Empirical Investigation of a Sufficient Statistic for Monetary Shocks

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The Sufficient Statistic Proposition

- In a multi sector economy with frictional price setting

- The cumulative response of output (CIR^Y) of industry j to small monetary shock (δ) is:

$$CIR^{Y_j}(\delta) \equiv \int_0^\infty Y_j(t)dt \ = \ \frac{\delta}{\epsilon} \ \frac{Kurt_j}{6 \ Freq_j} + o(\delta^2) \tag{1}$$

Alvarez, Lippi and: ...Paciello, (2016), ... Le Bihan (2016), ...Oskolkov (2020), ...Souganides (2021)

- **Intuition:**
  - Frequency (Freq): time units of propagation
  - Kurtosis (Kurt): measures lack of selection effect

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- **Intuition:**
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  - Kurtosis (Kurt): measures lack of selection effect

- **A theoretical result that holds for many models** :
  Random menu cost: Calvo (1983), Nakamura and Steinsson (10), Caballero and Engel (1993, 1999, 07), Golosov and Lucas (07), Dotsey and Wolman (20)...;
  Rational inattention : Taylor (1980), Reis (06), Woodford (09), Costain and Nakov (11)
  Multi product: Midrigan (11), Bonomo et al (20)

- **Scope of results**: small inflation, gap closed after adjustment (e.g. no price plans, or temp. price changes), brownian shocks

This paper

- We explore the empirical validity of the sufficient statistic proposition
- Using micro/sectoral CPI and PPI French data and exploiting cross sectoral variability

- Two empirical challenges, i.e. measure cross-sectional:
  - responses to monetary shocks, i.e. *CIR*
  - micro moments (frequency and kurtosis)

Empirical Implications of Sufficient Statistic

- Restate sufficient statistic proposition for CIR of prices, $CIR_T^{P_j}$, instead of output (better data for prices)
- Main theoretical prediction to be tested on the CIR of Prices

$$CIR_T^{P_j} = \delta T - \frac{\delta}{6} \frac{Kurt_j}{Freq_j} + \nu_j \tag{2}$$

- Using a first order Taylor expansion around means $\bar{F}, \bar{K}$:

$$CIR_T^{P_j} \approx CIR_T^{\bar{P}} - \frac{\delta}{6} \frac{\bar{K}}{\bar{F}} \frac{Kurt_j}{\bar{K}} + \frac{\delta}{6} \frac{\bar{K}}{\bar{F}} \frac{Freq_j}{\bar{F}} + \nu_j \tag{3}$$

Empirical Specification and Test

$$CIR_T^{P_j} = \alpha + \beta \left(\frac{Kurt_j}{Freq_j} \right) + \nu_j \qquad \text{(Constr Reg)}$$

- Theory predicts $\alpha = \delta T$ and $\beta = -\delta/6$
- Normalize shock to $\delta = -1\%$: implies: $\beta = 1/6$ and $\alpha = -T$
- With strategic complementarity: $\beta = -\delta \mathcal{S}/6$ (adds degree of freedom)
- To inspect significance of frequency and kurtosis:

$$CIR_T^{P_j} = \gamma + \beta^f \frac{Freq_j}{\bar{F}} + \beta^k \frac{Kurt_j}{\bar{K}} + \nu_j \qquad \text{(Unconstr Reg)}$$

- Theoretical predictions: $\beta^k = -\beta^f = \frac{\delta}{6} \frac{\bar{K}}{\bar{F}}$

▸ measurement error

Empirical Strategy

3 main steps – using granular French data on PPI and CPI:

1) Construct measures of **sectoral** effect of a monetary shock
→ a FAVAR model[1] estimated on **sectoral** and aggregate time series.
→ Obtain $CIR_T^{P_j}$

2) Use CPI/PPI **micro data** to
- calculate moments of price changes distribution: frequency, kurtosis,...
- at the **sector/product** level

3) Relate CIR's and product-level moments
→ Run the above-mentioned regressions

[1] (à la Bernanke, Boivin and Eliasz, 2005)

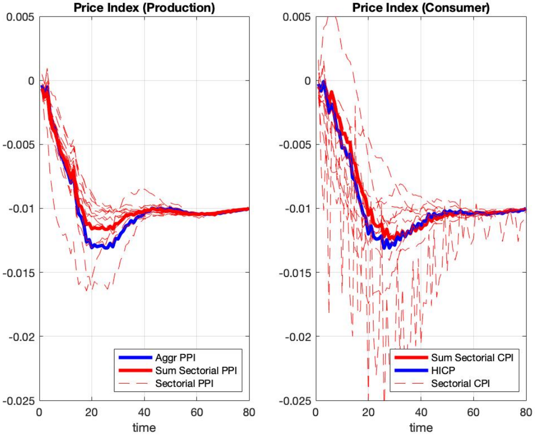
Step 1: Measure sectoral CIR to monetary shocks

- Estimate $CIR_T^{P^j}$ using FAVAR à la Bernanke, Boivin and Eliasz
  - VAR in 3-month Euribor i_t and unknown Factors, F_t:

$$\begin{bmatrix} F_t \\ i_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ i_{t-1} \end{bmatrix} + v_t \qquad (4)$$

  - Estimate Factors, using large number of time series, X_t
  - Compute IRFs of X_t (e.g. sectorial PPI and CPI)
- Identification
  - Recursive Cholesky identification strategy, as in BBE-2005
  - Add a long run "neutrality" restriction: all sectoral prices have the same response in the long run
- Alternative identifications:(i) Cholesky with no long run restriction, (ii) high-frequency w/ instrumental variable (Altavilla et al. 2019)
- Normalisation of shock so that the MP shock generates a -1% response in the price level, ie $\delta = -1\%$

Sectoral Price Responses to a Contractionary Shock



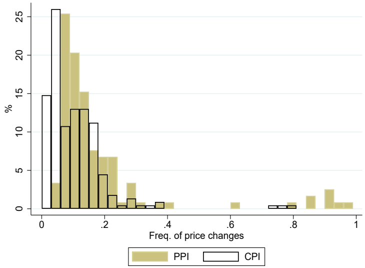
- Y-axis: log points in deviation from steady state
- Blue line: aggregate time series & Dashed red lines: sectorial IRF & Red line arithmetic average of dashed lines

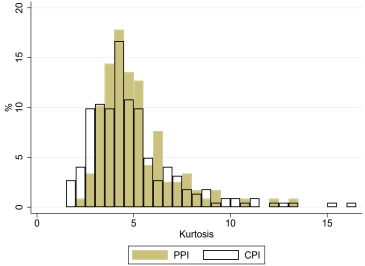
Summary stat

More IRF

Step 2: Cross Sectional Moments

Histogram of Freq and Kurt





Note: Histograms based on 118 sectors for PPI data and 227 sectors for CPI data

Micro price data sets:

- PPI data set - 1994-2005, manufacturing sector

  ≈ 1.5 millions price records

  118 NACE rev2 4-digit products (Gautier, 2008)
- CPI data set - 1994-2019, 60% CPI

  > 30 millions price records

  223 products at COICOP5

  (Berardi et al., 2015)

Step 3: Results Constrained Regression (PPI)

Scatter plot

$$CIR_T^{P_j} = \alpha + \beta \left(\frac{Kurt_j}{Freq_j} \right) + \nu_j$$

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
Kurt/Freq	0.0669**	0.0974***	0.328***	0.535***	0.192***	0.242***
	(0.0326)	(0.0355)	(0.105)	(0.162)	(0.0614)	(0.0801)
Constant	-20.57***	-35.16***	-22.84***	-38.95***	-34.27***	-52.21***
	(2.130)	(2.199)	(6.387)	(9.756)	(3.638)	(4.799)
Observations	118	118	118	118	118	118
R^2	0.041	0.082	0.117	0.135	0.131	0.118

- The **evidence** is supportive of the sufficient statistic result:
  - Coefficient of $Kurt/Freq$: positive and statistically significant
  - Constant term: negative and statistically significant

Tests

Results Unconstrained Regression (PPI)

$$CIR_T^{P_j} = \gamma + \beta^f \frac{Freq_j}{\bar{F}} + \beta^k \frac{Kurt_j}{\bar{K}} + \nu_j$$

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
freq/mean(freq)	-2.501*	-3.153**	-11.25***	-17.79***	-6.004**	-7.239*
	(1.279)	(1.314)	(4.232)	(6.641)	(2.776)	(3.761)
kurt/mean(kurt)	3.663*	4.665**	13.72**	21.49**	6.662**	7.922*
	(1.897)	(1.995)	(5.547)	(8.370)	(3.100)	(4.010)
Constant	-18.82***	-32.42***	-11.00*	-19.33**	-26.56***	-42.36***
	(2.208)	(2.166)	(6.054)	(8.855)	(3.011)	(3.960)
Observations	118	118	118	118	118	118
R^2	0.106	0.161	0.240	0.259	0.217	0.179

- Kurtosis and frequency are statistically significant
- F-test null: coefficients of $Freq/\bar{F} = -Kurt/\bar{K}$

Tests

Placebo Test: Sufficient Statistic

- Theory: zero derivative of CIR w/respect to odd moments, $\frac{\partial}{\partial \pi} CIR^{P_j}(\delta, \pi_j)\big|_{\pi_j=0} = 0$
  where π_j is sector *j* steady state inflation, or skewness
- Include other moments (e.g. mean and skewness of price changes) in the restricted regression
- These moments should not change the sign, nor be significantly different from zero

$$CIR_T^{P_j} = \alpha + \beta^r \frac{Kurt_j}{Freq_j} + \beta^m mean_j + \beta^v std_j + \beta^s skew_j + \nu_j \qquad (5)$$

Results of a Placebo Test (PPI)

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
Kurt/Freq	0.0849*	0.110**	0.340**	0.538**	0.168**	0.202**
	(0.0477)	(0.0488)	(0.135)	(0.205)	(0.0750)	(0.0989)
mean	-0.418	-0.479	-2.954	-4.724	-1.212	-1.408
	(0.905)	(1.000)	(2.527)	(3.925)	(1.432)	(1.857)
skew	1.759	1.006	-2.385	-5.930	-4.613	-6.889*
	(3.434)	(3.100)	(7.222)	(10.02)	(2.783)	(4.109)
sd	-0.940	-0.749	-2.054	-2.614	0.219	0.726
	(1.016)	(1.083)	(3.348)	(5.166)	(1.964)	(2.535)
Constant	-16.65***	-31.95***	-13.15	-26.11	-34.44***	-54.26***
	(4.669)	(4.791)	(12.69)	(19.14)	(7.221)	(9.552)
Observations	118	118	118	118	118	118
R^2	0.054	0.089	0.125	0.142	0.140	0.130

- Mean and skewness not statistically relevant
- Constant remains negative and statistically significant
- Coeff. *Kurt / Freq* very close to the one in constr. regression

