The New Keynesian Model
ECON 30020: Intermediate Macroeconomics

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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): wage stickiness and/or price stickiness
- Mathematically, what we are going to assume is that either the nominal wage or price level are predetermined (i.e. exogenous)
- 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
- Because it works out to be a bit simpler, we will focus on the sticky price model in class, though book covers both
Review: Neoclassical Model:

- Equilibrium conditions:

\[
C_t = C^d(Y_t - G_t, Y_{t+1} - G_t, r_t)
\]
\[
N_t = N^s(w_t, \theta_t)
\]
\[
N_t = N^d(w_t, A_t, K_t)
\]
\[
I_t = I^d(r_t, A_{t+1}, q_t, K_t)
\]
\[
Y_t = A_t F(K_t, N_t)
\]
\[
Y_t = C_t + I_t + G_t
\]
\[
M_t = P_t M^d(i_t, Y_t)
\]
\[
r_t = i_t - \pi^e_{t+1}
\]

- \(P_t\) is endogenous
- Nominal wage, \(W_t\), is \(W_t = w_t P_t\), and is also therefore endogenous
New Keynesian Model

- **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

- **Sticky wage model:**
  - $W_t = \bar{W}_t$ is now exogenous, rather than endogenous
  - Extreme form of wage stickiness: wage set “in advance,” worker has to supply as much labor as is demanded at this wage
  - This means that we replace the labor supply curve with the condition $w_t = \bar{W}_t / P_t$
Graphing the Equilibrium

- We will use the AD (aggregate demand) and AS (aggregate supply) curves to summarize the equilibrium.
- AD: stands for aggregate demand. Summarizes the following conditions:

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

- Differently than before, AD curve summarizes both real demand (the first three equations) and nominal demand (the last two).
- Classical dichotomy will no longer hold, so cannot separately analyze real and nominal sides of the economy.
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
- 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 \(\pi^e_{t+1}\) change
- Rule of thumb: LM curve shifts in the same direction as real balances, \(\frac{M_t}{P_t}\)
Deriving the LM Curve

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

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

- 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:
  - $A_{t+1}$, $q_t$, or $G_t$ increase (IS shifts); $M_t$ or $\pi^e_{t+1}$ increase (LM shifts)
  - $G_{t+1}$ decreases (IS shift)
- 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

\[ w_t \]

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

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

\[ P_t \]

\[ P_{0,t} \]

\[ P_{1,t} \]

\[ P_{2,t} \]

\[ Y_t = Y_t \]

\[ Y_t \]

\[ A_tF(K_t, N_t) \]
Neoclassical IS-LM-AD-AS Equilibrium
Sticky Price Model

- In 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:

\[
\begin{align*}
N_t &= N_s(w_t, \theta_t) \\
\bar{P}_t &= \bar{P}_t \\
Y_t &= A_t F(K_t, N_t)
\end{align*}
\]

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

\[ Y_t = A_t F(K_t, N_t) \]
Sticky Price IS-LM-AD-AS Equilibrium

\[ Y_t = Y_t \]

\[ A_t F(K_t, N_t) \]

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

\[ N_t \]

\[ P_t \]

\[ w_t \]

\[ r_t \]

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

\[ IS \]

\[ AD \]

\[ AS \]

\[ Y_t = Y_t \]

\[ Y_0,t \]

\[ Y_t \]
Increase in $M_t$

- Whereas in the neoclassical model $Y_t$ is *supply determined*, in the New Keynesian model output is *demand determined*
- First, figure out what $Y_t$ is, and then figure out what $N_t$ must be to support that
- In an increase in $M_t$ shifts the LM curve to the right, and hence the AD curve to the right as well
- With a horizontal (as opposed to 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 workers to work more, $w_t$ must rise
Increase in $M_t$: Graphically

0 subscript: original
1 subscript: post-shock

$\bar{w}_{t}$

$N^S(w_t, \theta_t)$

$N_{0,t}$

$N_{1,t}$

$Y_t$

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

$\bar{A}_t F(K_t, N_t)$

$Y_t = Y_t$

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

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

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

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

IS

AD'

