Price of Long-Run Temperature Shifts in Capital Markets

by Bansal, Kiku, and Ochoa

Discussion by Ric Colacito

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

A quote from the paper

"We focus on potentially catastrophic consequences of climate change [...] not limited to rising sea levels and drowning of currently populated coastlines and islands, intensified heat waves, severe droughts, storms and floods, destruction of ecosystems and wildlife, spreading of contagious tropical diseases, shortages of food and fresh water supply, significant destruction of property and human losses."

A Blockbuster Paper!

"We focus on potentially catastrophic consequences of climate change [...] not limited to rising sea levels and drowning of currently populated coastlines and islands, intensified heat waves, severe droughts, storms and floods, destruction of ecosystems and wildlife, spreading of contagious tropical diseases, shortages of food and fresh water supply, significant destruction of property and human losses."

A Blockbuster Paper!

"We focus on potentially catastrophic consequences of climate change [...] not limited to rising sea levels and drowning of currently populated coastlines and islands, intensified heat waves, severe droughts, storms and floods, destruction of ecosystems and wildlife, spreading of contagious tropical diseases, shortages of food and fresh water supply, significant destruction of property and human losses."

- Trailer for this paper

Theoretical contribution

- Representative agent has recursive preferences

$$U_t = (1-\delta)\log C_t + \delta\theta \log E_t \exp\left\{\frac{U_{t+1}}{\theta}\right\}$$

where $\theta = \frac{1}{1-\gamma} < 0$.

Theoretical contribution

- Representative agent has recursive preferences

$$U_t = (1-\delta)\log C_t + \delta E_t[U_{t+1}]$$

where $\theta = \frac{1}{1-\gamma} < 0$. If $\theta \to -\infty$: Expected Utility case.

Theoretical contribution

- Representative agent has recursive preferences

$$U_t = (1-\delta)\log C_t + \delta\theta \log E_t \exp\left\{\frac{U_{t+1}}{\theta}\right\}$$

where $\theta = \frac{1}{1-\gamma} < 0$.

Theoretical contribution

- Representative agent has recursive preferences

$$U_t \approx (1-\delta)\log C_t + \delta E_t[U_{t+1}] + \frac{\delta V_t[U_{t+1}]}{2\theta} + \frac{\delta E_t(U_{t+1} - E_t U_{t+1})^3}{6\theta^2} \ldots$$

where $\theta = \frac{1}{1-\gamma} < 0$. Conditional Moments matter.

Theoretical contribution

- Representative agent has recursive preferences

$$U_t = (1-\delta)\log C_t + \delta\theta \log E_t \exp\left\{\frac{U_{t+1}}{\theta}\right\}$$

where $\theta = \frac{1}{1-\gamma} < 0$.

Theoretical contribution

- Representative agent has recursive preferences

$$U_t = (1-\delta)\log C_t + \delta\theta \log E_t \exp\left\{\frac{U_{t+1}}{\theta}\right\}$$

where $\theta = \frac{1}{1-\gamma} < 0$.

- Consumption dynamics

$$\begin{aligned} \Delta c_t &= \mu_x + x_{t-1} + \sigma\varepsilon_t^c - \phi_c D_t \\ x_t &= \rho_x x_{t-1} + \varphi_x \sigma\varepsilon_t^x - \phi_x D_t \end{aligned}$$

where D_t is a Poisson jump

  - probability and size depend on temperature
  - temperature is increasing with emissions $\propto$ consumption

Theoretical contribution

- Representative agent has recursive preferences

$$U_t \approx (1-\delta)\log C_t + \delta E_t[U_{t+1}] + \frac{\delta V_t[U_{t+1}]}{2\theta} + \frac{\delta E_t(U_{t+1} - E_t U_{t+1})^3}{6\theta^2} \ldots$$

where $\theta = \frac{1}{1-\gamma} < 0$.

