A New Keynesian and Post Keynesian Model in a Simple Unified Framework

10th PKES Summer School
10 June 2021

Dr. Rafael Wildauer

UNIVERSITY of GREENWICH

Outline

Introduction

Introduction

- One of the key principles of Post Keynesian economic theory, distinguishing it from the mainstream ...
- **Principle of Effective Demand**
- What does it say?
  - Output and employment are (primarily) determined by aggregate demand not only in the short run but also in the medium and long run.
- So PK models are **demand determined** models (output is demand determined), ...
- while Neoclassical and New Keynesian models are mainly **supply determined** (beyond the short term).

Aims for this lecture

1. Introduce tractable demand and supply determined models
2. Compare the shared and distinct building blocks
3. Compare policy recommendations coming out of these models

A simple supply determined model

A simple supply determined model

- Main point of reference for supply determined model: New Keynesian Dynamic Stochastic General Equilibrium Model (DSGE) as in Clarida et al. (1999), for the standard (graduate) textbook see Woodford (2003).

- In this lecture I will use a reduced form similar to the reduced form of a NK-DSGE (similar to Gali & Gertler (2007)) to keep the math simple

- Similar models used by Carlin & Soskice (2014) and Mankiw (2016) in Chapter 15

- Both mainstream textbooks introduce it as stepping stone to NK-DSGE models

- Will use New Keynesian and supply determined model interchangeably

Our baseline New Keynesian model

- Consists of three building blocks (equations):
  (1) demand side (IS equation)
  (2) supply side (Philips curve, PC)
  (3) monetary policy (central bank reaction function, CB)

The demand side: IS equation

- "IS" refers to investment and saving
  (goods market equilibrium in closed economy)

$$Y_t = A - cr_{t-1} \qquad \text{(IS)}$$

where Y_t is real GDP in period t and r_{t-1} is the real interest rate in period t-1

- A represents all factors which affect aggregate demand other than the interest rate
- c: the interest rate sensitivity of consumption and investment
- time lag: households and firms need time to react

→ Higher real interest rates reduce output.
→ Expansionary fiscal policy corresponds to increase in A.

The supply side: The Philips curve

Carlin & Soskice (2014) specify the Phillips curve as:

$$\Pi_t = \Pi_{t-1} + \alpha(Y_t - Y^n) \tag{PC}$$

$$\Delta\Pi_t = \alpha(Y_t - Y^n) \tag{PC'}$$

where Π_t is the rate of inflation in period t and Y^n is natural or potential output, α: is a parameter capturing the sensitivity of inflation to the output gap

- Natural output is output level associated with stable inflation
- Inflation is result of excess demand.
- The **change** in inflation depends on the output gap. This is an **accelerationist** Phillips curve!

$\rightarrow$ PC: If actual output (Y_t) is above natural output (Y^n) inflation increases each period.

Monetary Policy: The CB reaction function

The central bank sets interest rates according to:

$$r_t = r^n + \frac{\alpha\beta}{c}\left(E[\Pi_{t+1}] - \Pi^T\right) \tag{CB}$$

- r^n is the real interest rate compatible with natural output Y^n, autonomous demand A and stable inflation at the inflation target: $\Pi_t = \Pi_{t-1} = \Pi^T$. We assume the CB has a fixed estimate of r^n.
- The CB is forward looking and has rational expectations (it correctly anticipates future inflation: $E[\Pi_{t+1}] = \Pi_{t+1}$)
- It sets interest rates based on deviation of future inflation from target (Π^T)

→ Central bank raises interest rates when it expects inflation above target.
→ Expansionary monetary policy corresponds to reduction in (estimate of) r^n.

Solving the model

How can we solve the closed economy baseline model?

The fastest way to do it with these stationary models is to make use of the fact that ...

in equilibrium the value of the endogenous variables does not change.

