The New Keynesian Model
ECON 30020: Intermediate Macroeconomics

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Readings

GLS Ch. 24 (the demand side)

GLS Ch. 25 (the supply side)

GLS Ch. 26 (effects of shocks)

New Keynesian Models

At risk of oversimplification, New Keynesian models are the leading alternative to the neoclassical / RBC model

"New" Keynesian: neoclassical backbone to these models. Just a twist on neoclassical model, not a fundamentally different framework

In the "medium run"/"long run" models are the same

Short-run difference: nominal rigidities. Wages and/or prices are imperfectly flexible. These frictions not operative over longer periods

New Keynesian Implications

1. Money is non-neutral

2. Demand shocks matter for output

3. Equilibrium of the model is inefficient

4. There is therefore scope for policy to improve outcomes in short run

Demand and Supply

The demand side of the neoclassical and New Keynesian models are the <u>same</u>

Differences arise on the supply side

Two basic variants (or mixture of the two):

- ▶ price stickiness
- ▶ nominal wage stickiness (GLS Appendix D)

This will require some change in the labor market – either the firm (price stickiness) or household (wage stickiness) is off its demand or supply schedule

We will focus on two versions of the sticky price model in class – the "Simple" sticky price model and "Partial" sticky price model

Review: Neoclassical Model

$$C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$$

$$N_t = N^s(w_t, \theta_t)$$

$$N_t = N^d(w_t, A_t, K_t)$$

$$I_t = I^d(r_t, A_{t+1}, f_t, K_t)$$

$$Y_t = A_t F(K_t, N_t)$$

$$Y_t = C_t + I_t + G_t$$

$$M_t = P_t M^d(i_t, Y_t)$$

$$r_t = i_t - \pi_{t+1}^e$$

New Keynesian Model: Simple Sticky Price Model

$P_t = \bar{P}_t$ is now <u>exogenous</u>, rather than endogenous

Extreme form of price stickiness: price level completely pre-determined

Replace labor demand curve with $P_t = \bar{P}_t$

Firm has to hire labor to meet demand at $\bar{P}_t$ rather than to maximize its value

New Keynesian Model: Partial Sticky Price Model

$P_t = \bar{P}_t + \gamma(Y_t - Y_t^f)$

$\bar{P}_t$ is again the exogenous component of the price level

$\gamma \geq 0$ a parameter. Y_t^f the <u>hypothetical</u> equilibrium level of output in neoclassical model

Nests simple sticky price model ($\gamma = 0$) and neoclassical model ($\gamma \to \infty$)

In terms of equations, replace labor demand curve with this modified expression for the price level

Simple Sticky Price Model

$$C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$$

$$N_t = N^s(w_t, \theta_t)$$

$$P_t = \bar{P}_t$$

$$I_t = I^d(r_t, A_{t+1}, f_t, K_t)$$

$$Y_t = A_t F(K_t, N_t)$$

$$Y_t = C_t + I_t + G_t$$

$$M_t = P_t M^d(i_t, Y_t)$$

$$r_t = i_t - \pi_{t+1}^e$$

Only <u>one</u> equation different from neoclassical model – swap labor demand for $P_t = \bar{P}_t$

Partial Sticky Price Model

$$C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$$

$$N_t = N^s(w_t, \theta_t)$$

$$P_t = \bar{P}_t + \gamma(Y_t - Y_t^f)$$

$$I_t = I^d(r_t, A_{t+1}, f_t, K_t)$$

$$Y_t = A_t F(K_t, N_t)$$

$$Y_t = C_t + I_t + G_t$$

$$M_t = P_t M^d(i_t, Y_t)$$

$$r_t = i_t - \pi_{t+1}^e$$

Again, swap labor demand with expression for P_t

Can think of Y_t^f as exogenous with respect to these equations – it is solution to the six real-side equations in neoclassical model

Graphing the Equilibrium

We will use the $\underline{AD}$ (aggregate demand) and $\underline{AS}$ (aggregate supply) curves to summarize the equilibrium

AD: set of (P_t, Y_t) pairs consistent with the following conditions holding:

$$C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$$
$$I_t = I^d(r_t, A_{t+1}, f_t, K_t)$$
$$Y_t = C_t + I_t + G_t$$
$$M_t = P_t M^d(i_t, Y_t)$$
$$r_t = i_t - \pi^e_{t+1}$$

