Generalizing the Model

- Up to now, have focused on endowment economies
  - exogenous real interest rate convenient for analytics
  - but can be misleading
- Now introduce nominal rigidities
  - track MP & FP impacts on real rates and output
Nominal Rigidities

- Follows Woodford (1998)
- Sticky prices: fraction $1 - \alpha$ of goods suppliers get to set a new price each period
- Continuum of identical households indexed by $j \in [0, 1]$, each specializes in production of single differentiated good
- Continuum of differentiated goods each period indexed by $z \in [0, 1]$
- Household $j$ maximizes

$$E_0 \left\{ \sum_{j=0}^{\infty} \beta^t \left[ u(C^j_t) + v \left( \frac{M^j_t}{P_t} \right) - w(y_t(j)) \right] \right\}$$

where $y_t(j)$: HH $j$'s supply of its product and

$$C^j_t \equiv \left[ \int_0^1 c_t^j(z)^{\frac{\theta-1}{\theta}} \, dz \right]^{\frac{\theta}{\theta-1}}, \quad \theta > 1$$
Nominal Rigidities

- Household $j$'s budget constraint

$$\int_0^1 p_t(z)c^j_t(z)dz + M^j_t + Q_{t,t+1}B^j_t \leq W^j_t + p_t(j)y_t(j) - P_t\tau_t$$

with $P_t \equiv \left[\int_0^1 p_t(z)^{1-\theta}dz\right]^{1-\theta}$ and $W^j_t \equiv M_{t-1} + B^j_{t-1}$

- Government's budget constraint

$$Q_{t,t+1}B_t = B_{t-1} + P_t\Delta_t - (M_t - M_{t-1})$$

with $\Delta_t \equiv -\tau_t$, primary deficit

- Aggregate resource constraint: $C_t = Y_t$
Nominal Rigidities

- Equilibrium conditions

\[ Q_{t,T} = \beta^{T-t} u'(Y_T) \frac{P_t}{P_T} \]

\[ \frac{v'(M_t/P_t)}{u'(Y_t)} = \frac{R_t - 1}{R_t} \]

\[ \frac{1}{R_t} = \beta E_t \left[ \frac{u'(Y_{t+1})}{u'(Y_t)} \frac{P_t}{P_{t+1}} \right] \]

\[ \lim_{T \to \infty} E_t [Q_{t,T} W_T] = 0 \]

- Integrating over all households, intertemporal HH bc

\[ \sum_{T=t}^{\infty} E_t \left\{ Q_{t,T} \left[ P_TC_T + \frac{R_T - 1}{R_T} M_T \right] \right\} = \sum_{T=t}^{\infty} E_t \left\{ Q_{t,T} \left[ P_T Y_T - P_T \tau_T \right] \right\} + M_{t-1} + B_{t-1} \]
Nominal Rigidities

▶ Price-setting behavior
  ► HH chooses new price, $P_t^*$, to satisfy

$$\sum_{k=0}^{\infty} \alpha^k E_t \left\{ Q_{t,t+k} Y_{t+k} \left( \frac{P_t^*}{P_{t+k}} \right)^{-\theta} \left[ P_t^* - \mu S_{t+k,t} \right] \right\} = 0$$

where $\mu \equiv \theta / (\theta - 1) > 1$: markup
  ► $S_{T,t}$: marginal cost at $T$ of good whose price was set at $t$

$$S_{T,t} = \frac{w'(Y_T \left( \frac{P_{t}^*}{P_T} \right)^{-\theta})}{u'(Y_T)} P_T$$

  ► and price index is

$$P_t = \left[ \alpha P_{t-1}^{1-\theta} + (1 - \alpha) P_t^* (1-\theta) \right]^{1/(1-\theta)}$$

▶ Flexible prices: $P_t^* = \mu S_{t,t}$, so $P_t = P^*$, $Y_t = Y^*$ where $Y^*$ solves $u'(Y^*) = \mu w'(Y^*)$
Fiscal Policy as Source of Instability

- Suppose there are no constraints on FP, so \( \{ \Delta_t \} \) is exogenous.
- Then fiscal disturbances must affect inflation, output, and interest rates, regardless of MP behavior.
- Proof by Contradiction: Suppose there is a MP that delivers stable prices despite fluctuations in \( \Delta_t \)
  - then \( Y_t = Y^* \) all \( t \)
  - \( R_t \) and \( M_t \) constant and
    \[ Q_{t,T} = \beta^{T-t}, \quad R^* = \beta^{-1}, \quad C_t = Y^* \]
    \[ \sum_{j=0}^{\infty} \beta^j \frac{R^* - 1}{R^*} m^* = m^* \]
  - HH’s intertemporal budget constraint is
    \[ \frac{W_t}{P^*} = m^* - \delta_t \]
    where \( \delta_t \equiv \sum_{j=0}^{\infty} \beta^j E_t \Delta_{t+j} \)
Fiscal Policy as Source of Instability

\[ \frac{W_t}{P^*} = m^* - \delta_t \]  

\[ \delta_t \equiv \sum_{j=0}^{\infty} \beta^j E_t \Delta_{t+j} \]

