Lecture 9: Price Rigidity and Menu Cost Models

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Start by Basic Facts

- How often do price setters change prices?
- Older literature on the 90s looking at very particular prices
  - Examples: Prices of newspapers. Retail prices in a particular supermarket.
- Bils Klenow (2004) use price change reports from the BLS
  - Covers roughly 70% of consumer expenditures
  - Average duration of a price is roughly 4-5 months
  - Suggests a frequency of price change of 20%
  - Average absolute change of price changes is large (10%).
- Back of the envelope calculation
  - If 20% of prices change by 10% every month. Does that suggest an inflation rate of 2% per month?
  - Clearly not. CPI inflation in the USA is roughly 2% **per year**
  - It must be that there are price increases and decreases at the same time
  - Textbook Calvo model doesn't get this right. No role for idiosyncratic price changes

What is a price change

- Above back-of-the-envelopes assumed “a price change is a price change”
- But some empirical issues
  - How do we treat temporary sales?
  - How do we treat seasonal price changes?
  - How do we treat substitutions?
  - Are all prices selected as a function of the **macro** environment?
- Big picture. We are interested in how macroeconomic policy induces price changes
- What matters is how sluggish is aggregate P to changes in aggregate demand

An example

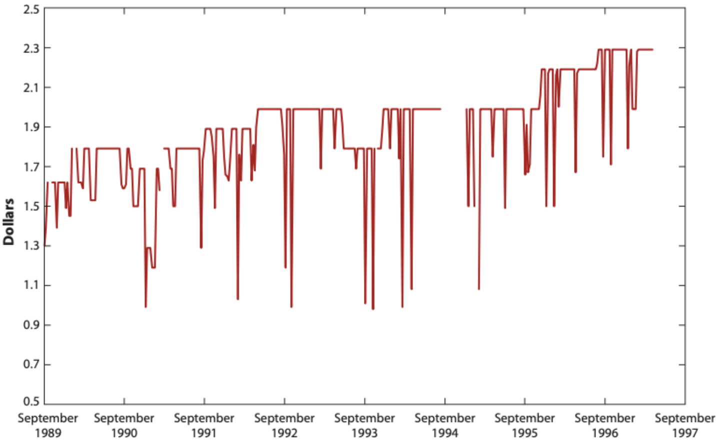


Figure 2

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

Source: Nakamura and Steinsson (2013)

An example

- Sales are frequent and large
- Regular price changes are lumpy and infrequent
- Is this price essentially flexible (117 price changes in 365 weeks)?
- Or essentially rigid (9 regular price changes over 7 years)?

Beyond an Example

TABLE II
FREQUENCY OF PRICE CHANGE BY MAJOR GROUP IN 1998–2005

		Regular prices				Prices				Sales	
		Median				Median					
Major group	Weight	Freq.	Impl. dur.	Mean freq.	Frac. up	Freq.	Impl. dur.	Mean freq.	Frac. up	Frac. price ch.	Frac. obs.
Processed food	8.2	10.5	9.0	10.6	65.4	25.9	3.3	25.5	54.7	57.9	16.6
Unprocessed food	5.9	25.0	3.5	25.4	61.2	37.3	2.1	39.5	53.3	37.9	17.1
Household furnishing	5.0	6.0	16.1	6.5	62.9	19.4	4.6	20.6	49.0	66.8	21.2
Apparel	6.5	3.6	27.3	3.6	57.1	31.0	2.7	30.1	36.1	87.1	34.5
Transportation goods	8.3	31.3	2.7	21.3	45.9	31.3	2.7	22.2	44.0	8.0	2.7
Recreation goods	3.6	6.0	16.3	6.1	62.0	11.9	7.9	13.7	51.3	49.1	10.9
Other goods	5.4	15.0	6.1	13.9	73.7	15.5	5.9	20.6	61.3	32.6	15.3
Utilities	5.3	38.1	2.1	49.4	53.1	38.1	2.1	49.4	53.1	0.0	0.0
Vehicle fuel	5.1	87.6	0.5	87.4	53.5	87.6	0.5	87.5	53.4	0.0	0.3
Travel	5.5	41.7	1.9	43.7	52.8	42.8	1.8	44.4	52.2	1.5	2.1
Services (excl. travel)	38.5	6.1	15.8	8.8	79.0	6.6	14.6	9.1	76.8	3.1	0.5
All sectors	100.0	8.7	11.0	21.1	64.8	19.4	4.6	26.5	57.1	21.5	7.4