- Consumption dynamics

$$\begin{aligned} \Delta c_t &= \mu_x + x_{t-1} + \sigma\varepsilon_t^c - \phi_c D_t \\ x_t &= \rho_x x_{t-1} + \varphi_x \sigma\varepsilon_t^x - \phi_x D_t \end{aligned}$$

where D_t is a Poisson jump
  - probability and size depend on temperature
  - temperature is increasing with emissions $\propto$ consumption

- Disasters are a source of uncertainty and skewness

Theoretical contribution

- Representative agent has recursive preferences

$$U_t \approx (1-\delta)\log C_t + \delta E_t[U_{t+1}] + \frac{\delta V_t[U_{t+1}]}{2\theta} + \frac{\delta E_t(U_{t+1} - E_t U_{t+1})^3}{6\theta^2} \ldots$$

where $\theta = \frac{1}{1-\gamma} < 0$.

- Consumption dynamics

$$\begin{aligned} \Delta c_t &= \mu_x + x_{t-1} + \sigma\varepsilon_t^c - \phi_c D_t \\ x_t &= \rho_x x_{t-1} + \varphi_x \sigma\varepsilon_t^x - \phi_x D_t \end{aligned}$$

where D_t is a Poisson jump
  - probability and size depend on temperature
  - temperature is increasing with emissions $\propto$ consumption

- Disasters are a source of uncertainty and skewness
  - Social cost (marginal utility) of emissions is large

Empirical contribution

- Temperature provides news about future probability and extent of disasters
- With EZ preferences, news shocks are priced
- There is a risk premium to compensate for temperature risk exposure
- In the cross-section, industries that are more exposed to temperature risk should command a larger premium

Comments

Comments

1. Assessing the calibration
2. Measuring climate exposure
3. Medium-Run Risk
4. Connection between model and empirical analysis

Assessing the Calibration

An extremely complex task.

Assessing the Calibration

An extremely complex task.

1. What is the probability of a climate induced economic disaster?

Assessing the Calibration

An extremely complex task.

1. What is the probability of a climate induced economic disaster?

2. What is the size of a climate induced disaster?

Assessing the Calibration

An extremely complex task.

1. What is the probability of a climate induced economic disaster?
   - probability of a climate disaster
   - probability that it affects the US economy
2. What is the size of a climate induced disaster?

Assessing the Calibration

An extremely complex task.

1. What is the probability of a climate induced economic disaster?
   - probability of a climate disaster
   - probability that it affects the US economy
2. What is the size of a climate induced disaster?
   - How widespread it is?
   - Risk-sharing?
   - Differential impact for developed/developing countries?

Assessing the Calibration

An extremely complex task.

1. What is the probability of a climate induced economic disaster?
   - probability of a climate disaster
   - probability that it affects the US economy
2. What is the size of a climate induced disaster?
   - How widespread it is?
   - Risk-sharing?
   - Differential impact for developed/developing countries?

