Keynesian Models

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Keynesian Models

- At risk of oversimplification, *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 (essentially) 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 Keynesian models are the same
- Differences arise on the supply side
- Consider two variants: wage stickiness and price stickiness
- Changes labor market equilibrium:
  - Not simultaneously on both labor demand and supply like in neoclassical model
  - Sticky wage model: labor determined from labor demand
  - Sticky price model: labor determined from labor supply
Going to use a new set of curves to summarize the demand side

None of this relies on price or wage stickiness; could (and will) apply these graphs to analyze neoclassical model

IS curve: same as $Y^d$ curve

LM curve: set of $(r_t, Y_t)$ where money market clears, holding $M_t$ and $P_t$ fixed

AD curve: set of $(P_t, Y_t)$ where on both IS and LM curves
Demand Side Equilibrium Conditions

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

- Investment:
  \[ I_t = I(r_t, A_{t+1}, q, K_t) \]

- Income = expenditure:
  \[ Y_t = C(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t) + I(r_t, A_{t+1}, q, K_t) + G_t \]

- Money demand:
  \[ M_t = P_t M^d(r_t + \pi^e_{t+1}, Y_t) \]

- Money supply:
  \[ M^s_t = M_t \]
IS Curve

- Stands for “Investment = Saving”
- Set of \((r_t, Y_t)\) pairs where (i) consumption chosen optimally, (ii) investment chosen optimally, and (iii) income = expenditure
- Identical to \(Y^d\) curve, just relabeling
- Shifts out if:
  1. \(\uparrow A_{t+1}, q, G_t\)
  2. \(\downarrow G_{t+1}, K_t\)
LM Curve

- Stands for “Liquidity = Money”
- Set of \((r_t, Y_t)\) pairs where money market clears, given values of \(M_t\) and \(P_t\)
- Basic idea of derivation: if \(\uparrow r_t\), must have \(\uparrow Y_t\) for money market to be in equilibrium at fixed \(P_t\) and \(M_t\)
- Shifts right if:
  1. \(\uparrow M_t\)
  2. \(\downarrow P_t\)
  3. \(\uparrow \pi_{t+1}^e\)
  4. Shifts right if real balances, \(\frac{M_t}{P_t}\), increase
(a) Initial money market equilibrium
(b) Point with higher $Y_t$, unchanged $r_t$
(c) New $(r_t, Y_t)$ pair consistent with money market equilibrium for $(M_t^0, P_t^0)$
AD Curve

- Set of \((P_t, Y_t)\) pairs where on both the IS and LM curve
- Therefore summarizes all five of the demand side equations
- Basic idea of derivation: if \(P_t\) goes up, LM shifts in, so \(Y_t\) where IS = LM is lower. So AD slopes down
- Will shift out if:
  1. IS shifts right (increases in \(A_{t+1}, q, G_t\), or decreases in \(G_{t+1}\) or \(K_t\)
  2. LM shifts right (increase in \(M_t\))
Aggregate Demand Curve

The diagram illustrates the interaction between the IS and LM curves in the context of the aggregate demand (AD) curve. The IS curve represents the intersection of the aggregate demand and supply curves, while the LM curve shows the balance between money supply and demand at different interest rates. The points $Y_t^1$, $Y_t^0$, and $Y_t^2$ correspond to different levels of aggregate demand, and $P_t^0$, $P_t^1$, and $P_t^2$ represent different price levels, impacting the overall equilibrium in the economy.

The AD curve shifts in response to changes in the IS and LM curves, demonstrating the dynamic interplay between money market conditions and the overall demand for goods and services.
AS Curve

- Aggregate Supply (AS): set of \((P_t, Y_t)\) pairs consistent with the production function and *some notion* of labor market equilibrium
- Summarizes the three equations related to supply side of the economy: production function, labor demand, and labor supply
- Neoclassical model: AS curve is vertical
- Keynesian model: AS curve is upward-sloping
  - Sticky nominal wages
  - Sticky prices
Neoclassical Model Supply Side Conditions

- Production function:
  \[ Y_t = A_t F(K_t, N_t) \]

- Labor supply:
  \[ N_t = N^s(w_t, H_t) \]

- Labor demand:
  \[ N_t = N^d(w_t, A_t, K_t) \]

- \( P_t \) not relevant, so AS will be vertical
Neoclassical AS

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

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

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

\[ P_t^0 \]
\[ P_t^1 \]
\[ P_t^2 \]

\[ Y_t^0 \]

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

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

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

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

\[ LM \]

\[ IS \]

\[ AD \]

\[ AS \]
Effects of Changes in Exogenous Variables

- Can use these graphs to examine the effects of changes in exogenous variables on endogenous variables
- *Exactly* the same outcomes, just different graphs
- I like the other graphical setup for the neoclassical model because it makes the classical dichotomy a bit more stark
Sticky Wages

