Micro and Macro Evidence on Inflation and Monetary Policy

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January 2022
Consensus in mainstream media that effects are large.
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Sometimes we forget this is surprising!

Monetary policy is fundamentally all about units!
  - Surprising it does anything at all
THE IMPORTANCE OF UNITS

Suppose I double the money supply
- If price level doubles...

Suppose I double the nominal interest rate
- If inflation rises by the same amount...

Suppose exchange rate devalues
- If $P_{US}/P_{For}$ adjusts by same amount...

...Then nothing “real” changes
March 13 2022: Clocks roll forward by one hour
  - Intended to optimize meeting times vs. daylight

If meeting times were set optimally already, DST wouldn’t matter
  - Apparently it does
  - More heart attacks on March 14
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“Obvious” reasons:
  - Coordination, simplicity, etc.
  - Similar arguments for prices
1. **Micro evidence**
   - Haircuts, washing machines, saltine crackers...
   - “Price rigidity”

2. **Macro evidence**
   - Discontinuity/ Heteroskedasticity-based identification
   - Regional data
   - “Phillips curves”
Source: Dhyne et al. (2006)
Coffee Wholesale and Commodity Prices

Source: Nakamura and Zerom (2010)
Measuring Price Rigidity: Harder than You Think

Figure 1
Response of Real Output and the Price Level to a One-Time Permanent Shock to Nominal Aggregate Demand

Figure 2
Price of Nabisco Premium Saltines 16 oz. at a Dominick’s Finer Foods Store in Chicago

Source: Nakamura and Steinsson (2013)
Frequency of Sales

Source: Nakamura-Steinsson-Sun-Villar (2018)
Note: To construct the frequency series plotted in this figure, we first calculate the mean frequency of price changes in each ELI for each year. We then take the weighted median across ELI's.

The most striking feature of this figure is that it is the frequency of price increases that varies with the inflation rate, while the frequency of price decreases is unresponsive. Nakamura and Steinsson (2008) show that this asymmetry arises naturally in the menu cost model when prices are drifting upward due to a positive average inflation rate. In this case, prices tend to "bunch" toward the bottom of their inaction region. Because of this bunching, when there is an aggregate shock that changes desired prices, there is a large response of the frequency of price increases (reflecting the relatively large mass at the bottom of the band), but a much smaller response of the frequency of price decreases. This is the same argument as the one described by Foote (1998) for why job destruction will be more volatile than job creation in declining industries.

One curious feature of Figure 12 is the spike in the frequency of price changes that occurs in 2008. Looking at Figure 13 and especially the analogous plot for food in Figure A.3 in the appendix, we see however, that inflation was highly volatile in 2008. It first spiked up due to the

Figure A.3 presents figures analogous to Figure 13 for two important sectors in our data: food and services. In this figure, the inflation rate that we plot on each panel is the sectoral inflation rate in that sector. In both sectors, the frequency of price increases covaries strongly with inflation, while the frequency of price decreases is largely flat.

Source: Nakamura-Steinsson-Sun-Villar (2018)
An alternative (arguably better) measure of price flexibility is the menu cost needed to match the frequency of price change at a particular point in time given the level of inflation at that time. If the menu cost model is able to match the frequency of price change over time with a constant menu cost, this would indicate that prices (excluding sales) have not become more flexible over time.

Figure 14 presents the results of this type of exercise. The broken lines in the figure are the frequency of price increases and decreases in the data. The solid lines are the frequency of price increases and price decreases from a simple menu cost model with a constant menu cost.

Evidently, the frequency of price change in the data tracts the model implies frequency of price change quite well over time as inflation rises and falls. If the costs of price adjustment had trended down over the past four decades, one would expect that our model would systematically underpredict the frequency of price change toward the end of the sample period. This is not the case.

Since our simple menu cost model with a fixed cost of price adjustment can explain the overall...
Consider a shock that causes households and firms to deleverage...

- Sharp increase in desire to save $\rightarrow$
- Drop in “natural” rate of interest
- Nominal rates are at ZLB
- Need inflation to make real rates fall
- In frictionless model: prices *jump* down and rise
- But will this really happen?
- If prices adjust more sluggishly, real rate may rise rather than fall!
1931: Economy in freefall

- Major banking crisis, US on Gold Standard
- Prices fell $\approx 30\%$ peak-trough
- Inflation massively negative
- Led to *elevated* real interest rates

- Huge turnaround when Roosevelt comes into office and goes off gold
More Generally

Inflation (and real interest rates) matter for modeling response to all shocks:

- Stock/house prices
- Optimism / “Animal Spirits”
- Tax rebates, etc.

