Dissecting Climate Risks: Are they Reflected in Stock Prices?

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Market-wide risks from climate change are multifaceted: Physical & Transition risks

- Does stock prices reflect these risks? The answer is not obvious (-) Survey studies (Krüger et al., 2020)
- Decarbonizing portfolios (Bessembinder, 2017)
- Does decarbonisation pay off? (Pedersen et al. 2020)
- Investors may be sensitive to short-term effects

Camp #1:
Physical risks are not priced
Need for government's intervention

Camp #2:
Physical risks are not priced & Government's intervention is priced, yet no need for intervention.

Faccini, Matin & Skiadopoulos
Dissecting Climate Risks
Motivation

- Market-wide risks from climate change are multifaceted: Physical & Transition risks

- **Do stock prices reflect these risks? The answer is not obvious**
  - (-) Survey studies (Krüger et al., 2020)
  - (-) Decarbonizing portfolios \(\Rightarrow\) ↑ transaction costs (Bessembinder, 2017)
  - (?) Does decarbonisation pay off? (Pedersen et al. 2020)
  - (+) Investors may be sensitive to short-term effects
Market-wide risks from climate change are multifaceted: Physical & Transition risks

Do stock prices reflect these risks? The answer is not obvious

- Survey studies (Krüger et al., 2020)
- Decarbonizing portfolios ⇒ ↑ transaction costs (Bessembinder, 2017)
- Does decarbonisation pay off? (Pedersen et al. 2020)
- Investors may be sensitive to short-term effects

Is it physical or transition risks which are priced?

Camp #1: Physical risks are not priced ⇒ Need for government’s intervention

Camp#2: Physical risks are not priced & Government’s intervention is priced, yet no need for intervention.
First time evidence on what types of market-wide climate risks are reflected in U.S. stock prices
1. **First time evidence** on what types of market-wide climate risks are reflected in U.S. stock prices

2. We dissect market-wide climate risks by textual analysis
   - **Novel measures** of market-wide physical & transition climate risks
This paper: Contributions

1. **First time evidence** on what types of **market-wide** climate risks are reflected in U.S. stock prices

2. We dissect market-wide climate risks by textual analysis
   - **Novel measures** of market-wide physical & transition climate risks

3. **Provide and validate** a possible explanation for the results
This paper: Contributions

1. **First time evidence** on what types of **market-wide** climate risks are reflected in U.S. stock prices

2. We dissect market-wide climate risks by textual analysis
   - **Novel measures** of market-wide physical & transition climate risks

3. **Provide and validate** a possible explanation for the results

4. **Document** which firms are the most exposed to these risks.
Dataset

  - More than 13 million articles from Refinitiv News Archive
  - Screening & looking for "climate change" or "global warming" → ≈34,000 articles
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  - More than 13 million articles from Refinitiv News Archive
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- U.S. common stocks returns & characteristics (daily data, CRSP, Compustat)

- Equity risk factors from authors’ websites

- ’E’ score from Refinitiv.
Decomposes the entire textual corpus into $K$ topics ($k = 1, \ldots, K$)

- **Topic** $k$: A probability distribution over unique words

Estimates **topic shares**: Percentage of a given article associated with the respective topic

- **Article**: A probability distribution over topics
- Intensity by which a topic appears in that article

**$k$-risk factor value at time $t$**: *Intensity of news coverage of a given topic on that day*

**We identify four topics**: Natural disasters, Global warming, International summits, U.S. climate policy.
- Increases in the factor → Bad news for the economy

- Risks which will materialize in the long-term.
- Increases in the factor → Bad news for the economy
- Risks which will materialize in the long-term.
Increases in the factor $\rightarrow$ Bad news for the economy

Risks which will materialize in the long-term.
- Increases → ?

