Bank Regulation and Stability: An Examination of the Basel Market Risk Framework

Gordon J. Alexander
University of Minnesota

Alexandre M. Baptista
The George Washington University

Shu Yan
University of South Carolina

October 20, 2011
Basel III and Beyond: Regulating and Supervising Banks in the Post-Crisis Era

Jointly organized by the Deutsche Bundesbank and the Centre for European Economic Research (ZEW)

1. Motivation

- Bank regulators:
  - – Value-at-Risk (VaR) is used to measure the risk in the trading books of large banks and to determine the corresponding minimum capital requirements;
  - – Stress Testing (ST) is used to assess whether banks withstand 'extreme' events.
- Practitioners:
  - – Banks use VaR and ST to set risk exposure limits (survey of Committee on the Global Financial System, 2005).
- Researchers:
  - – VaR is *not* sub-additive;
  - – VaR does *not* consider losses beyond VaR;
  - – Advocate Conditional-Value-at-Risk (CVaR): it is sub-additive, and considers losses beyond VaR.
- Our paper:
  - – Examines the extent of the conflict between: (1) the popularity of VaR and ST among regulators and practitioners; and (2) the advocacy of CVaR by researchers.
  - – More specifically, we examine the effectiveness of a risk management system based on *both* VaR and ST constraints in controlling CVaR.
  - – Put differently: is the joint use of VaR and ST 'equivalent' to the use of CVaR?

2. Main result

• The joint use of VaR and ST constraints allows the selection of portfolios with relatively *large* CVaRs.

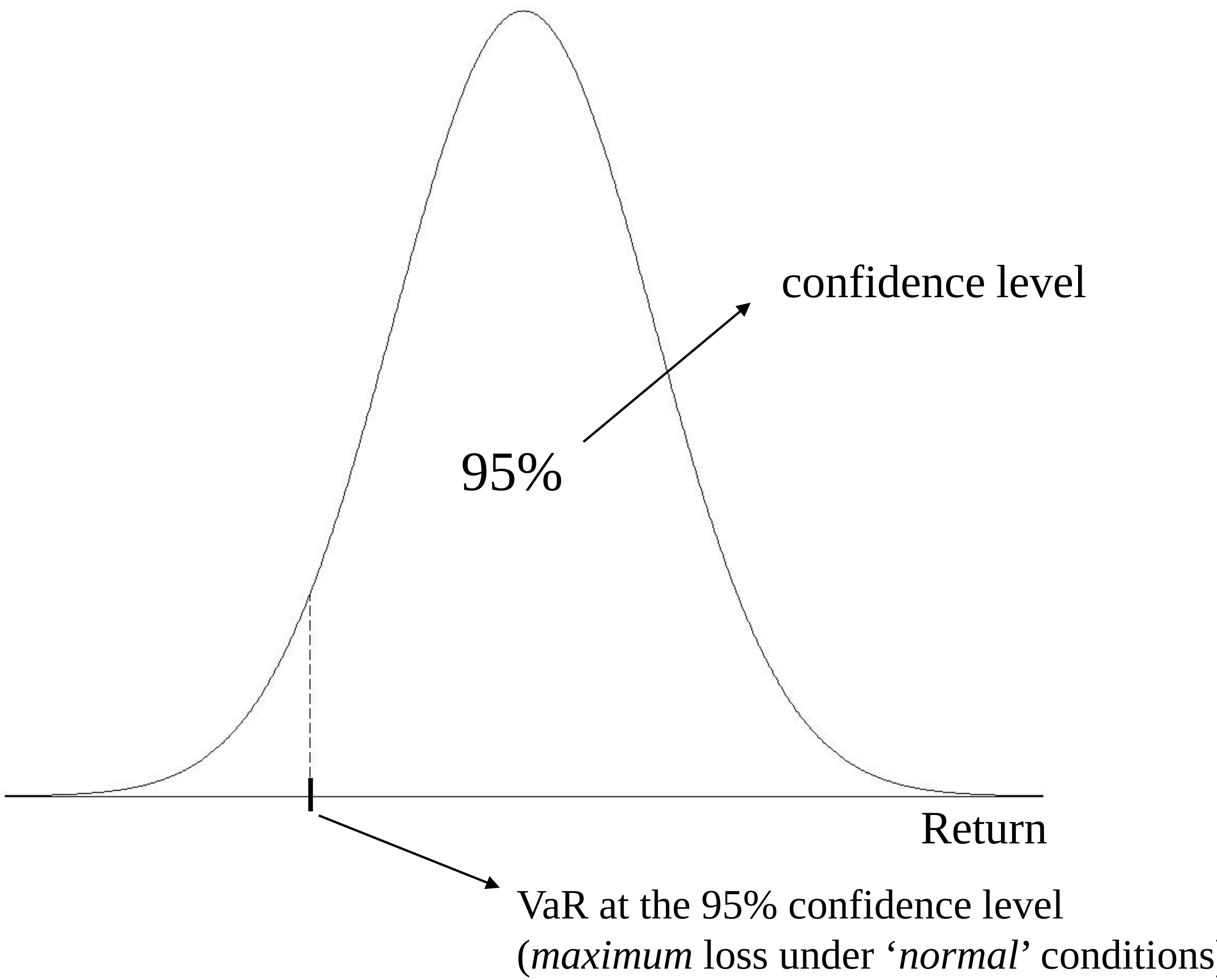
• Hence, the joint use of VaR and ST constraints is *ineffective* in controlling CVaR.

• This result is consistent with:
  – Banks around the world suffered sizeable trading losses during the recent crisis.
  – Trading losses notably exceeded VaR (and even minimum capital requirements).

• Our paper supports the view that the Basel market risk framework did *not* promote bank stability.

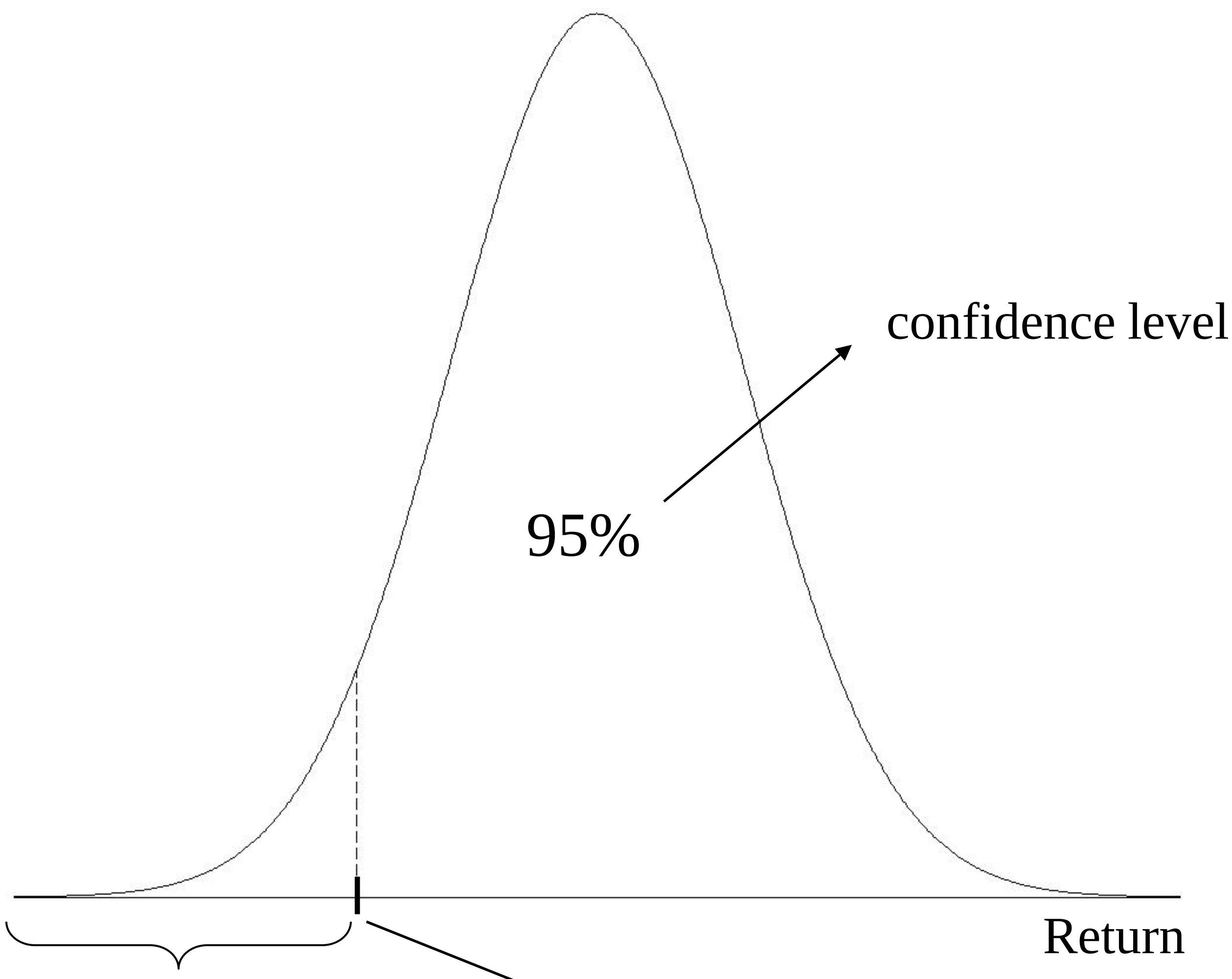
3. VaR, CVaR, and ST

For simplicity, consider a portfolio with a normally distributed return:



3. VaR, CVaR, and ST

For simplicity, consider a portfolio with a normally distributed return:

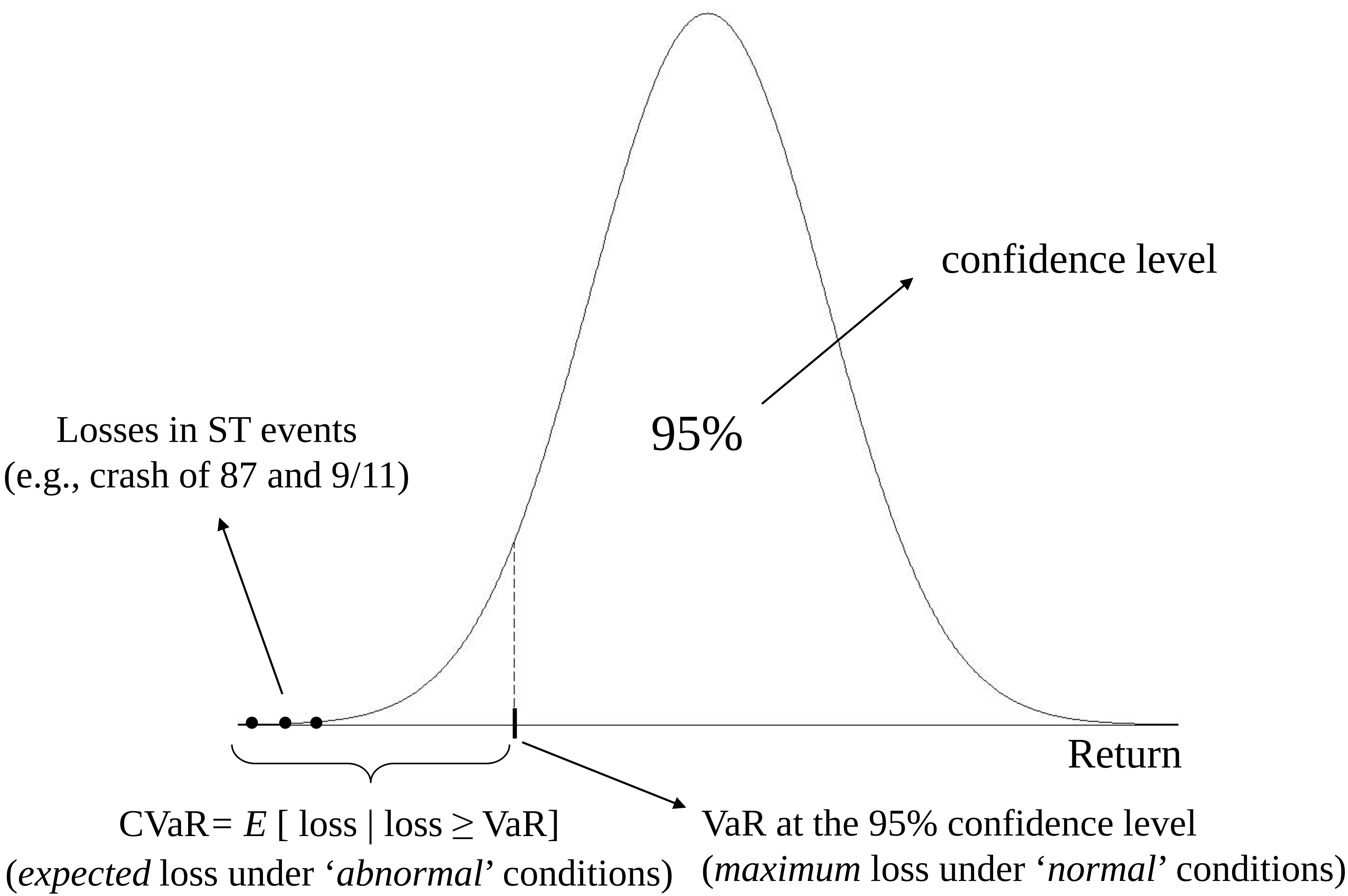


CVaR= *E* [loss | loss ≥ VaR]
(*expected* loss under '*abnormal*' conditions)