- Assume that the nominal wage, $W_t$, is set in advance (real wage is $w_t = W_t / P_t$)
- Call this value $\bar{W}_t$. Take it to be exogenous
- In general, can’t simultaneously be on labor demand and supply if nominal wage is fixed
- Assume labor is determined from labor demand curve. Not necessarily on labor supply
Supply Side Equations of Sticky Wage Keynesian Model

- Labor demand:
  \[ N_t = N^d(w_t, A_t, K_t) \]

- Production function:
  \[ Y_t = A_t F(K_t, N_t) \]

- Real wage:
  \[ w_t = \frac{\bar{W}}{P_t} \]

Mathematically, just swapping labor supply with expression determining the real wage in terms of the new exogenous variable, \( \bar{W} \)

- ↑ \( P_t \): decrease in \( w_t \) for fixed \( \bar{W} \), which makes \( N_t \) increase from labor demand, which means more \( Y_t \) from production function. AS upward-sloping
Sticky Wage AS

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

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

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

\[ \bar{W}/P_t^0 \]

\[ \bar{W}/P_t^1 \]

\[ P_t^0 \]

\[ P_t^1 \]

\[ W \cdot P_t^0 / W \cdot P_t^1 / A \]

\[ P_t^0 / P_t^1 \]

\[ Y_t = Y_t \]

\[ AS \]
Sticky Wage IS-LM-AD-AS
Monetary Non-Neutrality and Demand Shocks

- Increase in the money supply shifts LM curve right, which results in rightward shift of AD
- Since AS is not vertical, this results in an increase in $Y_t$, increase in $P_t$, and a decrease in $r_t$
- “Monetary transmission”: increase in money supply lowers real interest rate, which stimulates investment and consumption
- More output is produced because higher price level means lower real wage, which induces firms to hire more labor
- Because AS is not vertical, other demand shocks (shocks to IS curve) also result in output movements
- Demand shocks now matter
Supply Shocks

- Labor supply shocks don’t impact output in sticky wage Keynesian model, since we are not on the labor supply curve.
- Productivity shocks shift the AS curve and cause output to change (and price level to move in opposite direction).
- How output reacts relative to the neoclassical model is ambiguous: depends on slope of AD. Effect on employment is ambiguous.
- Assume that AD is sufficiently steep that output increases by less in the sticky wage model to a productivity shock than it would if wages were flexible.
- Rule of thumb: in Keynesian model, output reacts more to demand shocks and less to supply shocks than in neoclassical model.
### Summary of Effects in Sticky Wage Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\uparrow M_t$</th>
<th>$\uparrow A_t$</th>
<th>$\uparrow A_{t+1}$</th>
<th>$\uparrow q$</th>
<th>$\uparrow G_t$</th>
<th>$\uparrow G_{t+1}$</th>
<th>$\uparrow H_t$</th>
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<tbody>
<tr>
<td>Output</td>
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<td>+</td>
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<td>+</td>
<td>-</td>
<td>0</td>
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<tr>
<td>Hours</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
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<tr>
<td>Consumption</td>
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<td>?</td>
<td>?</td>
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<td>0</td>
</tr>
<tr>
<td>Investment</td>
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<td>?</td>
<td>+</td>
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<tr>
<td>Real interest rate</td>
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<tr>
<td>Real wage</td>
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<tr>
<td>Price level</td>
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<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>0</td>
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</tbody>
</table>

- Real wage countercyclical conditional on demand shocks
- To extent real wage is procyclical in data, this is not a great theory of demand-driven business cycles
Sticky Price Model

- An alternative assumption which generates an upward-sloping AS is sticky price assumption.
- Assume some product differentiation so that firms have some market power (and can therefore set prices), but in a way that doesn’t really impact rest of model.
- Demand for product of firm $j$ decreasing in the relative price of their good, $\frac{P_{j,t}}{P_t}$.
- Assume that some fraction of firms have to set their prices in advance based on an expectation of what the aggregate price level will be, $P_t^e$ (exogenous).
- These firms cannot change their individual price if the actual aggregate price level turns out different than expected.
- Rule of game: firms must produce sufficient output to meet demand at their relative price.
- So won’t be on labor demand curve.
Sticky Price AS

\[ P_t = P_t^e + \gamma(Y_t - Y_t^f) \]

- \( Y_t^f \): what output would equal in absence of price stickiness (i.e. what it would be in the neoclassical model)
- \( P_t^e \): what firms (exogenously) expected price level to be
- \( P_t \) and \( Y_t \): what the price level and output actually are
- \( \gamma > 0 \): parameter in essence governing what fraction of firms cannot adjust their price
- Basic idea: \( P_t > P_t^e \): firms that can’t adjust end up with lower relative prices than they’d like, therefore have to produce more, so \( Y_t > Y_t^f \)
\[ P_t = P_t^e + \gamma (Y_t^f - Y_t^f) \]