  - Bad or good news for the economy depending on which Party conquers the Congress

  - Risks will materialize in the short-term.
Asset pricing tests

- For each stock $i$, at each time $t$, we estimate the climate beta with respect to each textual factor $F_t$ separately

$$ r_{it} - r_{ft} = c_i + \beta_i F_t + \gamma_i' X_t + \epsilon_{it} $$

1. We sort stocks in (decile/quintile) portfolios based on $\beta_i$
2. Calculate monthly post-ranking portfolio returns (value-weighted)
3. Compute spread portfolio returns
4. Rolling window estimation: Repeat Steps (1 - 3) until we exhaust the sample
5. Estimate alpha of spread portfolio

Alternative models for estimating climate beta & alpha.
Asset pricing tests

- For each stock $i$, at each time $t$, we estimate the climate beta with respect to each textual factor $F_t$ separately

\[
\begin{align*}
    r_{it} - r_{ft} &= c_i + \beta_i F_t + \gamma_i' X_t + \varepsilon_{it}
\end{align*}
\]  

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- Alternative models for estimating climate beta & alpha.
### Alphas (Decile portfolios), 1st January 2000 - 31st December 2018

<table>
<thead>
<tr>
<th>Natural Disasters</th>
<th>Global Warming</th>
<th>Int. Summits</th>
<th>U.S. Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Market model</strong></td>
<td></td>
<td></td>
<td>0.96***</td>
</tr>
<tr>
<td>0.14</td>
<td>-0.0</td>
<td>0.12</td>
<td>(2.91)</td>
</tr>
<tr>
<td>(0.3)</td>
<td>(-0.2)</td>
<td>(0.42)</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: FF 3F model</strong></td>
<td></td>
<td></td>
<td>0.65**</td>
</tr>
<tr>
<td>0.07</td>
<td>0.20</td>
<td>0.53*</td>
<td>(2.34)</td>
</tr>
<tr>
<td>(0.24)</td>
<td>(0.67)</td>
<td>(1.73)</td>
<td></td>
</tr>
<tr>
<td><strong>Panel C: FFC model</strong></td>
<td></td>
<td></td>
<td>0.46*</td>
</tr>
<tr>
<td>-0.07</td>
<td>0.03</td>
<td>-0.49</td>
<td>(1.66)</td>
</tr>
<tr>
<td>(-0.24)</td>
<td>(0.10)</td>
<td>(1.65)</td>
<td></td>
</tr>
<tr>
<td><strong>Panel D: FF 5F model</strong></td>
<td></td>
<td></td>
<td>0.2***</td>
</tr>
<tr>
<td>0.03</td>
<td>0.05</td>
<td>-0.66**</td>
<td>(2.75)</td>
</tr>
<tr>
<td>(0.0)</td>
<td>(0.19)</td>
<td>(-2.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Panel E: FF 5F + momentum</strong></td>
<td></td>
<td></td>
<td>0.61**</td>
</tr>
<tr>
<td>0.27</td>
<td>-0.09</td>
<td>-0.76***</td>
<td>(2.25)</td>
</tr>
<tr>
<td>(0.9)</td>
<td>(-0.34)</td>
<td>(-2.63)</td>
<td></td>
</tr>
</tbody>
</table>
**Possible explanation**: Intertemporal hedging
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**Conjecture:** \( \downarrow \) U.S. climate policy signals \( \uparrow \) transition risks

- \( \rightarrow \) "bad" news for the economy
- \( \rightarrow \) deteriorates the investor’s opportunity set

**Investors would buy (short sell) stocks with negative (positive) textual climate betas**
Possible explanation: **Intertemporal hedging**

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**Strategies to check proposed explanation:** Check the risk-premium’s sign by ensuring that the conjecture holds
Possible explanation: **Intertemporal hedging**

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- → "bad" news for the economy
- → deteriorates the investor’s opportunity set

*Investors would buy (short sell) stocks with negative (positive) textual climate betas*

**Strategies to check proposed explanation:** Check the risk-premium’s sign by ensuring that the conjecture holds

1. *Choose* an appropriate sample period (Sub-sample analysis)
2. *Re-construct* the policy factor by marking the content of news (narrative analysis, Romer & Romer, 2010)
   - ⇒ Know what the factor fluctuations signal.
Subsample analysis