Notes. All frequencies are reported in percent per month. Durations are reported in months. Fractions are reported as percentages. Regular prices denote prices excluding sales. "Weight" denotes the CPI expenditure weight of the major group; "median freq." denotes the weighted median frequency of price change. It is calculated by first calculating the mean frequency of price change for each ELI and then taking a weighted median across ELIs within the major group using CPI expenditure weights. The other median statistics in this table are calculated in an analogous manner: "median impl. dur." is equal to $-1/\ln(1-f)$, where f is the median frequency of price change. "Mean freq." denotes the expenditure weighted mean frequency of price change; "frac. up" denotes the median fraction of price changes that are price increases; "frac. price ch." and "frac. obs." denote the expenditure weighted mean fraction of price changes that are due to sales and fraction of observations that are sales. The sector weights add up to 97.4% because used cars are not included in any sector.

Source: Nakamura and Steinsson (2008)

Sales seem special. CPI vs. PPI

TABLE VII
FREQUENCY OF PRICE CHANGE: COMPARISON OF CPI AND PPI CATEGORIES

Category	Number of matches	Frequency: CPI w/sales	Frequency: CPI nonsale	Frequency: PPI	Implied duration: CPI w/sales	Implied duration: CPI nonsale	Implied duration: PPI
Processed food	32	26.1	10.5	7.2	3.3	9.0	13.4
Unprocessed food	24	37.3	25.9	67.9	2.1	3.3	0.9
Household furnishings	27	23.0	6.5	5.6	3.8	14.9	17.3
Apparel	32	31.0	3.6	2.7	2.7	27.3	36.3
Recreation goods	16	14.5	6.8	6.1	6.4	14.2	15.9
Other goods	13	33.6	23.2	17.1	2.4	3.8	5.3

Notes. "Number of matches" denotes the number of ELIs matched to four-, six-, or eight-digit commodity codes within the PPI in the major group. "Frequency" denotes the median frequency of price change. "Implied duration" denotes $-1/\ln(1-f)$, where f is the median frequency of price change. Medians for the consumer price data are calculated by first calculating an average within each ELI and then calculating an expenditure-weighted median across ELIs within the major group. Medians for the producer price data are calculated by first calculating the mean frequency of price change for each cell code, then taking an unweighted median within a four-digit commodity code, and then taking a value-weighted median across four-digit commodity codes. All statistics are for the period 1998–2005.

Source: Nakamura and Steinsson (2008)

Price changes are large and plenty in both directions

TABLE VIII
ABSOLUTE SIZE OF PRICE CHANGES

		Regular prices			Sales			All prices
Major group	Weight	Median change	Median increase	Median decrease	Median change	Median ratio	Frac. price ch.	Median change
Processed food	8.2	13.2	11.5	17.6	33.1	2.6	57.9	26.5
Unprocessed food	5.9	14.2	13.9	15.0	35.1	2.5	37.9	27.1
Household furnishings	5.0	8.7	8.0	9.8	28.0	2.8	66.8	20.8
Apparel	6.5	11.5	10.0	13.3	37.1	3.1	87.1	30.2
Transportation goods	8.3	6.1	5.9	6.2	14.1	0.9	8.0	6.1
Recreation goods	3.6	10.1	8.7	12.0	32.9	3.1	49.1	18.9
Other goods	5.4	7.3	7.2	9.2	26.5	2.9	32.6	10.0
Utilities	5.3	6.3	6.2	6.4	12.6	1.6	0.0	6.3
Vehicle fuel	5.1	6.4	6.8	5.9	11.7	1.8	0.0	6.4
Travel	5.5	21.6	20.9	22.4	29.3	1.4	1.5	21.9
Services (excl. travel)	38.5	7.1	6.5	9.5	29.5	2.9	3.1	7.3
All sectors	100.0	8.5	7.3	10.5	29.5	2.6	21.5	10.7