VaR at the 95% confidence level
(*maximum* loss under '*normal*' conditions)

3. VaR, CVaR, and ST

For simplicity, consider a portfolio with a normally distributed return:



4. Methodology

- Allocation problem among *nine* asset classes:
  - – T-bills (assumed to be risk-free);
  - – Government bonds;
  - – Corporate bonds; and
  - – Six size/value-growth Fama-French portfolios.
- *Monthly* investment horizon;
- Historical simulation:
  - – 73% of banks that disclose methodology to estimate VaR report the use of historical simulation (Pérignon and Smith, 2010);
  - – Monthly data during the period 1982–2006;
  - – ST events: (i) 1987 stock market crash; and (ii) 9-11 (CGFS survey, 2005).
- Consider *three* different risk management systems based on:
  - – A single VaR constraint;
  - – Two ST constraints; and
  - – A single VaR constraint and two ST constraints.
- Examine whether each set of constraints precludes the selection of *all* portfolios with relatively *large* CVaRs;
  - – If a set of constraints precludes such portfolios, it is *effective* in controlling CVaR;
  - – Otherwise, it is *ineffective* in controlling CVaR.

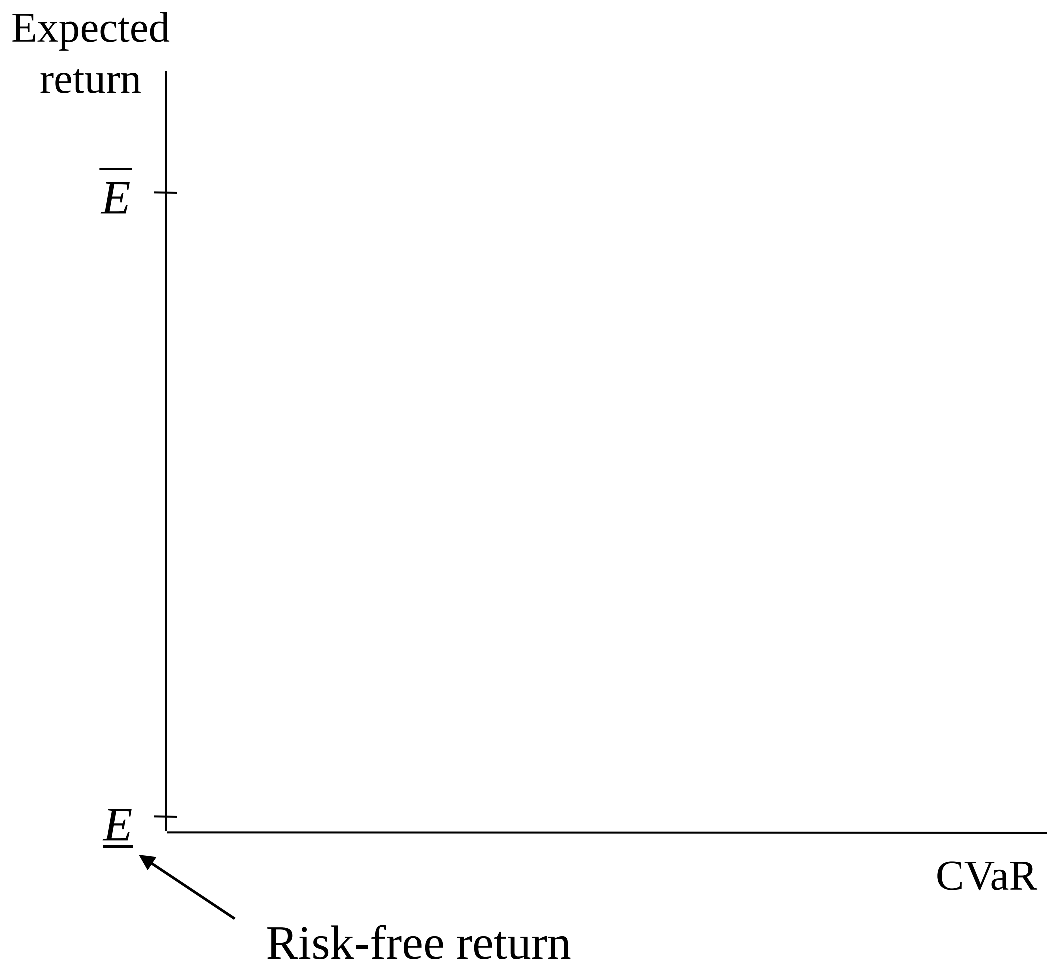
4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

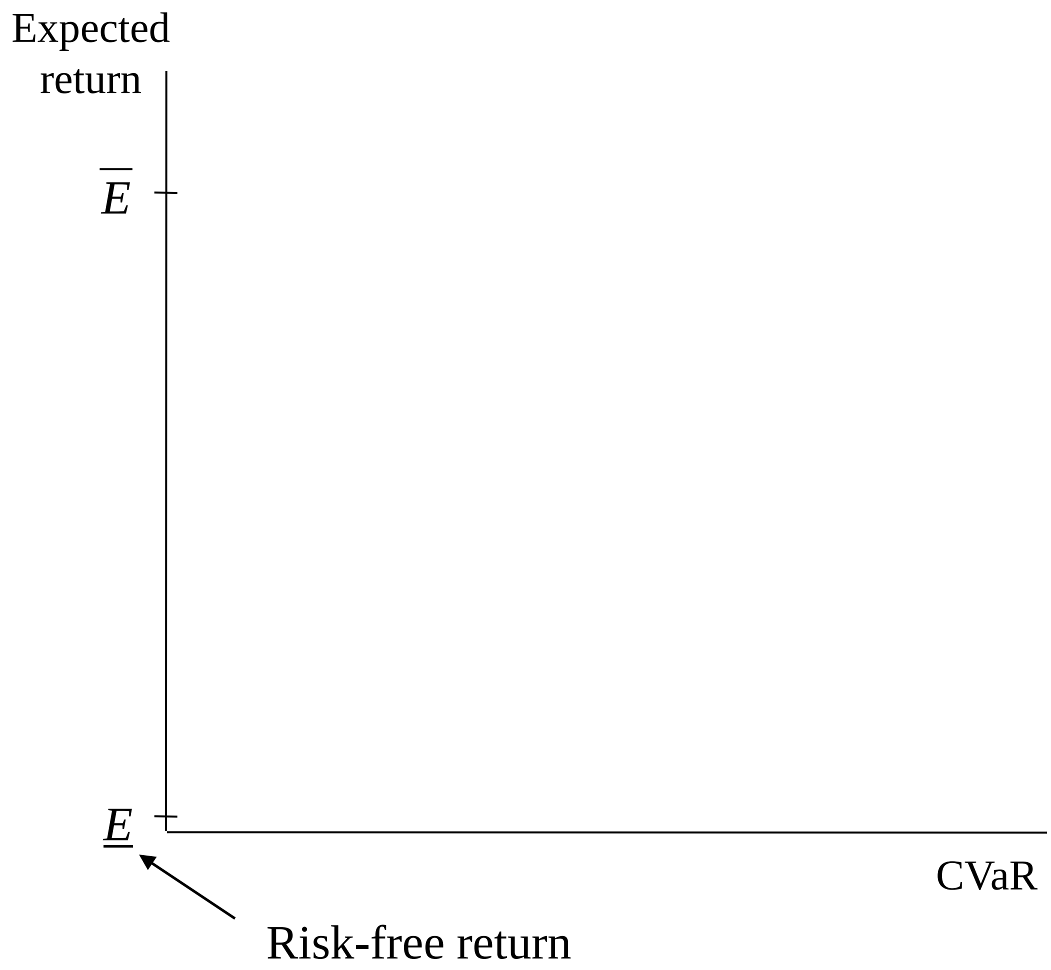


4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.



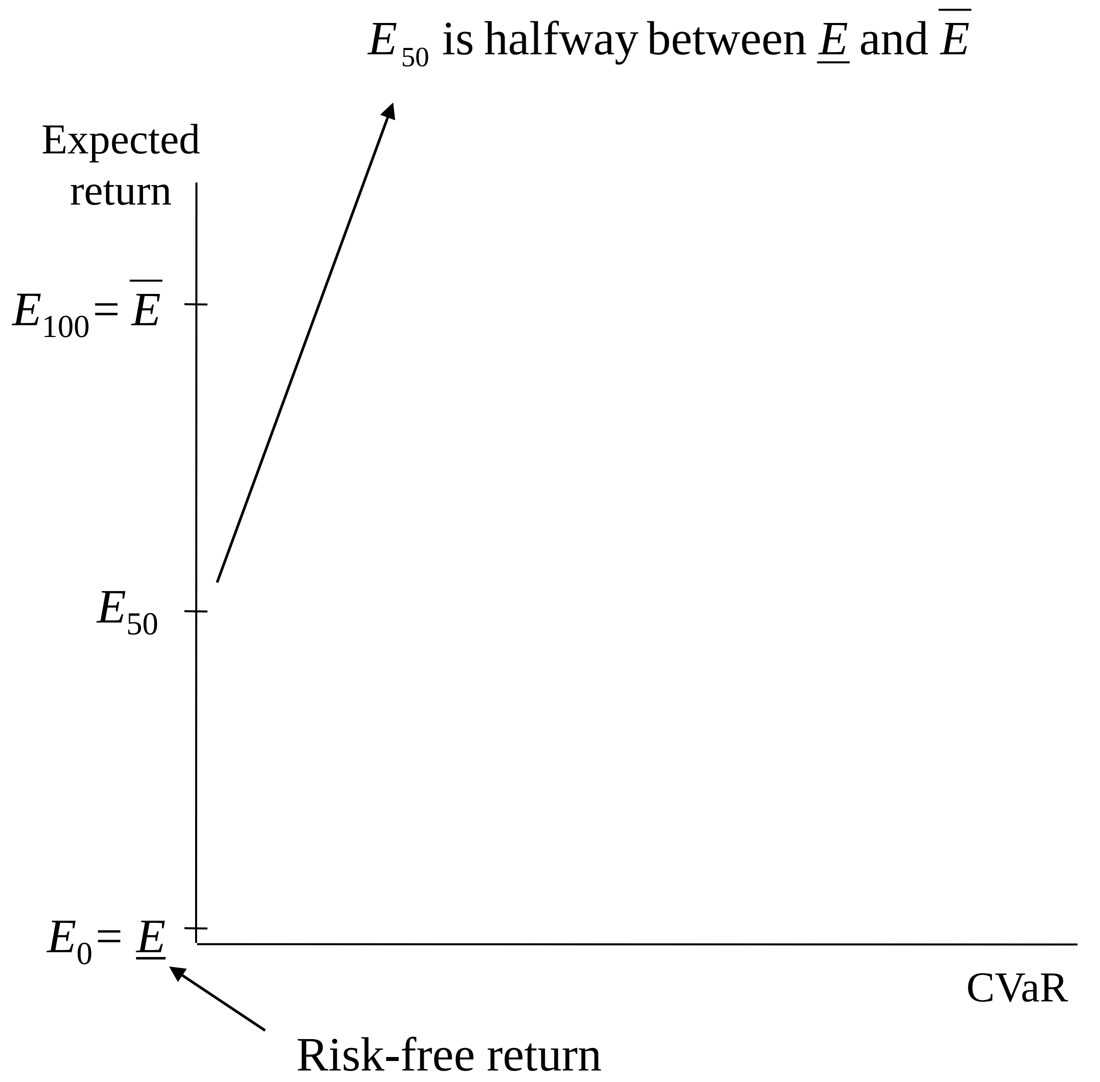
4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.