- Post Nov 2012:
  - Lack of a majority for Democrats in the U.S. House of Representatives
  - After 2014, the Democrats also lost control of the Senate
  - Trump took over in Nov. 2016

\[
\begin{array}{c|c|c|c|c}
\text{Decile sorts on U.S. Climate} & \text{Quintile sorts on U.S. Climate} \\
\hline
\text{Pre-2012} & \text{Post-2012} & \text{Pre-2012} & \text{Post-2012} \\
\hline
\text{Panel A: Market model} & & & \\
1.05^{**} & 0.4^{**} & 0.55 & 0.75^{***} \\
(2.33) & (2.12) & (1.55) & (2.9) \\
\hline
\text{Panel B: FF 3F model} & & & \\
0.35 & 0.9^{***} & 0.06 & 0.70^{***} \\
(0.91) & (3.06) & (0.17) & (3.11) \\
\hline
\text{Panel C: FFC model} & & & \\
0.17 & 0.97^{***} & -0.11 & 0.46^{**} \\
(0.46) & (3.29) & (-0.43) & (2.52) \\
\hline
\text{Panel D: FF 5F model} & & & \\
0.4 & 1.23^{***} & 0.45^{*} & 0.59^{**} \\
(1.23) & (3.2) & (1.73) & (2.15) \\
\hline
\text{Panel E: FF 5F + mom.} & & & \\
0.44 & 0.79^{***} & 0.21 & 0.42^{**} \\
(1.26) & (2.72) & (1.12) & (2.13) \\
\end{array}
\]
### Climate policy portfolio characteristics

#### Panel A: Fama-French-Carhart model

<table>
<thead>
<tr>
<th></th>
<th>1 (L)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>0.80*</td>
<td>1.03***</td>
<td>0.87***</td>
<td>0.89**</td>
<td>1.07***</td>
</tr>
<tr>
<td>(1.84)</td>
<td>(2.88)</td>
<td>(2.84)</td>
<td>(2.60)</td>
<td>(2.66)</td>
<td></td>
</tr>
<tr>
<td>Climate beta</td>
<td>-0.48</td>
<td>-0.16</td>
<td>0.00</td>
<td>0.15</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>E score</strong></td>
<td><strong>35.12</strong></td>
<td><strong>40.37</strong></td>
<td><strong>41.66</strong></td>
<td><strong>40.29</strong></td>
<td><strong>34.86</strong></td>
</tr>
<tr>
<td><strong>E score (change)</strong></td>
<td><strong>7.12</strong></td>
<td><strong>6.26</strong></td>
<td><strong>5.70</strong></td>
<td><strong>6.22</strong></td>
<td><strong>6.05</strong></td>
</tr>
<tr>
<td>log(size)</td>
<td>6.36</td>
<td>6.91</td>
<td>7.02</td>
<td>6.91</td>
<td>6.43</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>747.00</td>
<td>751.00</td>
<td>751.00</td>
<td>750.00</td>
<td>747.00</td>
</tr>
</tbody>
</table>

#### Panel B: Fama-French five-factor model

<table>
<thead>
<tr>
<th></th>
<th>1 (L)</th>
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<tbody>
<tr>
<td>Average return</td>
<td>0.71</td>
<td>1.01***</td>
<td>0.86***</td>
<td>0.95***</td>
<td>1.10***</td>
</tr>
<tr>
<td>(1.40)</td>
<td>(2.76)</td>
<td>(2.79)</td>
<td>(3.09)</td>
<td>(2.93)</td>
<td></td>
</tr>
<tr>
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<td>-0.16</td>
<td>0.00</td>
<td>0.16</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>E score</strong></td>
<td><strong>35.15</strong></td>
<td><strong>40.51</strong></td>
<td><strong>41.37</strong></td>
<td><strong>40.37</strong></td>
<td><strong>35.15</strong></td>
</tr>
<tr>
<td><strong>E score (change)</strong></td>
<td><strong>6.64</strong></td>
<td><strong>6.22</strong></td>
<td><strong>5.64</strong></td>
<td><strong>6.38</strong></td>
<td><strong>6.18</strong></td>
</tr>
<tr>
<td>log(size)</td>
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<td>6.92</td>
<td>7.01</td>
<td>6.91</td>
<td>6.43</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>747.00</td>
<td>748.00</td>
<td>752.00</td>
<td>752.00</td>
<td>747.00</td>
</tr>
</tbody>
</table>
Select articles with a topic share on the domestic policy factor > 40%
→ 3,500 articles
Select articles with a topic share on the domestic policy factor $> 40\% \rightarrow 3,500$ articles

Read each article and mark it with

- $+1$, if it signals an increase in transition risks,
- $-1$, if it signals a decrease in transition risks,
- $0$, if its content is mixed

Narrative factor value at time $t$: Sum of the marks given to the articles over day $t$. 

