Disasters, Recoveries, and Predictability

François Gourio

Boston University

2008
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption
- Barro [2006] revives this explanation
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption
- Barro [2006] revives this explanation
  - disasters are large and frequent (p=1.7%)
**Motivation**

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption
- Barro [2006] revives this explanation
  - disasters are large and frequent \((p=1.7\%)\)
  - stock returns \(<\) bond returns during disasters.
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption
- Barro [2006] revives this explanation
  - disasters are large and frequent (p=1.7%)
  - stock returns $\prec$ bond returns during disasters.
- Gabaix [2007]: time-varying risk of disasters can explain many asset pricing puzzles.
Motivation

- Rietz [1988]: "disaster" resolution of the equity premium puzzle.
  - small probability of large decrease in consumption

- Barro [2006] revives this explanation
  - disasters are large and frequent (p=1.7%)
  - stock returns < bond returns during disasters.

- Gabaix [2007]: time-varying risk of disasters can explain many asset pricing puzzles.

- An alternative to leading asset pricing models?
This presentation

- Tries to assess the robustness of the disaster explanation.
- In the model, disasters are permanent.
This presentation

- Tries to assess the robustness of the disaster explanation.
- In the model, disasters are permanent.
  - But in the data, it seems many disasters are followed by a "recovery".
This presentation

- Tries to assess the robustness of the disaster explanation.

- In the model, disasters are permanent.
  - But in the data, it seems many disasters are followed by a "recovery".
  - How does this affect the conclusions of Rietz & Barro?
This presentation

- Tries to assess the robustness of the disaster explanation.
- In the model, disasters are permanent.
  - But in the data, it seems many disasters are followed by a "recovery".
  - How does this affect the conclusions of Rietz & Barro?
- Can the disaster model account for other facts beyond the equity premium puzzle?
This presentation

- Tries to assess the robustness of the disaster explanation.
- In the model, disasters are permanent.
  - But in the data, it seems many disasters are followed by a "recovery".
  - How does this affect the conclusions of Rietz & Barro?
- Can the disaster model account for other facts beyond the equity premium puzzle?
  - time-series predictability of stock returns
This presentation

- Tries to assess the robustness of the disaster explanation.

- In the model, disasters are permanent.
  - But in the data, it seems many disasters are followed by a "recovery".
  - How does this affect the conclusions of Rietz & Barro?

- Can the disaster model account for other facts beyond the equity premium puzzle?
  - time-series predictability of stock returns
  - cross-sectional predictability of expected returns
Outline

1. Review of the Barro-Rietz model
2. Recoveries in the Data and in the Model \((AER \ P&P)\)
3. Time–Series Predictability \((FRL)\)
4. Cross-Section Predictability \((WP)\)
Barro-Rietz model

- Representative agent:
  \[ E \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}. \]

- Endowment Economy.

- Consumption = dividend process:
  \[
  \Delta \log C_t = \mu + \sigma \varepsilon_t, \text{ with probability } 1 - p, \\
  = \mu + \sigma \varepsilon_t + \log(1 - b), \text{ with probability } p, \\
  \varepsilon_t \text{ iid } N(0, 1).
  \]
Barro-Rietz: theoretical results

- Risk-free rate:

\[
\log R_f = - \log \beta + \gamma \mu - \frac{\gamma^2 \sigma^2}{2} - \log \left(1 - p + p(1 - b)^{-\gamma}\right).
\]
Barro-Rietz: theoretical results

- Risk-free rate:
  \[
  \log R_f = - \log \beta + \gamma \mu - \frac{\gamma^2 \sigma^2}{2} - \log \left(1 - p + p(1 - b)^{-\gamma}\right).
  \]
- Lower than in the standard model.
Barro-Rietz: theoretical results

- Risk-free rate:

\[
\log R_f = - \log \beta + \gamma \mu - \frac{\gamma^2 \sigma^2}{2} - \log \left(1 - p + p(1 - b)^{-\gamma}\right).
\]

- Lower than in the standard model.

- Equity Premium:

\[
\log \frac{E R^e}{R_f} = \sigma^2 \gamma + \log \left(\frac{(1 - p + p(1 - b)^{-\gamma})(1 - p + p(1 - b))}{1 - p + p(1 - b)^{1-\gamma}}\right).
\]
Barro-Rietz: theoretical results

- Risk-free rate:

\[
\log R_f = - \log \beta + \gamma \mu - \frac{\gamma^2 \sigma^2}{2} - \log \left(1 - p + p(1 - b)^{-\gamma}\right).
\]

- Lower than in the standard model.

- Equity Premium:

\[
\log \frac{ER^e}{R_f} = \sigma^2 \gamma + \log \left(\frac{(1 - p + p(1 - b)^{-\gamma})(1 - p + p(1 - b))}{1 - p + p(1 - b)^{1-\gamma}}\right).
\]

- Higher than in the standard model.
Risk-free rate:

\[ \log R_f = - \log \beta + \gamma \mu - \frac{\gamma^2 \sigma^2}{2} - \log \left(1 - p + p(1 - b)^{-\gamma}\right). \]

Lower than in the standard model.

