PhD Macro Core Part I:
Lecture 14 – Sticky Prices and Menu Costs Part II

Min Fang
University of Florida

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The Macro-Type Model of Sticky Prices

- Ss literature (i.e., Calvo) had gotten a bit stale in the late 90's
- Only so much you can do analytically (computers not yet good enough to simulate realistic models)
- Lack of data to discipline models
- Both things changed after 2000:
- Computers became powerful enough to simulate realistic models
- Bils and Klenow (2004) introduced a massive new source of data

Basic Facts: How Often Do Prices Change?

- Conventional wisdom in late 90's: Prices change once a year
- Cecchetti (1986), Carlton (1986), Kashyap (1995), Blinder et al. (1998)
- Bils and Klenow (2004) used BLS microdata from 95-97:
- Prices change every 4-5 months
- Spawned a large subsequent literature

Additional Facts about Price

- BLS microdata allowed researchers to document additional facts about price adjustment
- Klenow and Kryvtsov (2005,2008):
- Average absolute size of price changes large: about 10%
- Golosov-Lucas (2007):
  - 2.5% annual inflation
  - 20% of prices changing every month
  - Average absolute size of price change 10%
  - How can this be?
  - Evidence for large, transitory idiosyncratic shocks that drive price adjustment

The Micro-Type Model of Sticky Prices

- Golosov and Lucas (2007): Today
- Kehoe and Midrigan (2015): Not covered, Self-study
- Key Idea: Micro-found the pricing decisions

Modified Golosov-Lucas'07

- Households maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log C_t - \omega L_t\right]$$

where

$$C_t = \left[\int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} dz\right]^{\frac{\theta}{\theta-1}}$$

subject to:

$$P_t C_t + Q_{t,t+1} B_{t+1} \leqslant B_t + W_t L_t + \int_0^1 \Pi_t(z) dz$$

and natural borrowing limits

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Household Optimization

- Cost minimization implies

$$c_t(z) = C_t \left(\frac{p_t(z)}{P_t} \right)^{-\theta}$$

- Labor-leisure optimization yields:

$$W_t = \omega P_t C_t$$

- So, nominal wages are proportional to the nominal output

Monetary Policy

- Define nominal aggregate demand as:

$$S_t = P_t C_t$$

- Suppose central banks vary interest rate/money supply in such a way that log nominal aggregate demand follows a random walk:

$$\log S_t = \mu \log S_{t-1} + \eta_t$$

where $\eta_t \sim \mathrm{N}\left(0, \sigma_\eta^2\right)$.

- This is the aggregate source of uncertainty in the model

Firm's Problem

- Linear production function

$$y_t(z) = A_t(z)L_t(z)$$

- This implies that marginal cost of production is $W_t/A_t(z)$

- Idiosyncratic productivity follows an AR(1) in logs:

$$\log A_t(z) = \rho \log A_{t-1}(z) + \epsilon_t(z)$$

where $\epsilon_t(z) \sim \mathrm{N}\left(0, \sigma_\epsilon^2\right)$

Firm's Problem

- Firm maximizes the value of expected profits

$$E_t \sum_{\tau=0}^{\infty} D_{t,t+\tau} \Pi_{t+\tau}(z)$$

where profits are

$$\Pi_t(z) = p_t(z) y_t(z) - W_t L_t(z) - \chi_j W_t l_t(z) - P_t U$$

  - Firm must hire χ_j units of labor to change price
  - U fixed cost of operation (helpful to reconcile large markups with small profits)
  - $D_{t,t+\tau}$ is household's stochastic discount factor

How to Solve Firm's Problem

- "Perturbation methods" won't work due to fixed cost

- Alternative: Dynamic programming, i.e., set up a Bellman equation

$$V(Z_t) = \max_{p_t} \left[\Pi_t^R(z) + E\left[D_{t,t+1}^R V(Z_{t+1}) \right] \right]$$

$$\Pi_t^R(z) = C_t \left(\frac{p_t(z)}{P_t} \right)^{-\theta} \left(\frac{p_t(z)}{P_t} - \frac{1}{A_t(z)} \frac{W_t}{P_t} \right) - \chi_j \frac{W_t}{P_t} l_t(z) - U$$

  - Z_t denotes vector of state variables
  - Key question: What is the state?
  - Generic answer: All variables that affect the firm's value
  - $A_t(z), p_{t-1}(z)/P_t, C_t$
  - Any variable that is needed to forecast Z_{t+1} (e.g., C_{t+1} and P_{t+1})

How to Solve Firm's Problem: Not Today!