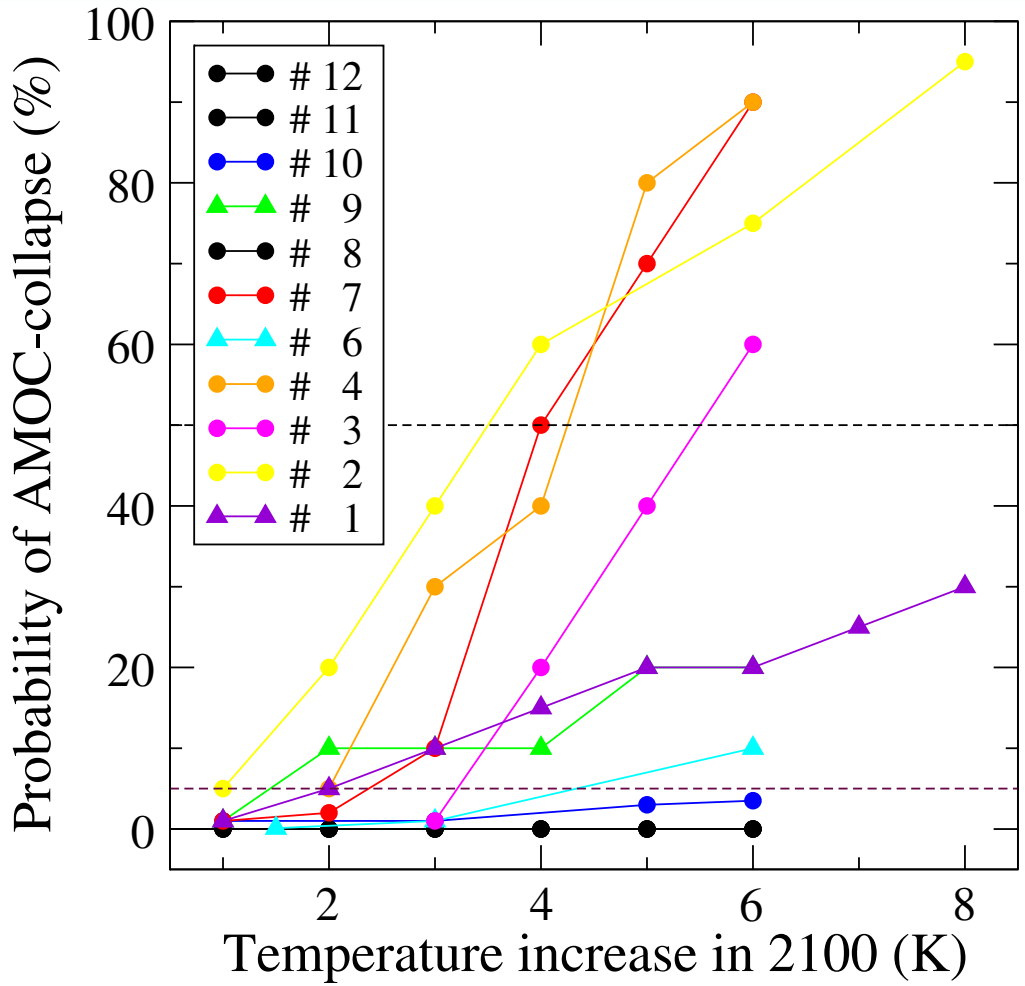
Example: probability of AMOC collapse

- Atlantic Meridional Overturning Circulation
- A large scale ocean circulation that flows northward near the surface in the Atlantic, sinks in cold high northern latitudes and returns to the Southern Ocean.
- Cessation of the circulation could lead to
  - strong cooling by several degrees
  - increase in sea level of up to 1 m in magnitude
  - warming of the Southern Ocean
  - ...

Example: probability of AMOC collapse

- Atlantic Meridional Overturning Circulation
- A large scale ocean circulation that flows northward near the surface in the Atlantic, sinks in cold high northern latitudes and returns to the Southern Ocean.
- Cessation of the circulation could lead to
  - strong cooling by several degrees
  - increase in sea level of up to 1 m in magnitude
  - warming of the Southern Ocean
  - ...
- How likely is the collapse of the AMOC?