Notes. The sample period is 1998–2005. "Regular prices" denotes prices excluding sales. "Weight" denotes the CPI expenditure weight of the major group. "Median change," "Median increase," and "Median decrease" refer to the weighted median absolute size of log price changes, increases, and decreases, respectively. The median absolute size of log price changes is calculated by first calculating the mean absolute size of log price changes for each ELI and then taking a weighted median across ELIs using CPI expenditure weights. Other median statistics are calculated in an analogous manner. "Median ratio" denotes the weighted median ratio of the mean absolute size of log price changes due to sales to the absolute size of log regular price changes within ELIs. For each ELI the mean size of sales is calculated for all price changes at the beginning and end of sales. "Frac. price ch." denotes the mean fraction of price changes that are due to sales. The sector weights add up to 97.4% because used cars are not included in any sector.

Source: Nakamura and Steinsson (2008)

Frequency of adjustment comoves with inflation - USA

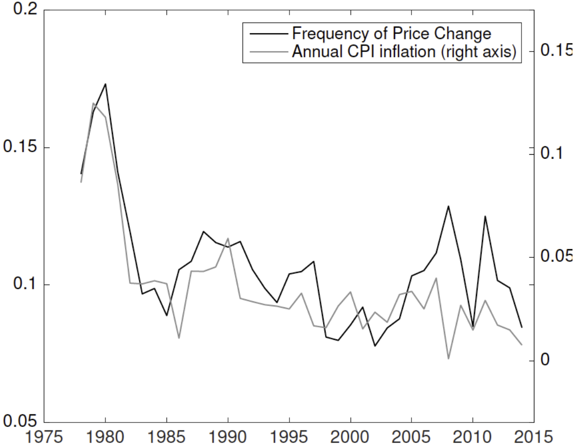
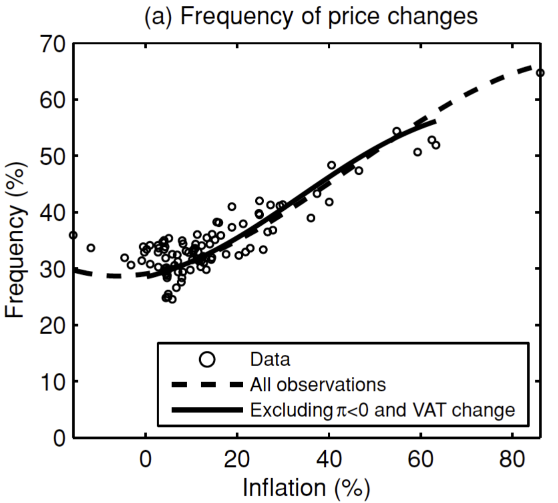


Figure 12: Frequency of Price Changes in U.S. Data

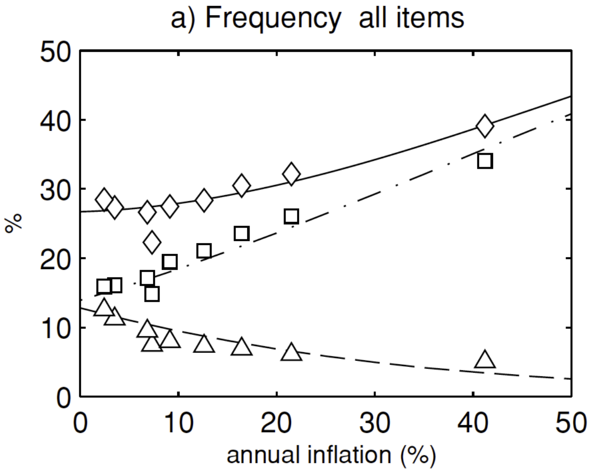
Source: Nakamura-Steinsson-Sun-Villar (2018)