Which means that in equilibrium we have for example $Y_t = Y_{t+1} = Y_{t+2} = Y^*$
We can apply this reasoning to all three endogenous variables and obtain:
(see Appendix for full detail)

- $Y^* = Y^n$
- $r^* = \frac{A - Y^n}{c}$
- $\Pi^* = \frac{c}{\alpha\beta}\left(\frac{A - Y^n}{c} - r^n\right) + \Pi^T$

Fiscal and monetary policy in the New Keynesian Model

- We are interested in the effect of a permanent fiscal expansion (increase in A)
- and a permanent monetary easing (reduction in r^n).
- Let's compute the effect on our equilibrium values:
- effect on equilibrium output $Y^* = Y^n$:

$$\frac{\partial Y^*}{\partial A} = 0 \qquad \text{and} \qquad \frac{\partial Y^*}{\partial r^n} = 0$$

- effect on equilibrium inflation $\Pi^* = \frac{c}{\alpha\beta}\left(\frac{A - Y^n}{c} - r^n\right) + \Pi^T$:

$$\frac{\partial \Pi^*}{\partial A} = \frac{1}{\alpha\beta} \qquad \text{and} \qquad \frac{\partial \Pi^*}{\partial r^n} = -\frac{c}{\alpha\beta}$$

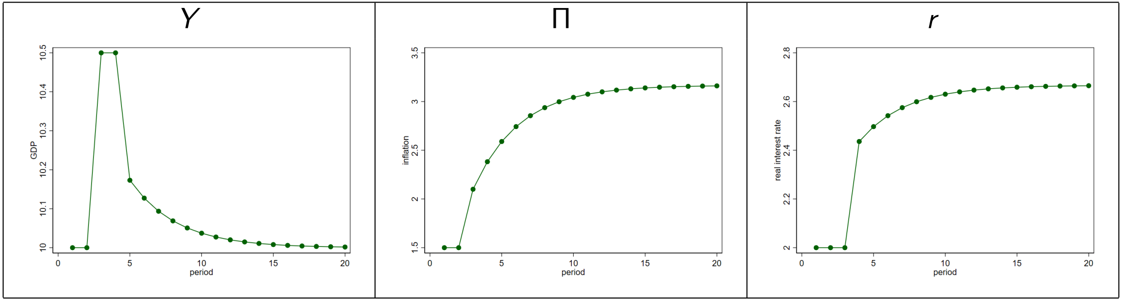
- effect on equilibrium real interest rate $r^* = \frac{A - Y^n}{c}$:

$$\frac{\partial r^*}{\partial A} = 1/c \qquad \text{and} \qquad \frac{\partial r^*}{\partial r^n} = 0$$

A permanent positive demand shock

We start from equilibrium: $Y^* = Y^n = 10$, $\Pi^* = 1.5$ and $r^* = 2$

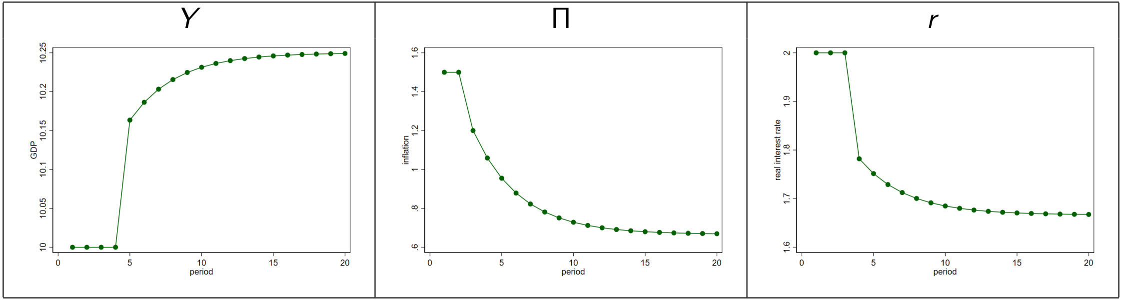
Then in period 3 a permanent positive demand shock occurs (e.g. permanent increase in gov spending):



A permanent positive supply shock

We start from equilibrium: $Y^* = Y^n = 10$, $\Pi^* = 1.5$ and $r^* = 2$

Then in period 3 a permanent positive supply shock occurs (e.g. higher productivity):



Key results and mechanisms at work

- Permanent demand shocks do NOT affect output equilibrium
  - We have short run effects
  - The reason is that inflation jumps and the central bank intervenes
  - Gov spending has not effect because the CB offsets it and conversely austerity works because the CB offsets it
- Permanent supply shock affects output equilibrium
  - Short and long run effects
  - Reason is inflation jumps (change in Y^n means new output level of stable inflation) and CB intervenes
- Overall, the supply side of the model in the form of the **accelerationist** Phillips curve dominates the long run behaviour

A simple demand determined model

A simple demand determined model

- In this section we will develop a model for which the principle of effective demand holds
- Equilibrium output is demand determined
- Several Post Keynesian authors have amended supply determined models such as Lavoie (2006), Setterfield (2006)
- Key difference is that they often also changed the mathematical apparatus
- Lavoie (2006) introduces a unit root and Setterfield (2006) turns the model into a system of 2 difference equations instead of 1
- My aim is to keep it simple and use the same mathematical apparatus (i.e. the model can be reduced to a single, stationary difference equation)

How is the new model different?