Not just monetary shocks!

Simple macro models:

- \( r \) matters for intertemporal substitution (affects \( C, I \))
- But is this the key mechanism?
- Role of banks may be crucial (e.g. credit constraints)
- Wealth effects of asset price responses
Suppose I invent the EmiDollar

- I have the “printing presses”
  (Can inject EmiDollars into your account, saved on my computer)
- I can make EmiFOMC announcements of interest rates on EmiDollars
- Does it matter?
Suppose I invent the EmiDollar

- I have the “printing presses”
  (Can inject EmiDollars into your account, saved on my computer)
- I can make EmiFOMC announcements of interest rates on EmiDollars
- Does it matter?
  - No, but why?
  - No one sets prices in EmiDollars
  - Monetary actions will cause changes in EmiDollar ex. rate vs. USD$

Unit of account matters!

(Obvious analogy with Bitcoin)
Empirical Evidence on Inflation Dynamics

1. Micro evidence
   - Haircuts, washing machines, saltine crackers...
   - “Price rigidity”

2. Macro evidence
   - Discontinuity/ Heteroskedasticity-based identification
   - Regional data
   - “Phillips curves”
US/German Real Exchange Rate

Source: Nakamura and Steinsson (2018)
Figure 1. Intraday Trading in Federal Funds Futures Contracts

(a) June 25, 2003 (July 2003 Contract)

Source: Gurkaynak-Sack-Swanson (2005)
Nakamura and Steinsson (2018):

- Simple summary statistic for Fed actions
- First principle component of changes in 5 interest rate futures
  - Fed Funds futures, Eurodollar futures
  - Span year after FOMC meeting
    (Similar to GSS 05 “path factor”)
- Sample period 2000-2014
<table>
<thead>
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<th>Nominal</th>
<th>Real</th>
<th>Inflation</th>
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<td>2Y Treasury Yield</td>
<td>1.10</td>
<td>1.06</td>
<td>0.04</td>
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<td>(0.33)</td>
<td>(0.24)</td>
<td>(0.18)</td>
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<td>5Y Treasury Yield</td>
<td>0.73</td>
<td>0.64</td>
<td>0.09</td>
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<td>(0.20)</td>
<td>(0.15)</td>
<td>(0.11)</td>
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<td>10Y Treasury Yield</td>
<td>0.38</td>
<td>0.44</td>
<td>-0.06</td>
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<td>(0.17)</td>
<td>(0.13)</td>
<td>(0.08)</td>
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<td>2Y Treasury Inst. Forward Rate</td>
<td>1.14</td>
<td>0.99</td>
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<td>(0.46)</td>
<td>(0.29)</td>
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<td>3Y Treasury Inst. Forward Rate</td>
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<td>0.88</td>
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<td>(0.43)</td>
<td>(0.32)</td>
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<tr>
<td>5Y Treasury Inst. Forward Rate</td>
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<td>10Y Treasury Inst. Forward Rate</td>
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<td></td>
<td>(0.18)</td>
<td>(0.12)</td>
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Effect of Monetary Shocks on Real Rates

Source: Nakamura-Steinsson (2016)
How long can price rigidity persist?

- Nominal price stickiness not the whole story!
  - Staggered price setting
  - Strategic complementarity among price setters
    (firm A’s optimal price increasing in firm B’s price)
- These features can potentially interact to create a lot of sluggishness
  - Pass-through regressions
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Reference: “The Slope of the Phillips Curve: Evidence from U.S. States” with Jonathon Hazell, Juan Herreno, Jon Steinsson
Classic literature attempts to estimate:

\[ \pi_t = -\kappa (u_t - u^*_{t}) + \beta E_t \pi_{t+1} + \nu_t \]

- First term: Response to unemp. gap \( u_t - u^*_{t} \)
  - Measure of aggregate demand
  - \( \kappa \) is “slope” of Phillips curve
  - “Old Keynesian” Phillips curve

- Second term: Expected inflation \( E_t \pi_{t+1} \)

- Third term: supply shocks: \( \nu_t \)
PHILLIPS CURVE: IDENTIFICATION

How to estimate?

\[ \pi_t = -\kappa(u_t - u^n_t) + \beta E_t \pi_{t+1} + \nu_t \]

Challenge:
- \( \pi_t, u_t, \) and \( E_t \pi_{t+1} \) are endogenous variables!
**Phillips Curve: Identification**

How to estimate?