- But \( W_t \) predetermined at \( t \)
- Equilibrium condition (IBC) \( \Rightarrow \) fiscal shock cannot change \( \delta_t \)
- Conclusion: Random variation in FP necessarily inconsistent with price stability
- Conclusion is independent of MP behavior
  - so nothing MP can do to offset instability
Analytics for Cashless Limit Version

Four-equation system

\[ y_t = E_t y_{t+1} - \sigma (i_t - E_t \pi_{t+1}) \]
\[ \pi_t = \beta E_t \pi_{t+1} + \kappa y_t \]
\[ b_t = i_t + \beta^{-1} (b_{t-1} - \pi_t) + (\beta^{-1} - 1) \Delta_t \]
\[ i_t = \alpha \pi_t + \varphi_t \]

Can show that

\[ (1 - \alpha \beta) \sum_{j=0}^{\infty} \beta^j E_t \pi_{t+j} = b_{t-1} + \beta \sum_{j=0}^{\infty} \beta^j E_t \varphi_{t+j} + (1 - \beta) \sum_{j=0}^{\infty} \beta^j E_t \Delta_{t+j} \] (†)

1. present value of inflation determined by policy shocks
2. more hawkish MP—higher \( \alpha \)—amplifies positive impacts of deficits & interest rates
Analytics for Cashless Limit Version

- Flexible-price case: \( \kappa = \infty \Rightarrow y_t \equiv 0 \)
- Constant real rate: \( i_t = E_t \pi_{t+1} \)
- Note that

\[
E_t \pi_{t+j} = \alpha^j \pi_t + \alpha^{j-1} \varphi_t + \alpha^{j-2} E_t \varphi_{t+1} + \ldots + \alpha E_t \varphi_{t+j-2} + E_t \varphi_{t+j-1}
\]

- Solve for \( \pi_t \) from (†)

\[
\pi_t = b_{t-1} + \beta (1 - \alpha \beta) \sum_{j=0}^{\infty} \beta^j E_t \varphi_{t+j} + (1 - \beta) \sum_{j=0}^{\infty} \beta^j E_t \Delta_{t+j} \quad (‡)
\]

1. higher inflation from higher PV deficits or interest rates
2. effect of deficits on \( \pi_t \) not affected by MP
3. more hawkish MP increases effect of deficits on expected \( \pi \)

- Note: \( E_t \pi_{t+1} \) from (‡) consistent
Return to sticky-price model: $0 < \kappa < \infty$
- output and real interest rate endogenous

Real rate: $r_{t+j} \equiv i_{t+j-1} - \pi_{t+j}$

Rewrite (†) as

$$\pi_t - \sum_{j=1}^{\infty} \beta^j E_t r_{t+j} = b_{t-1} + (1 - \beta) \sum_{j=0}^{\infty} \beta^j E_t \Delta_{t+j}$$

News about higher deficits shows up as a mix of
1. *higher* current inflation
2. *lower* path of real interest rates
3. transmits to *higher* output
4. MP behavior determines split between inflation & real activity
Analytics for Cashless Limit Version

- Combine Euler equation, Phillips curve, MP rule

\[ E_t \pi_{t+2} - \beta^{-1}(1 + \beta + \sigma \kappa)E_t \pi_{t+1} + \beta^{-1}(1 + \alpha \sigma \kappa)\pi_t = -\beta^{-1}\sigma \kappa \varphi_t \]

- Can show two real roots: \(|\lambda_1| < 1, |\lambda_2| > 1\)

- Solution for expected inflation

\[ E_t \pi_{t+1} = \lambda_1 \pi_t + (\beta \lambda_2)^{-1} \sigma \kappa \sum_{j=0}^{\infty} \lambda_2^{-j} E_t \varphi_{t+j} \]

- Solve recursively given exogenous \(\{\Delta_t, \varphi_t\}\), predetermined \(b_{t-1}\)
  1. solve for \(\pi_t\) from (†)
  2. \(\pi_t \& E_t \pi_{t+1}\) yield \(y_t\)
  3. \(i_t\) from MP rule
  4. \(b_t\) from government budget constraint
  5. repeat
Assume MP rule that doesn’t react to fiscal variables

\[ R_t = \Phi(\pi_t, Y_t) \]

