Inflation Distorts Relative Prices: Theory & Evidence

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Introduction

- **What are the welfare costs of permanently high inflation?**
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  inflation => distorts relative prices (when prices are sticky)

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  => no structural empirical evidence for this mechanism!

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  Why?
  Price distortion = gap between actual & counterfactual flexible price

- Provide structural evidence:
  Find strong & robust support for this mechanism!

Introduction: Existing Evidence

- United States:

  Nakamura, Steinsson, Sun & Vilar (QJE 2018)

  Sheremirov (JME 2020)

- Argentina: Alvarez et al.(QJE, 2019)

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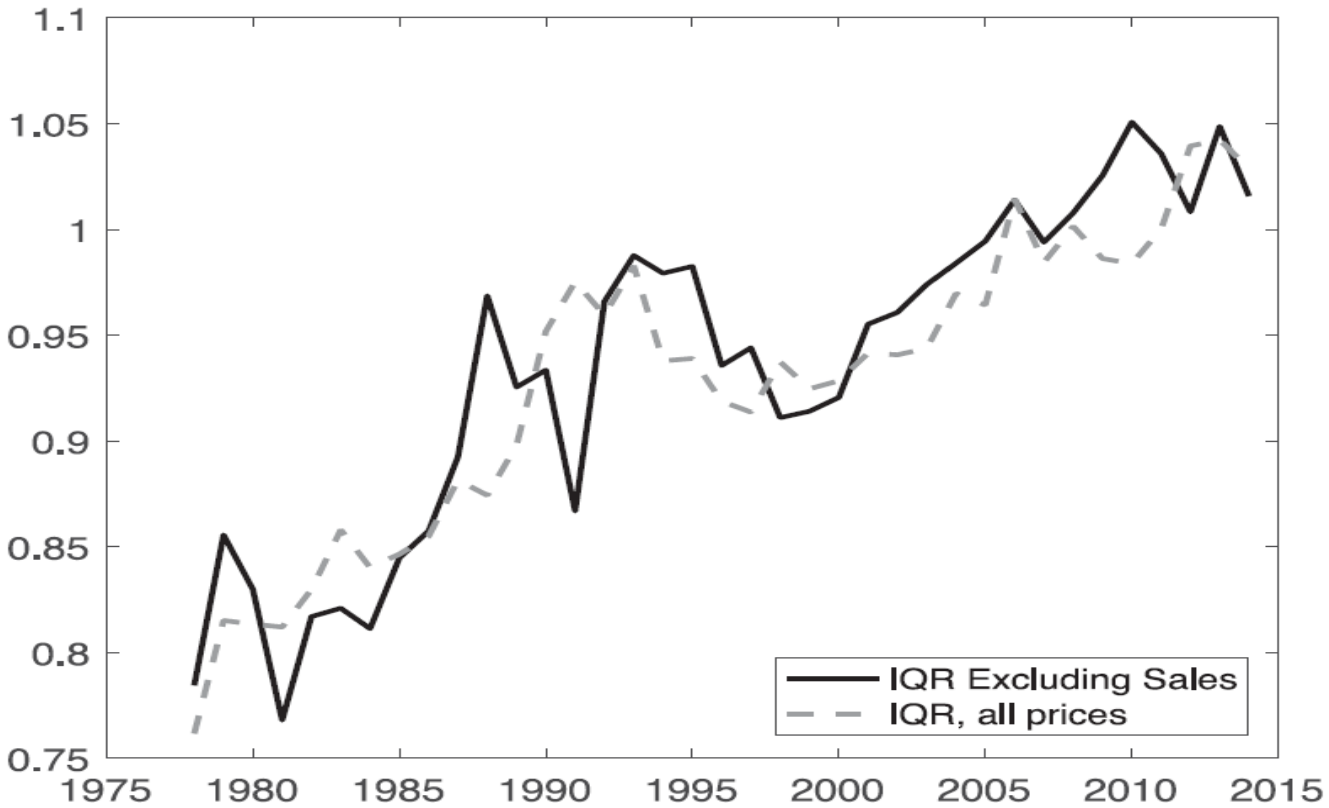

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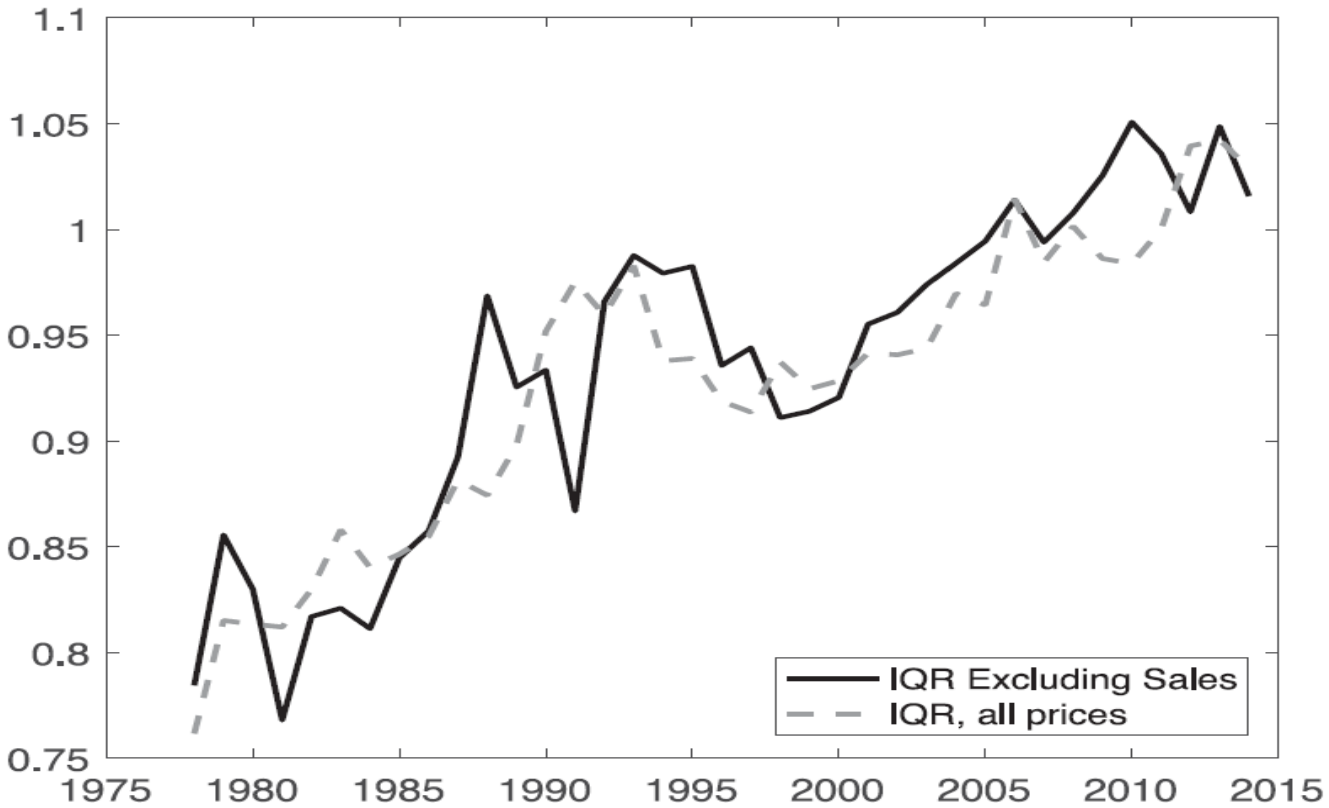

- Inflation & price dispersion: two time trends....

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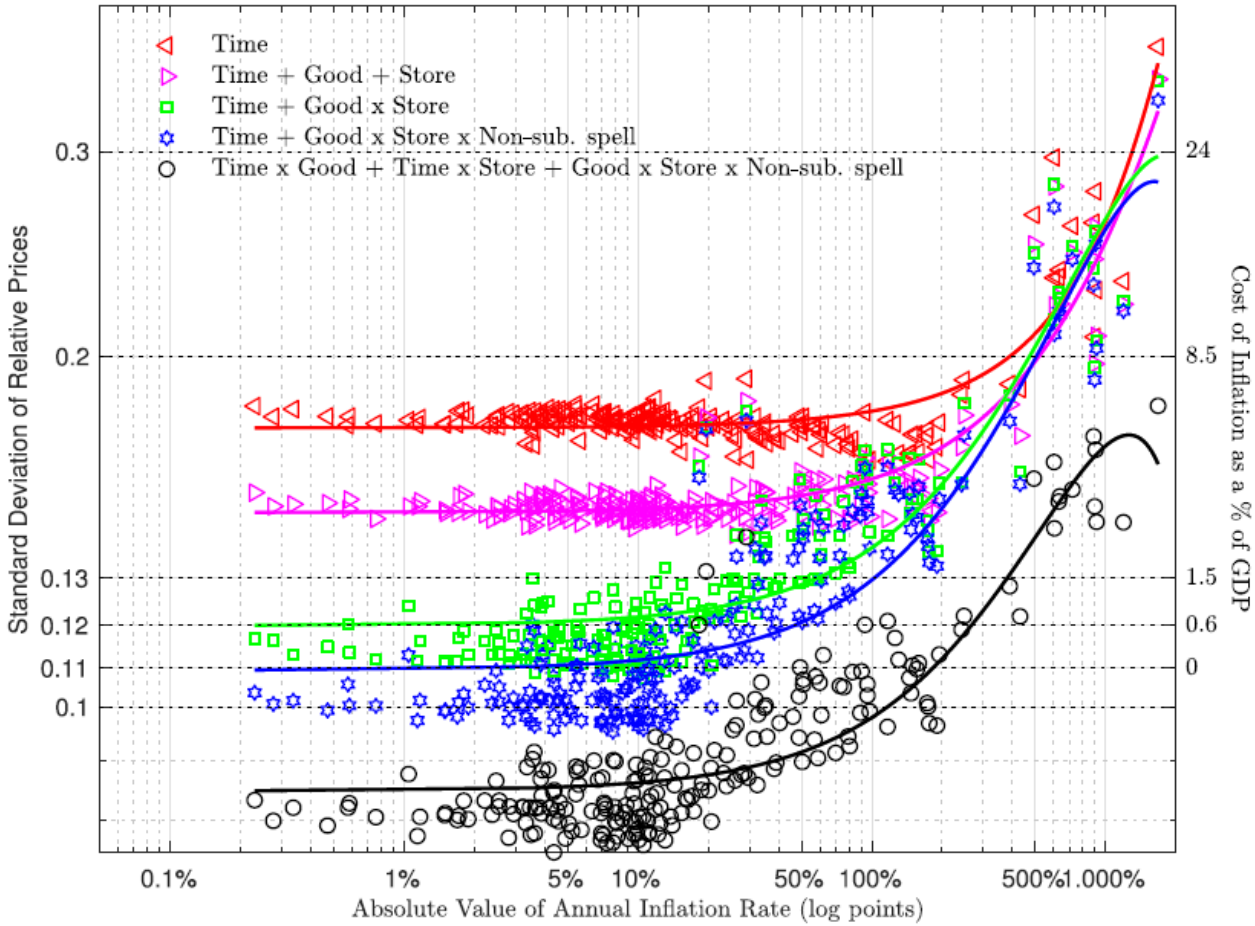

