DISCUSSION OF:

"Can Time-Varying Risk of Rare Disasters Explain Aggregate Stock Market Volatility?"

by JESSICA WACHTER

Christian Julliard

Department of Economics and FMG
London School of Economics, and CEPR

NBER's Summer Institute, Asset Pricing workshop
July 10^{th} 2008

Outline

Closely Related Literature and Contributions

Rare Events and the Equity Premium:

- Rietz (1988), Barro (2006), Danthine-Donaldson (1999), Copeland-Zhu (2006), Gabaix (2007) ... $\Rightarrow$ all calibration exercises
- Julliard and Ghosh (2008) (more on this later)

This paper's key ingredients:

1. Recursive utility (e.g. Barro-Ursua (2008))
2. Time varying probability of disasters

Main new finding:

- match the observed volatility of stock returns thanks to the time variation in the probability of disasters (e.g. Gabaix (2007), with "linearity generating" processes and time-varying recovery rate of stocks in disasters)

Closely Related Literature and Contributions

Rare Events and the Equity Premium:

- Rietz (1988), Barro (2006), Danthine-Donaldson (1999), Copeland-Zhu (2006), Gabaix (2007) ... $\Rightarrow$ all calibration exercises
- Julliard and Ghosh (2008) (more on this later)

This paper's key ingredients:

1. Recursive utility (e.g. Barro-Ursua (2008))
2. Time varying probability of disasters

Main new finding:

- match the observed volatility of stock returns thanks to the time variation in the probability of disasters (e.g. Gabaix (2007), with "linearity generating" processes and time-varying recovery rate of stocks in disasters)

Closely Related Literature and Contributions

Rare Events and the Equity Premium:

- Rietz (1988), Barro (2006), Danthine-Donaldson (1999), Copeland-Zhu (2006), Gabaix (2007) ... $\Rightarrow$ all calibration exercises
- Julliard and Ghosh (2008) (more on this later)

This paper's key ingredients:

1. Recursive utility (e.g. Barro-Ursua (2008))
2. Time varying probability of disasters

Main new finding:

- match the observed volatility of stock returns thanks to the time variation in the probability of disasters (e.g. Gabaix (2007), with "linearity generating" processes and time-varying recovery rate of stocks in disasters)

Closely Related Literature and Contributions

Rare Events and the Equity Premium:

- Rietz (1988), Barro (2006), Danthine-Donaldson (1999), Copeland-Zhu (2006), Gabaix (2007) ... $\Rightarrow$ all calibration exercises
- Julliard and Ghosh (2008) (more on this later)

This paper's key ingredients:

1. Recursive utility (e.g. Barro-Ursua (2008))
2. Time varying probability of disasters

Main new finding:

- match the observed volatility of stock returns thanks to the time variation in the probability of disasters (e.g. Gabaix (2007), with "linearity generating" processes and time-varying recovery rate of stocks in disasters)

Closely Related Literature and Contributions

Rare Events and the Equity Premium:

- Rietz (1988), Barro (2006), Danthine-Donaldson (1999), Copeland-Zhu (2006), Gabaix (2007) ... $\Rightarrow$ all calibration exercises
- Julliard and Ghosh (2008) (more on this later)

This paper's key ingredients:

1. Recursive utility (e.g. Barro-Ursua (2008))
2. Time varying probability of disasters

Main new finding:

- match the observed volatility of stock returns thanks to the time variation in the probability of disasters (e.g. Gabaix (2007), with "linearity generating" processes and time-varying recovery rate of stocks in disasters)

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

The Degrees of Freedom: Calibrating Disasters

The key elements – annual consumption disasters size and probability – are calibrated as follows:

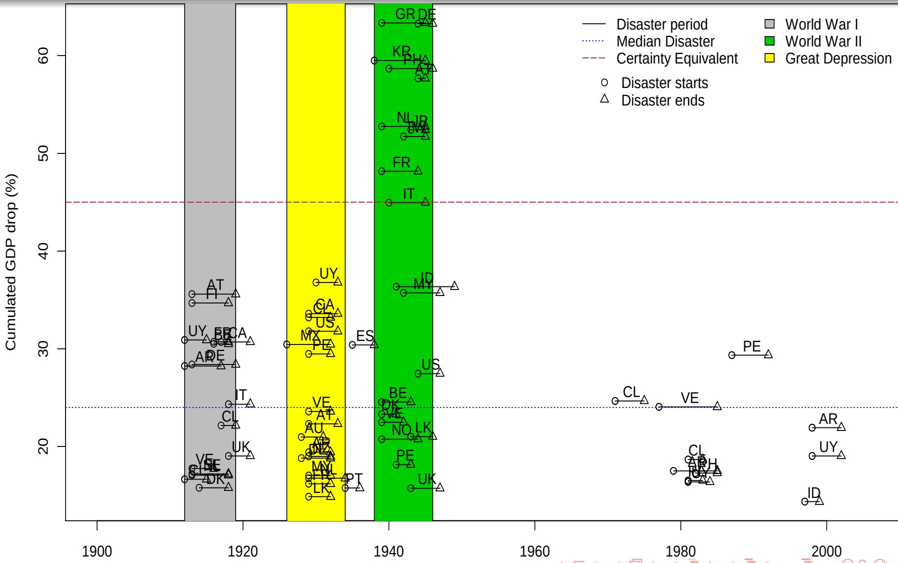
1. Average probability of disasters: from the empirical frequency, under cross-country independence assumption
2. Size of disasters: empirical distribution of multi-year cumulated GDP contractions (more on this later)

Note: both as in Barro (2006) (Maddison (2003) data on 35 countries over the period 1900-2000)

3. Volatility of the disaster probability: chosen to match the volatility of returns. Any benchmark?

Remark: results extremely sensitive to the calibrated values – need to report more sensitivity analysis in the paper.

Which Disasters Matter? Major 20^{th} Century GDP Disasters



Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: −40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions)

Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: -40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions)

Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: -40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions)

Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: -40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions).

Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: -40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions)

Remarks:

- Independence assumption clearly rejected

⇒ but small impact on key results

- Results driven entirely by events in the largest 14% of disasters (e.g. 9 disaster – 0.25% sample frequency)

⇒ dropping all other disasters reduces the equity premium by a mere 0.4%

Key disasters:

- most extreme WWII events: invasions, nuclear/fire-bombings, civil wars. Do government bonds pay-off in these states? Calibration: 60% of the time ⇒ stock excess return during disaster: -40.7%.

But: in the data, during these events stocks outperform bonds by an average 4.51% (Source: Barro (2006))

- In the data, it is only during the "smaller" 86% of disasters that bonds outperform stocks.

But: using only these "smaller" disasters the model cannot match the equity premium (too small contractions).

Market Returns and the Probability of Extreme Disasters

- Moreover, if time variation in the probability of extreme disasters is driving the volatility of returns, returns and risk premia should comove with the likelihood of these events.

⇒ Need evidence on this link.

A toy exercise: the "Doomsday Clock" (measures proximity to WWIII, biosecurity and climate change disasters. Source: *Bulletin of Atomic Scientists*, U-Chicago)

Market Returns and the Probability of Extreme Disasters

- Moreover, if time variation in the probability of extreme disasters is driving the volatility of returns, returns and risk premia should comove with the likelihood of these events.

⇒ Need evidence on this link.

