Uncertainty, Heterogeneous Beliefs, and Business Cycles: Macro and Micro Evidence

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Motivations

- Question: what are the impacts of changes in firms’ *forecast disagreement* over business cycles?
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- Measures: a range of proxies (indirect measures) of economic uncertainty, i.e. VIX, EPU, forecast disagreement, etc. (Bloom, 2014)
- Related: via the same channel as predicted by a theory of *economic uncertainty*?
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Question: what are the impacts of changes in firms’ forecast disagreement over business cycles?

Measures: a range of proxies (indirect measures) of economic uncertainty, i.e. VIX, EPU, forecast disagreement, etc. (Bloom, 2014)

Related: via the same channel as predicted by a theory of economic uncertainty?

Theoretically, second moment shocks to future productivity and/or demand (Bloom, 2009; Bloom et al., 2014)

Trigger of recession: short-run sharp decline (wait-and-see, or real-option effect) + quick rebound and possibly overshoot (convexity effect)

Evidence: (VIX) drop-rebound-overshoot (Bloom, 2009). (EPU) drop and slower recovery (Baker, Bloom and Davis, 2016).

Implicitly, suggesting the same channels of impacts
Disagreement, i.e. heterogeneous expectation is NOT quite uncertainty (forecast error); but affects asset prices and the corporate investments (Sadka and Scherbiba, 2007; Thakor and Whited, 2011)

\[ F(x_{t+1}) \neq \hat{F}(x_{t+1}) \]

Bachmann et. al., (2013) and Caldara et al. (2016): distinctive effects for the forecast disagreement in VAR exercises; unlike “wait and see”. 
Why Care About Forecast Disagreement?

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   - Proxies for the Economic Uncertainty: firm-specific productivity shock dispersion (Bloom et. al. 2014); *Economic Policy Uncertainty (EPU) index* (Baker, Bloom, and Davis, 2016)
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3. Panel setting: Instrumental variables constructed from USPTO patent data. Both within- and between-firm effects of uncertainty and disagreement on firms’ investments
Measures
Baseline Measures of Uncertainty and Forecast Disagreement

- Uncertainty
- Forecast Disagreement
Baseline Measures of Uncertainty and Forecast Disagreement

- **Uncertainty**
  - **UNC**: (Bloom et. al., 2014). Firm-specific TFP: $\hat{z}_{i,t}$; Annually Compustat data. estimated following Olley and Pakes (1996).

  \[ \hat{z}_{i,t+1} = \rho_z \hat{z}_{i,t} + \mu_i + \lambda_{t+1} + \sigma_{e,t} e_{i,t+1} \]  

- **Forecast Disagreement**
Baseline Measures of Uncertainty and Forecast Disagreement

- **Uncertainty**
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    \[
    \hat{z}_{i,t+1} = \rho_z \hat{z}_{i,t} + \mu_i + \lambda_{t+1} + \sigma_{e_i,t} e_{i,t+1}
    \]  
    (1)

- **Forecast Disagreement**
    
    \[
    DIS_t = \sqrt{F^+_{t} - F^-_{t} - (F^+_{t} - F^-_{t})^2}
    \]  
    (2)
Macro Evidence
Baseline Tri-variate Results

Figure: IRFs of Aggregate Investment (Ordering: Uncertainty, Disagreement, Investment).

Larger VAR Results I: **UNC-DIS** system; Ordering based on Bloom (2009)

**Figure:** First Row: to Uncertainty Shocks; Second Row: to Disagreement Shocks

![Graphs showing the impact of uncertainty and disagreement shocks on Investment and Industrial Production](image-url)

- **Investment**
  - First Row: Responses to Uncertainty Shocks
  - Second Row: Responses to Disagreement Shocks

- **Industrial Production**
  - First Row: Responses to Uncertainty Shocks
  - Second Row: Responses to Disagreement Shocks

- **Ordering**
  - FEV Decomposition

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**Ordering**

**FEV Decomposition**
Figure: First Row: to Uncertainty Shocks (EPU); Second Row: to Disagreement Shocks
Micro Evidence
Micro-evidence on firm-level investments