Government issues only 1-period nominal debt

\[ B_t = R_t[B_{t-1} + P_t \Delta_t - (M_t - M_{t-1})] \]

Steady state is

\[ \Delta_t = \Delta^* < 0, \quad \Phi(1, Y^*) = \beta^{-1} - 1, \quad R^* = \beta^{-1} \]

Log-linearize system around steady state
Equilibrium Consistent with Exogenous FP

- System is $(\hat{x}_t \equiv \ln(x_t) - \ln(x^*))$

\[
\hat{m}_t = \chi \left[ \sigma^{-1} \hat{Y}_t - \left( \frac{\beta}{1 - \beta} \right) \hat{R}_t \right]
\]

\[
\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(\hat{R}_t - E_t \hat{\pi}_{t+1})
\]

\[
\hat{R}_t = \phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t
\]

\[
\hat{b}_t = \hat{R}_t + \beta^{-1}(\hat{b}_{t-1} + \hat{\pi}_t) + (\beta^{-1} - 1)\hat{\Delta}_t + \gamma(\hat{m}_{t-1} - \hat{m}_t - \hat{\pi}_t)
\]

\[
\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \kappa \hat{Y}_t
\]

where \(\hat{\Delta}_t \equiv \Delta^* - \Delta_t, \sigma \equiv -\frac{u'(Y^*)}{u''(Y^*)Y^*}, \chi \equiv \frac{v'(m^*)}{v''(m^*)m^*}, \gamma \equiv \frac{m^*}{\beta b^*}\)

\[
\kappa \equiv \frac{(1 - \alpha)(1 - \alpha\beta)}{\alpha} \frac{\omega + \sigma}{\sigma(\omega + \theta)}, \omega \equiv \frac{w'(Y^*)}{w''(Y^*)Y^*}
\]

- Solve for \(\{\hat{Y}_t, \hat{\pi}_t, \hat{R}_t, \hat{b}_t, \hat{m}_t\}\) given \(\hat{\Delta}_t = \rho \Delta_{t-1} + \varepsilon_t\)
Impacts of Deficit

- With $\{\hat{\Delta}_t\}$ exogenous, unique eqm requires relatively weak reactions to inflation and output

\[-1 - \frac{1 + \beta}{\kappa} \phi_Y - \frac{2(1 + \beta)}{\kappa \sigma} < \phi_\pi < 1 - \frac{1 - \beta}{\kappa} \phi_Y\]

- Benchmark calibration

$\beta = .95, \kappa = .3, \chi = \sigma = 1, \gamma = .1, \rho = .6, Y^* = 1, b^*/Y^* = .5$

- Vary MP choices of $\phi_\pi$ and $\phi_Y$

Pegged interest rate: $\phi_\pi = \phi_Y = 0$
Weak lean against wind: $\phi_\pi = \phi_Y = .3$
Aggressive stance: $\phi_\pi = .9, \phi_Y = .5$
Impacts of Deficit: Pegged Rate

\[ \phi_{\pi} = \phi_Y = 0 \]

\[ \phi_{\pi} = \phi_Y = 0 \]

\[ \phi_{\pi} = \phi_Y = 0 \]

\[ \phi_{\pi} = \phi_Y = 0 \]
Impacts of Deficit: Pegged Rate

\[ \phi = \phi_Y = 0 \]

Inflation

\[ \phi = \phi_Y = 0 \]

Debt–Output

\[ \phi = \phi_Y = 0 \]

Money Growth

\[ \phi = \phi_Y = 0 \]

Deficit
Impacts of Deficit: More Hawkish

\[ \phi_{\pi} = \phi_{\gamma} = 0 \]
\[ \phi_{\pi} = \phi_{\gamma} = .3 \]

Output

\[ \phi_{\pi} = \phi_{\gamma} = 0 \]
\[ \phi_{\pi} = \phi_{\gamma} = .3 \]

Inflation

\[ \phi_{\pi} = \phi_{\gamma} = 0 \]
\[ \phi_{\pi} = \phi_{\gamma} = .3 \]

Nominal Rate

\[ \phi_{\pi} = \phi_{\gamma} = 0 \]
\[ \phi_{\pi} = \phi_{\gamma} = .3 \]

