THE ELUSIVE COSTS OF INFLATION: PRICE DISPERSION DURING THE U.S. GREAT INFLATION

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August 2016
What level of inflation should central banks target?

- Pre-crisis policy consensus to target roughly 2% inflation per year
- Academic studies argued for still lower rates
  (Schmitt-Grohe and Uribe, 2011; Coibon et al., 2012)

- Great Recession has lead to increasing calls for higher inflation targets
  - Blanchard, Dell’Ariccia, Mauro (2010), Ball (2014), Krugman (2014)
  - Blanco (2015)
Price Dispersion and the Costs of Inflation

- Higher inflation will lead to higher price dispersion
  - Prices will drift further from optimum between times of adjustment
  - Distorts allocative role of the price system
- In standard New Keynesian models, these costs are very large
  - Going from 0% to 12% inflation per year yields a 10% loss of welfare
- Much more costly than business cycle fluctuations in output in these same models
**THIS PAPER**

- Measure sensitivity of inefficient price dispersion to changes in inflation

**Challenges:**

1. Very limited variation in inflation over last 30 years!
   - We extend BLS micro-data on consumer prices back to 1977
   - Covers "Great Inflation" and Volcker disinflation

2. Difficulty in interpreting raw price dispersion
   - Heterogeneity in size and quality of products
   - Absolute size of price changes informative about inefficient price dispersion
**Figure:** CPI Inflation in the U.S. (excluding shelter)
**This Paper**

- Measure sensitivity of inefficient price dispersion to changes in inflation

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Elusive Costs of Inflation

No evidence of increased price dispersion in Great Inflation period:
- Absolute size of price change is completely flat over 1978-2014
- Even standard deviation of absolute size is completely flat

Main cost of inflation in New Keynesian models completely elusive
Optimality of low inflation based on these models needs to be reassessed

(Other costs of inflation may be important)
Have prices become more flexible over past 40 years?
- Tremendous technological change
- Perhaps changing prices has become cheaper

Regular prices no more flexible

Dramatic increase in frequency of temporary sales

Is this the form which increased flexibility takes?
- Service sector has no sales
- Prices not more flexible in service sector

Frequency of price change very sensitive to inflation

Both absolute size and frequency facts favor menu cost model over Calvo model
Earlier work on standard deviation of sectoral inflation:

- Vining and Elwertowski 76, Parks 78, Fisher 81

Earlier work on price change dispersion:

- Van Hoomissen 88, Lach and Tsiddon 92, Vavra 14;

Very limited literature on price dispersion:

- Alvarez et al. 16 (Argentine hyperinflation)
Why Is Inflation so Costly in Standard Sticky Price Models?
Households maximize

$$E_t \sum_{j=0}^{\infty} \beta^j [\log C_{t+j} - L_{t+j}]$$

where

$$C_t = \left[ \int_0^1 c_{it}^{\frac{\theta}{\theta-1}} \frac{\theta}{\theta-1} \right]^{\frac{\theta}{\theta-1}},$$

subject to

$$P_t C_t + Q_{it} B_{it} \leq W_t L_t + (D_{it} + Q_{it}) B_{it-1}.$$
Household optimization implies demand curves for individual products:

\[ c_{it} = \left( \frac{p_{it}}{P_t} \right)^{-\theta} C_t, \]

where

\[ P_t = \left[ \int_0^1 p_{it}^{1-\theta} \, di \right]^{\frac{1}{1-\theta}} \]

a labor supply equation

\[ \frac{W_t}{P_t} = C_t \]

and asset (dividend strip) valuation equation:

\[ V_{it}^j = E_t \left[ \beta^j \left( \frac{C_{t+j}}{C_t} \right)^{-1} D_{t+j} \right] \]
Firms:

- Monopoly suppliers of differentiated variety
- Face costs of changing prices (we consider different specifications)
- Production function:
  \[ y_{it} = A_{it} L_{it} \]
  where idiosyncratic productivity \( A_{it} \) follows AR(1) in logs
- Implies that marginal costs are
  \[ MC_{it} = \frac{W_t}{A_{it}} \]
Costs of Inflation in Sticky Price Models

- Monetary policy controls nominal aggregate demand $S_t = P_t Y_t$
- Nominal aggregate demand follows a random walk with drift:

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

- Prices set by firm $i$:
  \[ p_{it} = \frac{\theta}{\theta - 1} \frac{W_t}{A_{it}} \]

- Aggregating over all firms yields:
  \[ P_t = \frac{\theta}{\theta - 1} \frac{W_t}{A_f} \]

  where
  \[ A_f = \left[ \int_0^1 A_{it}^{\theta - 1} di \right]^{\frac{1}{\theta - 1}} \]

- Aggregation of production function yields:
  \[ Y_t = A_f L_t \]
Output, labor supply and real wage determined by:

Labor Supply: \( \frac{W_t}{P_t} = Y_t \)

Production Function: \( Y_t = A_f L_t \)

Markup: \( P_t = \Omega_f \frac{W_t}{A_f} \).