A toy exercise: the "Doomsday Clock" (measures proximity to WWIII, biosecurity and climate change disasters. Source: *Bulletin of Atomic Scientists*, U-Chicago)

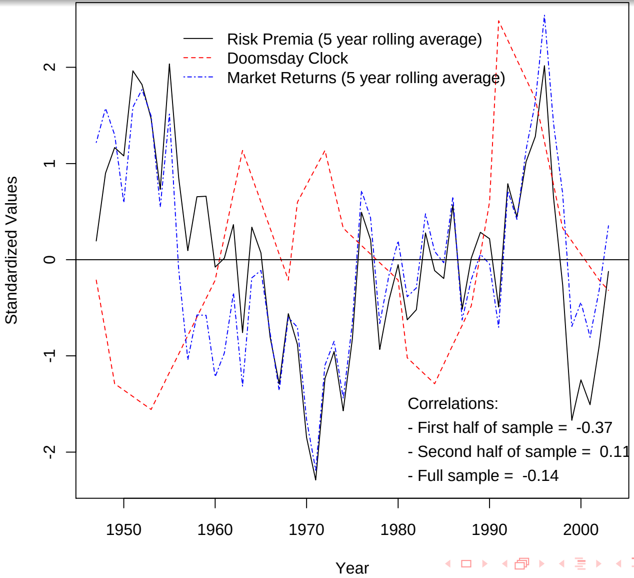
Market Returns and the Probability of Extreme Disasters

- Moreover, if time variation in the probability of extreme disasters is driving the volatility of returns, returns and risk premia should comove with the likelihood of these events.

⇒ Need evidence on this link.

A toy exercise: the "Doomsday Clock" (measures proximity to WWIII, biosecurity and climate change disasters. Source: *Bulletin of Atomic Scientists*, U-Chicago)

Market Returns and the Probability of Extreme Disasters



Time-Varying Intensity of Disasters

- The time-varying intensity of (Poisson) disasters is modeled as

$$d\lambda_t = \underbrace{\kappa}_{=.145}\left(\underbrace{\bar{\lambda}}_{=.017} - \lambda_t\right)dt + \underbrace{\sigma_\lambda}_{=.07}\sqrt{\lambda_t}dB_t$$

- This is a strong amplifier mechanism of the relevance of disasters since:
  1. the process can take unboundedly high values, and large values have non trivial probability cdf of λ_t
  2. when high values are reached, the process will tend to stay there for long (due to small κ) Simulated Time Path

⇒ Indeed, modest increases in RRA send the risk premium in the 3 digits range.

- It would be nice to provide a real world benchmark for the process ⇒ Index Options?

Calibrating Consumption Disasters

Time-Varying Intensity of Disasters

- The time-varying intensity of (Poisson) disasters is modeled as

$$d\lambda_t = \underbrace{\kappa}_{=.145}\left(\underbrace{\bar{\lambda}}_{=.017} - \lambda_t\right)dt + \underbrace{\sigma_\lambda}_{=.07}\sqrt{\lambda_t}dB_t$$

- This is a strong amplifier mechanism of the relevance of disasters since:
  1. the process can take unboundedly high values, and large values have non trivial probability ▸ cdf of λ_t
  2. when high values are reached, the process will tend to stay there for long (due to small κ) ▸ Simulated Time Path

$\Rightarrow$ Indeed, modest increases in RRA send the risk premium in the 3 digits range.

- It would be nice to provide a real world benchmark for the process $\Rightarrow$ Index Options?

▸ Calibrating Consumption Disasters

Time-Varying Intensity of Disasters

- The time-varying intensity of (Poisson) disasters is modeled as

$$d\lambda_t = \underbrace{\kappa}_{=.145}\left(\underbrace{\bar{\lambda}}_{=.017} - \lambda_t\right) dt + \underbrace{\sigma_\lambda}_{=.07}\sqrt{\lambda_t}\, dB_t$$

- This is a strong amplifier mechanism of the relevance of disasters since:
  1. the process can take unboundedly high values, and large values have non trivial probability ▸ cdf of λ_t
  2. when high values are reached, the process will tend to stay there for long (due to small κ) ▸ Simulated Time Path

⇒ Indeed, modest increases in RRA send the risk premium in the 3 digits range.

- It would be nice to provide a real world benchmark for the process ⇒ Index Options?