Unconstrained

CPI Results: Weaker than PPI

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
Constrained Model						
Kurt/Freq	-0.0170	-0.00245	0.0739*	0.150**	0.0495**	0.0720**
	(0.0165)	(0.0199)	(0.0423)	(0.0674)	(0.0242)	(0.0315)
Constant	-11.64***	-27.36***	-13.63*	-30.69***	-34.43***	-54.70***
	(2.809)	(3.285)	(6.954)	(11.02)	(3.434)	(4.419)
R^2	0.004	0.000	0.014	0.023	0.019	0.024
Unconstrained Model						
freq/mean(freq)	-4.920*	-8.540**	-34.84***	-58.62***	-16.36***	-21.30***
	(2.809)	(3.331)	(8.857)	(13.71)	(3.894)	(4.812)
kurt/mean(kurt)	4.359*	5.657**	4.276	5.519	7.132***	9.175***
	(2.328)	(2.594)	(2.909)	(4.518)	(2.201)	(2.806)
Constant	-12.61***	-24.70***	23.60***	35.92***	-20.74***	-36.08***
	(3.684)	(4.267)	(8.469)	(13.12)	(4.907)	(6.274)
R^2	0.065	0.132	0.477	0.529	0.350	0.342
Observations	223	223	223	223	223	223

Conclusions

- Use cross sectional data to test sufficient statistic proposition
- Evidence consistent with predictions for PPI, less robust for CPI:
  - Ratio $Kurt/Freq$ has predicted sign, and statistically significant
  - Do NOT reject hypothesis that $\frac{Kurt}{\bar{K}}$ and $\frac{Freq}{\bar{F}}$ have same effect in magnitude
  - Other moments (mean, std dev., skew.) statistically insignificant
  - Results hold for several robustness checks
    - Estimate FAVAR excluding CPI
    - Remove potential outliers of CIR^P, $\frac{Kur}{Freq}$, *Kur* or *Freq*
    - Add sectors fixed effects
  - For CPI, sales may play a role to explain less robust conclusions

BACKUP SLIDES

Empirical Implications of Sufficient Statistic

- Output's IRF at time s for **sector** j :

$$Y_j(s) = \frac{1}{\epsilon}\left[\delta - P_j(s)\right] \quad (6)$$

- Cumulated Impulse Response:

$$\text{Output } CIR_T^{Y_j} \equiv \int_0^T Y_j(s)ds \text{ \& Prices } CIR_T^{P_j} \equiv \int_0^T P_j(t)ds \quad (7)$$

- Thus for large horizon T :

$$CIR_T^{Y_j} = \frac{1}{\epsilon}\left(\delta T - CIR_T^{P_j}\right) \approx \frac{\delta}{6}\frac{1}{\epsilon}\frac{Kurt_j}{Freq_j} \quad (8)$$

- Main theoretical prediction to be tested on the CIR of Prices

$$CIR_T^{P_j} = \delta T - \frac{\delta}{6}\frac{Kurt_j}{Freq_j} + \nu_j \quad (9)$$

- Using a first order Taylor expansion around means $\bar{F}, \bar{K}$:

$$CIR_T^{P_j} \approx CIR_T^{\bar{P}} - \frac{\delta}{6}\frac{\bar{K}}{\bar{F}}\frac{Kurt_j}{\bar{K}} + \frac{\delta}{6}\frac{\bar{K}}{\bar{F}}\frac{Freq_j}{\bar{F}} + \nu_j \quad (10)$$

Step 1: Measure of sectoral CIR: Data (France)

- **Macro & sectoral time series**:
  - More than 300 sectoral-level price indices: CPI products at COICOP5 and PPI NACE Rev2 at 4-digits

  $\rightarrow$ Matching the micro data used in step 2
  - Aggregate Inflation, Industrial production, Unemployment rate, Consumption, 3-month Euribor
  - All series over 2005-2019 period (monthly)

Step 1: Measure sectoral CIR to monetary shocks

FAVAR methodology (Bernanke, Boivin, Eliasz, QJE 2005)

- i_t the 3 month Euribor; X_t matrix of M_X information variables
- X_t contains a large number of aggregate and sectoral time series
- F_t vector of M_F **unobserved** factors with $M_F << M_X$,

  Estimate $F_t's$ as principal components of X_t
- Estimate a VAR on $[F_t \; i_t]$

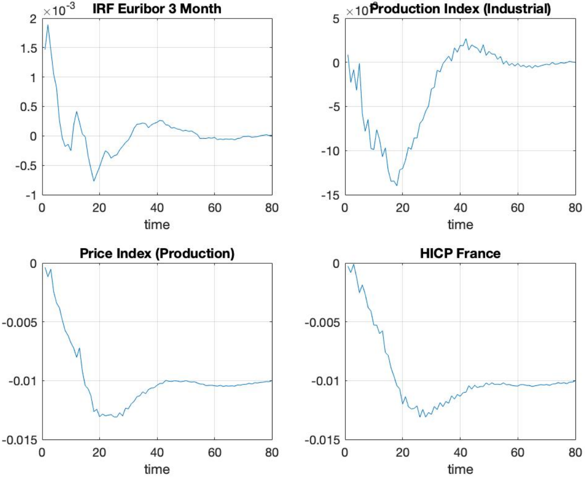
$$\begin{bmatrix} F_t \\ i_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ i_{t-1} \end{bmatrix} + v_t \qquad (11)$$

- **Impulse response function** of **each** X_t for a shock on i_t

$$X_t = \Theta^f F_t + \Theta^y i_t + e_t \qquad (12)$$

- e_t orthogonal to v_t and i.i.d. Θ's incorporate other restrictions

Aggregate Responses to Contractionary Shock



▸ More IRF

Alternative Policy Indicator: German Sov. Bond + IV "high frequency"

Identification	High-Frequency IV		High-Frequency IV	
Long-run Restriction	Yes		No	
	24 months	36 months	24 months	36 months
PANEL A: Producer Prices - Constrained model				
Kurt/Freq	0.186***	0.244***	0.293***	0.463***
	(0.0669)	(0.0775)	(0.0959)	(0.154)
Constant	-20.34***	-34.78***	-25.38***	-45.14***
	(4.393)	(4.993)	(5.932)	(9.271)
R^2	0.069	0.091	0.092	0.095
PANEL B: Producer Prices - Unconstrained model				
freq/mean(freq)	-5.148*	- 6.623**	-9.108**	-14.76**
	(2.627)	(2.973)	(3.684)	(5.895)
kurt/mean(kurt)	8.553**	10.98**	7.716	9.263
	(3.931)	(4.451)	(4.982)	(7.542)
Constant	-15.64***	-28.50***	-11.24*	-19.45**
	(5.071)	(5.651)	(6.250)	(8.931)
R^2	0.104	0.131	0.144	0.149
Observations	118	118	118	118

ONLY PPI. NoSeasAdj

Identification	Euribor				High-Frequency IV			
Long-run Restriction	No		Yes		No		Yes	
	24 months	36 months	24 months	36 months	24 months	36 months	24 months	36 months
PANEL A: Constrained model								
Kurt/Freq	0.348***	0.527***	0.0734**	0.0858***	0.432***	0.571***	0.240***	0.251***
	(0.117)	(0.173)	(0.0300)	(0.0279)	(0.137)	(0.185)	(0.0766)	(0.0752)
Constant	-29.50***	-47.13***	-21.41***	-34.12***	-38.37***	-56.29***	-30.89***	-43.82***
	(7.065)	(10.30)	(1.976)	(1.761)	(8.034)	(10.60)	(4.777)	(4.614)
R^2	0.104	0.112	0.052	0.087	0.115	0.112	0.102	0.118
PANEL B: Unconstrained model								
freq/mean(freq)	-12.30***	-18.31***	-2.349**	-2.306**	-13.41***	-17.43***	-7.233**	-7.120**
	(4.472)	(6.561)	(1.132)	(0.962)	(4.803)	(6.153)	(3.016)	(2.873)
kurt/mean(kurt)	12.89**	19.36**	2.986*	3.428**	12.16*	14.04	10.17**	10.72**
	(6.110)	(8.872)	(1.794)	(1.588)	(6.747)	(8.807)	(4.267)	(4.112)
Constant	-14.94**	-25.21**	-18.85***	-31.51***	-18.28**	-28.01***	-23.36***	-36.48***
	(6.872)	(9.685)	(2.379)	(2.065)	(7.808)	(9.966)	(5.117)	(4.866)
R^2	0.218	0.227	0.095	0.117	0.181	0.167	0.169	0.178
Observations	118	118	118	118	118	118	118	118

Robustness Results - PPI

- Sensitivity to outliers of CIR^P, $\frac{Kur}{Freq}$, *Kur* or *Freq* ▸ extreme-values
- Measurement of Kurtosis: correct for unobs-heterogeneity + trimming outliers in price change distribution ▸ Unobs-Het ▸ Trim-thresholds
- Add sectors fixed effects (2 - digit level, 24 dummies) ▸ within-sectors
- Removing sectors with ‘high’ inflation ▸ price-trend

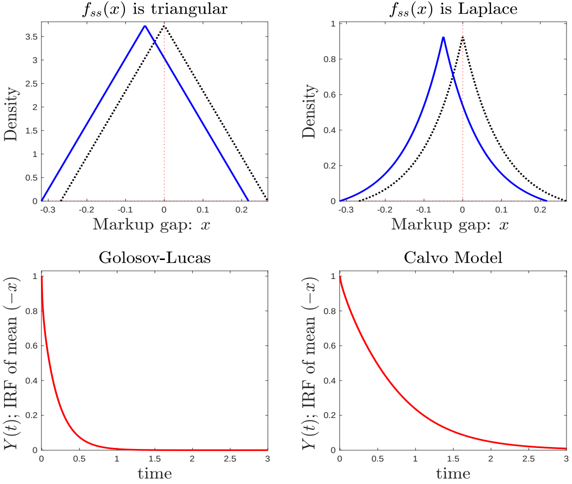
More CPI Results

- Placebo test
  - Placebo - Cons
  - Placebo - Uncons
- Test on coefficients
  - Coef. tests
- Roles of Sales:
  - Excluding food, Clothes, Furnishing (Sales - 1)
  - % of sales prices below the median (Sales - 2)
- Sector dummies
  - Sector dummies

Theory Setup - Additional Charts

- Output's IRF at time s for **sector** j : $Y^j(s) = -\frac{1}{\varrho} \int f(x,s)\, x\, dx$

Models have same $N = 1$, differ by $f_{ss}(x)$



Kurtosis =1 in GL Kurtosis =6 in Calvo

Theory Set Up –details , with Strategic Complementarity

Back

$$\text{HH Utility : } \int_0^\infty e^{-\rho t}\left(U(C(t)) - V(\ell(t)) - \alpha_a \ell_a(t) + \log \frac{M(t)}{P(t)} \right) dt$$

$$\text{CES aggregator } C(t) = \sum_{j=1}^{n} \left[\alpha_j^{1/\eta} \, C_j(t)^{(1-1/\eta)} \right]^{1/(1-1/\eta)}$$

$$\text{Kimball Aggregator } C_j(t) \;:\quad 1 = \left(\int_0^1 \Upsilon\left(\frac{c_{j,k}(t)}{C_j(t)} \, Aj, k(t) \right) dk \right)$$

- Linear technology $c_{j,k}(t) = \ell_{j,k}(t) \; / Z_{j,k}(t)$ all $k \in [0,1], t \geq 0$.
- Cost of each firm k is random: $d \log Z_{j,k}(t) = \sigma d\mathcal{W}_{j,k}(t)$, i.i.d.
- Kimball aggregator yields non-constant elasticity of demand
- Feasibility $\sum_{j=1}^{n} \int_0^1 \ell_{j,k}(t) dk = \ell(t)$ all $t \geq 0$
- Price changes: menu cost ψ_a units of ℓ_a.
- GE effect: shape of U, V, Υ summarized by constants B, θ.

