The Causal Impact of Macroeconomic Uncertainty on Expected Returns

Aditya Chaudhry

Chicago Booth

20th December 2021
Motivation

Does macroeconomic uncertainty cause time-variation in expected returns?

- Financial press often highlights macro uncertainty increases as causing negative stock returns.
- Theoretical evidence is mixed:
  - Long run risk models (Bansal & Yaron (2004)) imply expected returns increase in macro uncertainty.
  - Other models include opposing roles for “good” and “bad” uncertainty:
    - Pastor & Veronesi (2009), Segal, Shaliastovich & Yaron (2015), Bekaert, Engstrom & Xu (2020)
- Empirical evidence is mixed:
  - Dew-Becker, Giglio & Kelly (2016): Investors must be paid to hedge macroeconomic uncertainty.

How strong is the relationship quantitatively?
Motivation

Does macroeconomic uncertainty **cause** time-variation in expected returns?

- Financial press often highlights macro uncertainty increases as causing negative stock returns.
- Theoretical evidence is mixed:
  - Long run risk models (Bansal & Yaron (2004)) imply expected returns increase in macro uncertainty.
  - Other models include opposing roles for “good” and “bad” uncertainty:
    - Pastor & Veronesi (2009), Segal, Shaliastovich & Yaron (2015), Bekaert, Engstrom & Xu (2020)
- Empirical evidence is mixed:
  - Dew-Becker, Giglio & Kelly (2016): Investors must be paid to hedge macroeconomic uncertainty.

How strong is the relationship quantitatively?
Fundamental issue: Identification is a Nightmare

Exogenous variation in uncertainty is rare

\[ \Delta \mu_t = \lambda \sigma^2 \Delta \sigma^2_t + \epsilon_t \]

\[ \text{Corr}(\Delta \sigma^2_t, \epsilon_t) \neq 0 \]

- Many macro variables correlate with uncertainty
  - Macro expectations, risk aversion, etc.

Rare exogenous variation \(\rightarrow\) Identifying causal effects of uncertainty is difficult
This Paper: Clean Identification at High Frequency
Measure daily changes in macro uncertainty, expected returns

- Macro uncertainty: Options implied volatilities
- Expected returns: Function of realized returns

Use exogenous timing of macro announcements as instrument for uncertainty

- Announcements are prescheduled — conditional expectations cannot predictably move
- Higher moments can predictably move

The causal effect of macro uncertainty on expected returns

- One std. dev. rise in level of uncertainty raises long-run expected returns by 173 basis points.
- Macro uncertainty explains 10% (at most 32%) of variation in expected returns.
This Paper: Clean Identification at High Frequency
Measure daily changes in macro uncertainty, expected returns

- Macro uncertainty: Options implied volatilities
- Expected returns: Function of realized returns

Use exogenous timing of macro announcements as instrument for uncertainty

- Announcements are prescheduled — conditional expectations cannot predictably move
- Higher moments can predictably move

The causal effect of macro uncertainty on expected returns

- One std. dev. rise in level of uncertainty raises long-run expected returns by 173 basis points.
- Macro uncertainty explains 10% (at most 32%) of variation in expected returns.
This Paper: Clean Identification at High Frequency
Measure daily changes in macro uncertainty, expected returns

- Macro uncertainty: Options implied volatilities
- Expected returns: Function of realized returns

Use exogenous timing of macro announcements as instrument for uncertainty

- Announcements are prescheduled — conditional expectations cannot predictably move
- Higher moments can predictably move

The causal effect of macro uncertainty on expected returns

- One std. dev. rise in level of uncertainty raises long-run expected returns by 173 basis points.
- Macro uncertainty explains 10% (at most 32%) of variation in expected returns.
What is Macro Uncertainty?

Start with usual risk premium expression

\[ E_t[R_{t+1}] - R^f_t = -\text{Cov}_t(M_{t+1}, R_{t+1}) \]
\[ = -\text{Cov}_t(M_{t+1}, \text{Discount Rate Shock}) - \text{Cov}_t(M_{t+1}, \text{Dividend Growth Shock}) \]

- \( M_{t+1} \) is the SDF
- Second equality follows from Campbell (1991) return decomposition

Special case: Bansal & Yaron (2004)

- Physical conditional variance of common shock to consumption and dividend growth

In general: Conditional variance of common component of many macro series

- SDF & dividend growth may be functions of many macro variables
  - Macro uncertainty is variance of common component to all such variables
- Subjective variance may reflect physical macro volatility of posterior variance
What is Macro Uncertainty?

Start with usual risk premium expression

\[ E_t[R_{t+1}] - R_t^f = -Cov_t(M_{t+1}, R_{t+1}) \]

\[ = -Cov_t(M_{t+1}, \text{Discount Rate Shock}) - Cov_t(M_{t+1}, \text{Dividend Growth Shock}) \]

- \( M_{t+1} \) is the SDF
- Second equality follows from Campbell (1991) return decomposition

Special case: Bansal & Yaron (2004)

- Physical conditional variance of common shock to consumption and dividend growth

In general: Conditional variance of common component of many macro series

- SDF & dividend growth may be functions of many macro variables
  - Macro uncertainty is variance of common component to all such variables
- Subjective variance may reflect physical macro volatility of posterior variance
What is Macro Uncertainty?

Start with usual risk premium expression

\[ E_t[R_{t+1}] - R_t^f = -Cov_t(M_{t+1}, R_{t+1}) \]
\[ = -Cov_t(M_{t+1}, \text{Discount Rate Shock}) - Cov_t(M_{t+1}, \text{Dividend Growth Shock}) \]

- \( M_{t+1} \) is the SDF
- Second equality follows from Campbell (1991) return decomposition

Special case: Bansal & Yaron (2004)

- Physical conditional variance of common shock to consumption and dividend growth

In general: Conditional variance of common component of many macro series

- SDF & dividend growth may be functions of many macro variables
  - Macro uncertainty is variance of common component to all such variables
- Subjective variance may reflect physical macro volatility of posterior variance
Identification Strategy: Setting

- Expected returns linear in two factors — macro uncertainty $\sigma_t^2$ and $x_t$ (e.g. risk aversion)
- Representative agent learns about the latent state of the economy.
  - Prices assets based on conditional distributions over economic state variables.
  - One state variable: Next quarter’s consumption growth ($Q(t)$ is quarter day $t$ is in).
    \[
    \Delta \mu_t = \lambda_{\sigma^2} \Delta \sigma_t^2 + \lambda_x \Delta x_t \\
    \Delta \sigma_t^2 = \alpha_1 \Delta V_t[\Delta C_{Q(t)+1}] + \alpha_2 \Delta E_t[\Delta C_{Q(t)+1}] + \epsilon_{v,t+1} \\
    \Delta x_t = \delta_1 \Delta V_t[\Delta C_{Q(t)+1}] + \delta_2 \Delta E_t[\Delta C_{Q(t)+1}] + \epsilon_{x,t+1}, E_t[\epsilon_{v,t+1} \cdot \epsilon_{x,t+1}] = 0.
    \]

- Econometrician observes only:
  - Expected returns ($\mu_t$) and macro uncertainty ($\sigma_t^2$)
  - Not other driver: $x_t$

- Two identification problems:
  1. Isolating effect of conditional variance through all channels from effect of conditional mean.
  2. Isolating effect of $\sigma_t^2$ from $x_t$. 
Identification Strategy: Setting

- Expected returns linear in two factors — macro uncertainty $\sigma^2_t$ and $x_t$ (e.g. risk aversion)
- Representative agent learns about the latent state of the economy.
  - Prices assets based on conditional distributions over economic state variables.
  - One state variable: Next quarter’s consumption growth ($Q(t)$ is quarter day $t$ is in).

