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
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

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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 underestimates 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 ($\mu_i$)

common dollar marginal cost ($mc_i$)

idiosyncratic cost ($\eta_i$)

- Taking total derivative gives:

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

with

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

\[
\Delta p_{i,t} = \beta \Delta c e_{i,t} + Z'_{i,t} \gamma + \epsilon_{i,t}
\]

<table>
<thead>
<tr>
<th>Average medium-run pass-through</th>
<th>$\beta$</th>
<th>$se(\beta)$</th>
<th>$t$-stat</th>
<th>$N_{obs}$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.144</td>
<td>0.014</td>
<td>10.17</td>
<td>95284</td>
<td>0.067</td>
</tr>
</tbody>
</table>
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 $j$ and calculate dispersion of all that item’s price changes across time:
  - $DL_j = disp(\Delta p_{i,t} \mid i = j)$

- **Month-level dispersion:**
  - Fix month $k$, and calculate dispersion across the price changes of all items in that month:
  - $DM_k = disp(\Delta p_{i,t} \mid t = k)$
Let $DL_i = std(\Delta p_i)$ be the standard deviation of item $i$’s price changes (conditional on adjusting)

Split sample into quintiles by XSD and within each quintile, regress

$$\Delta p_{i,t} = \beta^j \Delta c e_{i,t} + Z_{i,t}^j \gamma + \epsilon_{i,t}$$
Item-Level Dispersion and Pass-Through

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Passthrough
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

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Passthrough
A Mechanical Relationship?

- Flex price benchmark:

\[ \Delta p_{i,t} = \beta^j \Delta e_{i,t} + \epsilon_{i,t} \]

\[ \Rightarrow \]

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

- What if only \( \beta \) (e.g. import intensity) varies across firms?
  - \( \text{var} (\Delta e_{i,t}) \) is observable
  - Average \( \text{var} (\Delta p_{i,t}) \), \( \beta \) observable
  - \( \text{var} (\epsilon_{i,t}) \) constant across firms (by assumption)
  - Use observables to back out \( \text{var} (\epsilon_{i,t}) \)
What Determines Individual Price Dynamics?

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

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

<table>
<thead>
<tr>
<th>Quintile</th>
<th>$\beta^j$</th>
<th>Actual $\text{var} (\Delta p)$</th>
<th>Implied $\text{var} (\Delta p)$</th>
<th>$\text{var} (\Delta e)$</th>
<th>$\text{var} (\epsilon)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.021</td>
<td>3.14e-4</td>
<td>1.83003e-2</td>
<td>6.25e-4</td>
<td>1.83e-2</td>
</tr>
<tr>
<td>5</td>
<td>.235</td>
<td>5.33e-2</td>
<td>1.83345e-2</td>
<td>6.25e-4</td>
<td>1.83e-2</td>
</tr>
</tbody>
</table>

- Price change variance almost entirely determined by idiosyncratic $\text{var} (\epsilon_{i,t})$ not $\text{var} (\Delta e_{i,t})$

- Heterogeneous $\beta$ can explain only .065% of observed relationship
Dispersion or Frequency?

- Run regressions split by $DI$ and $freq$
Product type

Item-Level Standard Deviation: Quintiles

- Differentiated Products
- Other Products

Pass-Through
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
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 $\sigma$ and super-elasticity $\varepsilon$
    - $C_j = \left[1 - \varepsilon \ln \left(\frac{\sigma}{\sigma-1} \frac{P_j}{P}\right)\right]^{\sigma/\varepsilon}; \quad \Gamma = \frac{\varepsilon}{\sigma-1+\varepsilon \ln \left(\frac{\sigma x_j}{\sigma-1}\right)}$
  - 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: $\Pi(P_j, A_j, P, E) = \left[P_j - \frac{W^{1-\alpha}(W^*)^\alpha}{A_j}\right] C_j$
  - Firms face menu costs of price adjustment $\kappa$ 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:

  \[
  \hat{\beta} = \frac{\text{cov}(\Delta p, \Delta e)}{\text{var}(\Delta e)} = \frac{\text{cov}(\beta \Delta e + \epsilon, \Delta e)}{\text{var}(\Delta e)} = \beta + \frac{\text{cov}(\epsilon, \Delta e)}{\text{var}(\Delta e)}
  \]

- With flex prices:

  \[
  \beta = \frac{\alpha}{1 + \Gamma}
  \]

- To increase pass-through:
  - Increase \( \alpha \) or lower \( \epsilon \) (and thus \( \Gamma \)).
  - Increase \( \kappa \) or lower \( \sigma_A \) since increases \( \text{cov}(\epsilon, \Delta e) \).
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

\[ \varepsilon \text{ (Markup Elasticity)} \]

\[ \kappa \text{ (Menu Cost)} \]

\[ \alpha \text{ (Import Intensity)} \]

\[ \sigma_A \text{ (Idiosyncratic Volatility)} \]
Cross-Item dispersion results conclusion

- Variation in either $\varepsilon$ or $\kappa$ can match relationship between $XSD$ and $MRPT$

- Only variation in $\varepsilon$ generates (the empirically correct) $corr(freq, XSD) > 0$

- Therefore variation in responsiveness is best able to match cross-sectional facts
In the paper we add aggregate shocks to $\varepsilon$, $\alpha$, $\kappa$, $\sigma_A$ to try to match time-series regressions.

Don’t have strong guidance for modeling the shocks so try different things.

Again find only $\varepsilon$ 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 $\approx 7\%$
  - Trade Collapse: pass-through $\approx 44\%$
  - Miss this huge variation if just calculate average

![Graph showing level of pass-through over time]

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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 $\varepsilon$ also generates time variation in price dispersion.
- Our model results suggest only variation in $\varepsilon$ 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