Firms problem (ignore industry heterogeneity)

- After second order approximation in equilibrium:

$$\rho v(x,t) = \min\Big\{ B\left(x+\theta X(t)\right)^2 + \frac{\sigma^2}{2} v_{xx}(x,t) + v_t(x,t) + \kappa \int_0^{\Psi} \min\{0\,,\ \psi + v(x^*(t),t) - v(x,t)\} dG(\psi)\,,\ \rho[\Psi + v(x^*(t),t)] \Big\}$$

- B: curvature, θ: strategic complementarity/substitutability.
- x is the markup deviation from static maximum
  $dx = \sigma d\mathcal{W}$ if there is no adjustment (no steady state inflation)
- Path $\{X(t)\}_{t=0}^{\infty}$: average of x's of all firms. time varying.
- Random fixed cost of price adjustment in period of length dt
  - can always pay Ψ or
  - with probability $\kappa\ dt$ draw fixed cost $\psi \sim G(\cdot)$, w/support on $[0,\Psi]$.
  - if prices are changed, price gap becomes $x^*(t)$

$$\rho v(x,t) = \min \Big\{ B\,(x + \theta X(t))^2 + \frac{\sigma^2}{2} v_{xx}(x,t) + v_t(x,t)$$
$$+ \kappa \int_0^{\Psi} \min\{0\,,\ \psi + v(x^*(t),t) - v(x,t)\} dG(\psi)\,,$$
$$\rho[\Psi + v(x^*(t),t)] \Big\}$$

- Decision rules described by $\underline{x}(t), x^*(t), \bar{x}(t), \Lambda(x,t)$:
  - If $x \notin (\underline{x}(t), \bar{x}(t))$, Pr adjust: $\Lambda(x,t)dt = 1$
  - If $x \in (\underline{x}(t), \bar{x}(t))$, Pr adjust: $\Lambda(\underline{x},t)dt = \kappa\, G\,(v(x,t) - v(x^*(t),t))\, dt$
  - after every price change: $x^*(t) = \arg\min_x v(x,t)$
- Fixed point with cross sectional distribution $f(x,t)$:

$$X(t) = \int_{\underline{x}(t)}^{\bar{x}(t)} x\, f(x,t) dx \text{ all } t \geq 0$$
$$f_t(x) = \frac{\sigma^2}{2} f_{xx}(x,t) - \Lambda(x,t) f(x,t) \text{ all } t, x \neq x^*(t), \underline{x}(t) \leq x \leq \bar{x}(t)$$

- Initial condition $f(x,0) = f(x+\delta)$, i.e. MIT shock on invariant f.

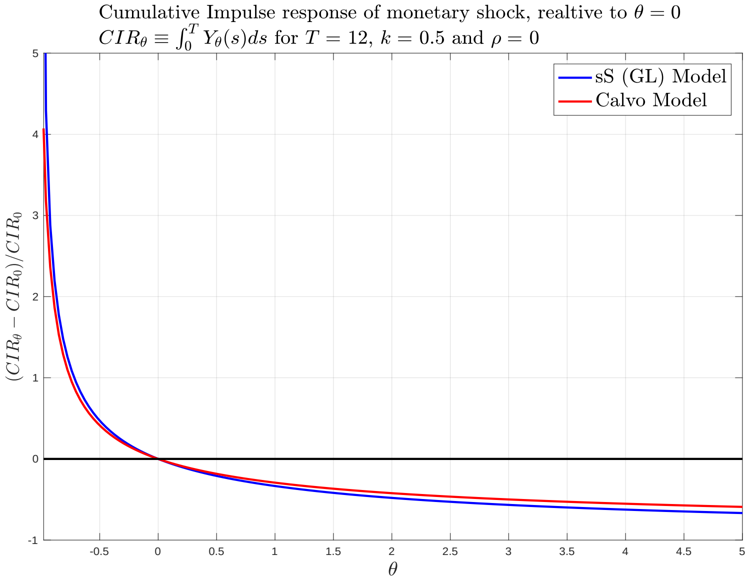
- Steady state, independent of θ
- To simplify, consider Calvo$^+$ indexed by $\mathcal{C} \equiv \frac{\kappa \bar{x}^2}{\sigma^2}$
  - Distribution $f(x)$ of markup-gaps x, shape depends **only** on $\mathcal{C}$
  - Distribution of price changes $q(x)$, shape depends **only** on $\mathcal{C}$.
  - *Freq* frequency price changes, depends on $\mathcal{C}$ and κ.
- Parameter θ and function $\mathcal{S}(\theta)$ below captures:
  - General Equilibrium effects on real wages, $\theta > 0$ and $\mathcal{S}(\theta) < 1$.
  - Industry (Economy) wide strategic complementarity, $\theta < 0$ and $\mathcal{S}(\theta) > 1$, if super-elasticity is positive.
- Sector j's output deviation from steady state

$$Y(t) = \frac{1}{\varrho}[\delta - P(t)] = -\frac{1}{\varrho} \int_{\underline{x}(t)}^{\bar{x}(t)} x\, f(x,t) dx$$

- Cumulative IRF: $CIR^Y \equiv \int_0^\infty Y(t)dt$

$$CIR^Y(\theta, \mathcal{C}, \kappa, \delta) \approx \mathcal{S}(\theta) \frac{\delta}{6} \frac{Kurt(\mathcal{C})}{Freq(\mathcal{S}, \kappa)}$$

Figure: Cumulative Impulse response of Monetary Shock, for a range of θ



Some direct evidence on GHF: gasoline prices

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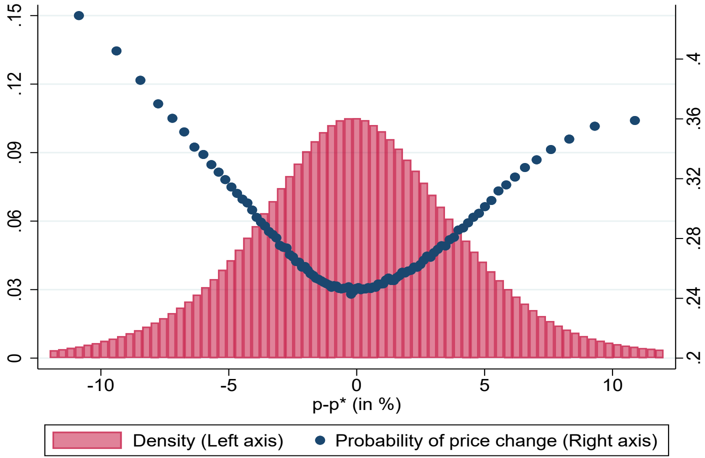
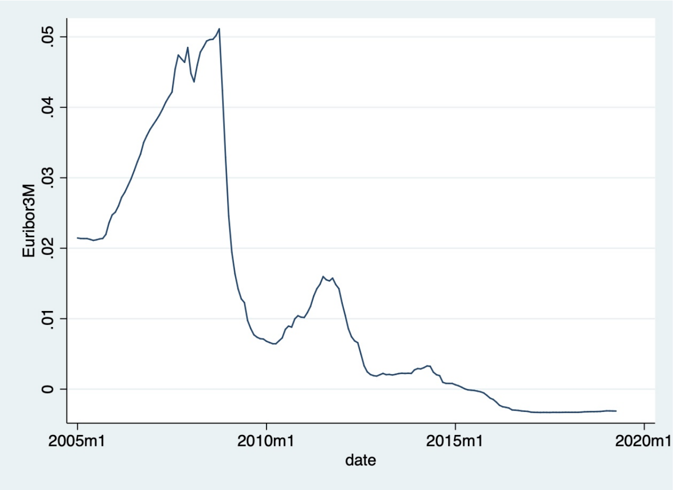
Price gaps $x_t = p_t - p_t^*$ where p_t^* is a linear function of wholesale gasoline price



Source: Gautier, Marx and Vertier, 2021, How do gasoline prices respond to a cost shock?, mimeo BdF

Y_t : 3-Month Euribor – strong downward trend



- Interest rate not stationary: filtered with HP

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Motivation for HP with $\lambda \in (200, 3000)$, PPI

- Interested in economic meaningful IRF

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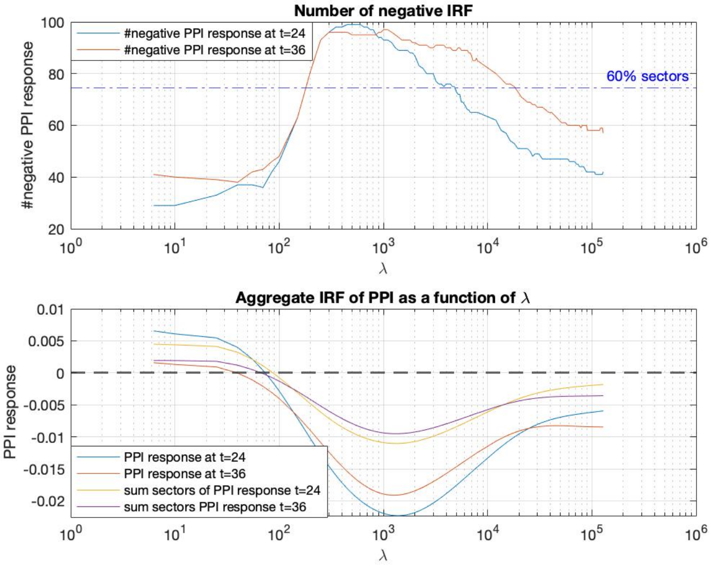
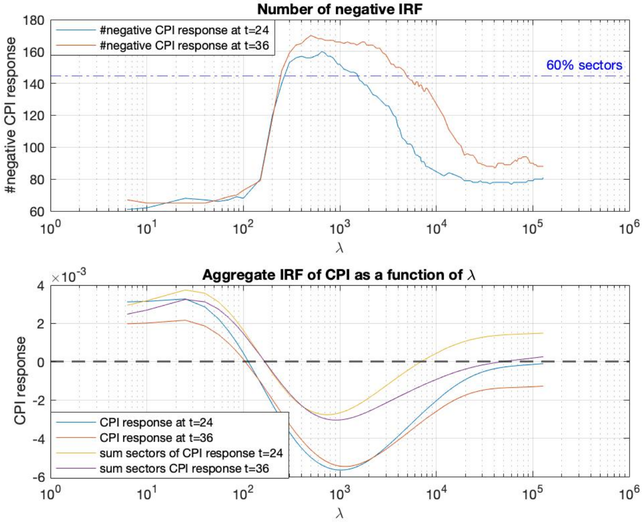