Solution:

\[
Y_t = \Omega_f^{-1} A_f \\
L_t = \Omega_f^{-1}.
\]

Notice that solution is independent of inflation.
EQUILIBRIUM WITH STICKY PRICES

Useful to consider analogous set of equations to flex price case:

Labor Supply: \[ \frac{W_t}{P_t} = Y_t \]

Production Function: \[ Y_t = A_t(\bar{\pi})(L_t - L_{pc}^t) \]

Price Setting: \[ P_t = \Omega_t(\bar{\pi}) \frac{W_t}{A_t(\bar{\pi})} \]

where \[ A_t(\bar{\pi}) = \left[ \int_0^1 \left( \frac{p_{it}}{P_t} \right)^{-\theta} A_{it}^{-1} di \right]^{-1} \]

and the last equations is simply definition of “aggregate markup” (\( \Omega_t(\bar{\pi}) \))
Solution:

\[ Y_t = \Omega_t(\bar{\pi})^{-1} A_t(\bar{\pi}) \]
\[ L_t = \Omega_t(\bar{\pi})^{-1} + L_{t}^{pc} \]

Three potential sources of welfare loss from inflation:

- Labor needed to change prices: \( L_{t}^{pc} \)
- Lower labor productivity: \( A_t(\bar{\pi}) < A_f \)
- Aggregate markup different: \( \Omega_t(\bar{\pi}) \neq \Omega_f \)
Welfare with Sticky Prices

- Measure of welfare (consumption equivalent loss):

\[ E \left[ \log \left( (1 + \Lambda) C^A_t \right) - L^A \right] = E \left[ \log \left( C^B_t \right) - L^B \right]. \]

- We consider several cases:
  - Menu cost model (constant fixed cost of price change)
  - Calvo model (randomly infinite or zero cost of price change)

- Calculate equilibrium numerically using methods described in Nakamura and Steinsson (2010)
CALIBRATION

- Already made several “calibration choices”:
  - Log utility in consumption
  - Linear disutility of labor
  - Linear production function
- Subjective discount factor: $\beta = 0.96^{1/12}$
- Elasticity of substitution between individual goods: $\theta = 4$
- Menu cost and standard deviation of idiosyncratic shocks set to match frequency and size of price changes
- Persistence of idiosyncratic shocks set to 0.7
Welfare Loss

- Menu Cost Model $\theta=4$
- Calvo Model $\theta=4$
- Menu Cost Model $\theta=7$
- Calvo Model $\theta=7$

Calvo Varying

Nakamura, Steinsson, Sun, Villar

Price Adjustment

August 2016
Output

Log Change from Flex Price Value vs. Annual Inflation

Menu Cost Model
Calvo Model

Labor

Log Change from Flex Price Value vs. Annual Inflation

Nakamura, Steinsson, Sun, Villar
Menu Cost Model:

- Welfare costs are small
- Welfare costs are unresponsive to moderate inflation

Calvo Model:

- Welfare costs rise rapidly with inflation
- Welfare costs arise from loss in labor productivity

\[ A_t(\bar{\pi}) = \left[ \int_0^1 \left( \frac{p_{it}}{P_t} \right)^{-\theta} A_{it}^{-1} d\pi \right]^{-1} \]
Inefficient Price Dispersion

- Menu Cost Model
- Calvo Model

Annual Inflation

Nakamura, Steinsson, Sun, Villar
Price Adjustment
August 2016
New Micro Data on Consumer Prices During the U.S. Great Inflation
We digitized micro data underlying the U.S. CPI for period May 1977 to October 1986
- Contains Great Inflation and Volcker disinflation periods
Obtained separately data for May 1987 to December 1987
Existing CPI Research Database has sample period from 1988 onward

Full sample 1978 to 2014
- Drop 1977 data (quality concerns)
- 6 month gap in 1986-1987
Information in Dataset

