

# The New Keynesian Model

## ECON 30020: Intermediate Macroeconomics

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# Readings

- ▶ GLS Ch. 21 (the demand side)
- ▶ GLS Ch. 22 (the supply side)
- ▶ GLS Ch. 23 (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
- ▶ Basic difference: nominal rigidities. Wages and/or prices are imperfectly flexible
- ▶ Means:
  1. Money is non-neutral
  2. Demand shocks matter
  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 same
- ▶ Differences arise on the supply side
- ▶ Two basic variants (or mixture of the two): price stickiness or nominal wage stickiness
- ▶ This will require some change in the labor market – either the firm (price stickiness) or household (wage stickiness) is off its supply or demand 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

- ▶ Equilibrium conditions:

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

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

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

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

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

$$Y_t = C_t + I_t + G_t$$

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

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

- ▶  $P_t$  is endogenous

# New Keynesian Model

- ▶ Simple sticky price model:
  - ▶  $P_t = \bar{P}_t$  is now exogenous, rather than endogenous
  - ▶ Extreme form of price stickiness: price level completely pre-determined
  - ▶ Replace labor demand curve with  $P_t = \bar{P}_t$ . Firm (which sets price), has to hire labor to meet demand at  $\bar{P}_t$  rather than to maximize its value
- ▶ 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 hypothetical equilibrium level of output in neoclassical model.
  - ▶ Nests simple sticky price model ( $\gamma = 0$ ) and neoclassical model ( $\gamma \rightarrow \infty$ )
  - ▶ Again replace labor demand curve with this modified expression for the price level

## Simple Sticky Price Model

- ▶ Equilibrium conditions:

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

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

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

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

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

$$Y_t = C_t + I_t + G_t$$

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

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

- ▶  $\bar{P}_t$  is exogenous
- ▶ Only *one* equation different from neoclassical model!

# Partial Sticky Price Model

- ▶ Equilibrium conditions:

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

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

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

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

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

$$Y_t = C_t + I_t + G_t$$

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

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

- ▶  $\bar{P}_t$  is exogenous
- ▶ Can think of  $Y_t^f$  as exogenous with respect to these equations
  - it is solution to the eight equations when we are on the labor demand curve in neoclassical model



## Graphing the Equilibrium

- ▶ We will use the AD (aggregate demand) and AS (aggregate supply) curves to summarize the equilibrium
- ▶ AD: stands for aggregate demand. Set of  $(P_t, Y_t)$  pairs consistent with the following conditions:

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

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

$$Y_t = C_t + I_t + G_t$$

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

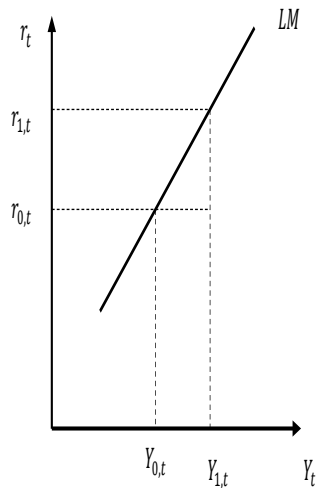
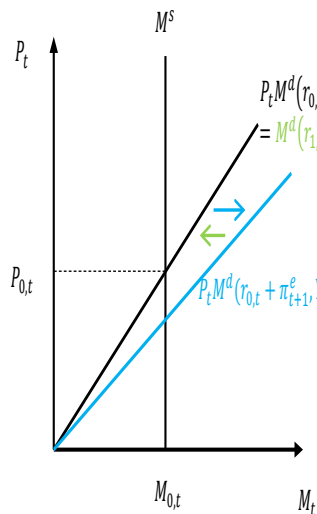
$$r_t = i_t - \pi_{t+1}^e$$

- ▶ Differently than before, AD curve summarizes *both* real demand (the first three equations, the *IS* curve) and nominal demand (the last two, what will be the *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 *identical* 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
- ▶ Go through graphical derivation
- ▶ LM curve will shift if  $M_t$ ,  $P_t$ , or  $\pi_{t+1}^e$  change
- ▶ Rule of thumb: LM curve shifts in the same direction as real balances,  $\frac{M_t}{P_t}$

