The Macroeconomics of Sticky Prices with Generalized Hazard Functions

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Motivation: state-dependent price changes

Prob. of price-change depends on “gap” from ideal price \( x \equiv p - p^* \)

Eichenbaum, Jaimovic, Rebelo (AER 2011)

Gautier and Le Saout (JMCB 2015)

Caballero-Engel’s : Generalized Hazard Function (GHF): \( \Lambda(x) \)
Relation to literature and new results

▶ Caballero-Engel’s: Generalized Hazard Function (GHF): $\Lambda(x)$
  Prob. of price-change depends on gap from ideal price

▶ Random Menu Cost model w/ idiosyncratic shocks:

▶ Several applications: Berger-Vavra (2018), Petrella et al. (2018),
  Woodford (2008), Constatin-Nakov (2011), others

▶ Three new analytic results:

  (T1) GHF increasing $\Rightarrow$ Dist. menu cost, (so $\iff$ ),

  (T2) Dist. of price changes $\Rightarrow$ GHF & dist. price gaps $f$, (so $\iff$ ).

  (T3) Sufficient statistic for monetary shock; $CIR^Y = \frac{\text{Kurtosis}}{6 \times \text{Frequency}} \times \text{shock}$,

  - Max CIR (kurtosis): Constant GHF (Calvo), Min: Golosov-Lucas.
Firm’s Problem: Bellman equation Caballero-Engel

- uncontrolled price gap $x$: driftless random walk w/variance $\sigma^2 dt$

$$r \nu(x) = \min \left\{ \frac{B x^2}{2} + \frac{\sigma^2}{2} \nu''(x) + \kappa \int_{0}^{\psi} \min \{ \psi + \nu(0) - \nu(x), 0 \} dG(\psi), \right.$$  

$$r(\nu(0) + \psi) \right\}$$

- Random cost $\psi$ drawn w/prob.: $\kappa dG(\psi)$ each period of length $dt$
- Pay $\Psi$ and adjust at any time.

- Optimal decision rule $\bar{x}(\psi)$ and $X$
  - If $|x| < X \rightarrow\text{adjust w/ prob.} \; \Lambda(x) = \kappa G(\nu(x) - \nu(0)) \text{ per } dt$
  - If $|x|$ reaches $X \rightarrow\text{adjust w/certainty} \; , \; \Lambda(X) dt = 1 \text{ standard sS.}$
  - Generalized Hazard Function $\Lambda(x)$, increasing in $|x|$

- Calvo: $\kappa > 0$, $G$ mass point at $\psi = 0$, and $\Psi = \infty$
- Golosov Lucas: $\kappa = 0 \text{ and } \Lambda(x) = 0, \; x \in (-X, X) \text{ and } \Psi < \infty$
(T1) – Inversion Result

▶ Caballero Engel: CDF $G \implies \Lambda$ increasing and symmetric GHF.

▶ **New result:** Take $\Lambda$ increasing and symmetric $\implies G$

  Fix volatility $\sigma^2 = \text{Var}(\Delta p) N_a$, curvature $B$, and discount rate $r$.

  Consider an upper bd $X$ & symmetric, weakly increasing GHF $\Lambda$.

  Then there is a unique $\Psi$ and CDF $G$ that rationalizes $X, \Lambda$.

▶ **Importance:** can use any weakly increasing symmetric GHF $\Lambda$ to fit data or write models.

▶ Solving Bellman equation and policy is hard, non-linear o.d.e.

  Solving for $G$ given $\Lambda$ **easy and constructive:** linear o.d.e.
  (discrete values on $G \implies$ linear system of eqns).

▶ Results holds if there is a drift $\mu$ on price gap $x$. 
Steady State: invariant gaps $f$ & price changes $q$

- Intermediate step: $f(x)$ invariant distribution of price gaps $x$
  
  Solves the KFE for all $x \in [-X, X]$, $x \neq 0$:

  $$f(x)\Lambda(x) = \frac{\sigma^2}{2}f''(x) \quad \text{and } f \text{ continuous at all } x$$

  with $f(-X) = f(X) = 0$ and $\int_{-X}^{X} f(x)dx = 1$.