- Annual Compustat Data. Non-financial firms, non-regulated utilities industry.
- Both linear and non-linear impact conditional on firm $i$'s productivity growth

$$\log\left(\frac{I}{K}\right)_{i,t} = \alpha_1 \log DIS_{t-1}^F + \alpha_2 \log UNC_{t-1} + \eta_i + \theta \log MPK_{i,t}$$
$$+ \beta_1 \log DIS_{t-1}^F \times \Delta PROD_{i,t} + \beta_2 \log UNC_{t-1} \times \Delta PROD_{i,t}$$
$$+ \beta_3 \Delta PROD_{i,t} + \epsilon_{i,t}. \quad (3)$$
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- Within-firm effects: $\alpha_1$ and $\alpha_2$ / Between-firm effects: $\beta_1$ and $\beta_2$
- $MPK_{i,t}$ marginal product of capital.
Micro-evidence on firm-level investments

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(3)

- Within-firm effects: $\alpha_1$ and $\alpha_2$ / Between-firm effects: $\beta_1$ and $\beta_2$
- $MPK_{i,t}$ marginal product of capital.
- Timing alignment: uncertain and disagree about year $t$. Robust for forecast dated at $t-1$, $DIS_{t-1}$ and forecast-relevant date regarding year $t$, $DIS_{t-1}^F$
- Uncertainty: $\alpha_2 < 0$ (wait and see; decline) and $\beta_2 > 0$ (convexity effect; rebound).
- Informational Disagreement Changes: $\alpha_1 < 0$ and $\beta_1 \leq 0$ ? (no aggregate rebound).
Dispersion of $TFP_{i,t} \neq$ Variability of productivity of a firm

Dispersion of beliefs about firm-specific business conditions reflects fundamental differences of productivity/demand,
Dispersion of $TFP_{i,t} \neq$ Variability of productivity of a firm

Dispersion of beliefs about firm-specific business conditions reflects fundamental differences of productivity/demand, as well as the *informational disagreement*. 
Dispersion of $TFP_{i,t}$ ≠ Variability of productivity of a firm

Dispersion of beliefs about firm-specific business conditions reflects fundamental differences of productivity/demand, as well as the informational disagreement.

Instruments data source: USPTO patent application data from 1970-2012
- R & D (patents) ⇒ real productivity
- Information processing technology adoption (IP patents) ⇒ reduce the informational noise
- Patent data by NACIS sectors are available ⇒ cross-sectional measures across firms
- Foreign-based patents filed with the U.S. to shed light on the U.S. investment panel
Endogeneity Issue: IV Estimations

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  - Foreign-based patents filed with the U.S. to shed light on the U.S. investment panel

- Two IVs: $\sigma_{N_{i,t}/N_t}$ / Information Processing Technology Penetration Index (IPPI) ($yearly changes$ enter to ensure stationarity)

- IV sets: levels and their interactions with firm-specific productivity growth
Two conventions of patent counts by USPTO: *Whole Counts* (WC) and *Fractional Counts* (FC).

WC: an informational processing patent (IPP) can be matched to non-IPP NAICS category (count as one for all the related NAICS categories).

FC: divides one equally for all matched NAICS categories.
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- \( WC \text{ No.} > FC \text{ No.} \): difference in patent counts within the category of information processing patent suggests *how many info processing patents are associated with all other industries*. 
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**WC No. > FC No.**: difference in patent counts within the category of information processing patent suggests *how many info processing patents are associated with all other industries*.

**IV**₂ is given by

\[
IPPI_t = \frac{\text{Num}^{\text{WC}}_{\text{IPP Code},t} - \text{Num}^{\text{FC}}_{\text{IPP Code},t}}{\text{Num}^{\text{FC}}_{\text{Non-IPP code},t}}
\]  

**codes**: Communications Equipment (3342, the baseline) and the Computer and Peripheral Equipment (3341)
Information Processing Technology Penetration Index (IPPI)

NOTES: NBER recession dates are shaded.
### IV Estimation First Stage Results: Within-firm Effects