$$\Delta \mu_t = \lambda_{\sigma^2} \Delta \sigma^2_t + \lambda_x \Delta x_t$$

$$\Delta \sigma^2_t = \alpha_1 \Delta V_t [\Delta C_{Q(t)+1}] + \alpha_2 \Delta E_t [\Delta C_{Q(t)+1}] + \epsilon_{V,t+1}$$

$$\Delta x_t = \delta_1 \Delta V_t [\Delta C_{Q(t)+1}] + \delta_2 \Delta E_t [\Delta C_{Q(t)+1}] + \epsilon_{x,t+1}, E_t[\epsilon_{V,t+1} \cdot \epsilon_{x,t+1}] = 0.$$

- Econometrician observes only:
  - Expected returns ($\mu_t$) and macro uncertainty ($\sigma^2_t$)
  - Not other driver: $x_t$

- Two identification problems:
  1. Isolating effect of conditional variance through all channels from effect of conditional mean.
  2. Isolating effect of $\sigma^2_t$ from $x_t$. 
Identification Strategy: Setting

- Expected returns linear in two factors — macro uncertainty $\sigma^2_t$ and $x_t$ (e.g. risk aversion)
- Representative agent learns about the latent state of the economy.
  - Prices assets based on conditional distributions over economic state variables.
  - One state variable: Next quarter’s consumption growth ($Q(t)$ is quarter day $t$ is in).

\[
\Delta \mu_t = \lambda \sigma^2_t + \lambda x_t \\
\Delta \sigma^2_t = \alpha_1 \Delta V_t[\Delta C_{Q(t)+1}] + \alpha_2 \Delta E_t[\Delta C_{Q(t)+1}] + \epsilon_v,t+1 \\
\Delta x_t = \delta_1 \Delta V_t[\Delta C_{Q(t)+1}] + \delta_2 \Delta E_t[\Delta C_{Q(t)+1}] + \epsilon_x,t+1, E_t[\epsilon_v,t+1 \cdot \epsilon_x,t+1] = 0.
\]

- Econometrician observes only:
  - Expected returns ($\mu_t$) and macro uncertainty ($\sigma^2_t$)
  - **Not** other driver: $x_t$

- Two identification problems:
  1. Isolating effect of conditional variance through all channels from effect of conditional mean.
  2. Isolating effect of $\sigma^2_t$ from $x_t$. 
Identification Strategy: Setting

- Expected returns linear in two factors — macro uncertainty $\sigma_t^2$ and $x_t$ (e.g. risk aversion)
- Representative agent learns about the latent state of the economy.
  - Prices assets based on conditional distributions over economic state variables.
    - One state variable: Next quarter’s consumption growth ($Q(t)$ is quarter day $t$ is in).
      \[
      \Delta \mu_t = \lambda \sigma^2_t + \lambda x \Delta x_t \\
      \Delta \sigma^2_t = \alpha_1 \Delta V_t[\Delta C_{Q(t+1)}] + \alpha_2 \Delta E_t[\Delta E_{Q(t+1)}] + \epsilon_{\nu,t+1} \\
      \Delta x_t = \delta_1 \Delta V_t[\Delta C_{Q(t+1)}] + \delta_2 \Delta E_t[\Delta E_{Q(t+1)}] + \epsilon_{x,t+1}, E_t[\epsilon_{\nu,t+1} \cdot \epsilon_{x,t+1}] = 0.
      \]
- Econometrician observes only:
  - Expected returns ($\mu_t$) and macro uncertainty ($\sigma^2_t$)
  - Not other driver: $x_t$

- **Two identification problems:**
  1. Isolating effect of conditional variance through all channels from effect of conditional mean.
  2. Isolating effect of $\sigma^2_t$ from $x_t$. 

Identifying Assumptions to Solve Problem 1

1. **Timing of pre-scheduled announcements is uncorrelated with all other relevant shocks:**

   \[ E[\epsilon_{t+1} \cdot 1(t = \text{announcement})] = 0, \]
   - BLS, BEA, Fed schedule announcements a year or more in advance on fixed schedule
   - Prior knowledge BEA will release the 2020 Q1 GDP estimate on April 29, 2020 is uncorrelated with other contemporaneous economic shocks (e.g. coronavirus news).

2. **Announcement timing does not systematically affect conditional expectations.** That is, \( \theta_{2,1} = 0 \)

   \[ \Delta E_t[\Delta C_{Q(t+1)}] = \theta_{2,0} + \theta_{2,1}1(t = \text{announcement}) + \nu_{2,t} \]
   - Failure of this assumption violates martingale property of conditional expectations. Let \( t' \) be an announcement day. Then on any previous day \( t' - j \):

   \[ E_{t' - j} [\Delta E_{t'}[\Delta C_{Q(t'+1)}]] \neq 0. \]

3. **Macro uncertainty loads on announcement timing.** That is, \( \beta_{\sigma^2,1} = \alpha_1 \theta_{1,1} \neq 0 \):

   \[ \Delta \sigma^2_t = \beta_{\sigma^2,0} + \beta_{\sigma^2,1}1(t \text{ is announcement}) + \epsilon_t \text{ (Relevance Condition)} \]
   - Higher moments (\( \Delta V_t[\Delta C_{Q(t+1)}] \)) can load on announcement timing. That is, \( \theta_{1,1} \neq 0 \)

   \[ \Delta V_t[\Delta C_{Q(t+1)}] = \theta_{1,0} + \theta_{1,1}1(t = \text{announcement}) + \nu_{1,t} \]
Identifying Assumptions to Solve Problem 1

1. Timing of pre-scheduled announcements is uncorrelated with all other relevant shocks:
   \[ E[\epsilon_{t+1} \cdot 1(t = \text{announcement})] = 0, \]
   - BLS, BEA, Fed schedule announcements a year or more in advance on fixed schedule
   - Prior knowledge BEA will release the 2020 Q1 GDP estimate on April 29, 2020 is uncorrelated with other contemporaneous economic shocks (e.g. coronavirus news).

2. Announcement timing does not systematically affect conditional expectations. That is, \( \theta_{2,1}=0 \)
   \[ \Delta E_t[\Delta C_{Q(t+1)}] = \theta_{2,0} + \theta_{2,1} 1(t = \text{announcement}) + \nu_{2,t} \]
   - Failure of this assumption violates \textit{martingale property of conditional expectations}. Let \( t' \) be an announcement day. Then on any previous day \( t' - j \):
     \[ E_{t'-j} \Delta E_{t'}[\Delta C_{Q(t'+1)}] \neq 0. \]

3. Macro uncertainty loads on announcement timing. That is, \( \beta_{\sigma,1} = \alpha_1 \theta_{1,1} \neq 0 \):
   \[ \Delta \sigma_t^2 = \beta_{\sigma,0}^2 + \beta_{\sigma,1}^2 1(t \text{ is announcement}) + \epsilon_t \text{ (Relevance Condition)} \]
   - Higher moments \( \Delta V_t[\Delta C_{Q(t+1)}] \) can load on announcement timing. That is, \( \theta_{1,1} \neq 0 \)
     \[ \Delta V_t[\Delta C_{Q(t+1)}] = \theta_{1,0} + \theta_{1,1} 1(t = \text{announcement}) + \nu_{1,t} \]
Identifying Assumptions to Solve Problem 1

1. Timing of pre-scheduled announcements is uncorrelated with all other relevant shocks:

\[ E[\epsilon_{t+1} \cdot 1(t = \text{announcement})] = 0, \]

- BLS, BEA, Fed schedule announcements a year or more in advance on fixed schedule
- Prior knowledge BEA will release the 2020 Q1 GDP estimate on April 29, 2020 is uncorrelated with other contemporaneous economic shocks (e.g. coronavirus news).