- The demand determined model exhibits two crucial differences:
  - It does not include exogenous natural output Y^n
  - It does not produce runaway inflation if outside equilibrium
- Both differences manifest in a different Phillips curve:

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(Y_t - Y_{t-1})$$

- We will keep the IS and the MP curve the same

Why these two differences?

- Why no natural output (Y^n)?
  - Assuming that equilibrium output is solely defined by supply factors is a special case
  - Allowing for a role of demand as well yields a more general model
  - abandoning the pure supply side determination of output equates to abandoning the idea of "natural output"
- Why no runaway inflation outside equilibrium?
  - The idea that inflation increases at a faster and faster pace if $Y \neq Y^n$ (without an intervention from the central bank) ...
  - stems from the wage-price spiral we assumed when deriving the PC (workers and firms passed on 100% of costs).
  - If workers and firms **cannot** pass on higher prices/wages **perfectly** we don'tget runaway inflation
  - This allows us to have stable equilibria at any output level given the corresponding demand (and supply) conditions (and monetary policy stance)

The structure of the model

- One equation for each main building block
- 1): demand side (IS equation)
- 2): supply side (**new** Philips curve)
- 3): monetary policy (central bank reaction function)
- I am calling it the **new** Philips curve to distinguish it from the SDM

The demand side: IS equation

- "IS" refers to investment and saving
  (goods market equilibrium in closed economy)

$$Y_t = A - cr_{t-1} \tag{1}$$

where Y_t is real GDP and r_t is the real interest rate

- A represents all factors which affect aggregate demand other than the interest rate
- c: the interest rate sensitivity of consumption and investment and depends on size of multiplier (larger multiplier, larger c, economy more interest sensitive)
- time lag: households and firms need time to react

The supply side: The **new** Philips curve

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(Y_t - Y_{t-1}) \tag{2}$$

- The greek capital letter Π (pronounced: pie) is used as the variable for the inflation rate
- the greek letter α (pronounced: alfa) is a parameter and reflects how strongly inflation reacts to an economic boom
- the greek letters γ_0 and γ_1 (pronounced: gamma) are parameters representing
  - γ_0: Institutional factors influencening the inflation rate of a country (e.g. private vs public health care)
  - γ_1: How easily workers and firms can break out of a wage price spiral
- compare it to the one Carlin & Soskice (2014) are using:

$$\Pi_t = \Pi_{t-1} + \alpha(Y_t - Y^n)$$

The supply side: The **new** Philips curve

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(Y_t - Y_{t-1})$$

- The first key point is that an economic boom is defined as deviation from prev period $Y_t - Y_{t-1}$
- not as deviation from natural output $Y_t - Y^n$
- Institutional factors like degree of competition influence inflation (γ_0) ...
- and because workers bargain over nominal wages, the wage price spiral does not last forever ($\gamma_1 < 1$)

Monetary Policy: The CB reaction function

The central bank (CB) sets interest rates according to:

$$r_t = r_0 + \frac{\alpha\beta}{c}\left(E[\Pi_{t+1}] - \Pi^T\right) \tag{3}$$

- r_0 is what we called the natural interest rate (which was the central bank's guess of the equilibrium real interest rate)
- Now r_0 is better interpreted as the monetary policy stance of the central bank (how expansionary is monetary policy)
- The CB has rational expectations (meaning it correctly anticipates future inflation: $E[\Pi_{t+1}] = \Pi_{t+1}$)
- It sets interest rates based on deviation of future inflation from target (Π^T)

Equilibrium of the demand determined model

- The solutions (see Appendix for details):

$$\Pi^* = \frac{\gamma_0}{1-\gamma_1}$$

$$r^* = r_0 + \frac{\alpha\beta}{c}\left(\Pi^* - \Pi^T\right) = r_0 + \frac{\alpha\beta}{c}\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$$

$$Y^* = A - cr^* = A - cr_0 - \alpha\beta\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$$

- We can see that autonomous demand (A) is part of the output equilibrium solution ...
- so demand plays a role for equilibrium output determination **alongside** the supply side factors (γ_0 and γ_1)
- Not only fiscal policy has equilibrium effects, also monetary policy (r_0 is part of equilibrium output)
- Equilibrium inflation purely determined by supply side factors, demand short term only.