▸ Calibrating Consumption Disasters

Time-Varying Intensity of Disasters

- The time-varying intensity of (Poisson) disasters is modeled as

$$d\lambda_t = \underbrace{\kappa}_{=.145} \left(\underbrace{\bar{\lambda}}_{=.017} - \lambda_t \right) dt + \underbrace{\sigma_\lambda}_{=.07} \sqrt{\lambda_t} dB_t$$

- This is a strong amplifier mechanism of the relevance of disasters since:
  1. the process can take unboundedly high values, and large values have non trivial probability ▸ cdf of λ_t
  2. when high values are reached, the process will tend to stay there for long (due to small κ) ▸ Simulated Time Path

$\Rightarrow$ Indeed, modest increases in RRA send the risk premium in the 3 digits range.

- It would be nice to provide a real world benchmark for the process $\Rightarrow$ Index Options?

▸ Calibrating Consumption Disasters

Time-Varying Intensity of Disasters

- The time-varying intensity of (Poisson) disasters is modeled as

$$d\lambda_t = \underbrace{\kappa}_{=.145}\left(\underbrace{\bar{\lambda}}_{=.017} - \lambda_t\right) dt + \underbrace{\sigma_\lambda}_{=.07}\sqrt{\lambda_t} dB_t$$

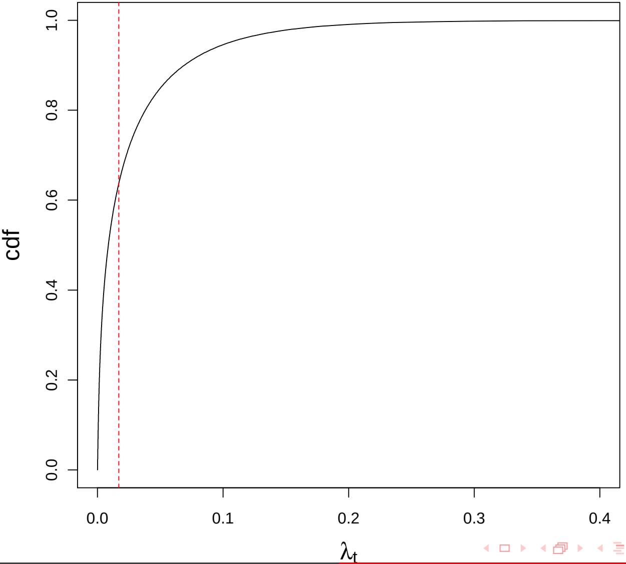
- This is a strong amplifier mechanism of the relevance of disasters since:
  1. the process can take unboundedly high values, and large values have non trivial probability cdf of λ_t
  2. when high values are reached, the process will tend to stay there for long (due to small κ) Simulated Time Path

⇒ Indeed, modest increases in RRA send the risk premium in the 3 digits range.

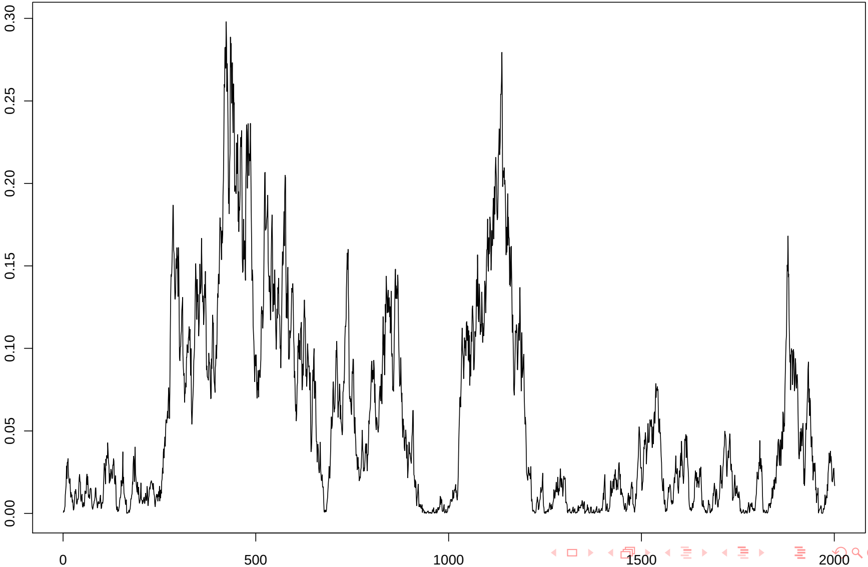
- It would be nice to provide a real world benchmark for the process ⇒ Index Options?

