Volatility and Pass-through

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Introduction

- How will the macroeconomy respond to shocks or policy changes at some point in time?
  - If we want to answer, how much attention needs to be paid to microeconomic agents in the economy?
- Long-standing debate that arises in:
  - Investment, price-setting, consumption, employment
- Largely a model driven debate
- In this paper we provide "model-free" empirical evidence that correctly predicting aggregate dynamics requires looking at micro data

Exchange Rate Evidence

- For this paper: focus on price-setting behavior of firms exporting to the US
- In tradition of long literature, exploit price responses to exchange rate movements
- Does pass-through vary across time and across firms?

Quick Overview

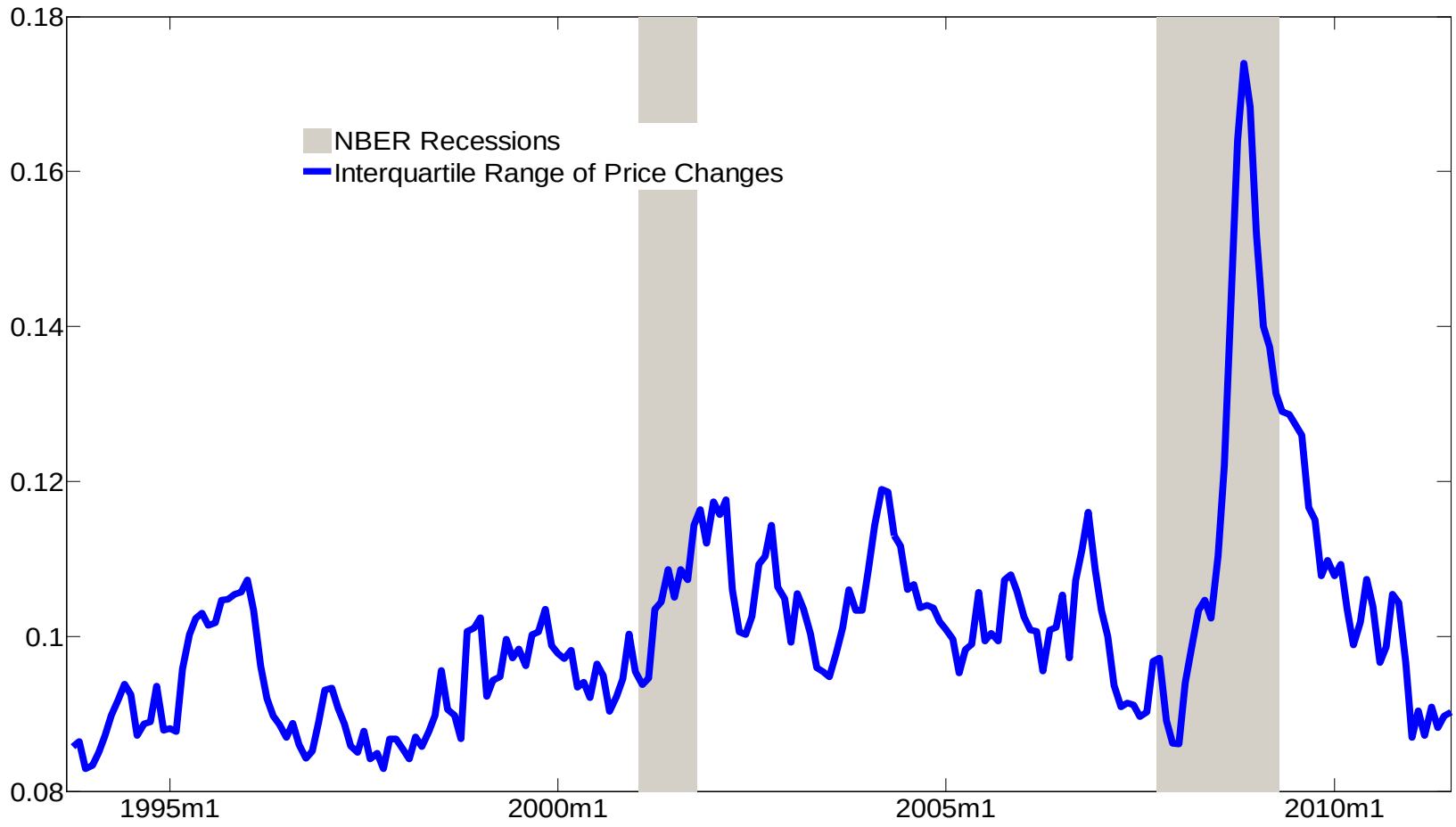
- Use simple idea to guide an empirical test:
  - If some firms are more "responsive" to shocks at some points in time:
    - Should have more disperse price changes
    - Should have higher exchange rate pass-through
- Test for empirical relationship between price change dispersion and pass-through and find strong support:
  - Items with high price change dispersion have high pass-through
  - Pass-through is high during times of high price change dispersion
- Try to control for every confounding covariate we can think of and show this empirical result is very robust