<table>
<thead>
<tr>
<th></th>
<th>IV Est. (1)</th>
<th>IV Est. (2)</th>
<th>IV Est. (3)</th>
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<td><strong>IV First Stage: log $UNC_{t-1}$</strong></td>
<td></td>
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<tr>
<td>$\Delta[Patent \ App \ Disp]_{t-1}$</td>
<td>12.300***</td>
<td>11.336***</td>
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<td>$\Delta[Patent \ App \ Disp]_{t-2}$</td>
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<td>2.574***</td>
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</tr>
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<td>$\Delta[Patent \ App \ Disp]_{t-6}$</td>
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<td>19.090***</td>
<td></td>
</tr>
<tr>
<td>$\Delta[Patent \ App \ Disp]_{t-7}$</td>
<td></td>
<td>10.295***</td>
<td></td>
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<tr>
<td>$\Delta IPPI_{t-1}$</td>
<td>-0.534***</td>
<td>-0.085</td>
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<td>$\Delta IPPI_{t-2}$</td>
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<td>0.740***</td>
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<td>9.805***</td>
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<td>$\Delta IPPI_{t-7}$</td>
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<td><strong>Instrument F Stat.</strong></td>
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<td>997.562</td>
<td>3483.510</td>
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<td>15.554***</td>
<td></td>
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<td>$\Delta[Patent \ App \ Disp]_{t-2}$</td>
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<td>7.909***</td>
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<td>$\Delta[Patent \ App \ Disp]_{t-6}$</td>
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<td>29.180***</td>
<td></td>
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<tr>
<td>$\Delta[Patent \ App \ Disp]_{t-7}$</td>
<td></td>
<td>8.445***</td>
<td></td>
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<tr>
<td>$\Delta IPPI_{t-1}$</td>
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<td>-5.708***</td>
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<tr>
<td>$\Delta IPPI_{t-2}$</td>
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<td>-4.498***</td>
<td></td>
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<tr>
<td>$\Delta IPPI_{t-6}$</td>
<td></td>
<td>-12.355***</td>
<td></td>
</tr>
<tr>
<td>$\Delta IPPI_{t-7}$</td>
<td></td>
<td>-11.933***</td>
<td></td>
</tr>
<tr>
<td><strong>Instrument F Stat.</strong></td>
<td>1221.334</td>
<td>596.193</td>
<td>3084.772</td>
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</tbody>
</table>

*Notes: Sample: 1970 - 2012. Bootstrapped S.E. not reported. 15% +, 10% *, 5% **, 1% ***
### Instrument Variable Estimates: Within-firm Effects

<table>
<thead>
<tr>
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<th>OLS Est.</th>
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</thead>
<tbody>
<tr>
<td>( \log UNC_{t-1} )</td>
<td>-0.296***</td>
<td>-1.154***</td>
<td>-1.011***</td>
<td>-1.108**</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.159)</td>
<td>(0.172)</td>
<td>(0.467)</td>
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<tr>
<td>( \log DIS_{t-1}^{F} )</td>
<td>-0.139***</td>
<td>-0.498**</td>
<td>-0.581***</td>
<td>-0.739</td>
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<td>(0.025)</td>
<td>(0.249)</td>
<td>(0.194)</td>
<td>(0.767)</td>
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<td>No. Obs</td>
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<td>65036</td>
<td>38861</td>
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<td>Hansen J P-val</td>
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<td>N/A</td>
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**Notes:** Sample: 1970 - 2012. Bootstrapped S.E. clustered at the firm level in parenthesis. 15% +, 10% *, 5% **, 1% ***
### IV Estimates: Uncertainty vs. Informational Disagreement Changes

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>IV (1)</th>
<th>IV (2)</th>
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<tr>
<td></td>
<td></td>
<td>IV Scheme 1</td>
<td>IV Scheme 2</td>
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<tr>
<td>$\log , UNC_{t-1}$</td>
<td></td>
<td>-0.270***</td>
<td>-0.906***</td>
<td>-0.711***</td>
<td>-0.903***</td>
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<tr>
<td></td>
<td></td>
<td>(0.026)</td>
<td>(0.138)</td>
<td>(0.141)</td>
<td>(0.131)</td>
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<tr>
<td>$\log , DIS^F_{t-1}$</td>
<td></td>
<td>-0.143***</td>
<td>-0.357+</td>
<td>-0.446**</td>
<td>-0.357*</td>
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<tr>
<td></td>
<td></td>
<td>(0.023)</td>
<td>(0.233)</td>
<td>(0.207)</td>
<td>(0.205)</td>
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<tr>
<td>$\log , UNC_{t-1} \times \Delta TFP_{i,t}$</td>
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<td>0.186***</td>
<td>1.517***</td>
<td>3.260***</td>
<td>1.362***</td>
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<td></td>
<td></td>
<td>(0.071)</td>
<td>(0.141)</td>
<td>(0.151)</td>
<td>(0.188)</td>
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<tr>
<td>$\log , DIS^F_{t-1} \times \Delta TFP_{i,t}$</td>
<td></td>
<td>0.056</td>
<td>-1.665</td>
<td>-3.993***</td>
<td>-1.671**</td>
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<tr>
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<td>(0.118)</td>
<td>(1.287)</td>
<td>(0.833)</td>
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<td>No. Obs.</td>
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<td>1st Stage F Stat. (UNC)</td>
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<td>652.980</td>
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<td>1st Stage F Stat. (DIS)</td>
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<td>606.257</td>
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<td>1st Stage F Stat. (UNC × Δ TFP)</td>
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<td>48.275</td>
<td>20.763</td>
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<td>1st Stage F Stat. (DIS × Δ TFP)</td>
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<td>43.036</td>
<td>25.294</td>
<td>37.553</td>
<td>41.240</td>
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</table>
Conclusion