Frequency of adjustment comoves with inflation - Mexico



Source: Gagnon (2009)

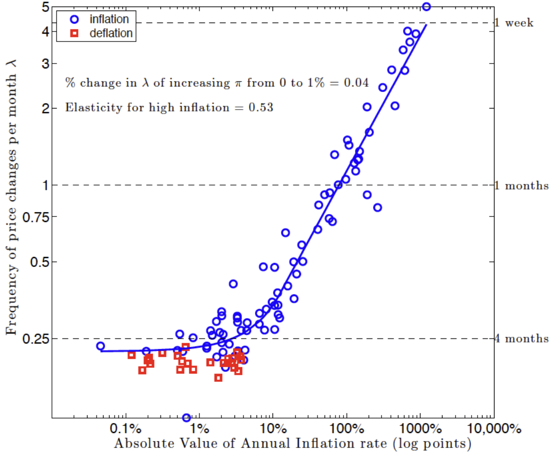
Frequency of adjustment comoves with inflation - Mexico



Source: Gagnon (2009). Diamonds: data on changes. Boxes: data on increases.
Triangles: data on decreases. Lines: corresponding statistics from model.

Frequency of adjustment comoves with inflation - Argentina

Figure 6: The Frequency of Price Changes (λ) and Expected Inflation.



Many arrows point in the same direction

- Remember in Calvo only one invariant parameter mattered: the frequency of price changes
- Perhaps our Calvo model is "too simple"
- Some reasons:
  - The frequency of price changes comoves with inflation
  - The share of price increases vs. price decreases moves with inflation
  - Absolute size of price changes does not comove with inflation
- Suggests that:
  - Maybe price resetters are "selected" (i.e., not a random sample of firms)
  - This issue in the literature is called "the selection effect"

Caplin-Spulger model

- The math is beyond the point. It can be explained easily intuitively.
- The monetary authority targets nominal GDP (easy to microfound with a central bank that targets the money supply and there is cash-in-advance constraint in the background)
- In logs $m_t = y_t + p_t$
- m_t is increasing. and desired prices are $p_t^* \propto m_t$
- Firms must pay a fixed cost to change their price
- When relative price goes below s firms adjust it to S
- These class of models that we will specify more, are called sS models
- Initial distribution of firms is uniform $\in [s, S]$.

Caplin-Spulger model

- Imagine m increases by an amount Δm
- Any firm with a relative price below $s + \Delta m$ will adjust (the increase in m puts them below s
- They all adjust to S
- Share of firms that adjust? Because of the uniform distribution:

$$\frac{\Delta m}{S - s}$$

- By how much do they adjust?

$$S - s$$

- Total price change

$$\Delta p = \frac{\Delta m}{S - s} S - s = \Delta m$$

- Change in total output?

$$\Delta y = \Delta m - \Delta p = 0$$

- Money is neutral!

Calvo vs. Caplin Spulberg

- In Calvo, firms that adjust their prices are chosen at random
- These may be firms that do not need to adjust their prices by much
- Many price adjustments are “wasted” in firms that adjust little when given the chance
- So the aggregate price level moves slowly
- In Caplin and Spulberg firms that change their price are firms that need to reset the most
- The aggregate price level moves rapidly

Calvo vs. Caplin-Spulberg

- Both models are extremes
- Calvo
  - Aggregate conditions have no effect on the share or the identity of firms that adjust
- Caplin Spulberg
  - Fully determine which, and how many firms adjust
  - Other very special assumptions (uniform initial distribution), Δm shocks do not alter the uniform distribution are very important

Golosov Lucas 07 (modified)