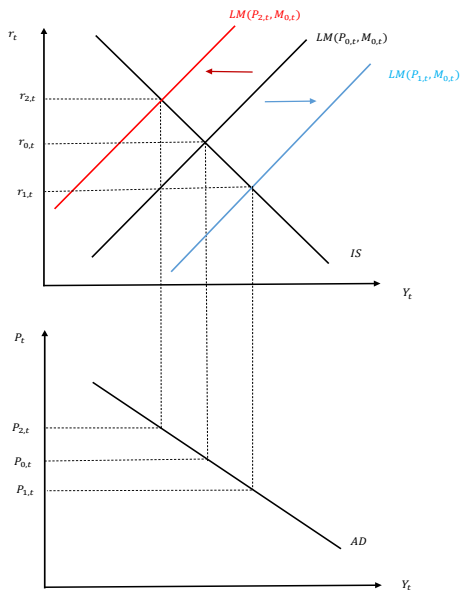
# Deriving the LM Curve



# 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
- ▶ Go through graphical derivation

# Deriving the AD Curve



## Shifts of the AD Curve

- ▶ The AD curve will shift if *either* the IS or LM curves shift (for reason other than  $P_t$ )
- ▶ This means that the AD curve will shift right if:
  - ▶  $A_{t+1}$  or  $G_t$  increase (IS shifts);  $M_t$  or  $\pi_{t+1}^e$  increase (LM shifts)
  - ▶  $f_t$  or  $G_{t+1}$  decrease (IS shifts)
- ▶ Note: we could use the AD curve to summarize the demand side of the neoclassical model as well
- ▶ Was just convenient to not since this emphasized classical dichotomy in the neoclassical model

# The Supply Side

- ▶ Generically, the AS curve is the set of  $(P_t, Y_t)$  pairs (i) consistent with the production function, (ii) *some* 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 as well as the New Keynesian model:

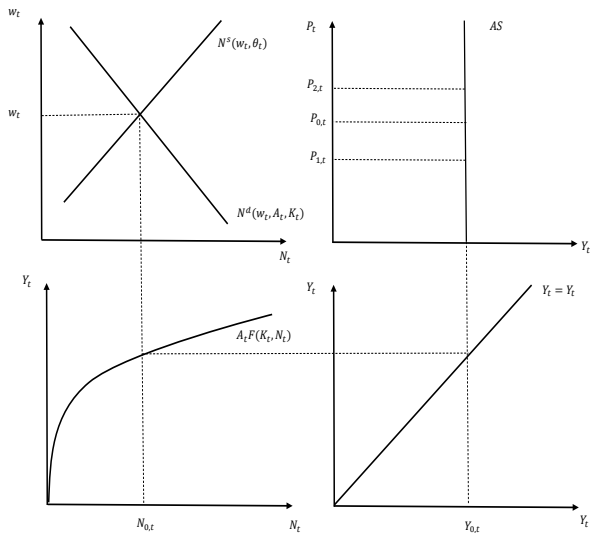
$$N_t = N^s(w_t, \theta_t)$$

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

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

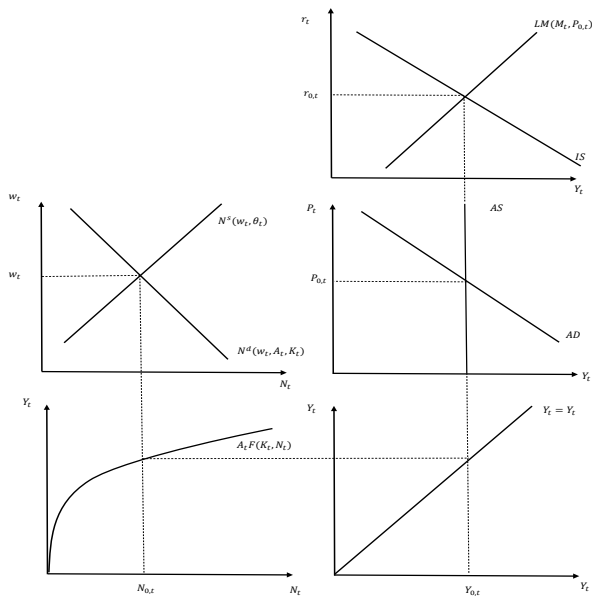
- ▶ Since  $P_t$  does not appear in these equations, the AS curve would be vertical in the neoclassical model

# 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 (think something like menu costs)
- ▶ Replace labor demand with this condition: firm has to meet demand at  $P_t$ , cannot optimally choose labor conditional on this
- ▶ Conditions:

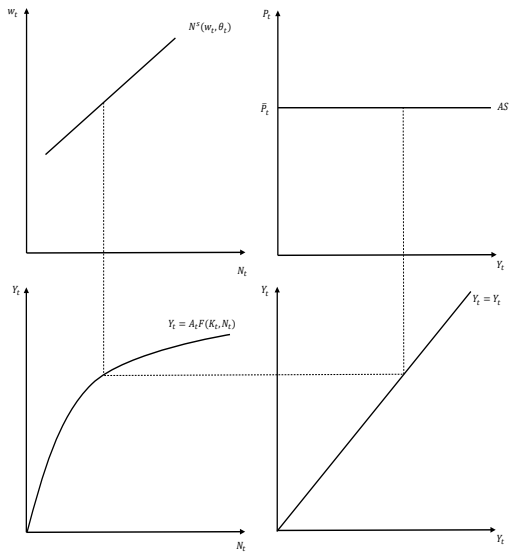
$$N_t = N^s(w_t, \theta_t)$$

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

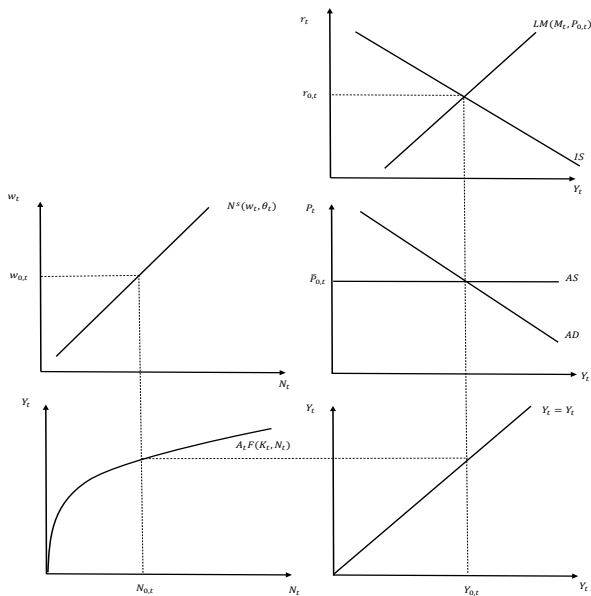
$$Y_t = A_t F(K_t, N_t)$$

- ▶ 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
- ▶ Conditions:

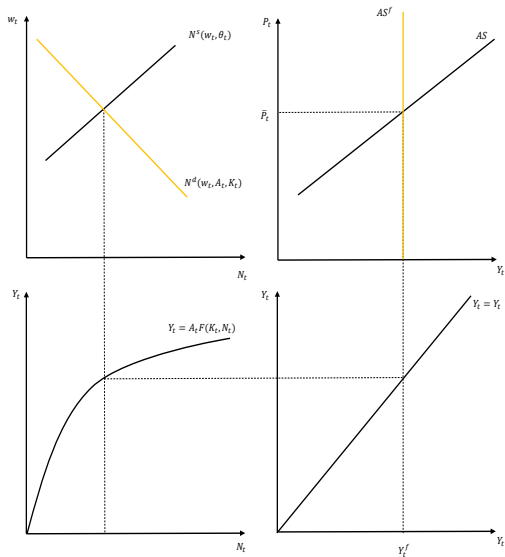
$$N_t = N^s(w_t, \theta_t)$$

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

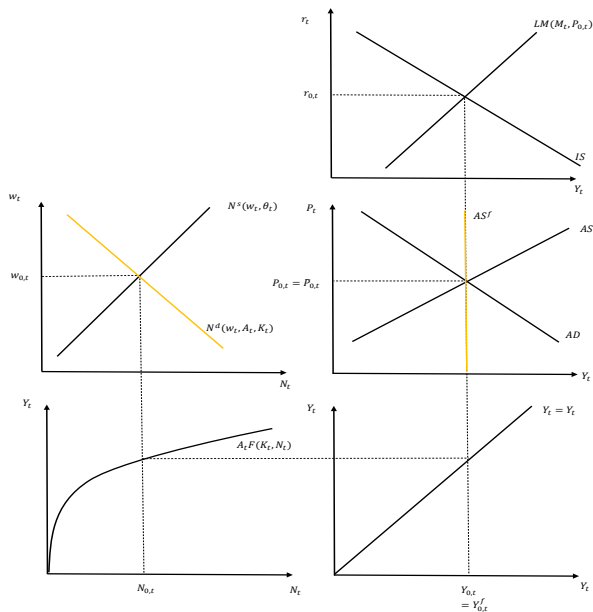
$$Y_t = A_t F(K_t, N_t)$$

- ▶ The AS curve will be upward-sloping with slope determined by  $\gamma$
- ▶ 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