Fiscal and monetary policy in the New Keynesian Model

- We are interested in the effect of a permanent fiscal expansion (increase in A) and a permanent monetary easing (reduction in r_0).
- Let's compute the effect on our equilibrium values:
- effect on equilibrium inflation $\Pi^* = \frac{\gamma_0}{1-\gamma_1}$:

$$\frac{\partial \Pi^*}{\partial A} = 0 \qquad \text{and} \qquad \frac{\partial \Pi^*}{\partial r_0} = 0$$

- effect on equilibrium real interest rate $r^* = r_0 + \frac{\alpha\beta}{c}\left(\Pi^* - \Pi^T\right)$:

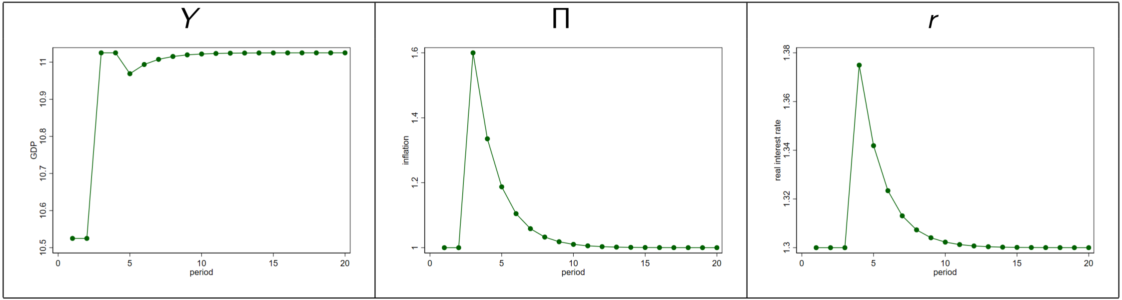
$$\frac{\partial r^*}{\partial A} = 0 \qquad \text{and} \qquad \frac{\partial r^*}{\partial r_0} = 1$$

- effect on equilibrium output $Y^* = A - cr^* = A - cr_0 - \alpha\beta\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$:

$$\frac{\partial Y^*}{\partial A} = 1 \qquad \text{and} \qquad \frac{\partial Y^*}{\partial r_0} = -c$$

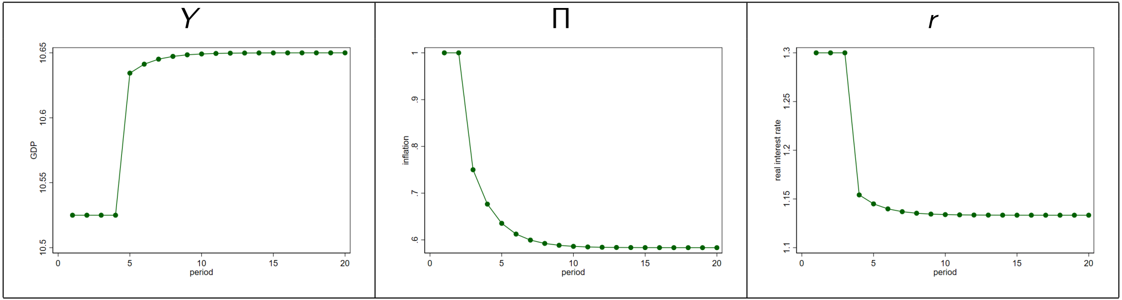
A permanent increase in gov spending

Impulse Response Functions after gov permanently increases expenditures in period 3:



A permanent increase in productivity

Impulse Response Functions after permanent productivity increases in period 3:



Key results and mechanisms at work

- Permanent demand shocks DO affect output equilibrium
  - Also have short run effects
  - CB only temporarily raises interest rates
  - Inflation only temporarily increases
- Permanent supply shock affects output equilibrium
  - Short and long run effects
  - Reason is inflation jumps (productivity gain feeds into lower prices) and CB lowers interest rates
- Because Phillips curve is **non-accelerationist**, inflation does not spiral out of control, less aggressive central bank

Conclusion

Let's compare them I

equilibrium	**demand determined model**	**supply determined model**
output	$Y^* = A - cr_0 - \alpha\beta\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$	$Y^* = Y^n$
inflation	$\Pi^* = \frac{\gamma_0}{1-\gamma_1}$	$\Pi^* = \frac{1}{\alpha\beta}\left[A - Y^n - cr^n\right] + \Pi^T$
real interest rate	$r^* = r_0 + \frac{\alpha\beta}{c}\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$	$r^* = \frac{A-Y^n}{c}$