- Household prefereces (log + linear)

$$\mathbb{E}_0 \sum \beta^t \left(\log C_t - \omega L_t\right)$$

- C a CES aggregator

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

- subject to a series of budget constraints

$$P_t C_t + Q_{t+1} B_{t+1} \leq W_t L_t + \int \Pi_t(z) dz$$

Household optimization

Very standard. Special case of our previous models

$$c_t(z) = C_t \left(\frac{p_t(z)}{P_t} \right)^{-\theta} \tag{1}$$

$$W_t = \omega P_t C_t \tag{2}$$

Notice that the real wage is proportional to consumption

Monetary policy

- Similar than in the simple Caplin Spulberg model

$$S_t = P_t C_t \tag{3}$$

- Central bank sets the money supply according to

$$\log S_t = \mu \log S_{t-1} + \eta_t \tag{4}$$

- for η distributed $N(0, \sigma_\eta^2)$
- η is the only aggregate shock

Firm's problem

- Linear production function on labor with idiosyncratic productivity shocks

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

- Marginal cost of production is $W_t/A_t(z)$
- $\log A_t(z) = \rho \log A_{t-1}(z) + \epsilon_t(z)$, for ϵ distributed $N(0, \sigma_\epsilon^2$

Firm's problem

- Maximize NPV of dividends

$$\mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t,t+k} \Pi_t(z)$$

- where profits are

$$\Pi_t(z) = p_t(z) y_t(z) - W_t L_t(z) - \chi_j W_t I_t(z)$$

- Hire χ_j units of labor to change prices
- Λ the SDF

Fixed cost

- Cannot log-linearize this problem. Kink because of fixed costs.
- Must go with dynamic programming

$$V(Z_t) = \max_{p_t} \Pi_t^R(z) + \mathbb{E}(\Lambda_{t,t+1}^R V(Z_{t+1}))$$

- where $\Pi^R(z) = C_t \left(\frac{p_t(z)}{P_t}\right)^{-\theta} \left(\frac{p_t(z)}{P_t} - \frac{1}{A_t(z)} \frac{W_t}{P_t}\right) - \chi_j \frac{W_t}{P_t} I_t(z)$
- Z_t are the state variables. What are the state variables?
- In general: everything that affects firms's value
- $A_t(z), p_{t-1}(z)/P_t, C_t$
- Any variable that you need to forecast C_{t+1}, P_{t+1}
- So you need the entire distribution of $A_t(z), p_{t-1}(z)/P_t$

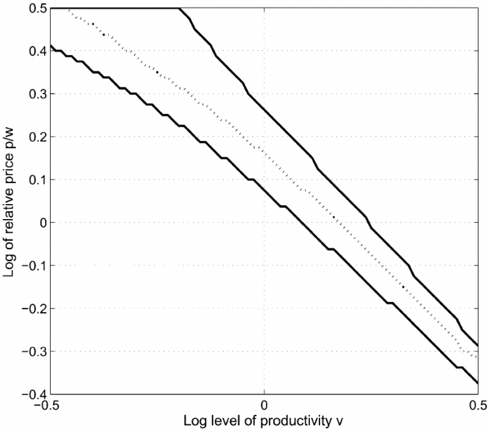
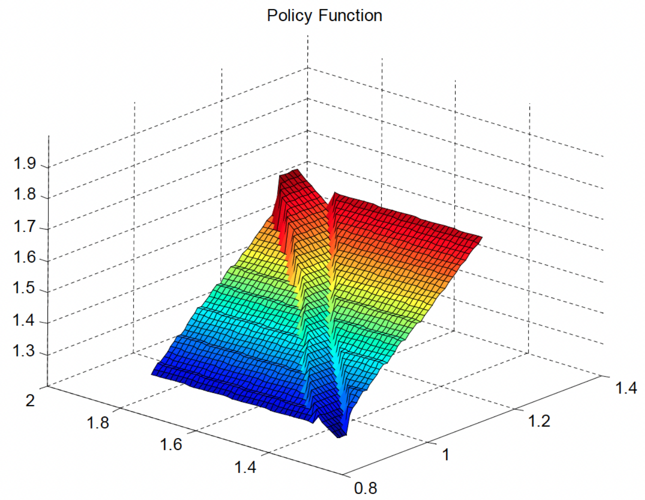


FIG. 1.—Pricing bounds for 0.64 percent quarterly inflation. Solid lines: upper and lower bounds $U(v)$ and $L(v)$. Dotted line: $g(v)$.