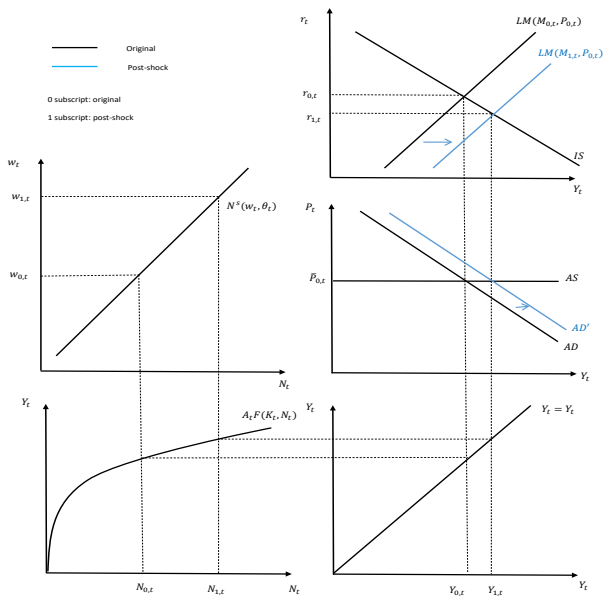


## Monetary Non-Neutrality

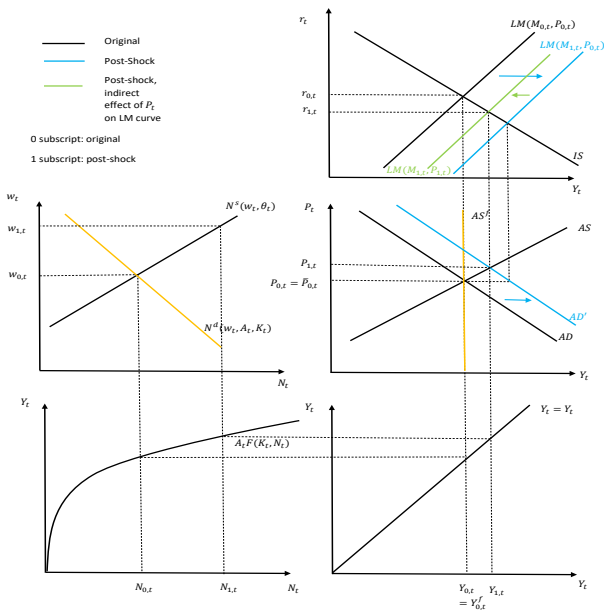
- ▶ Whereas in the neoclassical model  $Y_t$  is *supply determined*, in the New Keynesian model output is (fully or partially) *demand determined*
- ▶ First, figure out what  $Y_t$  is (where AD and AS intersect), and then figure out what  $N_t$  must be to support that
- ▶ An increase in  $M_t$  shifts 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



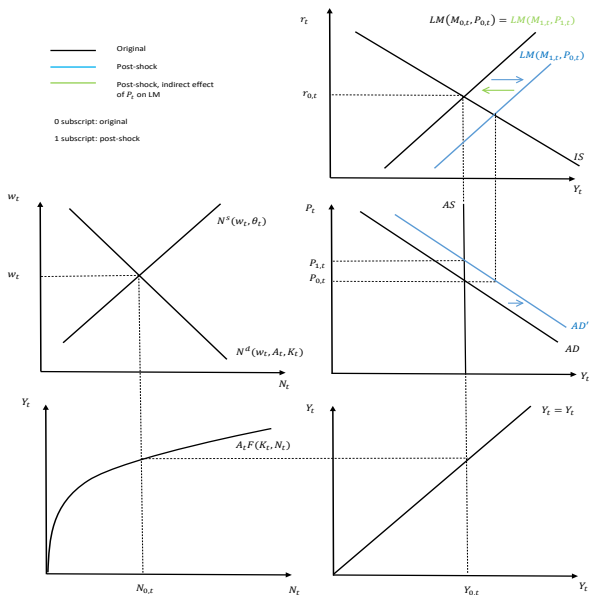
# Increase in $M_t$ : Graphically in Simple Sticky Price Model