Motivation for HP with $\lambda \in (200, 3000)$, CPI



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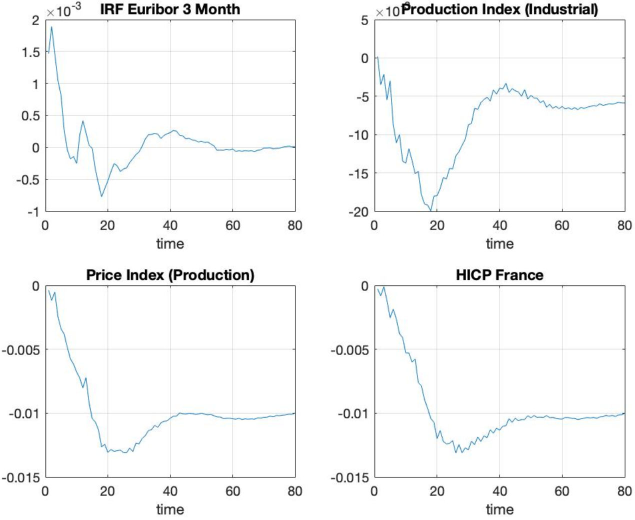
Aggregate IRF - Cholesky No LRR



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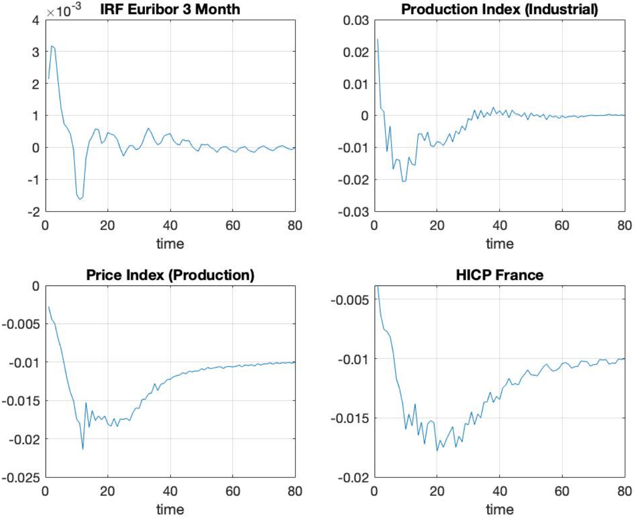
Aggregate IRF - HFI LRR



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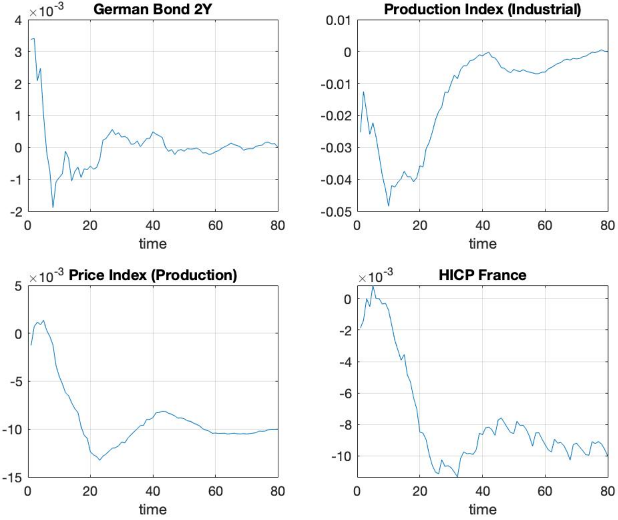
Aggregate IRF - German Bond LRR



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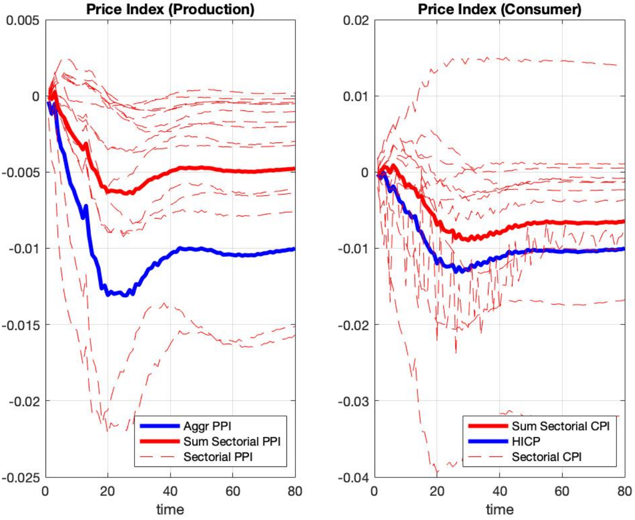
Sectoral IRF - Cholesky No LRR



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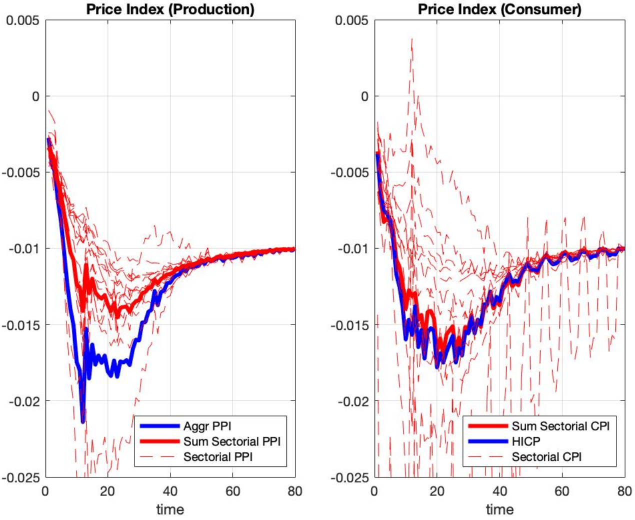
Sectoral IRF - HFI LRR



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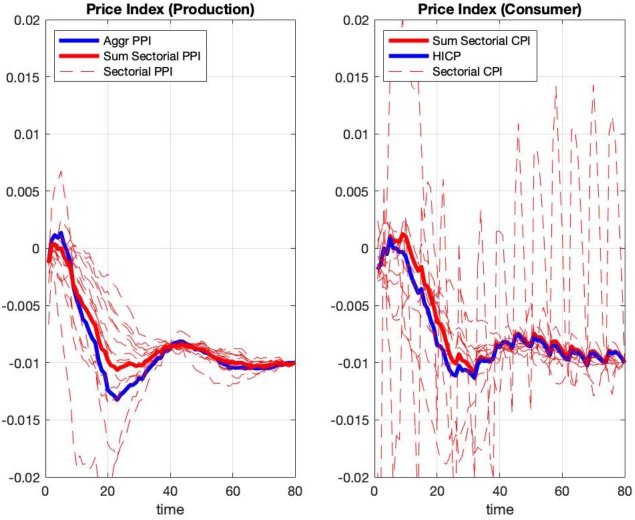
Sectoral IRF - German Bond LRR



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Summary Measures of Monetary Shock Effects

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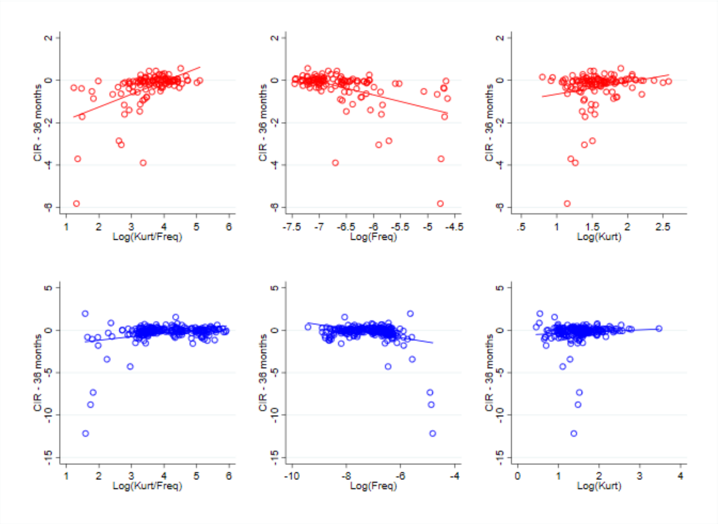
	Moments of the CIR distribution								
	Mean	Std. Dev.	min	5%	25%	50%	75%	95%	max
PANEL A: PRODUCER PRICES									
Cholesky - Long-run restriction									
24 months	-0.18	0.09	-0.64	-0.39	-0.18	-0.16	-0.14	-0.09	0.12
36 months	-0.31	0.10	-0.72	-0.55	-0.32	-0.29	-0.27	-0.22	-0.06
Cholesky - No long-run restriction									
24 months	-0.09	0.27	-1.73	-0.71	-0.07	-0.01	0.02	0.10	0.17
36 months	-0.16	0.41	-2.77	-0.82	-0.16	-0.03	0.01	0.13	0.27
High Frequency Instrument - Long-run restriction									
24 months	-0.26	0.15	-1.21	-0.50	-0.27	-0.21	-0.19	-0.11	-0.01
36 months	-0.42	0.20	-1.58	-0.80	-0.44	-0.36	-0.32	-0.23	0.11
PANEL B: CONSUMER PRICES									
Cholesky - Long-run restriction									
24 months	-0.13	0.22	-1.92	-0.38	-0.20	-0.12	-0.04	0.15	0.49
36 months	-0.28	0.25	-2.44	-0.61	-0.32	-0.24	-0.16	-0.01	0.19
Cholesky - No long-run restriction									
24 months	-0.07	0.50	-4.76	-0.42	-0.09	0.01	0.09	0.24	0.91
36 months	-0.17	0.80	-7.83	-0.74	-0.22	-0.04	0.10	0.32	1.27
High Frequency Instrument - Long-run restriction									
24 months	-0.30	0.29	-2.50	-0.84	-0.32	-0.23	-0.17	-0.07	0.02
36 months	-0.48	0.38	-3.28	-1.22	-0.51	-0.39	-0.30	-0.16	-0.03