- Krusell-Smith (1998):
  - Assume firms are slightly boundedly rational
  - Firms perceive price level as being a function of a small number of moments of the joint distribution of $(p_t(z)/P_t, A_t(z))$
- Response to a single unexpected shock
  - Conjecture path for endogenous aggregates
  - Solve household problem conditional on this by backward induction
  - Simulate and update conjecture

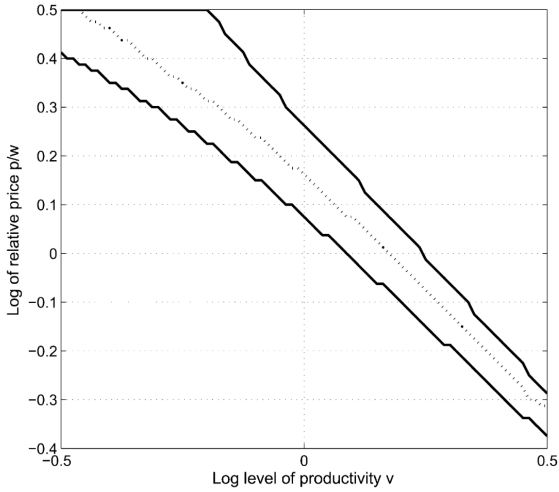
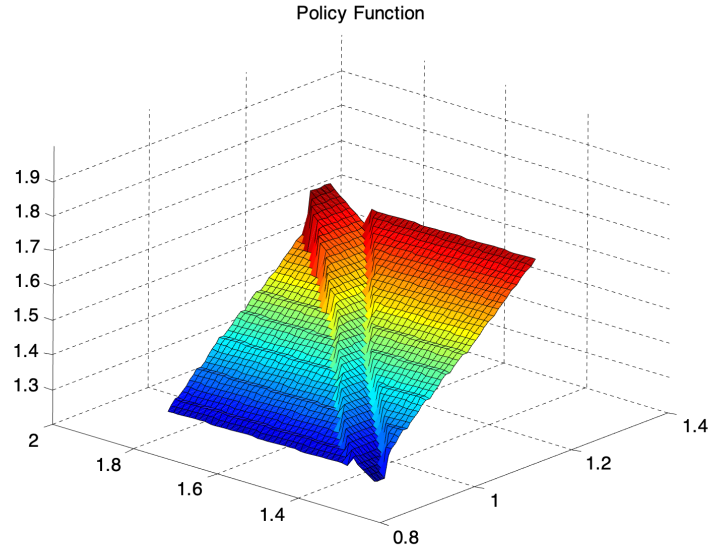


FIG. 1.—Pricing bounds for 0.64 percent quarterly inflation. Solid lines: upper and lower bounds $U(v)$ and $L(v)$. Dotted line: $g(v)$.

Source: Golosov and Lucas (2007)



Left axis: Prior price. Right axis: Marginal cost. Vertical axis: New price.

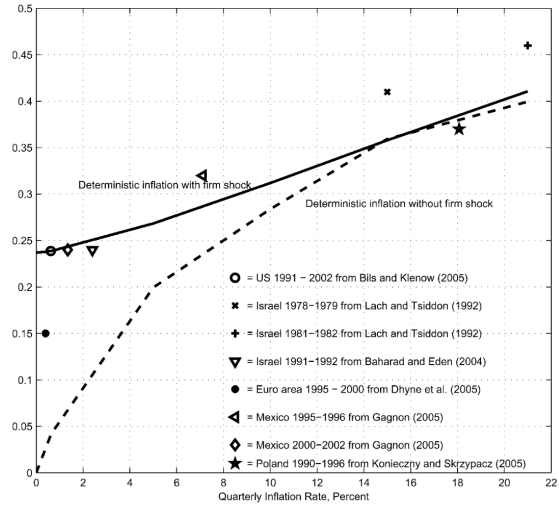
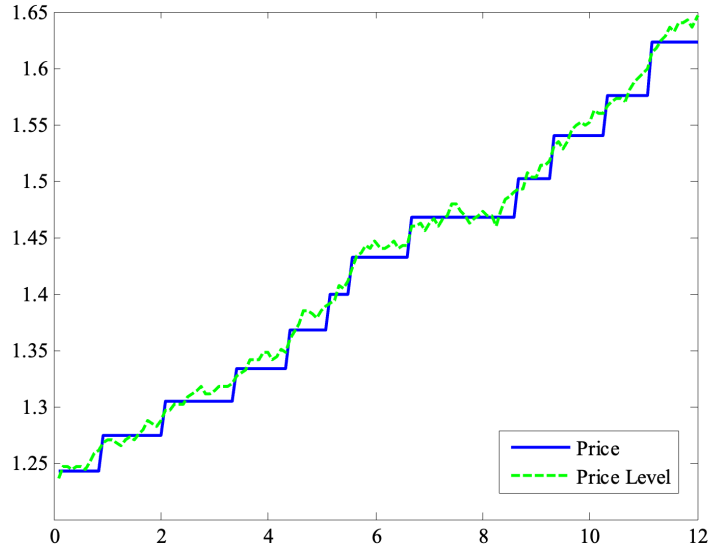
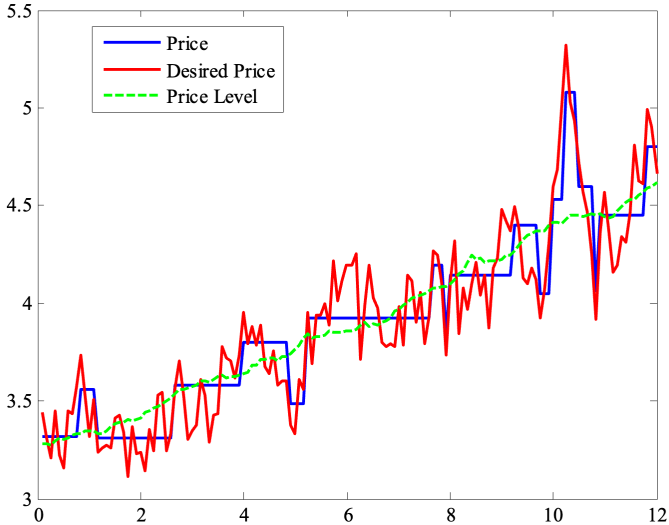