- Product category (ELI) (e.g., toothpaste)
- Location (e.g., Chicago)
- Outlet (e.g., Pathmark at corner of 125th St. and Lex Ave)
- Product (e.g., 2L bottle of Diet Coke)
- Price
- Sales flag, imputation flag

Sample size: Varies from 80k to 100k per month
Two phases:

- Scanning of microfilm images
  - Obsolete cartridges which don’t fit modern scanners
- Conversion of scanned images to machine readable form
  - Customer optical character recognition software
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Price Adjustment  
August 2016  
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Eliminating OCR Errors

- Great deal of redundancy on Scanned Images
  - Each image contains data from 12 months (i.e., current an 11 past months)
  - Each cell contains price and price change

- Two algorithms to verify accuracy:
  - Compare different price observations for product-month
    - Accept if two or more the same
  - Compare reported price change with calculated price change
    - Accept if the same

- Only use prices accepted by one of two algorithms
- Similar procedures for sales flag, imputations flag
Empirical Results
If all products were homogenous within product category ...  
... simply calculate cross-sectional variance

In practice, large amount of heterogeneity in size and quality within product category

This creates “efficient” dispersion in prices

“Efficient” dispersion may dwarf “inefficient” dispersion
Alternative approach: Focus on *absolute size* of price changes

- Absolute size reveals distance of prices from desired prices
- If prices are drifting further from desired level due to inflation, should change by more when they change
Mean Absolute Size of Price Changes

- **Menu Cost Model**
- **Calvo Model**

**Fraction of Original Price**

**Annual Inflation**

- **Calvo Varying**
- Nakamura, Steinsson, Sun, Villar
- Price Adjustment
- August 2016


Welfare losses non-linear in deviation of price from efficient price

\[ A_t(\bar{\pi}) = \left[ \int_0^1 \left( \frac{p_{it}}{P_t} \right)^{-\theta} A_{it}^{-1} \, di \right]^{-1} \]

Largest deviations matter disproportionately

Conditional on mean absolute size, standard deviation informative about prevalence of very large price changes
Standard Deviations of Absolute Size of Price Changes

Menu Cost Model
Calvo Model

Transitory Inflation
Calvo Varying

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Price Adjustment
August 2016
No evidence that mean or standard deviation of absolute size of price changes rose during Great Inflation

Suggests inefficient price dispersion not any higher during Great Inflation

Costs of inflation emphasized in New Keynesian models elusive
Frequency of Price Change

- Flip-side of “size” is frequency of price change
  - If size unaffected by inflation, frequency must vary
- Useful to distinguish between models of price setting:
  - Frequency constant in Calvo model ...
    - ... but varies with inflation in menu cost model
Frequency of Price Change

Menu Cost Model
Calvo Model

Transitory Inflation
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Frequency of Price Increases and Decreases

- Frequency of Price Increases
- Frequency of Price Decreases
- CPI Inflation (right axis)

Sectors

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Price Adjustment

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**Table**: Summary Statistics by Sample
Large changes in technology over past 40 years
Perhaps costs of changing prices have fallen?
This would make price changes more frequent

Can evolution of frequency of price (excluding sales) change be explained by menu cost model with a constant menu cost over entire sample period?
Have Prices Become More Flexible?

- Regular prices (excluding sales) have not become more flexible

- What about temporary sales? Have they become more prevalent?
Sales and Price Flexibility

- Frequency of temporary sales has increased dramatically
- What does this imply about aggregate price flexibility?
  - i.e., how rapidly aggregate price level responds to shocks
- Sizable recent literature has largely concluded that effects of sales on aggregate price flexibility are small:
  - Sales are very transient
  - Sales are strategic substitutes
  - Sales are “on autopilot”
CONCLUSIONS

- New micro dataset on consumer prices from Great Inflation period
- No evidence that price dispersion was higher during Great Inflation
- Main costs of inflation in New Keynesian models elusive in data
- No change in price flexibility of regular prices over 40 years
- Dramatic increase in frequency of temporary sales
Appendix
Welfare Loss

Menu Cost Model $\theta=4$
Calvo Model $\theta=4$
Menu Cost Model $\theta=7$
Calvo Model $\theta=7$
Calvo Varying $\theta=4$

Annual Inflation
Fraction of Flex Price Consumption
Welfare Loss
Standard Deviations of Absolute Size of Price Changes

- Menu Cost Model
- Calvo Model
- Calvo Varying