Relating CIR^P with $\frac{Kur}{Freq}$ - No LRR



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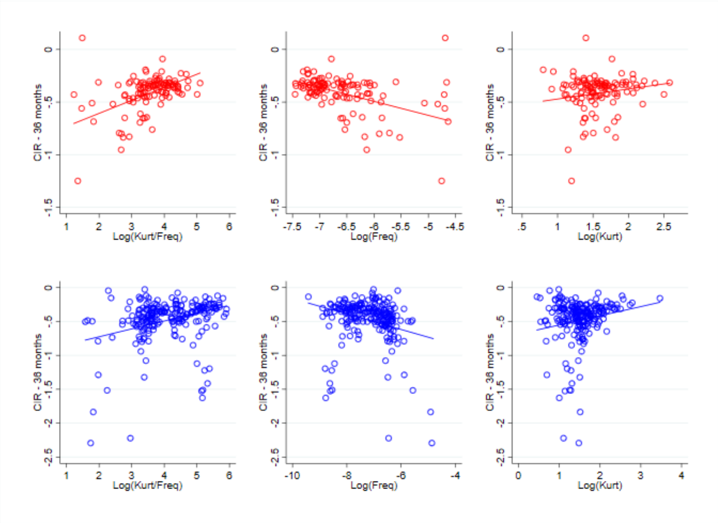
Relating CIR^P with $\frac{Kur}{Freq}$ - HFI



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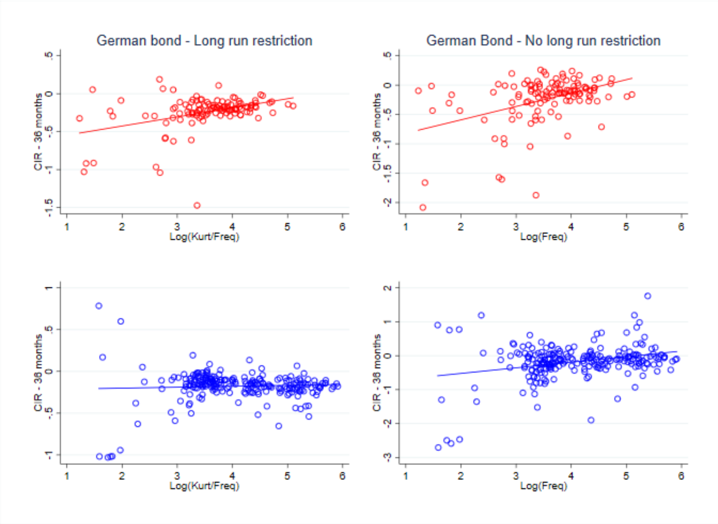
Relating CIR^P with $\frac{Kur}{Freq}$ - German Bond



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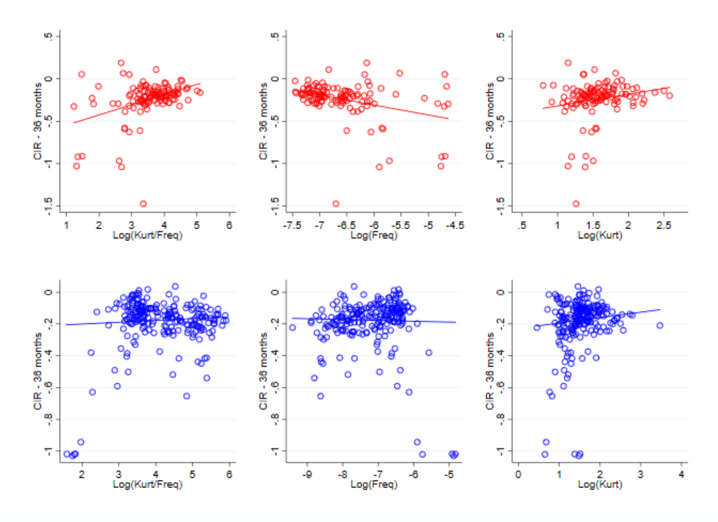
Relating CIR^P with $\frac{Kur}{Freq}$ - German Bond



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Measurement Error

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- Assume measurement error of the following type:
  - Extra spurious price changes every period
  - These spurious price changes are small.
- Analyzed/documented French CPI, US Scanner price data. comparing same stores/goods with online price data
- Effect: Increase Kurtosis & Frequency of Price changes, but leave ratio Kurtosis/Frequency unchanged.
- Bias $\propto$ fraction of spurios price changes
- Theory indicates to use Kurtosis/Frequency, but also measurement should be more robust.

- $N_{\Delta p}$: number of price changes per period (frequency)
- Δp: price changes, with mean zero and $Var(\Delta p) = \sigma^2_{\Delta p}$ and $Kurt(\Delta p) = m_{4,\Delta p}/\sigma^4_{\Delta p}$
- N_e spurious price changes per unit of time (frequency),
- e: spurious price changes, mean zero and $Var(e) = \sigma^2_e$ and $Kurt(e) = m_{4,e}/\sigma^4_e$
- Spurious and true price changes statistically independent
- $\tilde{N} = N_{\Delta p} + N_e$: measured price changes per period (freq.)
- $\tilde{\Delta} p$: measured price changes, with mean zero and

$$Kurt(\tilde{\Delta} p) = \frac{\theta m_{4,\Delta p}\sigma^4_{\Delta p} + (1-\theta) m_{4,e}\sigma^4_e}{\left(\theta\sigma^2_{\Delta p} + (1-\theta)\sigma^2_e\right)^2} \text{ with } \theta \equiv \frac{N_{\Delta p}}{\tilde{N}} \text{ so}$$

$$\lim_{\sigma^2_e \to 0} Kurt(\tilde{\Delta} p) = \frac{Kurt(\Delta p)}{\theta} \implies \lim_{\sigma^2_e \to 0} \frac{Kurt(\tilde{\Delta} p)}{\tilde{N}} = \frac{Kurt(\Delta p)}{N_{\Delta p}}$$

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Reverse regression: PPI

Back

Identification	Cholesky Long-run Restriction $T=24m$	Cholesky Long-run Restriction $T=36m$	Cholesky No Long-run Restriction $T=24m$	Cholesky No Long-run Restriction $T=36m$	High-Frequency IV Long-run Restriction $T=24m$	High-Frequency IV Long-run Restriction $T=36m$
$CIR_T^{P_j}$	0.612***	0.845***	0.358***	0.252***	0.681***	0.488***
	(0.220)	(0.186)	(0.0672)	(0.0477)	(0.130)	(0.103)
Constant	54.38***	69.69***	46.64***	47.52***	61.22***	63.92***
	(5.117)	(7.050)	(2.665)	(2.698)	(4.765)	(5.781)
Observations	118	118	118	118	118	118
R^2	0.041	0.082	0.117	0.135	0.131	0.118

- Coefficient expected to be equal to 6
- If mismeasurement of CIR, then coef between 0 and 6

Placebo Test: PPI - unconstrained

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
$Freq/\bar{F}$	-2.865*	-3.337**	-11.50**	-17.79**	-5.488*	-6.347
	(1.454)	(1.491)	(4.922)	(7.743)	(3.258)	(4.406)
$Kurt/\bar{K}$	3.026	4.066	10.13*	15.95*	5.823*	7.153
	(3.048)	(2.796)	(5.749)	(8.154)	(3.177)	(4.673)
Mean	-0.254	-0.186	-2.353	-3.699	-0.855	-0.927
	(0.792)	(0.851)	(2.242)	(3.486)	(1.285)	(1.699)
Skewness	1.798	0.793	-2.645	-6.643	-4.708*	-7.159*
	(3.359)	(2.989)	(7.065)	(9.668)	(2.589)	(3.855)
Standard dev.	-0.916	-0.625	-2.533	-3.331	0.245	0.837
	(1.297)	(1.306)	(4.158)	(6.425)	(2.460)	(3.229)
Constant	-13.33*	-28.68***	4.485	1.130	-27.87*	-47.18**
	(7.379)	(7.539)	(22.87)	(35.69)	(14.08)	(18.59)
Observations	118	118	118	118	118	118
R^2	0.118	0.164	0.246	0.264	0.228	0.195

Back

ONLY PPI. SeasAdj

Identification	Euribor				High-Frequency IV			
Long-run Restriction	No		Yes		No		Yes	
	24 months	36 months	24 months	36 months	24 months	36 months	24 months	36 months
PANEL A: Constrained model								
Kurt/Freq	0.334***	0.526***	-0.00175	0.00144	0.402***	0.595***	-0.0379**	-0.0356***
	(0.101)	(0.155)	(0.0118)	(0.00911)	(0.122)	(0.176)	(0.0150)	(0.0129)
Constant	-24.45***	-39.20***	-19.19***	-30.97***	-29.46***	-43.98***	-20.93***	-31.77***
	(6.149)	(9.375)	(0.837)	(0.646)	(7.485)	(10.74)	(0.931)	(0.793)
R^2	0.131	0.141	0.000	0.000	0.120	0.127	0.063	0.076
PANEL B: Unconstrained model								
freq/mean(freq)	-10.96***	-17.01***	-0.119	-0.0517	-12.80***	-18.61***	0.621	0.597
	(4.125)	(6.339)	(0.564)	(0.417)	(4.757)	(6.788)	(0.626)	(0.530)
kurt/mean(kurt)	14.43***	22.74***	-0.152	-0.0568	15.29**	22.49**	-1.493*	-1.532**
	(5.376)	(8.157)	(0.765)	(0.591)	(6.355)	(9.050)	(0.881)	(0.741)
Constant	-13.36**	-21.98**	-18.99***	-30.80***	-14.42*	-21.96**	-21.70***	-32.39***
	(5.859)	(8.704)	(1.055)	(0.816)	(7.432)	(10.47)	(1.058)	(0.887)
R^2	0.252	0.264	0.001	0.000	0.210	0.216	0.042	0.055
Observations	118	118	118	118	118	118	118	118

Regression Results: Outliers (PPI) (1/2)