2. Announcement timing does not systematically affect conditional expectations. That is, \( \theta_{2,1} = 0 \)

\[ \Delta E_t[\Delta C_Q(t+1)] = \theta_{2,0} + \theta_{2,1} 1(t = \text{announcement}) + \nu_{2,t} \]

- Failure of this assumption violates martingale property of conditional expectations. Let \( t' \) be an announcement day. Then on any previous day \( t' - j \):

\[ E_{t' - j} \left[ \Delta E_{t'}[\Delta C_{Q(t') + 1}] \right] \neq 0. \]

3. Macro uncertainty loads on announcement timing. That is, \( \beta_{\sigma 2,1} = \alpha_1 \theta_{1,1} \neq 0 \):

\[ \Delta \sigma_t^2 = \beta_{\sigma 2,0} + \beta_{\sigma 2,1} 1(t \text{ is announcement}) + \epsilon_t \text{ (Relevance Condition)} \]

- Higher moments (\( \Delta V_t[\Delta C_Q(t+1)] \)) can load on announcement timing. That is, \( \theta_{1,1} \neq 0 \)

\[ \Delta V_t[\Delta C_Q(t+1)] = \theta_{1,0} + \theta_{1,1} 1(t = \text{announcement}) + \nu_{1,t} \]
Announcement Resolution of Uncertainty Effect

- **Under Assumptions 1–3 can identify** (via reduced form regression):

\[
\Delta \mu_t = \lambda_0 + \lambda_{ARU} 1(t \text{ is announcement}) + \epsilon_t
\]

“Announcement Resolution of Uncertainty Effect” = \( \lambda_{ARU} = \lambda_{\sigma^2 a_1 \theta_{1,1}} + \lambda_x \delta_1 \theta_{1,1} \)

- Causal effect of announcement-induced change in uncertainty about consumption growth on expected returns
- Accounts for all channels through which changes in uncertainty affect expected returns
- Not contaminated by effect of contemporaneous shifts in first moments.
4. Announcement timing does not systematically affect any driver of expected returns except macro uncertainty. That is \( \beta_{x,1} = 0 \)

\[
\Delta x_t = \beta_{x,0} + \beta_{x,1} 1(t \text{ is announcement}) + \epsilon_t,
\]

\( \beta_{x,1} = 0 \) implies \( \Delta x_t \) does not load on \( \Delta V_t[\Delta C_{Q(t)+1}] \): \( \delta_1 = 0 \)

Under additional assumption we can identify (via 2SLS)

\[
\Delta \sigma_t^2 = \beta_{\sigma^2,0} + \beta_{\sigma^2,1} 1(t \text{ is announcement}) + \epsilon_t
\]

\[
\Delta \mu_{rt} = \lambda_0 + \lambda \Delta \sigma_t^2 + \nu_t
\]

“Effect of Macroeconomic Uncertainty” = \( \frac{\lambda_{ARU}}{\beta_{\sigma^2,1}} = \frac{\lambda \alpha_1 \theta_{1,1} + \lambda x \delta_1 \theta_{1,1}}{\alpha_1 \theta_{1,1}} = \lambda \sigma^2 \)
4. Announcement timing does not systematically affect any driver of expected returns except macro uncertainty. That is $\beta_{x,1} = 0$

$$\Delta x_t = \beta_{x,0} + \beta_{x,1} 1(t \text{ is announcement}) + \epsilon_t,$$

- $\beta_{x,1} = 0$ implies $\Delta x_t$ does not load on $\Delta V_t[\Delta C_{Q(t)+1}]: \delta_1 = 0$

Under additional assumption we can identify (via 2SLS)

$$\Delta \sigma^2_t = \beta_{\sigma^2,0} + \beta_{\sigma^2,1} 1(t \text{ is announcement}) + \epsilon_t$$

$$\Delta \mu_{rt} = \lambda_0 + \lambda_{\sigma^2} \Delta \sigma^2_t + \nu_t$$

"Effect of Macroeconomic Uncertainty" = $\frac{\lambda_{ARU}}{\beta_{\sigma^2,1}} = \frac{\lambda_{\sigma^2} \alpha_1 \theta_{1,1} + \lambda x \delta_1 \theta_{1,1}}{\alpha_1 \theta_{1,1}} = \lambda_{\sigma^2}$
Empirical Strategy

Estimate $\lambda_{ARU}$ under Assumptions 1–3

- Take Assumptions 1 and 2 as given since they prove innocuous
- Empirically verify Assumption 3

Provide suggestive evidence of Assumption 4 and estimate $\lambda_{\sigma^2}$

- Verify other potential expected return drivers from theory don’t move on announcements.
  - Time-varying risk aversion: Risk aversion index from Bekaert, Engstrom & Xu (2020) structural estimation of external habit model
  - Disaster risk: Options-implied crash probabilities from Bollerslev & Todorov (2011) (risk-neutral) and Martin (2017) (log-utility)
  - Intermediary leverage: Intermediary leverage ratio squared from He, Kelly & Manela (2017)
Empirical Strategy

Estimate $\lambda_{ARU}$ under Assumptions 1–3

- Take Assumptions 1 and 2 as given since they prove innocuous
- Empirically verify Assumption 3

Provide suggestive evidence of Assumption 4 and estimate $\lambda_{\sigma^2}$

- Verify other potential expected return drivers from theory don’t move on announcements.
  - **Time-varying risk aversion**: Risk aversion index from Bekaert, Engstrom & Xu (2020) structural estimation of external habit model
  - **Disaster risk**: Options-implied crash probabilities from Bollerslev & Todorov (2011) (risk-neutral) and Martin (2017) (log-utility)
  - **Intermediary leverage**: Intermediary leverage ratio squared from He, Kelly & Manela (2017)
High-Frequency Measurement

Daily measure of macro uncertainty

- Project monthly uncertainty index from Jurado, Ludvigson & Ng (2015) (JLN) onto daily implied volatilities of set of options (Dew-Becker, Giglio & Kelly (2019))
  - JLN index measures the common component of unforecastable variation in 132 macro series.
  - 7 underlyings: S&P 500, Crude Oil, Gold, Wheat, 10-Year Treasury Note, Corn, Soybean
High-Frequency Measurement

$\lambda_{ARU}$: announce. vs. non-announce. avg. diff. in changes in expected returns

- Use long-run expected returns ($\mu_{rt}$):

$$p_t - d_t = \frac{k}{1 - \rho} + \sum_{j \geq 0} \rho^j E_t [\Delta d_{t+1+j}] - \sum_{j \geq 0} \rho^j E_t [r_{t+1+j}]$$

\[\equiv \mu_{dt}\]

\[\equiv \mu_{rt}\]

- Change in long-run expected returns:

$$\Delta \mu_{r,t} = -E_{t-1} [r_t] + \mu_{rt} - \rho E_{t-1} [\mu_{rt}]$$

- By law of iterated expectations:

$$E [\Delta \mu_{rt} | 1(t = A)] = -E [r_t | 1(t = A)] + (1 - \rho) E [\mu_{rt} | 1(t = A)]$$

$$\leftrightarrow \lambda_{ARU} = -(E [r_t | t = A] - E [r_t | t \neq A])$$

$$+ (1 - \rho) (E [\mu_{rt} | t = A] - E [\mu_{rt} | t \neq A])$$

- Second term appears $\approx 0$ since empirically:

$$(1 - \rho) (E [p_t - d_t | t = A] - E [p_t - d_t | t \neq A]) \approx 0$$

- Hence: $\lambda_{ARU} \approx -(E [r_t | t = A] - E [r_t | t \neq A])$
High-Frequency Measurement

$\lambda_{ARU}$: announce. vs. non-announce. avg. diff. in changes in expected returns

- Use long-run expected returns ($\mu_{rt}$):

\[
p_t - d_t = \frac{k}{1 - \rho} + \sum_{j \geq 0} \rho^j E_t [\Delta d_{t+1+j}] - \sum_{j \geq 0} \rho^j E_t [r_{t+1+j}]
\]

\[
\equiv \mu_{dt}
\]

\[
\equiv \mu_{rt}
\]

- Change in long-run expected returns:

\[
\Delta \mu_{r,t} = -E_{t-1} [r_t] + \mu_{rt} - \rho E_{t-1} [\mu_{rt}]
\]