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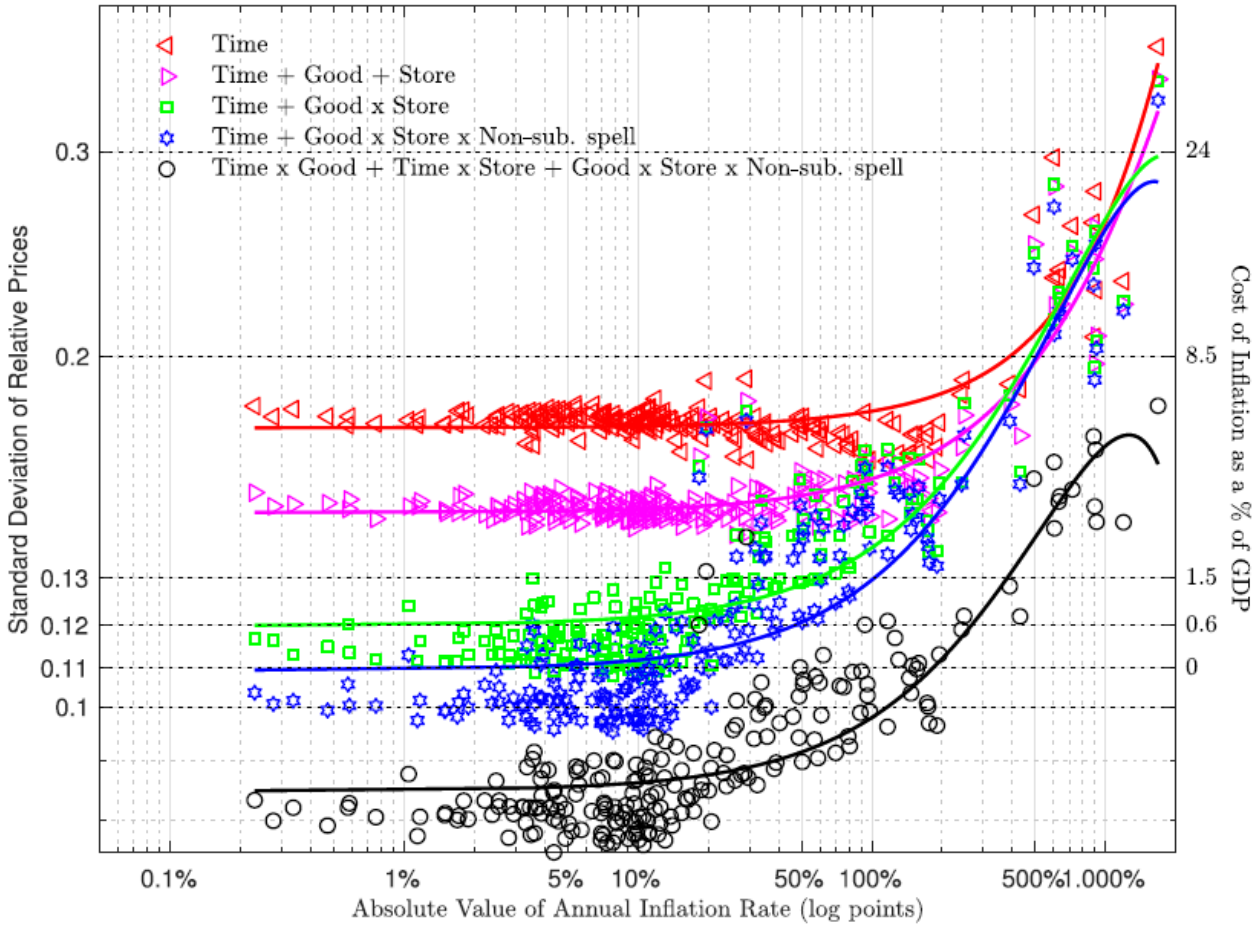
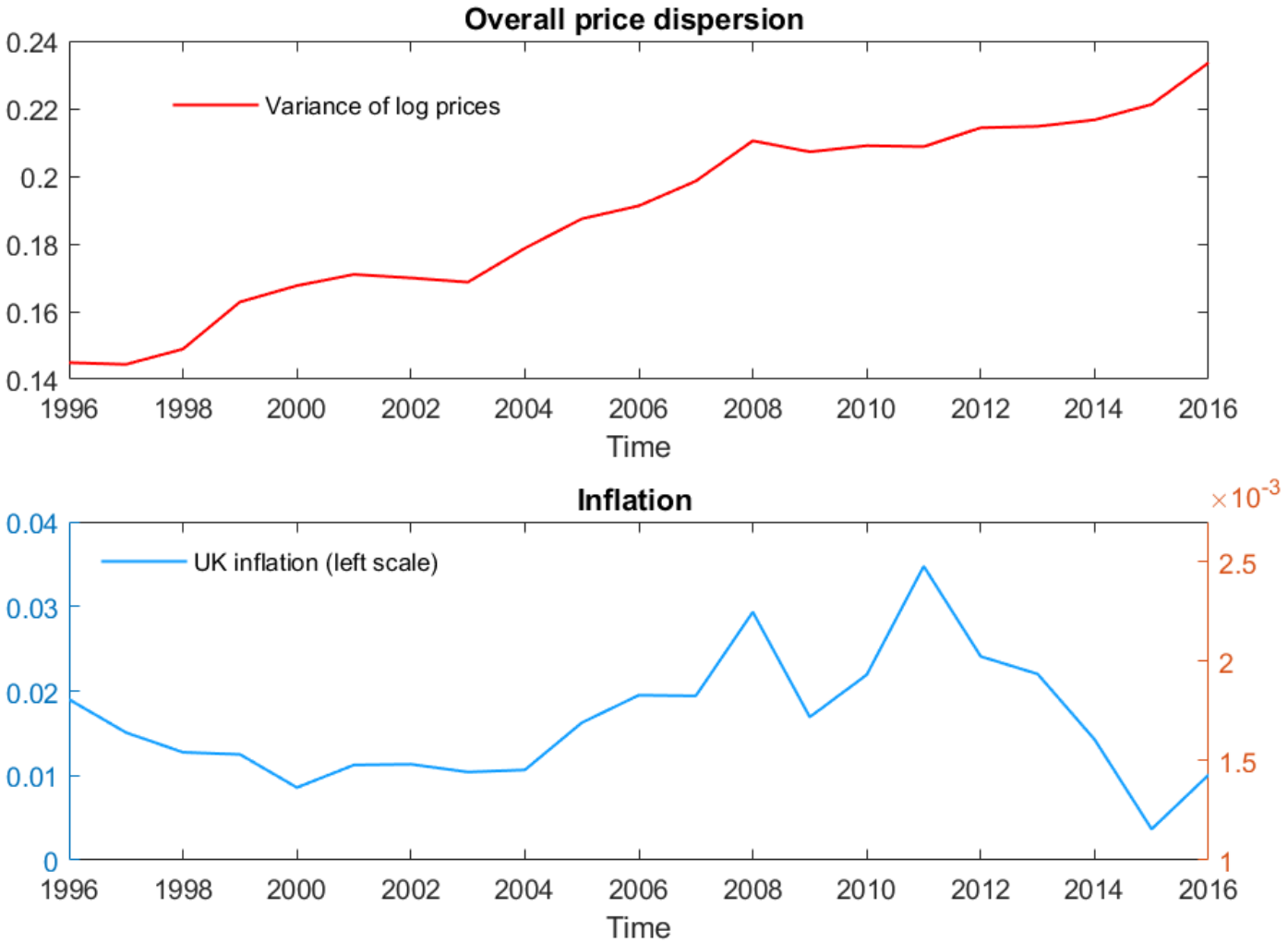


- Works under the assumption that flexible price dispersion is constant

Introduction: U.K. Evidence



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  #2 Regress residual dispersion in the cross-section products on product-specific measure of sub-optimal inflation

- Regression coefficient in #2 identifies:
  the marginal effect of inflation on inefficient price dispersion

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- Fine for time & state-dependent forms of price stickiness
- Requires no assumptions on cross-sectional disp. of flex prices over time

Main Finding

- **At product level:** strong & highly significant evidence

  Deviations of inflation from optimal level $=>$ distorts relative prices

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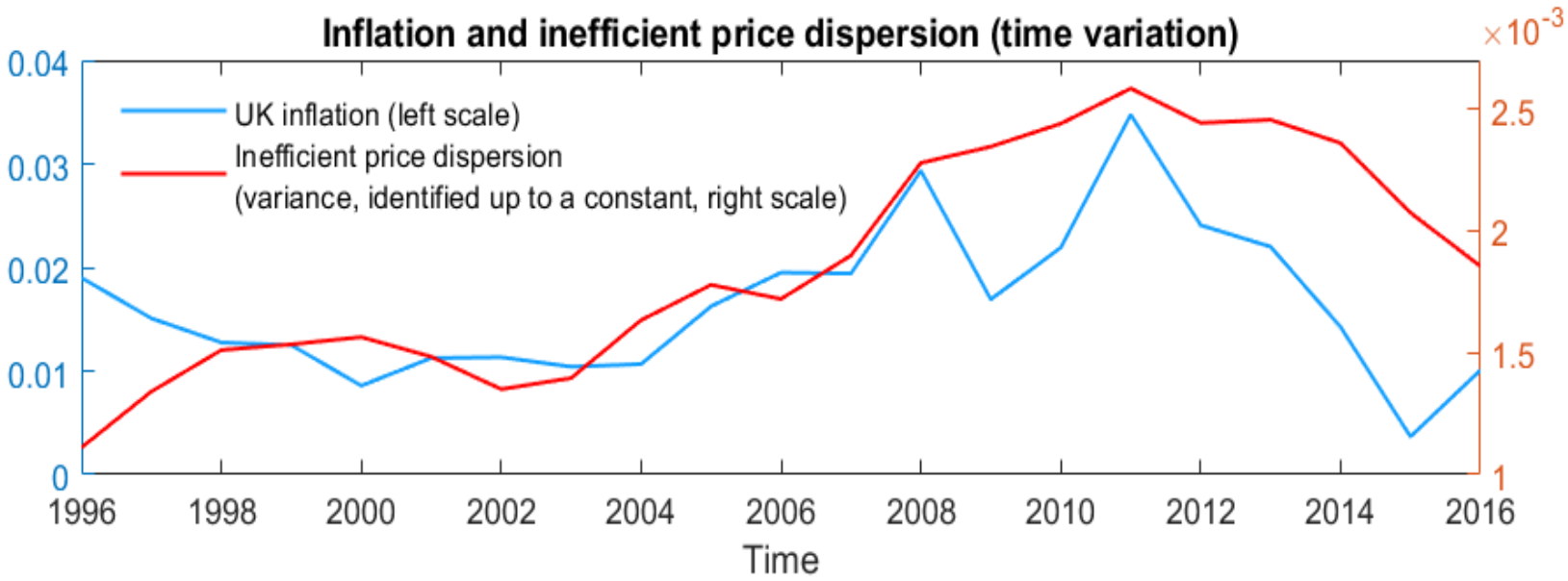
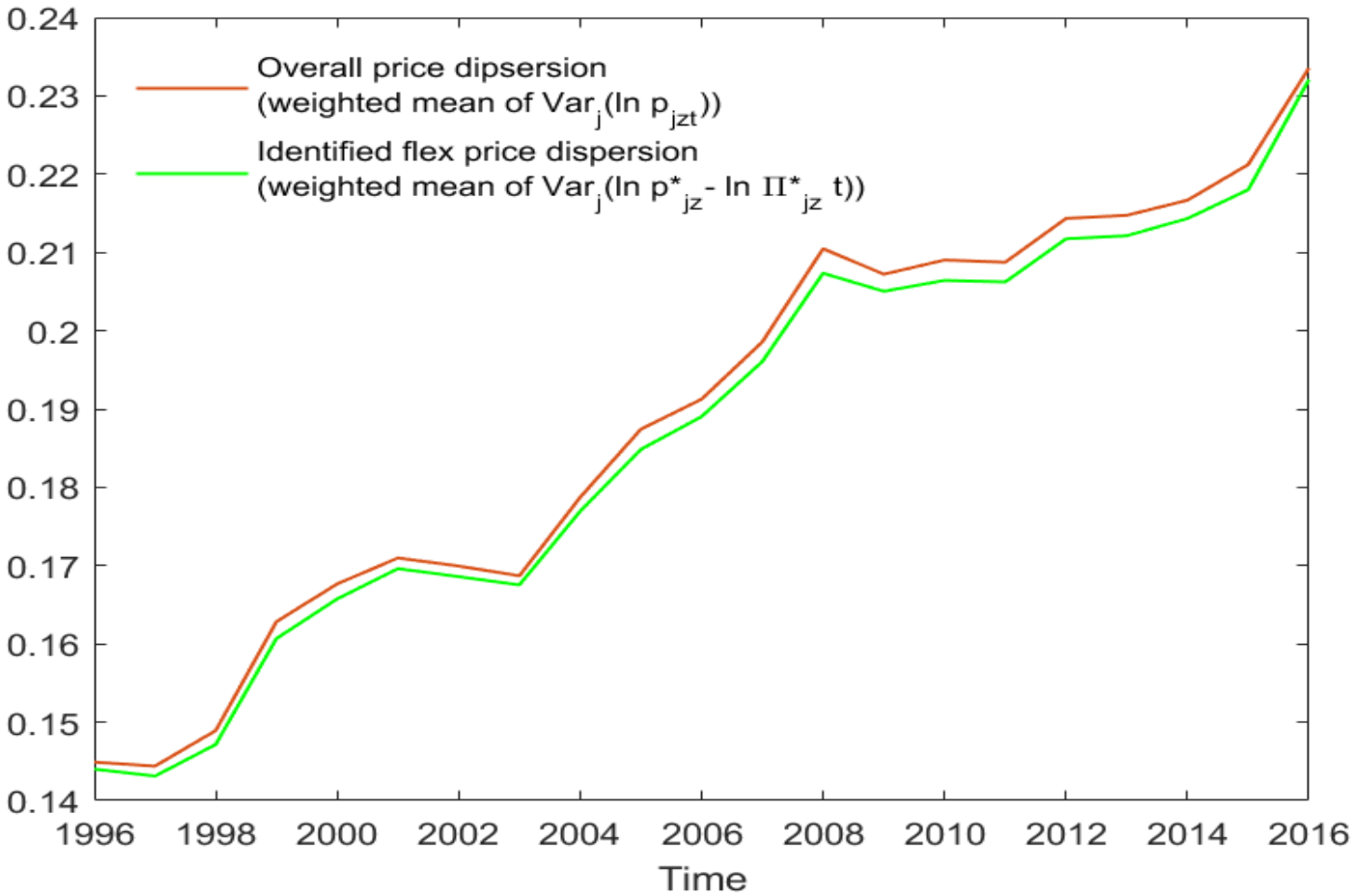
- **At product level:** strong & highly significant evidence
  Deviations of inflation from optimal level => distorts relative prices
- **At aggregate level:** price distortions covary positively w inflation



$$Correlation = +0.58,\ p\text{-}value = 0.01$$

Overall Price Dispersion: Driven by FlexPrice Dispersion



Structure of Talk

1. General Setup + Simple Example
2. Product-Level Empirical Evidence
3. Decompose Cross-Sectional Price Dispersion over Time

General Setup

- Product j is a physical product/service in a particular location
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- Per-period loss function

$$\left(\ln P_{jzt}/P_{zt} - \ln P^*_{jzt}/P_{zt}\right)^2$$

$\ln P^*_{jzt}/P_{zt}$: **flexible relative price**.