Back

Identification	Cholesky Long-run Restriction $T=24m$	Cholesky Long-run Restriction $T=36m$	Cholesky No Long-run Restriction $T=24m$	Cholesky No Long-run Restriction $T=36m$	High-Frequency IV Long-run Restriction $T=24m$	High-Frequency IV Long-run Restriction $T=36m$
PANEL A: CIR						
Kurt/Freq	0.0451*	0.0713**	0.200***	0.331***	0.131***	0.172***
	(0.0230)	(0.0275)	(0.0632)	(0.0916)	(0.0341)	(0.0452)
Constant	-19.18***	-33.53***	-14.56***	-26.00***	-30.61***	-48.11***
	(1.490)	(1.680)	(3.956)	(5.648)	(2.039)	(2.711)
R^2	0.042	0.087	0.111	0.135	0.144	0.138
PANEL B: Ratio						
Kurt/Freq	0.0762*	0.108***	0.320***	0.517***	0.181***	0.226***
	(0.0392)	(0.0352)	(0.0824)	(0.116)	(0.0444)	(0.0668)
Constant	-20.39***	-34.85***	-19.84***	-33.92***	-32.18***	-49.54***
	(2.388)	(2.146)	(5.050)	(7.031)	(2.580)	(3.861)
R^2	0.039	0.086	0.121	0.149	0.146	0.116
Observations	112	112	112	112	112	112

Regression Results: Outliers (PPI) (2/2)

Back

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
PANEL C: Kurtosis						
Kurt/Freq	0.0933**	0.134***	0.439***	0.713***	0.261***	0.328***
	(0.0404)	(0.0419)	(0.123)	(0.189)	(0.0714)	(0.0942)
Constant	-21.63***	-36.67***	-27.37***	-46.28***	-37.23***	-55.95***
	(2.452)	(2.479)	(7.198)	(10.94)	(4.073)	(5.406)
R^2	0.057	0.112	0.151	0.172	0.176	0.158
PANEL D: Frequency						
Kurt/Freq	0.0491	0.0866**	0.321***	0.542***	0.215***	0.281***
	(0.0308)	(0.0369)	(0.113)	(0.179)	(0.0679)	(0.0865)
Constant	-19.54***	-34.53***	-22.12***	-38.86***	-35.46***	-54.31***
	(2.049)	(2.281)	(6.795)	(10.55)	(3.839)	(4.886)
R^2	0.023	0.064	0.107	0.128	0.153	0.155
Observations	112	112	112	112	112	112

Regression Results: Kurto heterogeneity (PPI)

Back

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
PANEL A: Producer Prices - Constrained model						
Kurt/Freq	0.0837**	0.115***	0.348***	0.557***	0.190***	0.234***
	(0.0345)	(0.0384)	(0.112)	(0.175)	(0.0662)	(0.0862)
Constant	-20.49***	-34.79***	-20.30***	-34.47***	-32.33***	-49.60***
	(1.807)	(1.917)	(5.699)	(8.772)	(3.278)	(4.293)
R^2	0.045	0.080	0.093	0.103	0.090	0.078
PANEL B: Producer Prices - Unconstrained model						
$Freq/\bar{F}$	-2.408*	-3.066**	-11.16**	-17.71**	-6.048**	-7.328*
	(1.280)	(1.327)	(4.341)	(6.821)	(2.822)	(3.803)
$Kurt/\bar{K}$	4.458**	4.376**	6.163***	7.230**	-0.641	-2.262
	(2.027)	(1.746)	(2.263)	(3.135)	(2.236)	(3.571)
Constant	-19.71***	-32.22***	-3.540	-5.158	-19.21***	-32.08***
	(2.272)	(1.985)	(3.317)	(4.669)	(2.556)	(3.995)
R^2	0.146	0.185	0.220	0.231	0.192	0.162
Observations	118	118	118	118	118	118

Regression Results: Kurto small price changes (PPI)

Back

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
PANEL A: Outlier threshold - Constrained model						
Kurt/Freq	0.0554*	0.0806**	0.271***	0.441***	0.158***	0.199***
	(0.0283)	(0.0323)	(0.0933)	(0.146)	(0.0561)	(0.0728)
Constant	-19.78***	-33.99***	-18.89***	-32.51***	-31.95***	-49.28***
	(1.801)	(1.878)	(5.404)	(8.261)	(3.075)	(4.048)
R^2	0.031	0.062	0.088	0.101	0.098	0.088
PANEL B: Outlier threshold - small price changes - Unconstrained model						
$Freq/\bar{F}$	-2.417*	-3.037**	-10.90**	-17.23**	-5.819**	-7.011*
	(1.298)	(1.327)	(4.266)	(6.675)	(2.767)	(3.743)
$Kurt/\bar{K}$	2.490	3.403*	10.32**	16.51**	5.349*	6.565*
	(1.760)	(1.954)	(5.048)	(7.618)	(2.852)	(3.670)
Constant	-17.73***	-31.28***	-7.961	-14.92	-25.43***	-41.23***
	(2.321)	(2.331)	(6.351)	(9.352)	(3.310)	(4.402)
R^2	0.096	0.147	0.227	0.245	0.209	0.173
Observations	118	118	118	118	118	118

Regression Results: Kurto large price changes (PPI)

Back

Identification	Cholesky Long-run Restriction $T=24m$	Cholesky Long-run Restriction $T=36m$	Cholesky No Long-run Restriction $T=24m$	Cholesky No Long-run Restriction $T=36m$	High-Frequency IV Long-run Restriction $T=24m$	High-Frequency IV Long-run Restriction $T=36m$
PANEL C: Outlier threshold - Constrained model						
Kurt/Freq	0.0273	0.0415*	0.148**	0.244**	0.0881*	0.112*
	(0.0193)	(0.0245)	(0.0701)	(0.112)	(0.0453)	(0.0587)
Constant	-19.49***	-33.69***	-18.46***	-31.96***	-31.81***	-49.18***
	(1.906)	(2.116)	(6.073)	(9.448)	(3.652)	(4.786)
R^2	0.023	0.050	0.081	0.094	0.093	0.085
PANEL D: Outlier threshold - large price changes - Unconstrained model						
$Freq/\bar{F}$	-2.521*	-3.181**	-11.34***	-17.94***	-6.053**	-7.298*
	(1.306)	(1.345)	(4.308)	(6.752)	(2.806)	(3.794)
$Kurt/\bar{K}$	1.062	1.653	6.948	11.50*	4.095	5.210
	(1.267)	(1.513)	(4.257)	(6.687)	(2.812)	(3.647)
Constant	-16.20***	-29.38***	-4.141	-9.199	-23.94***	-39.59***
	(1.623)	(1.675)	(4.776)	(7.203)	(2.774)	(3.682)
R^2	0.089	0.137	0.223	0.243	0.210	0.176
Observations	118	118	118	118	118	118

Regression Results: Sector fixed effects (PPI)

Back

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
PANEL A: Constrained model						
Kurt/Freq	0.0366	0.0565*	0.187**	0.308***	0.119**	0.153**
	(0.0301)	(0.0321)	(0.0746)	(0.113)	(0.0483)	(0.0662)
Constant	-14.93***	-27.83***	-10.95	-21.18**	-27.53***	-44.18***
	(2.701)	(3.153)	(6.680)	(9.927)	(3.258)	(3.918)
R^2	0.371	0.440	0.521	0.549	0.527	0.476
PANEL B: Producer prices- Unconstrained model						
$Freq/\bar{F}$	-1.705	-1.951	-5.645	-8.545	-2.621	-2.957
	(1.310)	(1.274)	(3.587)	(5.466)	(2.336)	(3.375)
$Kurt/\bar{K}$	2.562	2.722	10.22**	15.54**	3.630	3.823
	(1.964)	(1.984)	(4.954)	(7.317)	(2.902)	(3.963)
Constant	-14.62***	-26.72***	-8.912	-17.16*	-24.30***	-39.57***
	(2.986)	(3.177)	(6.631)	(9.341)	(2.908)	(3.588)
R^2	0.396	0.462	0.544	0.567	0.525	0.467
Observations	118	118	118	118	118	118

Regression Results: Sector fixed effects (CPI)

Back

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
PANEL A: Constrained model						
Kurt/Freq	0.0246	0.0422*	0.0869*	0.147*	0.0821***	0.110***
	(0.0187)	(0.0224)	(0.0505)	(0.0814)	(0.0259)	(0.0337)
Constant	1.697	-14.68***	-0.568	-18.47***	-34.83***	-58.09***
	(2.922)	(2.760)	(3.821)	(5.835)	(2.039)	(3.063)
R^2	0.530	0.544	0.334	0.338	0.486	0.491
PANEL D: Consumer prices - Unconstrained model						
$Freq/\bar{F}$	-11.03***	-14.88***	-44.40***	-70.72***	-19.96***	-24.87***
	(1.623)	(1.883)	(6.174)	(9.915)	(2.697)	(3.495)
$Kurt/\bar{K}$	3.499	4.357*	-2.829	-6.232	4.020**	5.231*
	(2.458)	(2.456)	(3.174)	(5.412)	(1.988)	(2.688)
Constant	16.46***	5.828	73.59***	101.4***	-4.886	-20.75***
	(4.419)	(4.571)	(10.25)	(16.40)	(4.972)	(6.628)
R^2	0.678	0.743	0.765	0.766	0.747	0.723
Observations	223	223	223	223	223	223

Regression Results: 2-year German Bond (PPI)

Back

Identification	High-Frequency IV		High-Frequency IV	
Long-run Restriction	Yes		No	
	24 months	36 months	24 months	36 months
PANEL A: Producer Prices - Constrained model				
Kurt/Freq	0.186***	0.244***	0.293***	0.463***
	(0.0669)	(0.0775)	(0.0959)	(0.154)
Constant	-20.34***	-34.78***	-25.38***	-45.14***
	(4.393)	(4.993)	(5.932)	(9.271)
R^2	0.069	0.091	0.092	0.095
PANEL B: Producer Prices - Unconstrained model				
$Freq/\bar{F}$	-5.148*	-6.623**	-9.108**	-14.76**
	(2.627)	(2.973)	(3.684)	(5.895)
$Kurt/\bar{K}$	8.553**	10.98**	7.716	9.263
	(3.931)	(4.451)	(4.982)	(7.542)
Constant	-15.64***	-28.50***	-11.24*	-19.45**
	(5.071)	(5.651)	(6.250)	(8.931)
R^2	0.104	0.131	0.144	0.149
Observations	118	118	118	118

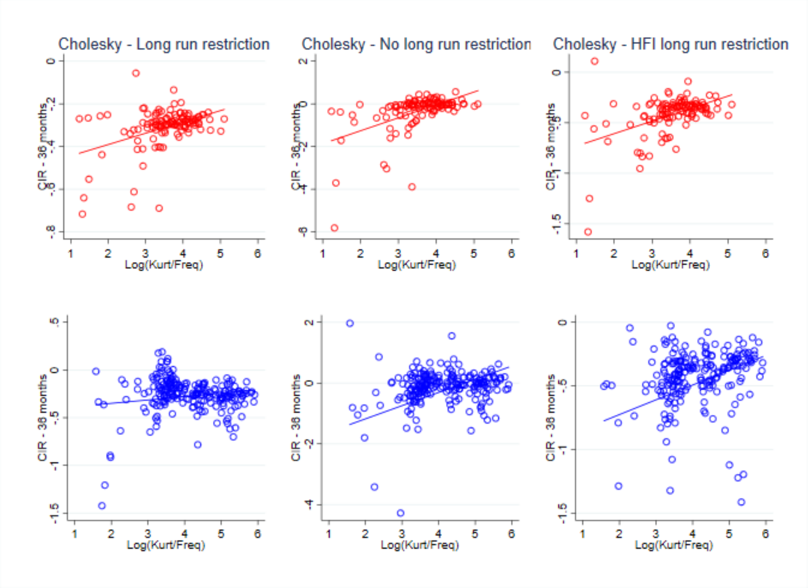
Regression Results: $<$ 5% average PPI inflation