AD: Real + Nominal

AD curve summarizes <u>both</u> real demand and nominal demand

▶ Real: consumption demand, investment demand, resource constraint (IS curve)

▶ Nominal: money demand and Fisher relationships (LM curve)

Classical dichotomy will no longer hold, so cannot separately analyze real and nominal sides of the economy

Nevertheless, could define and use the AD curve in the neoclassical model
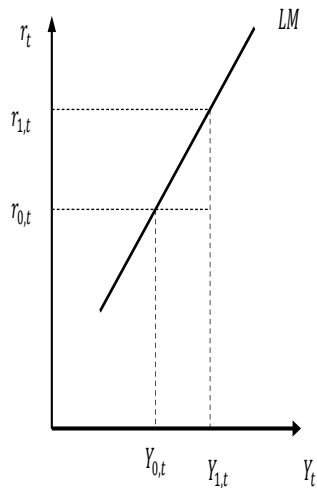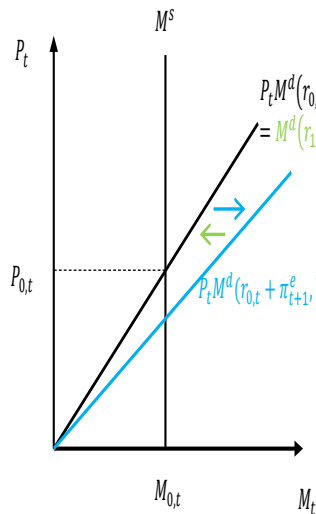
The IS and LM Curves

The IS curve is <u>identical</u> to before: set of (r_t, Y_t) pairs where the first three of the conditions hold

LM curve (liquidity = money): plots combinations of (r_t, Y_t) where last two equations hold. Combination of (r_t, Y_t) where money market clears

LM curve is upward-sloping in (r_t, Y_t) space. Basic idea: holding M_t and P_t fixed, if r_t goes up, Y_t must go up for money demand to equal money supply

LM curve will shift if M_t, P_t, or π_{t+1}^e change Rule of thumb: LM curve shifts <u>in the same direction as real balances</u>, $\frac{M_t}{P_t}$

Deriving the LM Curve

Left panel: axes P_t (vertical) and M_t (horizontal), with vertical line M^s at $M_{0,t}$.

$$P_t M^d\big(r_{0,t} + \pi^e_{t+1}, Y_{0,t}\big)$$
$$= M^d\big(r_{1,t} + \pi^e_{t+1}, Y_{1,t}\big)$$

$$P_t M^d\big(r_{0,t} + \pi^e_{t+1}, Y_{1,t}\big)$$

$P_{0,t}$

Right panel: axes r_t (vertical) and Y_t (horizontal), with upward-sloping line LM.

$r_{1,t}$, $r_{0,t}$, $Y_{0,t}$, $Y_{1,t}$

The AD Curve

The AD curve is the set of (P_t, Y_t) pairs where the economy is on both the IS and LM curves

Basic idea: P_t determines position of LM curve, which determines a Y_t where the LM curve intersects the IS curve

A higher P_t means the LM curve shifts in, which results in a lower Y_t

Hence, the AD curve is downward-sloping

Deriving the AD Curve
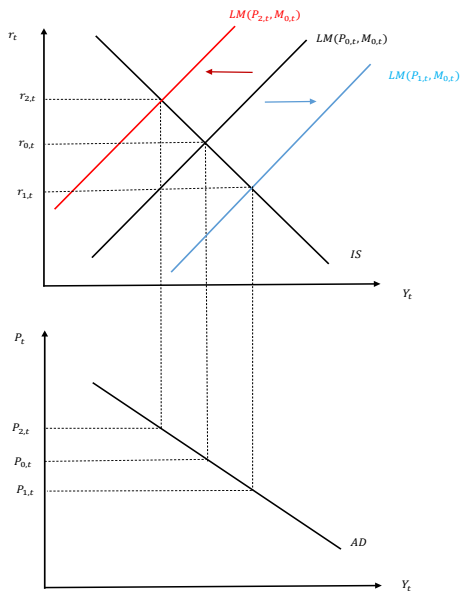
Shifts of the AD Curve