Equity Premium:

\[ \log \frac{ER^e}{R_f} = \sigma^2 \gamma + \log \left(\frac{(1 - p + p(1 - b)^{-\gamma}) (1 - p + p(1 - b))}{1 - p + p(1 - b)^{1-\gamma}}\right). \]

Higher than in the standard model.

Constant P-D ratio.
Barro-Rietz: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>discount factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$\mu$</td>
<td>trend growth</td>
<td>0.025</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>std dev of business cycle shocks</td>
<td>0.02</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>risk aversion</td>
<td>4</td>
</tr>
<tr>
<td>$p$</td>
<td>probability of disaster</td>
<td>0.017</td>
</tr>
<tr>
<td>$b$</td>
<td>historical distribution, equivalent to:</td>
<td>0.43</td>
</tr>
</tbody>
</table>

- Without disasters, equity premium $= 0.16\%$
### Barro-Rietz: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>discount factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$\mu$</td>
<td>trend growth</td>
<td>0.025</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>std dev of business cycle shocks</td>
<td>0.02</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>risk aversion</td>
<td>4</td>
</tr>
<tr>
<td>$p$</td>
<td>probability of disaster</td>
<td>0.017</td>
</tr>
<tr>
<td>$b$</td>
<td>historical distribution, equivalent to:</td>
<td>0.43</td>
</tr>
</tbody>
</table>

- Without disasters, equity premium $= 0.16\%$
- With disasters, equity premium $= 5.6\%$
## Barro-Rietz: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>discount factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$\mu$</td>
<td>trend growth</td>
<td>0.025</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>std dev of business cycle shocks</td>
<td>0.02</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>risk aversion</td>
<td>4</td>
</tr>
<tr>
<td>$p$</td>
<td>probability of disaster</td>
<td>0.017</td>
</tr>
<tr>
<td>$b$</td>
<td><strong>historical distribution</strong>, equivalent to:</td>
<td>0.43</td>
</tr>
</tbody>
</table>

- Without disasters, equity premium = 0.16%
- With disasters, equity premium = 5.6%
- Add gov’t default: w/probability 0.4, gov’t bonds default in disaster, and recovery rate = $1 - b$. → Reduces equity premium to 3.5%.
Barro-Rietz: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>discount factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$\mu$</td>
<td>trend growth</td>
<td>0.025</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>std dev of business cycle shocks</td>
<td>0.02</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>risk aversion</td>
<td>4</td>
</tr>
<tr>
<td>$p$</td>
<td>probability of disaster</td>
<td>0.017</td>
</tr>
<tr>
<td>$b$</td>
<td><strong>historical distribution</strong>, equivalent to:</td>
<td>0.43</td>
</tr>
</tbody>
</table>

- Without disasters, equity premium = 0.16%
- With disasters, equity premium = 5.6%
- Add gov’t default: w/probability 0.4, gov’t bonds default in disaster, and recovery rate = 1 $- b$. → Reduces equity premium to 3.5%.
- **Results driven by large disasters**: if keep only disasters $< 40\%$, EP = 0.8%.
Simulating a path of Log GDP in the Barro Model
Disasters in the Data

François Gourio (BU)
Measuring Recoveries

<table>
<thead>
<tr>
<th>Years after Trough</th>
<th>Growth from Trough</th>
<th>Loss from Peak</th>
<th>Growth from Trough</th>
<th>Loss from Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>-29.8</td>
<td>0.0</td>
<td>-41.5</td>
</tr>
<tr>
<td>1</td>
<td><strong>11.1</strong></td>
<td>-22.8</td>
<td><strong>16.1</strong></td>
<td>-32.7</td>
</tr>
<tr>
<td>2</td>
<td><strong>20.9</strong></td>
<td>-16.8</td>
<td><strong>31.3</strong></td>
<td>-24.2</td>
</tr>
<tr>
<td>3</td>
<td>26.0</td>
<td>-13.7</td>
<td>38.6</td>
<td>-20.4</td>
</tr>
<tr>
<td>4</td>
<td>31.5</td>
<td>-10.2</td>
<td>45.5</td>
<td>-16.9</td>
</tr>
<tr>
<td>5</td>
<td>37.7</td>
<td>-6.1</td>
<td>52.2</td>
<td>-13.4</td>
</tr>
</tbody>
</table>

The iid assumption is violated...
In the period after a disaster, there is a probability $\pi$ that consumption increases by $- \log(1 - b)$. 
Introducing Recoveries in the Model

- In the period after a disaster, there is a probability $\pi$ that consumption increases by $-\log(1 - b)$.
- $\pi = 0$: Barro-Rietz model.
Introducing Recoveries in the Model

- In the period after a disaster, there is a probability \( \pi \) that consumption increases by \( -\log(1 - b) \).
- \( \pi = 0 \): Barro-Rietz model.
- \( \pi = 1 \): Sure recovery.
Equity Premium with Recoveries

Figure:

François Gourio (BU)
How does P/D ratio change if you expect a recovery?

\[
\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},
\]
Explanation

How does P/D ratio change if you expect a recovery?

$$\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},$$

The possibility of a future recovery can increase or decrease the stock price, depending on $\gamma > 1$ or $\gamma < 1$. 
How does P/D ratio change if you expect a recovery?

\[
\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},
\]

The possibility of a future recovery can increase or decrease the stock price, depending on $\gamma > 1$ or $\gamma < 1$.