Real Rate

\[ \phi_{\pi} = \phi_{\gamma} = 0 \]
\[ \phi_{\pi} = \phi_{\gamma} = .3 \]
Impacts of Deficit: More Hawkish
Impacts of Deficit: Even More Hawkish

\[ \phi_\pi = .9, \phi_Y = .5 \]

\[ \phi_\pi = .9, \phi_Y = .5 \]

\[ \phi_\pi = .9, \phi_Y = .5 \]

\[ \phi_\pi = .9, \phi_Y = .5 \]
Impacts of Deficit: Even More Hawkish

- Inflation: \( \phi_\pi = .9, \phi_Y = .5 \)
- Debt–Output: \( \phi_\pi = .9, \phi_Y = .5 \)
- Money Growth: \( \phi_\pi = .9, \phi_Y = .5 \)
- Deficit: \( \phi_\pi = .9, \phi_Y = .5 \)
Sources of Fiscal Financing

- Write government budget constraint as

\[
\hat{b}_t + E_t \hat{\delta}_{t+1} = \hat{R}_t + \beta^{-1}(\hat{b}_{t-1} + \hat{\delta}_t - \hat{\pi}_t) + \gamma(\hat{m}_{t-1} - \hat{m}_t - \hat{\pi}_t)
\]

\[
\hat{\delta}_t \equiv (1 - \beta) \sum_{j=0}^{\infty} \beta^j E_t \hat{\Delta}_{t+j}
\]

- Solving for the present value of deficits

\[
\hat{\delta}_t = -\left(\hat{b}_{t-1} - \hat{\pi}_t\right) + \gamma \sum_{j=0}^{\infty} \beta^{j+1} E_t \hat{\mu}_{t+j} - \sum_{j=0}^{\infty} \beta^{j+1} E_t [\hat{R}_{t+j} - \hat{\pi}_{t+j+1}]
\]

\[
\hat{\mu}_t \equiv \hat{m}_t - \hat{m}_{t-1} + \hat{\pi}_t
\]
\[ \hat{\delta}_t = -(\hat{b}_{t-1} - \hat{\pi}_t) + \gamma \sum_{j=0}^{\infty} \beta^{j+1} E_t \hat{\mu}_{t+j} - \sum_{j=0}^{\infty} \beta^{j+1} E_t [\hat{R}_{t+j} - \hat{\pi}_{t+j+1}] \]

<table>
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<tr>
<th>Percentage Due to</th>
<th>( \hat{\pi}_t )</th>
<th>PV(seig)</th>
<th>(-PV(r))</th>
<th>PV((\pi))</th>
<th>PV((Y))</th>
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</thead>
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<tr>
<td>( \gamma = .1 )</td>
<td>39.6</td>
<td>9.4</td>
<td>51.0</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>( \phi_{\pi} = \phi_Y = 0 )</td>
<td>52.5</td>
<td>9.4</td>
<td>38.1</td>
<td>4.6</td>
<td>4.1</td>
</tr>
<tr>
<td>( \phi_{\pi} = \phi_Y = .3 )</td>
<td>88.4</td>
<td>10.0</td>
<td>1.6</td>
<td>36.9</td>
<td>6.9</td>
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<tr>
<td>( \phi_{\pi} = .9, \phi_Y = .5 )</td>
<td>43.7</td>
<td>0</td>
<td>56.3</td>
<td>2.3</td>
<td>3.4</td>
</tr>
<tr>
<td>( \phi_{\pi} = \phi_Y = 0 )</td>
<td>98.1</td>
<td>0</td>
<td>1.9</td>
<td>41.0</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Dynamic Impacts of Exogenous Serially Correlated Deficit Increase

seig: seigniorage; r: real discount rate; PV(X): present-value change in X; \( \gamma \equiv m^*/(\beta b^*) \); \( \phi_{\pi}, \phi_Y \): MP parameters
Implications: Monetary Policy Effects

- An open-market sale of $B$ reduces $M$, raises $R$
- If higher nominal $R$ means higher real $r$
  - holding FP fixed, this lowers $E_tPV(s)$
  - induces people to substitute out of government debt, into goods
  - raises aggregate demand
  - highly irregular
- Conventional view implicitly requires FP to generate *higher* expected surpluses
- If surpluses rise enough to raise $E_tPV(s)$, even with higher real discount rates.
  - tighter MP reduces demand and inflation
  - otherwise, demand and inflation rise
Implications: Monetary Policy Effects

- In new Keynesian model
  \[
  \hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma (\hat{R}_t - E_t \hat{\pi}_{t+1}) \\
  \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \kappa \hat{Y}_t \\
  \hat{\pi}_t = (b_{t-1} - \delta_t) - \gamma \sum_{j=0}^{\infty} \beta^{j+1} E_t \hat{\mu}_{t+j} + \sum_{j=0}^{\infty} \beta^{j+1} E_t [\hat{R}_{t+j} - \hat{\pi}_{t+j+1}] 
  \]