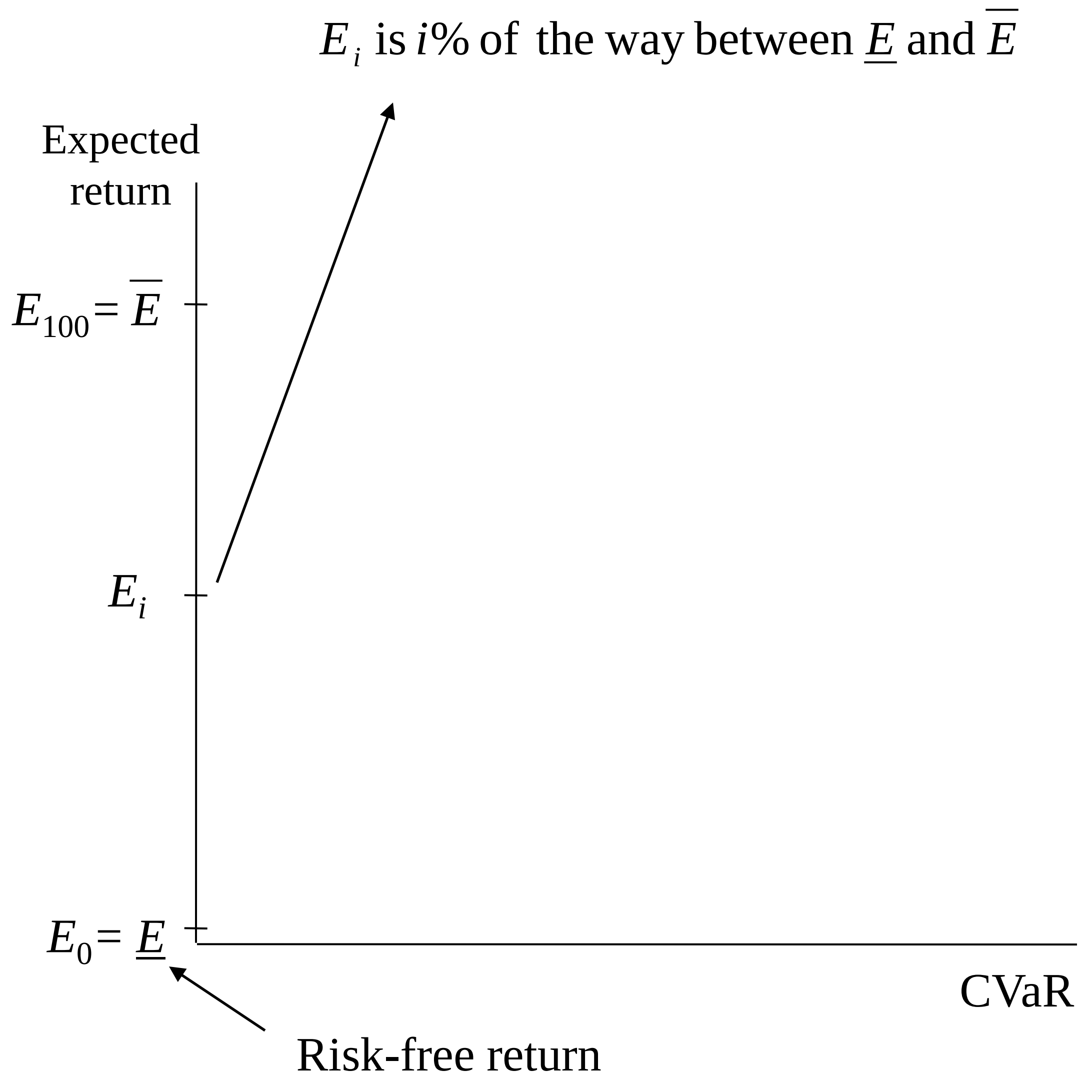
4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.



4. Methodology

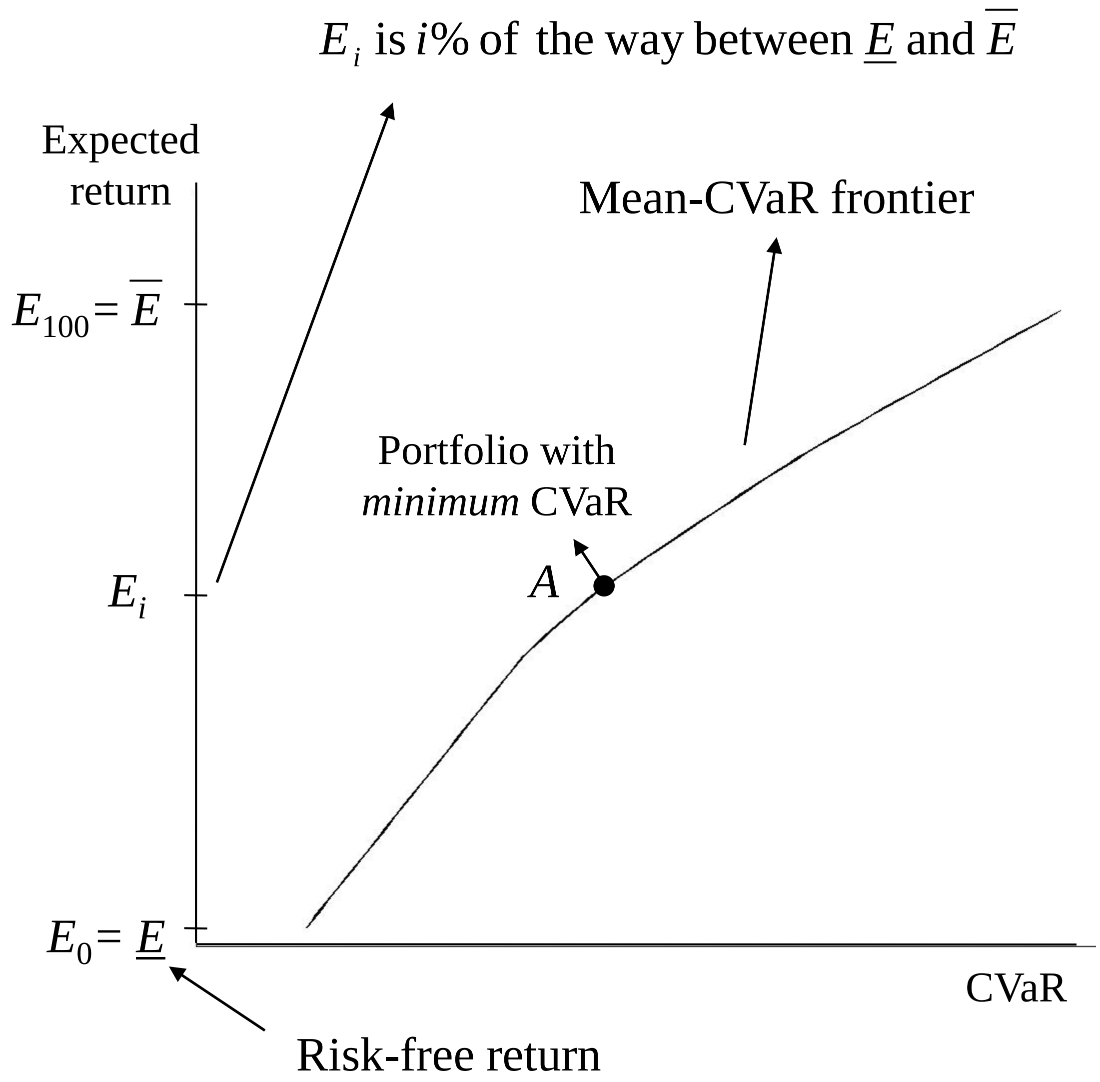
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



4. Methodology

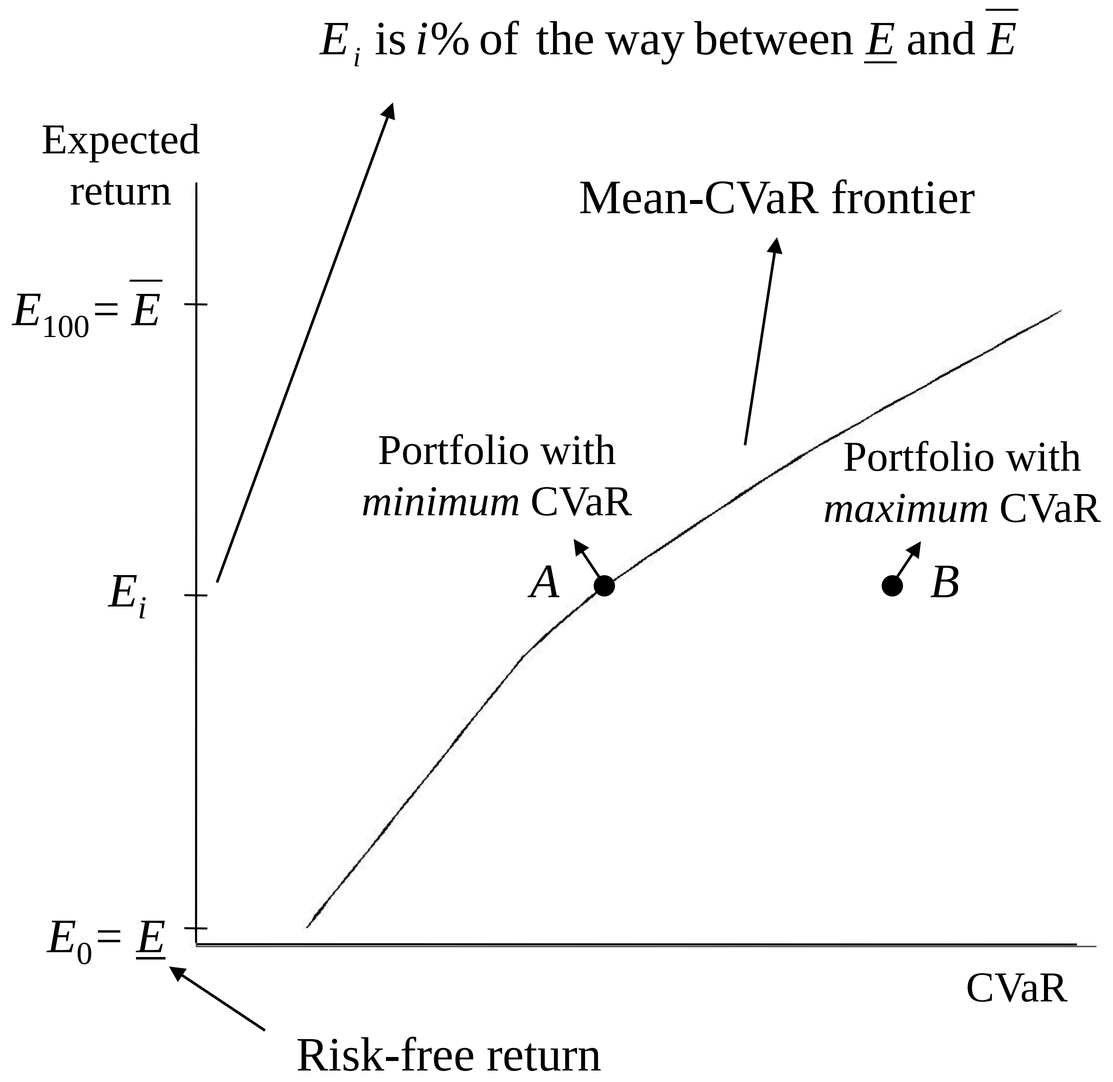
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