Intuition: two effects
How does P/D ratio change if you expect a recovery?

$$\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},$$

The possibility of a future recovery can increase or decrease the stock price, depending on $\gamma > 1$ or $\gamma < 1$.

Intuition: two effects

1. cash-flow effect: recovery will increase dividends (=consumption).

François Gourio (BU) Disasters and Asset Pricing 2008 13 / 41
How does P/D ratio change if you expect a recovery?

\[
\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},
\]

The possibility of a future recovery can increase or decrease the stock price, depending on \( \gamma > 1 \) or \( \gamma < 1 \).

Intuition: two effects

1. cash-flow effect: recovery will increase dividends (=consumption).
2. discount rate effect: recovery will increase consumption, so interest rates increase today.
How does P/D ratio change if you expect a recovery?

\[ \frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma}, \]

The possibility of a future recovery can increase or decrease the stock price, depending on \( \gamma > 1 \) or \( \gamma < 1 \).

Intuition: two effects

1. cash-flow effect: recovery will increase dividends (=consumption).
2. discount rate effect: recovery will increase consumption, so interest rates increase today.

With low IES, \( \frac{P_t}{C_t} \) falls more following a disaster if there is a possible recovery.
How does P/D ratio change if you expect a recovery?

$$\frac{P_t}{C_t} = E_t \sum_{k \geq 1} \beta^k \left( \frac{C_{t+k}}{C_t} \right)^{1-\gamma},$$

The possibility of a future recovery can increase or decrease the stock price, depending on $\gamma > 1$ or $\gamma < 1$.

Intuition: two effects

1. cash-flow effect: recovery will increase dividends (≡consumption).
2. discount rate effect: recovery will increase consumption, so interest rates increase today.

With low IES, $\frac{P_t}{C_t}$ falls more following a disaster if there is a possible recovery.

Ex-ante equities are riskier.
Effect of Recoveries with Epstein-Zin utility

François Gourio (BU)
Disasters and Asset Pricing
2008 14 / 41
Low IES: very high interest rates, low P-D ratio.
Implications of Recoveries for Asset Prices during Disasters

- Low IES: very high interest rates, low P-D ratio.
- High IES: not so high interest rates, P-D ratio rises slightly.
Implications of Recoveries for Asset Prices during Disasters

- Low IES: very high interest rates, low P-D ratio.
- High IES: not so high interest rates, P-D ratio rises slightly.
- Empirically: interest rate not so high, but P-D ratios fall (modestly).
Low IES: very high interest rates, low P-D ratio.
High IES: not so high interest rates, P-D ratio rises slightly.
Empirically: interest rate not so high, but P-D ratios fall (modestly).
May need higher risk in disasters to fit these data.
P-E ratio not really low in the Great Depression

P/E ratio, U.S., Shiller Data

P-E ratio is not low!
Prices and Earnings fell by similar amount
Time-Series Predictability: Empirical Evidence

- So far constant equity premium and P-D ratio, stock return is iid.
So far constant equity premium and P-D ratio, stock return is iid.

In data, equity premium varies over time:

\[ R_{t+1}^e - R_{t+1}^f = \alpha + \beta \frac{D_t}{P_t} + \epsilon_{t+1}, \]

\[ \beta = 3.83, \ t\text{-stat} = 2.61, \ R^2 = 7.4\% \]
So far constant equity premium and P-D ratio, stock return is iid.

In data, equity premium varies over time:

\[ R_{t+1}^e - R_{t+1}^f = \alpha + \beta \frac{D_t}{P_t} + \varepsilon_{t+1}, \]

\[ \beta = 3.83, \text{t-stat} = 2.61, R^2 = 7.4\% \]

Results very similar if predict equity returns:

\[ R_{t+1}^e = \alpha + \beta \frac{D_t}{P_t} + \varepsilon_{t+1}, \]

\[ \beta = 3.39 \text{ t-stat} = 2.28, R^2 = 5.8\% \]
So far constant equity premium and P-D ratio, stock return is iid.

In data, equity premium varies over time:

\[ R_{t+1}^e - R_{t+1}^f = \alpha + \beta \frac{D_t}{P_t} + \varepsilon_{t+1}, \]

\[ \beta = 3.83, \text{ t-stat} = 2.61, R^2 = 7.4\% \]

Results very similar if predict equity returns:

\[ R_{t+1}^e = \alpha + \beta \frac{D_t}{P_t} + \varepsilon_{t+1}, \]

\[ \beta = 3.39 \text{ t-stat} = 2.28, R^2 = 5.8\% \]

i.e., "predictability comes from risk premia, not the risk-free rate".
So far constant equity premium and P-D ratio, stock return is iid.

