu + z}{\alpha} \right)$$

$$= -\alpha (u_t - u_n)$$

7. Lucas critique

When try to predict - need to take into account inflation

Need to take into account how inflation will be determined

If gov says will keep inflation constant - they will take that into accant

14.02

the 3 big equations that control the economy

Okun - Production function

Phillips

AD

Quiz 2 MC + Long qu

Pratice quizzes should be posted soon

Production Function

$$Y = N$$

Output Labor

Add time

$$Y_t = N_t$$

Relax to allow for productivity + growing labor force

Productivity: $Y_t = A_t N_t$

↑ can increase over time

$$g_{Yt} = g_{At} + g_{Nt}$$ ← growth rates

↑ growth rate of A ↑ growth rate of N

$$g_{Xt} = \frac{X_t - X_{t-1}}{X_{t-1}}$$ proportional change

Unemployment: $N_t = L_t(1 - U_t)$

↑ unemployment rate $= \frac{U_t}{L_t}$

(2)

$$Y_t = A_t L_t (1 - u_t)$$

Before $Y_t = AL(1 - u_t)$

Now $Y_t = A_t L_t (1 - u_t)$

Can put it into growth rates

$$-g_{yt} = u_t - u_{t-1}$$

$$u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y)$$

$\bar{g}_y$ = natural growth rate of output (if unemployment steady) (at expected level unemp)

A is no longer 1

β usually < 1

Us

$\beta = 0.4$ $\quad \bar{g}_y = 3\%$

Phillips Curve

$$\pi_t - \pi_t^e = -\alpha(u_t - u_n)$$

Comes from Ws $W = P^e F(u, z)$

linear, α is coefficient

PS $P = (1 + \mu)W$

for now just assuming $\pi_t^e = \pi_{t-1}$

(3)

AD

from IS/LM

goods + services / money markets

$$Y = Y\left(\frac{M}{P}, G, T\right)$$

(+) (+) (−)

When M goes up, why does Y fall?

- price fixed
- $M_s = M_d$ – people want money; – if $10 dropped off helecopter people want it
- People want more money in pocket
- Less bonds wanted
- So, i ↓
- So investment ↑
- So output ↑

(Study!)

don't think about if more $ printed → inflation

Not a helecopter but Open market operations

$$Y_t = Y\left(\frac{M_t}{P_t}, \underbrace{G_t, T_t}\right)$$

will assume don't matter / Constant

$$= \gamma\left(\frac{M_t}{P_t}\right)$$

$$g_{Y_t} = \gamma\left(g_{M_t} - \pi_t\right)$$

Growth rate of quotient is the difference

So to put it together The Economy

OL $u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y)$

PC $\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$

AD $g_{yt} = \gamma(g_{mt} - \pi_t)$

all in equalibrium, all linked together

With year - can look at dynamics, steady state

exogenas

the parameters (β, α, γ), g_{mt}, $\bar{g}_y$, u_n

endogenas

u_t, π_t, g_{yt} for $t \geq 0$

Model is geared to what happens when g_{mt} changes

3 eq + 3 unknowns

- don't think u_{t-1}, π_{t-1} is exogenous

Real way is simultaneous solving

Book used a trick

Disinflation (g_{tm} ↓)

- 1. Start w/ one equation
- 2. Then plug into next, etc

Could just solve simultaneous

Book used shortcut - picked gav $g_{mt} - \pi_t$

That is why feedback loop ended in book

Solve backwards ↩

Eventually economy will reach a steady state

Steady state $\pi_t = \pi_{t-1} = \pi^{ss} = g_{mt} - g_y$ (things not changing in time anymore)

$u_t = u_{t-1} = u^{ss} = u_n$

$g_{yt} = \bar{g}_y = g_y^{ss}$

(6)

Fed says will slow growth of M
3% instead of 5%

As we saw output ↓ when g_m ↓
So demand falls. unemp has to ↑

When $U > U_n$ ~~then inflation ↓~~ wages ↓ so inflation ↓
So price ↓
Inflation ↓
So M/P ↑
So output ↑

All parameters are 1 or < 1 for system to converge

Problem Set # 4
14.02 Spring 2011
Due March 11

March 4, 2011

1 True/False [30 points]

Please state whether each of the following claims are True or False, and provide a brief justication for your answer. You may include graphs and equations to support your answer.

1. "A high level of expected inflation tends to increase actual inflation". [5 points]
2. "The AS equation implies a negative relation between inflation and unemployment, holding other factors constant". [5 points]
3. "Consider an economy on its medium run equilibrium. A temporary increase in nominal money growth reduces unemployment on impact. Then, unemployment steadily increases over time, monotonically converging back to its natural rate" [5 points]
4. "An increase in the rate of growth of money supply will have no impact on output growth in the medium run" [5 points]
5. "According to the Phillips curve, a mark-up shock will affect inflation inmediately and in the near future. The effects will vanish in the medium run." [5 points]
6. "Output growth makes the rate of unemployment decrease" [5 points]

2 Phillips curve [20 points]

Consider the framework of Chapter 7, with a wage setting relation given by

$$W_t = P_t^e (1 - \alpha u_t + z)$$

where W is the nominal wage, P^e is the expected price, u is the unemployment rate, and z captures unemployment benefits. Consider the standard price setting relation:

$$P_t = (1+\mu)\, W_t$$

where μ is the mark-up.

1. State the AS equation. [2 points]
2. Let $\pi_t = P_t/P_{t-1} - 1$, and $\pi_t^e = P_t^e/P_{t-1} - 1$. Show, step by step, how you can derive, from the AS relation, the following equation

$$\pi_t = \pi_t^e + (\mu + z) - \alpha u_t \tag{1}$$

   State if you are using any approximation rules, and which assumptions are required for these to work. [4 points]
3. Given expected inflation and unemployment, what is the effect of increasing unemployment benefits in period t on the rate of inflation in period t? Explain intuitively and in detail how the increase in z affects π_t. [4 points]
4. Suppose that expectatations are formed according to

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

   Explain briefly in words what this equation means. [4 points]
5. Can a single value of θ be used to account for the observed pattern of unemployment and inflation in the US from 1950 to 2000? [3 points]
6. Show that you can eliminate μ and z from equation (1) and express it as

$$\pi_t = \pi_t^e - \alpha\,(u_t - u_n) \tag{2}$$

   where u_n is the natural rate of unemployment. [3 points]

3 Inflation, Activity and Nominal Money Growth [50 points]

Consider the following dynamic economy

$$\begin{aligned} u_t - u_{t-1} &= -\beta\,(g_{Yt} - \bar{g}_Y) \\ \pi_t - \pi_{t-1} &= -\alpha\,(u_t - u_n) \\ g_{Yt} &= g_{mt} - \pi_t \end{aligned}$$

Suppose the economy is in a medium run equilibrium. The normal rate of output growth is $\bar{g}_Y = 2\%$. The central bank has fixed the rate of money growth to be $g_{mt} = 4\%$. Assume $\alpha = \beta = 1/2$.

1. Suppose that in labor markets, firms charge a markup of 20% over average cost ($\mu = 0.20$), and that the wage setting relation is $W = P^e(1-u)$. Find the natural rate of unemployment, u_n. [3 points]

2. What is the rate of inflation in the medium run equilibrium? [3 points]

3. Suppose that the economy is in its medium run equilibrium ($u_t = u_n$), when the central bank decides to *permanently* increase the rate of growth in the money supply to 5%. Compute the new medium run equilibrium levels of unemployment, inflation, and output growth. [3 points]

4. Denote by $t = 0$ the last period in which the economy is in its medium run equilibrium. Suppose that from $t = 1$ on, the central bank keeps $g_m = 5\%$. Compute the values of π_t, g_t and u_t for $t = 0, t = 1, t = 2, t = 3$ and $t = 4$. Display your results in table (columns are time periods, and rows are variables) [13 points]

5. After 4 periods, has the rate of inflation reached its new medium run level? [5 points]

6. Using a computer, compute the evolution of π_t, g_t and u_t for 50 periods (assume that in the first 3 periods $g_{m_t} = 4\%$, and in the last 47 periods $g_{mt} = 5\%$). You just need to report one graph for each variable. Is there a period in time in which unemployment exceeds its natural rate? [12 points]

7. Suppose now that the increase in money growth is not permanent but only lasts one period (i.e. assume that both in the first 3 periods and in the last 46 periods money growth is $g_{m_t} = 4\%$, while in period 4 it is $g_{mt} = 5\%$). Report a graph (or three graphs) with the time evolution of π_t, g_t and u_t. How does the time evolution of u_t compare with the one obtained in the previous question? (describe briefly, 3 lines max) [11 points]

TA Advice on P-set 4 #3

3/14

Solve for t_0 v_{t-1}, π_{t-1}

t_1 - use results, solve again π_t, v_t, g_{y_t}

Simultaneously

P-Set 4 Discarded Pages

(9) diff than table in book - changing nominal m

		0	1	2	3	4
nominal money growth (set)	g_m	4%	5%	5%	5%	5%
Output growth	g_{yt}	2%	$g_m - \pi_{t-1}$ ← not! $t-1$ 3%	$g_m - \pi_{t-1}$ $4\frac{3}{4}$%	$4\frac{1}{16}$	$4\frac{31}{32}$
Unemp rate	U_t	20%	$-\beta(g_{yt} - \bar{g}_y)$ $-\frac{1}{2}$% = 19.5%	$-1\frac{3}{8}$% = 18.125%	$-\frac{1}{16}$% = 18.0625	$-\frac{1}{64}$ = 18.01469
inflation	π_t	2%	$-\alpha(U_t - U_n)$ $-\frac{1}{4}$%	$-.56$%	$\frac{31}{32}$%	$\frac{63}{64}$
Real Money Growth	$g_m - \pi$	2%	$4\frac{3}{4}$%	$4\frac{1}{16}$	$4\frac{1}{32}$%	$4\frac{1}{64}$ (for fun)

↓ do in this order

Grand Circle

Realize once I have filled in these #'s

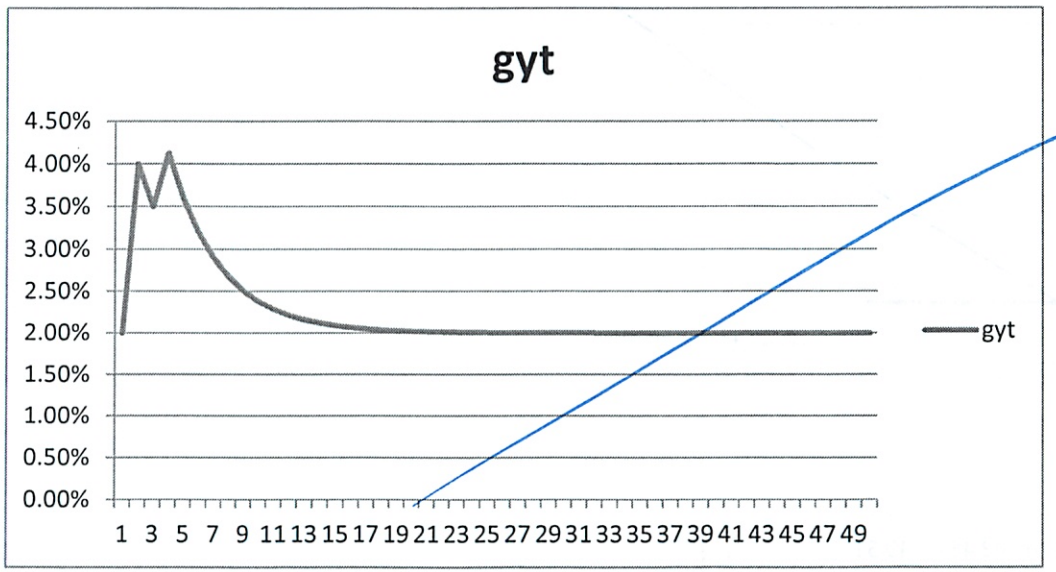
I think using last years inflation was a mistake, but where to start.

f) Working it out on spreadsheet
Will be more correct than table above
Fixing mistakes till chart matches theory

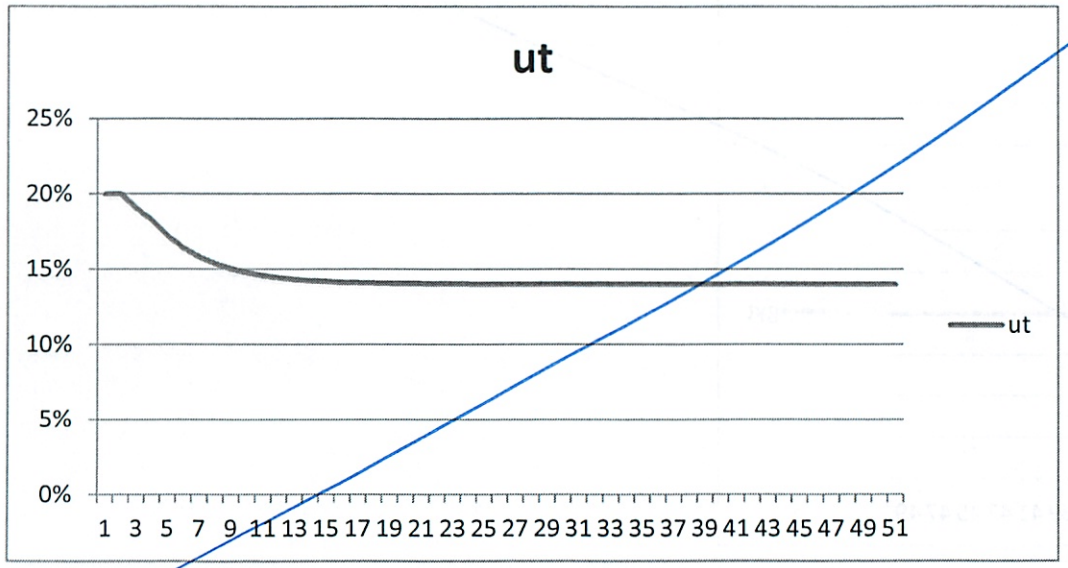
Unless my initial was not at equilibrium
$U_n = 14\%$