AD

$Y_t$

$P_t$

$w_{0,t}$

$w_{1,t}$
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

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

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

$IS$

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

$AS$

$AD'$

$AD$

$y = y$

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

$N^d(w_t, \theta_t)$

$N_t$

$w_t$

$P_t$

$w_t$

$P_{1,t}$

$P_{0,t}$

$r_t$

$r_{0,t}$

$Y_t$

$Y_t$

$Y_t$

$Y_t$

$N_{0,t}$

$N_t$

$N_t$

$N_{0,t}$

$Y_{0,t}$

$Y_{0,t}$
IS Shock

- Increase in $q_t$, $A_{t+1}$, $G_t$, or decrease in $G_{t+1}$: shifts IS curve to the right
- Results in AD curve shifting to the right, which means higher $Y_t$
- Higher $Y_t$ means that $N_t$ must rise
- Again, compare results to neoclassical model
Sticky Price Model: IS Shock

\[ w_t, P_t, Y_t, Y_t, Y_t \]

\[ N_t \]

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

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

\[ IS' \]

\[ IS \]

\[ AS \]

\[ AD' \]

\[ AD \]

\[ Y_t = Y_t \]

\[ r_t \]

\[ 0 \text{ subscript: original} \]

\[ 1 \text{ subscript: post-shock} \]
Increase in $A_t$

- Since $\bar{p}_t$ doesn’t change, in the sticky price model an increase in $A_t$ has no effect on $Y_t$
- Mechanically, this means that $N_t$ must fall
Increase in $A_t$: Graphically

Original

Post-shock

0 subscript: original
1 subscript: post-shock
Comparing Neoclassical and New Keynesian Models

- Useful rule of thumb: demand shocks have *bigger* effects in New Keynesian model and supply shocks *smaller* effects relative to neoclassical model.

- For productivity shock in particular, it is “contractionary” in sense of lowering hours worked.

- Some empirical debate on this:
  - Gali (1999) and Basu, Fernald, and Kimball (2006): positive productivity shock lowers hours in the *short run* (i.e. the New Keynesian model) and raises hours in the *medium run* (i.e. the neoclassical model).
  - Nevertheless, there is some debate about these empirical findings.
Increase in $\bar{P}_t$

- This is the only exogenous variable which will shift the AS curve in the sticky price model.
- Real world interpretation: increase in prices of intermediate inputs (e.g. price of oil).
- Results in AS shifting up, $Y_t$ falling, and $P_t$ rising. Sometimes called “stagflation” – prices (inflation) rising and output (employment) declining.
Graphical Effects: Increase in $\bar{P}_t$
### Summarizing Qualitative Effects in the Sticky Price Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\uparrow M_t$</th>
<th>$\uparrow$ IS curve</th>
<th>$\uparrow A_t$</th>
<th>$\uparrow \theta_t$</th>
<th>$\uparrow \bar{P}_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>$N_t$</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>$w_t$</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>$r_t$</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>$i_t$</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
</tbody>
</table>
The New Keynesian model is a special case of the neoclassical model – we simply swap labor demand with a fixed nominal price.

Call $Y_t^f$ the “flexible price” level of output – the level of output which would emerge in the neoclassical model.

If firm could adjust price, it would do so that it is on its labor demand curve, which would entail $Y_t = Y_t^f$.

Refer to $Y_t - Y_t^f$ as the output gap – the gap between actual output and what it would be in the absence of price stickiness.

To see this graphically, draw in a hypothetical AS curve for the neoclassical model – call this $AS^f$. 