Experts' (Dis)Agreement



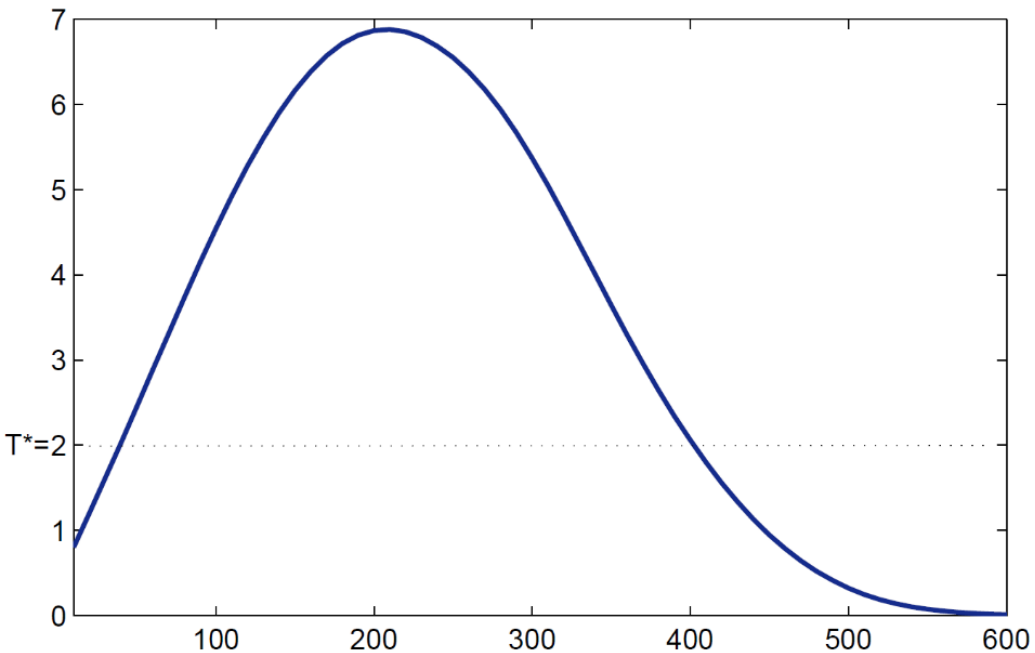
Source: Zickfeld et al. (Climate Change, 2007)