- Tighter monetary policy with fixed surpluses
  - raises \( \hat{R}_t - E_t \hat{\pi}_{t+1} \) in short run: lowers output
  - raises entire path of \( \{E_t \hat{\pi}_{t+j}\} \): raise inflation
  - appears as an adverse shift in the Phillips curve
- More hawkish MP—stronger response to inflation—prolongs rise in \( r \)
  - higher real debt service enhances wealth effects
  - raises inflation still more
Implications: Monetary Policy Effects

Serially correlated exogenous monetary policy contraction
Implications: Monetary Policy Effects

Serially correlated exogenous monetary policy contraction
Empirical Implications

- MP & FP shocks have very different effects in Regimes M & F
- Isn’t it easy to tell which regime generated observed data?
- No. For example, Regime F implies:
  - negative correlation between inflation & debt-GDP
  - positive correlation between inflation & money growth
  - *any* correlation between inflation & nominal debt growth
  - inflation can Granger-cause deficits
- Common misperception that Regime F creates high inflation
- Regime M can generate same pattern of correlations
- Are Regimes M & F observationally equivalent?
Real Discount Rates

$$\frac{M_{t-1} + Q_tB_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \frac{1}{r_{t,t+j}} s_{t+j}$$

- $r_{t,t+j}$ is j-step-ahead real discount rate
- Adjustments to eqm need not occur through $s_{t+j}$
  - price rigidities make future $r$’s important source of financing
- Changes in $E_t PV(s)$ need not occur through $s_{t+j}$
  - variations in expected $r$’s can have big effects on $E_t PV(s)$ with no change in $s$’s
- Leads to dramatic re-interpretations
\[
\frac{M_{t-1} + Q_t B_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \frac{1}{r_{t,t+j}} s_{t+j}
\]

- Flight to quality in financial crises and recessions
- Investors hold debt at lower expected returns
- As demand for debt rises, demand for goods falls
- Lower demand reduces inflation
- Intertemporal equilibrium condition’s role
  - lower \( r \)’s raises \( E_t PV(s) \) if surpluses unresponsive
  - higher \( E_t PV(s) \) raises value of debt
- Fluctuating discount rates can be a source of business cycles in Regime F—not in Regime M
- MP response: raise rates to increase aggregate demand
Implications: Discount Rates

- The 2008–2009 recession: conventional story doesn’t hold up (Cochrane)
- Sharp increase in precautionary demand for money
  - not met by supply
  - ⇒ lower demand & real output
- Fed flooded economy with reserves
  - no flight to money, out of bonds
  - no bank runs
- Instead, a flight to all quality—$M$ & $B$—out of goods
- Similar to convention, but focuses on all government debt, rather than just money
- Appropriate policy responses?
  - announce cuts in fiscal surpluses
  - if surpluses fixed and MP can affect real interest rates, then MP should raise rates
- Highly irregular
The Hungarian Case

- Hungarian facts courtesy of Magyar Nemzeti Bank
- Inflation targeting adopted since 2001 had mixed success
  - average inflation is lower
  - but still consistently above target
  - real interest rates have tended to be high
Hungary: Inflation Experience

Average inflation before IT: 17.8%

Average inflation after introducing IT: 5.3%
Hungary: Real Rates
The Hungarian Case

- Unfair to declare inflation targeting a failure

- Fiscal policy has been highly volatile
  - huge expansion 2002–2006 (6–7% GDP)
  - dramatic reversals: spending cuts & tax hikes
  - but government debt continued to rise as share of GDP

- About 50% of Hungarian government debt is in HUF—it’s nominal

- Even if only a small fraction in HUF, fiscal theory can operate
  - fiscal theory disappears only if all debt is indexed
Hungary: Government Debt–GDP Ratio
Inflation Targeting

- Like many countries, Hungary adopted IT without corresponding fiscal reforms
- Counterexamples include Chile, New Zealand, Norway, Sweden
  - to varying degrees, they imposed fiscal rules
  - in most cases, the rules have been obeyed
- Monetary & fiscal policies must be consistent
  - long-run IT must be consistent with long-run surpluses
  - most important: views about long-run surpluses must be anchored
- Ultimately, MP derives its power to control inflation from fiscal backing
  - no fiscal backing $\Rightarrow$ MP cannot achieve long-run IT
Hungarian Inflation Targeting