General Setup: Flexible Price Dynamics

$$\ln P^*_{jzt} / P_{zt} = \ln p^*_{jz} - t \cdot \ln \Pi^*_{jz} + \ln x_{jzt}$$

- $\ln p^*_{jz}$: product $\times$ location-specific fixed effect
  - unobserved quality/service/marginal cost/mark-ups
  - drawn at time of entry, arbitrary time-varying distribution

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- $\ln \Pi^*_{jz}$: product $\times$ location specific relative price trend
  - marginal cost trends
  - equal to the product-specific optimal inflation rate
  - drawn at the time of entry,arbitrary time-varying distr.
  - key source of identifying variation
  - empirical analysis: also non-linear time trends

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  - same stoch. process for all j

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  - same stoch. process for all j
- Note: no item $\times$ time fixed effects because *relative* price on l.h.s.
- Setup implies **no restrictions** on cross-sectional distribution of flex prices over time!

Identification: Simple Example

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- Prices adjust every N periods & constant inflation rate Π

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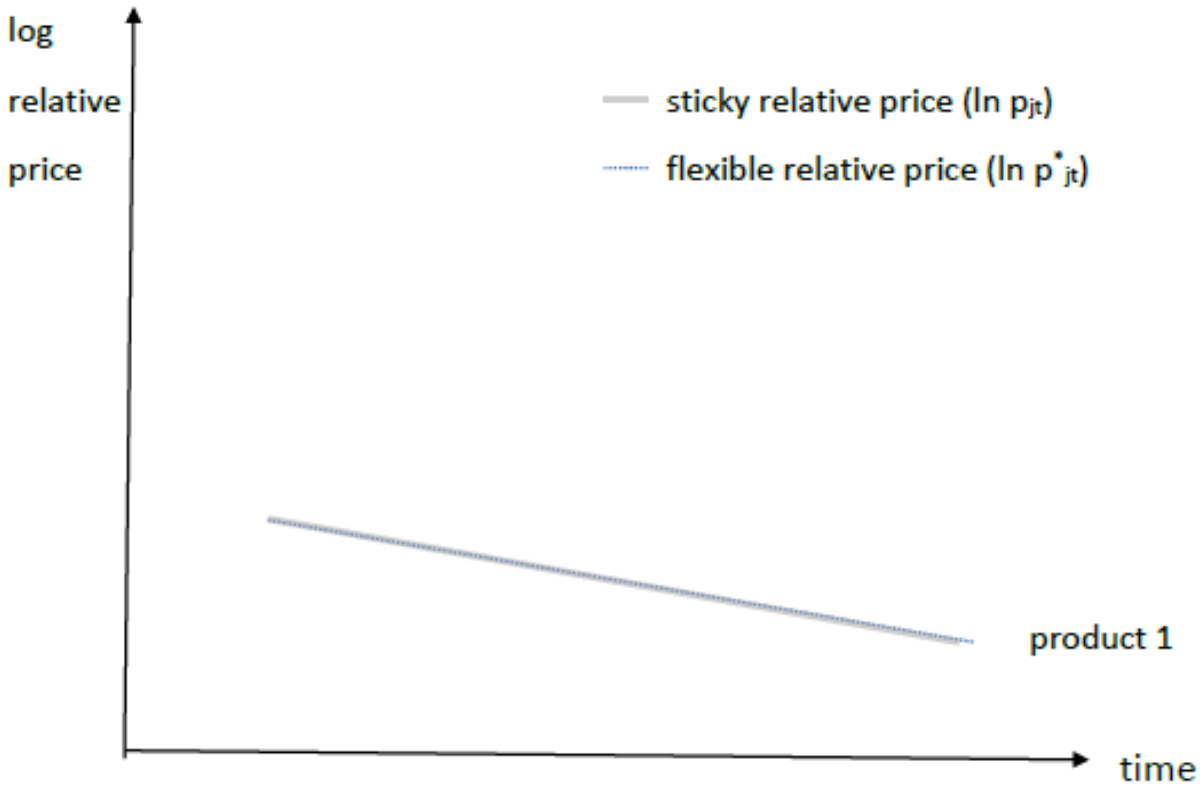

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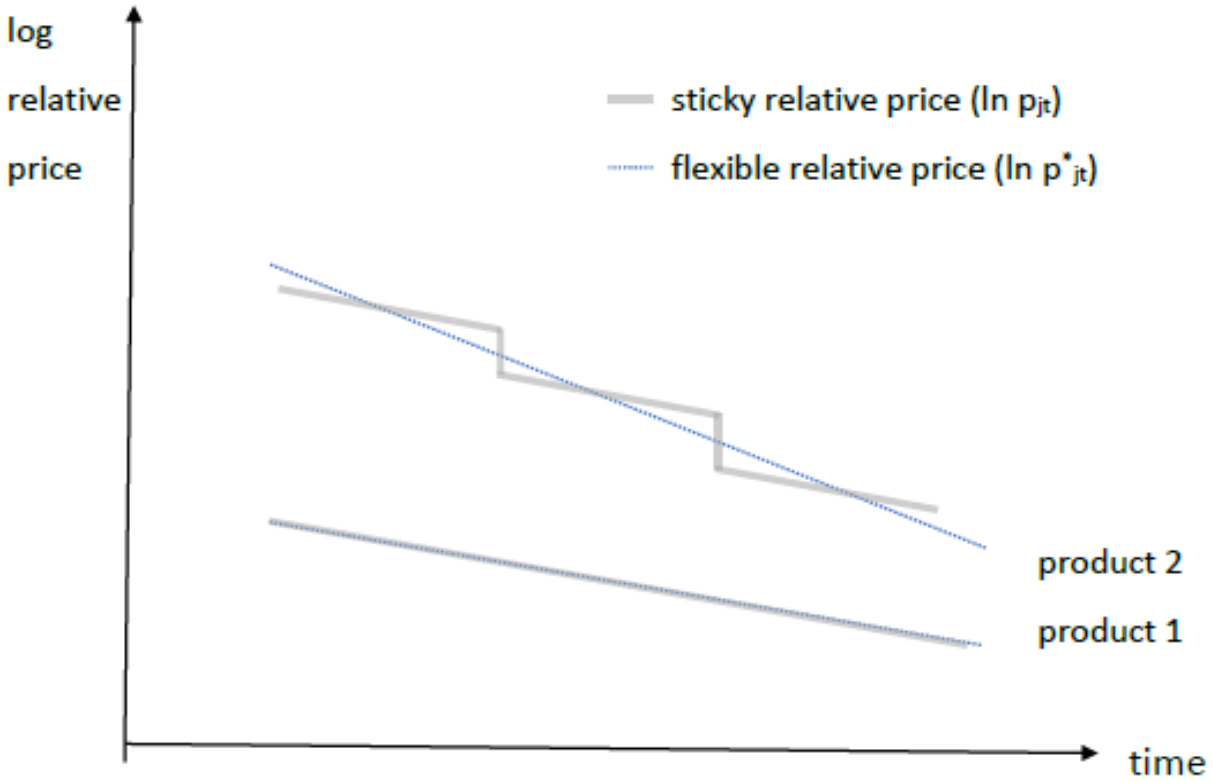

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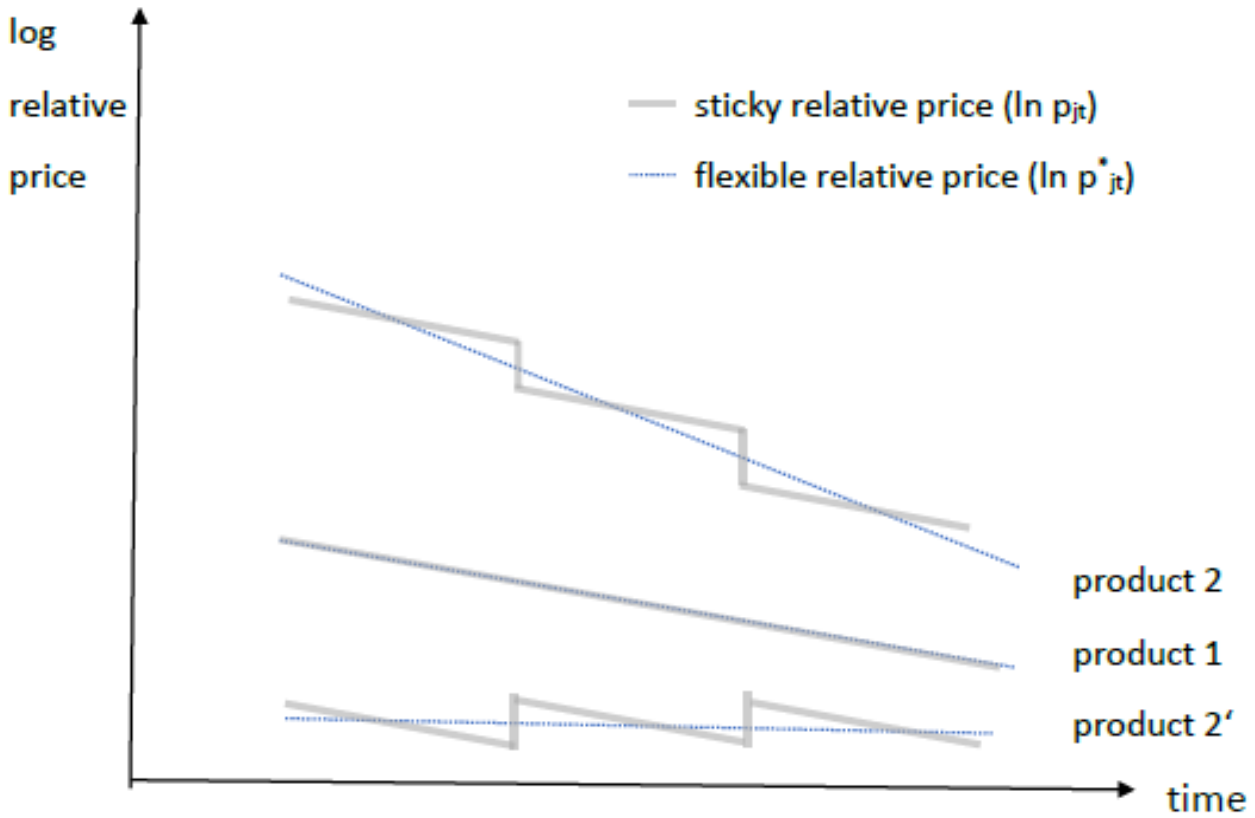