4. Methodology

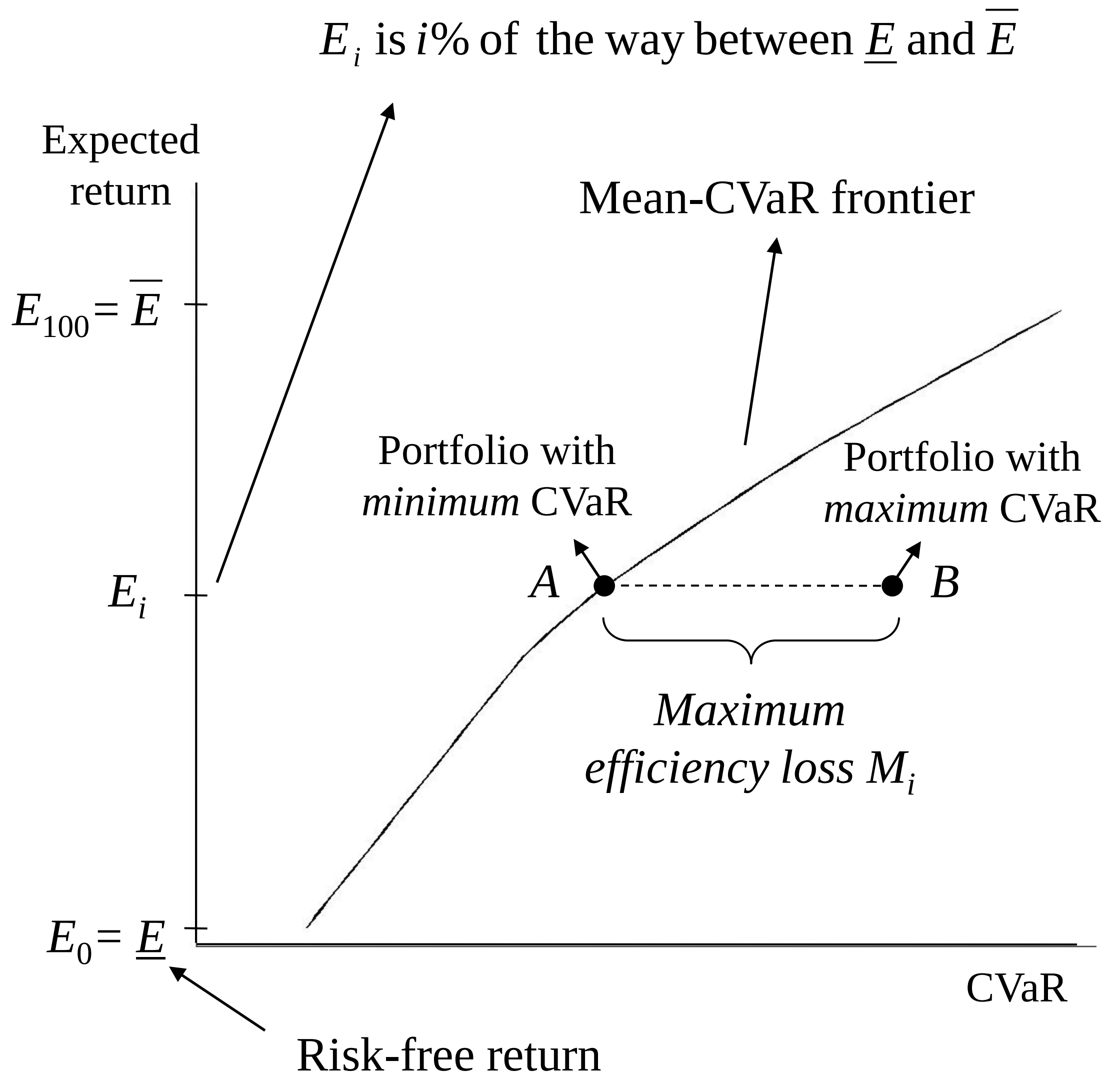
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



4. Methodology

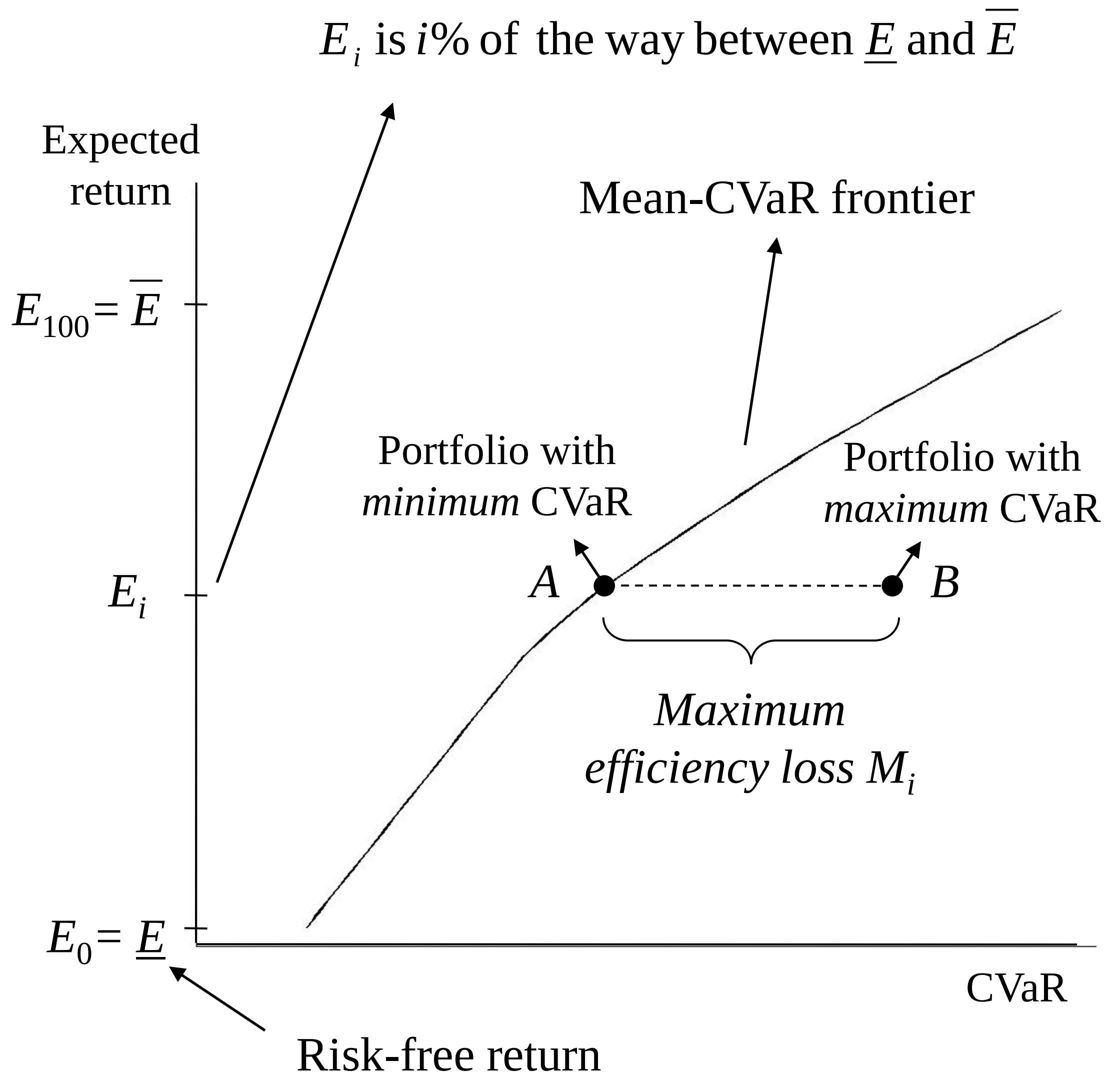
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



-> For example, if M_i = **<u>3%</u>**, then the VaR constraint allows the selection of a portfolio with a CVaR that *exceeds* the CVaR of the minimum CVaR portfolio by **<u>3%</u>**.

4. Methodology

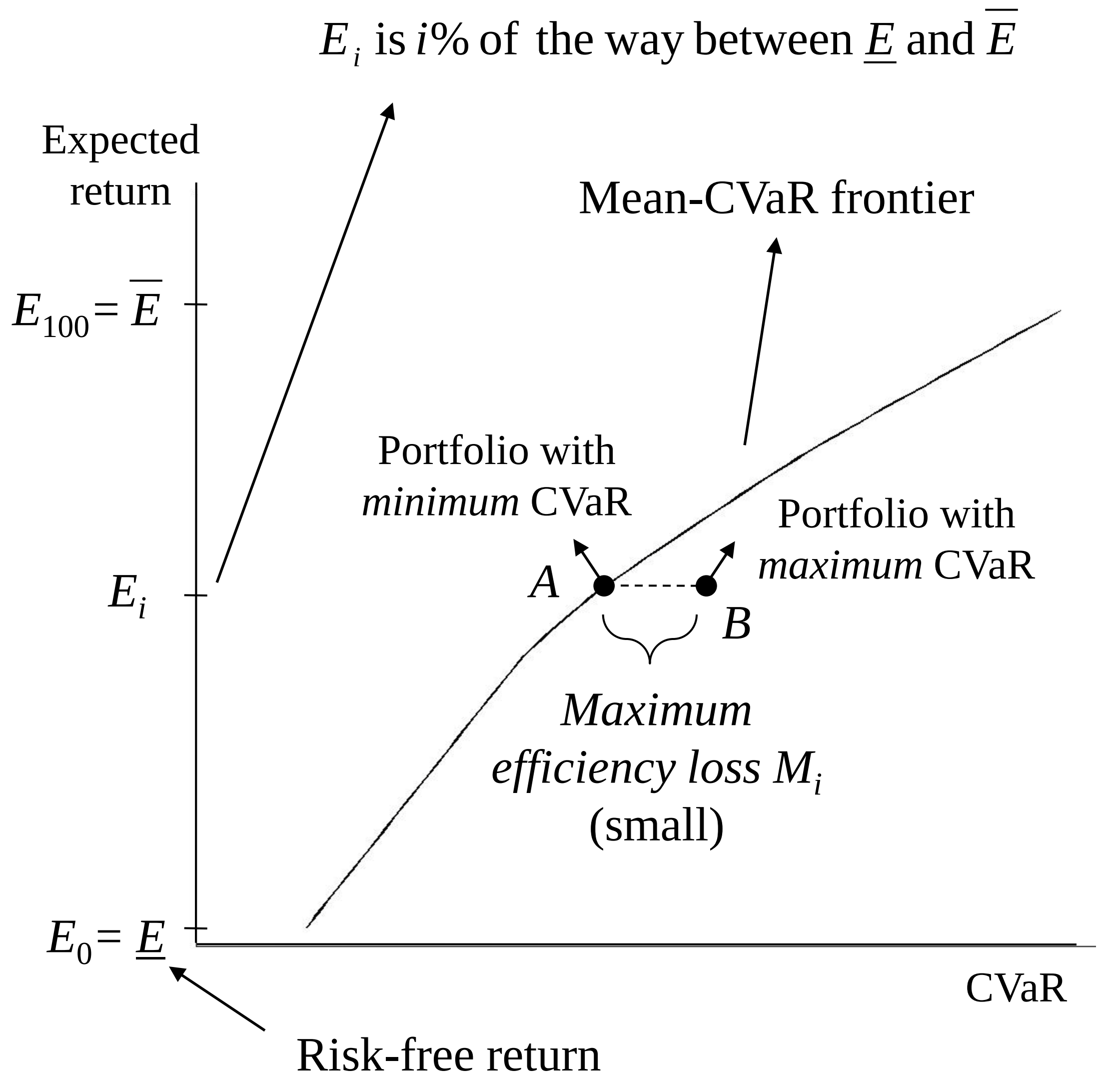
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



-> More generally, if maximum efficiency loss M_i is relatively *small*, then the VaR constraint is *effective* in controlling CVaR when the required expected return is E_i.