In data, equity premium varies over time:

\[ R_{t+1}^e - R_{t+1}^f = \alpha + \beta \frac{D_t}{P_t} + \epsilon_{t+1}, \]

\[ \beta = 3.83, \text{t-stat} = 2.61, R^2 = 7.4\% \]

Results very similar if predict equity returns:

\[ R_{t+1}^e = \alpha + \beta \frac{D_t}{P_t} + \epsilon_{t+1}, \]

\[ \beta = 3.39, \text{t-stat} = 2.28, R^2 = 5.8\% \]

i.e., "predictability comes from risk premia, not the risk-free rate".

Is the disaster model consistent with these patterns?
Theoretical Result: Time-Varying Probability of Disaster

- A1: representative consumer with CRRA utility.
Theoretical Result: Time-Varying Probability of Disaster

- A1: representative consumer with CRRA utility.
- A2: Consumption process:

\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} \text{ with prob } 1 - p_t,
\]

\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b), \text{ with prob } p_t,
\]

- A3: \( p_{t+1} \) is Markov: \( F(p_{t+1} | p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \). Then:

1. Equity premium increasing in \( p_t \),
2. Expected equity return \( E_{t+1} \) decreasing in \( p_t \),
3. P-D ratio is increasing in \( p_t \). γ > 1.

Intuition: high \( p_t \) leads to more (precautionary) savings, low interest rates, and high equity risk premium.
Theoretical Result: Time-Varying Probability of Disaster

- **A1**: representative consumer with CRRA utility.
- **A2**: Consumption process:

  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} \text{ with prob } 1 - p_t, \\
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b), \text{ with prob } p_t,
  \]

- **A3**: \( p_{t+1} \) is Markov: \( F(p_{t+1}|p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).
Theoretical Result: Time-Varying Probability of Disaster

- **A1:** representative consumer with CRRA utility.
- **A2:** Consumption process:
  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} \text{ with prob } 1 - p_t,
  \]
  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b) , \text{ with prob } p_t,
  \]
- **A3:** \( p_{t+1} \) is Markov: \( F(p_{t+1}|p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).
- Then:

Intuition: high \( p_t \) leads to more (precautionary) savings, low interest rates, and high equity risk premium.
Theoretical Result: Time-Varying Probability of Disaster

- **A1**: representative consumer with CRRA utility.
- **A2**: Consumption process:
  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} \text{ with prob } 1 - p_t, \\
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b), \text{ with prob } p_t,
  \]
- **A3**: \( p_{t+1} \) is Markov: \( F(p_{t+1} | p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).
- Then:

1. Equity premium increasing in \( p_t \),
Theoretical Result: Time-Varying Probability of Disaster

- A1: representative consumer with CRRA utility.
- A2: Consumption process:
  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} \text{ with prob } 1 - p_t,
  \]
  \[
  \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b), \text{ with prob } p_t,
  \]
- A3: \( p_{t+1} \) is Markov: \( F(p_{t+1}|p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).

Then:

1. Equity premium increasing in \( p_t \),
2. Expected equity return \( E_t R_{t+1}^e \) decreasing in \( p_t \).
Theoretical Result: Time-Varying Probability of Disaster

A1: representative consumer with CRRA utility.

A2: Consumption process:

\[ \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} \text{ with prob } 1 - p_t, \]
\[ \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b), \text{ with prob } p_t, \]

A3: \( p_{t+1} \) is Markov: \( F(p_{t+1} \mid p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).

Then:

1. Equity premium increasing in \( p_t \),
2. Expected equity return \( E_t R_{t+1}^e \) decreasing in \( p_t \),
3. P-D ratio is increasing in \( p_t \) iff \( \gamma > 1 \).
Theoretical Result: Time-Varying Probability of Disaster

- A1: representative consumer with CRRA utility.
- A2: Consumption process:
  \[ \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} \text{ with prob } 1 - p_t, \]
  \[ \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b), \text{ with prob } p_t, \]
- A3: \( p_{t+1} \) is Markov: \( F(p_{t+1}|p_t) \), and that \( p_{t+1} \) and realization of disaster are independent, conditional on \( p_t \).
- Then:
  1. Equity premium increasing in \( p_t \),
  2. Expected equity return \( E_t R_{t+1}^e \) decreasing in \( p_t \),
  3. P-D ratio is increasing in \( p_t \) iff \( \gamma > 1 \).
  
Intuition: high \( p_t \) leads to more (precautionary) savings, low interest rates, and high equity risk premium.
A conundrum for the disaster model

- Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.
A conundrum for the disaster model

- Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.
- The model cannot generate this:

$$\gamma > 1 \text{ (IES} < 1), \text{ the P-D ratio is increasing in } p_t, \text{ and a high P-D forecasts a high equity excess return.}$$

$$\gamma < 1 \text{ (IES} > 1), \text{ a high P-D ratio forecasts a low equity excess return but a high equity return.}$$

Neither fits the data.

"Interest rate too volatile in the model"

François Gourio (BU)
Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.