- Number of price changes per unit of time

  $$N_a = \int_{-X}^{X} f(x)\Lambda(x)dx + \frac{\sigma^2|f'(X)|}{N_a} \quad \# \text{with } x \text{ Pr(change)} + \text{Pr(change at barrier)}$$

- Price changes have mass point(s) at $\pm X$ if $X < \infty$

- Symmetric density of price changes $q$ for all $x \in (-X, X)$

  $$\Delta p = \begin{cases} 
  -x & \text{w/ density } q(x) = \frac{\Lambda(x)f(x)}{N_a} \text{ provided that } |x| < X, \\
  -X & \text{w/ probability mass } \frac{\sigma^2|f'(X)|}{N_a}
  \end{cases}$$
Example of density price changes: \( q(\Delta p) \)

Quadratic Hazard: \( \Lambda(x) = \kappa x^2 \), \( X = \infty \), different \( \eta \equiv \left( \frac{2\kappa}{\sigma^2} \right)^{\frac{1}{4}} \)
(T2) – Recovering \( f \), \( \Lambda \) and \( G \) from dist. \( q(\Delta p) \)

- Price changes have density \( \Delta p \sim q(\cdot) \) for \( x \in (-X, X) \).
- Assume \( q \) is symmetric., let \( Q \) be its CDF, so \( q = Q' \).
- Using equations above: \( q \implies f \implies \Lambda \):
  
  Invariant distribution \( f \):
  \[
  f(x) = \frac{2}{\text{Var}(\Delta p)} \left[ \int_{-\infty}^{\infty} (1 - Q(z)) \, dz \right]
  \]
  for all \( x \geq 0 \)

  and Generalized Hazard Function \( \Lambda \):
  \[
  \Lambda(x) = \frac{Na \text{Var}(\Delta p)}{2} \frac{q(x)}{\int_{x}^{\infty} (1 - Q(z)) \, dz}
  \]
  for all \( x > 0 \)

- Given \( \Lambda \) & previous recovery results, we get:
  \( q \implies f \implies \Lambda \implies G \) (distribution of menu cost)
  Recovery result can be extended to model with drift

- Easily extend case w/drift (Bailey-Blanco data by Lippi-Lotti)
Sketch of proof for case w/no drift

- **Model gives us:**

\[
\frac{\Lambda(x)f(x)}{N_a} = q(-x), \quad \frac{\sigma^2}{2} f''(x) = \Lambda(x)f(x) \quad \text{for all } x \geq 0
\]

- **Replace KFE into eqn for q and recall } \sigma^2 = Var(\Delta p) N_a:}

\[
\frac{\sigma^2}{2} \frac{f''(x)}{N_a} = q(-x) \quad \text{all } x \geq 0
\]

- Integrate w.r.t \( x \) twice gives \( f(x) \).
- Use \( f \) and definition of \( q \) again to get \( \Lambda \).

Similar argument where there is drift for (T1) and (T2).

**Summary:** Model \( \sim G \iff \Lambda \iff q \sim \text{Data} \)
A problem with investment data (large drift)

Data from Baley & Blanco $Q(-\Delta x)$

Hazard function $\Lambda(\Delta x)$

Invariant density $f(\Delta x)$

Cost CDF $G(\psi)$
Application to Cavallo’s online prices (zero drift)

Figure: Distribution of price changes - Histogram

Fitting Kernel density for $q$

Fitting a Gamma distribution for $q$

Pooling all products for category 561, COICOP label “Non-durable household goods”
Application: data corrected for Unobs. Heterogeneity

Recovered Hazard $\Lambda$ and density $f$  

Recovered cost distr. $g(\psi)$, $G(\psi)$

Pooling all products and correcting for heterogeneity
Comparison of three models

Same frequency of price changes $N_a = 1$
Same standard deviation of price changes $Std(\Delta)$

Generalized Hazard Function $\Lambda(x)$
Distribution price changes $q(x)$
Output IRF $Y(t)$
(T3) – Cumulative Response to Aggregate Shock

once and for all monetary (cost) shock of size $\delta$

GE model with NO strategic complementarity (as original GL)

Effect of aggregate price level $P(t; \delta)$ at horizon $t$

Effect on output $Y(t; \delta) = (1/\epsilon) [\delta - P(t, \delta)]$ at horizon $t$.