Climate disaster: this paper

Temperature anomaly $> 2^o$ triggers positive disaster probability

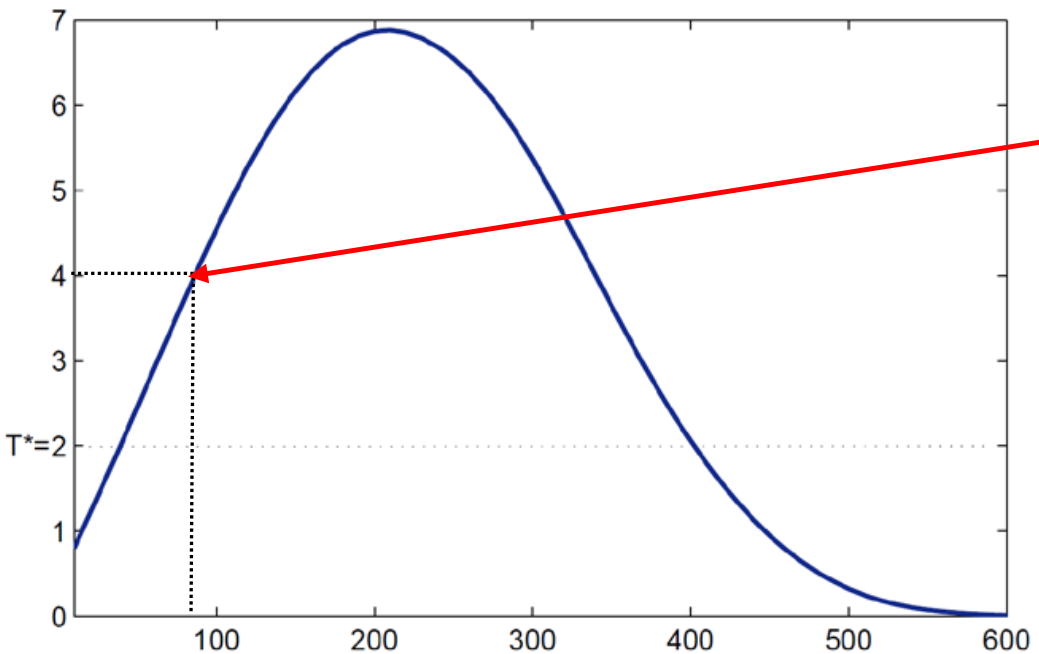
Climate disaster: this paper

Temperature anomaly $> 2^o$ triggers positive disaster probability



Climate disaster: this paper

Temperature anomaly $> 2^o$ triggers positive disaster probability

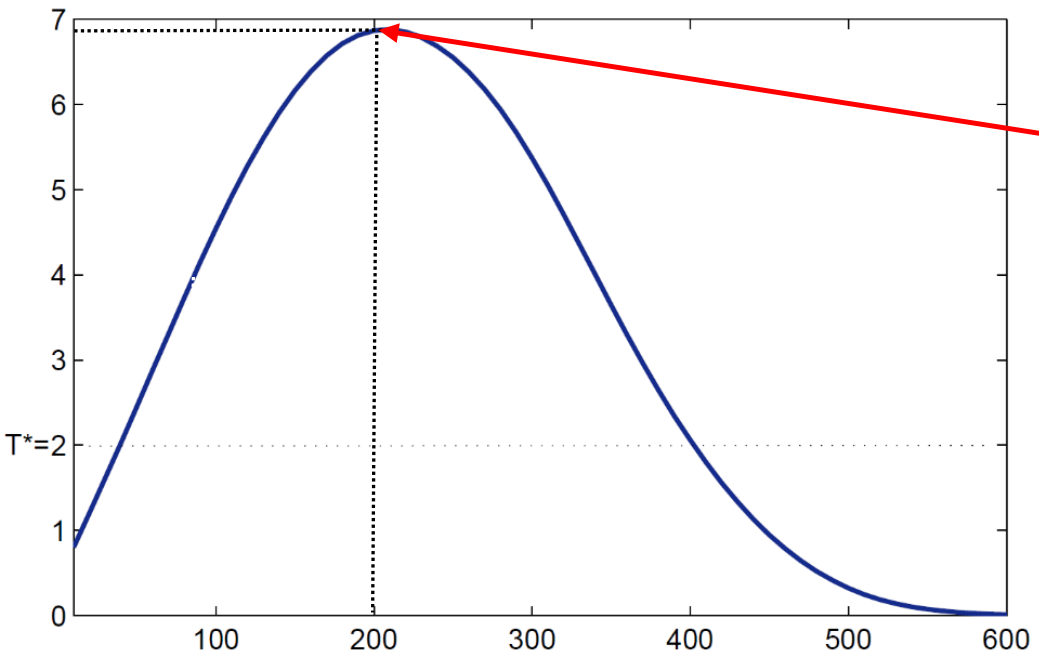


$d = 0.0011 * 4 + 0.0011 * 4\text{^}2$ =2.2%

$\pi = 0.0050 + 0.0033 * 4 = 1.82\%$

Climate disaster: this paper

Temperature anomaly $> 2^o$ triggers positive disaster probability



$d = 0.0011 * 7 + 0.0011 * 7\text{^}2$ =6.2%

$\pi = 0.0050 + 0.0033 * 7 = 2.81\%$

Calibration: thoughts

- Probability of a climate related disaster is very ambiguous
- This paper seems to be on the conservative side
- How to benchmark the size of the disaster?
- Is Barro the right reference for this?
- How confident are actual investors about these projections?

How do you identify exposure to climate?

How do you identify exposure to climate?

- This paper looks at exposure of labor force
  $\rightarrow$ Report by National Institute for Occupational Safety and Health

How do you identify exposure to climate?

- This paper looks at exposure of labor force
  $\rightarrow$ Report by National Institute for Occupational Safety and Health
  $\rightarrow$ Is this the only relevant dimension?

How do you identify exposure to climate?

- This paper looks at exposure of labor force
  $\rightarrow$ Report by National Institute for Occupational Safety and Health
  $\rightarrow$ Is this the only relevant dimension?

- Take a sector like "Property/Casualty" Insurance
  $\rightarrow$ low exposure of labor force
  $\rightarrow$ high exposure of profitability

How do you identify exposure to climate?

- This paper looks at exposure of labor force
  → Report by National Institute for Occupational Safety and Health
  → Is this the only relevant dimension?