- By law of iterated expectations:

\[
E [\Delta \mu_{rt} \mid 1(t = A)] = -E [r_t \mid 1(t = A)] + (1 - \rho)E [\mu_{rt} \mid 1(t = A)]
\]

\[
\leftrightarrow \lambda_{ARU} = -(E [r_t \mid t = A] - E [r_t \mid t \neq A])
\]

\[
+ (1 - \rho) (E [\mu_{rt} \mid t = A] - E [\mu_{rt} \mid t \neq A])
\]

- Second term appears $\approx 0$ since empirically regression

\[
(1 - \rho) (E [p_t - d_t \mid t = A] - E [p_t - d_t \mid t \neq A]) \approx 0
\]

- Hence: $\lambda_{ARU} \approx -(E [r_t \mid t = A] - E [r_t \mid t \neq A])$
High-Frequency Measurement

\( \lambda_{ARU} \): announce. vs. non-announce. avg. diff. in changes in expected returns

- Use long-run expected returns \( (\mu_{rt}) \):

\[
p_t - d_t = \frac{k}{1 - \rho} + \sum_{j \geq 0} \rho^j E_t [\Delta d_{t+1+j}] - \sum_{j \geq 0} \rho^j E_t [r_{t+1+j}]
\]

\( \equiv \mu_{dt} \)

\( \equiv \mu_{rt} \)

- Change in long-run expected returns:

\[
\Delta \mu_{r,t} = -E_{t-1} [r_t] + \mu_{rt} - \rho E_{t-1} [\mu_{rt}]
\]

- By law of iterated expectations:

\[
E [\Delta \mu_{rt} \mid 1(t = A)] = -E [r_t \mid 1(t = A)] + (1 - \rho)E [\mu_{rt} \mid 1(t = A)]
\]

\( \leftrightarrow \lambda_{ARU} = -(E [r_t \mid t = A] - E [r_t \mid t \neq A])
\]

\( + (1 - \rho) (E [\mu_{rt} \mid t = A] - E [\mu_{rt} \mid t \neq A]) \)

- Second term appears \( \approx 0 \) since empirically Regression

\[
(1 - \rho) (E [p_t - d_t \mid t = A] - E [p_t - d_t \mid t \neq A]) \approx 0
\]

- Hence: \( \lambda_{ARU} \approx - (E [r_t \mid t = A] - E [r_t \mid t \neq A]) \)
High-Frequency Measurement

$\lambda_{ARU}$: announce. vs. non-announce. avg. diff. in changes in expected returns

- Use long-run expected returns ($\mu_{rt}$):

$$p_t - d_t = \frac{k}{1 - \rho} + \sum_{j \geq 0} \rho^j E_t [\Delta d_{t+1+j}] - \sum_{j \geq 0} \rho^j E_t [r_{t+1+j}]$$

$$\equiv \mu_{dt} \quad \equiv \mu_{rt}$$

- Change in long-run expected returns:

$$\Delta \mu_{r,t} = -E_{t-1} [r_t] + \mu_{rt} - \rho E_{t-1} [\mu_{rt}]$$

- By law of iterated expectations:

$$\mathbb{E} [\Delta \mu_{rt} \mid 1(t = A)] = -\mathbb{E} [r_t \mid 1(t = A)] + (1 - \rho) \mathbb{E} [\mu_{rt} \mid 1(t = A)]$$

$$\leftrightarrow \lambda_{ARU} = - (\mathbb{E} [r_t \mid t = A] - \mathbb{E} [r_t \mid t \neq A]) + (1 - \rho) (\mathbb{E} [\mu_{rt} \mid t = A] - \mathbb{E} [\mu_{rt} \mid t \neq A])$$

- Second term appears $\approx 0$ since empirically

$$(1 - \rho) (\mathbb{E} [p_t - d_t \mid t = A] - \mathbb{E} [p_t - d_t \mid t \neq A]) \approx 0$$

- Hence: $\lambda_{ARU} \approx - (\mathbb{E} [r_t \mid t = A] - \mathbb{E} [r_t \mid t \neq A])$
<table>
<thead>
<tr>
<th>Macro Announcements</th>
<th>Macro Uncertainty</th>
<th>Asset Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ BEA:</td>
<td>○ Monthly JLN index</td>
<td>○ CRSP market value-weighted portfolio</td>
</tr>
<tr>
<td>- GDP</td>
<td>○ Option implied volatilities from CME:</td>
<td>○ Government bonds: CRSP Fixed Term Indexes</td>
</tr>
<tr>
<td>○ BLS:</td>
<td>- S&amp;P 500</td>
<td>○ Corporate bonds: AAA and BAA yields (FRED)</td>
</tr>
<tr>
<td>- CPI</td>
<td>- Crude Oil</td>
<td>○ Variance risk premium: NYSE TAQ data</td>
</tr>
<tr>
<td>- PPI</td>
<td>- Gold</td>
<td>○ TIPS: FRED</td>
</tr>
<tr>
<td>- Employment Cost Index</td>
<td>- Wheat</td>
<td>○ Exchange rates: Dollar exchange rates versus currency baskets (FRED)</td>
</tr>
<tr>
<td>- Unemployment</td>
<td>- 10-Year Treasury Note</td>
<td></td>
</tr>
<tr>
<td>○ Fed:</td>
<td>- Corn</td>
<td></td>
</tr>
<tr>
<td>- FOMC</td>
<td>- Soybean</td>
<td></td>
</tr>
</tbody>
</table>

Time Series: 1986 - 2016
Main Results: Macro Uncertainty Drives Expected Returns

\[ \Delta \sigma_t^2 = \beta_0 + \beta_1 1(t = \text{announcement}) + \epsilon_t \]

\[ -r_t = \lambda_0 + \lambda_1 \Delta \sigma_t^2 + \nu_t. \]

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>First Stage</th>
<th>Reduced Form</th>
<th>2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \sigma_t^2 )</td>
<td>0.2986***</td>
<td>-0.2158***</td>
<td>-0.0781**</td>
<td>0.3619***</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0269)</td>
<td>(0.0304)</td>
<td>(0.1380)</td>
</tr>
<tr>
<td>Announcement</td>
<td></td>
<td>-0.0368***</td>
<td>0.0473***</td>
<td>-0.0196</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0125)</td>
<td>(0.0131)</td>
<td>(0.0148)</td>
</tr>
<tr>
<td>const</td>
<td>-0.0368***</td>
<td>0.0473***</td>
<td>-0.0196</td>
<td>-0.0367***</td>
</tr>
<tr>
<td></td>
<td>(0.0125)</td>
<td>(0.0131)</td>
<td>(0.0148)</td>
<td>(0.0125)</td>
</tr>
<tr>
<td>N</td>
<td>7561</td>
<td>7561</td>
<td>7561</td>
<td>7561</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.07</td>
<td>0.01</td>
<td>0.00</td>
<td>-</td>
</tr>
</tbody>
</table>

Economic magnitudes

- Macro uncertainty increases by 1 \( \text{Std}[\Delta \sigma_t^2] \) → Expected returns increase by 36 bp
- Macro uncertainty increases by 1 \( \text{Std}[\sigma_t^2] \) → Expected returns increase by 173 bp
- **More aggressive:** Given Assumption 4 suggestive evidence, macro uncertainty explains 10% expected return variation.
- **Less aggressive:** Maybe still have OVB, macro uncertainty explains at most 32% expected return variation.
Conclusion

Macro uncertainty causes significant expected return movement

1. Macro uncertainty significantly falls on macro announcements.
2. ARU effect estimates illustrate that resolution of uncertainty causes significant decreases in expected returns.
3. Macro uncertainty causes 10% (or up to 32%) of variation in expected returns.