Went wrong by using previous inflation instead of solving simultaneously

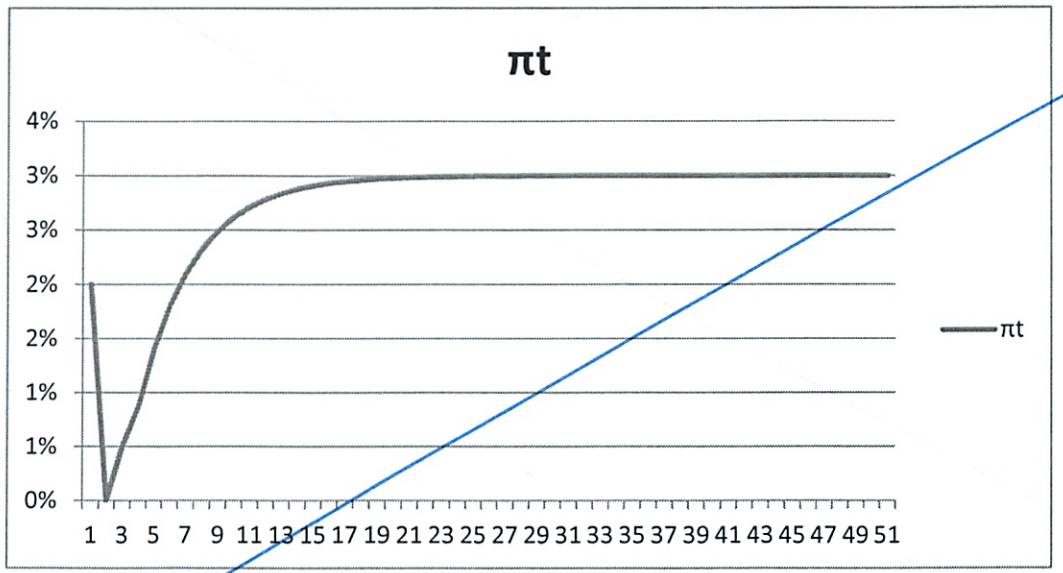
		0	1	2	3	4	5	6	7	8
Set Nominal Money Growth	g_m	4%	4%	4%	4%	5%	5%	5%	5%	5%
Output Growth	g_{yt}	2%	2.00%	4.00%	3.50%	4.13%	3.59%	3.20%	2.90%	2.67%
Unemp rate change	u_t-u_{t-1}	0	0.00%	-1.00%	-0.75%	-1.06%	-0.80%	-0.60%	-0.45%	-0.34%
Unemp rate	u_t	20%	20.000%	19.000%	18.250%	17.188%	16.391%	15.793%	15.345%	15.009%
Inflation	π_t	2%	0.00%	0.50%	0.88%	1.41%	1.80%	2.10%	2.33%	2.50%
Real Money Growth	$g_m-\pi_t$	2%	4.0000%	3.5000%	3.1250%	3.5938%	3.1953%	2.8965%	2.6724%	2.5043%



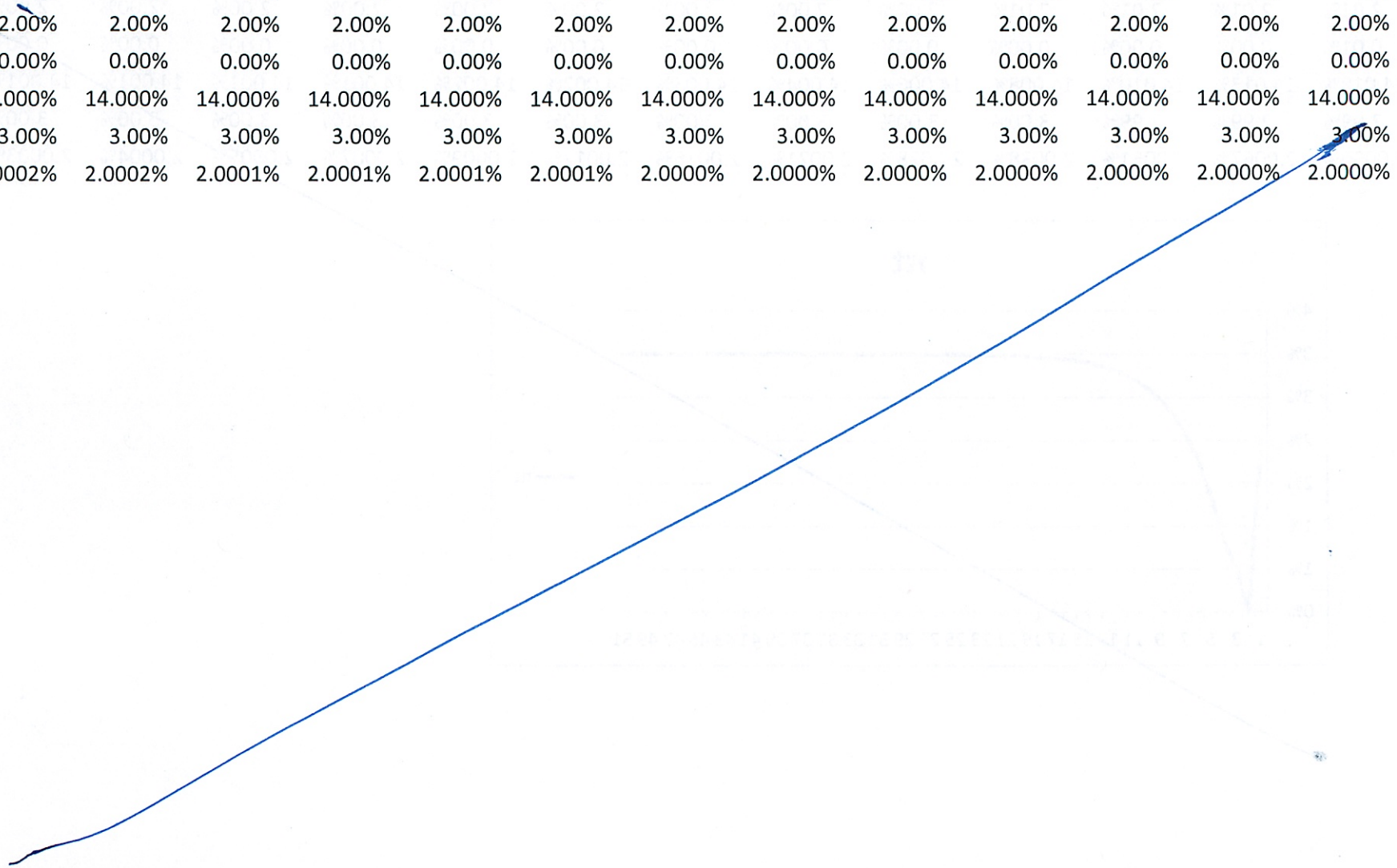
9	10	11	12	13	14	15	16	17	18	19	20	21
5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2.50%	2.38%	2.28%	2.21%	2.16%	2.12%	2.09%	2.07%	2.05%	2.04%	2.03%	2.02%	2.02%
-0.25%	-0.19%	-0.14%	-0.11%	-0.08%	-0.06%	-0.04%	-0.03%	-0.03%	-0.02%	-0.01%	-0.01%	-0.01%
14.756%	14.567%	14.425%	14.319%	14.239%	14.179%	14.135%	14.101%	14.076%	14.057%	14.043%	14.032%	14.024%
2.62%	2.72%	2.79%	2.84%	2.88%	2.91%	2.93%	2.95%	2.96%	2.97%	2.98%	2.98%	2.99%
2.3782%	2.2837%	2.2127%	2.1596%	2.1197%	2.0897%	2.0673%	2.0505%	2.0379%	2.0284%	2.0213%	2.0160%	2.0120%



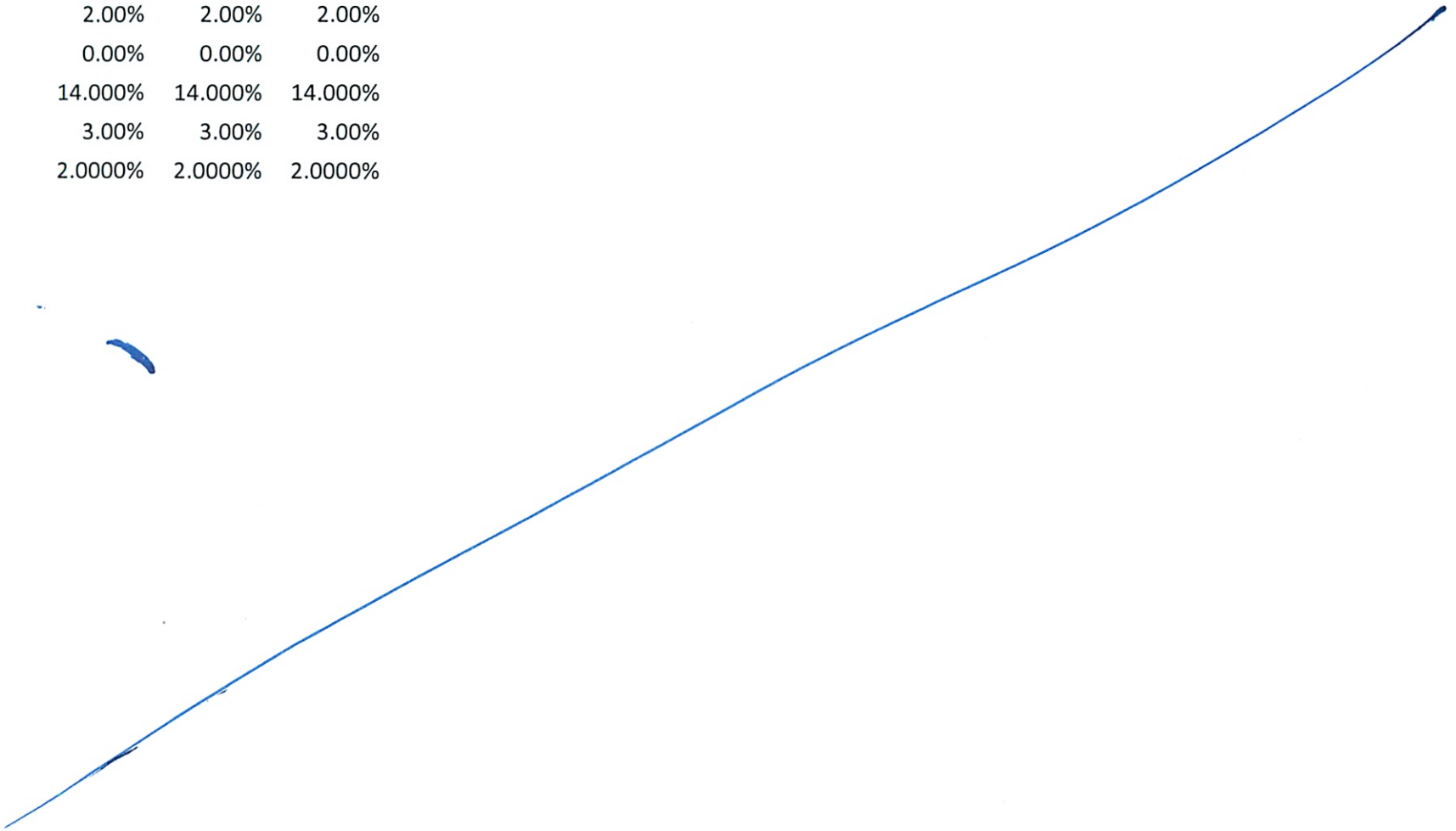
22	23	24	25	26	27	28	29	30	31	32	33	34
5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2.01%	2.01%	2.01%	2.01%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14.018%	14.013%	14.010%	14.008%	14.006%	14.004%	14.003%	14.002%	14.002%	14.001%	14.001%	14.001%	14.001%
2.99%	2.99%	2.99%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
2.0090%	2.0067%	2.0051%	2.0038%	2.0028%	2.0021%	2.0016%	2.0012%	2.0009%	2.0007%	2.0005%	2.0004%	2.0003%



35	36	37	38	39	40	41	42	43	44	45	46	47
5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%	14.000%
3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
2.0002%	2.0002%	2.0001%	2.0001%	2.0001%	2.0001%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%



48	49	50
5%	5%	5%
2.00%	2.00%	2.00%
0.00%	0.00%	0.00%
14.000%	14.000%	14.000%
3.00%	3.00%	3.00%
2.0000%	2.0000%	2.0000%