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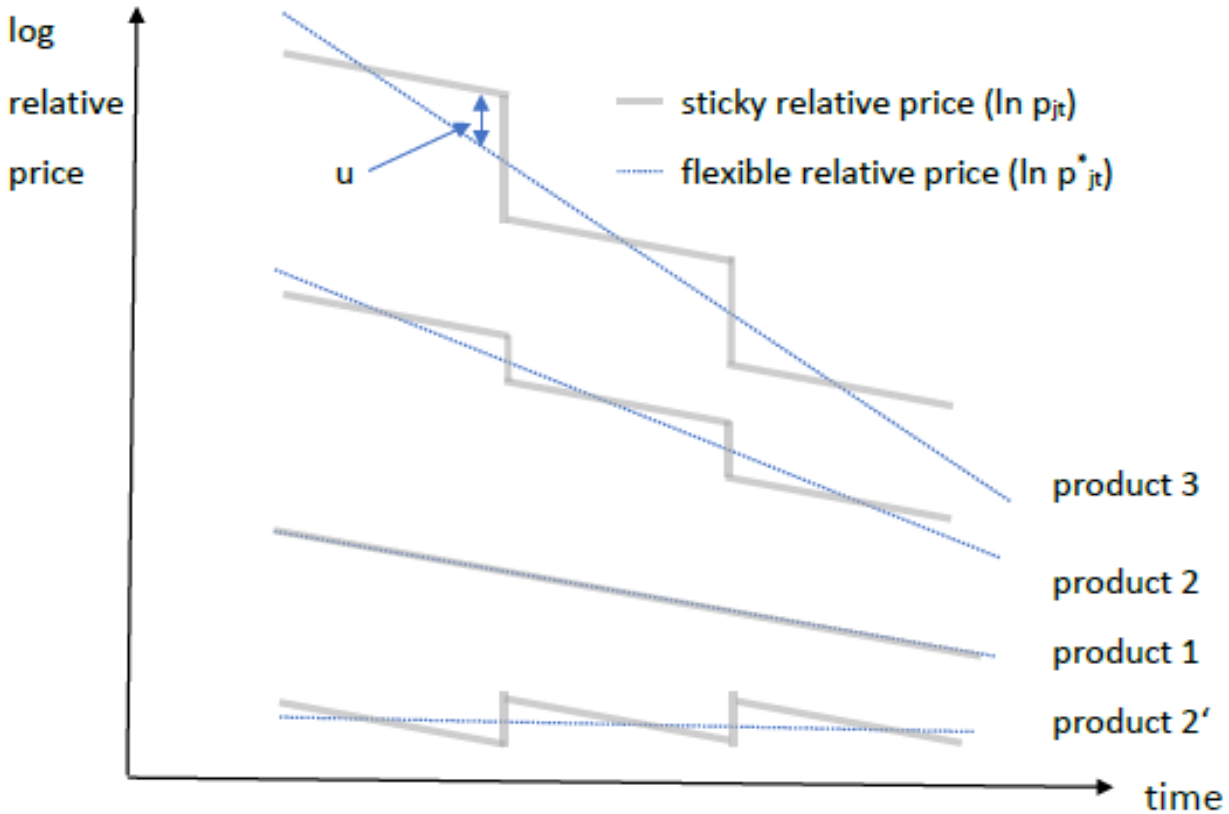

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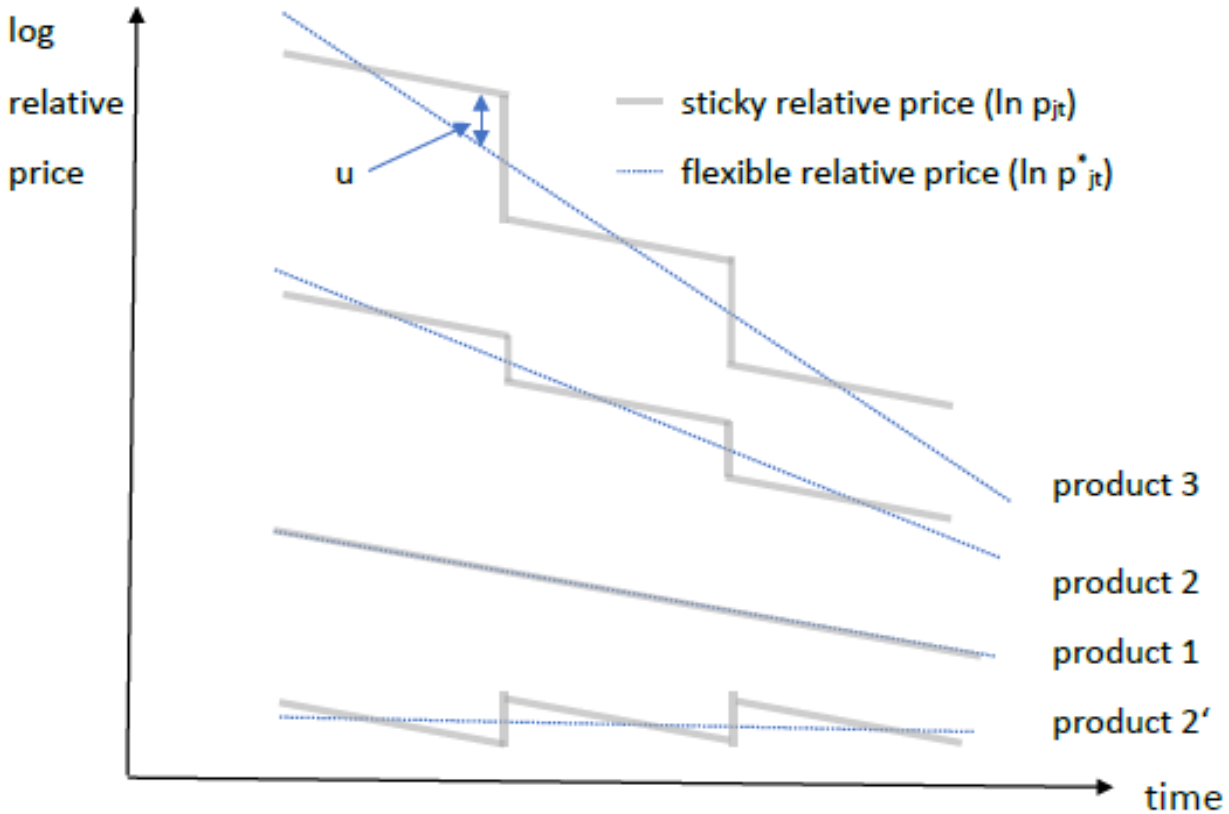

$$Var(u_{jt}) = c \cdot (\Pi - \Pi_j^*)^2 \text{ with } c = (N-1)N(N+1)/12 > 0$$

Empirical Structural Approach: General Case

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- **Step 1:** for *every* product j in expenditure item z

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- **Step 2:** in every item z regress across products:

$$Var(u_{jzt}) = v_z + c_z \cdot \underbrace{(\ln \Pi_z - \ln \Pi^*_{jz})}_{\text{dev. of infl. from optimal level}}^2$$

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- **With Calvo:** $c_z = \alpha / (1-\alpha)^2 > 0$
  Menu cost: $c_z = E[1/\Lambda^2] > 0$

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- With Calvo frictions: $f(x_{jzt}) \equiv (1-\alpha) E_t \sum_{i=0}^{\infty} \alpha^i \ln x_{jzt+i}$
- Cannot identify $\ln x_{jzt+i}$ from $f(x_{jzt})$ (only in special cases....)
  $\Rightarrow$ cannot identify the level of price distortions!

Empirical Structural Approach: General Case

- **But can identify the marginal effect of inflation on price dispersion:**

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- Look at 1033 U.K. expenditure items in the CPI data

  $=>$ get 1033 estimates $(\widehat{v}_z, \widehat{c}_z)$

  $\widehat{c}_z > 0$ as predicted by sticky price theory?

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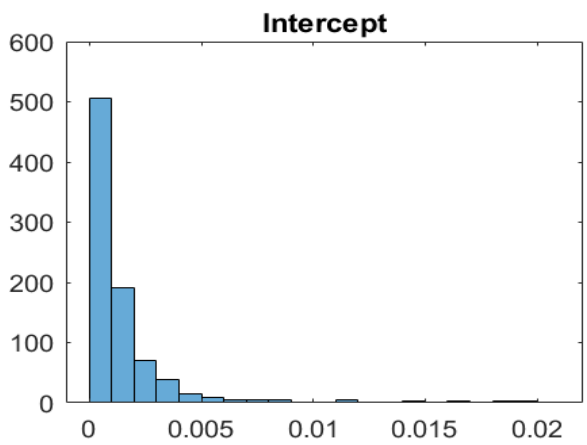
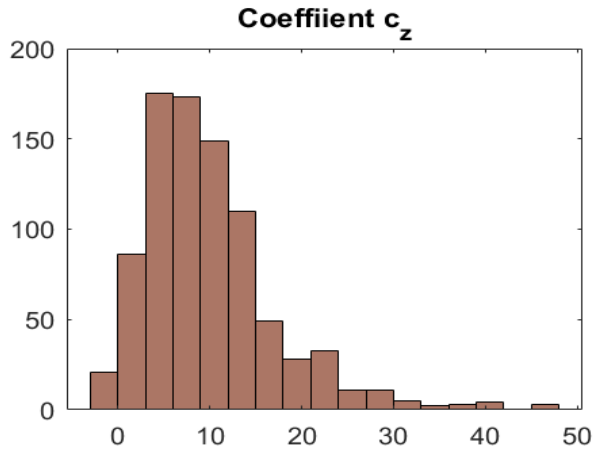
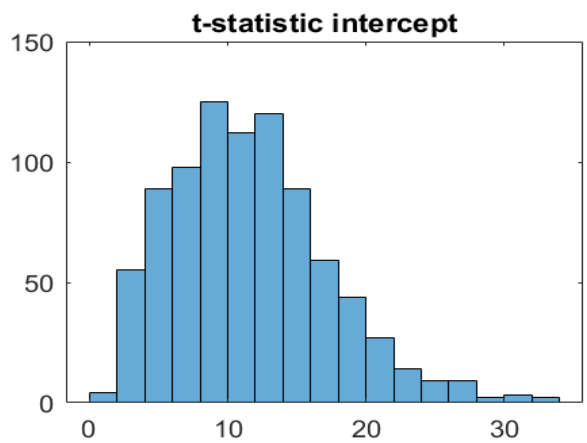
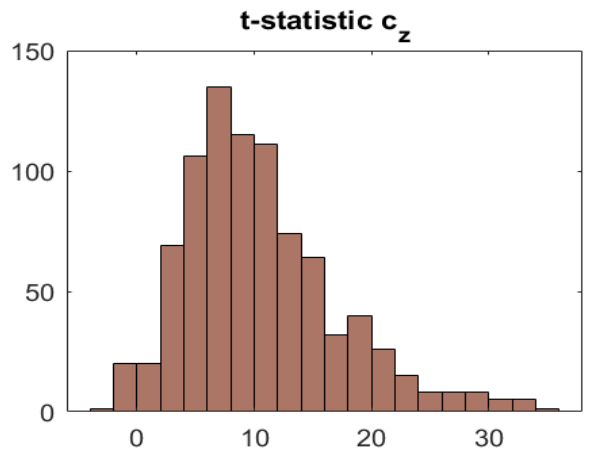
Baseline Estimates









Coefficients c_z: Covariation With Price Adj. Rates

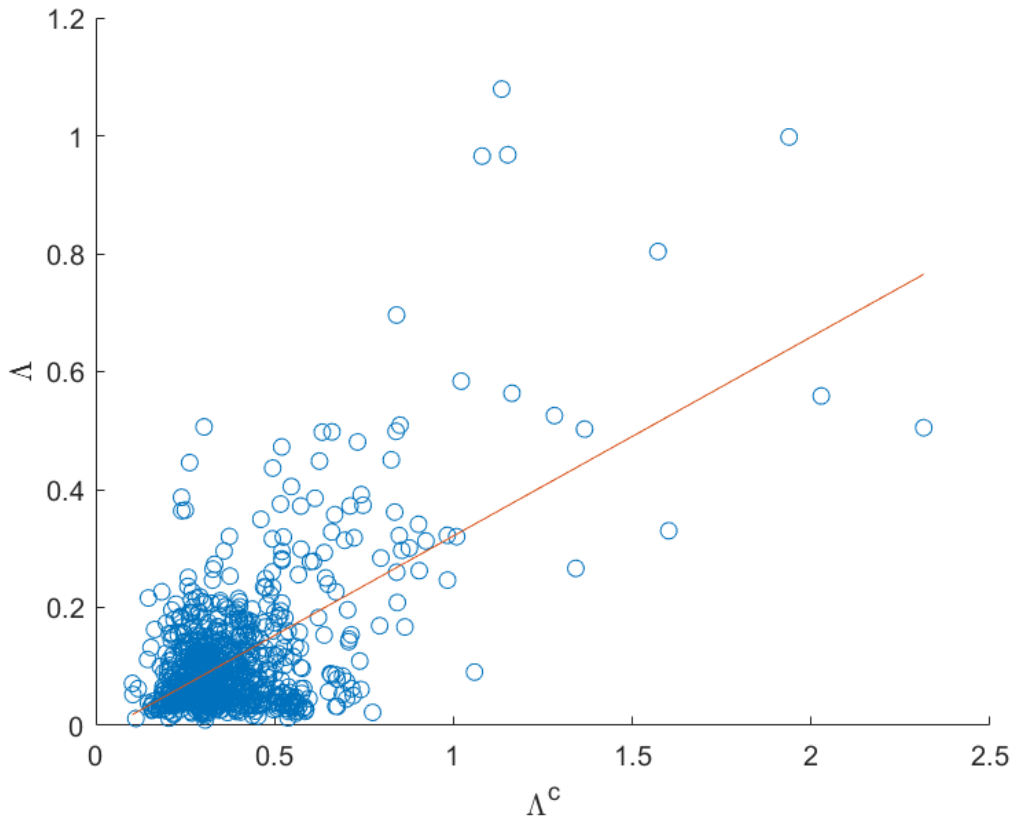


Figure: Obseved (Λ) and estimation-implied (Λ^c) price adjustment rates.