The model can not generate this:

- If $\gamma > 1$ (IES$<1$), the P-D ratio is *increasing* in $p_t$, and a high P-D forecasts a *high* equity excess return.
A conundrum for the disaster model

- Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.
- The model can not generate this:
  - If $\gamma > 1$ (IES $< 1$), the P-D ratio is *increasing* in $p_t$, and a high P-D forecasts a *high* equity excess return.
  - If $\gamma < 1$ (IES $> 1$), a high P-D ratio forecasts a low equity excess return but a *high* equity return.
A conundrum for the disaster model

- Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.
- The model can not generate this:
  - If $\gamma > 1$ (IES < 1), the P-D ratio is increasing in $p_t$, and a high P-D forecasts a high equity excess return.
  - If $\gamma < 1$ (IES > 1), a high P-D ratio forecasts a low equity excess return but a high equity return.
- Neither fits the data.
A conundrum for the disaster model

- Matching the regressions requires that the expected equity premium and expected equity return are positively correlated.
- The model can not generate this:
  - If $\gamma > 1$ (IES $< 1$), the P-D ratio is *increasing* in $p_t$, and a high P-D forecasts a *high* equity excess return.
  - If $\gamma < 1$ (IES $> 1$), a high P-D ratio forecasts a low equity excess return but a *high* equity return.
- Neither fits the data.
- "Interest rate too volatile in the model"
One solution: time-varying size of dividend disaster

- One resolution: size of dividend disaster change over time, but not size of consumption disaster:

\[ \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1}, \]
and \[ \Delta \log D_{t+1} = \mu + \sigma \varepsilon_{t+1}, \text{with probability } 1 - p; \]

or \[ \Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b), \]
and \[ \Delta \log D_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - d_t), \text{ with probability } p, \]
One solution: time-varying size of dividend disaster

- One resolution: size of dividend disaster change over time, but not size of consumption disaster:

\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1},
\]

and \( \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} \), with probability \( 1 - p \);

or \( \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b) \),

and \( \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - d_t) \), with probability \( p \),

- And \( d_t \) follows some Markov process.
One solution: time-varying size of dividend disaster

- One resolution: size of dividend disaster change over time, but not size of consumption disaster:

\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1},
\]
and \( \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} \), with probability \( 1 - p \);

or \( \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b) \),

and \( \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - d_t) \), with probability \( p \),

- And \( d_t \) follows some Markov process.

- Then, interest rates are constant and volatile risk premia.
One solution: time-varying size of dividend disaster

- One resolution: size of dividend disaster change over time, but **not** size of consumption disaster:

\[
\Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1},
\]
and
\[
\Delta \log D_{t+1} = \mu + \sigma \varepsilon_{t+1}, \text{with probability } 1 - p;
\]

or
\[
\Delta \log C_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - b),
\]
and
\[
\Delta \log D_{t+1} = \mu + \sigma \varepsilon_{t+1} + \log(1 - d_t), \text{ with probability } p,
\]

- And \( d_t \) follows some Markov process.
- Then, interest rates are constant and volatile risk premia.
- Matches the facts above, but
One solution: time-varying size of dividend disaster

One resolution: size of dividend disaster change over time, but not size of consumption disaster:

\[ \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1}, \]
and \[ \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1}, \] with probability \( 1 - p \);

or \[ \Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b), \]
and \[ \Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - d_t), \] with probability \( p \),

- And \( d_t \) follows some Markov process.
- Then, interest rates are constant and volatile risk premia.
- Matches the facts above, but
  - unusual "time-varying expected leverage" of stocks.
One solution: time-varying size of dividend disaster

- One resolution: size of dividend disaster change over time, but not size of consumption disaster:

\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1},
\]

and
\[
\Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1}, \text{ with probability } 1 - p;
\]

or
\[
\Delta \log C_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - b),
\]

and
\[
\Delta \log D_{t+1} = \mu + \sigma \epsilon_{t+1} + \log(1 - d_t), \text{ with probability } p,
\]

- And \(d_t\) follows some Markov process.
- Then, interest rates are constant and volatile risk premia.
- Matches the facts above, but
  - unusual "time-varying expected leverage" of stocks.
  - does not explain why "risk premia move all together"
Another solution: Epstein-Zin utility

• Can show analytically than an IES > 1 allows to get the correct sign.
Another solution: Epstein-Zin utility

- Can show analytically than an IES > 1 allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
Another solution: Epstein-Zin utility

- Can show analytically than an IES \( > 1 \) allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
- Leverage = 3, IES = 1.5.
Another solution: Epstein-Zin utility

- Can show analytically than an IES > 1 allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
- Leverage = 3, IES = 1.5.
- Probability of disaster oscillates between high and low state: transition probability $\pi$.

$$p_h = 0.017 + \varepsilon, \quad p_l = 0.017 - \varepsilon$$
Another solution: Epstein-Zin utility

- Can show analytically than an IES > 1 allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
- Leverage = 3, IES = 1.5.
- Probability of disaster oscillates between high and low state: transition probability $\pi$.

$$p_h = 0.017 + \varepsilon, \quad p_l = 0.017 - \varepsilon$$

- Pick parameters $\pi, \varepsilon$ to match $\sigma(P - D)$, regression slope:

$$\pi = 0.043, \quad \varepsilon \approx 0.017.$$
Another solution: Epstein-Zin utility