Relationship Between Data and Theory

- Our positive relationship between price change dispersion and pass-through is pure empirical result
- But once we have the empirical result, we try to understand it:
  - Build a model of exporting price-setters with various channels that affect price change dispersion and pass-through
  - Cannot explain our empirical results:
    - Heterogeneity in menu costs, calvo frequencies, import intensity, exchange rate volatility
    - Heterogeneity in volatility or "volatility shocks"
  - Can explain our empirical results:
    - Heterogeneity in markup elasticities or other forms of strategic complementarities

Lots of Time-Variation in Price Change Dispersion

- Why should we care?



Implications

- Model-free results:
  - Estimating aggregate pass-through without using evidence on micro dispersion overstates pass-through during low dispersion periods and understates it during high dispersion periods... by a lot
- Model-based results
  - Large literature studying "uncertainty" or "volatility" shocks
  - We find a strong relationship between dispersion and pass-through but can't be explained by volatility shocks
  - Variable markup/Competition based explanations much more promising

Outline

- Organizing framework
- Empirical results
- Quantitative model
- Why we should care

Organizing framework: flexible prices

- Optimal price is:

$$p_i = \mu_i + mc_i(e_i, \eta_i)$$

gross markup (μ_i)
common dollar marginal cost (mc_i)
idiosyncratic cost (η_i)

- Taking total derivative gives:

$$\Delta p_i = -\Gamma_i(\Delta p_i - \Delta p) + \alpha_i \Delta e_i + \Delta \eta_i$$

with $\Gamma_{in} \equiv \frac{\partial \mu_i}{\partial(\Delta p_i - \Delta p)}$ and $\alpha_i \equiv \frac{\partial mc_i}{\partial e_i}$

Organizing framework: pass-through and variance

- Exchange rate pass-through

$$\frac{\Delta p_i}{\Delta e_i} = \frac{\alpha_i}{1+\Gamma_i}$$

- Variance of prices

$$var(\Delta p_i) = \left(\frac{\alpha_i}{1+\Gamma_i}\right)^2 var(\Delta e_i) + \left(\frac{1}{1+\Gamma_i}\right)^2 var(\Delta \eta_i)$$

- Theory implies **positive** relationship between PT and variance: factors which increase pass-through ($\alpha \uparrow$ and $\Gamma \downarrow$) also increase variance
- Furthermore, will show α channel doesn't explain our results

Data

- BLS IPP micro data underlying import price indices
- Product data from survey
  - Record various transaction details for particular items including price and country of origin
  - Over 10,000 price observations per month
  - Wide range of imports
- IMF exchange rate data
- Data on US and foreign CPI and US GDP
- All results have country-sector fixed effects
- Robust to lots of alternative sample selection so I won't discuss

Benchmark Pass-through Measure

- How much of cumulated exchange rate movements are passed-through when an item adjusts?
- Let $\Delta_c e_{i,t}$ be the cumulative change in exchange rate since last price adjustment

$$\Delta p_{i,t} = \beta \Delta_c e_{i,t} + Z'_{i,t}\gamma + \epsilon_{i,t}$$

Average medium-run pass-through				
β	$se(\beta)$	t-stat	N_{obs}	R^2
0.144	0.014	10.17	95284	0.067