Implications

1. Asset pricing: Models of time-varying expected returns should account for macro uncertainty.
2. Macro: Uncertainty shocks can cause reductions in investment via increases in discount rates.
Literature

- Identification in asset pricing and macrofinance
  - Shleifer (1986); Harris & Gurel (1986); Du, Tepper & Verdelhan (2018); Nakamura & Steinsson (2018); Hartzmark & Sussman (2019); Koijen & Yogo (2019); Cieslak & Pang (2020); Gabaix & Koijen (2020)

- Effects of macro uncertainty
  - In macro:
    - Bloom (2009); Alexopoulos & Cohen (2009); Baker, Bloom & Terry (2020); Leduc & Liu (2016); Caldara, Fuentes-Albergo, Gilchrist & Zakrajsek (2016); Baker, Bloom & Davis (2016); Barrero, Bloom & Wright (2017)
  - In asset pricing:
    - Cross-sectional/unconditional: Bought & Kuehn (2013); Bali, Brown & Caglayan (2014); Bali & Zhou (2016); Kelly, Pastor & Veronesi (2016); Bali, Brown & Tang (2017); Della Corte & Krecetovs (2017); Xyngis (2017); Dew-Becker, Giglios & Kelly (2019); Heigermoser (2020)
    - Time series: Bekker, Hoerova & Lo Duca (2013); Segal, Shallastovich & Yaron (2014); Brogaard & Detzel (2015); Bekker, Engstrom & Wing (2008); Law, Song & Yaron (2019); Bekker, Engstrom & Xu (2020)
  - This paper: Achieve tight identification by moving to higher frequency.

- Drivers of time-varying expected returns
  - Campbell and Cochrane (1999); Bansal and Yaron (2004); Barro (2006); Wachter (2013); Bansal et al. (2014); Campbell et al. (2016); He & Krishnamurthy (2013)
  - This paper: Quantify effect of macro uncertainty.

- Asset pricing dynamics around macro announcements
  - Patterns in volatility:
  - Patterns in returns:
  - This paper: Demonstrate resolution of uncertainty on announcements causes decreases in expected returns.
Appendix: Generalization of Identification Model

- Can generalize this setup to include:
  - Multiple state variables
  - Higher moments
  - Multiple expected return drivers

- Can still identify:
  - Under Assumptions 1 and 2, the ARU effect.
  - Under Assumptions 1-3, the effect of macroeconomic uncertainty.

- Can use same model for expected cash flow growth and realized returns.
Appendix: Generalization of Identification Model

- Can relax the assumption that current quarter GDP growth is only relevant macro variable:

\[
\Delta \sigma_t^2 = \alpha_1' \Delta H_t + \alpha_2' \Delta E_t + \rho_v \epsilon_{f,t} + \sigma_v \epsilon_{v,t} \\
\Delta \bar{\mu}_t = \delta_1' \Delta H_t + \delta_2' \Delta E_t + \rho_x \epsilon_{f,t} + \sigma_r \epsilon_{r,t},
\]

where $V_{i,t}$ and $E_{i,t}$ are the conditional variance and mean of variable $i$.

- Under Assumptions 1 and 2, we can still identify the ARU effect:

\[
\lambda_{ARU} = \lambda_{\sigma^2} \alpha_1' \theta_{1,1} + \delta_1' \theta_{1,1}
\]

- Under Assumptions 1-3, we can still identify the effect of macroeconomic uncertainty:

\[
\lambda_{\sigma^2}
\]
Appendix: Only Macro Uncertainty Moves on Announcements

No other variable significantly loads on announcement indicator.

- Regression:
  \[ \Delta y_t = \gamma + \alpha 1(t = \text{announcement}) + \nu_t \]
  \[ y_t \in \left\{ (\text{Intermediary Leverage Ratio})^2, \text{Crash Probability}_t, RA_t, \text{Daily JLN} \right\} \]
  
  - All LHS variables scaled to mean zero and standard deviation one

<table>
<thead>
<tr>
<th>Source</th>
<th>Expected Return Driver</th>
<th>$\alpha$</th>
<th>F-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKM (2017)</td>
<td>Squared Intermediary Leverage</td>
<td>-0.0022</td>
<td>0.01</td>
</tr>
<tr>
<td>BT (2017)</td>
<td>Left Tail Vol</td>
<td>0.0554</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td>Down 10% Prob</td>
<td>0.0015</td>
<td>0.0022</td>
</tr>
<tr>
<td>Martin (2017)</td>
<td>1M Crash Prob</td>
<td>-0.0104</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>2M Crash Prob</td>
<td>-0.0244</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>3M Crash Prob</td>
<td>-0.0387</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>6M Crash Prob</td>
<td>-0.0360</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>12M Crash Prob</td>
<td>-0.0422</td>
<td>1.45</td>
</tr>
<tr>
<td>BEX (2020)</td>
<td>Risk Aversion</td>
<td>0.0012</td>
<td>0.0024</td>
</tr>
<tr>
<td>This Paper</td>
<td>Daily JLN</td>
<td>-0.2158</td>
<td>64.26</td>
</tr>
</tbody>
</table>

- Negative results provide suggestive evidence in support of Assumption 3
Appendix: Original JLN Index Construction

1. Specify dynamics of high-dimensional macroeconomic time series as following a factor-augmented VAR
   
   1.1 Conditioning variables specified by econometrician
   1.2 Latent factors following VAR(1)

2. Both shocks to the state vector and to predictors have time-varying variance
   
   2.1 Log conditional variances follow AR(1) processes.
   2.2 **Shocks to log conditional variance are independent of shocks to state vector or predictors**
      
      2.2.1 Distinct from e.g. VAR model with error term modeled as GARCH process

3. Four components of $h$-period ahead uncertainty:
   
   3.1 Autoregressive component of variance
   3.2 Predictor uncertainty term (from both latent factors and explicit predictors)
   3.3 Term due to stochastic volatility in state vector
   3.4 Covariance term

4. Macroeconomic uncertainty = average uncertainty across all series
Appendix: Measuring Daily Macro Uncertainty

- JLN index measures the common component of unforecastable variation in 132 macroeconomic series.
  - Analogous to time-varying volatility of common shock to consumption and dividend growth in Bansal & Yaron (2004).

- Daily implied volatilities for options on 7 underlyings from CME
  - S&P 500, Crude Oil, Gold, Wheat, 10-Year Treasury Note, Corn, Soybean

- Regress monthly JLN index onto average monthly implied volatility of each option:

\[
JLN_t = \alpha + \sum_{i=1}^{N} \beta_i IV_{it} + \epsilon_t.
\]

- Apply estimated coefficients to daily implied volatilities to obtain daily measure
Appendix: Daily Series of Macroeconomic Uncertainty

Regression Results
Appendix: Price-Dividend Level Regressions

<table>
<thead>
<tr>
<th></th>
<th>( p_t - d_t ) (Quarterly Smooth 240)</th>
<th>( p_t - d_t ) (Daily Smooth 240)</th>
<th>( p_t - d_t ) (Daily Smooth 120)</th>
<th>( p_t - d_t ) (Daily Smooth 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>const</strong></td>
<td>7.726e-05*** (8.051e-08)</td>
<td>7.823e-05*** (8.033e-08)</td>
<td>9.185e-05*** (8.072e-08)</td>
<td>1.056e-04*** (8.195e-08)</td>
</tr>
<tr>
<td><strong>Announcement</strong></td>
<td>2.360e-08 (1.718e-07)</td>
<td>3.099e-08 (1.708e-07)</td>
<td>2.945e-09 (1.716e-07)</td>
<td>1.699e-08 (1.738e-07)</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>7561</td>
<td>7561</td>
<td>7561</td>
<td>7561</td>
</tr>
<tr>
<td><strong>( R^2 )</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Regression of the end-of-day daily price-dividend ratio multiplied by \((1 - \rho)\) (daily \( \rho = 0.99998 \) from Pettenuzzo, Sabbatucci & Timmermann (2019) and alternative smoothing horizons (in days) to calculate the level of dividends) on announcement timing:

\[
(1 - \rho)(p_t - d_t) = b_0 + b_11(t = \text{announcement}) + \epsilon_t.
\]

The time period is 1986-11-20:2016-12-22.
Appendix: Stylized Example of Announcement Day Risk Premium

○ Assume day $t$ is the only announcement with ex-ante known risk premium of $p$:

$$E_t [r_{t+1}] = r + p.$$  

○ All other days have constant conditional expected returns at times $t$ and $t + 1$:

$$E_t [r_{t+1+j}] = E_{t+1} [r_{t+1+j}] = r, j \geq 1$$

$$\Delta \mu_{rt+1} = \sum_{j \geq 0} \rho^j E_{t+1} [r_{t+2+j}] - \sum_{j \geq 0} \rho^j E_t [r_{t+1+j}]$$  

$$= \sum_{j \geq 0} \rho^j r - \sum_{j \geq 1} \rho^j r - (r + p)$$  

$$= -p$$

○ So $\Delta \mu_{rt+1}$ captures decrease in long-run expected returns from day $t$ to $t + 1$. 