Output Cumulative IRF to $\delta$ shock: $M(\delta) = \int_0^\infty Y(t, \delta)dt$

Small shock $M(\delta) \approx M'(0)\delta$ since by definition $M(0) = 0$.

Keep same decision rules (extension using MFG’s)

Show that: $M(\delta) = \frac{1}{\epsilon} \frac{Kurt(\Delta p)}{6Na} \delta + O(\delta^2)$

$\epsilon$ GE elasticity unrelated to price setting –labor supply, etc.
Impulse response of output

\[ \frac{1}{\epsilon} \frac{\delta}{P(t)} \]

percent deviation from steady state

\( \frac{1}{\epsilon} [\delta - P(t)] \)

\( P(t) \)

time \( t \)
Sufficient Statistic for CIR

- Reminder is of third order:

\[ M(\delta) = M(0) + M'(0)\delta + \frac{1}{2} M''(0) \delta^2 + o(\delta^2) = \frac{1}{\epsilon} \frac{Kurt(\Delta p)}{6 N_a} \delta + o(\delta^2) \]

- Only weakly increasing \( \Lambda \) can be rationalized as random menu cost or optimal adjustment intensity model.

- Among the weakly increasing \( \Lambda \) the \textit{inverted-L} hazard \( \Lambda \) (i.e. Golosov and Lucas) has the smallest \( Kurt(\Delta p) = 1 \).

- Among the weakly increasing \( \Lambda \) the \textit{constant} hazard \( \Lambda \) (i.e. Calvo) has the largest \( Kurt(\Delta p) = 6 \).

- Non-monotone \( \Lambda \) may yield \( Kurt(\Delta p) > 6 \); can be arbitrarily large.

- \( Kurt(\Delta p) \) measures lack-of-selection selection for price increases after a positive aggregate shock.
Scope & limitations of sufficient statistic result

- Sufficient statistic \( \mathcal{M}'(0) = \frac{1}{\epsilon} \frac{Kurt(\Delta \rho)}{6 \, N_a} \)

- Holds in Calvo\(^+\) w/Multiproduct, and w/arbitrary Time dependent.

- Insensitive, up to first order, to:
  - steady state inflation \( \mu \):
    \[
    \left. \frac{\partial (\mathcal{M}'(0)(\mu))}{\partial \mu} \right|_{\mu=0} = 0
    \]
  - asymmetries in objective function

- In relative terms w/strategic complementarities \( \theta \)
  \[
  \mathcal{M}'(0; \theta) = \mathcal{M}'(0; 0) \left(1 + \Upsilon(\theta)\right)
  \]
  where \( \theta \) weight of optimal price on aggregate price.
  \( \Upsilon(\theta) \) independent of price setting statistics (Kurt & Freq.)

- Does NOT hold:
  - Large inflation/drift (Sheshinsky-Weiss, Blanco-Baley)
  - Firms do not close gap - “sales” (Alvarez-Lippi AEJ20, ERJ AER11)
Test sufficient statistic using cross industry data

Empirical Strategy:
3 main steps (using granular French data on PPI and CPI):

1) Construct measures of the effect of a monetary shock for different sectors, using a FAVAR (Bernanke, Boivin and Eliasz, 2005) estimated on sectoral and aggregate time series. Different identification strategies.

2) Using CPI/PPI micro data, calculate moments of the price change distribution at the product level for each sector: frequency, kurtosis, mean and skewness.

3) Relate - across sectors - product-level moments and the Cumulative Impulse Response to a monetary shock (i.e. $M$).