- Suppose Hungarian fiscal surpluses do *not* credibly adjust to stabilize debt
- What is the best monetary policy for Hungary?
- One response is obvious: *not* aggressive inflation targeting
  - without necessary fiscal backing, aggressive inflation fighting counterproductive
  - makes inflation & output more volatile
  - permanently aggressive inflation fighting generates explosive inflation
- Depending on maturity structure of debt, MP has power to determine the *timing* of inflation
  - but not average long-run inflation
Hungarian Inflation Targeting

- Optimal MP under fiscal dominance has not been thoroughly studied
  - see Cochrane’s *Econometrica* 2001 paper for a theory of optimal inflation smoothing in a frictionless model
- Existing work on optimal monetary-fiscal policy finds that Regime M dominates Regime F
  - given the observational equivalence between the regimes, this finding is puzzling
  - must stem from auxiliary assumptions, rather than policy behavior
- More basic research is needed
Hungarian Inflation Targeting

- What about practical advice?
- Bear in mind effects of real interest rates on $E_t PV(s)$
  - keeping real rates high to fight inflation keeps $E_t PV(s)$ low
  - low $E_t PV(s)$ depresses value of debt, encourages demand
  - higher demand leads to higher inflation
- High debt need not imply high inflation
  - if the debt is backed by surpluses, there is no inflation
  - if it’s backed by future seigniorage, it might be inflationary
  - effects of higher debt depend on $E_t PV(s)$
- Need to think about what anchors fiscal expectations
- Transmission mechanism: $E_t PV(s) \Rightarrow \pi_{t+j}$
  - anything that changes $E_t PV(s)$ can affect inflation before $s$’s change
A Provocative Proposal

- Many countries face substantial fiscal consolidation
- U.K. and U.S. in 2012
  - U.K. net national debt about 70% GDP
  - U.S. federal debt about 80% of GDP
- If debt is “risk-free” then bondholders must expect primary surpluses with present value consistent with current debt-GDP ratio
- Suppose consolidation aims to reduce ratio from 80% to 60%
- Two steps involved
  1. put current primary deficits on path to primary surpluses
  2. converge to long-run primary surpluses consistent with 60% ratio
A Provocative Proposal

- Regime M & Regime F consolidations look very different

- **Regime M Consolidation**
  1. raise taxes & cut spending to convert deficit to surplus
  2. continue to raise surplus to retire current debt toward 60%
  3. reduce surplus to level consistent with long-run debt target

- **Regime F Consolidation**
  1. raise taxes & cut spending to convert deficit to surplus
  2. reduce surplus to level consistent with long-run debt target

- Regime F does not require higher surpluses to retire debt
Hypothetical Conventional Consolidation

- To achieve the long-run reduction in debt, must
  - substantially cut spending or raise taxes to *overshoot* surplus target
  - can overshoot for decades
  - then can gradually reduce primary surpluses

- These short-run adjustments will certainly slow economic growth
  - slower growth will automatically reduce revenues & increase expenditures
  - these impacts are not reflected in the graph

- This is what many European countries have been doing, bringing new recessions

- What are the welfare costs of conventional consolidation?
Paths of Primary Surplus & Debt: Debt-GDP from 80% to 60% Surpluses Must *Overshoot* Long-Run Target
Alternative Fiscal Consolidations

- Conventional consolidation takes inflation off table
- What can inflation do?
  - government debt is nominal & long-term
  - current or future inflation devalues debt
  - can avoid overshooting surplus target
  - requires less fiscal adjustment
- But wait... there's more
  - if monetary policy prevents nominal rates from rising with inflation—as it has the past 4 years
  - then real interest rates fall
  - stimulates consumption & aggregate demand
- Alternative consolidation can avoid retarding growth
- What are the welfare costs of alternative consolidation?
Hypothetical Alternative Consolidation

Paths of Primary Surplus & Debt: Debt-GDP from 80% to 60%
Illustrative Model of Inflation Determination

- Endowment economy with infinitely-lived agents, at cashless limit
- Long-term *nominal* bonds, $B_{Mt}$, sell at price $P_{Mt}$
  - bond issued at $t$ pays $\rho^j$ dollars at $t + j + 1$
  - average duration of bond: $(1 - \beta \rho)^{-1}$
  - $\rho = 0$: all bonds 1 period

- FP: chooses primary surplus, $s_t$
- MP: chooses 1-period nominal interest rate, $R_t$
- Debt Management: chooses average maturity, $\rho$
- Equilibrium: $c_t = y$ for all $t$
Government Behavior