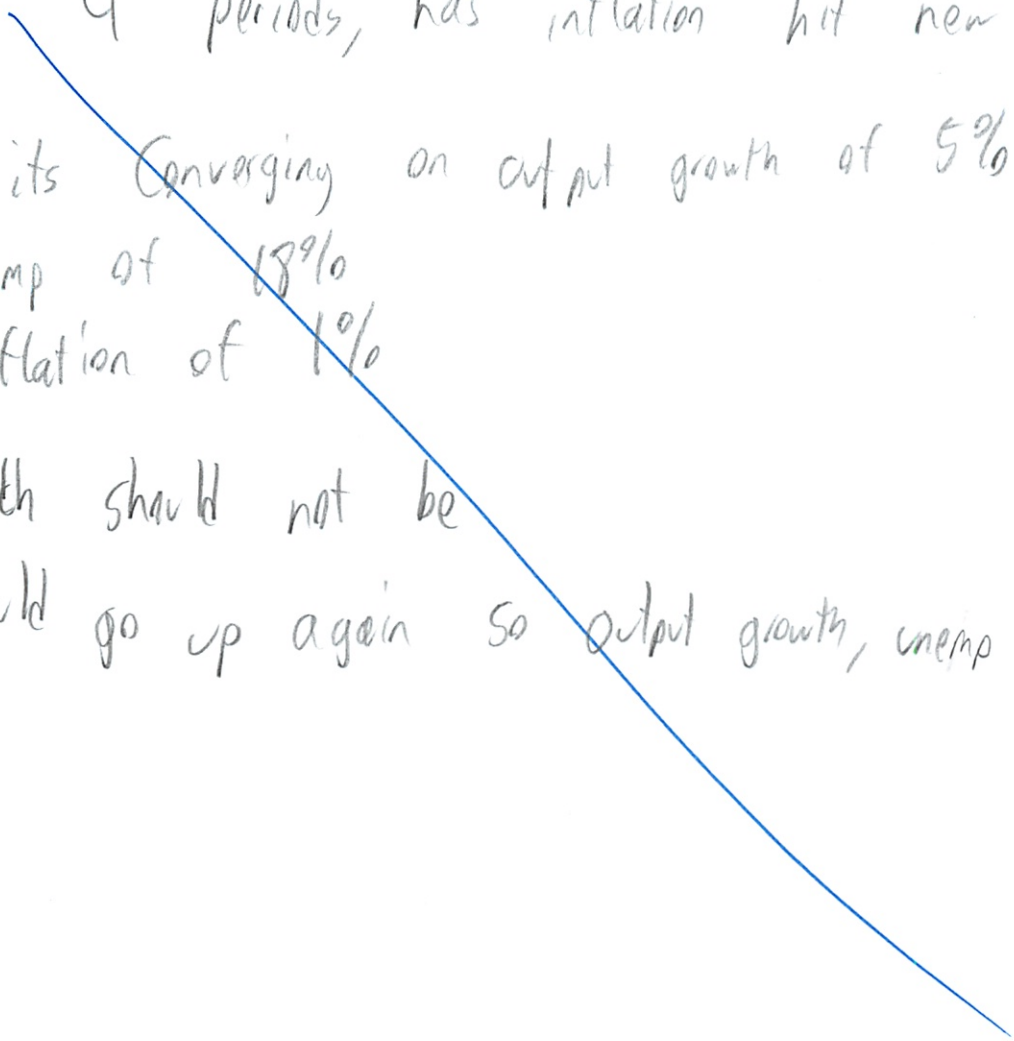


(10)

e) After 4 periods, has inflation hit new medium

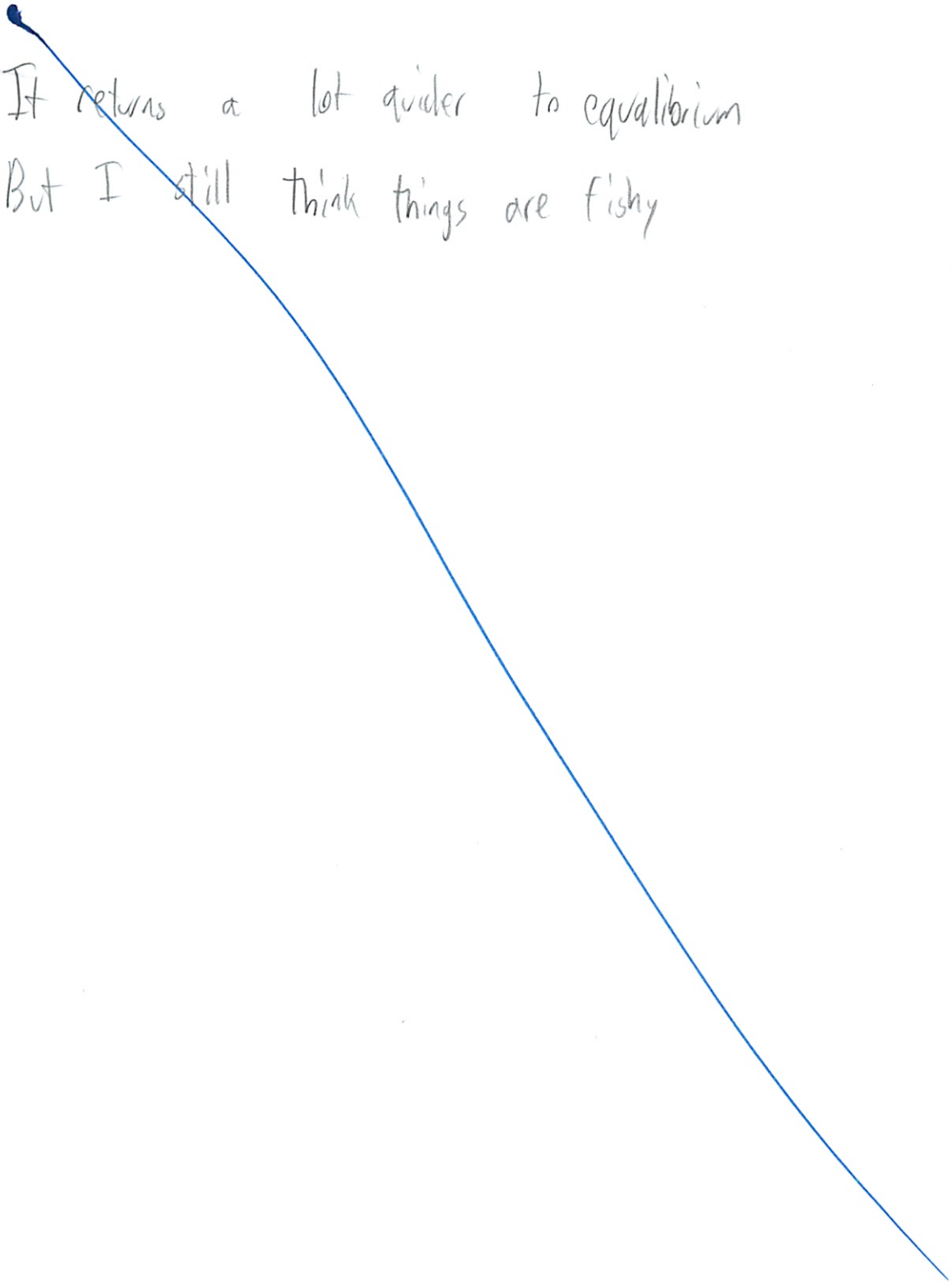
Yes its converging on output growth of 5%
Unemp of 8%
Inflation of 1%

- Which should not be
- Should go up again so output growth, unemp return to normal

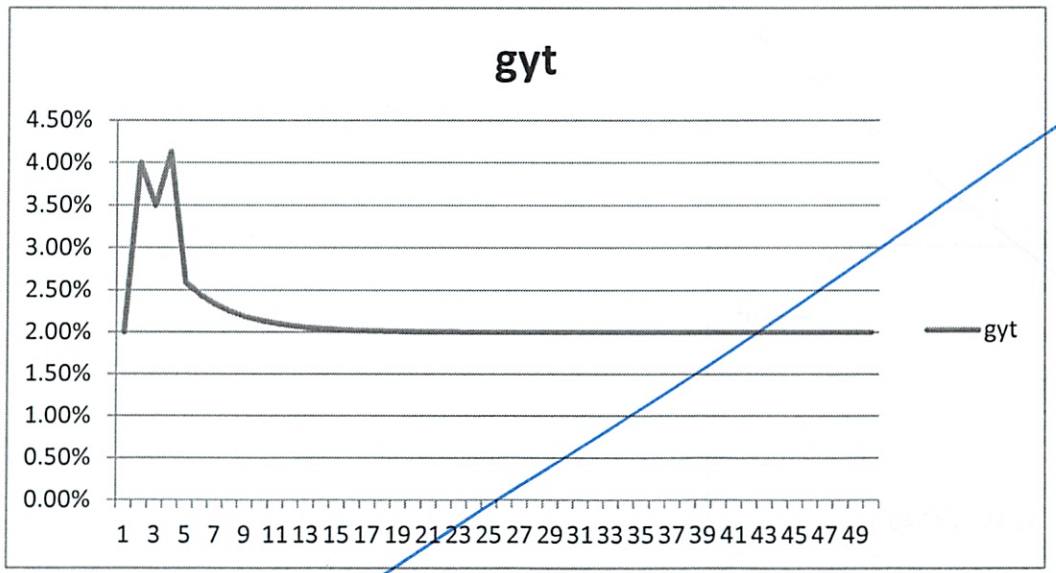


(16)

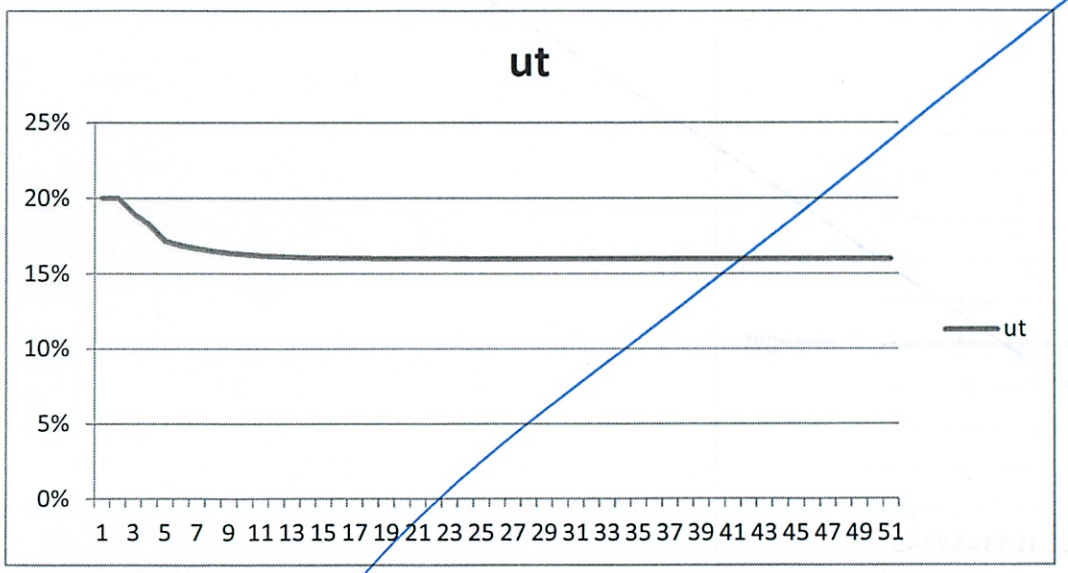
g) It returns a lot quicker to equalibrium
But I still think things are fishy



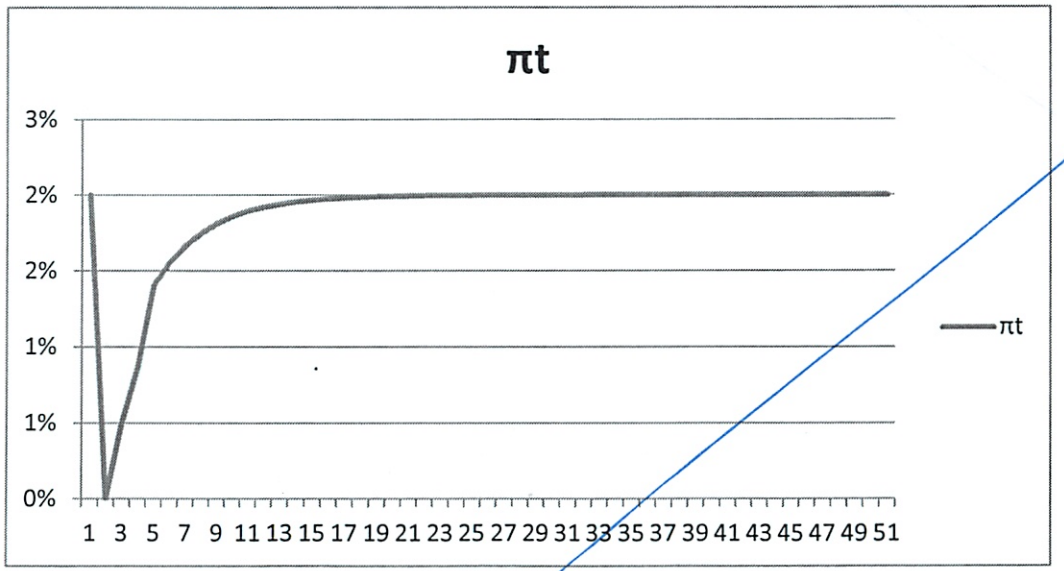
		0	1	2	3	4	5	6	7	8
Set Nominal Money Growth	g_m	4%	4%	4%	4%	5%	4%	4%	4%	4%
Output Growth	g_{yt}	2%	2.00%	4.00%	3.50%	4.13%	2.59%	2.45%	2.33%	2.25%
Unemp rate change	u_t-u_{t-1}	0	0.00%	-1.00%	-0.75%	-1.06%	-0.30%	-0.22%	-0.17%	-0.13%
Unemp rate	u_t	20%	20.000%	19.000%	18.250%	17.188%	16.891%	16.668%	16.501%	16.376%
Inflation	π_t	2%	0.00%	0.50%	0.88%	1.41%	1.55%	1.67%	1.75%	1.81%
Real Money Growth	g_m-π_t	2%	4.0000%	3.5000%	3.1250%	3.5938%	2.4453%	2.3340%	2.2505%	2.1879%