Back

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
PANEL A: Constrained model						
Kurt/Freq	0.0597*	0.0917**	0.309***	0.509***	0.190***	0.242***
	(0.0318)	(0.0350)	(0.103)	(0.161)	(0.0616)	(0.0805)
Constant	-19.95***	-34.68***	-21.03***	-36.50***	-34.05***	-52.25***
	(2.037)	(2.150)	(6.203)	(9.569)	(3.671)	(4.851)
R^2	0.042	0.085	0.127	0.142	0.129	0.118
PANEL B: Producer Prices - Unconstrained model						
$Freq/\bar{F}$	-2.615**	-3.243**	-11.65***	-18.37***	-6.092**	-7.294*
	(1.290)	(1.324)	(4.279)	(6.712)	(2.798)	(3.787)
$Kurt/\bar{K}$	2.817*	4.008**	11.29**	18.19**	6.322**	7.900*
	(1.604)	(1.808)	(4.838)	(7.521)	(3.095)	(4.056)
Constant	-17.54***	-31.44***	-7.149	-14.05**	-26.00***	-42.29***
	(1.637)	(1.790)	(4.549)	(7.011)	(2.985)	(4.029)
R^2	0.133	0.184	0.295	0.303	0.220	0.179
Observations	116	116	116	116	116	116

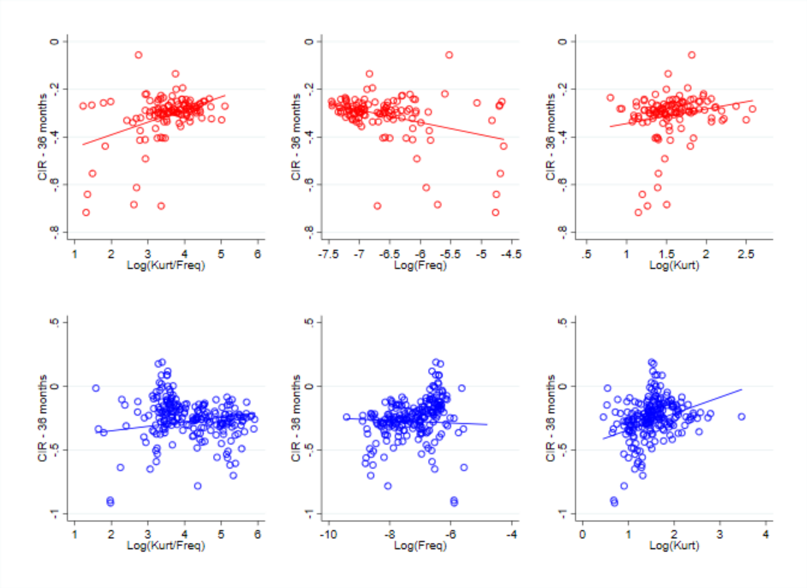
Step 3: Relating CIR^P with $\frac{Kur}{Freq}$

Back



Top - red: PPI & Bottom-blue CPI

Step 3: Relating CIR^P with $\frac{Kur}{Freq}$, *Kur* and *Freq*



Top - red: PPI & Bottom-blue CPI

More

More on PPI: Testing Model's Predictions

Back

- Under a strict interpretation, predicted coefficients are:
- In the constrained version of the model: $\beta = 1/6$ and $\alpha = -T$
- In the unconstrained version of the model: $\beta^k = -\beta^f = \frac{\delta}{6}\frac{\bar{K}}{\bar{F}}$

Identification	Cholesky LRR		Cholesky No LRR		High-Freq. IV LRR	
	$T = 24$	$T = 36$	$T = 24$	$T = 36$	$T = 24$	$T = 36$
PRODUCER PRICES						
Constrained model						
P-val $\beta = 1/6$	0.003	0.053	0.125	0.025	0.681	0.351
P-val $\alpha = -T$	0.111	0.702	0.042	0.763	0.006	0.000
Ratio α/β	-307.6	-360.9	-69.58	-72.82	-178.5	-216.0
Unconstrained model						
P-val $\beta_f = -\beta_k$	0.566	0.457	0.648	0.643	0.819	0.857
P-val $\beta_f = -\frac{\bar{K}}{6\bar{F}}$	0.130	0.325	0.111	0.047	0.577	0.460
P-val $\beta_k = \frac{\bar{K}}{6\bar{F}}$	0.679	0.915	0.098	0.044	0.477	0.389
P-val $\gamma = -T + \frac{\bar{K}}{6\bar{F}}$	0.743	0.687	0.161	0.170	0.100	0.007

More on CPI: Testing Model's Predictions

Back

- Under a strict interpretation, predicted coefficients are:
- In the constrained version of the model: $\beta = 1/6$ and $\alpha = -T$
- In the unconstrained version of the model: $\beta^k = -\beta^f = \frac{\delta}{6}\frac{\bar{K}}{\bar{F}}$

Identification	Cholesky LRR		Cholesky No LRR		High-Freq. IV LRR	
	$T = 24$	$T = 36$	$T = 24$	$T = 36$	$T = 24$	$T = 36$
Constrained model						
P-val $\beta = 1/6$	0.000	0.000	0.030	0.802	0.000	0.003
P-val $\alpha = -T$	0.000	0.009	0.001	0.630	0.003	0.000
Unconstrained model						
P-val $\beta_f = -\beta_k$	0.877	0.492	0.001	0.000	0.049	0.039
P-val $\beta_f = -\frac{\bar{K}}{6\bar{F}}$	0.281	0.860	0.003	0.000	0.032	0.006
P-val $\beta_k = \frac{\bar{K}}{6\bar{F}}$	0.124	0.377	0.208	0.591	0.710	0.664

CPI Regression Results: Placebo

▸ Back

Identification	Cholesky Long-run Restriction $T = 24m$	Cholesky Long-run Restriction $T = 36m$	Cholesky No Long-run Restriction $T = 24m$	Cholesky No Long-run Restriction $T = 36m$	High-Frequency IV Long-run Restriction $T = 24m$	High-Frequency IV Long-run Restriction $T = 36m$
Kurt/Freq	-0.0529**	-0.0308	0.0922	0.212**	0.0585*	0.0923**
	(0.0206)	(0.0253)	(0.0580)	(0.0929)	(0.0348)	(0.0455)
Mean	1.636**	1.498*	0.911	0.284	0.550	0.380
	(0.755)	(0.826)	(1.223)	(1.981)	(0.864)	(1.159)
Skewnes	2.109	5.033	10.83	19.63	11.30***	15.52***
	(3.699)	(4.102)	(8.134)	(13.28)	(4.227)	(5.603)
Standard dev.	-1.992**	-1.732*	2.204	5.291	0.332	0.795
	(0.860)	(1.044)	(2.358)	(3.684)	(1.166)	(1.486)
Constant	5.271	-12.17	-30.29	-71.69*	-35.49***	-58.97***
	(7.708)	(9.376)	(23.82)	(37.61)	(11.33)	(14.45)
Observations	223	223	223	223	223	223
R^2	0.067	0.038	0.027	0.050	0.036	0.045

CPI Regression Results: Placebo

▸ Back

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
$Freq/\bar{F}$	-6.170*	-10.12***	-37.39***	-62.37***	-17.81***	-23.07***
	(3.170)	(3.640)	(9.143)	(13.96)	(3.969)	(4.877)
$Kurt/\bar{K}$	-4.732*	-2.640	6.454	16.08	7.629	11.55*
	(2.733)	(3.216)	(6.959)	(11.74)	(4.688)	(6.434)
Mean	0.0898	-0.366	-3.328**	-6.085***	-1.505**	-2.092**
	(0.783)	(0.822)	(1.451)	(2.258)	(0.718)	(0.956)
Skewness	5.111	7.162	9.659*	14.77	8.489**	10.98**
	(4.335)	(4.393)	(5.724)	(9.326)	(3.586)	(4.974)
Standard dev.	-2.972***	-2.767**	0.0440	2.281	-0.00409	0.554
	(1.078)	(1.248)	(2.524)	(3.908)	(1.211)	(1.571)
Constant	21.50*	8.500	30.21	23.08	-15.71	-35.47*
	(11.82)	(13.60)	(29.17)	(45.66)	(14.13)	(18.48)
Observations	223	223	223	223	223	223
R^2	0.108	0.165	0.509	0.572	0.383	0.380

CPI Regression Results: Role of Sales

Back

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
PANEL A: Excluding food, clothing/footwear, furnishings - Constrained model						
Kurt/Freq	0.0467**	0.0692**	0.159**	0.257**	0.0993***	0.129***
	(0.0229)	(0.0290)	(0.0688)	(0.111)	(0.0342)	(0.0437)
Constant	-23.04***	-39.33***	-28.69**	-48.78**	-38.04***	-57.39***
	(4.330)	(5.454)	(12.67)	(20.35)	(6.312)	(8.042)
R^2	0.034	0.048	0.053	0.054	0.078	0.079
PANEL B: Excluding food, clothing/footwear, furnishings - Unconstrained model						
$Freq/\bar{F}$	-8.726***	-12.88***	-41.62***	-67.93***	-19.92***	-25.41***
	(1.218)	(1.514)	(5.832)	(9.581)	(2.792)	(3.633)
$Kurt/\bar{K}$	5.318**	6.718**	7.192**	9.855*	6.500***	8.122***
	(2.683)	(3.062)	(3.581)	(5.421)	(2.173)	(2.724)
Constant	-14.39***	-25.38***	23.61***	38.21***	-13.44***	-25.64***
	(3.494)	(3.996)	(6.327)	(10.11)	(3.537)	(4.559)
R^2	0.260	0.361	0.725	0.745	0.644	0.636
Observations	134	134	134	134	134	134

CPI Regression Results: Role of Sales

Back

Identification	Cholesky Long-run Restriction		Cholesky No Long-run Restriction		High-Frequency IV Long-run Restriction	
	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$	$T = 24m$	$T = 36m$
PANEL C: % of sales prices below the median - Constrained model						
Kurt/Freq	-0.000929	0.0316	0.157**	0.297**	0.133***	0.185***
	(0.0276)	(0.0342)	(0.0783)	(0.124)	(0.0374)	(0.0473)
Constant	-12.32**	-30.73***	-28.98*	-58.63**	-45.07***	-69.35***
	(5.440)	(6.705)	(14.92)	(23.51)	(7.003)	(8.771)
R^2	0.000	0.009	0.046	0.064	0.130	0.153
PANEL D: % of sales prices below the median - Unconstrained model						
$Freq/\bar{F}$	-8.872***	-13.71***	-46.39***	-76.50***	-23.27***	-29.96***
	(2.363)	(2.662)	(8.340)	(13.05)	(3.285)	(4.144)
$Kurt/\bar{K}$	0.410	2.409	1.933	4.958	7.194**	10.26***
	(2.749)	(3.355)	(5.007)	(7.617)	(2.802)	(3.579)
Constant	-3.958	-15.85***	33.29***	46.49***	-13.92***	-28.66***
	(4.625)	(5.405)	(9.066)	(13.62)	(4.492)	(5.665)
R^2	0.166	0.273	0.645	0.693	0.676	0.690
Observations	111	111	111	111	111	111

Comparison with Hong et al. (2020) (1/3)

Back

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

Comparison with HKPS (2020) (2/3)

Back

- 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! Ratio-Table 1 Ratio-Table 11

Comparison with HKPS (2020) (3/3)

Back

- 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.