Measuring Price Change Dispersion

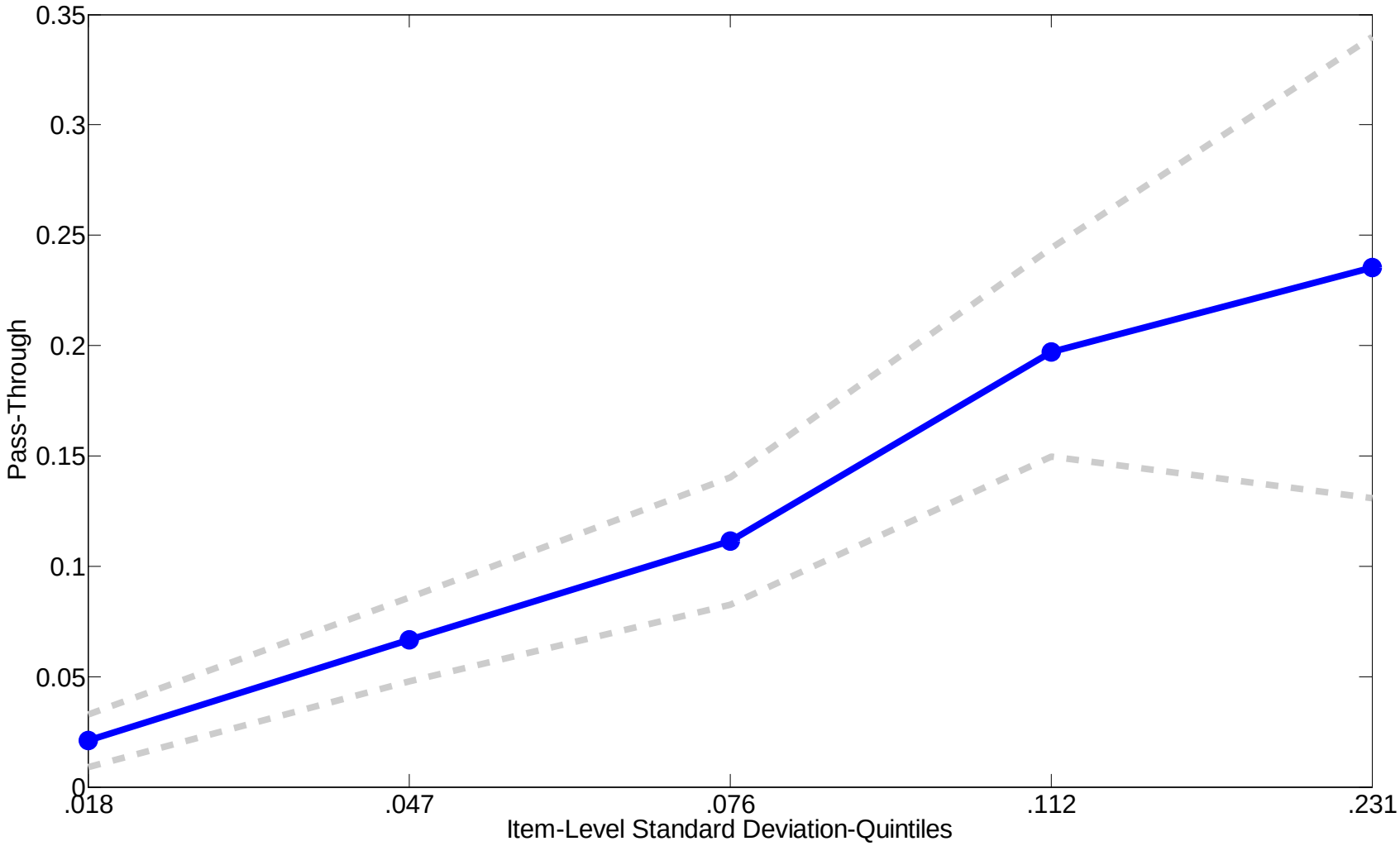
- Want to test if there is a relationship between price change dispersion and pass-through
- Measuring dispersion in the data:
  - Item-level dispersion:
  - Fix item j calculate dispersion of all that item's price changes across time:
  - $DI_j = disp(\Delta p_{i,t} | i = j)$
  - Month-level dispersion:
  - Fix month k, calculate dispersion across the price changes of all items in that month:
  - $DM_k = disp(\Delta p_{i,t} | t = k)$

Item-Level Dispersion and Pass-through

- Let $DI_i = std(\Delta p_i)$ be the standard deviation of item i's price changes (conditional on adjusting)
- Split sample into quintiles by XSD and within each quintile, regress