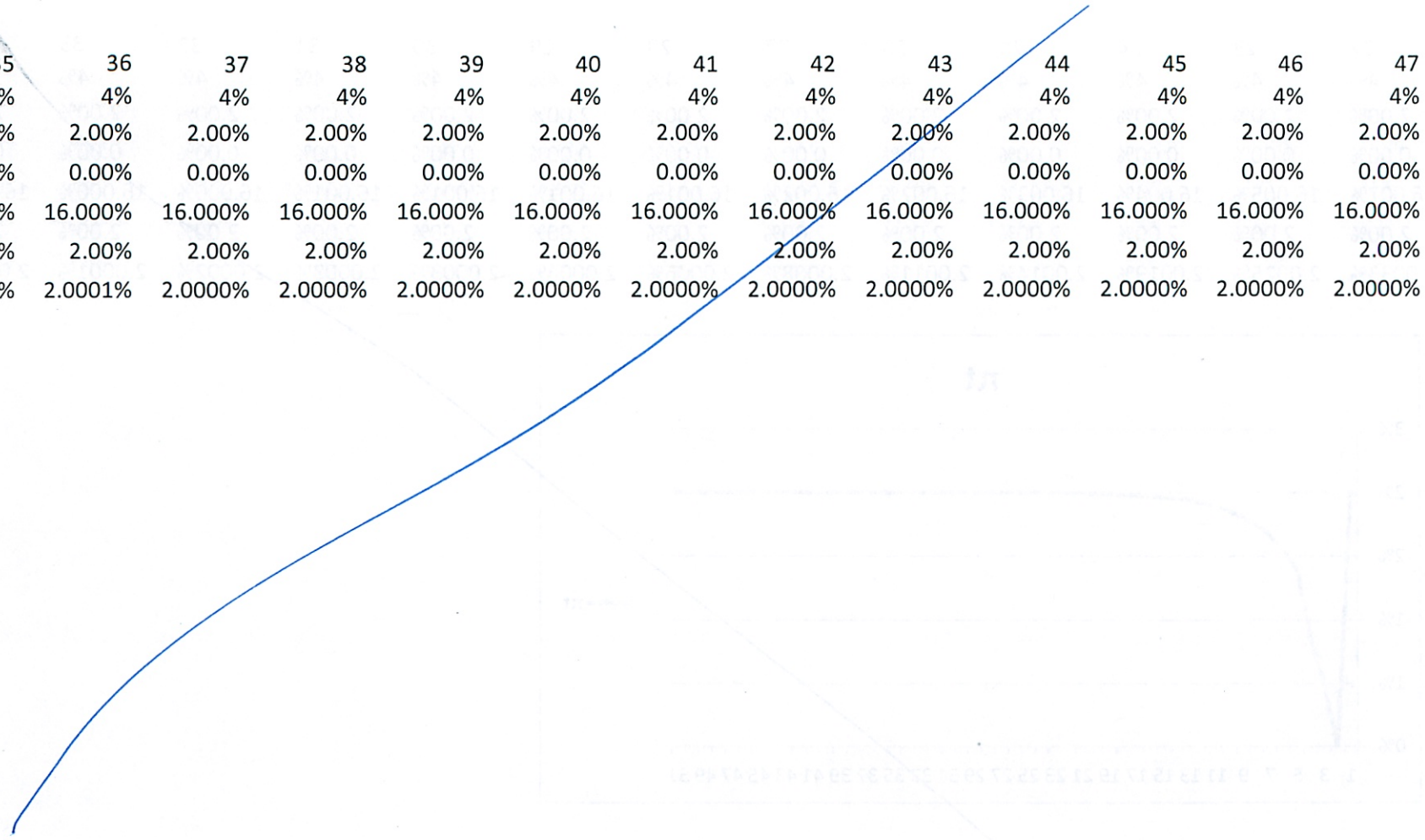
9	10	11	12	13	14	15	16	17	18	19	20	21
4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
2.19%	2.14%	2.11%	2.08%	2.06%	2.04%	2.03%	2.03%	2.02%	2.01%	2.01%	2.01%	2.01%
-0.09%	-0.07%	-0.05%	-0.04%	-0.03%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%
16.282%	16.211%	16.159%	16.119%	16.089%	16.067%	16.050%	16.038%	16.028%	16.021%	16.016%	16.012%	16.009%
1.86%	1.89%	1.92%	1.94%	1.96%	1.97%	1.97%	1.98%	1.99%	1.99%	1.99%	1.99%	2.00%
2.1409%	2.1057%	2.0793%	2.0594%	2.0446%	2.0334%	2.0251%	2.0188%	2.0141%	2.0106%	2.0079%	2.0060%	2.0045%



22	23	24	25	26	27	28	29	30	31	32	33	34
4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16.007%	16.005%	16.004%	16.003%	16.002%	16.002%	16.001%	16.001%	16.001%	16.001%	16.000%	16.000%	16.000%
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
2.0033%	2.0025%	2.0019%	2.0014%	2.0011%	2.0008%	2.0006%	2.0004%	2.0003%	2.0003%	2.0002%	2.0001%	2.0001%



35	36	37	38	39	40	41	42	43	44	45	46	47
4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%	16.000%
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
2.0001%	2.0001%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%	2.0000%



48	49	50
4%	4%	4%
2.00%	2.00%	2.00%
0.00%	0.00%	0.00%
16.000%	16.000%	16.000%
2.00%	2.00%	2.00%
2.0000%	2.0000%	2.0000%

Michael Plasmeier 85 14.02 Pset 4 3/11

Please don't write a novel next time!!! but +2 for effort :)

1. True. When wage setters expect inflation, then they raise nominal wages. This needs to be paid for with higher prices, so the higher prices come true and inflation happens.

2. True. The AS equation can be easily extended to the Phillips curve - where the original curve set a negative relation between unemployment and inflation

3. ~~True.~~ An increase in the money supply shifts the AD curve to the right and output to a higher level. This causes higher employment. Then due to the wage setters raising wages to keep real wages the same, output shrinks again. converges by oscillating not "from below" -3

4. True. Output does not grow in the medium run if the money supply grows due to the above reasoning.

5. True. $\pi_t = \pi^e_t + (\mu + z) - \alpha u_t$

Yes an markup increase will hide inflation However in the medium run, the wage setters will have taken the increase into account so that the increase does not continue to drive inflations increase

(2)

6. ~~True~~ $U_t - U_{t-1} = -\beta(g_{yt} - \bar{g})$

If $g_{yt} < \bar{g}$ then $\quad \nearrow \oplus$

$$U_t - U_{t-1} = \ominus \cdot \oplus$$
$$= \ominus$$

The change in the unemp rate will be negitive

-5

(3)

2. Phillips Curve

$$W_t = P_t^e (1 - \alpha u_t + z)$$

$$P_t = (1+\mu) W_t$$

a. State the AS equation

$$P_t = (1+\mu) P_t^e (1 - \alpha u_t + z)$$

$$= P_t^e (1+\mu)(1 - \alpha u_t + z)$$

b. $\pi_t = \dfrac{P_t}{P_{t-1}} - 1 \qquad \pi_t^e = \dfrac{P_t^e}{P_{t-1}} - 1$

Derive AS to $\pi_t = \pi_t^e + (\mu + z) - \alpha u_t$

[The appendix]

Go from expression in terms of price level to inflation rates

Divide both sides by last year's P_{t-1}

$$\frac{P_t}{P_{t-1}} = \frac{P_t^e}{P_{t-1}} (1+\mu)(1 - \alpha u_t + z)$$

Rewrite fraction

$$\frac{P_t}{P_{t-1}} = \frac{P_t - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t - P_{t-1}}{P_{t-1}}$$

$$= 1 + \pi_t$$

(4)

Do the same for the right

$$\frac{P_t^e}{P_{t-1}} = \frac{P_t^e - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t^e - P_{t-1}}{P_{t-1}} = 1 + \pi_t^e$$

So plug this in

$$(1 + \pi_t) = (1 + \pi_t^e)(1 + \mu)(1 - \alpha u_t + z)$$

Make it look friendlier

$$\frac{(1 + \pi_t)}{(1 + \pi_t^e)(1 + \mu)} = 1 - \alpha u_t + z$$

Can approximate with: as long as π_t, π_t^e, μ not large

$$\pi_t = \pi_t^e + (\mu + z) - \alpha u_t$$

size ✓

c) What does $z\uparrow$ do to π_t?

It increases π_t because an increase in z raises the price level (from previous chap.) but it raises wages since people can hold out longer for better pay.

An increase in wages requires a higher price level to pay for it which is the definition of inflation.

(b/c higher firm production costs)

(5)

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

This is the modified, expectations-augmented, accelerationist Phillips curve.

Friedman and Phillips believed that as wage-setters become aware of inflation, they would try to predict inflation and factor this into nominal wages ahead of time.

θ is the percentage of wage setters figuring inflation into next year's wages,

π_{t-1} is last years wages, Inflation is generally expected to be equal to last years' inflation in stable countries, This model assumes this

e) (next page) OK ✓

f) Eliminate μ, z to get $\pi_t = \pi_t^e - \alpha(u_t - u_n)$

Well by definition u_n is unemployment when $\pi_t = \pi e_t$

$$\pi_t = \pi_t^e + (\mu + z) - \alpha u_t$$

$$\pi_t - \pi_t^e = (\mu + z) - \alpha u_t$$

Set $\pi_t = \pi_t^e = 0$ for u_t to $= u_n$

$$0 = (\mu + z) - \alpha u_n$$

$$u_n = \frac{\mu + z}{\alpha}$$

Replace

$$\pi_t = \pi_t^e - \alpha(u_t - u_n)$$

(6)

Forgot on last page

e) Can a single value of θ to be used from 1950 to 2000?

No. People were not aware when Samuelson + Solow looked into it $\theta \approx 0$ (Wikipedia ~ 1960s)

But the book says than ~mid 1970s most people were aware and $\theta \approx 1$

(7)

3. Inflation, Activity, Nominal Money Growth

$$u_t - u_{t-1} = -\beta(g_{Y_t} - \bar{g}_Y)$$

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

$$g_{Y_t} = g_{m_t} - \pi_t$$

This is medium run equalibrium

$\bar{g}_Y$ = normal rate of growth = 2%

g_{m_t} = money growth, set by central bank = 4%

$\alpha = \beta = \frac{1}{2}$

a) Suppose $u = 20\%$

$W = P^e(1-u)$

Find u_n

u_n is when $\pi_t = \pi_{t-1}$ say when 0

$$0 = -\alpha(u_t - u_n)$$

I am guessing use typical price setting relation $P = (1+\mu)W$

$P = (1+\mu)P^e(1-u)$

$= P^e(1+\mu)(1-u)$

$\pi = \pi^e(1+\mu)(1-u)$

.... long deviation

Answer 3 -2 (16.67%)

7b ..

$\pi = \pi^e + \mu - u$

$\pi - \pi^e = \mu - u$

$0 = \mu - u$

$\mu = u$

So $.20 = \mu = u = .20$ X 12.67

(8)

b) What is the rate of inflation in medium-run equilibrium?

π = The adjusted nominal money growth

π = nominal money growth - nominal output growth

$\pi = \bar{g}_m - \bar{g}_Y$

$= .04 - .02 = .02 = 2\%$ /

c) Suppose the econ at medium run equilibrium

Central bank ↑ money supply 5% permanently

So for new medium run

$g_Y = \bar{g}_Y$ ← unchanged atpt growth

$U_t = U_n$ ← unchanged unemployment

$\pi = g_m - \bar{g}_Y$ ← constant

↑ ? increases

So increases

3% answer?