Calibrating Consumption Disasters

Cdf of λ_t



Simulated Time Path of λ_t



Calibrating Annual Consumption Disasters

This paper (as Barro (2006) and others):

1. calibrates disasters in a yearly model using cumulated multi-year contractions (average length of disasters is 3.5-4 years)
   Durations Annualized Disasters

   ⇒ the framework delivers at most a 2.2% risk premium using annualized disasters (risk averse agents fear much more a one year disaster than the same contraction spread over several periods).
   Lifetime Equivalent of One Disaster

2. assumes that consumption drops by as much as GDP

   ⇒ Mixed evidence: 152 crises for GDP and 95 for C; total C declines proportionately more during wartime crises. (US Great Depression contraction: GDP 31%; non-durable Consumption 17%)

Remark: these two assumptions alone rationalize the discrepancy with Julliard and Ghosh (2008) Counterfactual U.S. History

Calibrating Annual Consumption Disasters

This paper (as Barro (2006) and others):

1. calibrates disasters in a yearly model using cumulated multi-year contractions (average length of disasters is 3.5-4 years)

   Durations · Annualized Disasters

   ⇒ the framework delivers at most a 2.2% risk premium using annualized disasters (risk averse agents fear much more a one year disaster than the same contraction spread over several periods).

   Lifetime Equivalent of One Disaster

2. assumes that consumption drops by as much as GDP

   ⇒ Mixed evidence: 152 crises for GDP and 95 for C; total C declines proportionately more during wartime crises. (US Great Depression contraction: GDP 31%; non-durable Consumption 17%)

Remark: these two assumptions alone rationalize the discrepancy with Julliard and Ghosh (2008) Counterfactual U.S. History

Calibrating Annual Consumption Disasters

This paper (as Barro (2006) and others):

1. calibrates disasters in a yearly model using cumulated multi-year contractions (average length of disasters is 3.5-4 years)
   Durations | Annualized Disasters

⇒ the framework delivers at most a 2.2% risk premium using annualized disasters (risk averse agents fear much more a one year disaster than the same contraction spread over several periods).
   Lifetime Equivalent of One Disaster

2. assumes that consumption drops by as much as GDP

⇒ Mixed evidence: 152 crises for GDP and 95 for C; total C declines proportionately more during wartime crises. (US Great Depression contraction: GDP 31%; non-durable Consumption 17%)

Remark: these two assumptions alone rationalize the discrepancy with Julliard and Ghosh (2008) Counterfactual U.S. History

Calibrating Annual Consumption Disasters

This paper (as Barro (2006) and others):

1. calibrates disasters in a yearly model using cumulated multi-year contractions (average length of disasters is 3.5-4 years)
   ▸ Durations ▸ Annualized Disasters

⇒ the framework delivers at most a 2.2% risk premium using annualized disasters (risk averse agents fear much more a one year disaster than the same contraction spread over several periods).
▸ Lifetime Equivalent of One Disaster

2. assumes that consumption drops by as much as GDP

⇒ Mixed evidence: 152 crises for GDP and 95 for C; total C declines proportionately more during wartime crises. (US Great Depression contraction: GDP 31%; non-durable Consumption 17%)

Remark: these two assumptions alone rationalize the discrepancy with Julliard and Ghosh (2008) ▸ Counterfactual U.S. History