$$\Delta p_{i,t} = \beta^j \Delta_c e_{i,t} + Z'_{i,t}\gamma + \epsilon_{i,t}$$

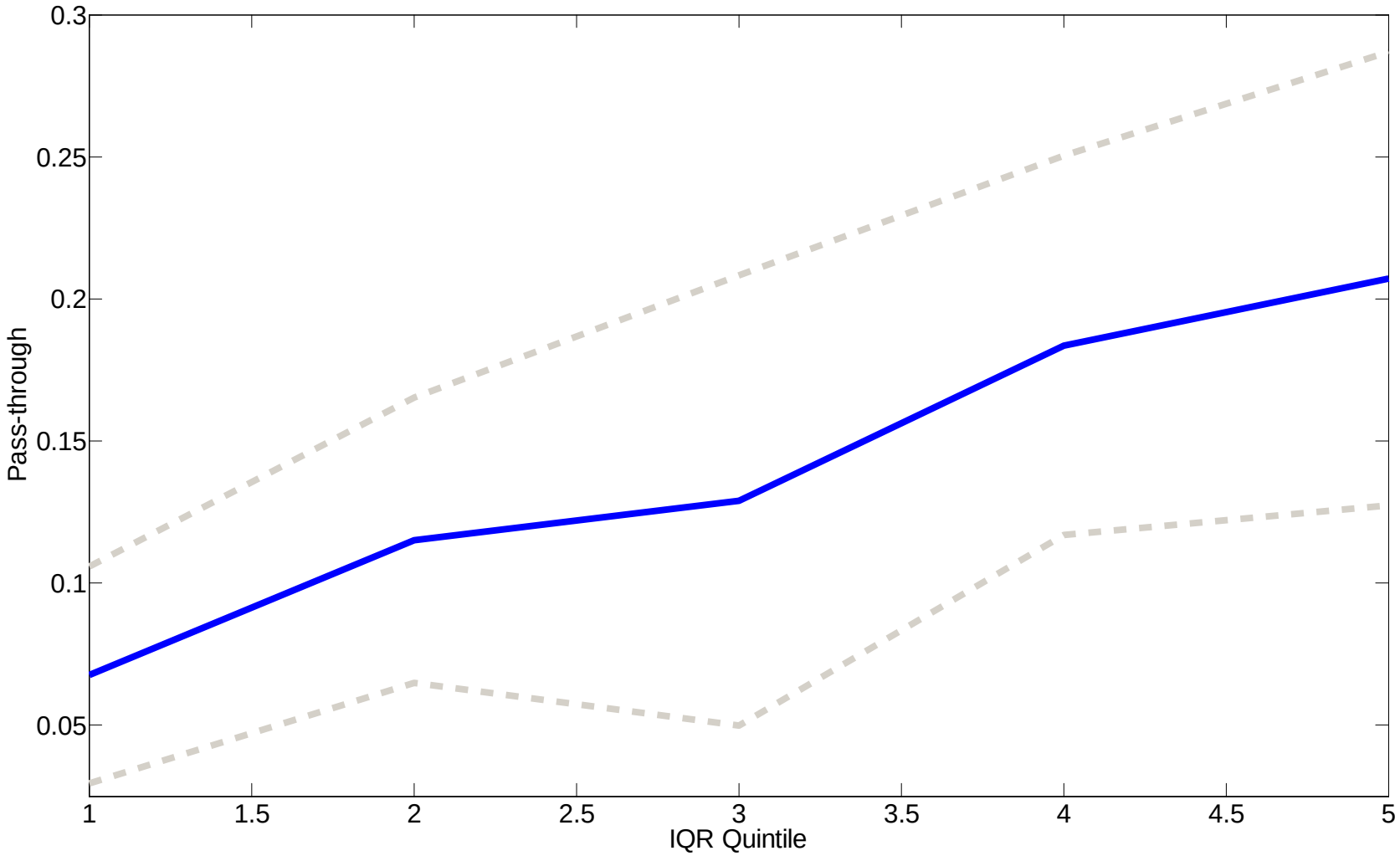
Item-Level Dispersion and Pass-Through



Month-Level Dispersion

- Same relationship in time-series using month-level dispersion?
- For each month, calculate IQR of price changes across items
- Divide time-series quintiles by IQR:

Month-Level Dispersion and Pass-Through



A Mechanical Relationship?

- Flex price benchmark:

$$\begin{aligned} \Delta p_{i,t} &= \beta^j \Delta e_{i,t} + \epsilon_{i,t} \\ &\Rightarrow \\ var\left(\Delta p_{i,t}\right) &= \left(\beta^j\right)^2 var\left(\Delta e_{i,t}\right) + var\left(\epsilon_{i,t}\right) \end{aligned}$$

- What if only β (e.g. import intensity) varies across firms?
  - $var\left(\Delta e_{i,t}\right)$ is observable
  - Average $var\left(\Delta p_{i,t}\right)$, β observable
  - $var\left(\epsilon_{i,t}\right)$ constant across firms (by assumption)
  - Use observables to back out $var\left(\epsilon_{i,t}\right)$

What Determines Individual Price Dynamics?

- If the only thing that varies across firms is β, should then be able to vary β and generate observed item-level dispersion