FIG. 3.—Fraction of prices changed each month

Source: Golosov and Lucas (2007)



Sample path without idiosyncratic shocks. Small price changes. No price decreases.



Sample path with idiosyncratic shocks.

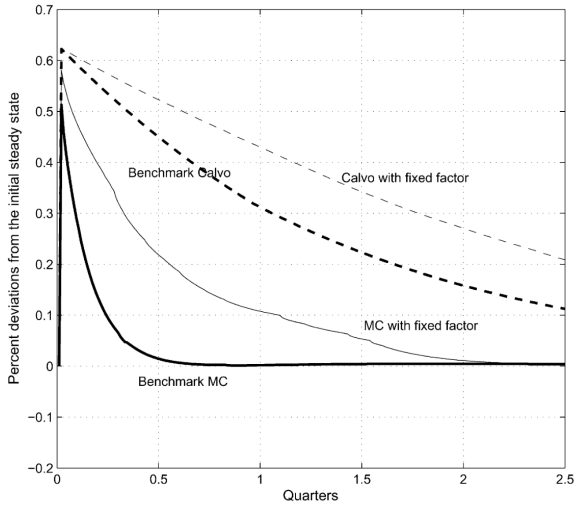


FIG. 5.—Output responses in menu cost and Calvo models

Source: Golosov and Lucas (2007)

Assault on Keynesian Economics

- Bils and Klenow (2004)
  - Prices change every 4-5 months
- Golosov and Lucas (2007)
  - Very strong selection effect
  - 6 times less monetary non-neutrality than in the Calvo model
  - Realistic menu cost model yields monetary non-neutrality that is "small and transient"!

Keynesian Economics Strick Back

- Perhaps the Golosov-Lucas model is not sufficiently realistic to yield credible policy conclusions
- Empirical Issues:
  - How should we treat temporary sales?
  - How does heterogeneity in price rigidity matter?
  - Are all price changes selected?
  - What is a realistic distribution of idiosyncratic shocks?

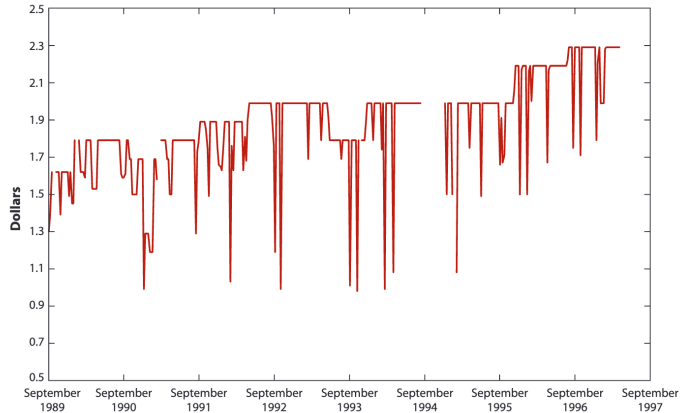


Figure 2

Price series of Nabisco Premium Saltines (16 oz) at a Dominick's Finer Foods store in Chicago.