HKPS 2020 - Table 1

Back

Cross-Sectional Determinants of Sectoral Price Response									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log $\frac{\text{Kurtosis}}{\text{Frequency}}$	-0.250***								
	(0.074)								
Log Frequency		0.422***				0.476***	0.471***	0.385***	0.252**
		(0.073)				(0.074)	(0.084)	(0.093)	(0.123)
Log Kurtosis			0.138			-0.151	-0.163	-0.138	-0.096
			(0.119)			(0.112)	(0.122)	(0.113)	(0.120)
Log Avg. Size				-0.316**			-0.054	-0.097	-0.004
				(0.148)			(0.207)	(0.213)	(0.192)
Log Standard Dev.					-0.158		0.033	0.053	-0.115
					(0.127)		(0.138)	(0.149)	(0.124)
Log Profit								-0.341**	-0.228
								(0.154)	(0.145)
$SD(e_k)$									10.625
									(12.229)
$\rho(e_k)$									0.595***
									(0.119)
NAICS 3 FE	X	X	X	X	X	X	X	X	X
R^2	0.429	0.502	0.394	0.407	0.393	0.509	0.509	0.519	0.597
N	148	148	148	148	148	148	148	147	147

Table 1: Decomposing Monetary Non-Neutrality

NOTE: This tables uses regression analysis to test the informativeness of pricing moments for monetary non-neutrality. We estimate the following specification: $log(IRF_{k,h}) = a + \alpha_j + \beta' M_k + \gamma' X_j + \epsilon_{k,h}$. Where $Log(IRF_{k,h})$ 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. α_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 the autocorrelation of sector level shocks. Robust standard errors in parentheses. *** Significant at

HKPS 2020 - Table 11

Back

Cross-Sectional Determinants of Sectoral Price Response Univariate Specifications						
	Baseline		Sample 1, IV Sample 2		Sample 2, IV Sample 1	
	(1)	(2)	(3)	(4)	(5)	(6)
Log $\frac{\text{Kurtosis}}{\text{Frequency}}$	-0.420***	-0.250***	-0.493***	-0.335***	-0.448***	-0.269***
	(0.060)	(0.074)	(0.066)	(0.074)	(0.071)	(0.077)
NAICS 3 FE		X		X		X
R^2	0.177	0.429	0.130	0.413	0.213	0.448
N	148	148	147	147	147	147
Log Frequency	0.448***	0.422***	0.470***	0.454***	0.507***	0.521***
	(0.056)	(0.073)	(0.060)	(0.078)	(0.067)	(0.094)
NAICS 3 FE		X		X		X
R^2	0.303	0.502	0.268	0.484	0.296	0.483
N	148	148	148	148	148	148
Log Kurtosis	0.289***	0.138	0.303**	0.072	0.301**	0.181
	(0.106)	(0.119)	(0.131)	(0.129)	(0.124)	(0.122)
NAICS 3 FE		X		X		X
R^2	0.042	0.394	0.035	0.395	0.026	0.382
N	148	148	147	147	147	147
Log Avg. Size	-0.594***	-0.316**	-0.497***	-0.313	-1.065***	-0.536**
	(0.120)	(0.148)	(0.182)	(0.231)	(0.205)	(0.234)
R^2	0.106	0.407	0.119	0.404	-0.095	0.373
N	148	148	148	148	148	148
Log Std. Dev.	-0.456***	-0.158	0.259	-0.031	0.865	0.743
	(0.141)	(0.127)	(0.412)	(0.474)	(0.536)	(0.595)
NAICS 3 FE		X		X		X
R^2	0.067	0.393	0.011	0.387	-0.028	0.355
N	148	148	147	147	147	147

Source: HKPS 2020, WP 875, Banco Central De Chile

HKPS 2020 - Table 12

Back

Cross-Sectional Determinants of Sectoral Price Response Multivariate Specifications						
	Baseline		Sample 1, IV Sample 2		Sample 2, IV Sample 1	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Frequency	0.520***	0.476***	0.561***	0.549***	0.623***	0.601***
	(0.056)	(0.074)	(0.062)	(0.074)	(0.072)	(0.099)
Log Kurtosis	-0.222**	-0.151	-0.237*	-0.223*	-0.313**	-0.220*
	(0.104)	(0.112)	(0.127)	(0.120)	(0.125)	(0.118)
NAICS 3 FE		X		X		X
R^2	0.320	0.509	0.277	0.481	0.331	0.501
N	148	148	147	147	147	147
Log Frequency	0.501***	0.471***	0.668***	0.610***	0.594***	0.581***
	(0.074)	(0.084)	(0.111)	(0.121)	(0.107)	(0.118)
Log Kurtosis	-0.165	-0.163	-0.062	-0.129	-0.307	-0.270
	(0.117)	(0.122)	(0.190)	(0.201)	(0.189)	(0.212)
Log Avg. Size	0.113	-0.054	0.298	0.212	-0.161	-0.107
	(0.212)	(0.207)	(0.278)	(0.326)	(0.296)	(0.279)
Log Std. Dev.	-0.213	0.033	-0.597	-0.387	-0.052	0.230
	(0.156)	(0.138)	(0.555)	(0.731)	(0.670)	(0.816)
NAICS 3 FE		X		X		X
R^2	0.327	0.509	0.132	0.428	0.327	0.492
N	148	148	147	147	147	147

Source: HKPS 2020, WP 875, Banco Central De Chile

Back

Theory Background and Setup - 1: Firm's Problem

- Price gap: $x = p - p^*$
  x a random walk (shocks to nominal marginal costs): $dx = \sigma d\mathcal{B}$ (if no price change)

- Period profit (deviation from unconstrained optimal): $-Bx^2$

- Random menu-cost: each period w/prob $\kappa\, dt$ firm draws cost $\psi \sim G(\cdot)$

- Firm's trade-off: profit losses vs. price adjustment cost
  Minimizes expected PV cost (discounted at rate r). and chooses the optimal times and size of price adjustment as function of state x.
- Bellman equation

$$r\, v(x) = \min \Big\{ Bx^2 + \frac{\sigma^2}{2} v''(x) + \underbrace{\kappa \int_0^{\Psi} \min \{\psi + v(0) - v(x)\, , 0\} dG(\psi)}_{\text{expected change due to price adjust}}\, ,$$

$$r \quad \underbrace{(v(0) + \Psi)}_{\text{pay } \Psi \text{ \& change price}} \quad \Big\}$$

Theory Setup - 2: Optimal decision rule

- ... summarized by a Generalized Hazard Function $\Lambda(x)$:
  - **Adjust with proba.** $\Lambda(x) = \kappa\, G\,(v(x) - v(0))$ per dt and set $x = 0$ if price reset
  - $\Lambda(x)$ given by proba of drawing menu cost smaller than benefit of adjusting.

- Properties of $\Lambda(x)$:
  - Adjustment probability increases with $|x|$ (Caballero-Engel)
  - In a Calvo set up, $\Lambda(x) = \lambda$
  - In a standard menu cost (Golosov-Lucas) set up:
    - $\Lambda(x) = 0$ for any value of $x \in (\underline{X}, \bar{X})$ (Inaction zone)
    - Proba of adjustment is $(\Lambda(x)dt) = 1$ at thresholds

Theory Setup - 3: Cross-Sectional Moments

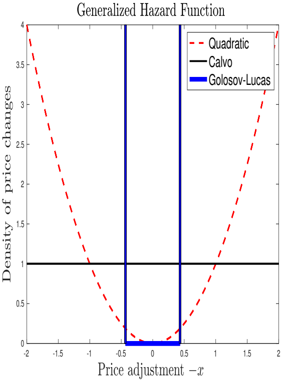
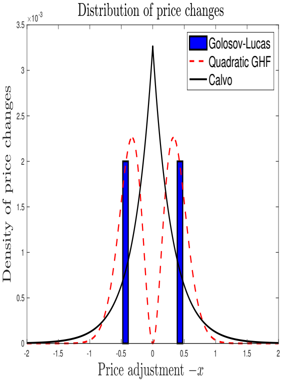
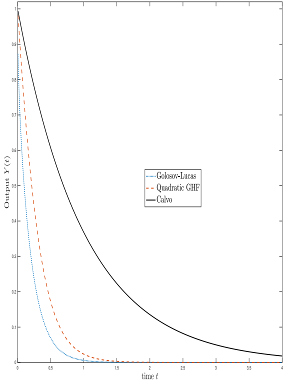
Policy rule $\Lambda(x)$ yields steady state behavior of cross section:

- $f_{ss}(x)$ steady state cross sectional distribution of price gaps
- N frequency of price changes, $N \equiv \int \Lambda(x)$
- $q(x)$ cross sectional density of price changes
  where $q(x) \equiv \Lambda(x) f_{ss}(x) / N$

Theory Setup - 4: Aggregate nominal shock and IRF

3 particular cases of the GHF model

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

Generalized Hazard Function $\Lambda(x)$	Distribution price changes $q(x)$	Output IRF $Y(t)$
		

The Sufficient Statistic Proposition - wrapping up

- CIR^Y of industry j to small monetary shock (δ) :

$$CIR^{Y_j}(\delta) = \frac{\delta}{\epsilon} \frac{Kurt_j}{6\,Freq_j} + o(\delta^2) \tag{13}$$

- **Intuition:**
  - Frequency (Freq): time units of propagation
  - Kurtosis (Kurt): measures lack of selection effect
- **Holds for many models**
- **Scope of results, however**:

- small inflation
- gap closed after adjustment: no price plans, no temp. price changes
- brownian shocks