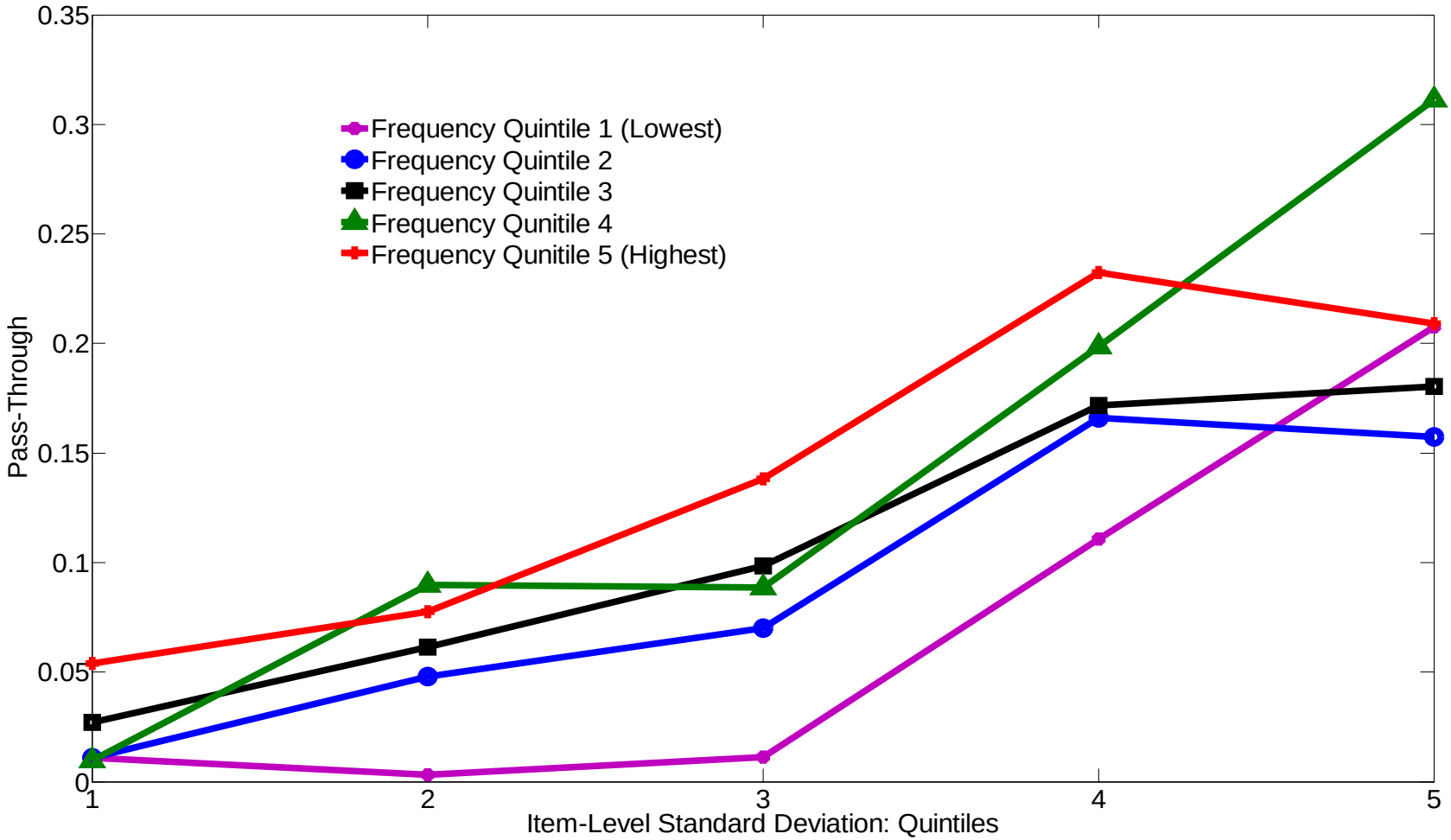
$$var\left(\Delta p_{i,t}\right) = \left(\beta^{j}\right)^{2} var\left(\Delta e_{i,t}\right) + var\left(\epsilon_{i,t}\right)$$

Quintile	β^j	Actual $var\left(\Delta p\right)$	Implied $var\left(\Delta p\right)$	$var\left(\Delta e\right)$	$var\left(\epsilon\right)$
1	.021	3.14e-4	1.83003e-2	6.25e-4	1.83e-2
5	.235	5.33e-2	1.83345e-2	6.25e-4	1.83e-2