- \( \gamma \) large: relatively flexible prices and vice-versa

\[ Y_t^f \]
Labor Market

- Key difference between sticky wage and sticky price model: labor market
- In sticky price model, firms are off labor demand – they have to hire labor to meet demand, so labor and real wage determined from labor supply curve. Opposite in sticky wage model
- Supply side equations:

\[ N_t = N^s(w_t, H_t) \]
\[ Y_t = A_t F(K_t, N_t) \]
\[ P_t = P_t^e + \gamma(Y_t - Y_t^f) \]

- Relative to neoclassical model, replace labor demand with AS
\[ Y_t = A_t F(K_t, N_t) \]

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

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

\[ P_t = P_t^e + \gamma(Y_t - Y_t^f) \]

\[ Y_t = Y_t \]
Sticky Price IS-LM-AD-AS
Effects of Shocks

- Monetary and other demand shocks matter in a qualitatively similar way (in terms of effects on output and price level) in sticky price model as in sticky wage model.

- In this model both supply shocks, $A_t$ and $H_t$, affect $Y_t$, but less than they would if prices were flexible (no ambiguity here).

- Effect of an increase in $A_t$ on employment is ambiguous.

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Comparing Sticky Prices vs. Wages

In terms of $Y_t$, $P_t$, $r_t$, $C_t$, and $I_t$: qualitatively the same

But different in terms of labor market

Sticky wage model: real wage countercyclical conditional on demand shocks

- Positive demand shocks directly lower real wage, inducing firms to hire more labor

Sticky price model: real wage procyclical conditional on demand shocks

- Positive demand shocks lower some firm’s relative prices, forcing them to produce more, which requires paying a higher real wage

Real wages procyclical in data → sticky price model provides better account of demand-driven fluctuations
Supply Shocks

- In sticky price model, output reacts less to changes in $A_t$ and $H_t$ than it would with flexible prices.
- In sticky wage model, output reacts less to change in $H_t$ than it would with flexible wages, ambiguous with respect to $A_t$.
  - Assume slope of AD is such that output reacts less to change in $A_t$ than in neoclassical model.
- In both models, effect of change in $A_t$ on $N_t$ is ambiguous.
- Bottom line: Keynesian model features bigger role for demand shocks and smaller role for supply shocks relative to neoclassical model.
Empirical Evidence

- Evidence that both prices and wages are sticky – Bils and Klenow (2004) and Barrattieri, Basu, and Gottschalk (2014)
  - But some disagreement about how sticky and how important this is
- Also some (contested) evidence that hours/employment decline after positive changes in $A_t$ – Gali (1999)
- Price and wage rigidity: also can explain apparent causal relationship between money and real output
Different “Runs”

- Price and wage rigidity: fundamentally *short run* phenomena
- What happens as we transition to *medium run* when prices and wages are flexible
  - Short run: prices and wages sticky, Keynesian model
  - Medium run: prices and wages flexible, think about capital as fixed, neoclassical model
  - Long run: capital accumulation, Solow model
- Neoclassicals and Keynesians differ over how important price and wage stickiness are and how long prices and wages are sticky (i.e. how long it takes to get from short run to medium run)
Dynamics

- In short run of Keynesian model, no guarantee that $Y_t = Y^f_t$ (where $Y^f_t$ is the neoclassical equilibrium level of output)
- Sticky wage model: $Y_t < Y^f_t$ means that the real wage is too high, so downward pressure on nominal wage
- Sticky price model: $Y_t < Y^f_t$ means that some firms have relative prices that are too high and therefore were surprised, would like to lower their prices
- In either case, what ought to happen is this: as we transition from medium to short run, the AS curve (in either sticky price or sticky wage model) should shift in such a way that it intersects the AD curve at $Y^f_t$
- Mechanically, in sticky wage model, if $Y_t < Y^f_t$ then $\bar{W}$ falls, shifting AS out. In sticky price model, if $Y_t < Y^f_t$, then $P^e_t$ falls, shifting AS out
AS curve shifts from transition from short run to medium run to “close the gap”
Implications

- Limits to monetary non-neutrality
  - Central bank can stimulate output in short run, but can’t do so forever – the AS curve will shift so that output equals $Y_t^f$, which is independent of $M_t$

- There ought to exist some relationship between the output gap, $Y_t - Y_t^f$, and inflation (growth rate of price level). Positive output gaps put upward pressure on inflation and negative gaps downward pressure on inflation

- Phillips Curve: something like:

  $$\pi_t = \varphi(Y_t - Y_t^f), \quad \varphi > 0$$
Phillips Curve: Empirical Evidence

Output Gap: HP Filter

Output Gap: CBO Potential