- Take a sector like “Property/Casualty” Insurance
  → low exposure of labor force
  → high exposure of profitability

- Standard & Poor, 2012 Industry Outlook

  "Looking ahead, we believe higher catastrophe losses, a relatively weak macroeconomic environment, lower investment yields and the tapering off of the benefit of reserve releases are likely to weigh on profitability for the overall P/C industry"

Exposure of Real Estate

Exposure of Real Estate

- Bloomberg in April 2017:
  "Climate change poses nightmare scenario for Florida coast. Americas trillion-dollar coastal property bubble could burst before the sea consumes a single house."

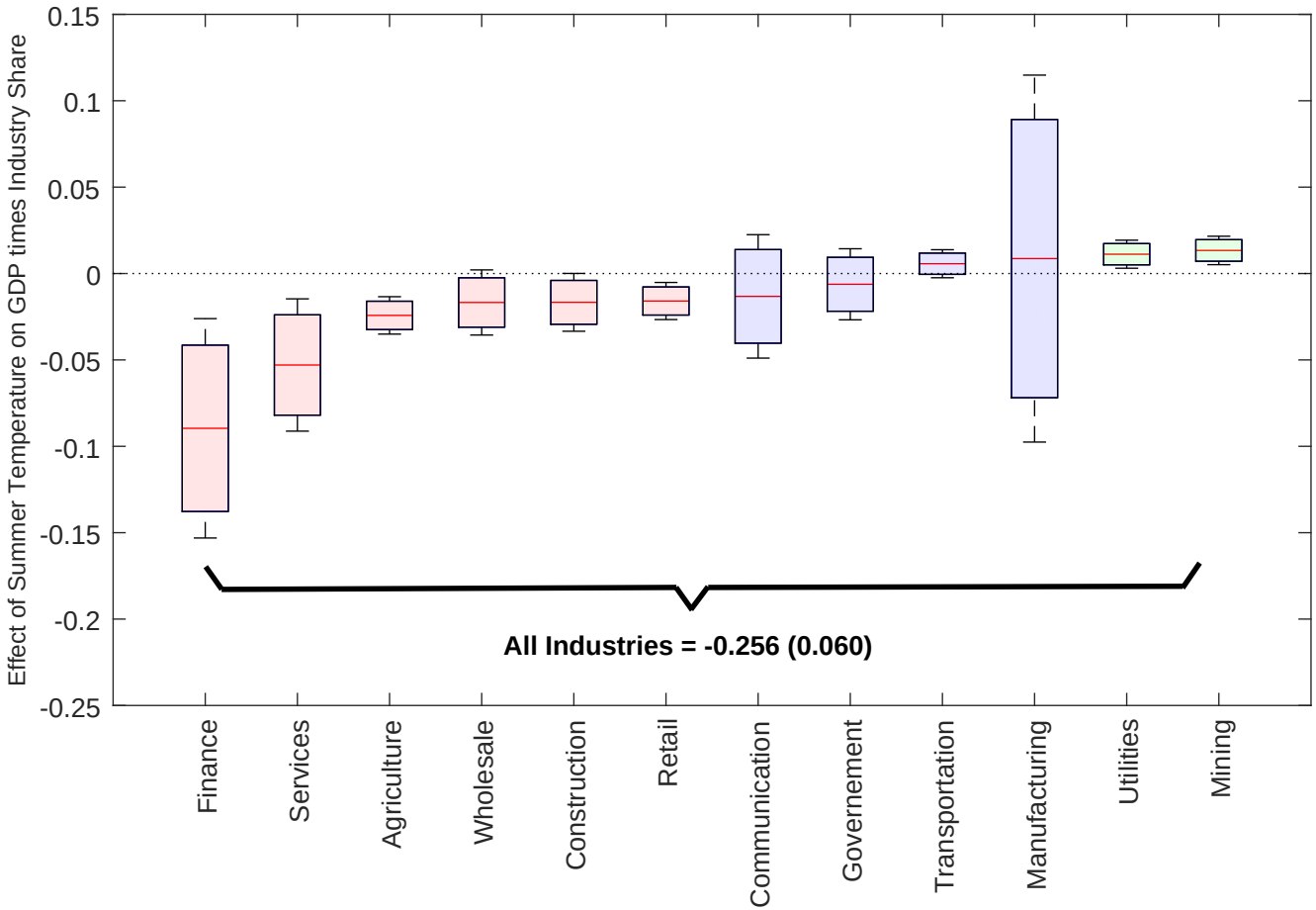
Exposure of Real Estate

- Bloomberg in April 2017:
  "Climate change poses nightmare scenario for Florida coast. Americas trillion-dollar coastal property bubble could burst before the sea consumes a single house."
- Other expensive real-estate location are likely to be exposed