4. Methodology

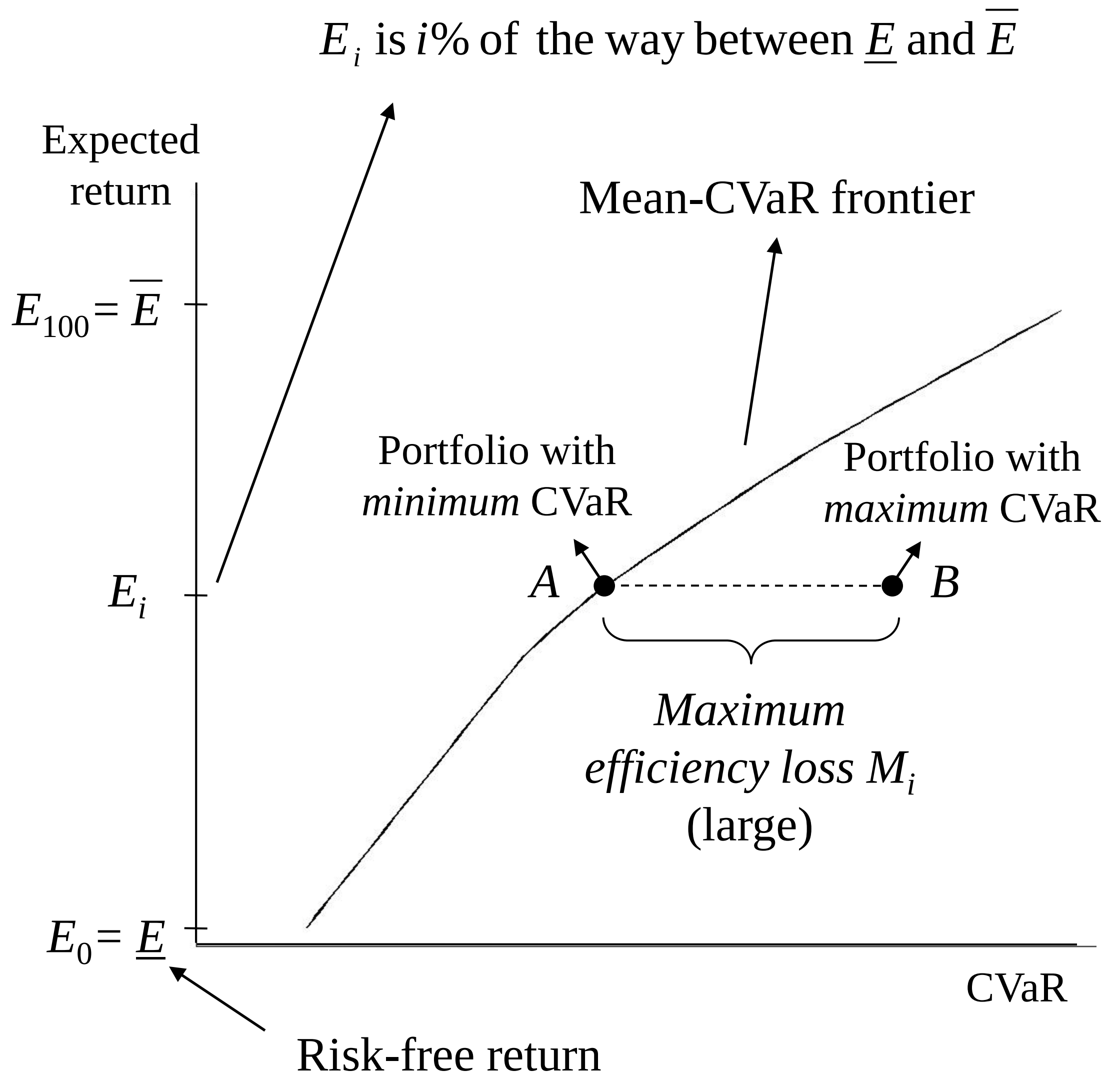
1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.



-> However, if maximum efficiency loss M_i is relatively *large*, then the VaR constraint is *ineffective* in controlling CVaR when the required expected return is E_i.

4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

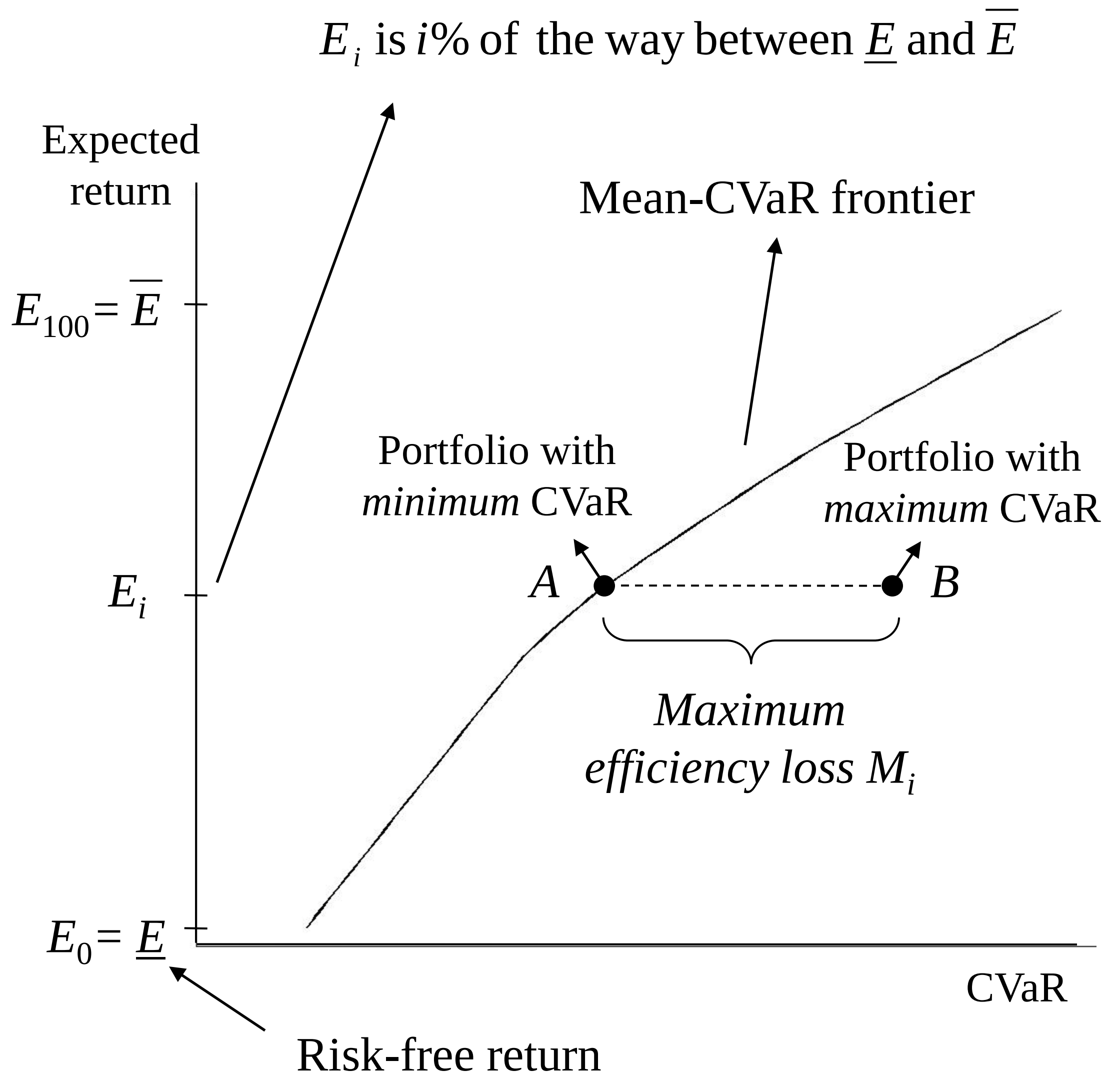
2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.

6. Compute *average* and *largest* efficiency losses



4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

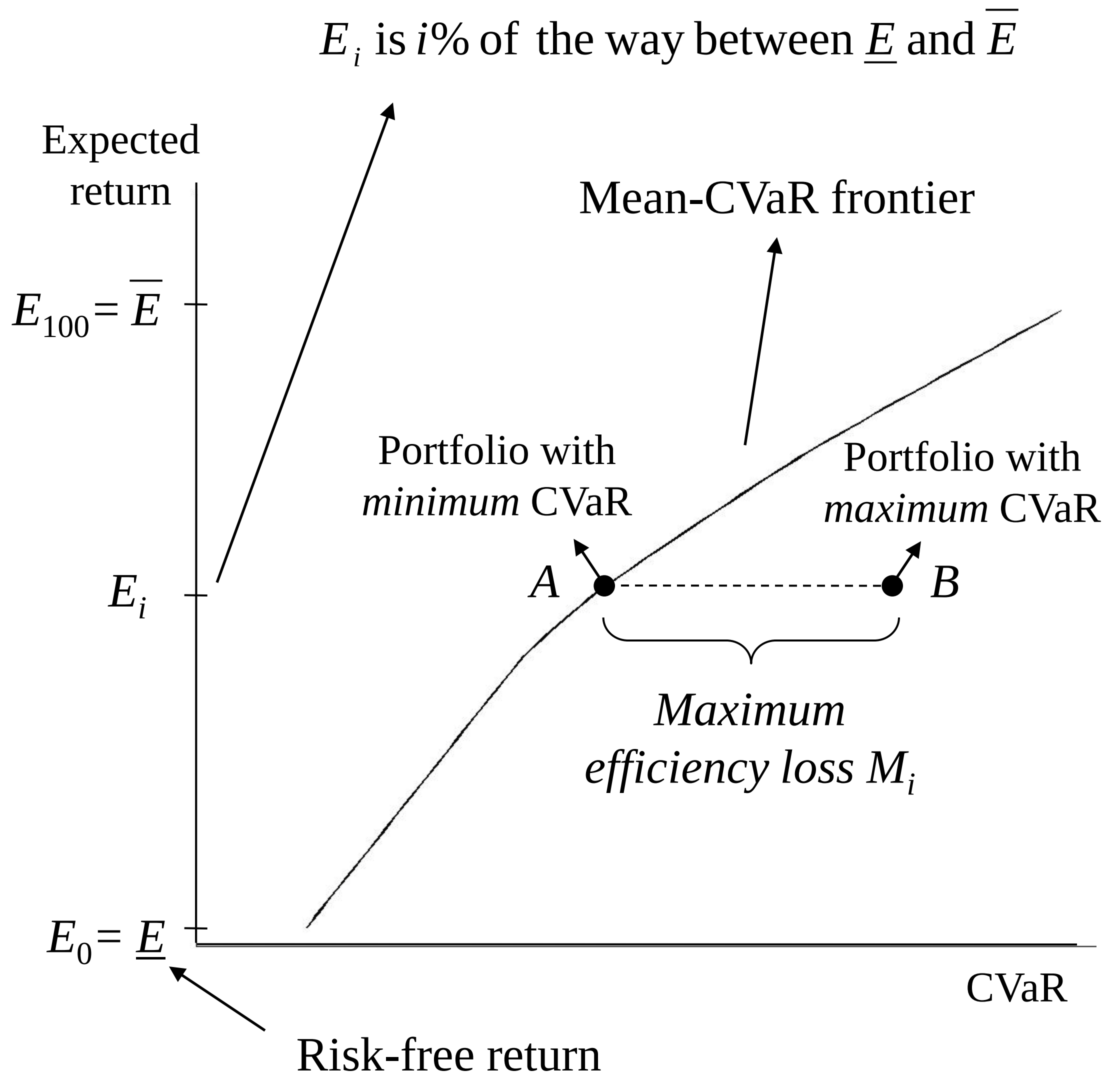
2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.