Faccini, Matin & Skiadopoulos

Dissecting Climate Risks
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Read each article and mark it with

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0, if its content is mixed

Narrative factor value at time $t$: Sum of the marks given to the articles over day $t$. 
By construction, decreases in the factor signal good news for the economy.

⇒ Risk premium of the U.S. climate policy narrative factor: It should be negative under the hedging argument.
### Asset pricing tests: Narrative factor (Decile)

<table>
<thead>
<tr>
<th></th>
<th>2000-2018</th>
<th>2000-2012</th>
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</tr>
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<tbody>
<tr>
<td><strong>Panel A: Market model</strong></td>
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<td></td>
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<tr>
<td></td>
<td>-0.64*</td>
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<td>(-4.30)</td>
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<td><strong>Panel C: FFC model</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-0.85***</td>
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<td>-1.37***</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.31</td>
<td>0.00</td>
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</tr>
<tr>
<td></td>
<td>(-1.07)</td>
<td>(0.00)</td>
<td>(-3.40)</td>
</tr>
</tbody>
</table>
Conclusions

1. We dissect market-wide climate risk in its multiple sources
2. Examine whether these are priced in U.S. stocks
3. Provide & validate an explanation: Intertemporal hedging

Results:
We identify four market-wide textual factors with a clear interpretation
Only U.S. climate policy is priced
This evidence is driven by the post-2012 era

Implications:
1. It is the government’s intervention and not physical risks
2. Climate policy risks have started to be priced only recently
3. Investors reward …rms which improve their environmental pro…le
4. Results are consistent with both camps

Future research:
Why are not all risks priced? Investors’ short-termism and/or lack of information, or not systemic.
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Thank you for your attention and time!


gskiado@unipi.gr, g.skiadopoulos@qmul.ac.uk
Related literature

Climate Finance empirical literature
- Giglio et al. (2021a)
- Real estate: Bernstein et al. (2019), Baldauf et al. (2020), Giglio et al. (2021b)
- Bonds: Painter (2020), Seltzer et al. (2020), Goldsmith-Pinkham et al. (2021), Duan et al. (2021)
- Options: Ilhan et al. (2021), Cao et al. (2021)
- Stocks: Oesteich and Tsiakas (2015), Bansal et al. (2017), Hong et al. (2019), Görgen et al. (2019), Bolton & Kacperczyk (2021a, b), Hsu et al. (2021), Pastor et al. (2021)

Textual analysis in financial markets
(Gentzkow et al., 2019)

Market-wide climate factors
- Engle et al. (2020), Huynh and Xia (2020), Alekseev et al. (2021)

Firm-specific climate factors
- Kölbel et al. (2020), Li et al. (2020) and Sautner et al. (2020, 2021)

Construction of accurate ESG ratings (Berg et al., 2020).
Climate Finance empirical literature (Giglio et al., 2021a)

- **Real estate**: Bernstein et al. (2019), Baldauf et al. (2020), Giglio et al. (2021b)
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   - **Stocks**: Oesteich and Tsiakas (2015), Bansal et al. (2017), Hong et al. (2019), Görgen et al. (2019), Bolton & Kacperczyk (2021a, b), Hsu et al. (2021), Pastor et al. (2021)

2. **Textual analysis in finance** (Gentzkow et al., 2019)

   - **Market-wide climate factors**: Engle et al. (2020), Huynh and Xia (2020), Alekseev et al. (2021)
   - **Firm-specific climate factors**: Kölbel et al. (2020), Li et al. (2020) and Sautner et al. (2020, 2021)
1 **Climate Finance empirical literature** (Giglio et al., 2021a)
   - **Real estate**: Bernstein et al. (2019), Baldauf et al. (2020), Giglio et al. (2021b)
   - **Bonds**: Painter (2020), Seltzer et al. (2020), Goldsmith-Pinkham et al. (2021), Duan et al. (2021)
   - **Options**: Ilhan et al. (2021), Cao et al. (2021)
   - **Stocks**: Oesteich and Tsiakas (2015), Bansal et al. (2017), Hong et al. (2019), Görgen et al. (2019), Bolton & Kacperczyk (2021a, b), Hsu et al. (2021), Pastor et al. (2021)