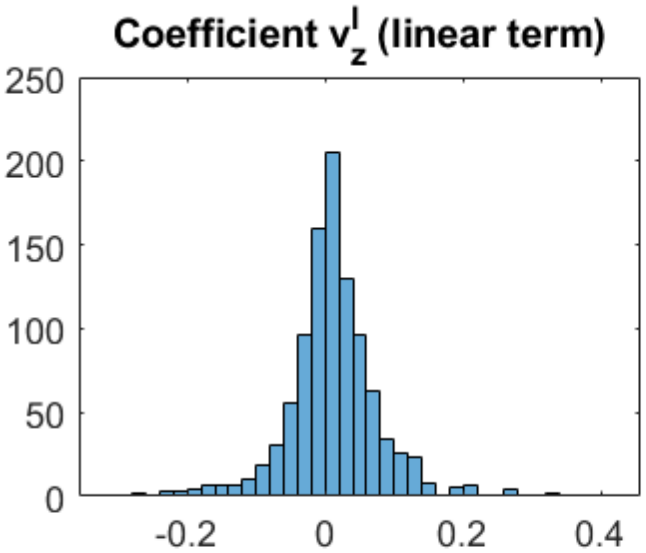
Correlation $= +0.6$, regression slope $= +0.34$

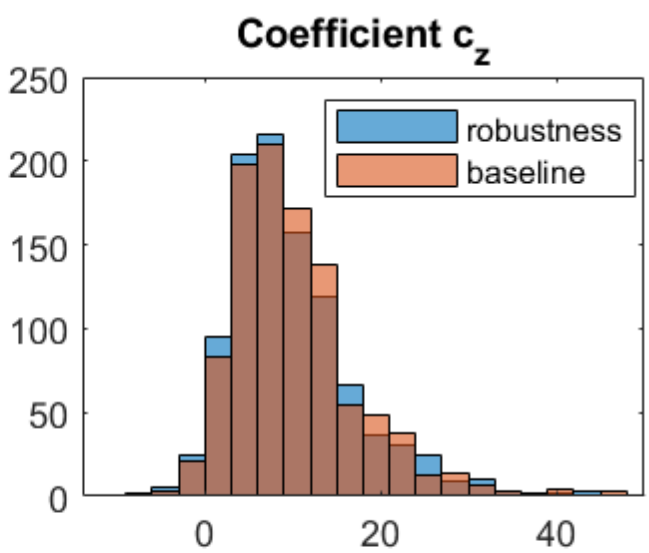
Adding Linear Terms in 2nd Stage Reg

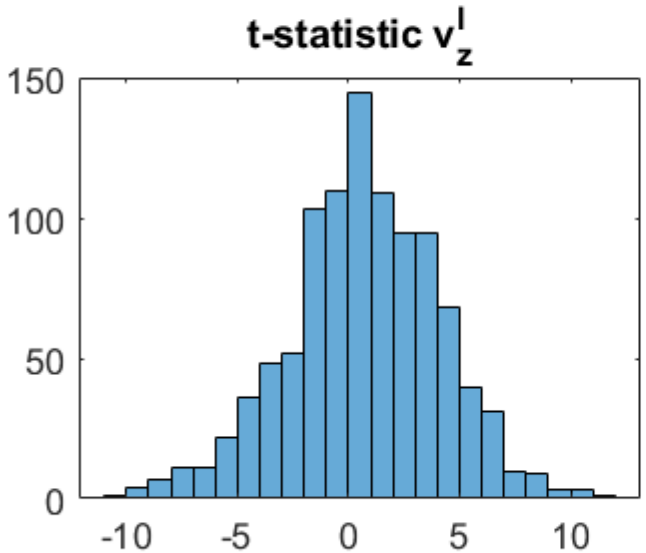
$$Var(u_{jzt}) = v_z + v_z^l \cdot (\ln \Pi_z - \ln \Pi_{jz}^*) + c_z \cdot (\ln \Pi_z - \ln \Pi_{jz}^*)^2$$

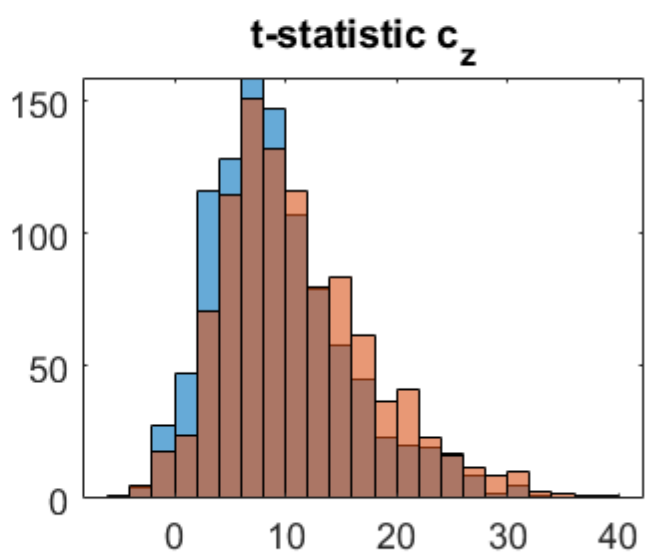
Is $v_z^l = 0$ as predicted by the theory?

Adding Linear Terms in 2nd Stage Reg









Nonlinear Trend in 1st Stage Reg

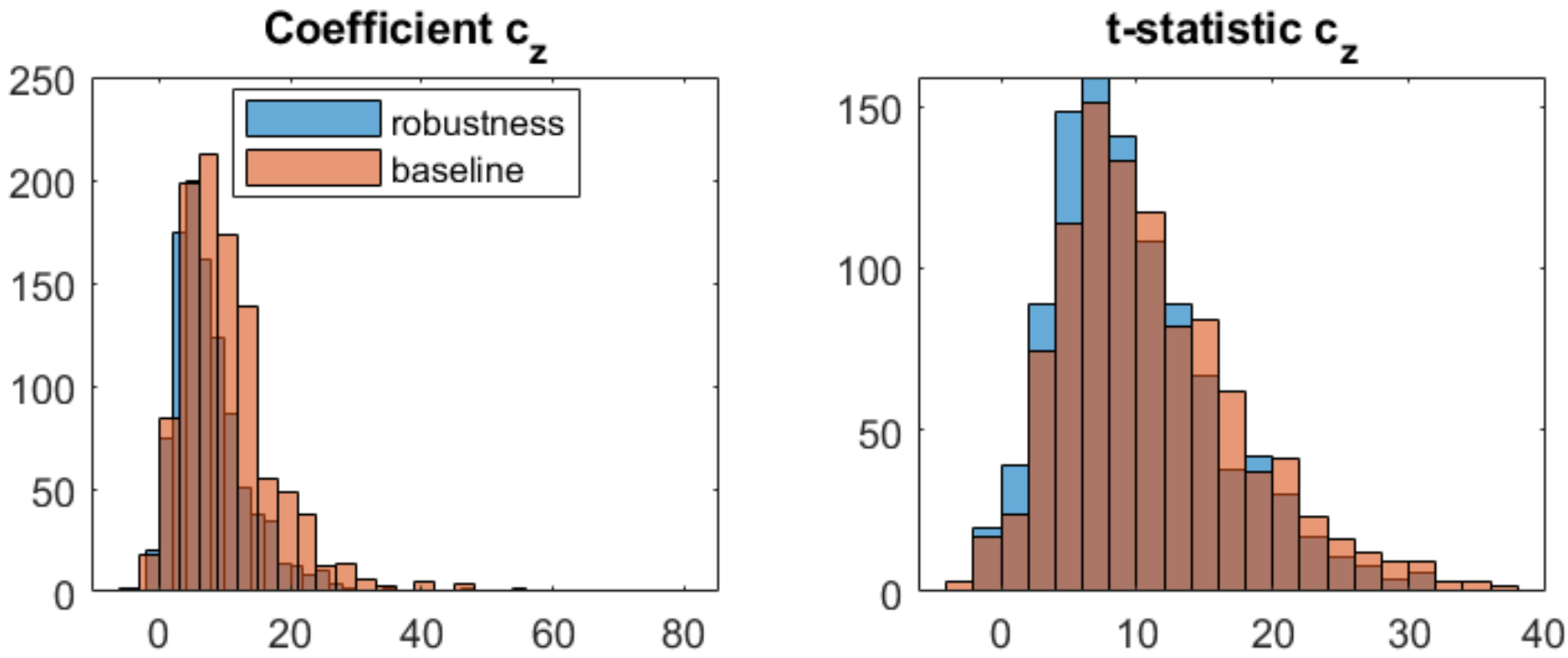
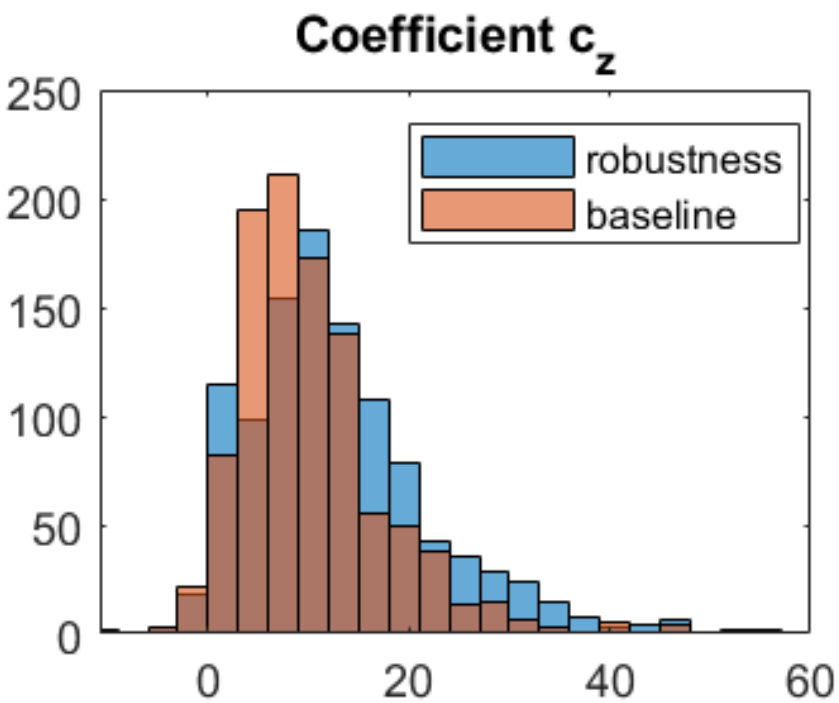
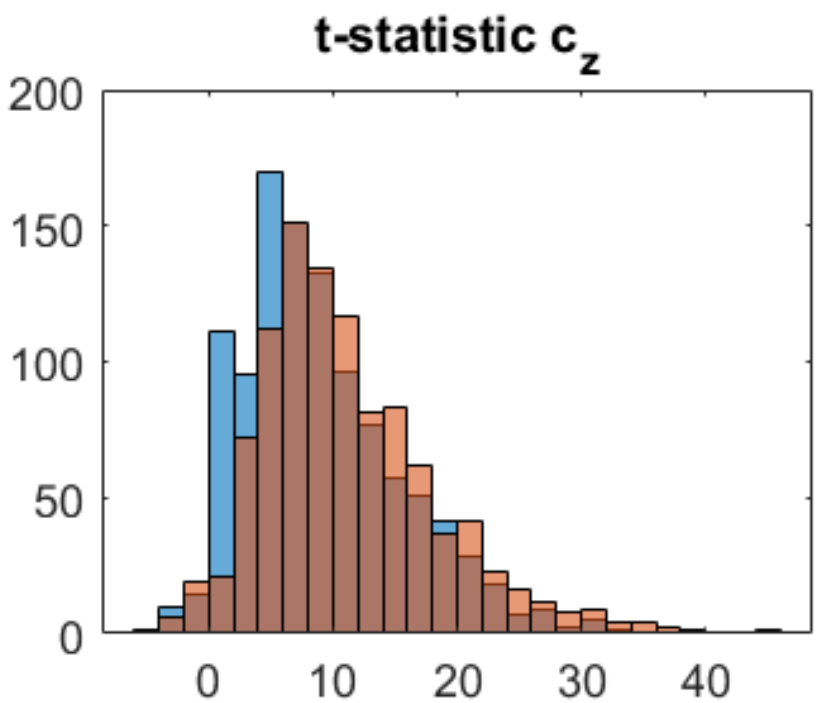