Calibrating Annual Consumption Disasters

This paper (as Barro (2006) and others):

1. calibrates disasters in a yearly model using cumulated multi-year contractions (average length of disasters is 3.5-4 years)
   ▸ Durations ▸ Annualized Disasters

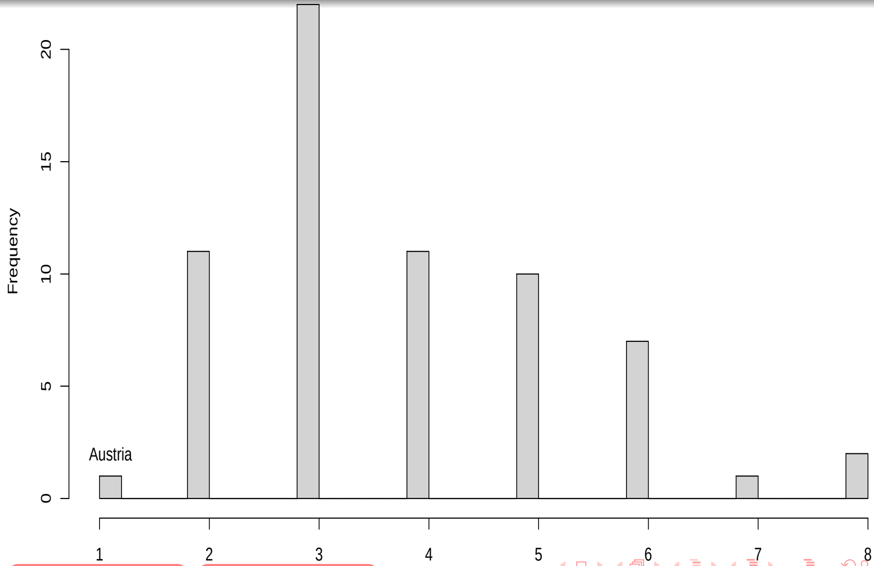
⇒ the framework delivers at most a 2.2% risk premium using annualized disasters (risk averse agents fear much more a one year disaster than the same contraction spread over several periods).
▸ Lifetime Equivalent of One Disaster

2. assumes that consumption drops by as much as GDP

⇒ Mixed evidence: 152 crises for GDP and 95 for C; total C declines proportionately more during wartime crises. (US Great Depression contraction: GDP 31%; non-durable Consumption 17%)

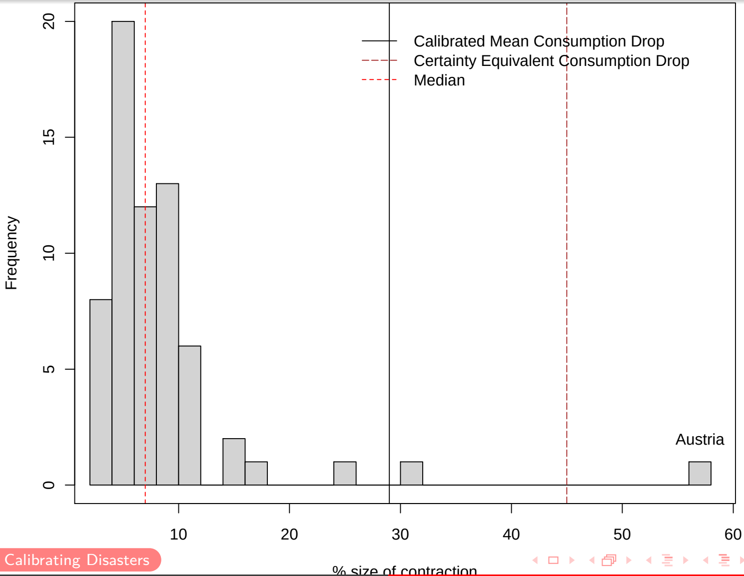
Remark: these two assumptions alone rationalize the discrepancy with Julliard and Ghosh (2008) ▸ Counterfactual U.S. History