- Can show analytically than an IES > 1 allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
- Leverage = 3, IES = 1.5.
- Probability of disaster oscillates between high and low state: transition probability $\pi$.

\[ p_h = 0.017 + \varepsilon, \quad p_l = 0.017 - \varepsilon \]

- Pick parameters $\pi, \varepsilon$ to match $\sigma(P - D)$, regression slope:

\[ \pi = 0.043, \quad \varepsilon \sim 0.017. \]

- Highly volatile probability of disaster.
Another solution: Epstein-Zin utility

- Can show analytically than an IES $> 1$ allows to get the correct sign.
- Trying to match this quantitatively using Barro’s parameters.
- Leverage = 3, IES = 1.5.
- Probability of disaster oscillates between high and low state: transition probability $\pi$.

\[ p_h = 0.017 + \varepsilon, \quad p_l = 0.017 - \varepsilon \]

- Pick parameters $\pi, \varepsilon$ to match $\sigma(P - D)$, regression slope:

\[ \pi = 0.043, \quad \varepsilon \approx 0.017. \]

- Highly volatile probability of disaster.
- Equity premium too high then.
If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.
Cross-Sectional Tests

- If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.
- Ex.: defense stocks, gold, ...

François Gourio (BU)
Disasters and Asset Pricing
Cross-Sectional Tests

- If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.
- Ex.: defense stocks, gold, ...
- Puzzles in the finance literature: value - size - momentum.
Cross-Sectional Tests

- If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.
- Ex.: defense stocks, gold, ...
- Puzzles in the finance literature: value - size - momentum.
- Distinguish two models:
Cross-Sectional Tests

- If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.
- Ex.: defense stocks, gold, ...
- Puzzles in the finance literature: value - size - momentum.
- Distinguish two models:
  - baseline Barro-Rietz model: constant probability of disaster, but different exposures to disasters.
If disasters drive equity risk premia, assets which do relatively better in disasters should have low average returns.

Ex.: defense stocks, gold, ...

Puzzles in the finance literature: value - size - momentum.

Distinguish two models:

1. baseline Barro-Rietz model: constant probability of disaster, but different exposures to disasters.

2. Gabaix-style model: time-varying prob of disaster, and perhaps no disaster realized in sample.
9/11 as ‘Natural Experiment’

- Use the return on 9/17 as a proxy for exposure to disaster:

![Graph showing correlations between stock returns and defensive investments.](image)

Mean return of defense, gold, tobacco stocks is not low!

François Gourio (BU)  
Disasters and Asset Pricing  
2008  
24 / 41
9/11 as ‘Natural Experiment’

- Use the return on 9/17 as a proxy for exposure to disaster:

> Mean return of defense, gold, tobacco stocks is not low!
Fama-French 25 returns on 9-17 vs. mean excess returns

\[ \text{correl} = -0.16965 \]
### Data from 9-17-01

<table>
<thead>
<tr>
<th></th>
<th>$E(R)$</th>
<th>Return on 9-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>HML</td>
<td>0.40</td>
<td>-0.93</td>
</tr>
<tr>
<td>t-stat</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>SMB</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>t-stat</td>
<td>2.19</td>
<td></td>
</tr>
<tr>
<td>UMD</td>
<td>0.76</td>
<td>2.72</td>
</tr>
<tr>
<td>t-stat</td>
<td>5.01</td>
<td></td>
</tr>
<tr>
<td>SV-SG</td>
<td>0.49</td>
<td>-0.20</td>
</tr>
<tr>
<td>t-stat</td>
<td>4.14</td>
<td></td>
</tr>
</tbody>
</table>
Measuring the Exposure to Large Negative Market Returns

- Measure exposure to large decreases in the stock market.

First step: find $\beta_{di}$ by a time-series regression, for each asset:

$$R_{it} + 1 = \alpha_i + \beta_{di} R_{mt} + 1 + \epsilon_{it} + 1.$$

Second step: do $\beta_{di}$ "explain" the differences in average returns?

"Disaster CAPM"

Measuring the Exposure to Large Negative Market Returns

- Measure exposure to large decreases in the stock market.
- First step: find $\beta_i^d$ by a time-series regression, for each asset:

$$R_{t+1}^i - R_{t+1}^f = \alpha_i + \beta_i^d \left( R_{t+1}^m - R_{t+1}^f \right) \times 1_{R_{t+1}^m - R_{t+1}^f < -10} + \epsilon_{it+1}.$$
Measure exposure to large decreases in the stock market.

First step: find $\beta_i^d$ by a time-series regression, for each asset:

$$R_{t+1}^i - R_{t+1}^f = \alpha_i + \beta_i^d \left( R_{t+1}^m - R_{t+1}^f \right) \times 1_{R_{t+1}^m - R_{t+1}^f < -10} + \epsilon_{it+1}.$$ 

Second step: do $\beta_i^d$ "explain" the differences in average returns?
Measuring the Exposure to Large Negative Market Returns

- Measure exposure to large decreases in the stock market.
- First step: find $\beta_i^d$ by a time-series regression, for each asset:

$$R_{t+1}^i - R_{t+1}^f = \alpha_i + \beta_i^d \left( R_{t+1}^m - R_{t+1}^f \right) \times 1_{R_{t+1}^m - R_{t+1}^f < -10} + \epsilon_{it+1}.$$ 

- Second step: do $\beta_i^d$ "explain" the differences in average returns?
- "Disaster CAPM"
Measure exposure to large decreases in the stock market.