-3

d) $A = 0$ medium run equilibrium

$t > 0$ → central bank $g_m = 5\%$

Calculate changes over time

d)

Solve Simultaneously:

- for U_t, π_t, g_{yt}
- using $\pi_{t-1}, U_{t-1}, \bar{g}_y, U_n$, g_{mt}, β, α as exogenous

$$U_t - U_{t-1} = -\beta(g_{yt} - \bar{g}_y)$$
$$\pi_t - \pi_{t-1} = -\alpha(U_t - U_n)$$
$$g_{yt} = g_{mt} - \pi_t$$

Resolve each period

		0	1	2	3	4
Nominal $ growth (set)	g_m	4%	5%	5%	5%	5%
Output growth	g_{yt}	2%	2.8%	2.48%	2.296%	1.82088%
Unemp rate	U_t	20%	19.6%	19.36%	19.2960%	19.3856%
inflation	π_t	2%	2.2%	2.52%	2.872%	3.17920%
		↑ from prev section	↑ Solve Sim.			

e) No! Inflation has not reached new medium level. The Excel graph shows stability only after ~40 periods

f) Solve on spreadsheet w/ matrix coefficient

$U - U_{t-1} = -.5(g - .02)$

$U = -.5(g - .02) + U_{t-1}$

$\rightarrow U = -.5g + .01 + U_{t-1}$

$P - \pi_{t-1} = -.5(U - .2)$

$P = -.5(U - .2) + \pi_{t-1}$

$\rightarrow P = -.5U + .1 + \pi_{t-1}$

$\rightarrow g = .04 - P$

Do $A^{-1} \cdot B$

A: values; B: constants

Need to put in matrix form

$.5g + U = .01 + U_{t-1}$

$.5U + P = .1 + \pi_{t-1}$

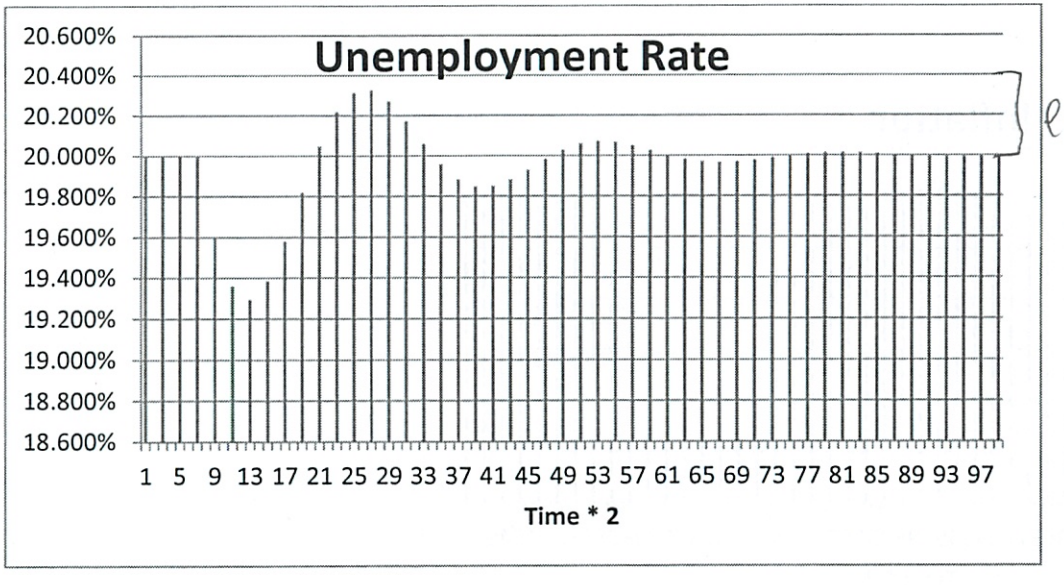
$g + P = .04$

#6/f

Set Nominal Money Growth	Matrix	u	p	g	constant		0		1
						g_m	4%		4%
Unemp rate	u	1	0	0.5	0.01	u_t	20%	21%	20.000%
Inflation	p	0.5	1	0	0.1	π_t	2%	12%	2.00%
Output Growth	g	0	1	1	0	g_{yt}	2%	4%	2.00%
Real Money Growth						$g_m-\pi_t$	2%		2.0000%

Unemp rate	20.000%
Inflation	2.00%
Output Growth	2.00%

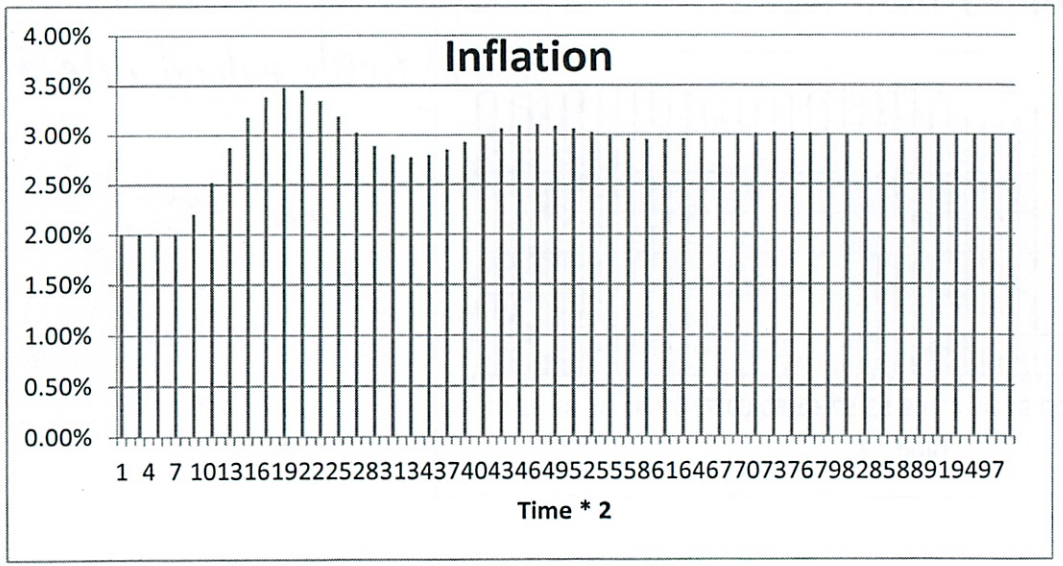
rounded more than it should



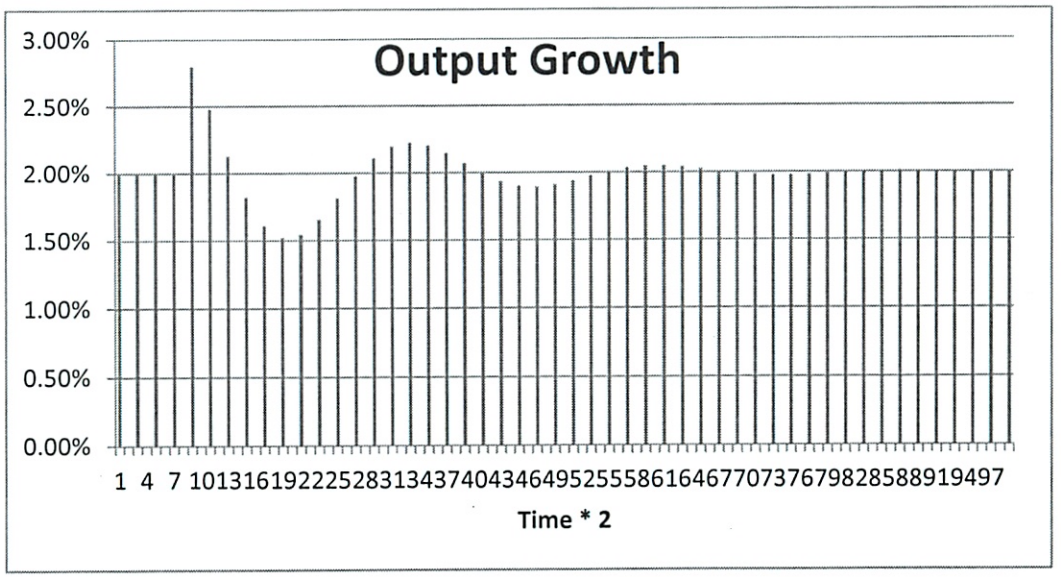
exceeds natural rate

but level should be ~16.7 (5%)

	2		3		4		5		6	
	4%		4%		5%		5%		5%	
21%	20.000%	21%	20.000%	21%	20.000%	21%	19.600%	21%	19.360%	20%
12%	2.00%	12%	2.00%	12%	2.00%	12%	2.20%	12%	2.52%	13%
4%	2.00%	4%	2.00%	4%	2.00%	5%	2.80%	5%	2.48%	5%
	2.0000%		2.0000%		3.0000%		2.8000%		2.4800%	
	20.000%		20.000%		20.000%		19.600%		19.360%	
	2.00%		2.00%		2.00%		2.20%		2.52%	
	2.00%		2.00%		2.00%		2.80%		2.48%	



7		8		9		10		11		12
5%		5%		5%		5%		5%		5%
19.296%	20%	19.386%	20%	19.580%	21%	19.820%	21%	20.048%	21%	20.220%
2.87%	13%	3.18%	13%	3.39%	13%	3.48%	13%	3.46%	13%	3.35%
2.13%	5%	1.82%	5%	1.61%	5%	1.52%	5%	1.54%	5%	1.65%
2.1280%		1.8208%		1.6109%		1.5208%		1.5445%		1.6546%
19.296%		19.386%		19.580%		19.820%		20.048%		20.220%
2.87%		3.18%		3.39%		3.48%		3.46%		3.35%
2.13%		1.82%		1.61%		1.52%		1.54%		1.65%



	13		14		15		16		17	
	5%		5%		5%		5%		5%	
21%	20.314%	21%	20.327%	21%	20.271%	21%	20.173%	21%	20.059%	21%
13%	3.19%	13%	3.02%	13%	2.89%	13%	2.80%	13%	2.77%	13%
5%	1.81%	5%	1.98%	5%	2.11%	5%	2.20%	5%	2.23%	5%
	1.8118%		1.9751%		2.1108%		2.1972%		2.2268%	
	20.314%		20.327%		20.271%		20.173%		20.059%	
	3.19%		3.02%		2.89%		2.80%		2.77%	
	1.81%		1.98%		2.11%		2.20%		2.23%	

18		19		20		21		22		23
5%		5%		5%		5%		5%		5%
19.957%	21%	19.883%	21%	19.848%	21%	19.850%	21%	19.882%	21%	19.931%
2.79%	13%	2.85%	13%	2.93%	13%	3.00%	13%	3.06%	13%	3.10%
2.21%	5%	2.15%	5%	2.07%	5%	2.00%	5%	1.94%	5%	1.90%
2.2052%		2.1468%		2.0708%		1.9958%		1.9366%		1.9020%
19.957%		19.883%		19.848%		19.850%		19.882%		19.931%
2.79%		2.85%		2.93%		3.00%		3.06%		3.10%
2.21%		2.15%		2.07%		2.00%		1.94%		1.90%

	24		25		26		27		28	
	5%		5%		5%		5%		5%	
21%	19.984%	21%	20.029%	21%	20.060%	21%	20.073%	21%	20.068%	21%
13%	3.11%	13%	3.09%	13%	3.06%	13%	3.03%	13%	2.99%	13%
5%	1.89%	5%	1.91%	5%	1.94%	5%	1.97%	5%	2.01%	5%
	1.8939%		1.9086%		1.9387%		1.9750%		2.0090%	
	19.984%		20.029%		20.060%		20.073%		20.068%	
	3.11%		3.09%		3.06%		3.03%		2.99%	
	1.89%		1.91%		1.94%		1.97%		2.01%	

29		30		31		32		33		34
5%		5%		5%		5%		5%		5%
20.051%	21%	20.027%	21%	20.002%	21%	19.982%	21%	19.970%	21%	19.966%
2.97%	13%	2.95%	13%	2.95%	13%	2.96%	13%	2.97%	13%	2.99%
2.03%	5%	2.05%	5%	2.05%	5%	2.04%	5%	2.03%	5%	2.01%
2.0345%		2.0479%		2.0491%		2.0402%		2.0251%		2.0079%
20.051%		20.027%		20.002%		19.982%		19.970%		19.966%
2.97%		2.95%		2.95%		2.96%		2.97%		2.99%
2.03%		2.05%		2.05%		2.04%		2.03%		2.01%

	35		36		37		38		39	
	5%		5%		5%		5%		5%	
21%	19.969%	21%	19.978%	21%	19.990%	21%	20.001%	21%	20.010%	21%
13%	3.01%	13%	3.02%	13%	3.02%	13%	3.02%	13%	3.02%	13%
5%	1.99%	5%	1.98%	5%	1.98%	5%	1.98%	5%	1.98%	5%
	1.9926%		1.9819%		1.9769%		1.9775%		1.9825%	
	19.969%		19.978%		19.990%		20.001%		20.010%	
	3.01%		3.02%		3.02%		3.02%		3.02%	
	1.99%		1.98%		1.98%		1.98%		1.98%	

40		41		42		43		44		45
5%		5%		5%		5%		5%		5%
20.015%	21%	20.016%	21%	20.014%	21%	20.009%	21%	20.003%	21%	19.998%
3.01%	13%	3.00%	13%	3.00%	13%	2.99%	13%	2.99%	13%	2.99%
1.99%	5%	2.00%	5%	2.00%	5%	2.01%	5%	2.01%	5%	2.01%
1.9900%		1.9980%		2.0048%		2.0093%		2.0110%		2.0102%
20.015%		20.016%		20.014%		20.009%		20.003%		19.998%
3.01%		3.00%		3.00%		2.99%		2.99%		2.99%
1.99%		2.00%		2.00%		2.01%		2.01%		2.01%

