Inventories, Markups and Real Rigidities

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New Keynesian Business Cycle Models

- Predictions sensitive to dynamics of costs
  - Real marginal cost volatile: short-lived effect of ΔM
    - Chari-Kehoe-McGrattan
  - Real marginal cost sticky: long-lived effects of ΔM
    - Woodford, Christiano-Eichenbaum-Evans, Smets-Wouters

Our Question:

1. How does real marginal cost respond to ΔM?
   - How do markups respond to ΔM?
2. What accounts for slow response P to M?
   - $P =$ markup $\times$ cost
   - (Countercyclical) variation markups?
   - Sticky costs?

Recent findings

- Consensus in recent work:
  - Real effects of M mostly due to sticky costs
  - E.g., Christiano, Eichenbaum, Evans (2005)
  - Consumers prices flexible, wages/producer prices sticky
- Difficult map wages/producer prices into marginal cost
  - Statements about marginal cost: *quantities*

Our approach

- Study data on inventories
- Idea: accumulate inventories if costs low after $\Delta M > 0$
    - Price = markup $\times$ marginal valuation of inventory:

$$P = \text{markup} \times V'(inv)$$

    - Buy inventories to equate marginal valuation to cost:

$$V'(inv) = cost$$

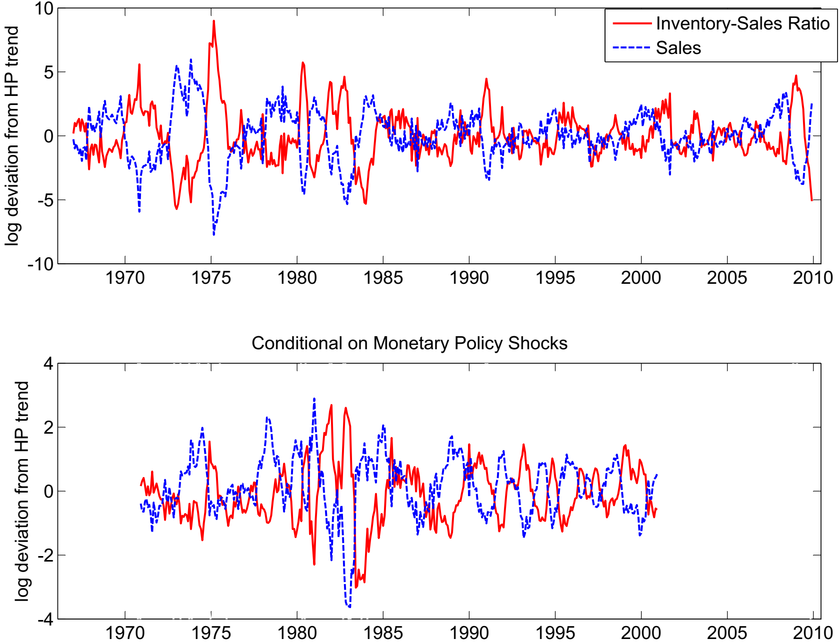
        - cost includes multiplier on quantity constraints etc.

Our findings

- Data: inventories $\approx$ constant over cycle
- Model: need strongly countercyclical markups to account data
  - Countercyclical markup variation accounts up to 80 % real effects of ΔM
- Bils-Kahn (2000), Khan and Thomas (2007)

Data

- Bureau of Economic Analysis (NIPA), monthly
  - Sales, Inventories
    - Manufacturing and Trade
    - Retail
  - All real
    - Unconditional (HP-filtered)
    - Conditional on M shocks


10
5
0
-5
-10
log deviation from HP trend
Inventory-Sales Ratio
Sales
1970
1975
1980
1985
1990
1995
2000
2005
2010
Conditional on Monetary Policy Shocks
4
2
0
-2
-4
log deviation from HP trend
1970
1975
1980
1985
1990
1995
2000
2005
2010

- Statistics conditional on CEE M shocks. Similar unconditional.

	Manufact. & Trade	Retail
$\rho(\ln IS_t, \ln S_t)$	-0.70	-0.58
$\sigma(\ln IS_t)/\sigma(\ln S_t)$	0.96	1.43
$\varepsilon_{IS,S}$	-0.67	-0.83
$\varepsilon_{I,S}$	0.33	0.17
$\sigma(S+\Delta I)/\sigma(S)$	1.10	1.15

- Sales up 1% $\Rightarrow$ inventories up only 0.33%

Model Overview

1. Consumers

- Organized unions. Change wages every 12 months (Calvo).
- Own capital. Rent to manufacturers. Work.
- Cash in advance: $Pc \leq M$

2. Final good firms. Competitive.

- Assemble final good from continuum intermediate goods
- Good-specific productivity shocks

3. Intermediate good firms. Monopolistically competitive.

- Can store goods. Depreciate at δ_z.
- Produce using capital and labor
- Choose p and y before learn uncertain demand.