First step: find $\beta_i^d$ by a time-series regression, for each asset:

$$R_{t+1}^i - R_{t+1}^f = \alpha_i + \beta_i^d \left( R_{t+1}^m - R_{t+1}^f \right) \times 1_{R_{t+1}^m - R_{t+1}^f < -10} + \varepsilon_{it+1}.$$ 

Second step: do $\beta_i^d$ "explain" the differences in average returns?

"Disaster CAPM"

Evaluating the "Disaster CAPM"

Figure: CAPM (top panel) and Disaster CAPM (bottom panel).
Disaster Beta and Market Beta are highly correlated
Estimating the model with time-varying probability of disaster and Epstein-Zin utility (work in progress)

- probability of disaster unobservable $\Rightarrow$ SDF unobserved.
Estimating the model with time-varying probability of disaster and Epstein-Zin utility (work in progress)

- probability of disaster unobservable $\Rightarrow$ SDF unobserved.
- solution: extract probability of disaster from asset prices.
Estimating the model with time-varying probability of disaster and Epstein-Zin utility (work in progress)

- probability of disaster unobservable $\Rightarrow$ SDF unobserved.
- solution: extract probability of disaster from asset prices.
- e.g., use the P-D ratio: $\frac{P_t}{D_t} = f(p_t; \text{parameters})$. 

François Gourio (BU)

Disasters and Asset Pricing
Estimating the model with time-varying probability of disaster and Epstein-Zin utility (work in progress)

- probability of disaster unobservable $\Rightarrow$ SDF unobserved.
- solution: extract probability of disaster from asset prices.
- e.g., use the P-D ratio: $\frac{P_t}{D_t} = f(p_t; \text{parameters})$. 
- given $p_t$, construct the SDF $M$ and test the conditions $E(MR^e_i) = 0$. 
Implied Probability of Disaster

François Gourio (BU)
Predicted mean returns vs. Data mean returns
Conclusions

- In the data, most disasters are not permanent.
Conclusions

- In the data, most disasters are not permanent.
- Incorporating this in the model changes the conclusions:
Conclusions

- In the data, most disasters are **not** permanent.
- Incorporating this in the model changes the conclusions:
  - $\text{IES} > 1 \rightarrow$ lower risk premia.
Conclusions

- In the data, most disasters are **not** permanent.

- Incorporating this in the model changes the conclusions:
  - $\text{IES} > 1 \rightarrow$ lower risk premia.
  - $\text{IES} < 1 \rightarrow$ higher risk premia.
Conclusions

- In the data, most disasters are **not** permanent.
- Incorporating this in the model changes the conclusions:
  - $\text{IES} > 1$ → lower risk premia.
  - $\text{IES} < 1$ → higher risk premia.
- TS predictability hard to reconcile with the disaster model.
Conclusions

- In the data, most disasters are not permanent.
- Incorporating this in the model changes the conclusions:
  - $\text{IES}>1 \rightarrow$ lower risk premia.
  - $\text{IES}<1 \rightarrow$ higher risk premia.
- TS predictability hard to reconcile with the disaster model.
  - Impossible to get with CRRA and changing probability of disaster.
Conclusions

- In the data, most disasters are **not** permanent.
- Incorporating this in the model changes the conclusions:
  - $\text{IES} > 1 \rightarrow$ lower risk premia.
  - $\text{IES} < 1 \rightarrow$ higher risk premia.
- TS predictability hard to reconcile with the disaster model.
  - **Impossible** to get with CRRA and changing probability of disaster.
  - Requires highly volatile prob of disaster with E-Zin utility.
In the data, most disasters are **not** permanent.

Incorporating this in the model changes the conclusions:

- $\text{IES} > 1 \rightarrow$ lower risk premia.
- $\text{IES} < 1 \rightarrow$ higher risk premia.

TS predictability hard to reconcile with the disaster model.

- **Impossible** to get with CRRA and changing probability of disaster.
- Requires highly volatile prob of disaster with E-Zin utility.
- Time-varying size of dividend disaster. Unappealing.
Conclusions

- In the data, most disasters are not permanent.
- Incorporating this in the model changes the conclusions:
  - IES > 1 → lower risk premia.
  - IES < 1 → higher risk premia.
- TS predictability hard to reconcile with the disaster model.
  - Impossible to get with CRRA and changing probability of disaster.
  - Requires highly volatile prob of disaster with E-Zin utility.
  - Time-varying size of dividend disaster. Unappealing.
  - Need high IES → tension with the need for low IES for recoveries.
In the data, most disasters are not permanent.

Incorporating this in the model changes the conclusions:

- $\text{IES} > 1 \rightarrow$ lower risk premia.
- $\text{IES} < 1 \rightarrow$ higher risk premia.

TS predictability hard to reconcile with the disaster model.