The AD curve will shift if <u>either</u> the IS or LM curves shift (for reason other than P_t, which would be a movement <u>along</u> the AD curve)

This means that the AD curve will shift right if:

▶ A_{t+1} or G_t increase (IS shifts)
▶ f_t or G_{t+1} decrease (IS shifts)
▶ M_t or π_{t+1}^e increase (LM shifts)

Note: we could use the AD curve to summarize the demand side of the neoclassical model as well

The Supply Side

Generically, the AS curve is the set of (P_t, Y_t) pairs (i) consistent with the production function, (ii) <u>some</u> notion of labor market equilibrium, and (iii) any exogenous restriction on nominal price or wage adjustment

Can use the AS curve to summarize the neoclassical model if we want:

$$N_t = N^s(w_t, \theta_t)$$
$$N_t = N^d(w_t, A_t, K_t)$$
$$Y_t = A_t F(K_t, N_t)$$

Since P_t does not appear in these equations, the AS curve would be vertical in the neoclassical model

The Neoclassical AS Curve
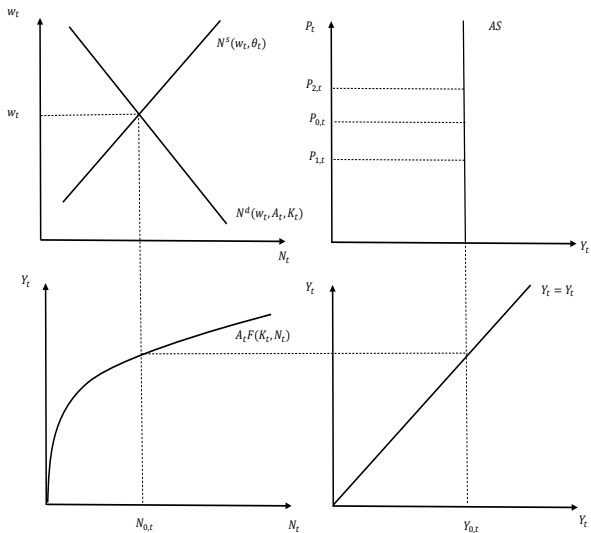
Neoclassical IS-LM-AD-AS Equilibrium
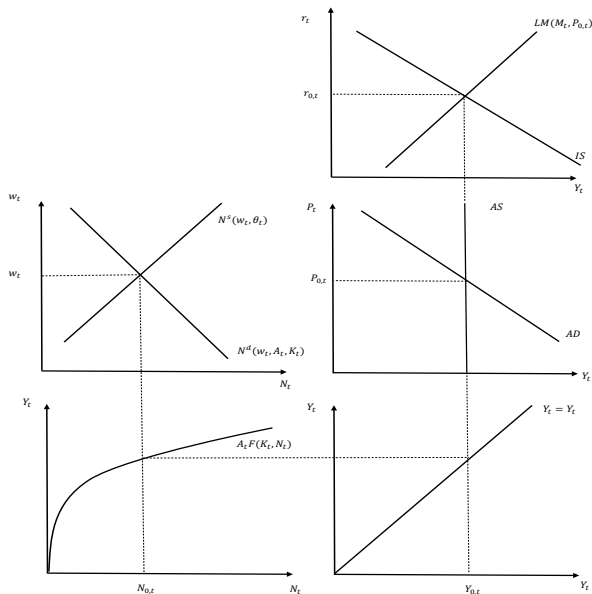
Simple Sticky Price Model

In simple sticky price model, assume that $P_t = \bar{P}_t$ is predetermined and hence exogenous

Replace labor demand with this condition: firm has to meet demand at P_t, cannot optimally choose labor conditional on this