- $E_t [r_{t+j}]$
- $E_{t+1} [r_{t+j}]$

```
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$t$</td>
<td>$t+1$</td>
<td>$t+2$</td>
<td>$t+3$</td>
<td>…</td>
</tr>
<tr>
<td>$r+p$</td>
<td>$r$</td>
<td>$r$</td>
<td>$r$</td>
<td>…</td>
</tr>
<tr>
<td>$E_t [r_{t+j}]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$t$</td>
<td>$t+1$</td>
<td>$t+2$</td>
<td>$t+3$</td>
<td>…</td>
</tr>
<tr>
<td>$r$</td>
<td>$r$</td>
<td>$r$</td>
<td>$r$</td>
<td>…</td>
</tr>
<tr>
<td>$E_{t+1} [r_{t+j}]$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
Appendix: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>( r_t )</th>
<th>( \Delta \sigma_t^2 )</th>
<th>( 1(t = \text{announcement}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>7561</td>
<td>7561</td>
<td>7561</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0369</td>
<td>-2.9953e-06</td>
<td>.22100</td>
</tr>
<tr>
<td>Std</td>
<td>1.1230</td>
<td>7.8697e-03</td>
<td>.41495</td>
</tr>
<tr>
<td>Min</td>
<td>-18.7956</td>
<td>-8.0745e-02</td>
<td>0</td>
</tr>
<tr>
<td>Median</td>
<td>0.0813</td>
<td>-1.1239e-04</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>10.8749</td>
<td>9.8578e-02</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix: Monthly JLN Regression Results

Regression:

\[ JLN_t = \alpha + \sum_{i=1}^{N} \beta_i IV_{it} + \epsilon_t \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Monthly JLN</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>0.7654***</td>
</tr>
<tr>
<td></td>
<td>(0.0074)</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>0.1126***</td>
</tr>
<tr>
<td></td>
<td>(0.0319)</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>0.1057***</td>
</tr>
<tr>
<td></td>
<td>(0.0177)</td>
</tr>
<tr>
<td>Gold</td>
<td>0.2512***</td>
</tr>
<tr>
<td></td>
<td>(0.0361)</td>
</tr>
<tr>
<td>Wheat</td>
<td>-0.0249</td>
</tr>
<tr>
<td></td>
<td>(0.0403)</td>
</tr>
<tr>
<td>10-year Note</td>
<td>0.2829**</td>
</tr>
<tr>
<td></td>
<td>(0.1240)</td>
</tr>
<tr>
<td>Corn</td>
<td>-0.0919*</td>
</tr>
<tr>
<td></td>
<td>(0.0520)</td>
</tr>
<tr>
<td>Soybean</td>
<td>0.2235***</td>
</tr>
<tr>
<td></td>
<td>(0.0400)</td>
</tr>
<tr>
<td>N</td>
<td>362</td>
</tr>
<tr>
<td>R2</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Appendix: Macro Uncertainty Falls on Announcements
Macro uncertainty decreases 0.21 standard deviations on announcements

- First-Stage Regression:
  \[ \Delta \sigma_t^2 = \gamma + \sum_{j=-5}^{5} \alpha_j 1(t - j = \text{announcement}) + \epsilon_t. \]

  - Standardize \( \Delta \sigma_t^2 \) to have mean 0 and standard deviation 1
  - -0.21 standard deviation decrease in macro uncertainty on announcement days
Appendix: ARU Causes Expected Returns to Fall

\[ y_t = \lambda_0 + \lambda_{ARU} 1(t \text{ is announcement}) + \epsilon_t \]

\[ y_t = r_t, \Delta \mu dt, \text{ or } \Delta \mu_{rt} \]

\[
\begin{array}{l|c}
- r_t \\
\hline
\text{Announcement} & -0.0781^{**} \\
& (0.0304) \\
\text{const} & -0.0196 \\
& (0.0148) \\
N & 7561 \\
R^2 & 0.00 \\
\end{array}
\]

- ARU causes \( \lambda_{ARU} = 7.8 \) basis points decline in expected returns.
Regression:

\[ \Delta \text{Daily } JLN_t = \gamma + \sum_{j=-5}^{5} \alpha_j 1(t - j = \text{announcement}) + \epsilon_t \]

<table>
<thead>
<tr>
<th>( \Delta \sigma_t^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-5</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-3</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

N 7608  
\( R^2 \) 0.01
Figure: Coefficients and 95% confidence intervals for $\beta_{h,1}$ from the regression:

$$\Delta \text{Daily JLN}_{h,t} = \beta_{h,0} + \beta_{h,1}1(t = \text{announcement}) + \epsilon_t.$$
## Appendix: Correlations Among Expected Return Drivers

<table>
<thead>
<tr>
<th></th>
<th>ILR²</th>
<th>LTV</th>
<th>−10% Prob</th>
<th>1MO CP</th>
<th>2MO CP</th>
<th>3MO CP</th>
<th>6MO CP</th>
<th>12MO CP</th>
<th>RA</th>
<th>$\sigma_t^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILR²</td>
<td>1.000</td>
<td>0.115</td>
<td>0.083</td>
<td>0.053</td>
<td>0.032</td>
<td>0.059</td>
<td>0.070</td>
<td>0.025</td>
<td>0.341</td>
<td>0.152</td>
</tr>
<tr>
<td>LTV</td>
<td>0.115</td>
<td>1.000</td>
<td>0.148</td>
<td>0.055</td>
<td>0.085</td>
<td>0.104</td>
<td>0.065</td>
<td>0.028</td>
<td>0.183</td>
<td>0.117</td>
</tr>
<tr>
<td>−10% Prob</td>
<td>0.083</td>
<td>0.148</td>
<td>1.000</td>
<td>0.024</td>
<td>0.042</td>
<td>0.045</td>
<td>0.016</td>
<td>0.005</td>
<td>0.038</td>
<td>0.068</td>
</tr>
<tr>
<td>1MO CP</td>
<td>0.053</td>
<td>0.055</td>
<td>0.024</td>
<td>1.000</td>
<td>0.321</td>
<td>0.054</td>
<td>0.186</td>
<td>0.044</td>
<td>-0.120</td>
<td>0.059</td>
</tr>
<tr>
<td>2MO CP</td>
<td>0.032</td>
<td>0.085</td>
<td>0.042</td>
<td>0.321</td>
<td>1.000</td>
<td>0.531</td>
<td>0.204</td>
<td>0.109</td>
<td>0.110</td>
<td>0.042</td>
</tr>
<tr>
<td>3MO CP</td>
<td>0.059</td>
<td>0.104</td>
<td>0.045</td>
<td>0.054</td>
<td>0.531</td>
<td>1.000</td>
<td>0.259</td>
<td>0.135</td>
<td>0.108</td>
<td>0.051</td>
</tr>
<tr>
<td>6MO CP</td>
<td>0.070</td>
<td>0.065</td>
<td>0.016</td>
<td>0.186</td>
<td>0.204</td>
<td>0.259</td>
<td>1.000</td>
<td>0.146</td>
<td>0.067</td>
<td>0.090</td>
</tr>
<tr>
<td>12MO CP</td>
<td>0.025</td>
<td>0.028</td>
<td>0.005</td>
<td>0.044</td>
<td>0.109</td>
<td>0.135</td>
<td>0.146</td>
<td>1.000</td>
<td>0.038</td>
<td>0.006</td>
</tr>
<tr>
<td>RA</td>
<td>0.341</td>
<td>0.183</td>
<td>0.038</td>
<td>-0.120</td>
<td>0.110</td>
<td>0.108</td>
<td>0.067</td>
<td>0.038</td>
<td>1.000</td>
<td>0.131</td>
</tr>
<tr>
<td>$\sigma_t^2$</td>
<td>0.152</td>
<td>0.117</td>
<td>0.068</td>
<td>0.059</td>
<td>0.042</td>
<td>0.051</td>
<td>0.090</td>
<td>0.006</td>
<td>0.131</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Robustness Checks

Alternative expected return measures

- Options-implied lower bounds from Martin (2017) and Gao & Martin (2019)

Expected cash flow measures

- Subjective expected log divided growth lower bound from Gao & Martin (2019)