Findings:

- Expected sign & magnitudes of coefficients across industries.
- Other moments (inflation, variance, skewness) not significant.
- Significant for PPI, borderline for CPI.
Extensions and future work

- Alternative foundations for GHF (inattention), as Woodford.
- Equivalent identification using spell durations
- Computation of entire IRF using eigenfunctions-eigenvalues
- Example: Flexibility Index: not sufficient statistic for CIR.
- Future Work: models with strategic complementarities (MFG)
Empirical Investigation of a Sufficient Statistic for Monetary Shocks

Fernando Alvarez, Andrea Ferrara, Erwan Gautier, Hervé Le Bihan, and Francesco Lippi
Empirical Implication of Sufficient Statistic

- Output’s IRF at time $s$ for sector $j$:
  \[ Y_j(s) = \frac{1}{\varrho_j} \left[ \delta - P_j(s) \right] \]

- Cumulated Impulse Response:
  Output $CIR_T^Y = \int_0^T Y_j(s) ds$ & Prices $CIR_T^P = \int_0^T P_j(t) ds$

- Thus, for large horizon $T$, we have:
  \[ CIR_T^Y = \frac{1}{\varrho_j} \left( \delta T - CIR_T^P \right) \approx \frac{\delta}{\varrho_j} \frac{Kurt_j}{6 Freq_j} \]

- Main theoretical prediction to be tested:
  \[ CIR_T^P = \delta T - \frac{\delta}{6} \frac{Kurt_j}{Freq_j} + \epsilon_j \quad (1) \]

- Using a first order Taylor expansion around means $\bar{F}, \bar{K}$:
  \[ CIR_T^P \approx CIR_T^\bar{P} - \frac{\delta}{6} \frac{Kurt_j}{\bar{F}} \frac{\bar{K}}{\bar{K}} + \frac{\delta}{6} \frac{\bar{K}}{\bar{F}} \frac{Freq_j}{\bar{F}} + \epsilon_j \quad (2) \]
Data (France)

- **Macro time series:**
  - More than 300 sectoral-level price indices: CPI products at COICOP5 and PPI NACE Rev2 at 4-digits
  - Aggregate Inflation, Industrial production, Unemployment rate, Consumption, 3-month Euribor
  - Benchmark: all series over 2005-2019 period (monthly)

- **Micro price data sets:**
  - CPI micro data set (1994-2019, 60% CPI), 223 products at COICOP5 (Berardi et al. 2015)
Step 1: Measure sectoral CIR to monetary shocks

FAVAR methodology (Bernanke Boivin, Eliasz, QJE 2005)

- $Y_t$ is the 3 month Euribor; $X_t$ matrix of $M$ information variables
- $F_t$ unobserved factors (principal components of $X_t) << M$
- Estimate a VAR on $[F_t \ Y_t]$

\[
\begin{bmatrix}
F_t \\
Y_t
\end{bmatrix} = \Phi(L) \begin{bmatrix}
F_{t-1} \\
Y_{t-1}
\end{bmatrix} + \nu_t
\] (3)

- Impulse response function of each $X_t$ for a shock on $Y_t$

- Replace $F_t$ by estimated Factors $\hat{F}$, using $X_t$ containing a large number of aggregate and sectorial time series in:

\[
X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t
\] (4)

- Estimated factors $\hat{F}_t$ are the principal component of $X_t$
Step 1: Measure sectoral CIR to monetary shocks

- **Identification**
  - Recursive Cholesky identification strategy, as in BBE-2005
  - Add a long term "neutrality" restriction: output comes back to its original level + all sectoral prices have the same response in the long run
  - Normalisation of the shock so that the MP shock generates a 1% response in the price level, ie $\delta = 1\%$
  - Alternative identifications: Cholesky with no long run restriction, high-frequency instrumental variable (Altavilla et al. 2019)

- Filtering the Euribor
Step 3: Results Constrained Regression (PPI)

\[ CIR_T^{pj} = -T\delta + \frac{\delta}{6} \frac{Kurt_j}{Freq_j} \]