Supply-side conditions:
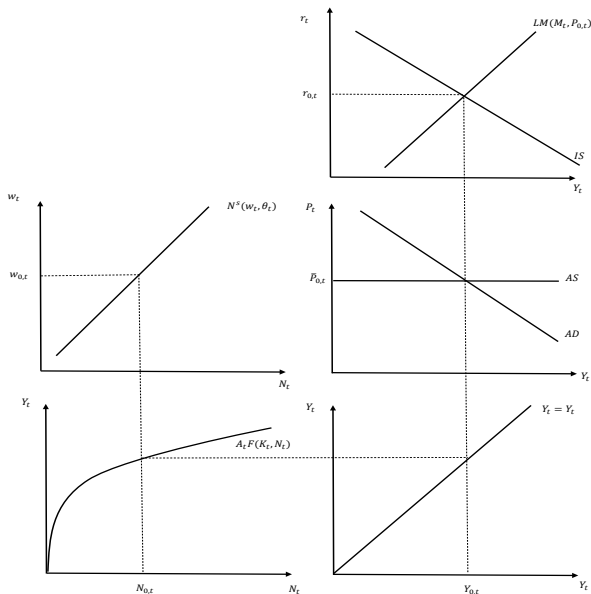
$$
\begin{aligned}
N_t &= N^s(w_t, \theta_t) \\
P_t &= \bar{P}_t \\
Y_t &= A_t F(K_t, N_t)
\end{aligned}
$$

The AS curve will just be horizontal at $\bar{P}_t$. Can only shift if $\bar{P}_t$ changes exogenously

The Simple Sticky Price AS Curve
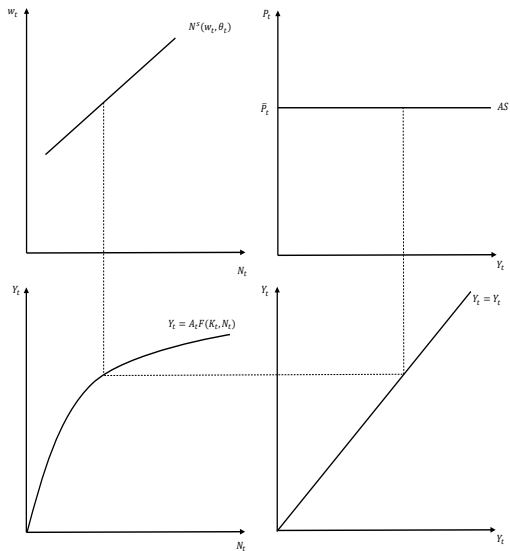
Simple Sticky Price IS-LM-AD-AS Equilibrium

Partial Sticky Price Model

In partial sticky price model, P_t is "partially" sticky but also depends on "output gap": $P_t = \bar{P}_t + \gamma(Y_t - Y_t^f)$

Replace labor demand with this condition: firm has to meet demand at P_t, cannot optimally choose labor conditional on this

Supply-side conditions:

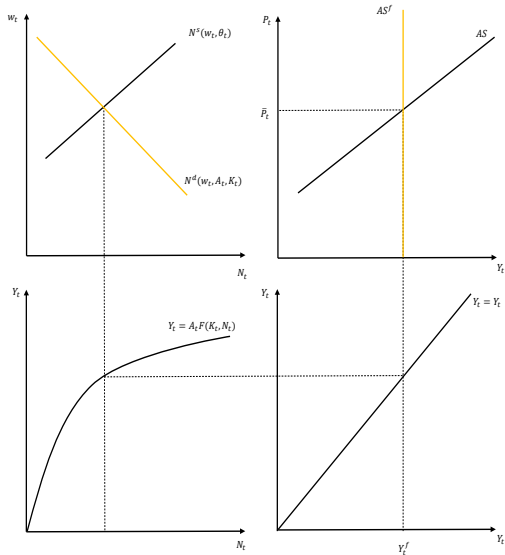$$N_t = N^s(w_t, \theta_t)$$
$$P_t = \bar{P}_t + \gamma(Y_t - Y_t^f)$$
$$Y_t = A_t F(K_t, N_t)$$

The AS curve will be upward-sloping, with slope determined by γ

Crosses point $P_t = \bar{P}_t$ at $Y_t = Y_t^f$, where Y_t^f can graphically be found where labor supply intersects hypothetical labor demand

AS^f: hypothetical neoclassical AS curve (sometimes called LRAS)