- Options-implied dividend strip prices as in van Binsbergen, Brandt & Koijen (2012)

Alternative macroeconomic uncertainty measures

- Alternative JLN index horizons (1 and 3 months)
- Rolling out-of-sample daily index construction
- S&P 500 implied volatility

Heterogeneity across announcements
Uncertainty Explains Significant Price Variation in Other Asset Classes

\[
\Delta \text{Daily JLN}_t = \beta_0 + \beta_1 1(t = \text{announcement}) + \epsilon_t
\]

\[
\Delta P_t = \lambda_0 + \lambda_1 \Delta \text{Daily JLN}_t + \nu_t
\]
Appendix: 2SLS Results - Other Assets

- 2SLS Regression:

\[
\Delta \text{Daily JLN}_t = \beta_0 + \beta_1 \Delta(t = \text{announcement}) + \epsilon_t
\]

\[
\Delta P_t = \lambda_0 + \lambda_1 \Delta \text{Daily JLN}_t + \epsilon_t,
\]

<table>
<thead>
<tr>
<th>Asset Type</th>
<th>ARU 1 STD Effect</th>
<th>1 Level STD Effect</th>
<th>% Variance Explained</th>
<th>Upper Bound % Variance Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIPS Spread (5YR)</td>
<td>-0.0012</td>
<td>0.0055</td>
<td>0.1343</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>(0.0021)</td>
<td>(0.0099)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIPS Spread (10YR)</td>
<td>-0.0014</td>
<td>0.0067</td>
<td>0.1653</td>
<td>3.56</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.0075)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1YR Treas</td>
<td>-0.0016</td>
<td>0.0078</td>
<td>0.0626</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>(0.0017)</td>
<td>(0.0082)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2YR Treas</td>
<td>-0.0042***</td>
<td>0.0198***</td>
<td>0.1594</td>
<td>11.01</td>
</tr>
<tr>
<td></td>
<td>(0.0019)</td>
<td>(0.0091)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5YR Treas</td>
<td>-0.0061***</td>
<td>0.0288***</td>
<td>0.2323</td>
<td>21.14</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7YR Treas</td>
<td>-0.0063***</td>
<td>0.0299***</td>
<td>0.2411</td>
<td>21.75</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.0101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10YR Treas</td>
<td>-0.0063***</td>
<td>0.03***</td>
<td>0.2416</td>
<td>24.03</td>
</tr>
<tr>
<td></td>
<td>(0.0019)</td>
<td>(0.0097)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20YR Treas</td>
<td>-0.0059***</td>
<td>0.0279***</td>
<td>0.2246</td>
<td>24.74</td>
</tr>
<tr>
<td></td>
<td>(0.0017)</td>
<td>(0.0088)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30YR Treas</td>
<td>-0.0059***</td>
<td>0.0279***</td>
<td>0.2244</td>
<td>25.61</td>
</tr>
<tr>
<td></td>
<td>(0.0017)</td>
<td>(0.0087)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treas Slope</td>
<td>-0.0022*</td>
<td>0.0102*</td>
<td>0.0822</td>
<td>5.77</td>
</tr>
<tr>
<td></td>
<td>(0.0012)</td>
<td>(0.0059)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treas Curvature</td>
<td>-0.0008</td>
<td>0.0039</td>
<td>0.0318</td>
<td>3.85</td>
</tr>
<tr>
<td></td>
<td>(0.0006)</td>
<td>(0.0028)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AAA Corp Bond</td>
<td>-0.0046***</td>
<td>0.0238***</td>
<td>0.9251</td>
<td>23.77</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.0083)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAA Corp Bond</td>
<td>-0.0044***</td>
<td>0.023***</td>
<td>0.8941</td>
<td>22.97</td>
</tr>
<tr>
<td></td>
<td>(0.0014)</td>
<td>(0.0081)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credit Spread</td>
<td>0.0002</td>
<td>-0.0008</td>
<td>-0.031</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>(0.0007)</td>
<td>(0.0034)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRP (1)</td>
<td>-5.2685***</td>
<td>25.7762***</td>
<td>190.732</td>
<td>17.24</td>
</tr>
<tr>
<td></td>
<td>(1.9759)</td>
<td>(10.861)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRP (22)</td>
<td>-1.3785***</td>
<td>6.7954***</td>
<td>50.419</td>
<td>45.01</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(1.7145)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USD (Broad)</td>
<td>-0.0001</td>
<td>0.0003</td>
<td>0.0015</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USD (Major Currencies)</td>
<td>-0.0</td>
<td>0.0002</td>
<td>0.0007</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0006)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
\[ \Delta \text{Daily JLN}_t = \beta_0 + \beta_1 1(t = \text{announcement}) + \epsilon_t \]

\[ \Delta \text{ER}_t = \lambda_0 + \lambda_1 \Delta \text{Daily JLN}_t + \nu_t \]

<table>
<thead>
<tr>
<th>ARU</th>
<th>1 STD Effect</th>
<th>1 Level STD Effect</th>
<th>% Variance Explained</th>
<th>Upper Bound</th>
<th>% Variance Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP Lower Bound - 1</td>
<td>-0.0188*** (0.0045)</td>
<td>0.0884*** (0.0228)</td>
<td>0.4083</td>
<td>42.36</td>
<td>95.87</td>
</tr>
<tr>
<td>EP Lower Bound - 2</td>
<td>-0.0162** (0.0071)</td>
<td>0.0764** (0.0332)</td>
<td>0.3528</td>
<td>12.42</td>
<td>42.57</td>
</tr>
<tr>
<td>EP Lower Bound - 3</td>
<td>-0.0138* (0.0082)</td>
<td>0.065* (0.038)</td>
<td>0.3</td>
<td>6.91</td>
<td>31.81</td>
</tr>
<tr>
<td>EP Lower Bound - 6</td>
<td>-0.0192** (0.0087)</td>
<td>0.0906** (0.0402)</td>
<td>0.4184</td>
<td>10.56</td>
<td>36.96</td>
</tr>
<tr>
<td>EP Lower Bound - 12</td>
<td>-0.0504*** (0.0139)</td>
<td>0.2374*** (0.0681)</td>
<td>1.096</td>
<td>29.71</td>
<td>72.49</td>
</tr>
<tr>
<td>LVIX - 1</td>
<td>-0.0327*** (0.0052)</td>
<td>0.154*** (0.0314)</td>
<td>0.7111</td>
<td>80.15</td>
<td>156.95</td>
</tr>
<tr>
<td>LVIX - 2</td>
<td>-0.0086** (0.0038)</td>
<td>0.0405** (0.018)</td>
<td>0.1871</td>
<td>11.39</td>
<td>39.8</td>
</tr>
<tr>
<td>LVIX - 3</td>
<td>-0.0084** (0.0043)</td>
<td>0.0396** (0.0198)</td>
<td>0.183</td>
<td>9.19</td>
<td>35.95</td>
</tr>
<tr>
<td>LVIX - 6</td>
<td>-0.0091* (0.0047)</td>
<td>0.0429** (0.0216)</td>
<td>0.1982</td>
<td>8.48</td>
<td>33.39</td>
</tr>
<tr>
<td>LVIX - 12</td>
<td>-0.0245*** (0.0071)</td>