Source: Nakamura and Steinsson (2013)

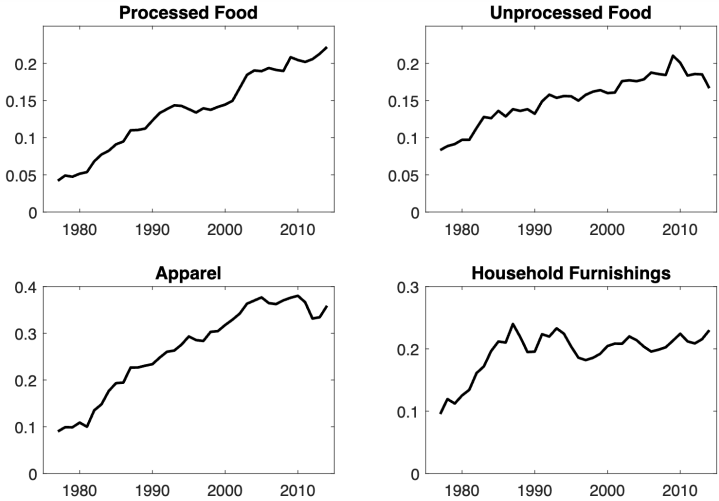
Price Rigidity

- Two features stand out:
  - Change in "regular" price is infrequent and "lumpy": Only 9 "regular price" changes in 7 years
  - Frequent temporary discounts (sales): 117 price changes in 365 weeks
  - Does this product have essentially flexible prices?
  - Or is it’s price highly rigid?

Table: Frequency of Price Change by Major Group 1998-2005

Major Group	Weight	Reg. Price Freq.	Price Freq.	Frac. Price Ch. Sales
Processed Food	8.2	10.5	25.9	57.9
Unprocessed Food	5.9	25.0	37.3	37.9
Household Furnishing	5.0	6.0	19.4	66.8
Apparel	6.5	3.6	31.0	87.1
Transportation Goods	8.3	31.3	31.3	8.0
Recreation Goods	3.6	6.0	11.9	49.1
Other Goods	5.4	15.0	15.5	32.6
Utilities	5.3	38.1	38.1	0.0
Vehicle Fuel	5.1	87.6	87.6	0.0
Travel	5.5	41.7	42.8	1.5
Services (excl. Travel)	38.5	6.1	6.6	3.1

Source: Nakamura and Steinsson (2008)



Source: Nakamura-Steinsson-Sun-Villar (2018)

Table 1 Frequency of price change in consumer prices

	Median		Mean	
	Frequency	Implied duration	Frequency	Implied duration
Nakamura & Steinsson (2008)				
Regular prices (excluding substitutions 1988–1997)	11.9	7.9	18.9	10.8
Regular prices (excluding substitutions 1998–2005)	9.9	9.6	21.5	11.7
Regular prices (including substitutions 1988–1997)	13.0	7.2	20.7	9.0
Regular prices (including substitutions 1998–2005)	11.8	8.0	23.1	9.3
Posted prices (including substitutions 1998–2005)	20.5	4.4	27.7	7.7
Klenow & Kryvtsov (2008)				
Regular prices (including substitutions 1988–2005)	13.9	7.2	29.9	8.6
Posted prices (including substitutions 1988–2005)	27.3	3.7	36.2	6.8

Source: Nakamura and Steinsson (2013)

Table 2 Transience of temporary sales

	Fraction return after one-period sales	Frequency of regular price change	Frequency of price change during one-period sales	Average duration of sales
Processed food	78.5	10.5	11.4	2.0
Unprocessed food	60.0	25.0	22.5	1.8
Household furnishings	78.2	6.0	11.6	2.3
Apparel	86.3	3.6	7.1	2.1

The sample period is 1998–2005. The first data column gives the median fraction of prices that return to their original level after one-period sales. The second is the median frequency of price changes excluding sales. The third lists the median monthly frequency of regular price change during sales that past one month. The monthly frequency is calculated as $1-(1-f)^{0.5}$, where f is the fraction of prices that return to their original levels after one-period sales. The fourth data column gives the weighted average duration of sale periods in months. Data taken from Nakamura & Steinsson (2008).

Source: Nakamura and Steinsson (2013)

Is a Price Change Just a Price Change?

- Temporary sales have very special empirical characteristics
- They are highly transient
- They very often return to the original price
- Strongly suggests that firms are not reoptimizing
- How do these empirical characteristics affect the degree to which temporary sales enhance the flexibility of the aggregate price level?

Kehoe and Midrigan (2015): Just a Summary

- Menu cost model
- Firms can change prices for one period at lower cost
  - Change regular price permanently ("buy" a new price)
  - Temporary sale ("rent" a new price)
- Timing of sales chosen optimally and responds to macro shocks
- Nevertheless, sales generate very little aggregate price flexibility
- Results on monetary non-neutrality close to those if sales had been excluded