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<tr>
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<tr>
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<td>Long-run Restriction</td>
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<td></td>
<td>( T = 24m )</td>
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<tr>
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<td>( T = 36m )</td>
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<tr>
<td>Kurt/Freq</td>
<td>0.0669** (0.0326)</td>
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<td></td>
<td>0.0974*** (0.0355)</td>
</tr>
<tr>
<td>Constant</td>
<td>-20.57*** (2.130)</td>
</tr>
<tr>
<td></td>
<td>-35.16*** (2.199)</td>
</tr>
<tr>
<td>Obs.</td>
<td>118</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.041</td>
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<td></td>
<td>0.082</td>
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The **evidence** is supportive of the sufficient statistic result:

- Coefficient of \( kurt / freq \): positive and statistically significant
- Constant term: negative and statistically significant
Results Unconstrained Regression (PPI)

\[
CIR_T^{Pi} \approx CIR_T^P - \frac{\bar{K}}{\bar{F}} \delta \frac{Kurt_j}{6} + \frac{\bar{K}}{\bar{F}} \delta \frac{Freq_j}{6}
\]

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<th>Identification</th>
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<td>( T = 24m )</td>
<td>( T = 36m )</td>
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<tr>
<th></th>
<th>( Freq/\bar{F} )</th>
<th>( Kurt/\bar{K} )</th>
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<th>( Kurt/\bar{K} )</th>
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<tbody>
<tr>
<td>( Freq/\bar{F} )</td>
<td>-2.501* (1.279)</td>
<td>3.663* (1.897)</td>
<td>-23.65*** (8.897)</td>
<td>28.83** (11.66)</td>
<td>-26.56*** (3.011)</td>
<td>6.662** (3.100)</td>
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<td>( Kurt/\bar{K} )</td>
<td>-3.153** (1.314)</td>
<td>4.665** (1.995)</td>
<td>-37.41*** (13.96)</td>
<td>45.17** (17.59)</td>
<td>-42.36*** (3.960)</td>
<td>7.922* (4.010)</td>
</tr>
<tr>
<td>Constant</td>
<td>-18.82*** (2.208)</td>
<td>-32.42*** (2.166)</td>
<td>-23.13* (12.73)</td>
<td>-40.64** (18.61)</td>
<td>-26.56*** (3.011)</td>
<td>-42.36*** (3.960)</td>
</tr>
<tr>
<td>Obs.</td>
<td>118</td>
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<tr>
<td>( R^2 )</td>
<td>0.106</td>
<td>0.161</td>
<td>0.240</td>
<td>0.259</td>
<td>0.217</td>
<td>0.179</td>
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</table>

- Kurtosis and frequency are statistically significant
- F-test null: coefficients of \( Freq/\bar{F} = -Kurt/\bar{K} \)
More Tests on the Model’s Predictions

Under a strict interpretation, predicted coefficients are:

- In constrained version of model: $\beta = 1/6$ and $\alpha = -T$
- In unconstrained version of model: $\beta^k = -\beta^f = \delta \frac{\bar{K}}{\bar{F}}$

<table>
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<tr>
<th>Identification</th>
<th>Cholesky LRR $T = 24$</th>
<th>Cholesky No LRR $T = 24$</th>
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<td>$T = 36$</td>
<td>$T = 36$</td>
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<tr>
<td>Constrained model</td>
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<tr>
<td>P-val $\beta = 1/6$</td>
<td>0.003</td>
<td>0.019</td>
<td>0.681</td>
</tr>
<tr>
<td>P-val $\alpha = -T$</td>
<td>0.111</td>
<td>0.076</td>
<td>0.006</td>
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</table>

| Unconstrained model |                        |                           |                             |
| P-val $\beta^f = -\beta^k$ | 0.566                  | 0.648                     | 0.819                       |
| P-val $\beta^f = -\frac{\bar{K}}{\bar{F}}$ | 0.130                  | 0.033                     | 0.577                       |
| P-val $\beta^k = \frac{\bar{K}}{\bar{F}}$ | 0.679                  | 0.039                     | 0.477                       |