	46		47		48		49		50
	5%		5%		5%		5%		5%
21%	19.995%	21%	19.993%	21%	19.993%	21%	19.994%	21%	19.996%
13%	2.99%	13%	3.00%	13%	3.00%	13%	3.00%	13%	3.00%
5%	2.01%	5%	2.00%	5%	2.00%	5%	2.00%	5%	2.00%
	2.0075%		2.0038%		2.0001%		1.9972%		1.9953%
	19.995%		19.993%		19.993%		19.994%		19.996%
	2.99%		3.00%		3.00%		3.00%		3.00%
	2.01%		2.00%		2.00%		2.00%		2.00%

#7/g

	Matrix	u	p	g	constant		0		1	
Set Nominal Money Growth						g_m	4%		4%	
Unemp rate	u	1	0	0.5	0.01	u_t	20%	21%	20.000%	21%
Inflation	p	0.5	1	0	0.1	π_t	2%	12%	2.00%	12%
Output Growth	g	0	1	1	0	g_{yt}	2%	4%	2.00%	4%
Real Money Growth						$g_m-\pi_t$	2%		2.0000%	

Unemp rate	20.000%
Inflation	2.00%
Output Growth	2.00%

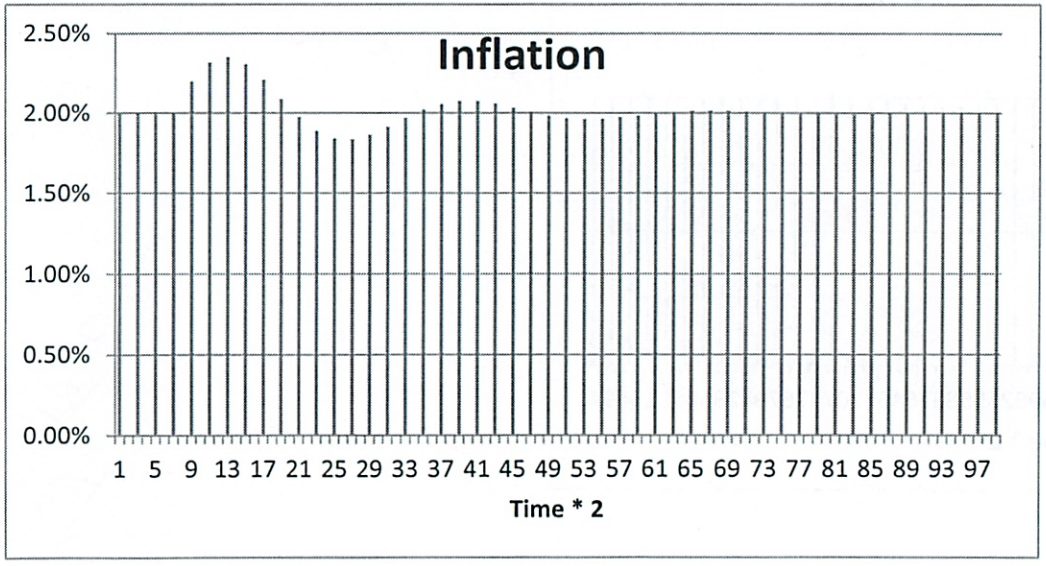
Should be closer to #7 &

#7 asks for comparison to #6?

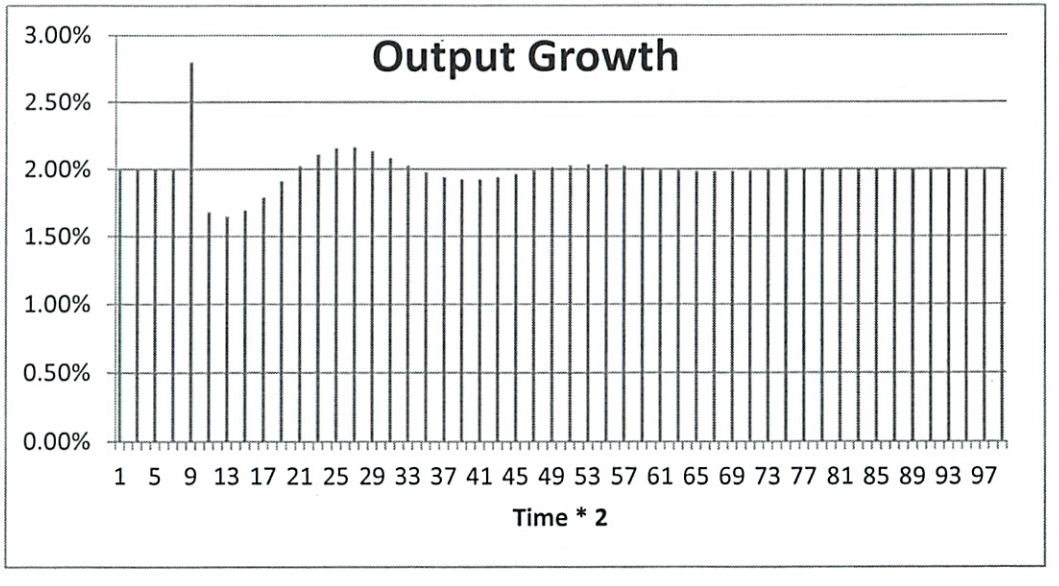
B+

- similar shape
- milder effects
- faster convergence

2		3		4		5		6		7		8
4%		4%		5%		4%		4%		4%		4%
20.000%	21%	20.000%	21%	20.000%	21%	19.600%	21%	19.760%	21%	19.936%	21%	20.090%
2.00%	12%	2.00%	12%	2.00%	12%	2.20%	12%	2.32%	12%	2.35%	12%	2.31%
2.00%	4%	2.00%	4%	2.00%	5%	2.80%	4%	1.68%	4%	1.65%	4%	1.69%
2.0000%		2.0000%		3.0000%		1.8000%		1.6800%		1.6480%		1.6928%
20.000%		20.000%		20.000%		19.600%		19.760%		19.936%		20.090%
2.00%		2.00%		2.00%		2.20%		2.32%		2.35%		2.31%
2.00%		2.00%		2.00%		2.80%		1.68%		1.65%		1.69%



	9		10		11		12		13		14	
	4%		4%		4%		4%		4%		4%	
21%	20.195%	21%	20.240%	21%	20.228%	21%	20.173%	21%	20.094%	21%	20.012%	21%
12%	2.21%	12%	2.09%	12%	1.98%	12%	1.89%	12%	1.84%	12%	1.84%	12%
4%	1.79%	4%	1.91%	4%	2.02%	4%	2.11%	4%	2.16%	4%	2.16%	4%
	1.7901%		1.9099%		2.0238%		2.1101%		2.1572%		2.1634%	
	20.195%		20.240%		20.228%		20.173%		20.094%		20.012%	
	2.21%		2.09%		1.98%		1.89%		1.84%		1.84%	
	1.79%		1.91%		2.02%		2.11%		2.16%		2.16%	



15		16		17		18		19		20		21
4%		4%		4%		4%		4%		4%		4%
19.945%	21%	19.901%	21%	19.887%	21%	19.897%	21%	19.927%	21%	19.965%	21%	20.002%
1.86%	12%	1.91%	12%	1.97%	12%	2.02%	12%	2.06%	12%	2.08%	12%	2.08%
2.14%	4%	2.09%	4%	2.03%	4%	1.98%	4%	1.94%	4%	1.92%	4%	1.92%
2.1357%		2.0864%		2.0297%		1.9784%		1.9416%		1.9239%		1.9250%
19.945%		19.901%		19.887%		19.897%		19.927%		19.965%		20.002%
1.86%		1.91%		1.97%		2.02%		2.06%		2.08%		2.08%
2.14%		2.09%		2.03%		1.98%		1.94%		1.92%		1.92%

	22		23		24		25		26		27	
	4%		4%		4%		4%		4%		4%	
21%	20.032%	21%	20.049%	21%	20.053%	21%	20.046%	21%	20.031%	21%	20.013%	21%
12%	2.06%	12%	2.03%	12%	2.01%	12%	1.99%	12%	1.97%	12%	1.96%	12%
4%	1.94%	4%	1.97%	4%	1.99%	4%	2.01%	4%	2.03%	4%	2.04%	4%
	1.9408%		1.9653%		1.9919%		2.0147%		2.0301%		2.0363%	
	20.032%		20.049%		20.053%		20.046%		20.031%		20.013%	
	2.06%		2.03%		2.01%		1.99%		1.97%		1.96%	
	1.94%		1.97%		1.99%		2.01%		2.03%		2.04%	

28		29		30		31		32		33		34
4%		4%		4%		4%		4%		4%		4%
19.995%	21%	19.983%	21%	19.976%	21%	19.975%	21%	19.980%	21%	19.987%	21%	19.996%
1.97%	12%	1.97%	12%	1.99%	12%	2.00%	12%	2.01%	12%	2.02%	12%	2.02%
2.03%	4%	2.03%	4%	2.01%	4%	2.00%	4%	1.99%	4%	1.98%	4%	1.98%
2.0341%		2.0254%		2.0135%		2.0012%		1.9911%		1.9848%		1.9829%
19.995%		19.983%		19.976%		19.975%		19.980%		19.987%		19.996%
1.97%		1.97%		1.99%		2.00%		2.01%		2.02%		2.02%
2.03%		2.03%		2.01%		2.00%		1.99%		1.98%		1.98%

	35		36		37		38		39		40	
	4%		4%		4%		4%		4%		4%	
21%	20.004%	21%	20.009%	21%	20.012%	21%	20.011%	21%	20.009%	21%	20.005%	21%
12%	2.02%	12%	2.01%	12%	2.00%	12%	2.00%	12%	1.99%	12%	1.99%	12%
4%	1.98%	4%	1.99%	4%	2.00%	4%	2.00%	4%	2.01%	4%	2.01%	4%
	1.9847%		1.9892%		1.9950%		2.0006%		2.0050%		2.0075%	
	20.004%		20.009%		20.012%		20.011%		20.009%		20.005%	
	2.02%		2.01%		2.00%		2.00%		1.99%		1.99%	
	1.98%		1.99%		2.00%		2.00%		2.01%		2.01%	

41		42		43		44		45		46		47
4%		4%		4%		4%		4%		4%		4%
20.001%	21%	19.998%	21%	19.995%	21%	19.994%	21%	19.995%	21%	19.996%	21%	19.998%
1.99%	12%	1.99%	12%	2.00%	12%	2.00%	12%	2.00%	12%	2.00%	12%	2.00%
2.01%	4%	2.01%	4%	2.00%	4%	2.00%	4%	2.00%	4%	2.00%	4%	2.00%
2.0080%		2.0068%		2.0045%		2.0017%		1.9992%		1.9973%		1.9963%
20.001%		19.998%		19.995%		19.994%		19.995%		19.996%		19.998%
1.99%		1.99%		2.00%		2.00%		2.00%		2.00%		2.00%
2.01%		2.01%		2.00%		2.00%		2.00%		2.00%		2.00%

	48		49		50
	4%		4%		4%
21%	20.000%	21%	20.001%	21%	20.002%
12%	2.00%	12%	2.00%	12%	2.00%
4%	2.00%	4%	2.00%	4%	2.00%
	1.9963%		1.9970%		1.9982%
	20.000%		20.001%		20.002%
	2.00%		2.00%		2.00%
	2.00%		2.00%		2.00%

Solutions

Problem Set # 4
14.02 Spring 2011
Due March 11

March 16, 2011

1 True/False [30 points]

Please state whether each of the following claims are True or False, and provide a brief justication for your answer. You may include graphs and equations to support your answer.

1. "A high level of expected inflation tends to increase actual inflation". [5 points]

   ANSWER. True. We can see this in the AS relation. If wage setters expect P^e to be high, they will demand a high wage, which will result in a higher price level P.

2. "The AS equation implies a negative relation between inflation and unemployment, holding other factors constant". [5 points]

   ANSWER. True, see derivations in the textbook.

3. "Consider an economy on its medium run equilibrium. A temporary increase in nominal money growth reduces unemployment on impact. Then, unemployment steadily increases over time, monotonically converging back to its natural rate" [5 points]

   ANSWER. False. See part 7 of question 2. While it is true that unemployment decreases on impact, it is not true that it then converges "from below" back to its natural level. As shown in the graph below, unemployment converges to its natural level by oscillating.

4. "An increase in the rate of growth of money supply will have no impact on output growth in the medium run" [5 points]

   ANSWER. True. In the medium run, output growth is equal to its normal rate.

5. "According to the Phillips curve, a mark-up shock will affect inflation inmediately and in the near future. The effects will vanish in the medium run." [5 points]

   ANSWER. True. As can be seen in equation 8.6 of the textbook, a shock to μ in period t increases current inflation (π_t), which in turn increases inflation at $t+1$ (π_{t+1}), but by less. As time goes by, the effects vanish.

6. "Output growth makes the rate of unemployment decrease" [5 points]

   ANSWER. FALSE. Output growth has to be bigger than the normal growth rate (for example, 3% in the US) for unemployment to go down. This is because of growth in the size of the labor force, and labor productivity growth.

2 Phillips curve [20 points]

Consider the framework of Chapter 7, with a wage setting relation given by

$$W_t = P_t^e (1 - \alpha u_t + z)$$

where W is the nominal wage, P^e is the expected price, u is the unemployment rate, and z captures unemployment benefits. Consider the standard price setting relation:

$$P_t = (1 + \mu) W_t$$

where μ is the mark-up.