Exposure of Real Estate

- Bloomberg in April 2017:
  "Climate change poses nightmare scenario for Florida coast. Americas trillion-dollar coastal property bubble could burst before the sea consumes a single house."
- Other expensive real-estate location are likely to be exposed
- Same logic of the empirical analysis of the paper should apply to the cross-section of regional real estate

Exposure using impact on industry GDP



Source: Colacito, Hoffmann, and Phan (2016)

Medium-Run Risk?

Medium-Run Risk?

- Companies care about the expected future costs of
  - adapting to climate change
  - implementing policy aimed at containing carbon emissions

Medium-Run Risk?

- Companies care about the expected future costs of
  - adapting to climate change
  - implementing policy aimed at containing carbon emissions
- These costs are closer in time and more tangible

Medium-Run Risk?

- Companies care about the expected future costs of
  - adapting to climate change
  - implementing policy aimed at containing carbon emissions
- These costs are closer in time and more tangible
- Example: an increasing number of companies are self-pricing their carbon emissions

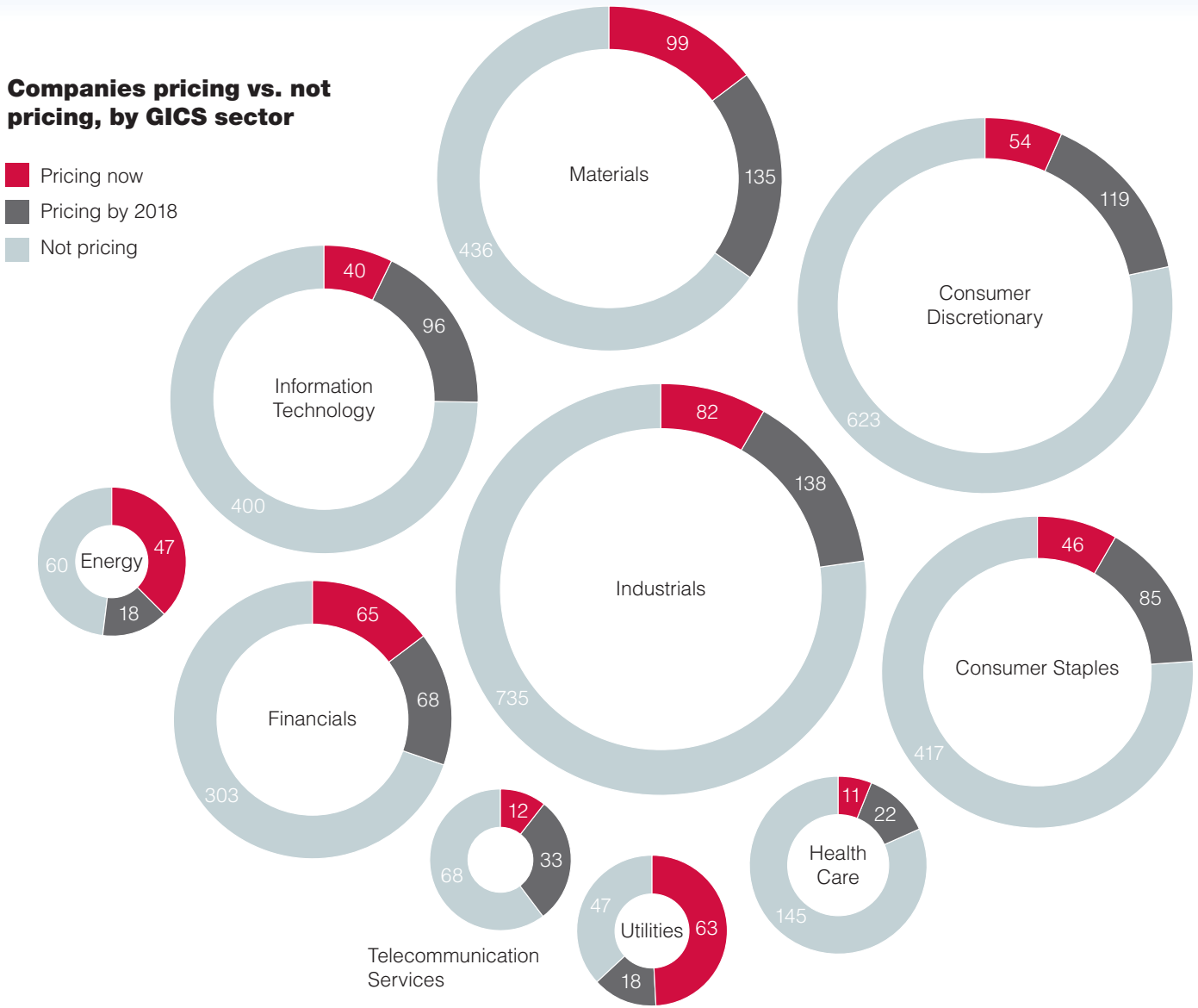
Medium-Run Risk?