6. Compute *average* and *largest* efficiency losses, and average and largest *relative* efficiency losses



$$\textit{relative}\ \text{efficiency loss} = \frac{\text{efficiency loss}}{\text{CVaR of portfolio on the mean-CVaR frontier}}$$

4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

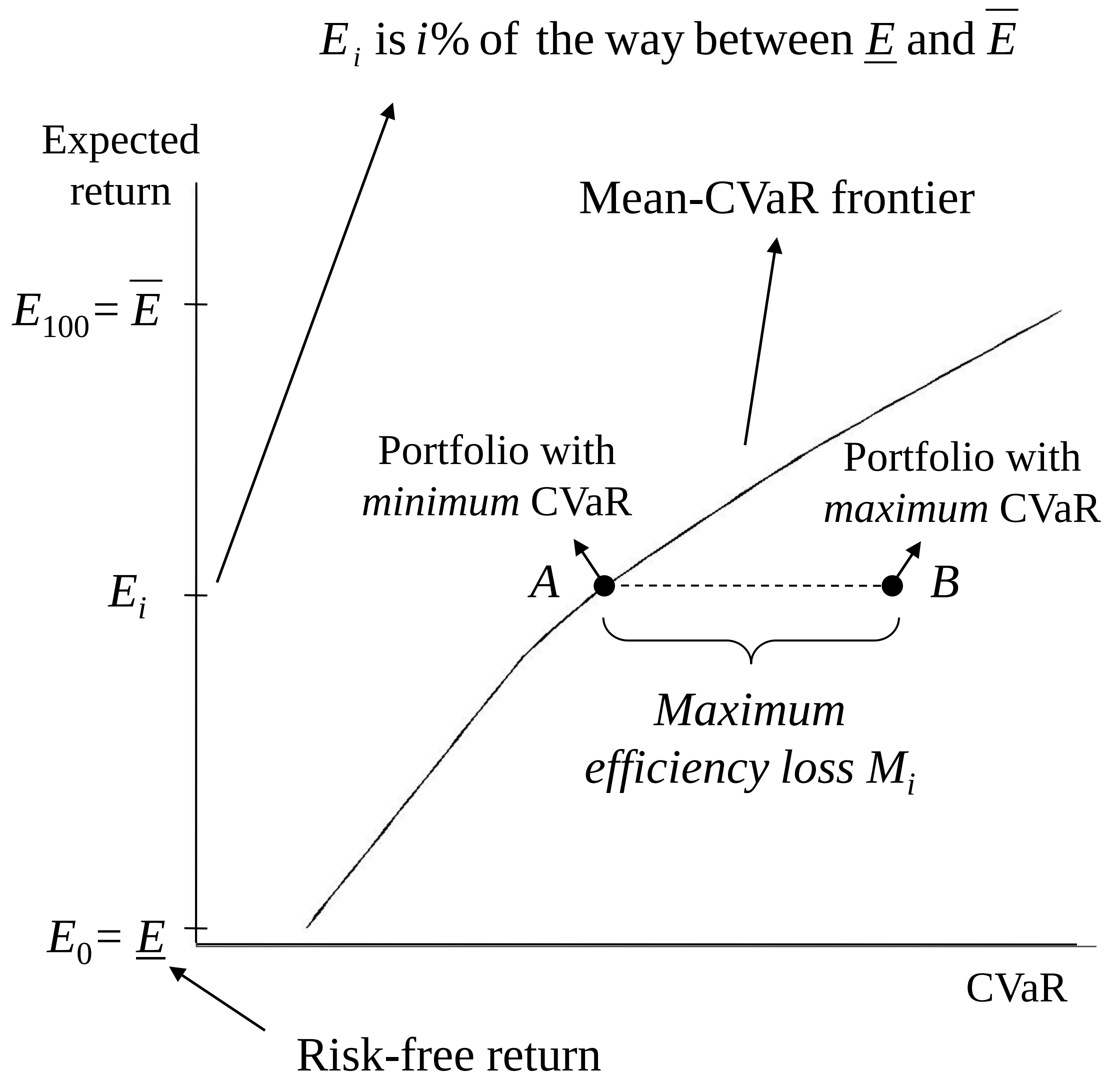
3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.

6. Compute *average* and *largest* efficiency losses, and average and largest *relative* efficiency losses

$$\textit{relative}\ \text{efficiency loss}_B = \frac{M_i}{\text{CVaR}_A}$$



For example, if the relative efficiency loss is **100%**, then the VaR constraint allows the selection of a portfolio with a CVaR that is **twice** as large as the CVaR of the minimum CVaR portfolio.

4. Methodology

1. Choose confidence level α (e.g., 99%) and VaR bound V (e.g., 4%) for the constraint.

2. Given the VaR constraint, find *maximum* feasible expected return $\overline{E}$ (the minimum expected return $\underline{E}$ is set to the risk-free return).

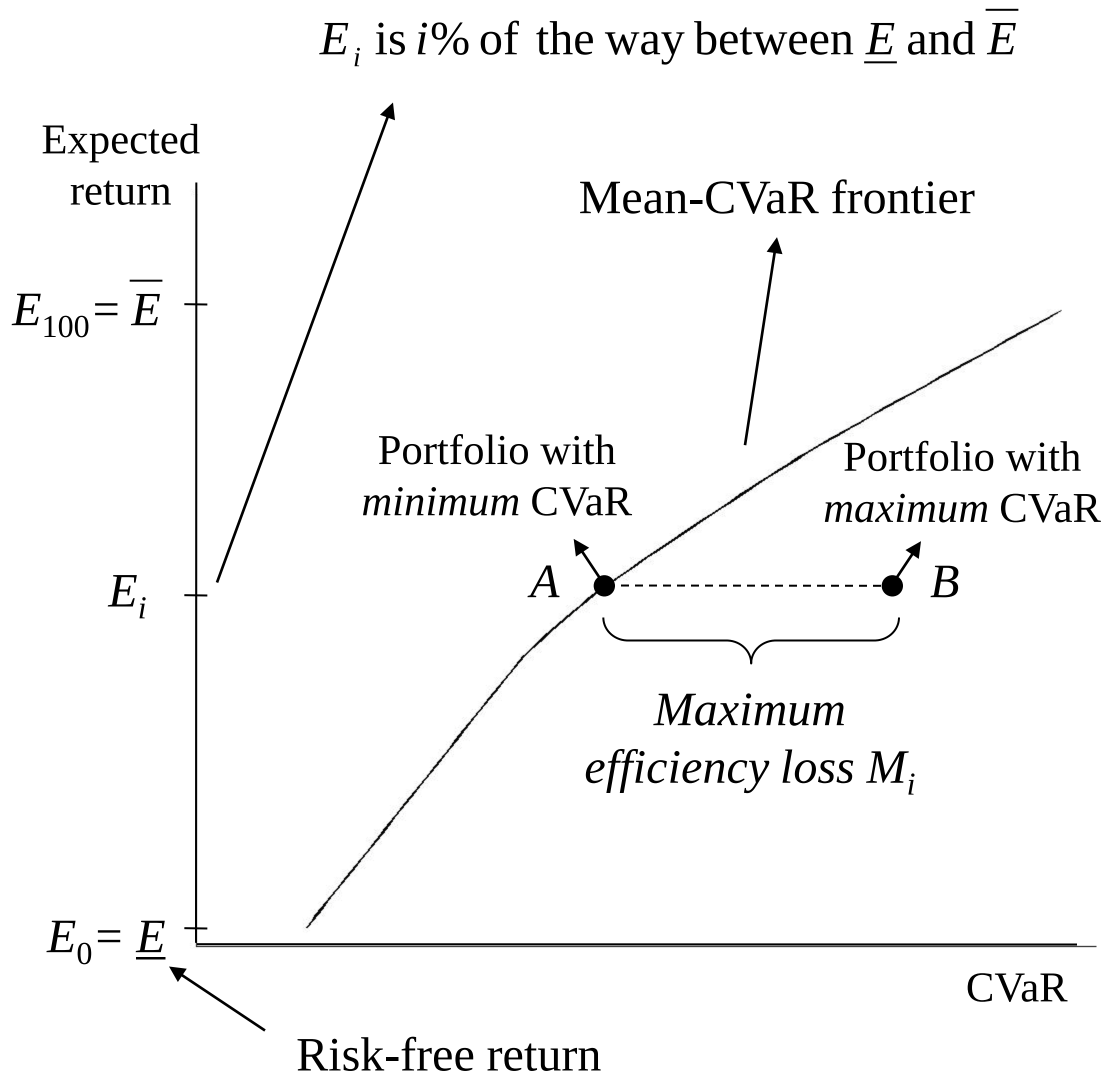
3. Determine $\delta = (\overline{E} - \underline{E})/100$.

4. Construct grid of expected returns: $E_0 = \underline{E}$; $E_1 = \underline{E} + \delta$; ... ; $E_{100} = \overline{E}$.

5. For each value in this grid E_i, find *maximum* efficiency loss M_i.

6. Compute *average* and *largest* efficiency losses, and average and largest *relative* efficiency losses

$$\textit{relative}\text{ efficiency loss}_B = \frac{M_i}{\text{CVaR}_A}$$



• As CVaR ↓ 0, the relative efficiency loss ↑ ∞;
• In the computation of average and largest relative efficiency losses, we only consider levels of expected return for which the CVaR in the denominator is *larger* than 1%.

5. Results: VaR constraint (fixed bound)

	Fixed bound	
Confidence level α	99%	
Bound V	4%	8%
Efficiency loss:		
Average	8.25	14.94
Largest	11.11	20.97
Relative efficiency loss:		
Average	366.99	501.75
Largest	934.56	1844.67
Maximum feasible expected return	1.59	2.07

5. Results: VaR constraint (fixed bound)

	Fixed bound	
Confidence level α	99%	
Bound V	**4%**	8%
Efficiency loss:		
Average	**8.25**	14.94
Largest	11.11	20.97
Relative efficiency loss:		
Average	**366.99**	501.75
Largest	934.56	1844.67
Maximum feasible expected return	1.59	2.07

- *Small* bound (tight constraint)
- *Large* average loss
- *Large* average *relative* loss

5. Results: VaR constraint (fixed bound)

	Fixed bound	
Confidence level α	99%	
Bound V	**4%**	**8%**
Efficiency loss:		
Average	**8.25**	**14.94**
Largest	11.11	20.97
Relative efficiency loss:		
Average	366.99	501.75
Largest	934.56	1844.67
Maximum feasible expected return	1.59	2.07

- *Larger* bound (looser constraint)
- *Larger* average loss

5. Results: VaR constraint (fixed bound)

	Fixed bound	
Confidence level α	99%	
Bound V	**4%**	**8%**
Efficiency loss:		
Average	8.25	14.94
Largest	11.11	20.97
Relative efficiency loss:		
Average	**366.99**	**501.75**
Largest	934.56	1844.67
Maximum feasible expected return	1.59	2.07

- *Larger* bound (looser constraint)
- *Larger* average loss
- *Larger* average *relative* loss

5. Results: VaR constraint (fixed bound)

	Fixed bound	
Confidence level α	99%	
Bound V	**4%**	**8%**
Efficiency loss:		
Average	8.25	14.94
Largest	11.11	20.97
Relative efficiency loss:		
Average	366.99	501.75
Largest	934.56	1844.67
Maximum feasible expected return	**1.59**	**2.07**

- *Larger* bound (looser constraint)
- *Larger* average loss
- *Larger* average *relative* loss
- *Larger maximum f*easible expected return

6. Results: VaR constraint (fixed versus variable bounds)

	Fixed bound		**Variable bound**
Confidence level α	99%		99%
Bound V	4%	8%	Depends on E
Efficiency loss:			
Average	8.25	14.94	3.86
Largest	11.11	20.97	9.56
Relative efficiency loss:			
Average	366.99	501.75	105.93
Largest	934.56	1844.67	174.24
Maximum feasible expected return	1.59	2.07	2.16

6. Results: VaR constraint (fixed versus variable bounds)

	Fixed bound		Variable bound
Confidence level α	99%		99%
Bound V	**4%**	8%	**Depends on *E***
Efficiency loss:			
Average	**8.25**	14.94	**3.86**
Largest	11.11	20.97	9.56
Relative efficiency loss:			
Average	366.99	501.75	105.93
Largest	934.56	1844.67	174.24
Maximum feasible expected return	1.59	2.07	2.16

Advantages of variable bounds:

- *Smaller* average loss

6. Results: VaR constraint (fixed versus variable bounds)

	Fixed bound		Variable bound
Confidence level α	99%		99%
Bound V	**4%**	8%	**Depends on *E***
Efficiency loss:			
Average	8.25	14.94	3.86
Largest	11.11	20.97	9.56
Relative efficiency loss:			
Average	**366.99**	501.75	**105.93**
Largest	934.56	1844.67	174.24
Maximum feasible expected return	1.59	2.07	2.16

Advantages of variable bounds:

- *Smaller* average loss
- *Smaller average relative* loss

6. Results: VaR constraint (fixed versus variable bounds)

	Fixed bound		Variable bound
Confidence level α	99%		99%
Bound V	**4%**	8%	**Depends on *E***
Efficiency loss:			
Average	8.25	14.94	3.86
Largest	11.11	20.97	9.56
Relative efficiency loss:			
Average	366.99	501.75	105.93
Largest	934.56	1844.67	174.24
Maximum feasible expected return	**1.59**	2.07	**2.16**

Advantages of variable bounds:

- *Smaller* average loss
- *Smaller average relative* loss
- *Larger* maximum feasible expected return

- Variable bounds are more *effective* in controlling CVaR than fixed bound

6. Results: VaR constraint (fixed versus variable bounds)

	Fixed bound		**Variable bound**
Confidence level α	99%		**99%**
Bound V	4%	8%	**Depends on E**
Efficiency loss:			
Average	8.25	14.94	**3.86**
Largest	11.11	20.97	9.56
Relative efficiency loss:			
Average	366.99	501.75	**105.93**
Largest	934.56	1844.67	174.24
Maximum feasible expected return	1.59	2.07	2.16

