A SIMULATION EXPERIMENT OF RANKING INDICES FOR MITIGATION RISKS

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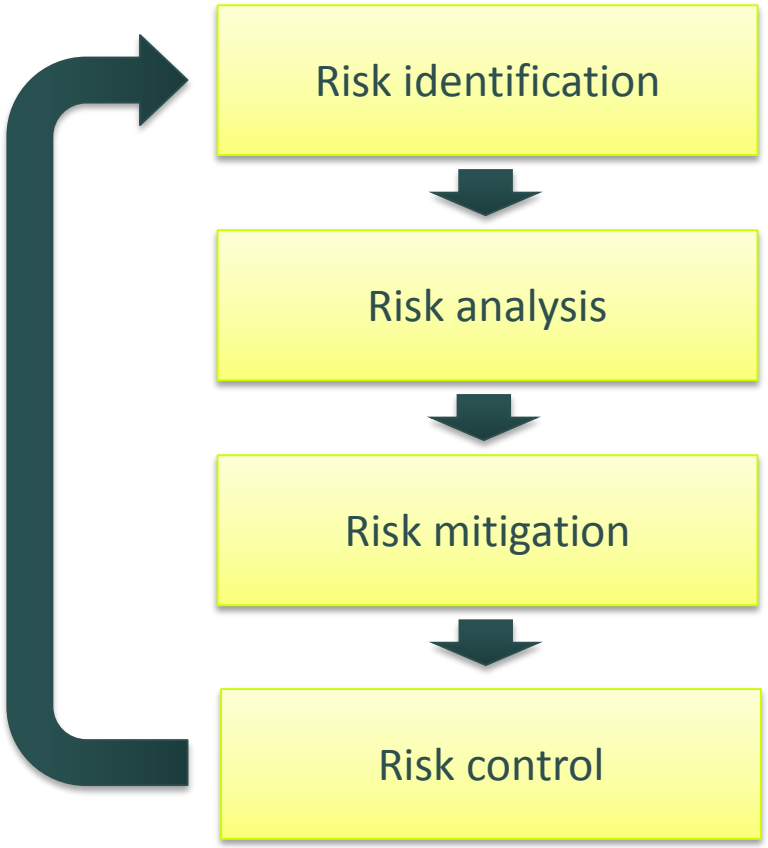
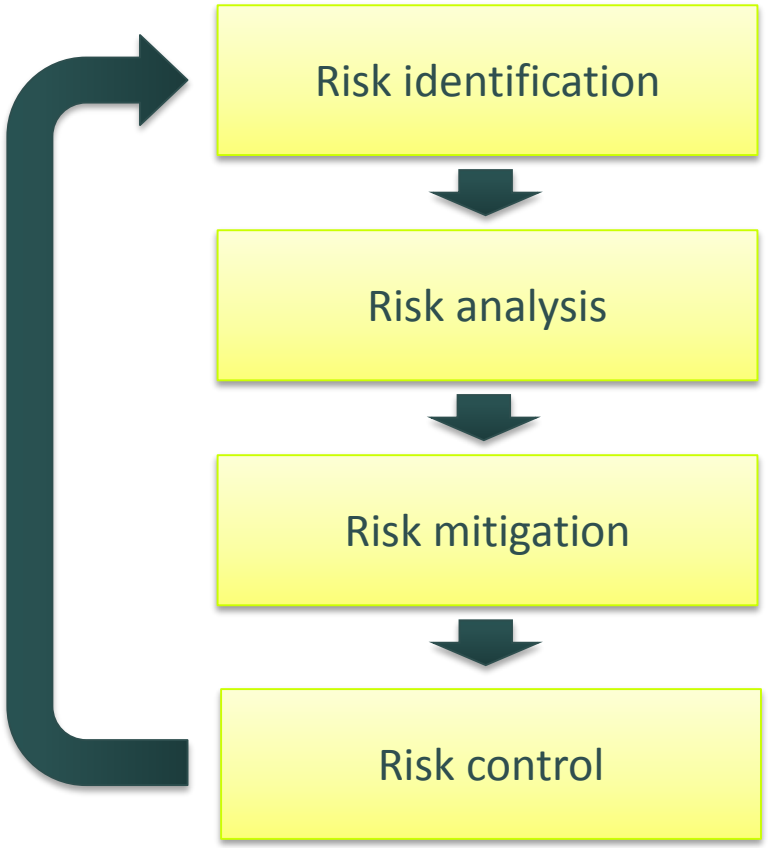
Risk management 101



Risk management 101



- Quantify probabilities and impacts of risks
- Assess the impact on project objectives
- Calculate the project objectives