Duration of Disasters (in years)



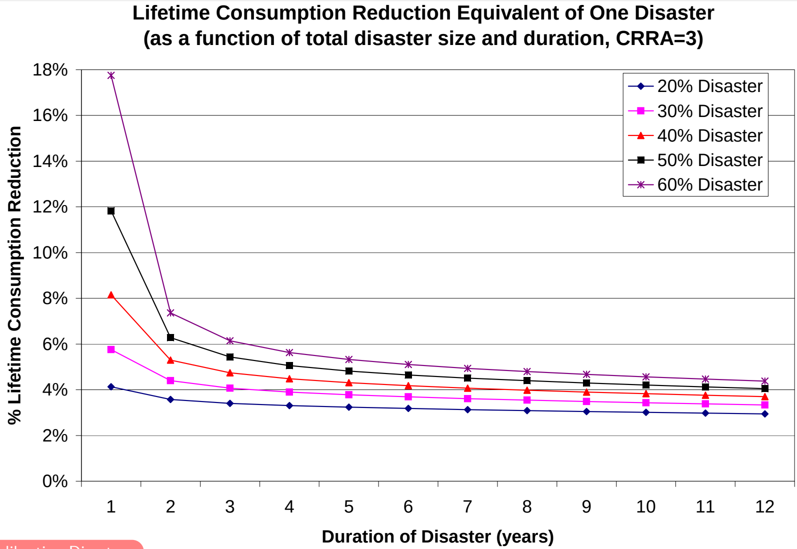
▸ Calibrating Disasters ▸ Annualized Disasters

Annualized GDP Disasters



Calibrating Disasters

Consumption Reduction Equivalent of One Disaster



Calibrating Disasters

A Counterfactual U.S. History

Consider:

1. replacing the four consumption data points of the Great Depression period, with one calibrated disaster equal to the cumulated GDP contraction during the same period;
2. applying the methodology of Julliard and Ghosh (2008) to this counterfactual 1929-2006 sample

Note: in the true sample $\hat{\gamma} \geq 32$, the CCAPM is rejected, and under the rare events hypothesis the observed equity premium puzzle would be very unlikely to arise.

Table 4: Estimation and Counterfactual EPP with Calibrated Disaster

	EL	*ET*	*BEL*	*BETEL*
Panel B. U.S. Great Depression Cumulated GDP Drop.				
$\hat{\gamma}$	11 (2.7)	11 (2.7)	11 [6.3, 19.8]	11 [6.4, 19.7]
$\chi^2_{(1)}$	0.07 (.792)	0.07 (.784)		
$\Pr(\gamma \leq 10 \mid \text{data})$			29.13%	28.71%
$\Pr\left(epp_i^T(\gamma) \geq epp^T(\gamma)\right)$	43.60%	43.30%		

A Counterfactual U.S. History

Consider:

1. replacing the four consumption data points of the Great Depression period, with one calibrated disaster equal to the cumulated GDP contraction during the same period;
2. applying the methodology of Julliard and Ghosh (2008) to this counterfactual 1929-2006 sample

Note: in the true sample $\hat{\gamma} \geq 32$, the CCAPM is rejected, and under the rare events hypothesis the observed equity premium puzzle would be very unlikely to arise.

Table 4: Estimation and Counterfactual EPP with Calibrated Disaster

	EL	*ET*	*BEL*	*BETEL*
Panel B. U.S. Great Depression Cumulated GDP Drop.				
$\hat{\gamma}$	11 (2.7)	11 (2.7)	11 [6.3, 19.8]	11 [6.4, 19.7]
$\chi^2_{(1)}$	0.07 (.792)	0.07 (.784)		
$\Pr(\gamma \leq 10 \mid \text{data})$			29.13%	28.71%
$\Pr\left(epp_i^T(\gamma) \geq epp^T(\gamma)\right)$	43.60%	43.30%		

A Counterfactual U.S. History

Consider:

1. replacing the four consumption data points of the Great Depression period, with one calibrated disaster equal to the cumulated GDP contraction during the same period;
2. applying the methodology of Julliard and Ghosh (2008) to this counterfactual 1929-2006 sample

Note: in the true sample $\hat{\gamma} \geq 32$, the CCAPM is rejected, and under the rare events hypothesis the observed equity premium puzzle would be very unlikely to arise.