- Government’s choices of \( \{R_t, s_t, B_{Mt}\} \) and \( \rho \) satisfy

\[
\frac{P_{Mt}B_{Mt}}{P_t} + s_t = \frac{(1 + \rho P_{Mt})B_{Mt-1}}{P_t}
\]

- For now, government not optimizing
  - posit *ad hoc*—but typical—rule
  - on agenda: compute welfare consequences of alternative consolidation schemes
- Government’s choices constrained by conditions for equilibrium
  - market clearing
  - household’s first-order conditions
  - household’s transversality condition: optimal behavior limits growth rate of government debt
Asset-Pricing Relations

\[ \frac{1}{R_t} = \beta E_t \left( \frac{1}{\pi_{t+1}} \right) \]

\[ P_{Mt} = \frac{1}{R_t} E_t (1 + \rho P_{Mt+1}) \]

These imply

\[ P_{Mt} = \beta \sum_{j=0}^{\infty} (\beta \rho)^j E_t \left( \prod_{i=0}^{j} \frac{1}{\pi_{t+i+1}} \right) \]

\[ = \sum_{j=0}^{\infty} \rho^j E_t \left( \prod_{i=0}^{j} \frac{1}{R_{t+i}} \right) \]
An Equilibrium Condition

- Imposing equilibrium, asset-pricing relations, transversality

\[
\frac{(1 + \rho P_{Mt})B_{Mt-1}}{P_t} = \sum_{j=0}^{\infty} \beta^j E_t s_{t+j}
\]

(IEC)

- In conventional consolidation...
  - MP unconstrained: determines equilibrium \( \{P_t\} \Rightarrow \{P_{Mt}\} \)
  - FP constrained: chooses \( \{s_t\} \) to satisfy (IEC)

- In the alternative consolidation...
  - FP unconstrained: determines equilibrium \( \{P_t, P_{Mt}\} \)
  - MP constrained: determines \textit{timing} of inflation
Thought Experiment

- Take path of $\{s_t\}$ for 2012–2022 from Congressional Budget Office “Budget Projections,” March 2012
  - conventional consolidation: $s_t$ for 2023 & 2024 increases by 1% each year
  - alternative consolidation: $s_t$ reaches long-run target early

- Debt-output, $P_{Mt}B_{Mt}/P_t$
  - initial: 80%
  - target: 60%

- Model calibration
  1. real interest rate 2%
  2. initial inflation 2%
  3. vary average maturity
Conventional Consolidation

- MP obeys
  \[
  \frac{1}{R_t} = \frac{1}{R^*} + \alpha \left( \frac{1}{\pi_t} - \frac{1}{\pi^*} \right)
  \]

- Combine with Euler equation
  \[
  E_t \left( \frac{1}{\pi_{t+1}} - \frac{1}{\pi^*} \right) = \frac{\alpha}{\beta} \left( \frac{1}{\pi_t} - \frac{1}{\pi^*} \right)
  \]

- Unique bounded solution when \( \alpha > \beta \) is
  \[
  \pi_t = \pi^* \text{ for all } t
  \]
Conventional Consolidation

- After CBO projection period, $s_t$ obeys
  \[ s_t = s^* + \gamma (P_{Mt-1} b_{Mt-1} - P^*_M b^*_M) \]

- Impose the Euler equation
  \[ E_{t-1} \left( \frac{1 + \rho P_{Mt}}{\pi_t} \right) = \frac{1}{\beta} P_{Mt-1} \]
  on government’s flow constraint and substitute $s$ rule
  \[ E_t \left( \frac{P_{Mt+1} b_{Mt+1} - P^*_M b^*_M}{P_{t+1}} \right) = (\beta^{-1} - \gamma) \left( \frac{P_{Mt} b_{Mt} - P^*_M b^*_M}{P_t} \right) \]

- $\gamma > \beta^{-1} - 1$ stabilizes debt, ensuring (IEC) holds
- Overshooting: $P_{Mt-1} b_{Mt-1} > P^*_M b^*_M \Rightarrow s_t > s^*$
Conventional Consolidation

- With MP aggressively targeting inflation...
  - inflation cannot be used to reduce value of debt
  - consolidation *requires* surplus to overshoot long-run target
  - higher surpluses retire debt to achieve 60% target

- In reasonable model, where taxes distort & government spending affects demand...
  - during overshooting, output will fall
  - choice of $\gamma$ determines speed of adjustment
    - higher $\gamma$ amplifies overshooting, exacerbating economic downturn
    - lower $\gamma$ prolongs adjustment period, keeping output persistently weak