- *Large* average loss
- *Large average relative* loss

- VaR constraint with variable bounds is still *ineffective* in controlling CVaR

7. Results: variable bounds (VaR versus ST constraints)

	Constraints	
	VaR	**ST**
Confidence level α	99%	99%
Efficiency loss:		
Average	**3.86**	**15.54**
Largest	9.56	26.97
Relative efficiency loss:		
Average	105.93	505.27
Largest	174.24	2280.65

- *Larger* average loss

7. Results: variable bounds (VaR versus ST constraints)

	Constraints	
	VaR	**ST**
Confidence level α	99%	99%
Efficiency loss:		
Average	**3.86**	**15.54**
Largest	9.56	26.97
Relative efficiency loss:		
Average	**105.93**	**505.27**
Largest	174.24	2280.65

- *Larger* average loss
- *Larger average relative* loss

• The use of ST constraints is even *less effective* in controlling CVaR than the use of a VaR constraint

7. Results: variable bounds (VaR and ST constraints)

	Constraints		
	VaR	**ST**	**VaR + ST**
Confidence level α	99%	99%	99%
Efficiency loss:			
Average	**3.86**	**15.54**	**1.96**
Largest	9.56	26.97	4.03
Relative efficiency loss:			
Average	105.93	505.27	56.56
Largest	174.24	2280.65	138.53

- *Smaller* average loss

7. Results: variable bounds (VaR and ST constraints)

	Constraints		
	VaR	**ST**	**VaR + ST**
Confidence level α	99%	99%	99%
Efficiency loss:			
Average	**3.86**	**15.54**	**1.96**
Largest	9.56	26.97	4.03
Relative efficiency loss:			
Average	**105.93**	**505.27**	**56.56**
Largest	174.24	2280.65	138.53

- *Smaller* average loss
- *Smaller average relative* loss

• Hence, there are notable benefits arising from using *both* VaR and ST constraints (relative to using just one type of constraint).

7. Results: variable bounds (VaR and ST constraints)

	Constraints		
	VaR	ST	**VaR + ST**
Confidence level α	99%	99%	99%
Efficiency loss:			
Average	3.86	15.54	**1.96**
Largest	9.56	26.97	4.03
Relative efficiency loss:			
Average	105.93	505.27	**56.56**
Largest	174.24	2280.65	138.53

- *Large* average loss
- *Large average relative* loss

• However, the joint use of VaR and ST constraints is *ineffective* in controlling CVaR.

8. Robustness checks

- Consider additional cases:

  1. A larger number of ST events (87 crash, 9-11, 97 Asian crisis, 98 Russian crisis);

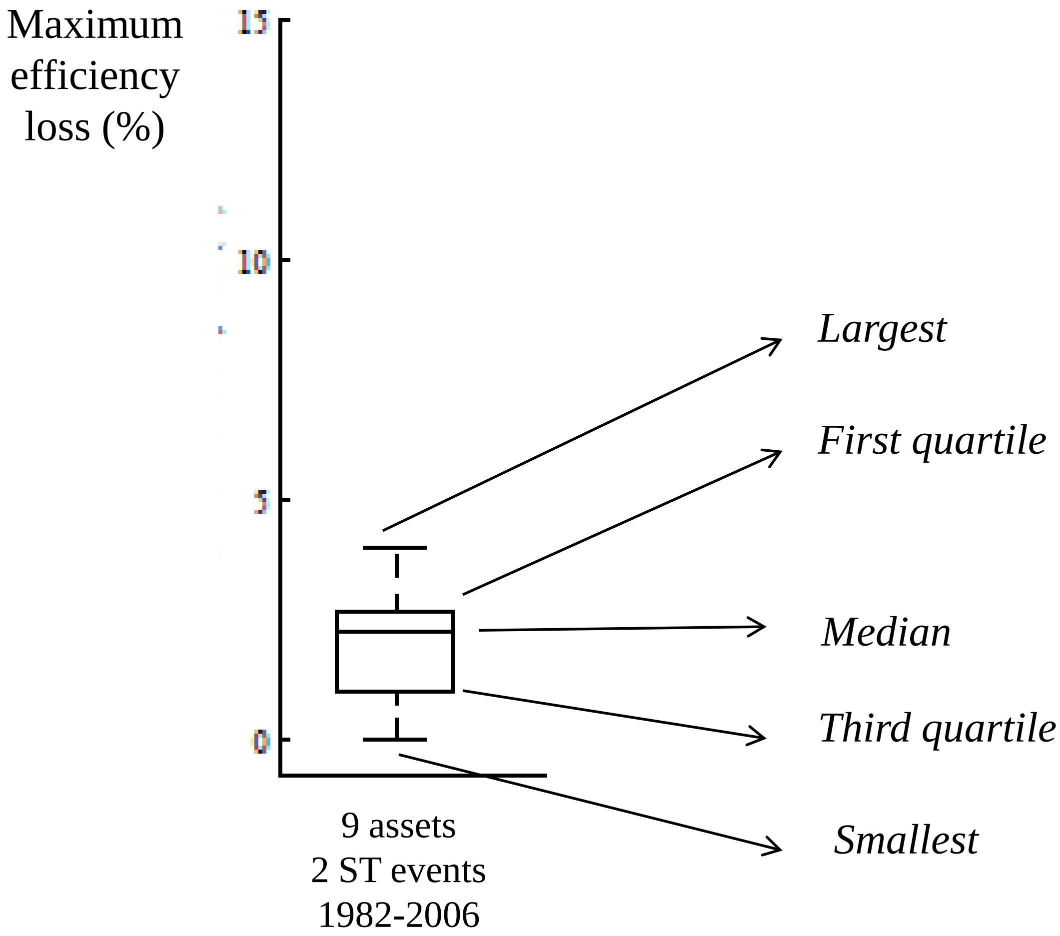
  2. A larger number of assets (T-bills, T-bonds, corporate bonds, ten size Fama-French portfolios);

  3. Larger numbers of *both* ST events and asset classes;

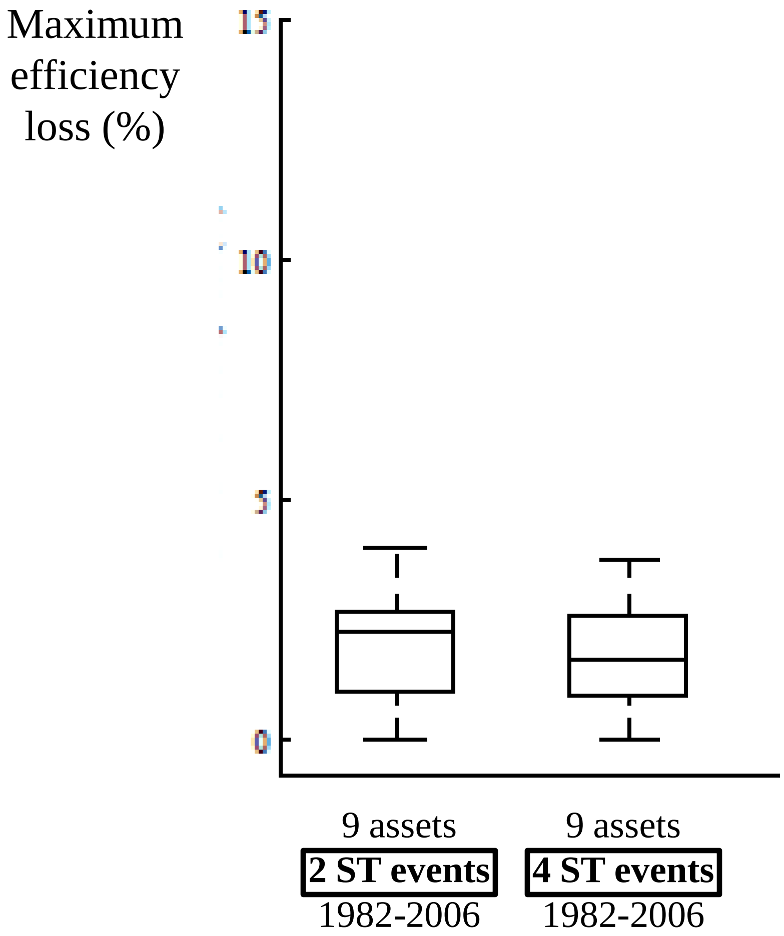
  4. Data during the period 1982-2009; and

  5. Daily data.

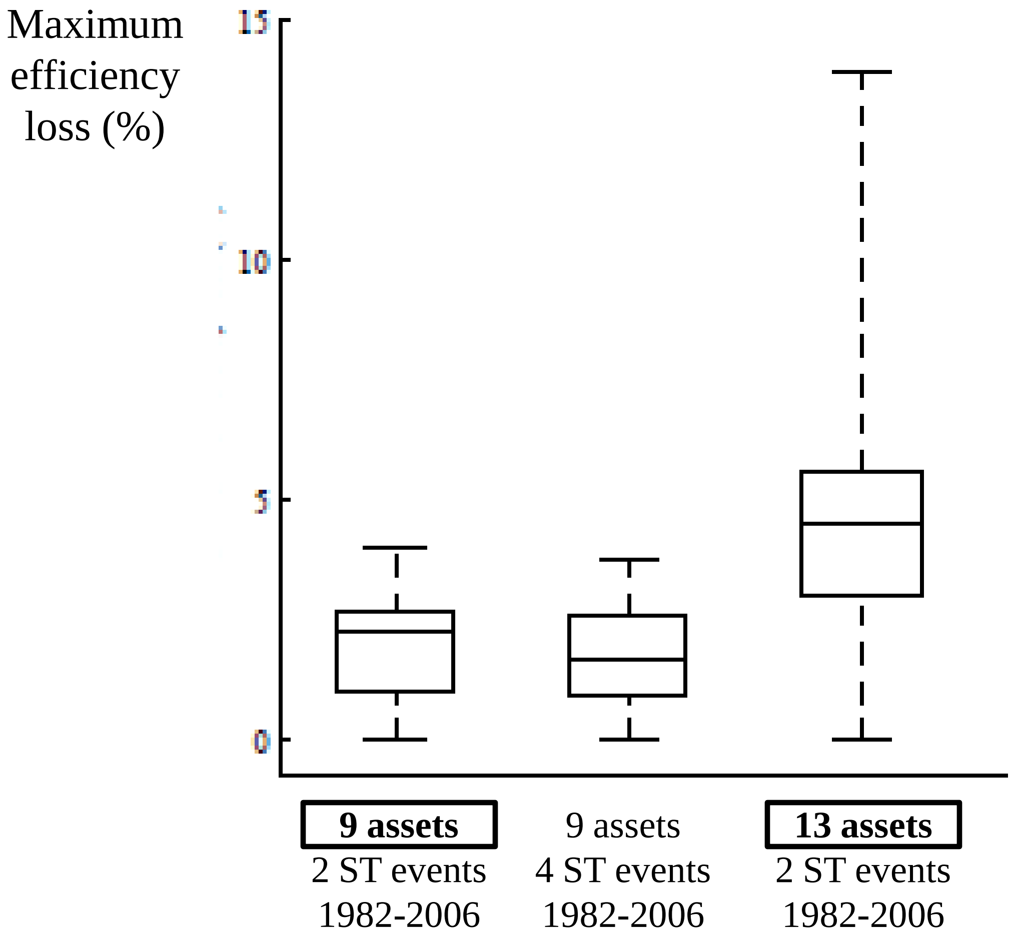
8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