Figure: Nonlinear time trend in first-stage regression

Within Product Variation of Residuals

$$\widehat{Var}_1(u_{jzt}) - \widehat{Var}_2(u_{jzt}) = c_z \left(\left(\ln \widehat{\Pi^1_z / \Pi^*_{jz}} \right)^2 - \left(\ln \widehat{\Pi^2_z / \Pi^*_{jz}} \right)^2 \right) + v_{jz}$$





Robustness

- Results also robust to including sales prices into regression
- **What does not work:** assuming optimal inflation is zero

$$Var(u_{jzt}) = v_z + c_z \cdot \Pi_z(j)^2$$

$\Pi_z(j)$: inflation rate in item z *over the lifetime* of product j

No Effects with Only Inflation as RHS variabe

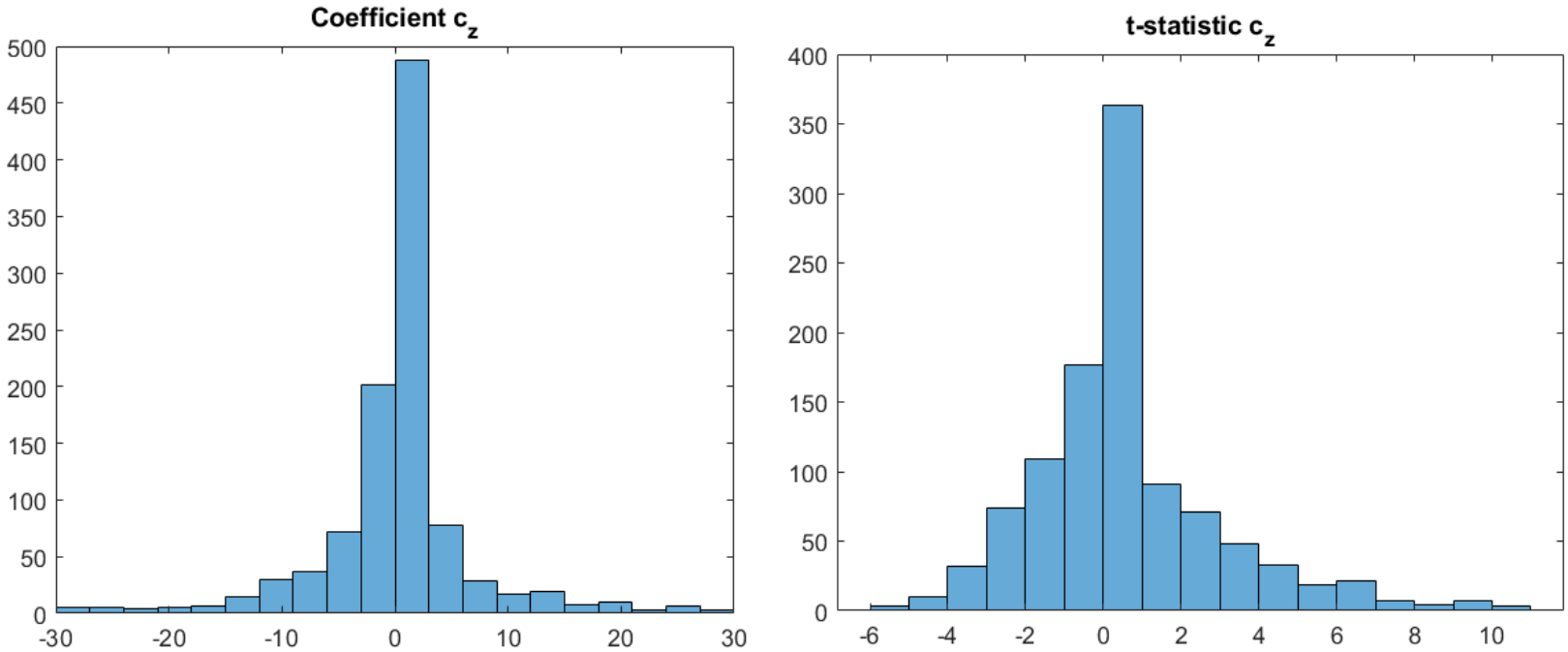


Figure: Estimation with actual inflation only on r.h.s.

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1. General Setup + Simple Example
2. Product-Level Empirical Evidence
3. **Decompose Cross-Sectional Price Dispersion over Time:**
   - time-varying component of flexible price dispersion
   - time-varying component of inefficient dispersion

Aggregate Results

- **Can decompose cross-sectional dispersion of prices into:**
  - identifiable component of flex price distribution (slope & intercept)
  - a residual component
- *Time variation* in the residual component:

  captures time variation in inefficient price dispersion due to inflation.
- Level of residual component does *not identify* level of inefficient dispersion (idiosyncratic shocks)

Aggregate Results

Theorem

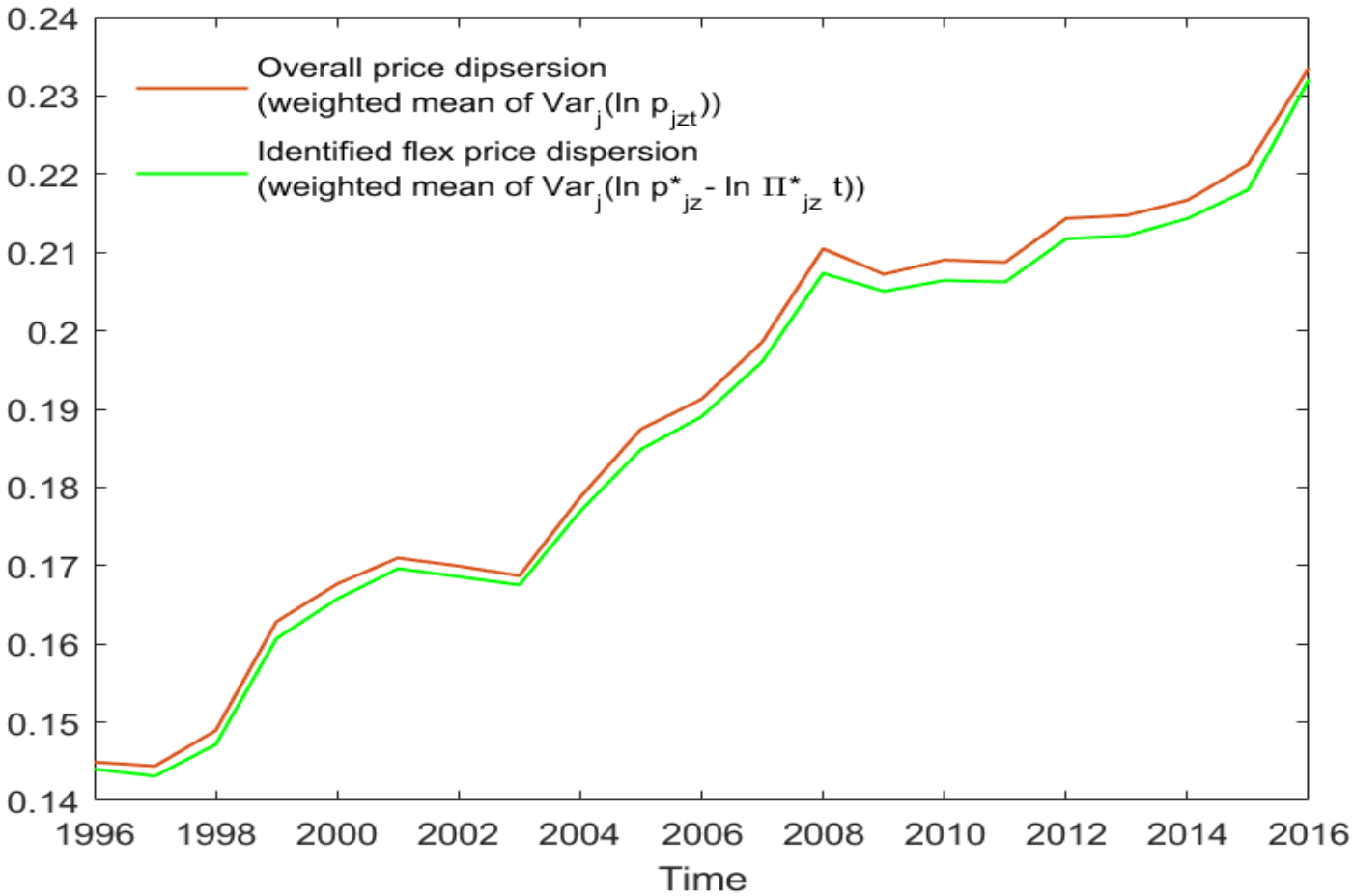
The cross-sectional dispersion of prices $Var^j(\ln p_{jzt})$ *in expenditure category* z *at time* t *can be decomposed as follows*

$$Var^j(\ln P_{jzt}/P_{zt}) = Var^j(\ln p^*_{jz} - \ln \Pi^*_{jz} \cdot t) + Var^j(u_{jzt}) \tag{1}$$

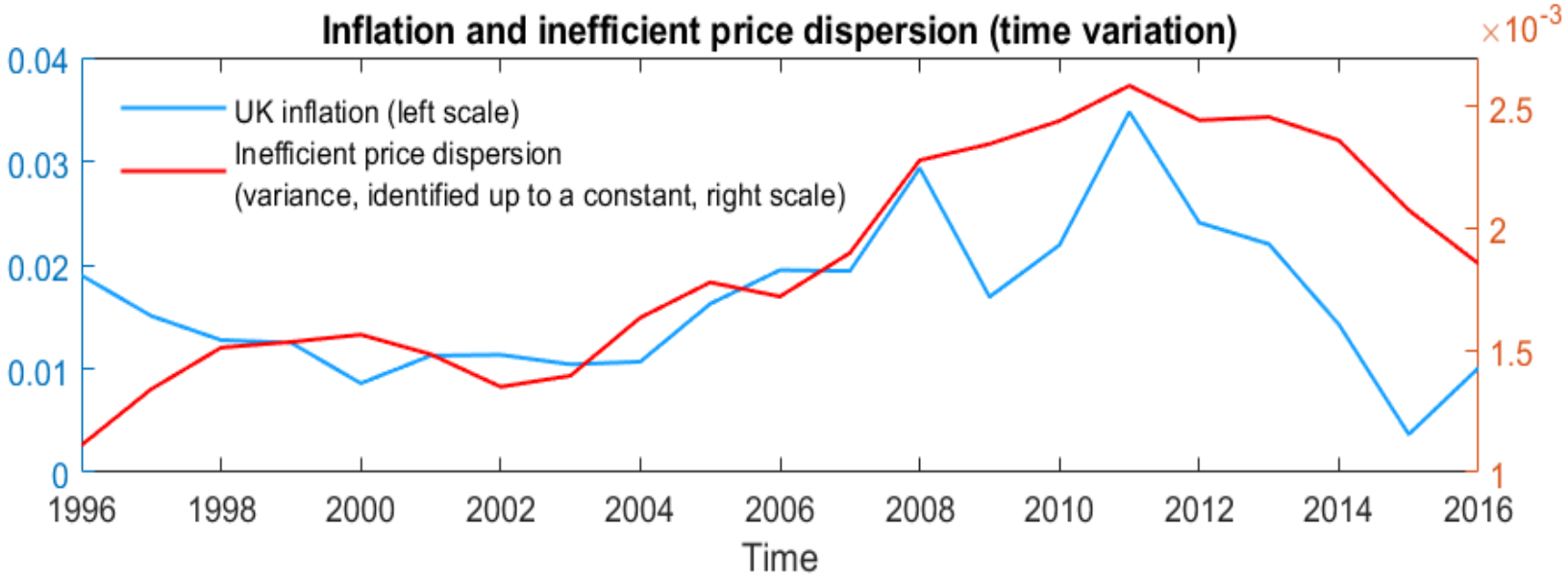
where

$$Var^j(u_{jzt}) = v_z + c_z \cdot \sum_i (\ln \Pi_z - \ln \Pi^{*i}_z)^2 m^i_z. \tag{2}$$

Overall Price Dispersion: Driven by FlexPrice Dispersion



Inflation and Aggregate Price Dispersion



Correlation$= +0.58$ $(p\text{-}value = 0.01)$

Lower & upper bound on inefficient dispersion: StdDev of log prices $\in$ [3.9%, 5%]

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  positive correlation driven by products with low optimal inflation

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- In each expenditure category:
  - 1/3 of products with highest optimal inflation:
    average opt. inflation between 2.5% and 5.5% over time
  - 1/3 of products with lowest optimal inflation:
    average opt. inflation between -10 to -6% over time

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  - 1/3 of products with highest optimal inflation:
    average opt. inflation between 2.5% and 5.5% over time
  - 1/3 of products with lowest optimal inflation:
    average opt. inflation between -10 to -6% over time

- Correlation between inflation and inefficient dispersion:
  - top group: +0.19 with p-value 0.40
  - bottom group: +0.54 with p-value of 0.01

Summary

- Monetary models used in CBs & academia postulate that the welfare costs of inflation are due to distortions in relative prices
- We find strong support for this notion at the product level
- At the aggregate level:
  - inefficient price dispersion covaries positively with aggregate inflation
  - inefficient price dispersion due to inflation large:
    estimates suggest a StdDev of log prices of at least 3.9%
  - upward trend in overall price dispersion reflects upward trend in flexible price dispersion

The Absolute Size of Price Changes....