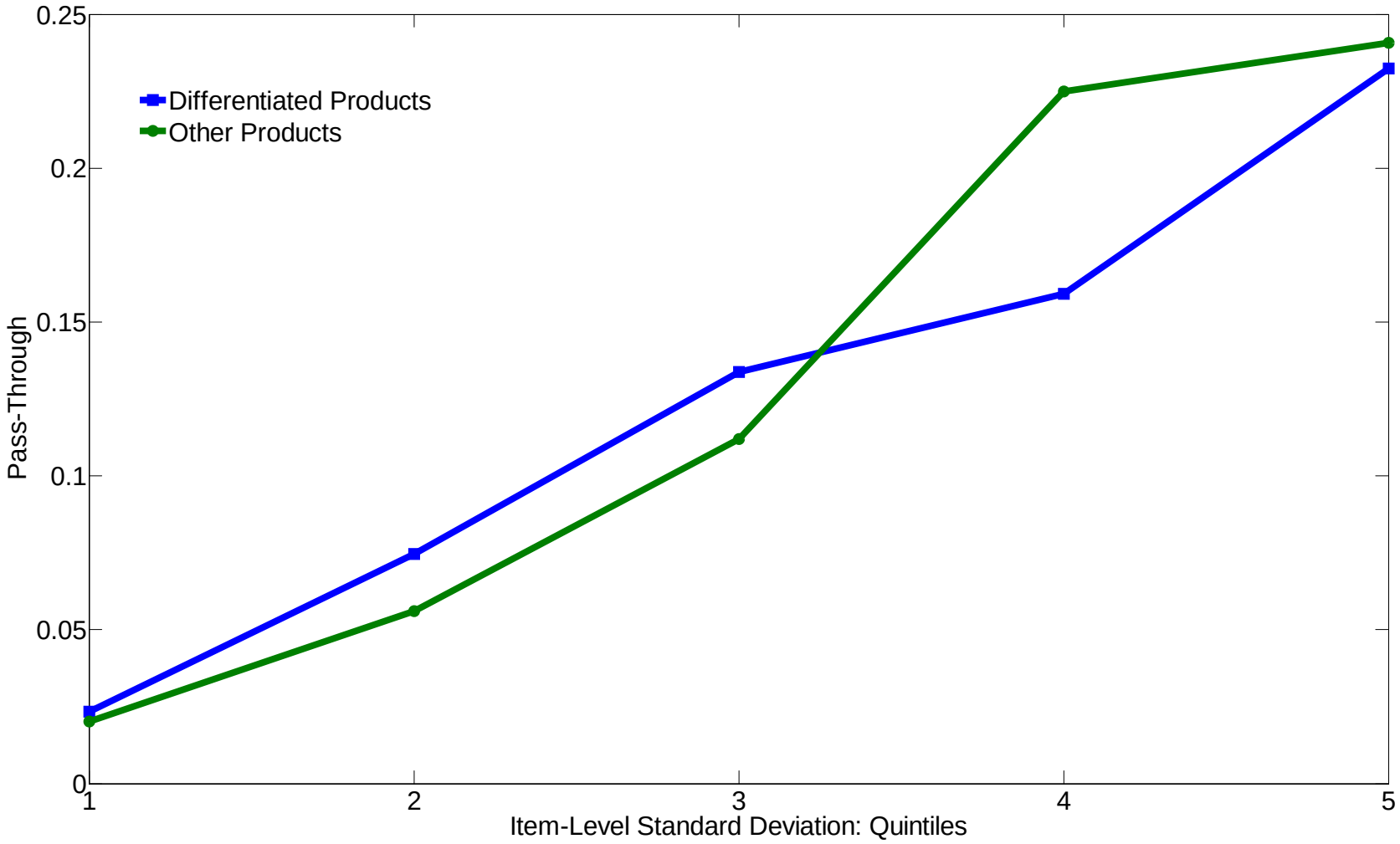
- Price change variance almost entirely determined by idiosyncratic $var\left(\epsilon_{i,t}\right)$ not $var\left(\Delta e_{i,t}\right)$
- Heterogeneous β can explain only .065% of observed relationship

Dispersion or Frequency?

- Run regressions split by *DI* and *freq*



Product type



Robustness

- Don't have time to talk about them all, but results very robust:
- Run more structured specification that allows for more controls:
  - Control for item-frequency, aggregate frequency, product substitution, time-trends, seasonality, business cycle measures
- Rerun results for alternative sample selection and exchange rate measures:
  - OECD countries instead of all-countries
  - Differentiated/Manufactured items instead of all items
  - Trade weighted exchange rates
  - Rerun time-series results using aggregate data
- Quantile regressions and trimmed outliers in OLS
- Placebo regressions with #obs, #changes

Section 4

Models

Models

- As pure empirical statement, we've shown looking at micro data on price dispersion is important for predicting pass-through, but...
- What explains the positive relationship between pass-through and price dispersion? Is this really evidence for heterogeneous responsiveness?
- Build a model to assess different possibilities. Heterogeneity in:
  - Menu costs?
  - Volatility?
  - Import intensity?
  - Responsiveness?
  - Exchange rate volatility?
  - "Common-ness" of shocks

Modeling Exchange Rate Pass-through

- Assess Calvo and Menu cost version of model in Gopinath and Itshkhoki (2010)
  - Firms face Kimball demand with elasticity σ and super-elasticity ε
    - $C_j = \left[1 - \varepsilon \ln\left(\frac{\sigma}{\sigma-1}\frac{P_j}{P}\right)\right]^{\sigma/\varepsilon}$; $\Gamma = \frac{\varepsilon}{\sigma - 1 + \varepsilon \ln\left(\frac{\sigma x_j}{\sigma-1}\right)}$
  - Firm costs depend on idiosyncratic productivity A_j and exchange rate E
    - E follows random walk
    - $\log A_j = \rho_A + \sigma_A \epsilon_j$
  - Firm profits: $\Pi\left(P_j, A_j, P, E\right) = \left[P_j - \frac{W^{1-\alpha}(W^*)^{\alpha}}{A_j}\right] C_j$
  - Firms face menu costs of price adjustment κ or Calvo fairies
- Calibrate and solve model in standard ways - all our results robust to different calibrations

What Affects Pass-through?