Table 4: Estimation and Counterfactual EPP with Calibrated Disaster

	EL	*ET*	*BEL*	*BETEL*
Panel B. U.S. Great Depression Cumulated GDP Drop.				
$\hat{\gamma}$	11 (2.7)	11 (2.7)	11 [6.3, 19.8]	11 [6.4, 19.7]
$\chi^2_{(1)}$	0.07 (.792)	0.07 (.784)		
$\Pr(\gamma \leq 10 \mid \text{data})$			29.13%	28.71%
$\Pr\left(epp_i^T(\gamma) \geq epp^T(\gamma)\right)$	43.60%	43.30%		

A Counterfactual U.S. History

Consider:

1. replacing the four consumption data points of the Great Depression period, with one calibrated disaster equal to the cumulated GDP contraction during the same period;
2. applying the methodology of Julliard and Ghosh (2008) to this counterfactual 1929-2006 sample

Note: in the true sample $\hat{\gamma} \geq 32$, the CCAPM is rejected, and under the rare events hypothesis the observed equity premium puzzle would be very unlikely to arise.

Table 4: Estimation and Counterfactual EPP with Calibrated Disaster

	EL	*ET*	*BEL*	*BETEL*
Panel B. U.S. Great Depression Cumulated GDP Drop.				
$\hat{\gamma}$	11 (2.7)	11 (2.7)	11 [6.3, 19.8]	11 [6.4, 19.7]
$\chi^2_{(1)}$	0.07 (.792)	0.07 (.784)		
$\Pr(\gamma \leq 10 \mid \text{data})$			29.13%	28.71%
$\Pr\left(epp_i^T(\gamma) \geq epp^T(\gamma)\right)$	43.60%	43.30%		

A Counterfactual U.S. History

Consider:

1. replacing the four consumption data points of the Great Depression period, with one calibrated disaster equal to the cumulated GDP contraction during the same period;
2. applying the methodology of Julliard and Ghosh (2008) to this counterfactual 1929-2006 sample

Note: in the true sample $\hat{\gamma} \geq 32$, the CCAPM is rejected, and under the rare events hypothesis, the observed equity premium puzzle would be very unlikely to arise.

Table 4: Estimation and Counterfactual EPP with Calibrated Disaster

	EL	*ET*	*BEL*	*BETEL*
Panel B. U.S. Great Depression Cumulated GDP Drop.				
$\hat{\gamma}$	11 (2.7)	11 (2.7)	11 [6.3, 19.8]	11 [6.4, 19.7]
$\chi^2_{(1)}$	0.07 (.792)	0.07 (.784)		
$\Pr(\gamma \leq 10 \mid \text{data})$			29.13%	28.71%
$\Pr\left(epp_i^T(\gamma) \geq epp^T(\gamma)\right)$	43.60%	43.30%		

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).

Conclusion and Suggestions

Baseline:

- Well executed and innovative modeling of rare disasters.
- To accept the results at face value, one has to believe in Barro's calibration of disasters.

Suggestions:

- needs some evidence on the link between time varying probability of disasters and market returns;
- extreme calibration of disasters could be avoided by adding learning (e.g. Geweke (2001), Weitzman (2007)).
  This would also:
  - generate an endogenous time variation in the perceived probability of disasters (e.g. Cogley-Sargent (2007));
  - deliver time-varying volatility and asymmetric volatility reaction to good and bad news (e.g. Veronesi (2004));
  - generate potential for sun-spot equilibria (e.g. Sandroni (1998)).