- **Impossible** to get with CRRA and changing probability of disaster.
- Requires highly volatile prob of disaster with E-Zin utility.
- Time-varying size of dividend disaster. Unappealing.
- Need high $\text{IES} \rightarrow \text{tension}$ with the need for low $\text{IES}$ for recoveries.

Cross-sectional evidence is mixed.
Barro’s measures of disasters

- Data on **GDP per capita** in XXth century (Maddison).
- 20 OECD countries + 15 countries from Latin America and Asia.
- Defines disaster as fall in GDP greater than 15% (peak-to-trough).
- Finds 60 disasters.
- Prob of disaster = $\frac{60}{35} = 1.7\%$ per year.
- Average peak-to-trough decline is 29%.
- Mainly WWI, Great Depression, WWII, Latin America post WWII.
Figure: Impact of the speed of recovery on the unconditional equity premium in the model, for two elasticities of substitution parameters.
Another interesting case: disasters not "pure jumps" but occur over several years.
Another interesting case: disasters not "pure jumps" but occur over several years.

i.e. positive autocorrelation at beginning of disasters.
Another interesting case: disasters not "pure jumps" but occur over several years.

i.e. positive autocorrelation at beginning of disasters.

The previous analysis applies in reverse:
Another interesting case: disasters not "pure jumps" but occur over several years.

i.e. positive autocorrelation at beginning of disasters.

The previous analysis applies in reverse:

- low IES $\rightarrow$ lower risk premia;
Another interesting case: disasters not "pure jumps" but occur over several years.

i.e. positive autocorrelation at beginning of disasters.

The previous analysis applies in reverse:

- low IES $\rightarrow$ lower risk premia;
- high IES $\rightarrow$ higher risk premia.
Cross-Sectional Tests: Theory

\[ \Delta \log D_{it} = \mu_i + \lambda_i \varepsilon_t \]

\[ = \mu_i + \lambda_i \varepsilon_t + \eta_i \log(1 - b) \]

- Exposure to "business cycle shocks" \( \lambda_i \).

François Gourio (BU)
Cross-Sectional Tests: Theory

\[ \Delta \log D_{it} = \mu_i + \lambda_i \epsilon_t \]
\[ = \mu_i + \lambda_i \epsilon_t + \eta_i \log(1 - b) \]

- Exposure to "business cycle shocks" \( \lambda_i \).
- Exposure to disasters \( \eta_i \).
Cross-Sectional Tests: Theory

\[ \Delta \log D_{it} = \mu_i + \lambda_i \varepsilon_t \]
\[ = \mu_i + \lambda_i \varepsilon_t + \eta_i \log(1 - b) \]

- Exposure to "business cycle shocks" \( \lambda_i \).
- Exposure to disasters \( \eta_i \).
- Implied stock \( i \) excess return:

\[ \log \frac{ER^e_i}{R^f} = \lambda_i \sigma \gamma + \log \left( \frac{(1 - p + p(1 - b)^{-\gamma})(1 - p + p(1 - b)^{\eta_i})}{1 - p + p(1 - b)^{\eta_i - \gamma}} \right). \]
Motivation for 1-factor disaster model

CAPM and 1f disaster model on whole sample

François Gourio (BU)
Effect of Recoveries with Epstein-Zin utility

<table>
<thead>
<tr>
<th>Probability of a recovery $\pi$</th>
<th>0.00</th>
<th>0.30</th>
<th>0.60</th>
<th>0.90</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>IES = 0.25</td>
<td>3.31</td>
<td>4.62</td>
<td>5.91</td>
<td>7.19</td>
<td>7.64</td>
</tr>
<tr>
<td>IES = 0.50</td>
<td>3.31</td>
<td>3.30</td>
<td>3.03</td>
<td>2.26</td>
<td>1.68</td>
</tr>
<tr>
<td>IES = 1</td>
<td>3.31</td>
<td>2.69</td>
<td>1.94</td>
<td>1.00</td>
<td>0.54</td>
</tr>
<tr>
<td>IES = 2</td>
<td>3.31</td>
<td>2.42</td>
<td>1.52</td>
<td>0.63</td>
<td>0.30</td>
</tr>
</tbody>
</table>

*Table:* Equity premium, as a function of the intertemporal elasticity of substitution (IES) and the probability of a recovery.
## Effect of Recoveries with Epstein-Zin utility

<table>
<thead>
<tr>
<th></th>
<th>$ER^b$</th>
<th>$ER^e$</th>
<th>$\sigma(R^e)$</th>
<th>$\sigma(R^b)$</th>
<th>$\sigma(D)$</th>
<th>$\sigma(pd)$</th>
<th>$\beta_{ReR^b}$</th>
<th>$\beta_{Re}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>1.62</td>
<td>16.47</td>
<td>23.55</td>
<td>2.55</td>
<td>6.48</td>
<td>.411</td>
<td>3.77</td>
<td>2.750</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>1.03</td>
<td>8.91</td>
<td>15.04</td>
<td>4.36</td>
<td>14.9</td>
<td>.415</td>
<td>3.83</td>
<td>3.39</td>
</tr>
</tbody>
</table>