If mismeasurement, the estimated coefficient can be downward biased ie ranging between 0 and 1/6
Placebo Test: Sufficient Statistic

- Theory: zero derivative of CIR w/respect to odd moments, 
  \[ \frac{\partial}{\partial \pi} CIR_p^j (\delta, \pi_j) \bigg|_{\pi_j=0} = 0 \]
  where \( \pi_j \) is sector \( j \) steady state inflation, or skewness

- Include other moments (mean and skewness of price changes) in the restricted regression

- These moments should not change the sign, nor be significantly different from zero
  \[ CIR_T^p = \alpha + \beta^r \frac{Kurt_j}{Freq_j} + \beta^m mean_j + \beta^s skew_j + \epsilon_j \] (5)
### Results of a Placebo Test (PPI)

<table>
<thead>
<tr>
<th>Identification</th>
<th>Cholesky Long-run Restriction $T = 24m$</th>
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<th>Cholesky No Long-run Restriction $T = 36m$</th>
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<th>High-Frequency IV Long-run Restriction $T = 36m$</th>
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<tbody>
<tr>
<td>Kurt/Freq</td>
<td>0.0849* (0.0477)</td>
<td>0.715** (0.284)</td>
<td>0.168** (0.0750)</td>
<td>0.202** (0.0989)</td>
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<td>Mean</td>
<td>-0.418 (0.905)</td>
<td>-6.211 (5.311)</td>
<td>-1.212 (1.432)</td>
<td>-1.408 (1.857)</td>
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<td>Skewness</td>
<td>1.759 (3.434)</td>
<td>-5.014 (15.18)</td>
<td>-4.613 (2.783)</td>
<td>-6.889* (4.109)</td>
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<td>Standard dev.</td>
<td>-0.940 (1.016)</td>
<td>-4.317 (7.037)</td>
<td>0.219 (1.964)</td>
<td>0.726 (2.535)</td>
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<tr>
<td>Constant</td>
<td>-16.65*** (4.669)</td>
<td>-27.65 (26.68)</td>
<td>-34.44*** (7.221)</td>
<td>-54.26*** (9.552)</td>
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<tr>
<td>Obs.</td>
<td>118</td>
<td>118</td>
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<tr>
<td>$R^2$</td>
<td>0.054</td>
<td>0.125</td>
<td>0.140</td>
<td>0.140</td>
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- Mean and skewness not statistically relevant
- Constant remains negative and statistically significant
- Coeff. Kurt/Freq very close to the one in constr. regression
CPI Results: Weaker than PPI

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<td><strong>Constrained Model</strong></td>
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<tr>
<td>Kurt/Freq</td>
<td>-0.0170</td>
<td>-0.0025</td>
<td>0.115*</td>
<td>0.233**</td>
<td>0.0495**</td>
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<td>(0.0165)</td>
<td>(0.0199)</td>
<td>(0.0658)</td>
<td>(0.105)</td>
<td>(0.0242)</td>
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<tr>
<td>Constant</td>
<td>-11.64***</td>
<td>-27.36***</td>
<td>-21.20*</td>
<td>-47.72***</td>
<td>-34.43***</td>
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<tr>
<td></td>
<td>(2.809)</td>
<td>(3.285)</td>
<td>(10.81)</td>
<td>(17.13)</td>
<td>(3.434)</td>
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<tr>
<td>$R^2$</td>
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<td>0.014</td>
<td>0.023</td>
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<td>Freq/$\bar{F}$</td>
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## Reverse regression: PPI

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<tr>
<td>CIR</td>
<td>0.612*** (0.220)</td>
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<td>0.170*** (0.0320)</td>
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<td>0.681*** (0.130)</td>
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<tr>
<td></td>
<td>0.845*** (0.186)</td>
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<td>0.120*** (0.0227)</td>
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<td>0.488*** (0.103)</td>
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<td>46.64*** (2.665)</td>
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<td>61.22*** (4.765)</td>
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<td>69.69*** (7.050)</td>
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<td>47.52*** (2.698)</td>
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<td>63.92*** (5.781)</td>
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- Coefficient expected to be equal to 6
- If mismeasurement of CIR, then coef between 0 and 6
## Placebo Test: PPI - unconstrained