- Companies care about the expected future costs of
  - adapting to climate change
  - implementing policy aimed at containing carbon emissions
- These costs are closer in time and more tangible
- Example: an increasing number of companies are self-pricing their carbon emissions
- According to a Carbon Disclosure Project (CDP) report, companies are doing this in response to investors demanding assurance that companies are
  - lowering their risk exposure to policies that place a price on carbon
  - reallocating capital to deliver higher returns in a low-carbon economy

Medium-Run Risk?

- Companies care about the expected future costs of
  - adapting to climate change
  - implementing policy aimed at containing carbon emissions
- These costs are closer in time and more tangible
- Example: an increasing number of companies are self-pricing their carbon emissions
- According to a Carbon Disclosure Project (CDP) report, companies are doing this in response to investors demanding assurance that companies are
  - lowering their risk exposure to policies that place a price on carbon
  - reallocating capital to deliver higher returns in a low-carbon economy
- Substantial uncertainty on projected extent of incremental adoption of this policy going forward

Carbon Pricing



Which risk are returns responding to?

Which risk are returns responding to?

1. The ambiguous probability and extent of a catastrophic event many years into the future?

Which risk are returns responding to?

1. The ambiguous probability and extent of a catastrophic event many years into the future?
2. The increasingly more likely medium-run cost of having to adapt to new climate change regulation (either voluntary or involuntary)?

Which risk are returns responding to?

1. The ambiguous probability and extent of a catastrophic event many years into the future?
2. The increasingly more likely medium-run cost of having to adapt to new climate change regulation (either voluntary or involuntary)?
3. Both? None?

Which risk are returns responding to?

1. The ambiguous probability and extent of a catastrophic event many years into the future?
2. The increasingly more likely medium-run cost of having to adapt to new climate change regulation (either voluntary or involuntary)?
3. Both? None?

Equivalently, can we cast the problem as one of (temperature related) tax uncertainty?

Connection between model and data

- Spell out connection between representative agent/single good model and cross-sectional analysis
- What is the parametric connection between the cross-sectional risk-premium of high/low exposed sectors and deeper model's parameters?
- How large is the differential impact of climate disasters?
- Can you connect it to micro evidence?

Concluding Remarks

The climate change inaction risk premium:

Concluding Remarks

The climate change inaction risk premium:

"Without bolder action, our children won't have time to debate the existence of climate change; they'll be busy dealing with its effect"

Concluding Remarks

The climate change inaction risk premium:

"Without bolder action, our children won't have time to debate the existence of climate change; they'll be busy dealing with its effect"

President Barack Obama, during Farewell speech in Chicago