Dynamics
A Negative Output Gap

Sticky price model
Hypothetical flexible price model

0 subscript: equilibrium value
f superscript: hypothetical flexible price equilibrium

\[ r_t \]
\[ P_t \]
\[ N_t \]
\[ Y_t \]

\[ N^d(w_t, A_t, K_t) \]
\[ P^f(w_0, t) \]
\[ N^s(w_t, \theta_t) \]

\[ LM(M_t, P_{0,t}) \]
\[ IS \]
\[ AS^f \]
\[ AD \]

\[ Y_t = Y_t \]
Transition from Short Run to Medium Run

- If the firm is producing less than it would like, it will face pressure to lower its price.
- Hence, as we transition from short run (price fixed) to medium run (price flexible), the firm will lower its price, $\bar{P}_t$.
- This will cause the AS curve to shift down, and output to rise.
- This pressure will persist until “the gap is closed.”
Closing the Gap

Sticky price model
Hypothetical flexible price model
Sticky price model, post price adjustment

0 subscript: equilibrium value
f superscript: hypothetical flexible price equilibrium
1 subscript: equilibrium value after price adjustment

$w_{t} = w_{0,t}$
$w_{1,t} = w_{f}^{f}$
$N^d(w_t, A_t, K_t)$
$N^e(w_t, \theta_t)$

$P_t$

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

$r_t$

$LM(M_t, P_{0,t}^f) = LM(M_t, P_{1,t})$

$IS$

$Y_t$

$r_{0,t}$

$r_{f,t} = r_{0,t}$

$f$

$P_{0,t}$

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

$P_{f,t}$

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

$AS'$

$AD$

$AS$

$w_{0,t}$

$w_{f}$

$N_t$

$N_{t}$

$Y_{t}$

$Y_{t} = Y_{t}$

$N_{0,t} = N_{f,0}^{f}$

$N_{1,t} = N_{f,1}^{f}$

$Y_{0,t} = Y_{0,f}^{f}$

$Y_{1,t} = Y_{1,f}^{f}$

$A_t F(K_t, N_t)$

$A_1 F(K_0, N_0)$

$Y_t = Y_t$

$Y_t = Y_t$
Dynamic Response to Shocks

- Can use this approach to think about effects of shocks in both short run and medium run
- In short run, AS curve is fixed, and we determine endogenous variables with that fixed AS curve
- In the medium run, the AS curve adjusts to “close the gap.” Can graphically do this by thinking about a hypothetical vertical “medium run” AS curve ($AS^f$).
Phillips Curve

- This analysis suggests that there ought to exist a positive relationship between the output gap, $Y_t - Y_t^f$, and the inflation rate, $\pi_t$ (the change in prices).
- Positive output gaps put upward pressure on prices, and negative gaps downward pressure on prices.
- The Phillips Curve formalizes this idea. Something like:

$$\pi_t = \gamma (Y_t - Y_t^f), \quad \gamma > 0$$
Empirical Relationship Between Inflation and the Output Gap

- Masks sub-sample differences
- Ambiguity about how to measure $Y_t^f$ empirically
Can Monetary Policy Permanently Engineer Higher Output?

▶ No
▶ Can temporarily raise output by increasing $M_t$, but in medium run this puts upward pressure on prices and the effect goes away
▶ Continually trying to raise output will only result in more inflation
▶ Further, it may cause the firm to anticipate the change in $M_t$, which could cause the AS curve to shift simultaneously with the AD shift, resulting in no effect of monetary expansion on output
▶ It is really only unanticipated monetary expansion that can stimulate output, and even then only for a while
Fully Anticipated Increase in $M_t$, so that $\bar{P}_t$ also rises
Costless Disinflation

- Can central bank lower prices (disinflation) without incurring an output loss?
- Conventional wisdom for 1980-1982 recession was that it was caused by Fed trying to get inflation under control (negative monetary shock)
- Suppose that the Fed announces in advance that it is going to reduce $M_t$. If firms believe this, they may adjust prices down in anticipation, causing AS curve to shift down at same time the AD shifts in
- In principle, this allows for a reduction in $P_t$ with no change in $Y_t$ – i.e. costless disinflation
- Underscores importance of central bank credibility and communication: for this to work, people must believe the central bank, and the central bank must clearly communicate its objectives