- $\Delta p_{i,t} = \beta \Delta e + \epsilon$ implies:

$$\widehat{\beta} = \frac{cov\left(\Delta p, \Delta e\right)}{var\left(\Delta e\right)} = \frac{cov\left(\beta \Delta e + \epsilon, \Delta e\right)}{var\left(\Delta e\right)} = \beta + \frac{cov\left(\epsilon, \Delta e\right)}{var\left(\Delta e\right)}$$

- With flex prices:

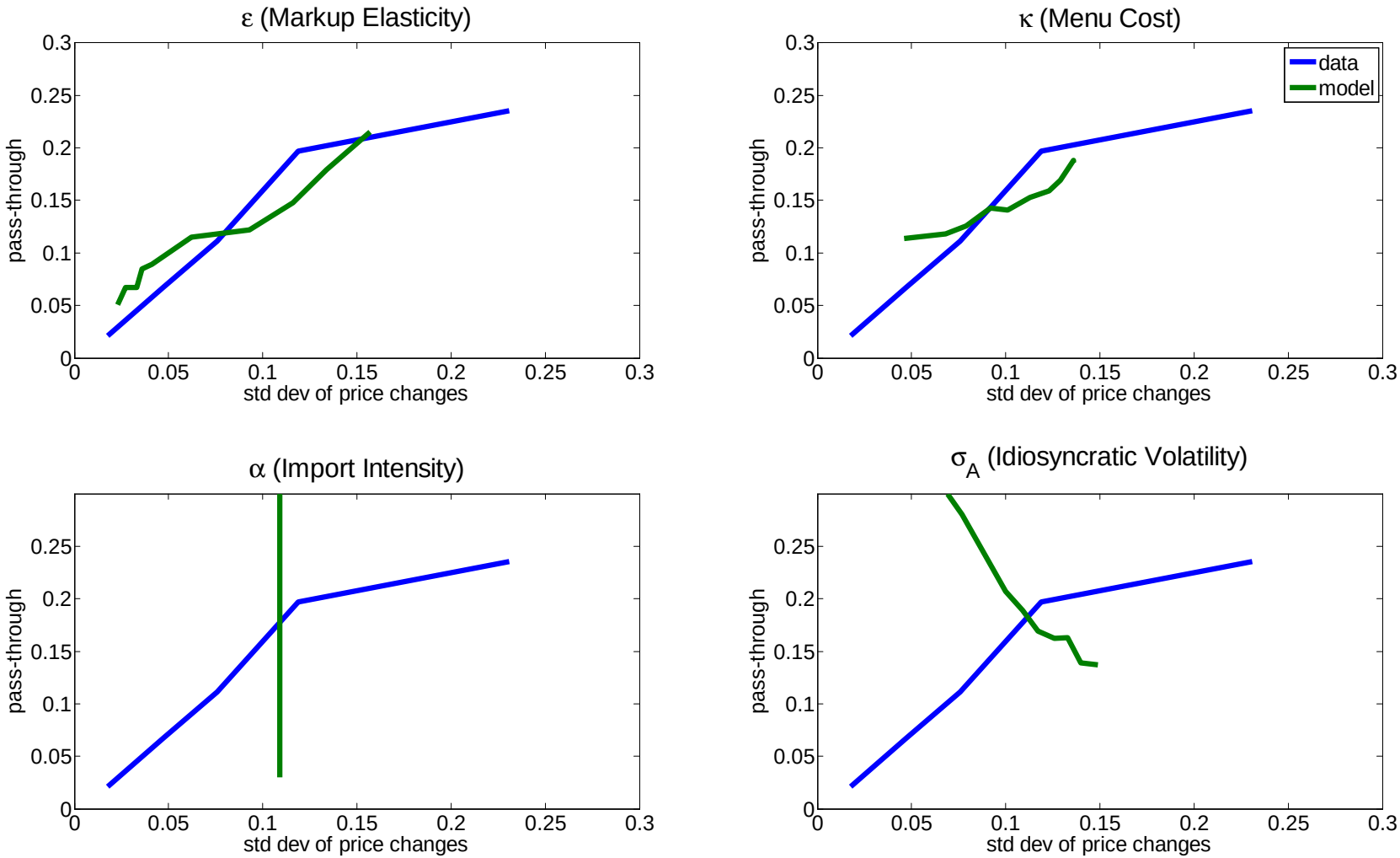
$$\beta = \frac{\alpha}{1 + \Gamma}$$

- To increase pass-through
  - Increase α or lower ε (and thus Γ).
  - Increase κ or lower σ_A since increases $cov\left(\epsilon, \Delta e\right)$