# Increase in $M_t$ : Graphically in Partial Sticky Price Model



# Increase in $M_t$ : Graphically in Neoclassical Model



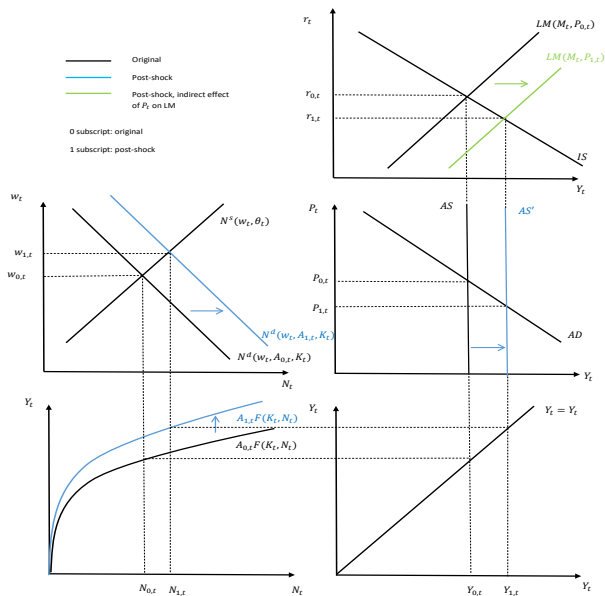
# Monetary Non-Neutrality

- ▶ 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  $\gamma$ )
- ▶ Nests two cases:  $\gamma = 0$  simply sticky price,  $\gamma \rightarrow \infty$  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

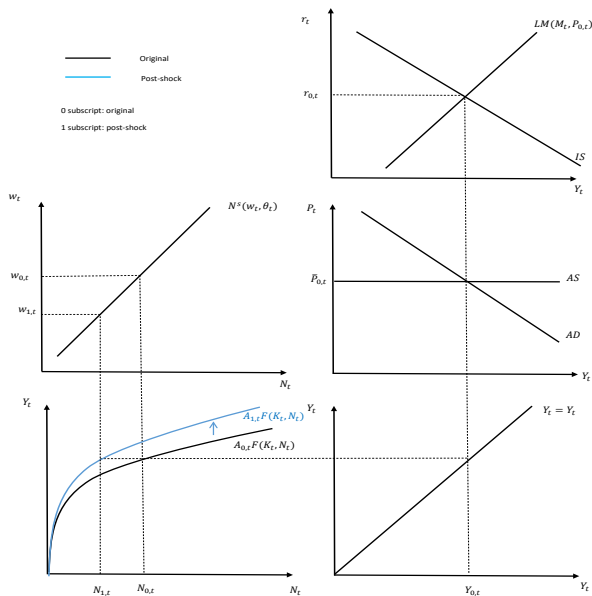
# Supply Shocks

- ▶ Supply shocks ( $A_t$ ,  $\theta_t$ , 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 *less* to supply shocks
- ▶ Extent to which it reacts less depends upon slope of AS curve

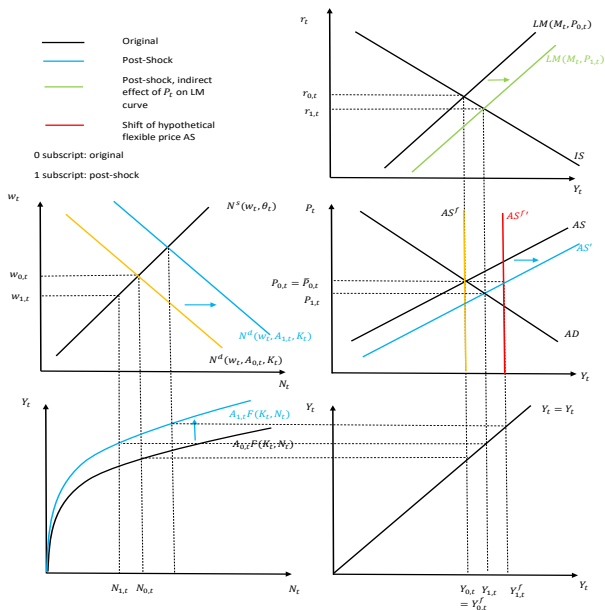
# Increase in $A_t$ : Graphically in Neoclassical Model