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<td>$Freq / \bar{F}$</td>
<td>-2.865* (1.454)</td>
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<td>$Kurt / \bar{K}$</td>
<td>3.026 (3.048)</td>
<td>21.29* (12.09)</td>
<td>5.823* (3.177)</td>
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<tr>
<td>Mean</td>
<td>-0.254 (0.792)</td>
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<td>Skewness</td>
<td>1.798 (3.359)</td>
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<td>Standard dev.</td>
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Regression Results: Sector fixed effects (PPI)

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**PANEL A: Constrained model**

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<th>Kurt/Freq</th>
<th>0.0366 (0.0301)</th>
<th>0.0565* (0.0321)</th>
<th>0.393** (0.157)</th>
<th>0.647*** (0.239)</th>
<th>0.119** (0.0483)</th>
<th>0.153** (0.0662)</th>
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<tr>
<td>Constant</td>
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<td>-44.18*** (3.918)</td>
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<td>0.521</td>
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<td>0.527</td>
<td>0.476</td>
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</table>

**PANEL B: Unconstrained model**

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<tr>
<th>Kurt/¯F</th>
<th>-1.705 (1.310)</th>
<th>-1.951 (1.274)</th>
<th>-11.87 (7.540)</th>
<th>-17.96 (11.49)</th>
<th>-2.621 (2.336)</th>
<th>-2.957 (3.375)</th>
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<tr>
<td>Kurt/¯K</td>
<td>2.562 (1.964)</td>
<td>2.722 (1.984)</td>
<td>21.48** (10.41)</td>
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<td>3.630 (2.902)</td>
<td>3.823 (3.963)</td>
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<td>-24.30*** (2.908)</td>
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### Regression Results: 2-year German Bond (PPI)

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<td>Kurt/Freq</td>
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<td><strong>PANEL B: Producer Prices - Unconstrained model</strong></td>
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<td>Freq/$\bar{\Phi}$</td>
<td>-5.148*</td>
<td>-6.623**</td>
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<td>(2.973)</td>
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<td>Kurt/$\bar{\Phi}$</td>
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</table>
Hong-Klepacz-Pasten-Schoenle "The Real Effects of Monetary Shocks: Evidence from Micro Pricing Moments" (2020) Banco Central Chile, WP 875

- HKPS (2020) carry out a similar empirical exercise to ours, using US cross sectoral PPI moments
- Compute IRF of prices using FAVAR and other approaches, and relate these to sectoral moments
- Main claim: hypothesis “kurtosis over frequency is a sufficient statistic” is rejected

However, several weaknesses and shortcuts
Issue #1: The outcome variable in the regressions is the *level response of prices*, while the theory concerns the *cumulated response of output*: the dependent variable in their regressions is *not* the one that the theory focuses on.

Issue #2: In most of their regressions, Kur/Freq ratio is a significant determinant or price (or sales) response to monetary policy shock, in line with theory!
Issue #3: When removing sectoral “fixed effects” in the cross sector regression (with N=148), both Freq and Kur, are separately significant with expected sign.

Table 12

Issue #4: Claim by HKPS is (Kur/Freq) cannot be a ”sufficient statistic” because $R^2$ are $<< 1$. $R^2 = 1$ is an inadequate criterion. In most datasets, measurement errors weaken the fit of the relation between variables.
## Cross-Sectional Determinants of Sectoral Price Response

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<tr>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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<td>Log Frequency</td>
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<td>0.471***</td>
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</table>