Let's compare them II

	supply determined model	**demand determined model**
output	▪ demand only relevant in short run ▪ $Y^* = Y^n$ determined by tech and lab mkt institutions ▪ if $Y^* \neq Y^n$ inflation explodes (**accelerationist PC**)	▪ demand relevant in short + long run ▪ excess demand only triggers temporary inflation ▪ **non-accelerationist** Phillips Curve (PC)
inflation	▪ inflation caused by excess demand or supply shocks ▪ accelerationist PC: exploding wage-price spirals	▪ inflation in the long run determined by institutions ▪ **non-accelerationist PC**: wage-price spirals die down ▪ **acyclical inflation**
int rate	▪ set by CB to control Π ▪ determined by agg dem and supply	▪ set by CB to control Π ▪ CB controls Π only in short run

Modelling

- Keep in mind the only difference between the two models are the two specifications of the Phillips curve

- An accelerationist Phillips curve in the SDM: $\Pi_t = \Pi_{t-1} + \alpha(Y_t - Y^n)$

- and a non-accelerationist Phillips curve in the DDM: $\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(Y_t - Y_{t-1})$

Economic Policy Implications

- Most importantly there is consensus on the short run behaviour: demand matters
- **Fiscal policy:** only effective in the short term (SDM) vs can be used to establish full employment (DDM)
- **Monetary policy:** ensure Π not spiralling out of control (SDM) vs can be used for demand management / rigid inflation target counterproductive (DDM)
- The IS and the monetary policy rule are the same.
- How we think about wage and price setting is crucial.

Summers vs Yellen

- Inflation talk after financial crisis and now (Summers) strongly influenced by ...
- idea of an **accelerationist** Phillips curve and ...
- unanchored inflation expectations.
- US finance minister Janet Yellen expects inflationary pressure to be transitory (like in the demand determined Phillips curve)
- Over the next year we should be able to settle this question.

References I

Carlin, W. & Soskice, D. (2014), *Macroeconomics: Institutions, Instability, and the Financial System*, Oxford University Press.

Clarida, R., Galí, J. & Gertler, M. (1999), 'The science of monetary policy: A new keynesian perspective', *Journal of Economic Literature* **37**(4), 1661–1707.

Gali, J. & Gertler, M. (2007), 'Macroeconomic modeling for monetary policy evaluation', *Journal of Economic Perspectives* **21**(4), 25–45.

Lavoie, M. (2006), 'A post-keynesian amendment to the new consensus on monetary policy', *Metroeconomica* **57**(2), 165–192.

Mankiw, N. (2016), *Macroeconomics*, Worth Publishers A Macmillan Education Imprint, New York.

Setterfield, M. (2006), 'Is inflation targeting compatible with post keynesian economics?', *Journal of Post Keynesian Economics* **28**(4), 653–671.

Woodford, M. (2003), *Interest and Prices*, Princeton University Press.

Appendix

Appendix

Solving the NK Baseline Model

In equilibrium the value of the endogenous variables does not change!

Let's apply this reasoning to the Phillips curve: $\Pi_t = \Pi_{t-1} + \alpha(Y_t - Y^n)$

We can use: $\Pi_t = \Pi_{t-1} = \Pi^*$ and $Y_t = Y_{t+1} = Y_{t+2} = Y^*$, plug that into the Phillips curve

What we get is: $\Pi^* = \Pi^* + \alpha(Y^* - Y^n)$ and we can simplify that

and obtain:

$$Y^* = Y^n$$

So we have our first solution.

Let's use the solution for output $Y^* = Y^n$ to derive the other solutions

First we can formulate the IS curve with equilibrium values:

$Y^* = A - cr^*$

and we know already that $Y^* = Y^n$ and thus our IS curve becomes:

$Y^e = A - cr^*$ which we can use to express r^* as

$r^* = \frac{A - Y^n}{c}$

So we have the second solution: $r^* = \frac{A - Y^n}{c}$

Now we can make use of the second solution $r^* = \frac{A-Y^n}{c}$ and $\Pi_t = \Pi_{t+1} = \Pi^*$ and plug them into the monetary policy rule:

$r^* = r^n + \frac{\alpha\beta}{c}(\Pi^* - \Pi^T)$

$\frac{A-Y^n}{c} = r^n + \frac{\alpha\beta}{c}(\Pi^* - \Pi^T)$ which we can simplify to:

$$\Pi^* = \frac{c}{\alpha\beta}\left(\frac{A-Y^n}{c} - r^n\right) + \Pi^T$$

which is our third and final solution.