1. State the AS equation. [2 points]

   ANSWER. As always,

   $$P_t = P_t^e (1 + \mu)(1 - \alpha u_t + z)$$

2. Let $\pi_t = P_t/P_{t-1} - 1$, and $\pi_t^e = P_t^e/P_{t-1} - 1$. Show, step by step, how you can derive, from the AS relation, the following equation

   $$\pi_t = \pi_t^e + (\mu + z) - \alpha u_t \qquad (1)$$

   State if you are using any approximation rules, and which assumptions are required for these to work. [4 points]

   ANSWER. See appendix of Chapter 8 in the texbook. Yes, we are using the approximation rules

   $$(1 + x)(1 + y) \approx 1 + x + y$$

   $$\frac{1 + x}{1 + y} \approx 1 + x - y$$

   which require that x and y are small numbers.

3. Given expected inflation and unemployment, what is the effect of increasing unemployment benefits in period t on the rate of inflation in period t? Explain intuitively and in detail how the increase in z affects π_t. [4 points]

   ANSWER. An increase in unemployment benefits z leads to an inmediate increase in inflation. The intuition is that more generous unemployment benefits make the prospects of unemployment less distressing, thus increasing the bargaining power of workers. This increases wages at a given unemployment rate. In turn, this increases production costs, so price setters translate this to an increase in the price level. Given the price level of the previous period, P_{t-1}, this results in an increase in the inflation rate.

4. Suppose that expectatations are formed according to

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

   Explain briefly in words what this equation means. [4 points]

   ANSWER. This equation says that when inflation is positive in one period, workers and firms expect inflation to be positive in the next period as well. This means that people realize that inflation is persistent.

5. Can a single value of θ be used to account for the observed pattern of unemployment and inflation in the US from 1950 to 2000? [3 points]

   ANSWER. No. Before the 60s, a value of $\theta = 0$ could do a good job in fitting the data on unemployment and inflation. To account for the data after 1970 or so, we need a positive (close to 1) value of θ. See 166-169 in the textbook for more details.

6. Show that you can eliminate μ and z from equation (1) and express it as

$$\pi_t = \pi_t^e - \alpha (u_t - u_n) \tag{2}$$

   where u_n is the natural rate of unemployment. [3 points]

   ANSWER. See page 171 in the textbook.

3 Inflation, Activity and Nominal Money Growth [50 points]

Consider the following dynamic economy

$$\begin{aligned} u_t - u_{t-1} &= -\beta (g_{Yt} - \bar{g}_Y) \\ \pi_t - \pi_{t-1} &= -\alpha (u_t - u_n) \\ g_{Yt} &= g_{mt} - \pi_t \end{aligned}$$

Suppose the economy is in a medium run equilibrium. The normal rate of output growth is $\bar{g}_Y = 2\%$. The central bank has fixed the rate of money growth to be $g_{mt} = 4\%$. Assume $\alpha = \beta = 1/2$.

1. Suppose that in labor markets, firms charge a markup of 20% over average cost ($\mu = 0.20$), and that the wage setting relation is $W = P^e(1-u)$. Find the natural rate of unemployment, u_n. [3 points]

   ANSWER.

$$1 = 1.20(1-u_n) \rightarrow u_n = 1 - \frac{1}{1.2} = 16.67\%$$

   [**Note:** There is a small inconsistency in the set-up of this question. In part 1, we are given a wage setting relation of the form $W = P^e(1-u)$). But Phillips curve given in the set-up is consistent with $W = P^e(1-\alpha u)$. Thus, we will also take as correct the following answer:

$$1 = 1.20\left(1 - \frac{1}{2}u_n\right) \rightarrow u_n = 2(1 - \frac{1}{1.2}) = 2 * 16.67 = 33.34\%$$

   For the remainder of the question, we will take $u_n = 16.67\%$ to be the natural rate of unemployment. If you use $u_n = 33.34\%$ instead, you will get different numbers but your answers should be qualitatively similar to the ones reported below.]

2. What is the rate of inflation in the medium run equilibrium? [3 points]

   ANSWER. The AD equation tells us

$$2\% = 4\% - \pi$$

   so that $\pi = 2\%$.

3. Suppose that the economy is in its medium run equilibrium ($u_t = u_n$), when the central bank decides to *permanently* increase the rate of growth in the money supply to 5%. Compute the new medium run equilibrium levels of unemployment, inflation, and output growth. [3 points]

   ANSWER. Clearly u_n and $\bar{g}_Y$ are independent of g_m. The new rate of inflation in the MR is such that

$$2\% = 5\% - \pi_t$$

   so that $\pi = 3\%$.

4. Denote by $t = 0$ the last period in which the economy is in its medium run equilibrium. Suppose that from $t = 1$ on, the central bank keeps $g_m = 5\%$. Compute the values of π_t, g_t and u_t for $t = 0, t = 1, t = 2, t = 3$ and $t = 4$. Display your results in table (columns are time periods, and rows are variables) [13 points]

   ANSWER. We can substitute g_{Yt}, and express the system as

$$\begin{aligned} u_t &= \frac{4}{5}u_{t-1} + \frac{2}{5}\pi_{t-1} - \frac{2}{5}g_{mt} + \frac{2}{5}\bar{g}_Y + \frac{1}{5}u_n \\ \pi_t &= \pi_{t-1} - \frac{1}{2}(u_t - u_n) \end{aligned}$$

or

$$\begin{aligned} u_t &= \frac{4}{5}u_{t-1} + \frac{2}{5}\pi_{t-1} - 1.2\% + \frac{1}{5}u_n \\ \pi_t &= \pi_{t-1} - \frac{1}{2}(u_t - u_n) \end{aligned}$$

Given u_{t-1}, π_{t-1} these two equations determine u_t, π_t.

For $t = 1$ note that $u_0 = u_n$, and $\pi_0 = 2\%$.Thus

$$\begin{aligned} u_1 &= 16.67\% - 1.2\% + \frac{2}{5}2\% = 16.27\% \\ \pi_1 &= 2\% - \frac{1}{2}(16.27\% - 16.67\%) = 2.2\% \end{aligned}$$

And $g_{Y1} = 5\% - 2.2\% = 2.8\%$. For $t = 2$,

$$\begin{aligned} u_2 &= \frac{4}{5} * 16.27\% - 1.2\% + \frac{2}{5} * 2.2\% + \frac{1}{5} * 16.67\% = 16.03\% \\ \pi_2 &= 2.2\% - \frac{1}{2}(16.03\% - 16.67\%) = 2.52\% \end{aligned}$$

So: $g_{Y2} = 5\% - 2.52\% = 2.48\%$

For t=3, we have

$$\begin{aligned} u_3 &= \frac{4}{5} * 16.03\% - 1.2\% + \frac{2}{5} * 2.52\% + \frac{1}{5} * 16.67\% = 15.966\% \\ \pi_3 &= 2.52\% - \frac{1}{2}(15.966\% - 16.67\%) = 2.872\% \end{aligned}$$

so $g_{Y3} = 5\% - 2.912\% = 2.088\%$

For t=4:

$$\begin{aligned} u_4 &= \frac{4}{5} * 15.966\% - 1.2\% + \frac{2}{5} * 2.872\% + \frac{1}{5} * 16.67\% = 16.056\% \\ \pi_4 &= 2.872\% - \frac{1}{2}(16.056\% - 16.67\%) = 3.179\% \end{aligned}$$

: so $g_{Y4} = 5\% - 3.179\% = 1.821\%$

Summarizing the results in one table:

	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$
g_{mt}	4%	5%	5%	5%	5%
π_t	2%	2.2%	2.52%	2.872%	3.179%
g_{Yt}	2%	2.8%	2.68%	2.088%	1.821%
u_t	16.67%	16.27%	16.03%	15.966%	16.05%

5. After 4 periods, has the rate of inflation reached its new medium run level? [5 points]

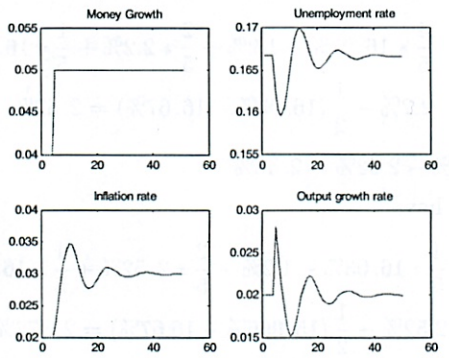
   ANSWER. No, it is still oscillating.

6. Using a computer, compute the evolution of π_t, g_t and u_t for 50 periods (assume that in the first 3 periods $g_{m_t} = 4\%$, and in the last 47 periods $g_{mt} = 5\%$). You just need to report one graph for each variable. Is there a period in time in which unemployment exceeds its natural rate? [12 points]

   ANSWER. To do this question, just plug this system of difference equations into MATLAB

$$\begin{aligned} u_t &= \frac{1}{1+\alpha\beta}u_{t-1} + \frac{\beta}{1+\alpha\beta}\pi_{t-1} + \frac{\alpha\beta u_n + \beta\bar{g}_Y - \beta g_{mt}}{1+\alpha\beta} \\ \pi_t &= \pi_{t-1} - \alpha\left(u_t - u_n\right) \end{aligned}$$

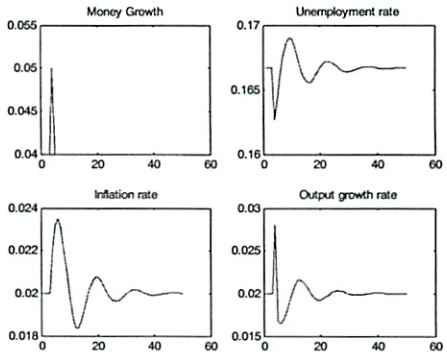
   The evolution of the variables is:



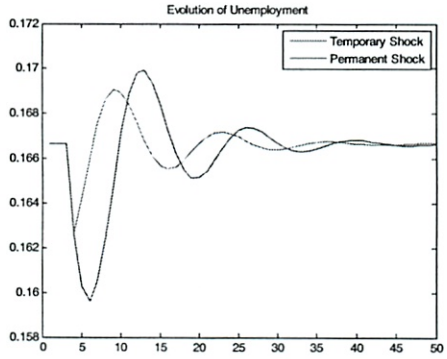
   After the initial period of lower unemployment, there is a period in which unemployment is higher than its natural rate.

7. Suppose now that the increase in money growth is not permanent but only lasts one period (i.e. assume that both in the first 3 periods and in the last 46 periods money growth is $g_{m_t} = 4\%$, while in period 4 it is $g_{mt} = 5\%$). Report a graph (or three graphs) with the time evolution of π_t, g_t and u_t. How does the time evolution of u_t compare with the one obtained in the previous question? (describe briefly, 3 lines max) [11 points]

ANSWER.



We see that the transitory increase in money growth generates a qualitatively similar pattern on u_t but the effects are milder and go away faster. This can be better seen in the following graph which shows the evolution of u_t both under the transitory and the permanent shock



Problem Set # 4
14.02 Spring 2011
Due March 11

March 3, 2011

1 True/False [40 points]

Please state whether each of the following claims are True or False, and provide a brief justication for your answer. You may include graphs and equations to support your answer.

1. "A high level of expected inflation tends to increase actual inflation". [5 points]

   ANSWER. True. We can see this in the AS relation. If wage setters expect P^e to be high, they will demand a high wage, which will result in a higher price level P.

2. "The AS equation implies a negative relation between inflation and unemployment, holding other factors constant". [5 points]

   ANSWER. True, see derivations in the textbook.

3. "Consider an economy on its medium run equilibrium. A temporary increase in nominal money growth reduces unemployment on impact. Then, unemployment steadily increases over time, and converges back to its natural rate" [5 points]

   ANSWER. False. See part 7 of question 2. While it is true that unemployment decreases on impact, it is not true that it then converges "from below" back to its natural level. As shown in the graph below, unemployment converges to its natural level by oscillating.

4. "An increase in the rate of growth of money supply will have no impact on output growth in the medium run" [5 points]

   ANSWER. True. In the medium run, output growth is equal to its normal rate.

5. "According to the Phillips curve, a mark-up shock will affect current and future levels of inflation" [5 points]

   ANSWER. True. As can be seen in equation 8.6 of the textbook, a shock to μ in period t increases current inflation (π_t), which in turn increases inflation at $t+1$ (π_{t+1}). Thus, the shock propagates to all future periods.

6. "Output growth makes the rate of unemployment decrease" [5 points]

   ANSWER. FALSE. Output growth has to be bigger than the normal growth rate (for example, 3% in the US) for unemployment to go down. This is because of growth in the size of the labor force, and labor productivity growth.

2 Inflation, Activity and Nominal Money Growth [60 points]

Consider the following dynamic economy

$$\begin{aligned} u_t - u_{t-1} &= -\beta\left(g_{Yt} - \bar{g}_Y\right) \\ \pi_t - \pi_{t-1} &= -\alpha\left(u_t - u_n\right) \\ g_{Yt} &= g_{mt} - \pi_t \end{aligned}$$

Suppose the economy is in a medium run equilibrium. The normal rate of output growth is $\bar{g}_Y = 2\%$. The central bank has fixed the rate of money growth to be $g_{mt} = 4\%$. Assume $\alpha = \beta = 1/2$.