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   - **Firm-specific climate factors**: Kölbel et al. (2020), Li et al. (2020) and Sautner et al. (2020, 2021)

3 **Construction of accurate ESG ratings** (Berg et al., 2020).
Labeling Topics: Global warming

- temperature
- cause
- global emissions
- celsius
- nations
- rise
- fuel gas
- heat
- fossil
- temperatures
- unite
- world
- study
- increase
- report
- limit
- greenhouse
- limit
- century
- scientists
- dioxide
- carbon
- warm cut
- cool
- degrees
- percent
- level
Labeling Topics: International summits

Topic 17

countries, nations, agreement, minister
meet, unite, cut, develop, summit, kyoto, new, leaders, global, state, world, deal, world

Japan, rich, agree, rich, protocol, pact, tell, talk, copenhagen, greenhouse, warm, emissions
### Topics: Correlations

<table>
<thead>
<tr>
<th>U.S. Climate policy</th>
<th>Int'l summits</th>
<th>Global warming</th>
<th>Natural disasters</th>
<th>mktrf</th>
<th>hml</th>
<th>smb</th>
<th>rmw</th>
<th>cma</th>
<th>umd</th>
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<td>0.31</td>
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**1.** Low correlations ⇒ LDA has successfully dissected climate risks

**2.** Why the low correlations? Long-term vs. Short-term effects.
### Asset pricing tests: Narrative factor (Quintile)

<table>
<thead>
<tr>
<th></th>
<th>2000-2018</th>
<th>2000-2012</th>
<th>2012-2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Market model</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-0.23</td>
<td>-0.01</td>
<td>-0.71</td>
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<tr>
<td></td>
<td>(-0.77)</td>
<td>(-0.02)</td>
<td>(-1.52)</td>
</tr>
<tr>
<td><strong>Panel B: FF 3F model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.58***</td>
<td>-0.20</td>
<td>-1.05***</td>
</tr>
<tr>
<td></td>
<td>(-2.64)</td>
<td>(-0.78)</td>
<td>(-3.67)</td>
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<tr>
<td><strong>Panel C: FFC model</strong></td>
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<tr>
<td></td>
<td>-0.48**</td>
<td>-0.24</td>
<td>-0.93***</td>
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<tr>
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<td>(-2.30)</td>
<td>(-1.05)</td>
<td>(-2.86)</td>
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<tr>
<td><strong>Panel D: FF 5F model</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>-0.39*</td>
<td>-0.16</td>
<td>-0.69**</td>
</tr>
<tr>
<td></td>
<td>(-1.89)</td>
<td>(-0.62)</td>
<td>(-2.53)</td>
</tr>
<tr>
<td><strong>Panel E: FF 5F + momentum</strong></td>
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<tr>
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<td>-0.26</td>
<td>-0.05</td>
<td>-0.60**</td>
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<td>(-1.20)</td>
<td>(-0.19)</td>
<td>(-2.08)</td>
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</table>
Do climate policy factors conflate EPU / Political risks?

- Conditional bivariate sorts (Bali et al., 2017)
- Control variables: EPU (Baker et al., 2016), Political risk (Hassan et al., 2019)

<table>
<thead>
<tr>
<th>First control variable:</th>
<th>EPU</th>
<th>PRisk</th>
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<tbody>
<tr>
<td><strong>Panel A: Market model</strong></td>
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<td>(2.44)</td>
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<td><strong>Panel B: FF 3F model</strong></td>
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<tr>
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<td>0.7***</td>
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<td></td>
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<td>(2.84)</td>
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<tr>
<td>Narrative</td>
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<td>-0.84***</td>
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<td>(-2.75)</td>
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<td><strong>Panel C: FFC model</strong></td>
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<tr>
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<td>0.42**</td>
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<td>(2.2)</td>
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<tr>
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<td><strong>Panel E: FF 5F + momentum</strong></td>
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<td>(3.06)</td>
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<td>Narrative</td>
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<td>-0.57**</td>
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</tbody>
</table>