The Partial Sticky Price AS Curve

Partial Sticky Price IS-LM-AD-AS Equilibrium
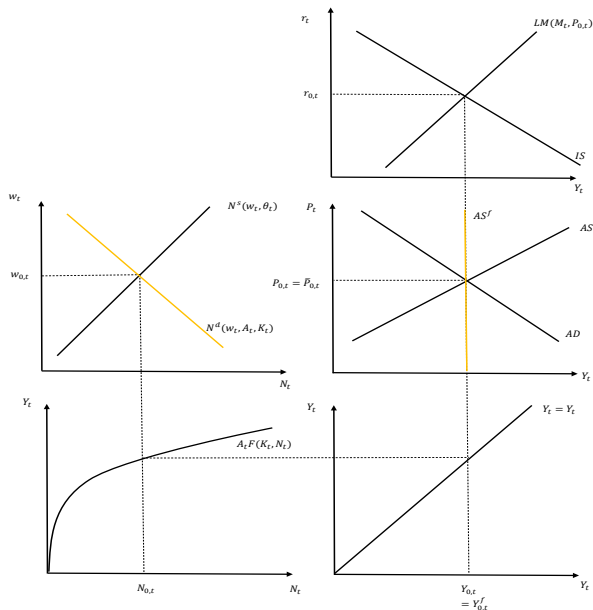
Monetary Non-Neutrality

Whereas in the neoclassical model Y_t is <u>supply-determined</u>, in the New Keynesian model output is (fully or partially) <u>demand-determined</u>

First, figure out what Y_t is (where AD and AS intersect), and <u>then</u> figure out what N_t must be to support that

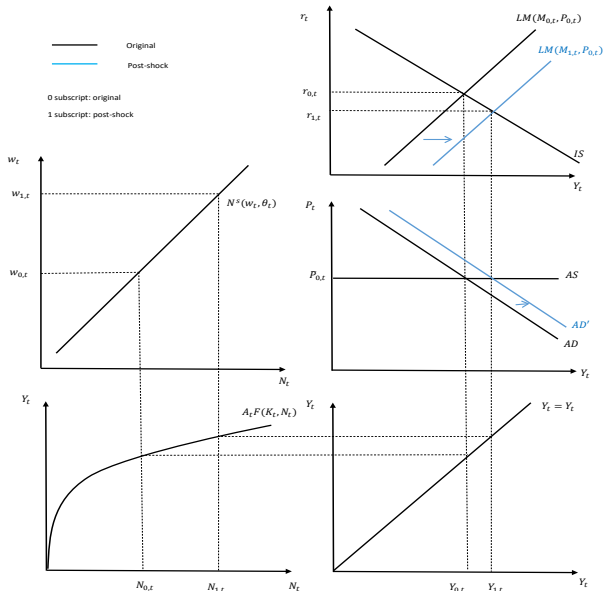An increase in M_t shifts the LM curve to the right, and hence the AD curve to the right as well

With a non-vertical AS curve, this results in a higher Y_t and lower r_t

The lower r_t stimulates I_t; lower r_t plus higher Y_t means C_t is higher

To support higher Y_t, N_t must rise

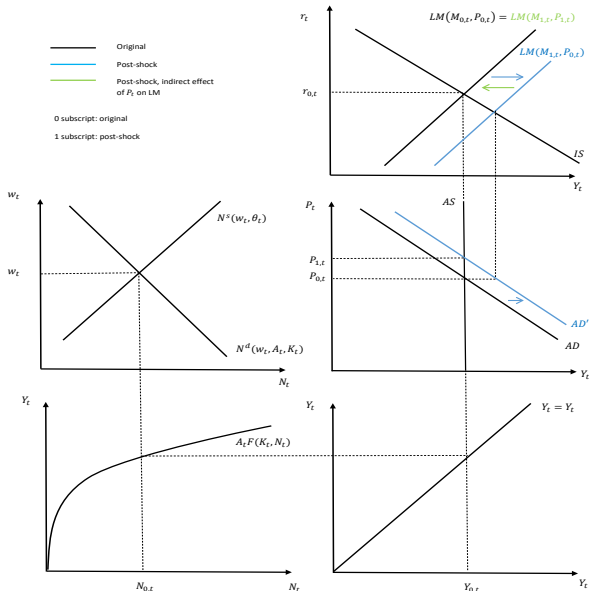To induce household to work more, w_t must rise

Increase in M_t: Graphically in Simple Sticky Price Model

Increase in M_t: Graphically in Partial Sticky Price Model

Increase in M_t: Graphically in Neoclassical Model

Original

Post-shock

Post-shock, indirect effect of P_t on LM

0 subscript: original

1 subscript: post-shock

r_t

$LM(M_{0,t}, P_{0,t}) = LM(M_{1,t}, P_{1,t})$

$LM(M_{1,t}, P_{0,t})$

$r_{0,t}$

IS

Y_t

w_t

$N^s(w_t, \theta_t)$

w_t

$N^d(w_t, A_t, K_t)$

N_t

P_t

AS

$P_{1,t}$
$P_{0,t}$

AD'