**Table 1: Decomposing Monetary Non-Neutrality**

**Note:** This table uses regression analysis to test the informativeness of pricing moments for monetary non-neutrality. We estimate the following specification: $\log(\text{IRF}_{k,h}) = a + \alpha_j + \beta'M_k + \gamma'X_j + \epsilon_{k,h}$. Where $\log(\text{IRF}_{k,h})$ is the log of the 24-month cumulative sectoral response of prices to a monetary shock from our FAVAR analysis. $M_k$ contains one of our industry-level pricing moments: frequency, kurtosis, the ratio of the two statistics, average size, and standard deviation of price changes, or the full set of pricing moments. $\alpha_j$ are three-digit NAICS industry fixed effects and are included in all specifications. $X_j$ are sector-level controls including gross profit rate, the volatility of sector-level shocks, and other controls.
### Cross-Sectional Determinants of Sectoral Price Response Univariate Specifications

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<td>(0.205)</td>
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<tr>
<td><strong>R²</strong></td>
<td>0.106</td>
<td>0.119</td>
<td>-0.095</td>
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<td><strong>N</strong></td>
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<tr>
<td><strong>Log Std. Dev.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.456***</td>
<td>0.259</td>
<td>0.865</td>
</tr>
<tr>
<td></td>
<td>(0.141)</td>
<td>(0.412)</td>
<td>(0.536)</td>
</tr>
<tr>
<td><strong>NAICS 3 FE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td>0.067</td>
<td>0.011</td>
<td>-0.028</td>
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Source: HKPS 2020, WP 875, Banco Central De Chile
## Cross-Sectional Determinants of Sectoral Price Response Multivariate Specifications

<table>
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<tr>
<th></th>
<th>Baseline (1)</th>
<th>Baseline (2)</th>
<th>Sample 1, IV Sample 2 (3)</th>
<th>Sample 2, IV Sample 1 (5)</th>
<th>Sample 2, IV Sample 1 (6)</th>
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<tbody>
<tr>
<td><strong>Log Frequency</strong></td>
<td>0.520***</td>
<td>0.476***</td>
<td>0.561***</td>
<td>0.549***</td>
<td>0.623***</td>
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<tr>
<td></td>
<td>(0.056)</td>
<td>(0.074)</td>
<td>(0.062)</td>
<td>(0.074)</td>
<td>(0.072)</td>
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<tr>
<td><strong>Log Kurtosis</strong></td>
<td>-0.222**</td>
<td>-0.151</td>
<td>-0.237*</td>
<td>-0.223*</td>
<td>-0.313**</td>
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<tr>
<td></td>
<td>(0.104)</td>
<td>(0.112)</td>
<td>(0.127)</td>
<td>(0.120)</td>
<td>(0.125)</td>
</tr>
<tr>
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<tr>
<td><strong>R^2</strong></td>
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<td>0.509</td>
<td>0.277</td>
<td>0.481</td>
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<tr>
<td><strong>Log Frequency</strong></td>
<td>0.501***</td>
<td>0.471***</td>
<td>0.668***</td>
<td>0.610***</td>
<td>0.594***</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.084)</td>
<td>(0.111)</td>
<td>(0.121)</td>
<td>(0.107)</td>
</tr>
<tr>
<td><strong>Log Kurtosis</strong></td>
<td>-0.165</td>
<td>-0.163</td>
<td>-0.062</td>
<td>-0.129</td>
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<td></td>
<td>(0.117)</td>
<td>(0.122)</td>
<td>(0.190)</td>
<td>(0.201)</td>
<td>(0.189)</td>
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<tr>
<td><strong>Log Avg. Size</strong></td>
<td>0.113</td>
<td>-0.054</td>
<td>0.298</td>
<td>0.212</td>
<td>-0.161</td>
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<tr>
<td></td>
<td>(0.212)</td>
<td>(0.207)</td>
<td>(0.278)</td>
<td>(0.326)</td>
<td>(0.296)</td>
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<tr>
<td><strong>Log Std. Dev.</strong></td>
<td>-0.213</td>
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<td>(0.156)</td>
<td>(0.138)</td>
<td>(0.555)</td>
<td>(0.731)</td>
<td>(0.670)</td>
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<tr>
<td><strong>NAICS 3 FE</strong></td>
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<tr>
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<td>0.509</td>
<td>0.132</td>
<td>0.428</td>
<td>0.327</td>
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