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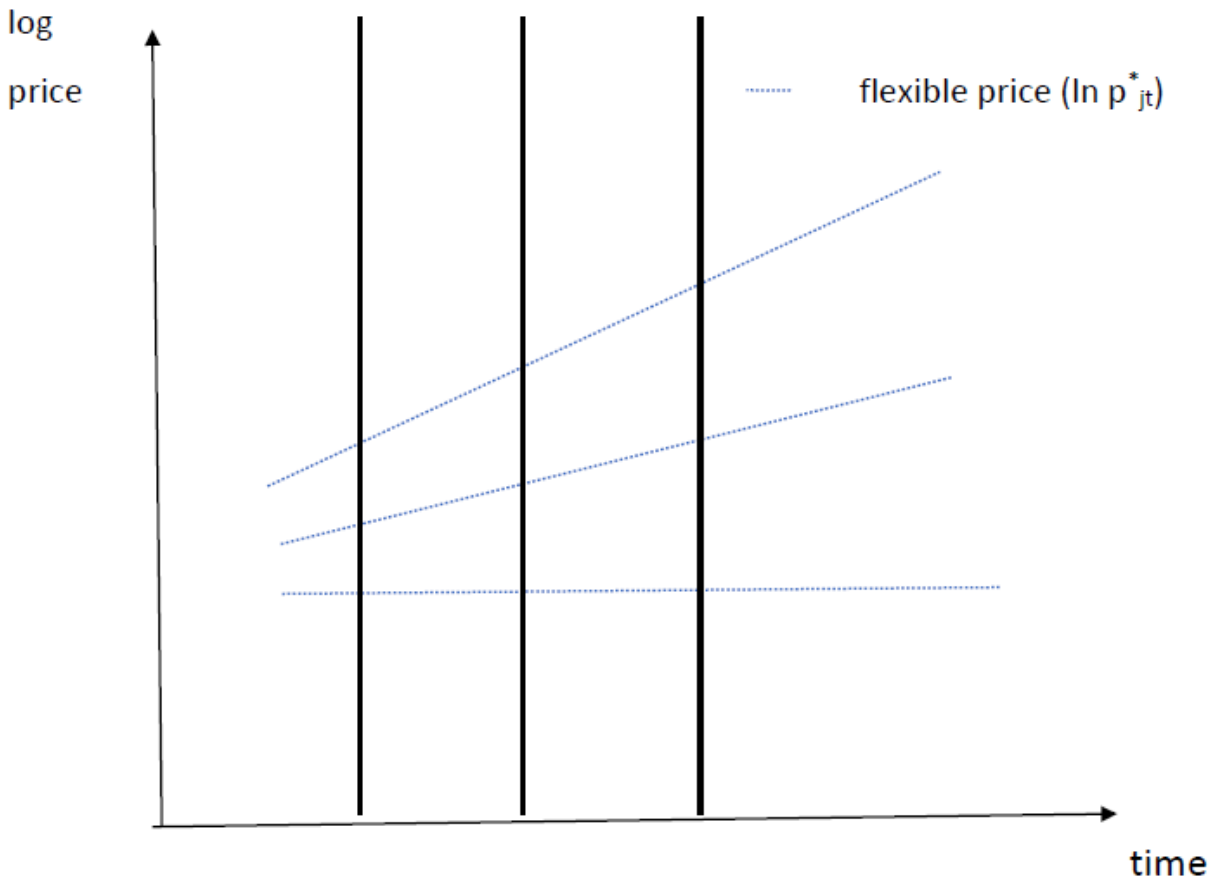
- Consider case with constant inflation & fully flexible prices $=>$ by definition no relative price distortions !
- Nevertheless positive relationship between absolute size of price changes and suboptimal inflation

The Absolute Size of Price Changes....



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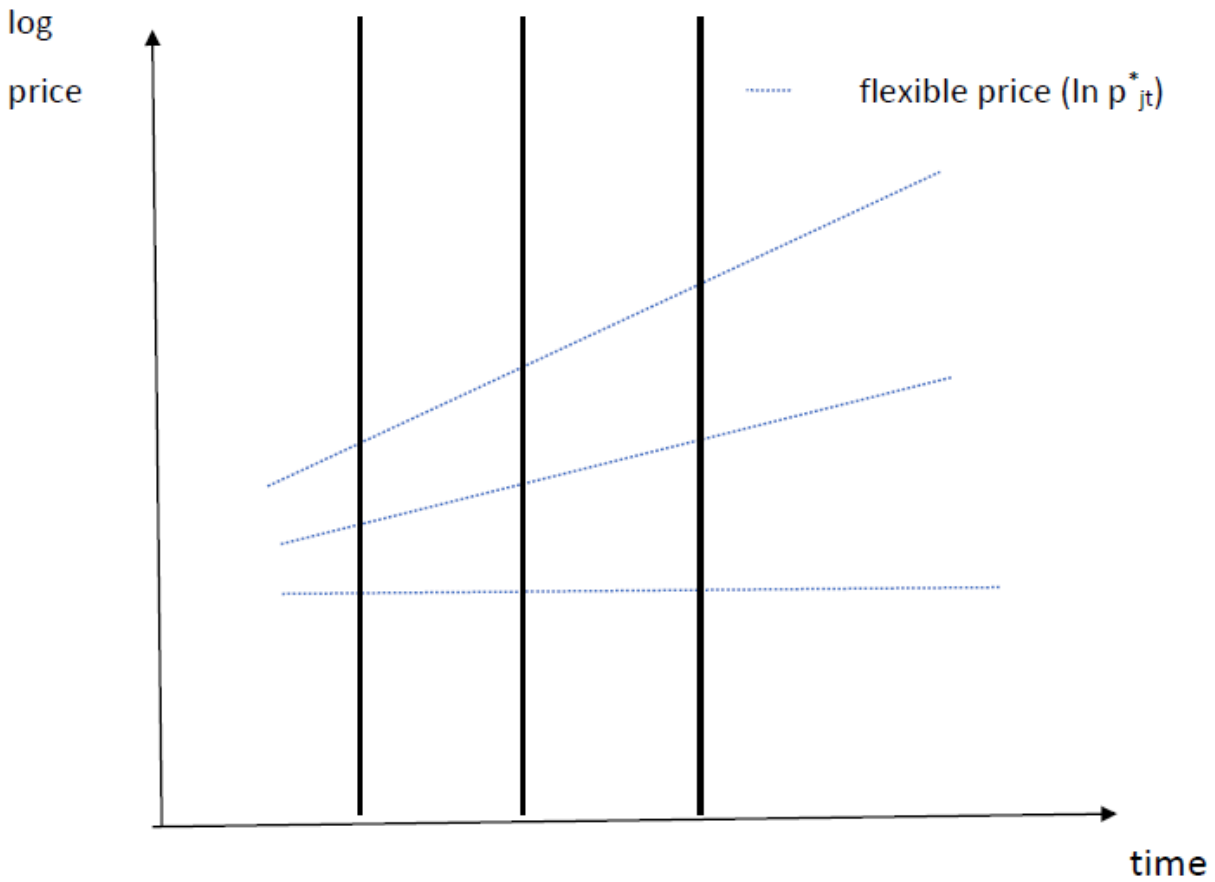
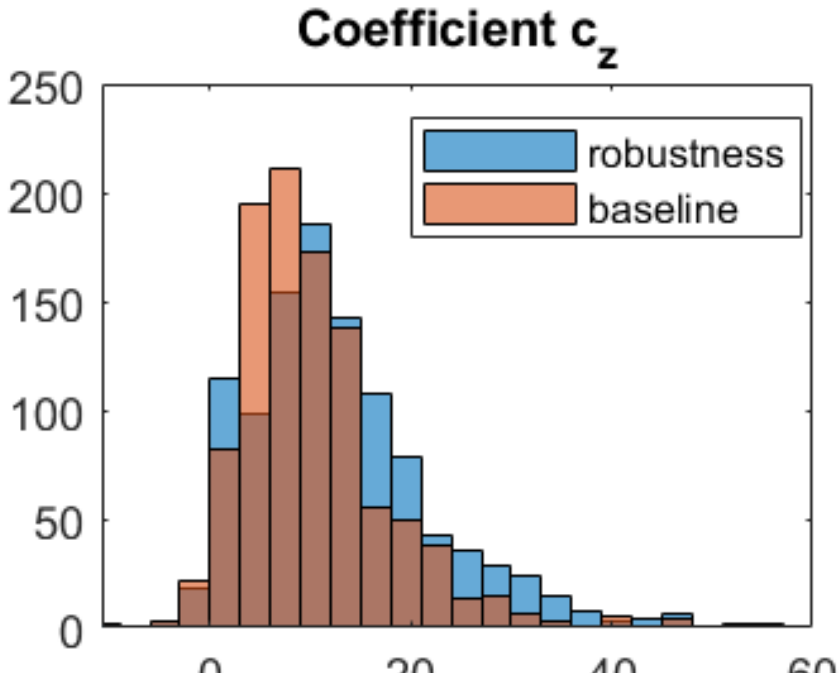
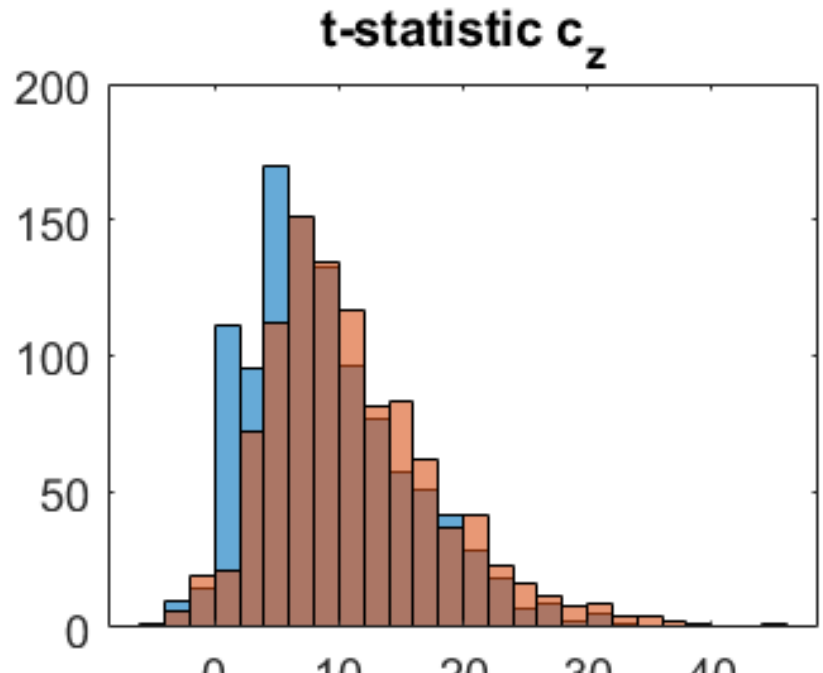


We have: $abs(\text{price change}) = c \cdot abs(\Pi_z - \Pi^*_{zj})$ with $c > 0$
but no relative price distortions at all!