Now we know that in the closed economy baseline model in equilibrium the three endogenous variables take on the following values:

- $Y^* = Y^n$
- $r^* = \frac{A - Y^n}{c}$
- $\Pi^* = \frac{c}{\alpha\beta}\left(\frac{A-Y^n}{c} - r^n\right) + \Pi^T$

Each equilibrium value is equal to an expression consisting only of exogenous variables (Y^n, Π^T, r^n) or exogenous parameters (A, c, α, β) or both.

Only if we assume that the central bank is fully rational and can always correctly set $r^n = \frac{A-Y^n}{c} = r^*$ will it be able to hit its inflation target.
Because if $r^n = \frac{A-Y^n}{c} = r^*$ then $\Pi^* = \frac{c}{\alpha\beta}\left(\frac{A-Y^n}{c} - \frac{A-Y^n}{c}\right) + \Pi^T = \Pi^T$

Appendix

The PK baseline model

Solving the model I

- We have a system of three equations. How do we solve systems of equations?
- We will eliminate variables from the system by substitution.
- We start by substituting the IS curve ($Y_t = A - cr_{t-1}$) into the Phillips curve $\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(Y_t - Y_{t-1})$ twice:
- once for Y_t and once for T_{t-1}, pay attention to the shift in the time subscript!

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} + \alpha(A - cr_{t-1} - A + cr_{t-2})$$

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha c(r_{t-1} - r_{t-2})$$

- We have successfully eliminated Y. Now let's plug in the monetary policy rule $r_t = r_0 + \frac{\alpha\beta}{c}\left(\Pi_{t+1} - \Pi^T\right)$ into this equation: again, twice!

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha c(r_0 + \frac{\alpha\beta}{c}\left(\Pi_t - \Pi^T\right) - r_0 - \frac{\alpha\beta}{c}\left(\Pi_{t-1} - \Pi^T\right))$$

Solving the model II

- Let's simplify:

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha c (r_0 + \frac{\alpha\beta}{c}\left(\Pi_t - \Pi^T\right) - r_0 - \frac{\alpha\beta}{c}\left(\Pi_{t-1} - \Pi^T\right))$$

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha^2 \beta (\left(\Pi_t - \Pi^T\right) - \left(\Pi_{t-1} - \Pi^T\right))$$

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha^2 \beta \left(\Pi_t - \Pi_{t-1}\right)$$

- This is a first order linear difference equation. Let's find the particular solution first!
- So we use the characteristic of an equilibrium that in equilibrium the variable does not change anymore

Solving the model III

- So we use the characteristic of an equilibrium that in equilibrium the variable does not change anymore

- Let's use $\Pi^* = k$ as our trial solution and plug it in:

$$\Pi_t = \gamma_0 + \gamma_1 \Pi_{t-1} - \alpha^2 \beta \left(\Pi_t - \Pi_{t-1}\right)$$

$$k = \gamma_0 + \gamma_1 k - \alpha^2 \beta \left(k - k\right)$$

$$k = \gamma_0 + \gamma_1 k$$

$$\Pi^* = k = \frac{\gamma_0}{1 - \gamma_1}$$

- This is the particular solution (equilibrium) for inflation

- Let's use it to find equilibrium output (Y^*) and the equilibrium real interest rate (r^*)

Solving the model IV

$$\Pi^* = \frac{\gamma_0}{1-\gamma_1}$$

- We will exploit the fact that in equilibrium (i.e. all variables are in equilibrium) all three equations still need to hold:

$$r_t = r_0 + \frac{\alpha\beta}{c}\left(\Pi_{t+1} - \Pi^T\right)$$

$$r^* = r_0 + \frac{\alpha\beta}{c}\left(\Pi^* - \Pi^T\right)$$

$$r^* = r_0 + \frac{\alpha\beta}{c}\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$$

- That is our equilibrium real interest rate

Solving the model V

- The last step is to use the equilibrium real interest rate in the IS curve:

$$Y_t = A - cr_{t-1}$$

$$Y^* = A - cr^*$$

$$Y^* = A - cr_0 - c\frac{\alpha\beta}{c}\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$$

$$Y^* = A - cr_0 - \alpha\beta\left(\frac{\gamma_0}{1-\gamma_1} - \Pi^T\right)$$

- That is our equilibrium output