\[ \pi_t = -\kappa (u_t - u^n_t) + \beta E_t \pi_{t+1} + \nu_t \]

Challenge:

- \( \pi_t, u_t, \) and \( E_t \pi_{t+1} \) are endogenous variables!
  - Very challenging identification problem
  - OLS won’t work
  - Similar to demand curve estimation
    (but with some added twists)
  - Not impossible!
  - But need careful identification approaches / instruments
Can “solve forward” previous equation to get:

$$\pi_t = -\kappa E_t \sum_{j=0}^{\infty} \beta^j \tilde{u}_{t+j} + E_t \pi_{t+\infty} + \omega_t$$

Notes:

- $\tilde{u}_{t+j}$ is cyclical unemployment
- First term reflects Phillips curve slope
discounted present value $\rightarrow$ persistence matters
- Second term is long run inflation expectations $E_t \pi_{t+\infty}$
THE ROLE OF THE LONG-RUN INFLATION TARGET

\[ \pi_t = -\kappa E_t \sum_{j=0}^{\infty} \beta^j \tilde{u}_{t+j} + E_t \pi_{t+\infty} + \omega_t \]

- Long-run inflation target major determinant of current inflation
  - Has a coefficient of one
  - Current inflation moves one-for-one with beliefs about long-run inflation target

- Inflation can vary without \textbf{any} variation in output gap, purely due to \( E_t \pi_{t+\infty} \)
  - Potentially a source of severe omitted variables bias when estimating \( \kappa \)
LONG-RUN INFLATION EXPECTATIONS

Core CPI Inflation - Research Series
Long-Run SPF Forecast of CPI Inflation

Year
Regional Business Cycles

Nakamura-Steinsson (UC Berkeley)  Micro and Macro Evidence
Regional Variation:

- Texas goes into boom but Illinois does not
Regional Phillips Curves?

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Could we use diff-in-diff approach?

- How much does inflation rise in Texas relative to Illinois?
Regional Variation:
- Texas goes into boom but Illinois does not

Could we use diff-in-diff approach?
- How much does inflation rise in Texas *relative* to Illinois?
- Panel data has many advantages
  - More datapoints, more options for identification
Not obvious we can use slope of *relative* Phillips curve to learn about slope of *aggregate* Phillips curve

Regional analysis is about “relative” prices
(not aggregate inflation)

Fundamentally different experiments
Not obvious we can use slope of *relative* Phillips curve to learn about slope of *aggregate* Phillips curve

Regional analysis is about “relative” prices (not aggregate inflation)

Fundamentally different experiments

Problem of external validity
Regional Phillips Curve: Simple Model

Simple structural model implies:

\[
\pi_{Ht}^N = -\kappa E_t \sum_{j=0}^{\infty} \beta^j \tilde{u}_{H,t+j} - \lambda E_t \sum_{j=0}^{\infty} \beta^j \hat{p}_{H,t+j}^N + E_t \pi_{t+\infty} + \omega_{Ht}^N,
\]

Long-run inflation expectations are constant across regions and can be replaced with time fixed effects:

\[
\pi_{Ht}^N = -\kappa E_t \sum_{j=0}^{\infty} \beta^j \tilde{u}_{H,t+j} - \lambda E_t \sum_{j=0}^{\infty} \beta^j \hat{p}_{H,t+j}^N + \gamma_t + \omega_{Ht}^N,
\]

Even beyond this exact equivalence, may still be informative about \(\kappa\)

(Nakamura and Steinsson, 2018; Andrews, Gentzkow and Shapiro, 2020)
**An Aside: What is $\kappa$?**

- Neoclassical model: Very large $\kappa$
  - Prices respond efficiently
- Keynesian model: Small $\kappa$
  - Is this all about price rigidity?
  - No!
  - Price rigidity easiest to measure
  - But $\kappa$ small largely due to “real rigidities”
  - Lack of full response conditional on price change
  - e.g., Wage rigidities, strategic complementarities in pricing, monopsony power, decreasing returns etc. (much harder to measure)
Regional Phillips Curve: Identification

Can leverage panel structure for identification

\[
\text{ Tradable Demand}_{i,t} = \sum_{x \in T} \bar{S}_{x,i} \times \Delta \log S_{-i,x,t}
\]

- \( \bar{S}_{x,i} \): Average employment share of industry \( x \) in state \( i \) over time
- \( \log S_{-i,x,t} \): National employment share of industry \( x \) at time \( t \)

Identifying assumption: supply shocks not simultaneously correlated with both shifts \( \Delta \log S_{-i,x,t} \) and shares \( \bar{S}_{x,i} \)