Intermediate good firms

- Technology

$$y_i\left(s^t\right) = \left(l_i\left(s^t\right)^{\alpha} k_i\left(s^t\right)^{1-\alpha}\right)^{\gamma},$$

- Marginal cost:

$$\Omega\left(s^t\right) y_i\left(s^t\right)^{\frac{1}{\gamma}-1}, \qquad \Omega\left(s^t\right) = \chi W\left(s^t\right)^{\alpha} R\left(s^t\right)^{1-\alpha}$$

Intermediate good firms. Flexible prices

- End of period inventories: $m_i(s^{t-1})$

- Beginning of period inventories: $z_i(s^t) = m_i(s^{t-1}) + y_i(s^t)$

- Friction: choose $y_i(s^t)$, $P_i(s^t)$ before learn $v_i(s^t)$

- Sales:

$$q_i\left(s^t\right) = \min\left(v_i\left(s^t\right)\left(\frac{P_i\left(s^t\right)}{P\left(s^t\right)}\right)^{-\theta} q\left(s^t\right),\ z_i\left(s^t\right)\right)$$

- Inventories:

$$m_i\left(s^t\right) = \left(1 - \delta_z\right)\left(z_i\left(s^t\right) - q_i\left(s^t\right)\right)$$

Decision Rules with constant returns, $\gamma = 1$

$$\max_{P_i(s^t),\ z_i(s^t)} \left(P_i\left(s^t\right) - \Omega'\left(s^t\right)\right) R\left[P_i\left(s^t\right), z_i\left(s^t\right)\right] - \left(\Omega\left(s^t\right) - \Omega'\left(s^t\right)\right) z_i\left(s^t\right)$$

- $R\left[P_i\left(s^t\right), z_i\left(s^t\right)\right]$: expected sales
- $\Omega'\left(s^t\right) = \left(1 - \delta_z\right) \int_{s^{t+1}} Q\left(s^{t+1} | s^t\right) \Omega\left(s^{t+1}\right) ds^{t+1}$:

  marginal valuation inventories

Inventory Rules with constant returns, $\gamma = 1$

- Let $v_i^* \left(s^t\right) = \frac{z_i\left(s^t\right)}{\left(\frac{P_i\left(s^t\right)}{P\left(s^t\right)}\right)^{-\theta} q\left(s^t\right)}$, $\qquad r_i \left(s^t\right) = \frac{\Omega'\left(s^t\right)}{\Omega\left(s^t\right)}$

- Inventory decision:

$$1 - \Phi\left(\log v_i^* \left(s^t\right)\right) = \frac{1 - r_i \left(s^t\right)}{P_i \left(s^t\right) / \Omega \left(s^t\right) - r_i \left(s^t\right)}$$

- Inventories more sensitive to r_i than markups:

$$\hat{v}_i^* \left(s^t\right) = \xi \left[\left(1 - \bar{\Phi}\right) \bar{b} \left[\hat{P}_i \left(s^t\right) - \hat{\Omega} \left(s^t\right)\right] + \beta \left(1 - \delta_z\right) \bar{\Phi} \hat{r}_i \left(s^t\right)\right]$$

- one-to-one mapping $v_i(s^t)$ and $m_i(s^t)$ (data)

Parametrization

- Standard.

- Two key inventory parameters

  - Inventory depreciation, $\delta_z = 0.91\%$
  - Std. dev. demand shocks, $\sigma_v = 0.63$

- Choosen to match:

  - I/S ratio = 1.4 months
  - Frequency stockouts 5% (Bils 04)

  - δ_z similar direct measures inventory carrying costs

Flexible prices (constant markups)

- Study response to money growth shocks:

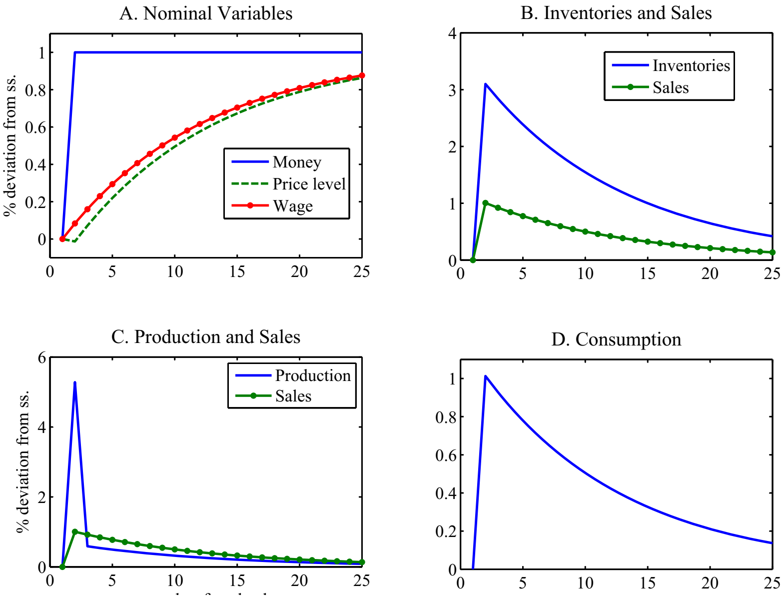
$$\ln M_t / M_{t-1} = \varepsilon(s^t)$$

- Three variations:
    - Constant returns to labor. $(\gamma = \alpha = 1)$
    - Firm-level decreasing returns. No K $(\gamma = 2/3, \alpha = 1)$
    - Firm-level constant returns. Capital $(\gamma = 1, \alpha = 2/3)$

- Return to holding inventories (log-preferences):

$$r_{i,t} = \beta \left(1 - \delta_z\right) E_t \frac{1}{\exp\left(\varepsilon_{t+1}\right)} \left(\frac{W_{t+1}}{W_t}\right)^{\alpha} \left(\frac{R_{t+1}}{R_t}\right)^{1-\alpha} \left(\frac{y_{i,t+1}}{y_{i,t}}\right)^{\frac{1}{\gamma}-1}$$

Constant returns to labor, $\alpha = \gamma = 1$



Economy with constant markups

	$\epsilon_{I,S}$	$\sigma(Y)/\sigma(S)$
Data	0.33	1.10
Constant returns labor	3.1	3.1
Firm DRS	2.2	1.7
Capital	1.4	1.4

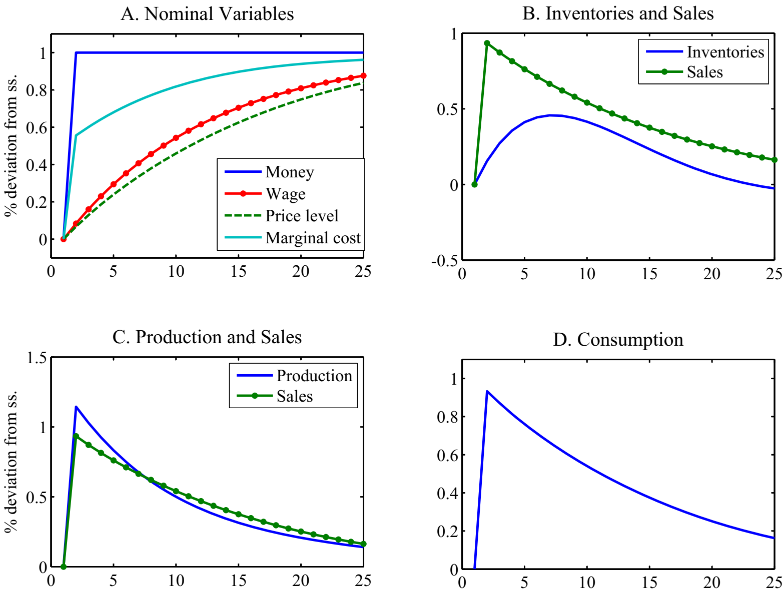
Constant markups: cannot account inventory data

Countercyclical markups (prices Δ every 8 months)

	$\epsilon_{I,S}$	$\sigma(Y)/\sigma(S)$
Data	0.33	1.10
Constant returns labor	2.7	2.9
Firm DRS	0.5	1.14
Capital	0.11	1.07

Countercyclical markups: can account inventory data

Sticky prices and firm DRS



Measure role of markups

- Cash-in-advance:

$$\ln(c_t) = \ln(M_t) - \ln(P_t) = \underbrace{\ln(M_t) - \ln(\Omega_t)}_{\textit{cost term}} + \underbrace{\ln(\Omega_t) - \ln(P_t)}_{\textit{markup term}}$$

- Decompose role of cost and markup variation
  - Vary share of K to match inventory data exactly
  - Also study economies with IES $= 0.5$ and Taylor rule

Measure role of markups

	$\epsilon_{I,S}$	Markup contribution
Data	0.33	??
Original	0.33	0.53
IES = 0.5	0.33	0.80
Taylor rule	0.33	0.80

Countercyclical markups account 80% real effects of M shocks