<td>0.1152*** (0.0345)</td>
<td>0.5319</td>
<td>27.02</td>
<td>67.98</td>
</tr>
</tbody>
</table>
Appendix: 2SLS Results for Expected Cash Flow Growth Series

- Regression:

\[ \Delta \text{Expected Cash Flow Growth}_{t} = \beta_0 + \beta_1 1(t = \text{announcement}) + \epsilon_t \]

<table>
<thead>
<tr>
<th>Reduced Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_{dt}^{PST}$</td>
</tr>
<tr>
<td>$\mu_{dt}^{GM} - 12M (y)$</td>
</tr>
<tr>
<td>$\mu_{dt}^{GM} - 12M (dp)$</td>
</tr>
<tr>
<td>$\mu_{dt}^{GM} - 12M (y, \text{Version 2})$</td>
</tr>
<tr>
<td>$\mu_{dt}^{GM} - 12M (dp, \text{Version 2})$</td>
</tr>
<tr>
<td>Div Strip - 12M</td>
</tr>
<tr>
<td>Div Strip - 24M</td>
</tr>
</tbody>
</table>
Appendix: Gao & Martin (2020) $E_t[g_{t+1}]$ Lower Bound

\[
E_t[r_{t+1} - r_{f,t+1}] \geq LVIX_t
\]

\[
\iff E_t[g_{t+1}] \geq r_{f,t+1} + LVIX_t - E_t[r_{t+1} - g_{t+1}]
\]

\[
= r_{f,t+1} + LVIX_t - (a^h_0 + a^h_1 h_t) \equiv \mu_{dt}^{GM}
\]

\[
h_t = \log(D_t/P_t) \text{ or } \log(1 + D_t/P_t)
\]

**Figure:** Expected dividend growth from PST (2019) and expected log dividend growth lower bounds from GM (2020). Y-axis units are in absolute terms (i.e. 0.10 is an annual expected growth rate of 10%).
Appendix: Put-Call Parity Implied Dividend Strip Prices

Left: Daily time series of prices for 6, 12, and 24-month dividend strips on the S&P 500, extracted from S&P 500 index options and put-call parity:

\[ P_{t,T} = p_{t,T} - c_{t,T} + S_t - X e^{-r_{t,T}(T-T)}. \]

Right: Fitted expected dividend growth using equity yield \( e_t^{(h)} = \frac{1}{h} \ln \left( \frac{D_t}{P_t^{(h)}} \right) \):

\[ \Delta(h) D_t = \beta_0^{(h)} + \beta_1^{(h)} e_t^{(h)} + \epsilon_t^{(h)}. \]
Appendix: 2SLS Results - Dividend Forecasting Regressions

- Regression:

\[ \Delta(h)D_t = \beta_0^{(h)} + \beta_1^{(h)} e_t^{(h)} + \epsilon_t^{(h)} \]

<table>
<thead>
<tr>
<th></th>
<th>12 Months</th>
<th>24 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>( e_t^{(1.0)} )</td>
<td>-0.4858***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.1423)</td>
<td></td>
</tr>
<tr>
<td>( e_t^{(2.0)} )</td>
<td></td>
<td>-1.0021***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1976)</td>
</tr>
<tr>
<td>const</td>
<td>0.0722***</td>
<td>0.1658***</td>
</tr>
<tr>
<td></td>
<td>(0.0156)</td>
<td>(0.0343)</td>
</tr>
<tr>
<td>N</td>
<td>83</td>
<td>79</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.36</td>
<td>0.38</td>
</tr>
<tr>
<td>Date Range</td>
<td>1996 - 2016</td>
<td>1996 - 2015</td>
</tr>
</tbody>
</table>
Appendix: Return Betas on Expected Dividend Growth

- Regression:

\[ r_t = \beta_0^{(h)} + \beta_1^{(h)} \Delta g_t^{(h)} + \epsilon_t^{(h)}. \]

<table>
<thead>
<tr>
<th>Returns</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta g_t^{(1)} )</td>
<td>0.1008***</td>
</tr>
<tr>
<td>(0.0117)</td>
<td></td>
</tr>
<tr>
<td>( \Delta g_t^{(2)} )</td>
<td>0.0939***</td>
</tr>
<tr>
<td>(0.0132)</td>
<td></td>
</tr>
<tr>
<td>const</td>
<td>0.0195</td>
</tr>
<tr>
<td>(0.0166)</td>
<td>0.0194</td>
</tr>
<tr>
<td>(0.0170)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>5155</td>
</tr>
<tr>
<td>4943</td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.03</td>
</tr>
<tr>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>
Appendix: 2SLS Results for Alternative Macroeconomic Uncertainty Series

- Regression:

\[ \Delta \text{ Macro Uncertainty}_t = \beta_0 + \beta_1 \cdot 1(t = \text{announcement}) + \epsilon_t \]
\[ -r_t = \lambda_0 + \lambda_1 \Delta \text{ Macro Uncertainty} + \nu_t. \]

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>First Stage</th>
<th>Reduced Form</th>
<th>2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma^2_{12,t} )</td>
<td>0.2986***</td>
<td>-0.2158***</td>
<td>-0.0781**</td>
<td>0.3619***</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0269)</td>
<td>(0.0304)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>( \sigma^2_{1,t} )</td>
<td>0.2708***</td>
<td>-0.191***</td>
<td>-0.0781**</td>
<td>0.4088***</td>
</tr>
<tr>
<td></td>
<td>(0.0304)</td>
<td>(0.0272)</td>
<td>(0.0304)</td>
<td>(0.1582)</td>
</tr>
<tr>
<td>( \sigma^2_{3,t} )</td>
<td>0.2891***</td>
<td>-0.197***</td>
<td>-0.0781**</td>
<td>0.3964***</td>
</tr>
<tr>
<td></td>
<td>(0.0315)</td>
<td>(0.0272)</td>
<td>(0.0304)</td>
<td>(0.1523)</td>
</tr>
<tr>
<td>( \sigma^2_{SP500,t} )</td>
<td>0.4008***</td>
<td>-0.1918***</td>
<td>-0.0781**</td>
<td>0.4071***</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.0285)</td>
<td>(0.0304)</td>
<td>(0.1522)</td>
</tr>
<tr>
<td>( \sigma^2_{OOS,t} )</td>
<td>0.195***</td>
<td>-0.098***</td>
<td>-0.0908***</td>
<td>0.9266**</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.0296)</td>
<td>(0.0339)</td>
<td>(0.4264)</td>
</tr>
</tbody>
</table>
### Appendix: Heterogeneity Across Announcement Types

<table>
<thead>
<tr>
<th>Announcement Type</th>
<th>OLS</th>
<th>First Stage</th>
<th>Reduced Form</th>
<th>2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Announcements (GDP and Unemployment)</td>
<td>0.2986***</td>
<td>-0.1471***</td>
<td>-0.0660</td>
<td>0.4486</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0356)</td>
<td>(0.0412)</td>
<td>(0.0326)</td>
</tr>
<tr>
<td>Price Announcements (CPI, PPI, and ECI)</td>
<td>0.2986***</td>
<td>-0.2281***</td>
<td>-0.0434</td>
<td>0.1902</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0383)</td>
<td>(0.0423)</td>
<td>(0.1815)</td>
</tr>
<tr>
<td>Monetary Policy Announcements (FOMC)</td>
<td>0.2986***</td>
<td>-0.1512***</td>
<td>-0.2269***</td>
<td>1.5006**</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0580)</td>
<td>(0.0703)</td>
<td>(0.6724)</td>
</tr>
<tr>
<td>All but Monetary Policy Announcements (GDP, Unemployment, CPI, PPI, ECI)</td>
<td>0.2986***</td>
<td>-0.2186***</td>
<td>-0.0635**</td>
<td>0.2906**</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0283)</td>
<td>(0.0319)</td>
<td>(0.1424)</td>
</tr>
</tbody>
</table>