Within Product Variation

$$\widehat{Var}_1(u_{jzt}) - \widehat{Var}_2(u_{jzt}) = c_z \left(\left(\widehat{\ln \Pi_z^1 / \Pi_{jz}^*} \right)^2 - \left(\widehat{\ln \Pi_z^2 / \Pi_{jz}^*} \right)^2 \right) + v_{jz}, \tag{3}$$





Introduction: Existing Evidence

- Nakamura, Steinsson, Sun & Vilar (QJE, 2018):
  Secular decrease in inflation $\Leftrightarrow$ secular increase in log price dispersion

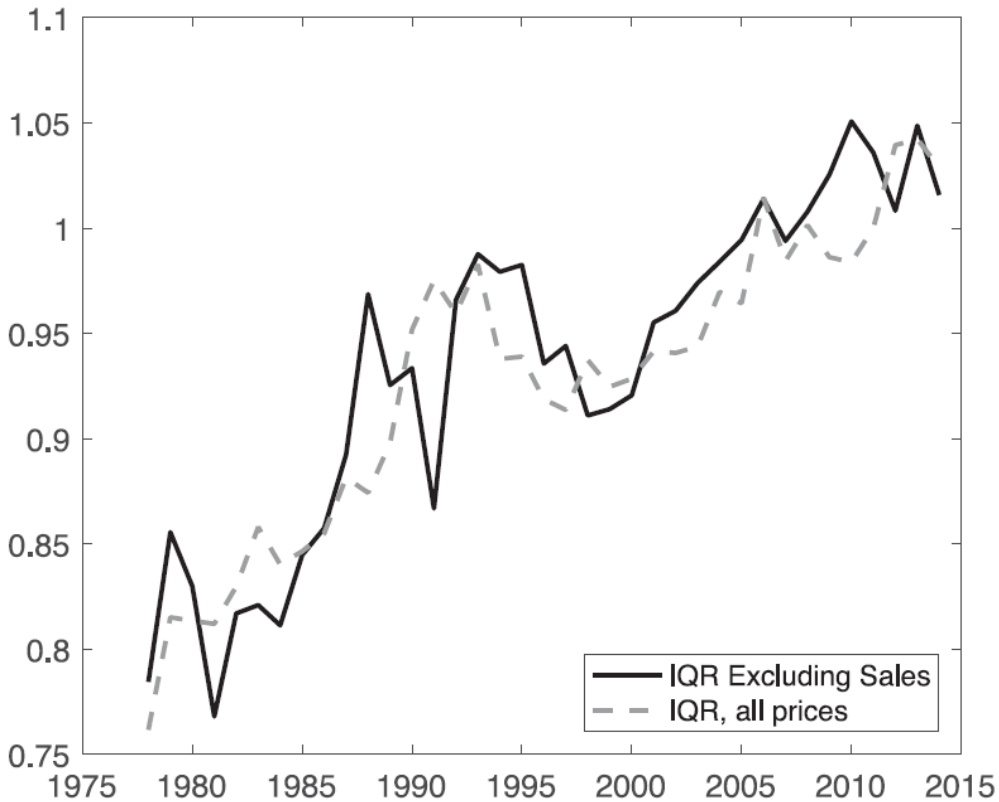


FIGURE VI

Dispersion of Log Prices within ELI

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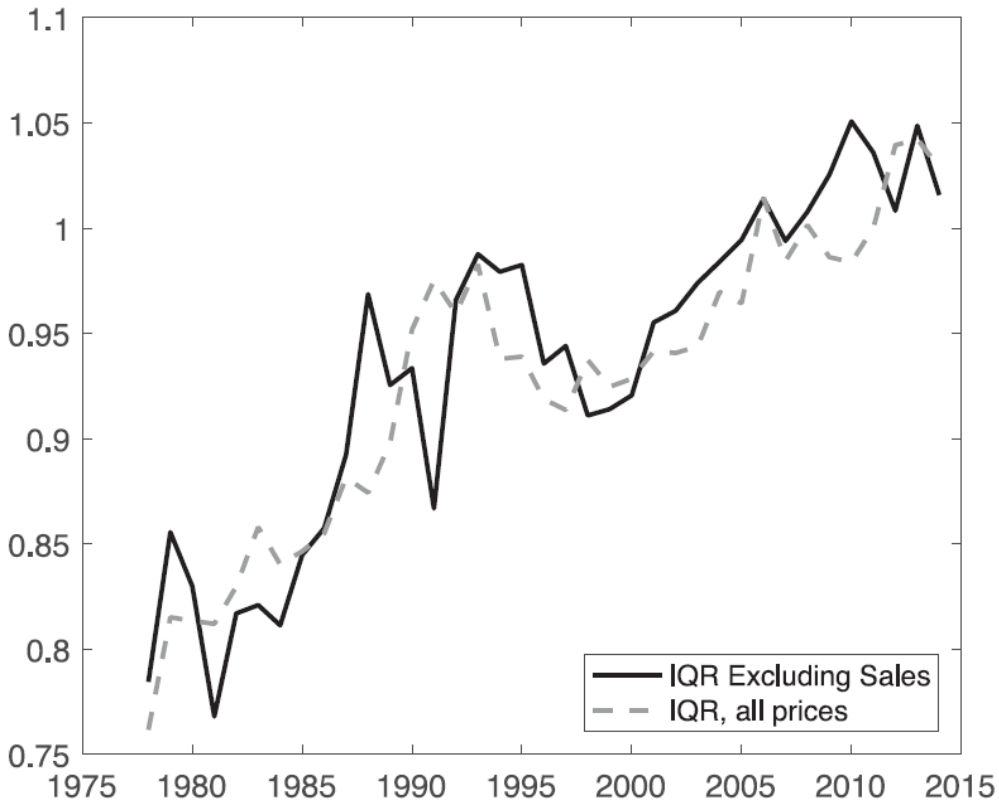

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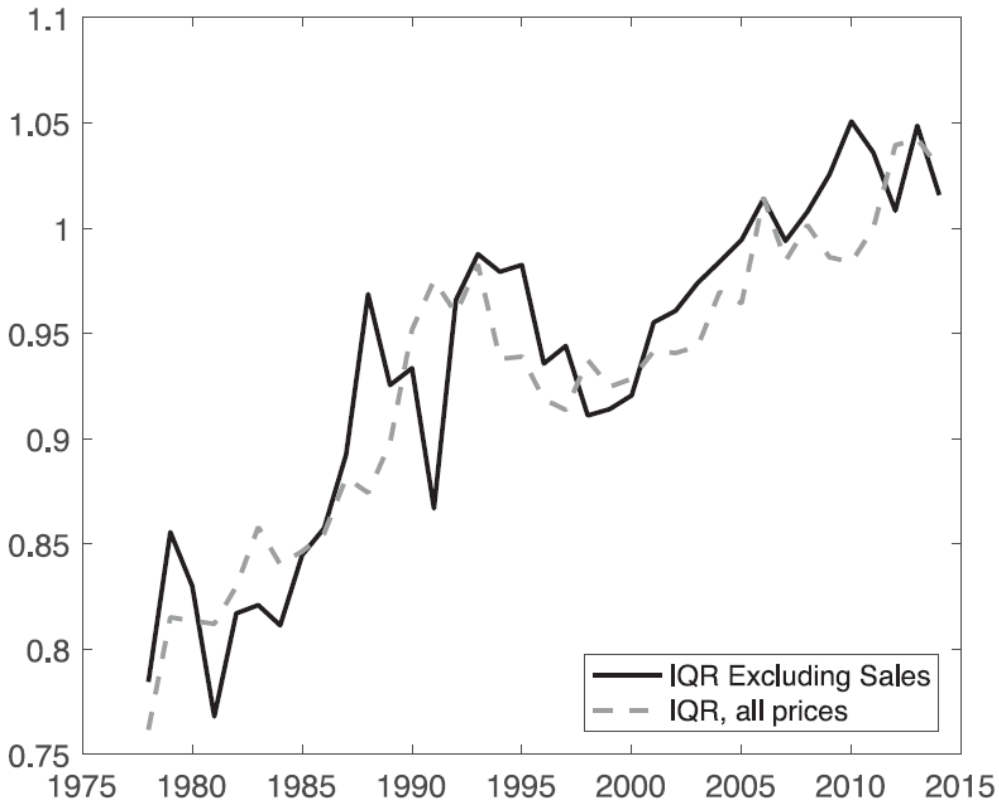

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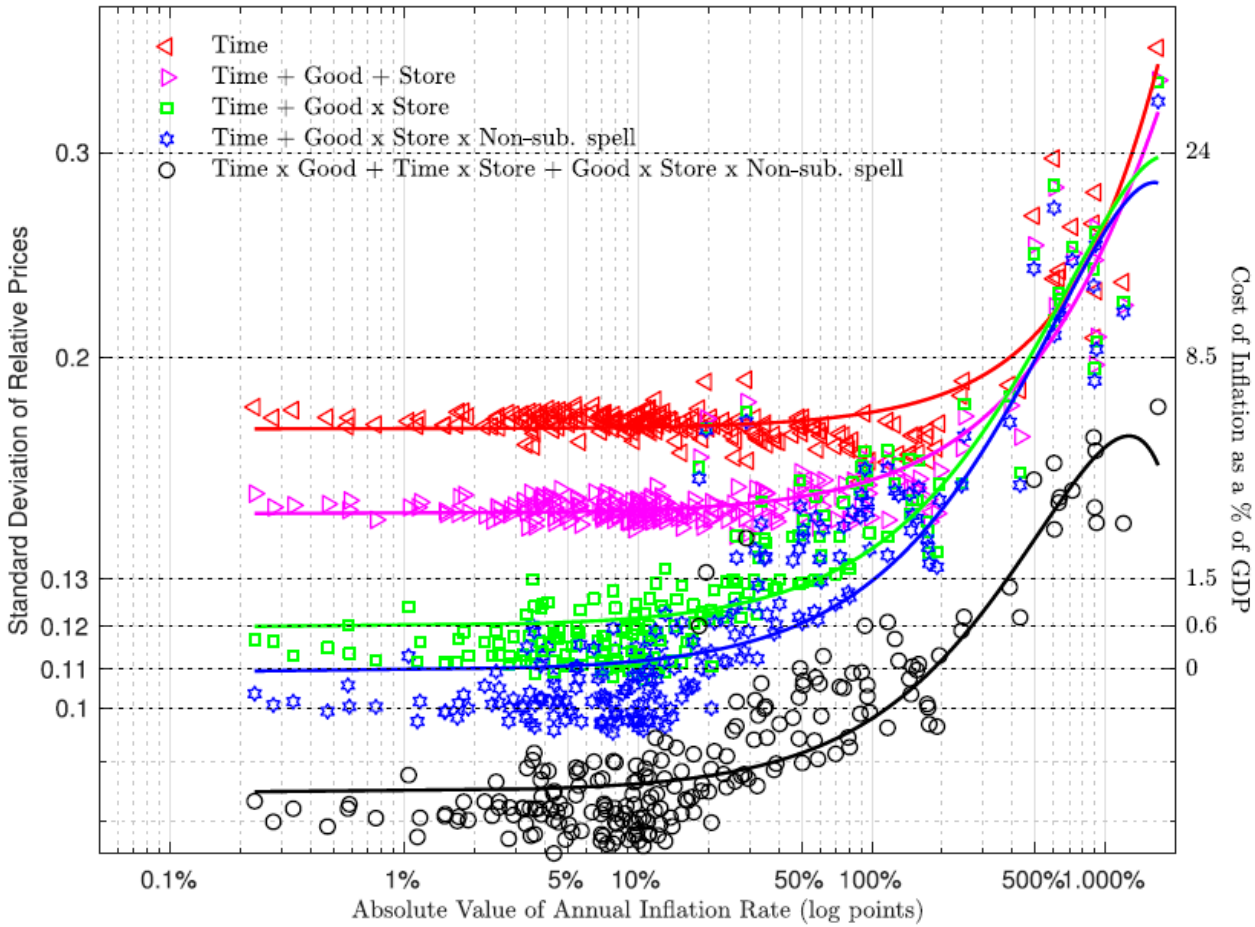

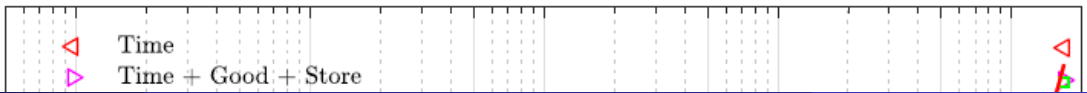

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