AD

Y_t

Y_t

$A_t F(K_t, N_t)$

$N_{0,t}$

N_t

Y_t

$Y_t = Y_t$

$Y_{0,t}$

Y_t
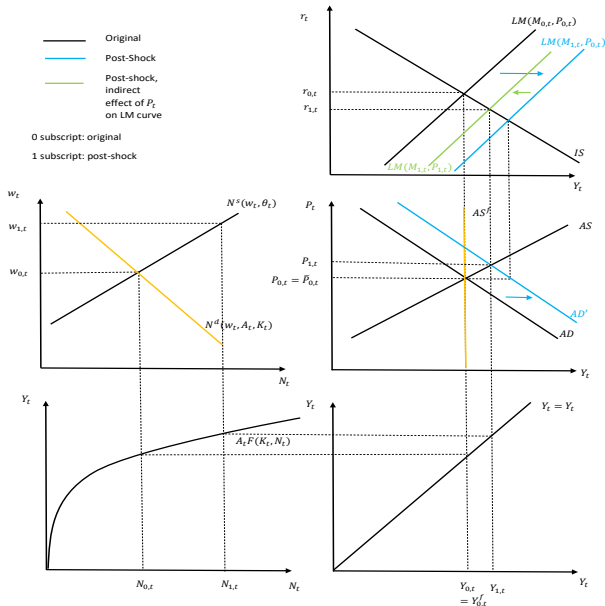
Monetary Non-Neutrality: Simple Intuition

When M_t goes up, holding everything else fixed, households would like to buy more stuff

If price of stuff can't adjust, they will buy more stuff

If price of stuff can adjust, they won't buy more stuff

Some form of nominal rigidity is key to getting changes in money to have real effects

Example: Daylight Savings Time

▶ Doesn't actually change amount of sunlight
▶ But if we don't adjust the time school/work starts, changing the clocks means it is darker (or lighter) when we go in
▶ This can have real effects, at least for a while

Monetary Non-Neutrality: In the Model

A change in the money supply affects real variables in New Keynesian model

Has bigger effect on real variables the flatter is the AS curve (i.e. the smaller is γ)

Nests two cases: $\gamma = 0$ simply sticky price, $\gamma \to \infty$ is neoclassical (where money is neutral)

Intuition: if P_t is imperfectly flexible, then changes in M_t must cause real balances, $\frac{M_t}{P_t}$, to change

But for money market to clear, this requires changes in r_t and Y_t

Amount r_t and Y_t must change depends on how much real balances move, which depends on how sticky P_t is

Supply Shocks

Supply shocks (A_t, θ_t, or K_t) cause the AS curve to shift

General rule of thumb: if price level is sticky (so AS curve is non-vertical), output reacts <u>less</u> to supply shocks than if prices were flexible

Extent to which it reacts less depends upon slope of AS curve (value of γ)

