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:

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

\[ N_t = N^s(w_t, \theta_t) \]

\[ N_t = N^d(w_t, A_t, K_t) \]

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

\[ Y_t = A_t F(K_t, N_t) \]

\[ Y_t = C_t + I_t + G_t \]

\[ M_t = P_t M^d(i_t, Y_t) \]

\[ r_t = i_t - \pi_t^{e} \]

- \( P_t \) 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:

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

\[ N_t = N^s(w_t, \theta_t) \]

\[ P_t = \bar{P}_t \]

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

\[ Y_t = A_tF(K_t, N_t) \]

\[ Y_t = C_t + I_t + G_t \]

\[ M_t = P_tM^d(i_t, Y_t) \]

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

▶ \( \bar{P}_t \) is exogenous

▶ Only one equation different from neoclassical model!
Partial Sticky Price Model

- Equilibrium conditions:

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

\[ N_t = N^s(w_t, \theta_t) \]

\[ P_t = \bar{P}_t + \gamma(Y_t - Y^f_t) \]

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

\[ Y_t = A_t F(K_t, N_t) \]

\[ Y_t = C_t + I_t + G_t \]

\[ M_t = P_t M^d(i_t, Y_t) \]

\[ r_t = i_t - \pi^e_{t+1} \]

- \( \bar{P}_t \) is exogenous
- Can think of \( Y^f_t \) 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:

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

\[
l_t = I^d(r_t, A_{t+1}, f_t, K_t)
\]

\[
Y_t = C_t + I_t + G_t
\]

\[
M_t = P_tM^d(i_t, Y_t)
\]

\[
r_t = i_t - \pi^e_{t+1}
\]

- 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

\[ P_t M^d(r_{0,t} + \pi_{t+1}^e, Y_{0,t}) = M^d(r_{1,t} + \pi_{t+1}^e, Y_{1,t}) \]

\[ P_t M^d(r_{0,t} + \pi_{t+1}^e, Y_{0,t}) \]
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.
- Go through graphical derivation.
Deriving the AD Curve

\[ Y_t \]

\[ P_t \]

\[ r_t \]

\[ IS \]

\[ LM(P_{0,t}, M_{0,t}) \]

\[ LM(P_{1,t}, M_{0,t}) \]

\[ LM(P_{2,t}, M_{0,t}) \]

\[ AD \]
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
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

\[ Y_t = Y_t \]

\[ w_t \]

\[ N^d(w_t, A_t, K_t) \]

\[ N^f(w_t, \theta_t) \]

\[ A_t F(K_t, N_t) \]

\[ P_t \]

\[ P_0, t \]

\[ P_1, t \]

\[ P_{2, t} \]

\[ N_0, t \]

\[ N_t \]

\[ Y_0, t \]

\[ Y_t \]
Neoclassical IS-LM-AD-AS Equilibrium

\[ w_t, \quad P_t, \quad Y_t, \quad N_t, \quad A_t, \quad K_t, \quad r_t \]

\[ LM(M_t, P_{0,t}) \]

\[ IS \]

\[ AD \]

\[ AS \]

\[ Y_t = Y_t \]

\[ N_{0_t}, \quad N_t, \quad Y_{0,t}, \quad Y_t \]
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

\[ Y_t = A_t F(K_t, N_t) \]

\[ N^*(w_t, \theta_t) \]
Simple Sticky Price IS-LM-AD-AS Equilibrium

\[\begin{align*}
\omega_t & \quad P_t \\
\gamma_t & \quad Y_t \quad Y_t
\end{align*}\]
Partial Sticky Price Model

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

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

► Conditions:

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

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

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

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

► Crosses point $P_t = \bar{P}_t$ at $Y_t = Y^f_t$, where $Y^f_t$ 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

Original
Post-shock

0 subscript: original
1 subscript: post-shock
Increase in $M_t$: Graphically in Partial Sticky Price Model

0 subscript: original
1 subscript: post-shock

$w_0, t = w_1, t$
$P_0, t = P_1, t$
$N^d(w_t, A_t, K_t)$
$N^s(w_t, \theta_t)$

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

$IS$
$AD'$
$AD$

$Y_{0,t} = Y_{1,t}$
$Y_t = Y_t$

$r_t$

$r_0, t$
$r_1, t$

$Y_t$
$N_t$
$P_t$
$w_t$
$N_0, t$
$N_1, t$
$N_t$
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
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, $\gamma \to \infty$ 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 ($A_t$, $\theta_t$, 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

- Original
- Post-shock
- Post-shock, indirect effect of $P_t$ on LM

0 subscript: original
1 subscript: post-shock

Original
Post-shock
Post-shock, indirect effect of $P_t$ on LM
Increase in $A_t$: Simple Sticky Price Model
Increase in $A_t$: Partial Sticky Price Model

0 subscript: original
1 subscript: post-shock

Original
Post-Shock
Post-shock, indirect effect of $P_t$ on LM curve
Shift of hypothetical flexible price AS

$\bar{r}_{0,t} = \bar{r}_{1,t}$

$N^d(w_t, \theta_t)$

$P_{0,t} = \bar{P}_{0,t}$

$P_{1,t}$

$LM(M_t, P_{0,t})$

$LM(M_t, P_{1,t})$

$IS$

$AS^f$

$AS'_{1,t}$

$AD$

$A_{1,t}^f(K_t, N_t)$

$A_{0,t}^f(K_t, N_t)$

$Y_t = Y_t$

$Y_{0,t} = Y_{0,t}'$

$Y_{1,t} = Y_{1,t}'$

$Y_{0,t}' = Y_{1,t}'$

$N_t$

$N_{0,t}$

$N_{1,t}$

$w_t$

$w_{0,t}$

$w_{1,t}$

$P_t$

$r_t$

$\frac{\partial}{\partial w_t} N^d(w_t, A_{0,t}, K_t)$

$\frac{\partial}{\partial P_t} N^d(w_t, A_{1,t}, K_t)$
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

- **Graph 1:** The original labor supply curve is labeled $N^s(w_t, \theta_t)$, and the post-shock labor supply curve is labeled $N^s(w_t, A_t, K_t)$. The labor demand curve is labeled $A_t F(K_t, N_t)$.

- **Graph 2:** The IS curve is labeled as $IS$, and the LM curve is labeled as $LM(M_t, P_{1,t})$ and $LM(M_t, P_{0,t})$. The original interest rate is $r_0$, and the post-shock interest rate is $r_1$.

- **Graph 3:** The original aggregate supply curve is labeled $AS$, and the post-shock aggregate supply curve is labeled $AD'$.
Positive IS Shock: Simple Sticky Price Model
Positive IS Shock: Partial Sticky Price Model

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.