1. Suppose that in labor markets, firms charge a markup of 20% over average cost ($\mu = 0.20$), and that the wage setting relation is $W = P^e(1-u)$. Find the natural rate of unemployment, u_n. [5 points]

   ANSWER.

$$1 = 1.20\left(1 - u_n\right) \rightarrow u_n = 1 - \frac{1}{1.2} = 16.67\%$$

2. What is the rate of inflation in the medium run equilibrium? [5 points]

   ANSWER. The AD equation tells us

$$2\% = 4\% - \pi$$

   so that $\pi = 2\%$.

3. Suppose that the economy is in its medium run equilibrium ($u_t = u_n$), when the central bank decides to *permanently* increase the rate of growth in the money supply to 5%. Compute the new medium run equilibrium levels of unemployment, inflation, and output growth. [5 points]

ANSWER. Clearly u_n and $\bar{g}_Y$ are independent of g_m. The new rate of inflation in the MR is such that

$$2\% = 5\% - \pi_t$$

so that $\pi = 3\%$.

4. Denote by $t = 0$ the last period in which the economy is in its medium run equilibrium. Suppose that from $t = 1$ on, the central bank keeps $g_m = 5\%$. Compute the values of π_t, g_t and u_t for $t = 0, t = 1, t = 2, t = 3$ and $t = 4$. Display your results in table (columns are time periods, and rows are variables) [15 points]

ANSWER. We can substitute g_{Yt}, and express the system as

$$\begin{aligned} u_t &= \frac{4}{5}u_{t-1} + \frac{2}{5}\pi_{t-1} - \frac{2}{5}g_{mt} + \frac{2}{5}\bar{g}_Y + \frac{1}{5}u_n \\ \pi_t &= \pi_{t-1} - \frac{1}{2}(u_t - u_n) \end{aligned}$$

or

$$\begin{aligned} u_t &= \frac{4}{5}u_{t-1} + \frac{2}{5}\pi_{t-1} - 1.2\% + \frac{1}{5}u_n \\ \pi_t &= \pi_{t-1} - \frac{1}{2}(u_t - u_n) \end{aligned}$$

Given u_{t-1}, π_{t-1} these two equations determine u_t, π_t.

For $t = 1$ note that $u_0 = u_n$, and $\pi_0 = 2\%$.Thus

$$\begin{aligned} u_1 &= 16.67\% - 1.2\% + \frac{2}{5}2\% = 16.27\% \\ \pi_1 &= 2\% - \frac{1}{2}(16.27\% - 16.67\%) = 2.2\% \end{aligned}$$

And $g_{Y1} = 5\% - 2.2\% = 2.8\%$. For $t = 2$,

$$\begin{aligned} u_2 &= \frac{4}{5} * 16.27\% - 1.2\% + \frac{2}{5} * 2.2\% + \frac{1}{5} * 16.67\% = 16.03\% \\ \pi_2 &= 2.2\% - \frac{1}{2}(16.03\% - 16.67\%) = 2.52\% \end{aligned}$$

So: $g_{Y2} = 5\% - 2.52\% = 2.48\%$

For t=3, we have

$$\begin{aligned} u_3 &= \frac{4}{5} * 16.03\% - 1.2\% + \frac{2}{5} * 2.52\% + \frac{1}{5} * 16.67\% = 15.966\% \\ \pi_3 &= 2.52\% - \frac{1}{2}(15.966\% - 16.67\%) = 2.872\% \end{aligned}$$

so $g_{Y3} = 5\% - 2.912\% = 2.088\%$

For t=4:

$$u_4 = \frac{4}{5} * 15.966\% - 1.2\% + \frac{2}{5} * 2.872\% + \frac{1}{5} * 16.67\% = 16.056\%$$

$$\pi_4 = 2.872\% - \frac{1}{2}(16.056\% - 16.67\%) = 3.179\%$$

: so $g_{Y4} = 5\% - 3.179\% = 1.821\%$

Summarizing the results in one table:

	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$
g_{mt}	4%	5%	5%	5%	5%
π_t	2%	2.2%	2.52%	2.872%	3.179%
g_{Yt}	2%	2.8%	2.68%	2.088%	1.821%
u_t	16.67%	16.27%	16.03%	15.966%	16.05%

5. After 4 periods, has the rate of inflation reached its new medium run level? [5 points]

   ANSWER. No, it is still oscillating.

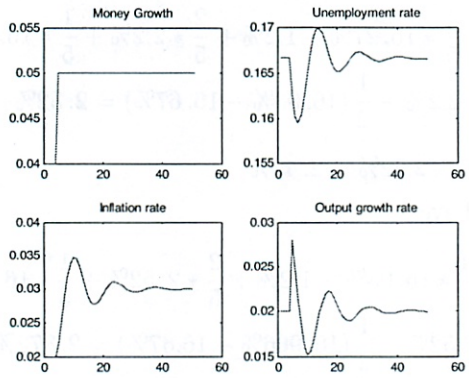
6. Using a computer, compute the evolution of π_t, g_t and u_t for 50 periods (assume that in the first 3 periods $g_{m_t} = 4\%$, and in the last 47 periods $g_{mt} = 5\%$). You just need to report one graph for each variable. Is there a period in time in which unemployment exceeds its natural rate? [13 points]

   ANSWER. To do this question, just plug this system of difference equations into MATLAB

$$u_t = \frac{1}{1+\alpha\beta}u_{t-1} + \frac{\beta}{1+\alpha\beta}\pi_{t-1} + \frac{\alpha\beta u_n + \beta\bar{g}_Y - \beta g_{mt}}{1+\alpha\beta}$$

$$\pi_t = \pi_{t-1} - \alpha(u_t - u_n)$$

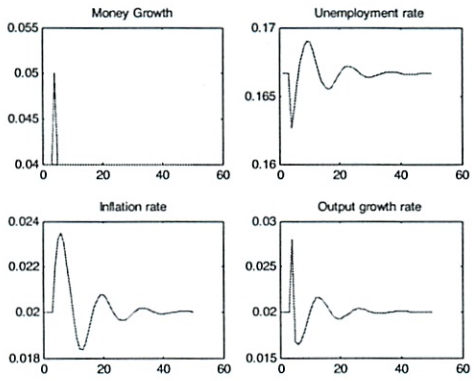
   The evolution of the variables is:



After the initial period of lower unemployment, there is a period in which unemployment is higher than its natural rate.

7. Suppose now that the increase in money growth is not permanent but only lasts one period (i.e. assume that both in the first 3 periods and in the last 46 periods money growth is $g_{m_t} = 4\%$, while in period 4 it is $g_{mt} = 5\%$). Report a graph (or three graphs) with the time evolution of π_t, g_t and u_t. How does the time evolution of u_t compare with the one obtained in the previous question? (describe briefly, 3 lines max) [12 points]

   ANSWER.



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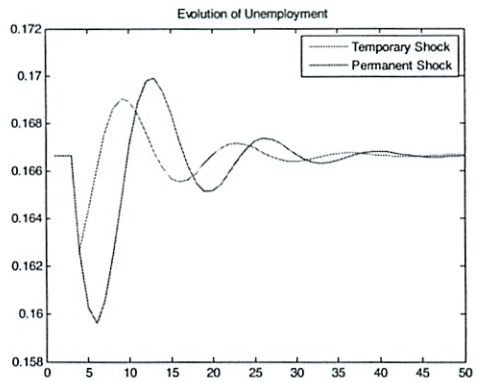


14.02 Exam Review

3/16

Multipliers

IS/LM

IS

$Z = C(Y-T) + \bar{I} + G$

$Y = Z$

Assume $C_0(Y-T) = C_0 + C_1(Y-T)$

C_0: autonomous spending; C_1: marginal propensity to consume

C_1 gives us the multiplier effect

$Z = C_0 + C_1 Y - C_1 T + \bar{I} + G$

$Y = Z$ - Y is GDP - one way to measure - look at income in econ

If $Y \uparrow$, $Z \uparrow$ (demand for goods), $Y \uparrow$ so multiplier

But it converges!

Blue Pen ran out → Solve for y

$$Y = \underbrace{\frac{1}{1-C_1}}_{\text{multiplier}} (C_0 - C_1 T + \bar{I} + G)$$

Highest multiplier when $C_1 = 1$

Then Y would be ∞

But $C_1 < 1$

Why G works

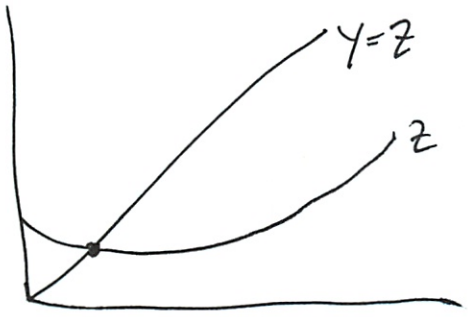
(2)

In this model $G \to \frac{1}{1-c_1}$

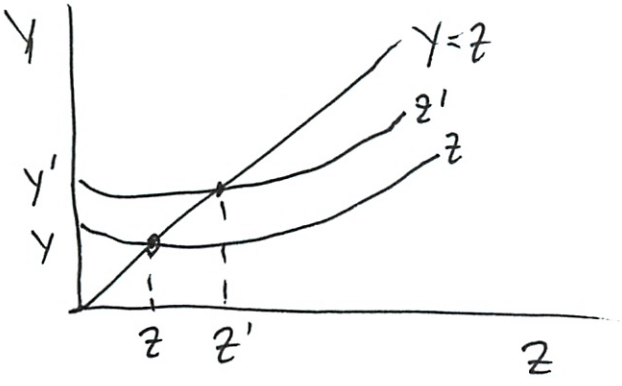
$T \to \frac{c_1}{1-c_1}$ Taxes less effective to stimulate econ

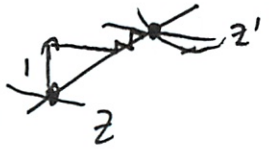
c_1 can be changed by pres going on TV + telling people to spend

That was the value after all convergence



If ↑ G





make supply = demand ↑ repeat till converges

Income ↑

↑

set $\Delta G = 1$

so $Z \uparrow 1$

$Y \uparrow 1$

$Z \uparrow c_1$

$Y \uparrow c_1$

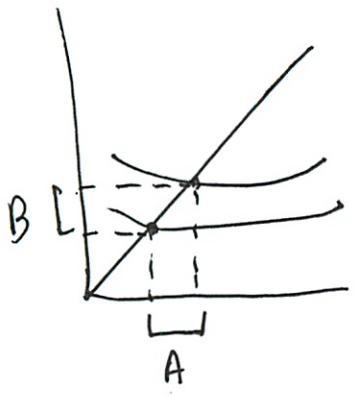
$Z \uparrow c_1^2$

$Y \uparrow c_1^2$ ← since $c_1 < 1$ it shrinks

⋮ becomes 0

Sum of steps $= 1 + c_1^* + c_1^2 + c_1^3 + \ldots = \frac{1}{1-c_1}$

(3)



$$\text{multiplier} = \frac{A}{B}$$

Money Multiplier

LM market

plain LM has no multipliers

$$\frac{M^d}{P} = Y \cdot L(i)$$

$$M^s = M$$

$$M^d = M^s$$

But this forgets that there banks in society ← important caveats like

(I understand the general ideas - but not and how it all fits together - not comfortable /w/)

Central Bank

Assets	Liab
Bonds	Money - reserves - currency

← since people can ask Central bank for stuff in exchange for $

Banks

Assets	Liabs
Reserves	Deposits
Loans	
Bonds	

Consider both of these as →

(4)

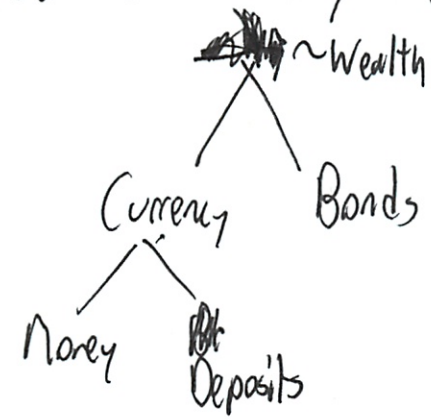
Reserves = money banks need to keep on hand

Currency = Dollar bills

So now find demand + supply for money

$$\frac{M^d}{P} = Y \cdot L(i)$$

- ~~demand currency or deposit~~



$CU^d = c\, M^d$

$D^d = (1-c) M^d$] behavioral

c based on situation?

- lose faith in bank c↑
- but if theft common, banks safe c↓

$R = \theta D$] set by law

↑

banks must keep a certain amt in reserves = reserve req

if θ ↑ bank could not pay withdraws

" ↓ " " " ~~interest~~ loan for investments

(5)

$R^d = \theta D^d$ banks → consumers

$H^d = R^d + CU^d$

↑ Central bank money

$H^s = H$

$M^d = R^d + CU^d$

$= \theta D^d + CU^d$

$= \theta(1-c) M^d + c M^d$

$= [\theta(1-c) + c] = M^d$

$H^d = H^s$

$H = \underbrace{[\theta(1-c) + c]}_{\text{Money Multiplier}} P \cdot Y \cdot L(i)$

↑ H is "high powered money" - since central bank $ gets multiplied