Increase in A_t: Graphically in Neoclassical Model
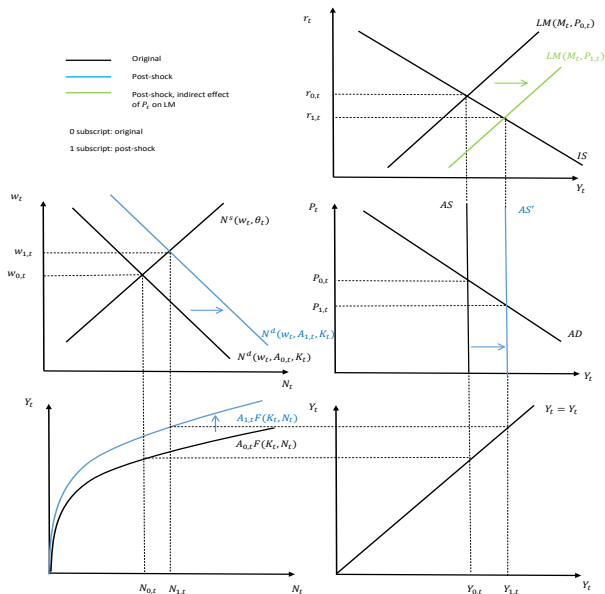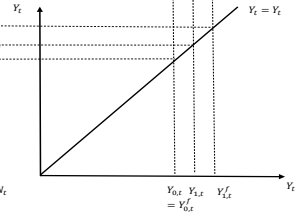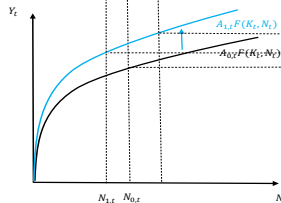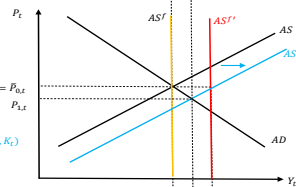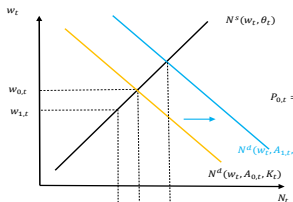
Increase in A_t: Simple Sticky Price Model
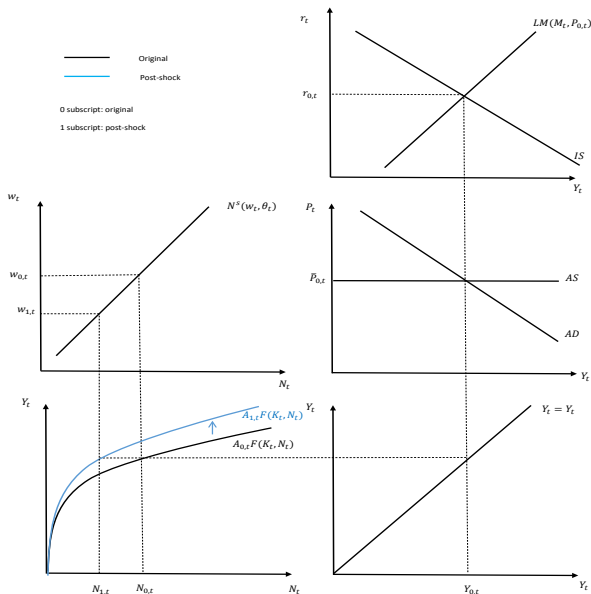
Increase in A_t: Partial Sticky Price Model
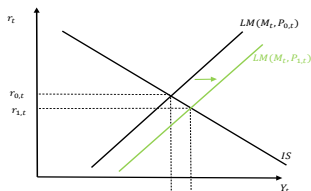
# Economy Reacts Differently to Supply Shocks

Output (and other real variables) <u>under-react</u> to supply shock the stickier are prices (i.e. the flatter is the AS curve)

In extreme case, output doesn't react at all to productivity shock (simple sticky price model), so N_t falls. In partial sticky price model, effect of A_t on N_t is ambiguous
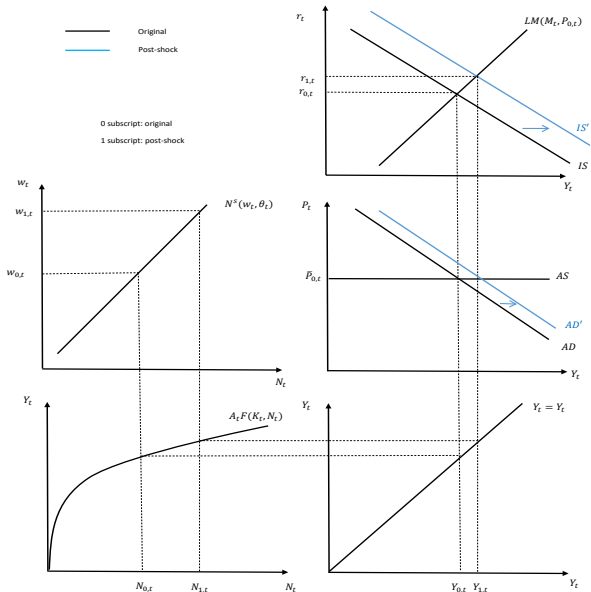
Intuition: to get people to buy more stuff, the price level must fall. But if it can't fall, they won't buy more stuff