- “Drops-rebound-overshoot” effects of changes in productivity uncertainty are robust at the macro level.

- Forecast disagreement identifies a different type of second moment aggregate shocks, related to the information diffusion among firms.

- Increases in the dispersion of heterogeneous beliefs can depress the economy regardless of whether these belief changes are backed by good or bad economic fundamentals.

- At the micro-level: larger uncertainty promotes the between-firm capital reallocation while informational disagreement freezes it.

- Implications: a recession, a slow recovery, and obstructed capital reallocation can be results of second moment shocks to non-fundamentals in absent of adverse aggregate productivity/demand shocks.
Thank You Very Much!
IRFs of Federal Funds Rate: Uncertainty and Disagreement Shocks
Tri-variate Results II: Disagreement Ordered First

Figure: IRFs of Aggregate Investment: Uncertainty and Disagreement Shocks

The disagreement index is constructed following Bachmann et al. (2013)

Cross-sectional belief dispersion based on the numbers of firms that responded to a survey question probing their views about their own business conditions in six months relative to the survey date.

The survey was conducted by Philadelphia Fed with data stored in the Business Outlook Survey Database.

Disagreement Index is defined as:

\[ DIS_t = \sqrt{F_t^+ + F_t^- - (F_t^+ - F_t^-)^2} \]  (5)

The fractions of responding firms with beliefs of increase and decrease are denoted by \( F_t^+ \) and \( F_t^- \) respectively.

The closer of this index is to 1, the greater magnitude of cross-sectional belief heterogeneity.
Alternative Measures

- Index of Economic Policy Uncertainty (**EPU**): based on the frequency of newspaper references to policy-related economic uncertainty. See details in Baker, Bloom and Davis (2016).

- Dispersion of Forecasts Measures Based on Philadelphia Fed’s Survey of Professional Forecasters data (**SPF**): Data from 1990Q1 up to 2013Q4 in line with Bloom (2014). Six month ahead forecasts about the U.S. real GDP and the industrial production. Difference between the 75th percentile and the 25th percentile (the interquartile range) of the point forecasts surveyed.
Standard Measures of Uncertainty


- Stock market volatility, dispersion of firm-level TFPs, private agents’ heterogeneous beliefs about the future aggregate and idiosyncratic business conditions (forecast disagreement); Economic Policy Uncertainty Index (Davis et. al., 2016)
Assumption: dispersion of ex-post idiosyncratic TFPs does not respond to exogenous change in the dispersion of forecasts in this quarter

Larger system following Bloom (2009): log(S&P500 stock market index), log(uncertainty measure), log(disagreement measure), Federal Funds Rate, log(average hourly earnings in manufacturing), log(consumer price index), weekly average hours in manufacturing, log(non-farm payroll employment), log(real gross private domestic investment), and log(industrial production)
MPK Measures

- sales-to-capital ratio
- current operating income-to-capital ratio
- cash flow - capital ratio
<table>
<thead>
<tr>
<th>Horizon:</th>
<th>One Quarter</th>
<th>One Year</th>
<th>Three Years</th>
<th>Five Years</th>
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<tr>
<td><strong>Aggregate Investment</strong></td>
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<td>UNC</td>
<td>0.10</td>
<td>2.92</td>
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<td>DIS</td>
<td>2.58</td>
<td>8.21</td>
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<td><strong>Industrial Production</strong></td>
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<tr>
<td>UNC</td>
<td>0.22</td>
<td>4.82</td>
<td>3.64</td>
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<tr>
<td>DIS</td>
<td>3.90</td>
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