# Increase in $A_t$ : Simple Sticky Price Model



# Increase in $A_t$ : Partial Sticky Price Model

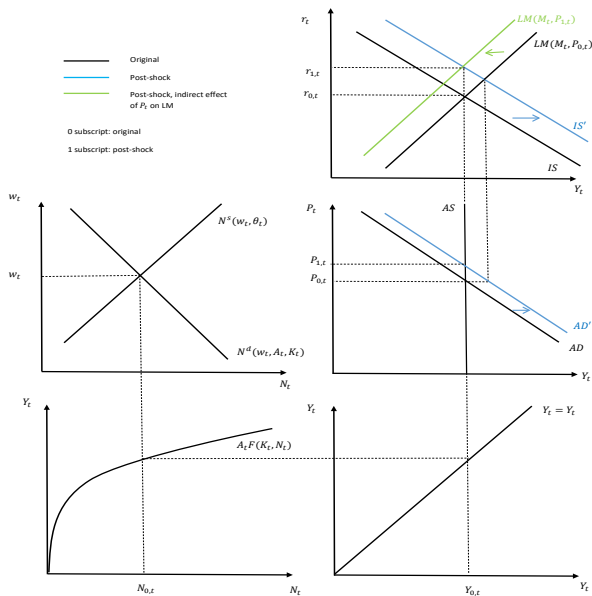




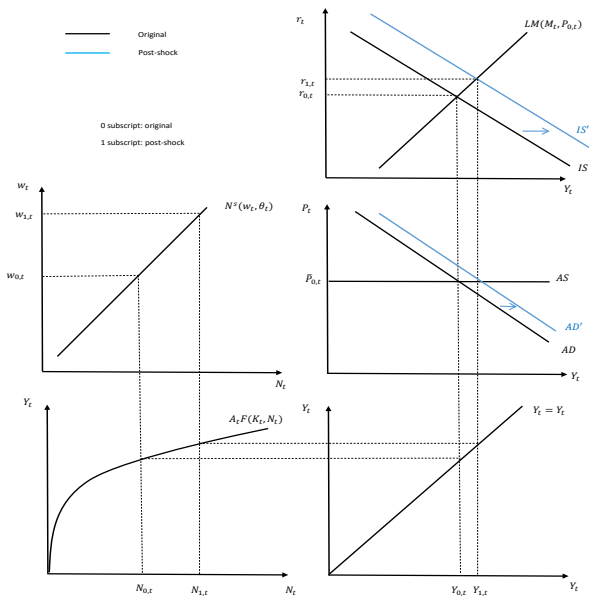
## Economy Reacts Differently to Supply Shocks

- ▶ Output (and other real variables) *under-react* to supply shock the stickier are prices (i.e. the flatter is the AS curve)
- ▶ In extreme case, output don't react at all to productivity shock (simple sticky price model), so  $N_t$  falls.
- ▶ Basic intuition: for 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

# Positive IS Shock: Graphically in Neoclassical Model

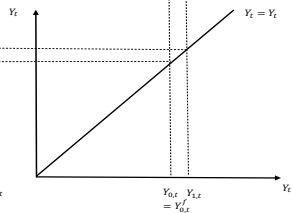
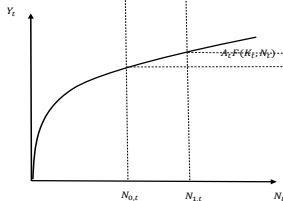
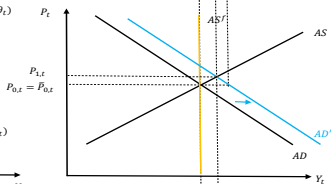
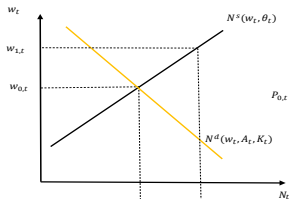
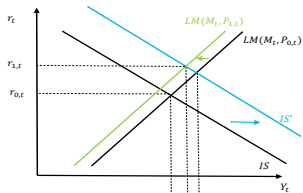


# Positive IS Shock: Simple Sticky Price Model



# Positive IS Shock: Partial Sticky Price Model

- Original
  - Post-Shock
  - Post-shock, indirect effect of  $P_t$  on LM curve
- 0 subscript: original  
1 subscript: post-shock



## 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.  $\frac{M_t}{P_t}$  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