Source: Golosov and Lucas (2007)



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

Source: Golosov and Lucas (2007)

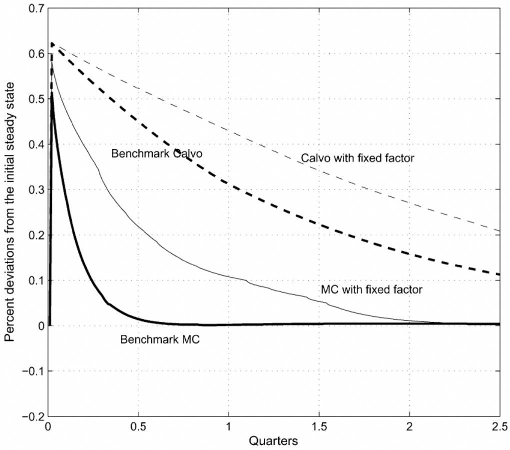


FIG. 5.—Output responses in menu cost and Calvo models

Source: Golosov and Lucas (2007)

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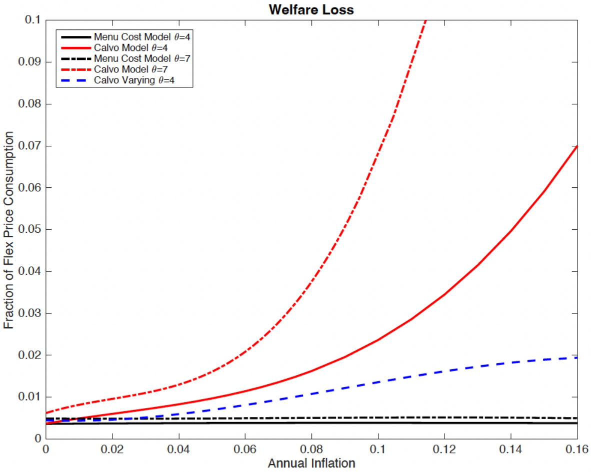
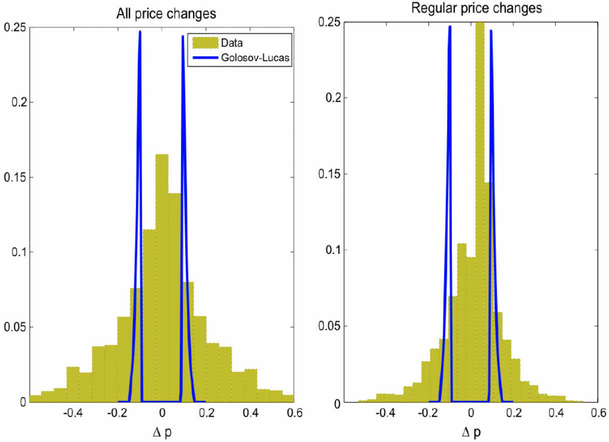


Source: Nakamura Steinsson Sun Villar (2018)

Issues with Golosov Lucas (2007)

- Calibrated using Bils Klenow numbers
- Golosov and Lucas (2007): Monetary non-neutrality is small and transient. But!
  - Remember our discussion about regular vs. sales.
  - Abstracts from sectoral heterogeneity in price rigidity. Paula will talk how important this is
  - Odd predictions about the distribution of price changes (see next slide)
  - Once “fixed” menu cost model waaay closer to Calvo
  - But we saw Calvo fails in many dimensions too!

Distribution of p changes: Data vs. GL model



Source: Midrigan (2011)

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