Intuition:
- Oil boom increases labor demand and wages in Texas
- “Demand shock” for Texan restaurants
- Oil boom does not differentially affect production technology for restaurants in Texas
**Figure:** Scatterplots—Non-Tradeable Inflation and Unemployment

Regional identification (RHS) yields more stable Phillips curve; Much less flattening
Volcker disinflation: Inflation fell *mostly* due to lower long-run inflation expectations (regime change)
- Only $\approx 2\%$ due to higher unemployment
- Need supply shocks (oil shocks) to explain high inflation in early 80s
Volcker disinflation: Inflation fell *mostly* due to lower long-run inflation expectations (regime change)

- Only \( \approx 2\% \) due to higher unemployment
- Need supply shocks (oil shocks) to explain high inflation in early 80s

Underscores importance of long-run beliefs about inflation!

- But how does the monetary authority change (keep control over) \( E_t \pi_{t+∞} \)
- Fundamentally hard!!
- Sometimes beliefs do change rapidly
  (e.g., Volcker disinflation, ends of hyperinflations)
- How does the Fed convince people that it is “serious” about inflation?
Many (unsuccessful) attempts to curb inflation in 70’s

- Nixon 1971: Wage and price controls
- Ford 1974: Inflation “public enemy number one”

WIN: Whip inflation now

Carter:

- “Persistent high inflation threatens the economic security of our country”
- Oct 1979: Appoints Paul Volcker Chairman of Fed
In 1979/80 the newly appointed chairman of the U.S. Federal Reserve, Paul Volcker

- Sets as a goal to bring inflation below 4%
- Dramatically raises interest rates
- Fed funds rate reached record high of 20% in 1980!

Volcker tightened policy dramatically

- Caused massive recession
- Didn’t get fired

Perhaps this was crucial in changing beliefs about long-run monetary regime
Lessons from the Past

1. Long-run inflation expectations key driver of inflation

2. Demand-driven inflation:
   1% increase in unemp. $\rightarrow$ 1/3% increase in inflation
   (Regional estimates)
   - Assumes stable inflation expectations
   - Normal shock persistence

3. Shelter/rent has highest $\kappa$

4. Hard to explain experience of 1970s/80s without supply shocks
Core CPI and Unemployment: Pre-COVID, Post-1990

Pre-COVID:
Including COVID:
THE CURRENT SITUATION

Initial Shock

- Unemployment spiked to historic levels
- Inflation fell by *much less* than $1/3\%$ for each $1\%$ inc. in unemployment

Why?

1. Shock much less persistent: integral matters
   - Recall: $\kappa E_t \sum_{j=0}^{\infty} \beta^j \tilde{u}_{t+j}$

2. Supply shocks
   - Sick workers, caring for sick workers, new safety regulations, etc. etc.
CPI: Shelter vs. Non-Shelter

Green line: Unemployment
Red Line: CPI shelter  Grey Line: CPI Non-shelter

Source: U.S. Bureau of Labor Statistics
Last 9 Months

- Big spike in inflation
- Even though unemployment higher than pre-COVID

Unemployment imperfect measure of labor market tightness

- Vacancies very high
- Unprecedented decline in labor force participation
- Sectoral shifts in labor market
- Unprecedented speed of recovery
Supply shocks are back!

- Declining labor force participation
- Direct costs of COVID for firms (sick days, safety precautions etc.)
- Also, relative price shocks
  - Massive structural shift from services to goods
  - “Looks like” supply shock in a model

1970s: Led to inflation expectations to become unhinged, pulling up nominal anchor
Labor Force Participation

Source: U.S. Bureau of Labor Statistics
Goods Spending: Frac. Total Consumer Expenditures

Source: U.S. Bureau of Economic Analysis
LONG-RUN INFLATION EXPECTATIONS

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Long-Run SPF Forecast of CPI Inflation

Year

Core CPI Inflation - Research Series
Long-Run SPF Forecast of CPI Inflation
ALTERNATIVE MEASURES: LONG-RUN INFLATION EXPECTATIONS

TIPS -- 10Y Break Even Inflation
SPF -- 5Y CPI Inflation Expectations
SPF -- 10Y CPI Inflation Expectations
Understanding “unit of account” crucial in understanding many phenomena in economics and finance

- Inflation, real interest rate
- Monetary policy
- Digital currencies

Many approaches to studying have synergies

- Micro/granular data
- Natural experiments
- Discontinuity/based
- Structural modeling