- Should we take inflation off the table?
Alternative Consolidations

- FP sets \( \{s_t\} \) exogenously—indpendently of debt
- MP sets \( \{R_t\} \) to react weakly to inflation

\[
\frac{(1 + \rho P_{Mt}) B_{Mt-1}}{P_t} = \sum_{j=0}^{\infty} \beta^j E_t s_{t+j} \tag{IEC}
\]

- In (IEC): right-side given, \( B_{Mt-1} \) predetermined
- (IEC) determines continuum of \((P_t, P_{Mt})\) combinations
- Can think of this as \( E_t PV(s) \) determining

\[
\sum_{j=0}^{\infty} (\beta \rho)^j E_t \frac{P_{t-1}}{P_{t+j}}
\]

The expected present value of inflation

- Longer maturity—higher \( \rho \)—permits inflation to be postponed
Alternative Consolidation #1

- MP pegs $R_t = R^* \Rightarrow \pi_{t+j} = \pi^* \quad j \geq 1$
  - all inflation occurs at $t$
  - future inflation at $\pi^* = 2\%$
  - $P_{Mt} = P^*_M$ all $t \geq 0$

- (Not a realistic scenario, as it requires flexible prices)
paths of inflation & bond prices: debt-gdp from 80% to 60%
Alternative Consolidation #2

- Examine tradeoff between current & (fixed) future inflation

\[
\frac{(1 + \rho P_{Mt})B_{Mt-1}}{P_t} = \sum_{j=0}^{\infty} \beta^j E_t s_{t+j} \quad \text{(IEC)}
\]

- With fixed future inflation, \( \pi^F \)

\[
P_{Mt} = \frac{\beta}{\pi^F - \rho \beta}
\]

\[
\frac{\pi^F}{\pi_t (\pi^F - \rho \beta)} = \frac{E_t PV(s)}{b_{Mt-1}}
\]

- Consolidation changes \( E_t PV(s) \), given initial \( b_{Mt-1} \) at 80%

- Note \( \rho = 0 \) \( \Rightarrow \) future inflation off the table
<table>
<thead>
<tr>
<th>Average Maturity</th>
<th>Current Inflation ($\pi_t$)</th>
<th>Future Inflation ($\pi^F$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>5-year</td>
<td>16.4</td>
<td>13.1</td>
</tr>
<tr>
<td>7-year</td>
<td>10.8</td>
<td>8.0</td>
</tr>
<tr>
<td>10-year</td>
<td>7.4</td>
<td>4.8</td>
</tr>
<tr>
<td>20-year</td>
<td>3.9</td>
<td>1.7</td>
</tr>
<tr>
<td>30-year</td>
<td>2.9</td>
<td>0.8</td>
</tr>
<tr>
<td>50-year</td>
<td>2.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Feasible Current Inflation ($\pi_t$) and Future Inflation ($\pi^F$) Combinations & Average Debt Maturity (Annual %)
Alternative Consolidation #2

- Longer average maturity, more can spread inflation over time
- Requires a particular monetary policy
- Long maturities imply small inflation cost to consolidation
- Some realities
  1. in U.S., Fed has been *shortening* outstanding maturity via QE II & III
     - efforts to reduce long rates to stimulate growth
  2. irony: with fears of *deflation*, this is precisely the policy to pursue
  3. further irony: no policy makers are seriously considering this option
Where To Go From Here

1. Employ new Keynesian model
   ▶ sticky prices: higher inflation lowers real interest rates
   ▶ lower real rates raise output, consumption, investment
   ▶ get an economic expansion from alternative consolidation

2. Introduce distorting taxes & government spending

3. Compare welfare costs of conventional & alternative consolidation

4. Brings back into the picture an old topic: optimal maturity structure of government debt
Take Aways

- In a world where FP cannot be relied on to adjust surpluses as needed to stabilize debt...

1. it is impossible for MP to stabilize the economy
2. fiscal disturbances will always affect output, inflation & interest rates
3. more aggressive MP will exacerbate the instability
4. fluctuations in “confidence” that affect real interest rates will transmit into fluctuations in output & inflation
5. sudden flights to quality or away from junk can have real effects
6. tighter MP raises debt service, wealth, aggregate demand, and inflation
Take Aways

1. Conventional perceptions of inflation miss a channel for fiscal inflation
   - channel may be important in times of fiscal stress
2. Perception that MP can always stop an inflation that breaks out assumes the necessary fiscal backing will always be forthcoming
   - when fiscal limit possible, the assumption breaks down
3. If inflation has fiscal roots, MP cannot offset it
4. Two policy options:
   i. impose enforceable rules on fiscal behavior
   ii. give different mandates to central banks