Matching the Cross-Item Dispersion Results

- Holding other parameters at baseline, vary menu costs, volatility and super elasticity and look at effects on MRPT, XSD and freq

Figure: Menu Cost Comparative Statics



Cross-Item dispersion results conclusion

- Variation in either ε or κ can match relationship between XSD and $MRPT$
- Only variation in ε generates (the empirically correct) $corr(freq, XSD) > 0$
- Therefore variation in responsiveness is best able to match cross-sectional facts

Aggregate shocks

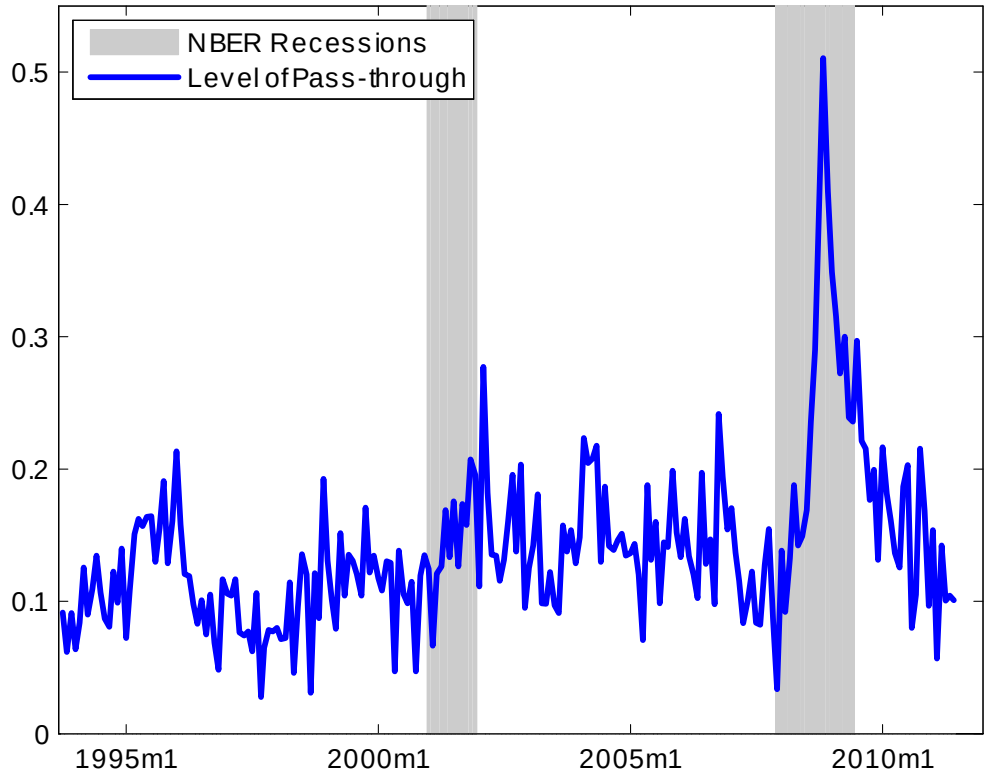
- In the paper we add aggregate shocks to ε, α, κ, σ_A to try to match time-series regressions
- Don't have strong guidance for modeling the shocks so try different things
- Again find only ε consistent with the data

Implications of our Results

- We think our results are interesting for 2 reasons
  1. Direct evidence that micro data matters for aggregate pass-through
  2. Our results suggest "uncertainty/volatility" shocks are probably not what explains countercyclical dispersion

1. Pass-Through Varies Across Time

- Our estimates:
  - Mid 90s: pass-through $\simeq 7\%$
  - Trade Collapse: pass-through $\simeq 44\%$
  - Miss this huge variation if just calculate average



2. Uncertainty shocks vs time-varying responsiveness

- Existing literature on countercyclical dispersion (e.g. Bloom et al; Vavra; Arellano et al) has implicitly embraced $\sigma_A \uparrow$ as way to explain time series variation in dispersion
- However, variation in ε also generates time variation in price dispersion
- Our model results suggest only variation in ε can explain the time-series relationship between MRPT and XSD
    - Our exchange rate shock let's us identify time-varying responsiveness vs. heteroscedastic shocks

Conclusions

- Empirically, aggregate pass-through moves strongly across time with microeconomic price change dispersion
  - Provides "model-free" evidence that micro data matters for aggregate dynamics
- Show that this arises naturally through variation in "responsiveness"
  - Other channels like volatility shocks don't work
- Future work:
  - Thinking about what could drive "responsiveness" shocks
  - Thinking about ways to apply empirical strategy to alternative environments