In terms of the money market: to clear (i.e. to be on LM curve), $\frac{M_t}{P_t}$ must fall. But if P_t is restricted in how much it can fall, r_t and Y_t must react less than if P_t were flexible
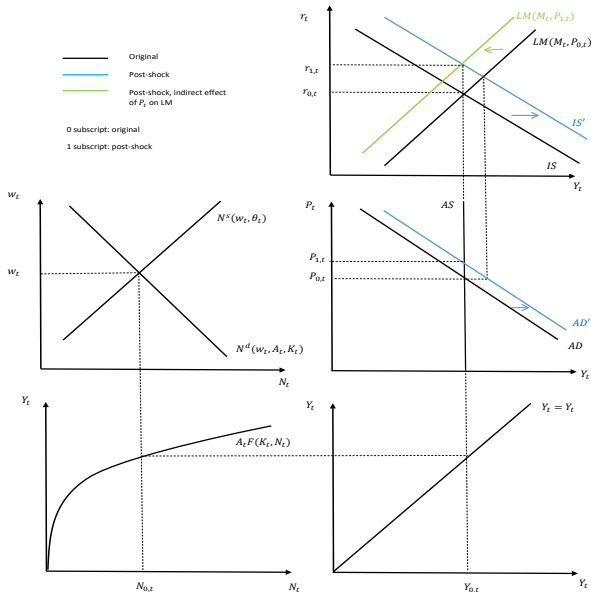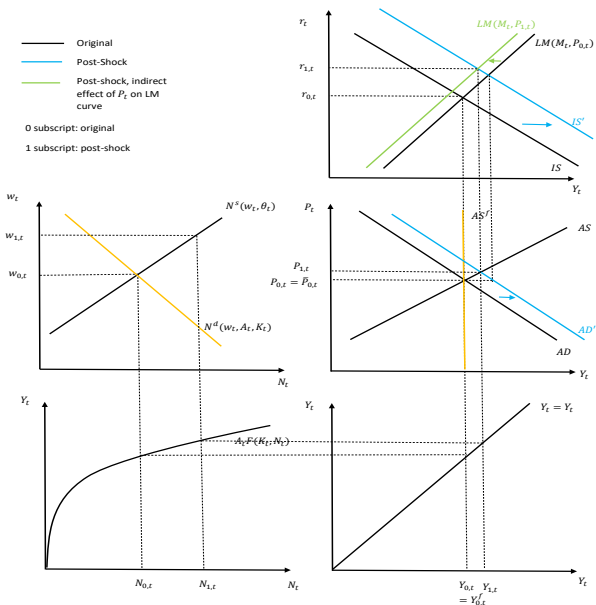
Positive *IS* Shock: Simple Sticky Price Model

Positive *IS* Shock: Partial Sticky Price Model

Demand Shocks Matter

Output reacts to *IS* shocks, the more so the flatter is the *AS* curve

In contrast, r_t under-reacts relative to neoclassical case

Intuition: after an IS shock, people want to buy more stuff. In the neoclassical model, P_t would rise to offset this. But if it can't rise, people will end up buying more stuff – demand matters

Money market intuition. $\frac{M_t}{P_t}$ needs to fall and r_t to rise to implement neoclassical equilibrium after a positive *IS* shock (e.g. increase in A_{t+1} or decrease in f_t)

But if P_t can't fall, r_t can't rise as much and Y_t must rise for money market to clear

Conclusion

The New Keynesian model is the same as the neoclassical model except P_t is not perfectly flexible

Means AS is non-vertical and not on labor demand curve

Money is non-neutral, demand shocks matter, and economy reacts differently to supply shocks

Coming agenda:

1. Think about dynamics – how does P_t adjust so as to converge to neoclassical equilibrium as economy transitions from short run to medium run?

2. Think about policy – if Y_t^f is efficient, no guarantee that $Y_t = Y_t^f$. Scope for policy

3. Think about constraints on policy – the zero lower bound (ZLB) on nominal interest rate

Some Extensions

Sticky wages instead of sticky prices (GLS Appendix D)

- ▶ Similar in terms of AS curve
- ▶ But different implications for labor market – off the labor supply curve, not off the labor demand curve

MP curve instead of LM curve (GLS Appendix E)

- ▶ No need to reference money at all
- ▶ Central bank / government sets nominal interest rate according to some rule
- ▶ Has inflation rate, π_t, instead of price level, P_t, on vertical axis in AD-AS diagram