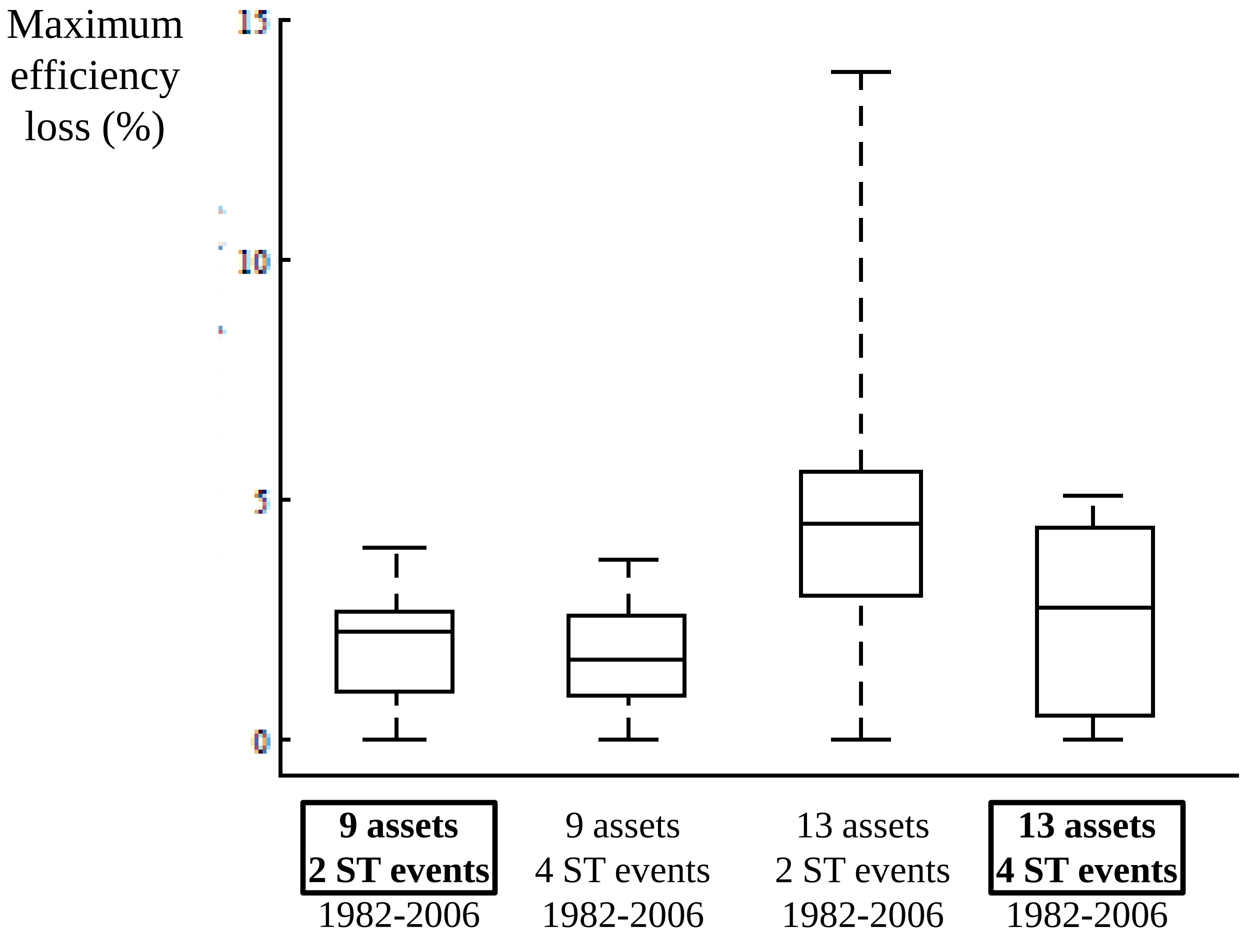
8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



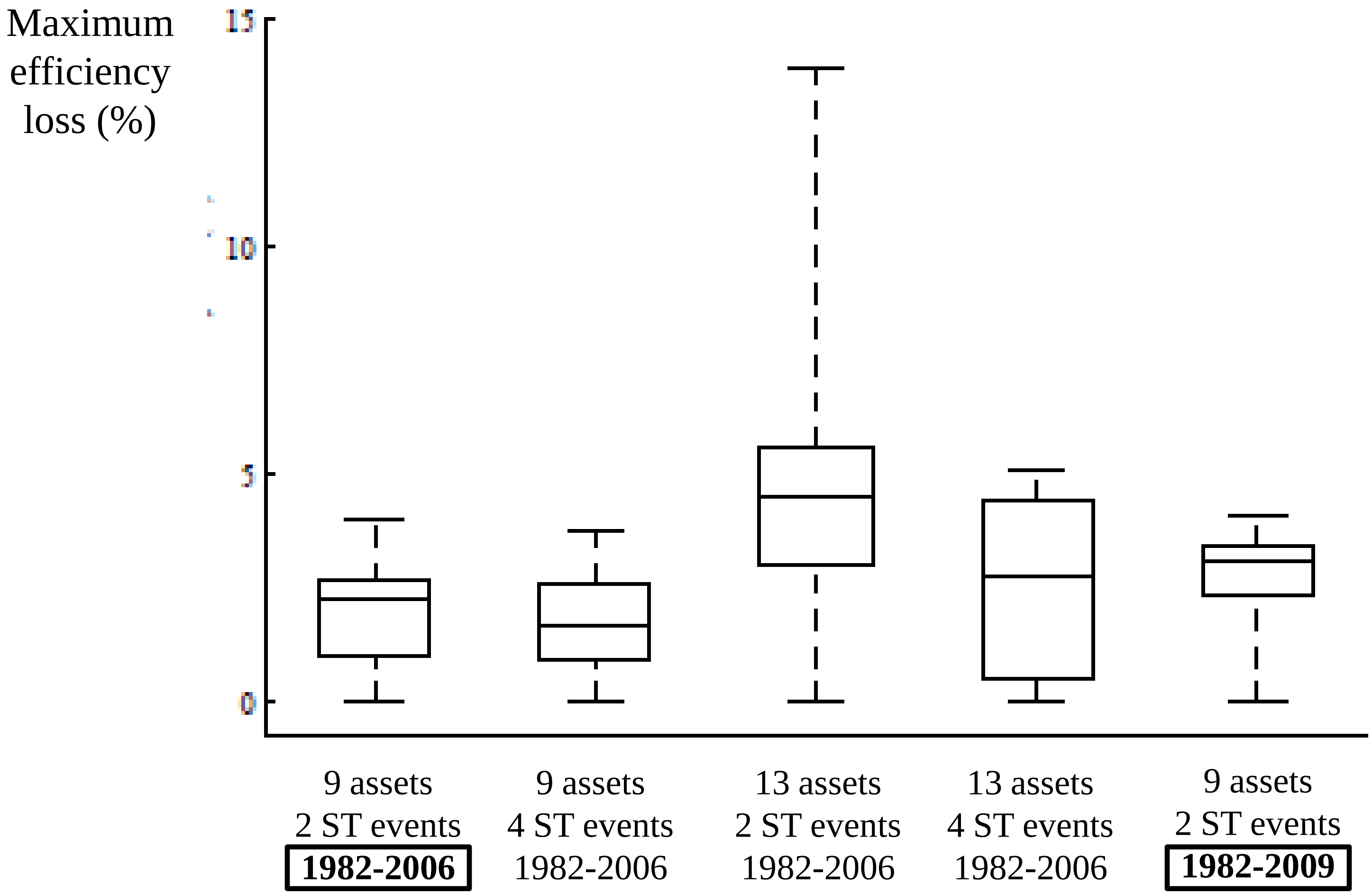
8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



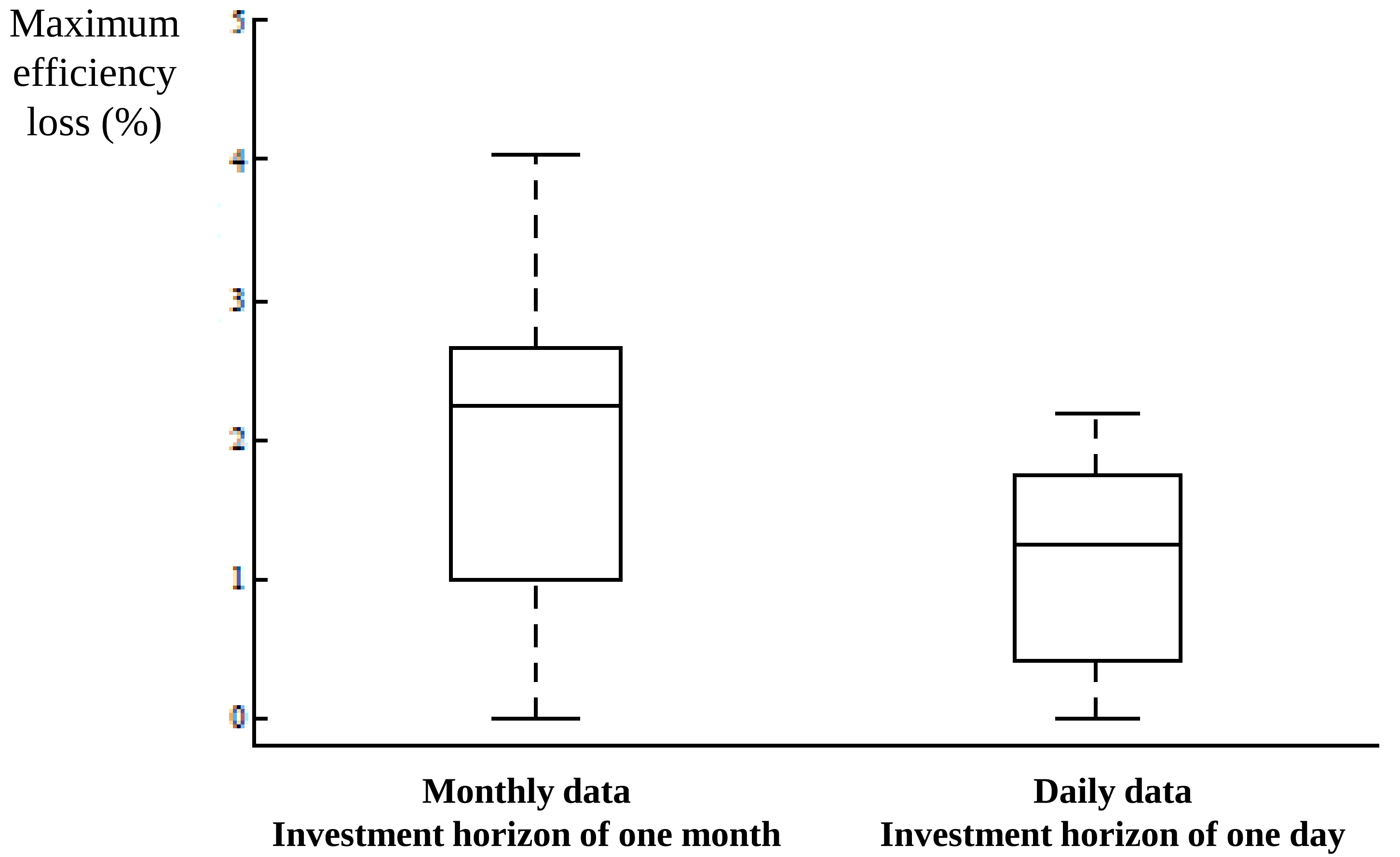
8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



8. Robustness checks
(box plots of efficiency losses with VaR and ST constraints)



• In sum, all robustness checks indicate that the joint use of VaR and ST constraints is still *ineffective* in controlling CVaR.

9. Conclusion

• The joint use of VaR and ST constraints allows the selection of portfolios with relatively *large* CVaRs.

• Hence, the joint use of VaR and ST constraints is *ineffective* in controlling CVaR.

• This result is consistent with:
  – Banks around the world suffered sizeable trading losses during the recent crisis.
  – Trading losses notably exceeded VaR (and even minimum capital requirements).

• Our paper supports the view that the Basel market risk framework did *not* promote bank stability.

10. Related Research

- Revised Basel market risk framework: stressed VaR
  - *Motivation:* revised framework is based on VaR, stressed VaR, and ST.
  - *Question*: is the revised framework *effective* in controlling tail risk?
  - *Main result I*: a risk management system based on the revised framework still allows the selection of trading portfolios with substantive tail risk.
  - *Main result II*: while the minimum capital requirements set by the original framework for such portfolios can be wiped out by losses during a period of just one day, this is much less likely with the revised framework.
  - *Reference*: Alexander, Baptista, and Yan, 2011, A comparison of the original and revised Basel market risk frameworks for regulating bank capital.

10. Related Research

- An alternative: using multiple VaR constraints
  - *Motivation*: practitioners and regulators criticize the performance of VaR during the recent crisis, but still use it.
  - *Question*: does there exist *more effective* VaR-based risk management systems?
  - *Main result*: regulations and risk management systems based on *multiple* VaR constraints are *more effective* in reducing tail risk than those based on a *single* VaR constraint.
  - *Reference*: Alexander, Baptista, and Yan, 2011, When more is less: Using multiple constraints to reduce tail risk, *Journal of Banking and Finance*, forthcoming.