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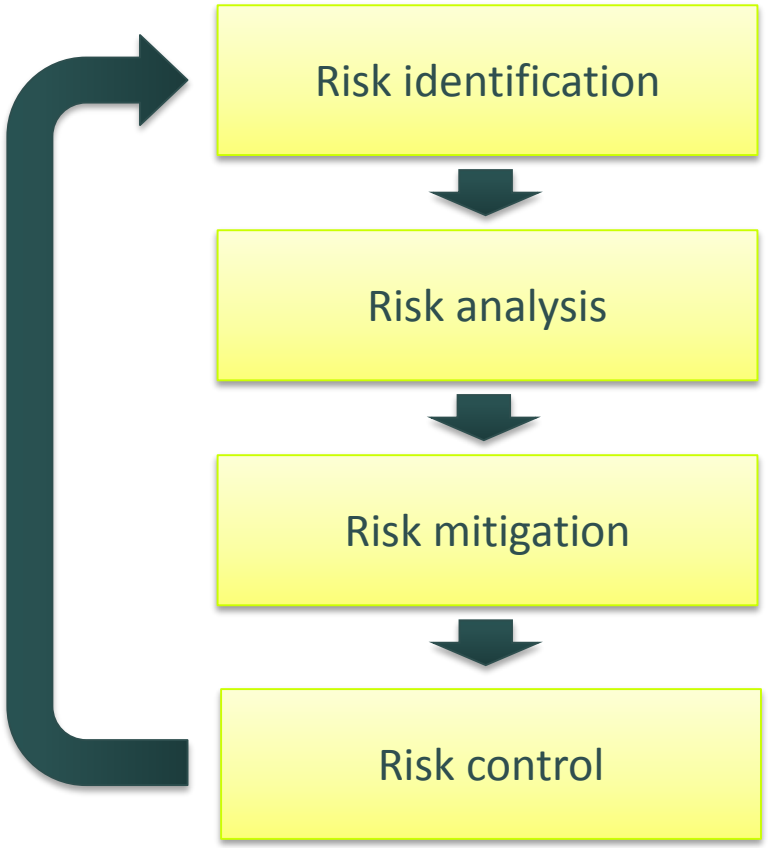

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- Assess the impact on project objectives
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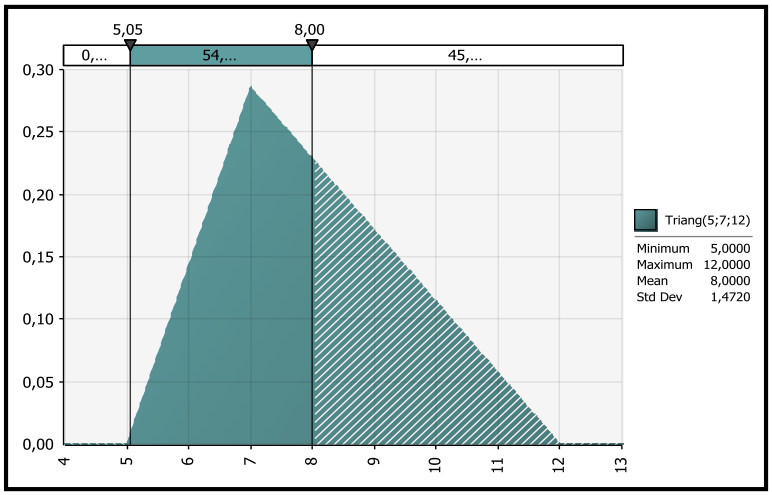
Where to start?

PROJECT RISK MANAGEMENT: CURRENT APPROACH

Uncertainty is captured in activity durations:

- Normal distribution
- Triangular distribution
- Beta distribution



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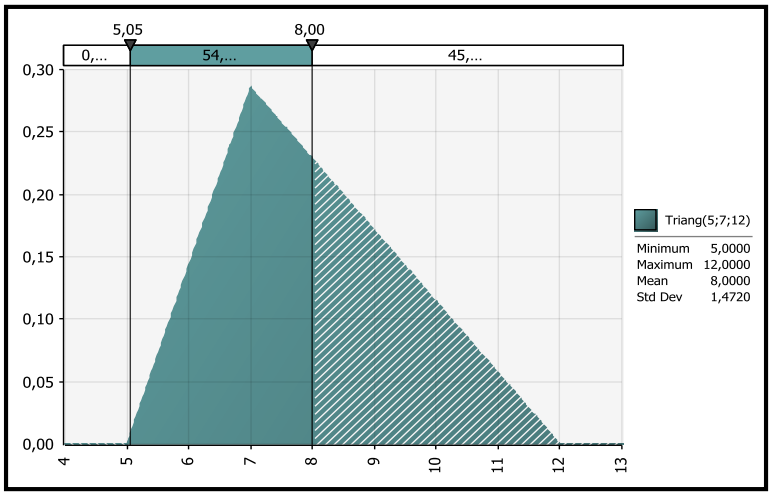
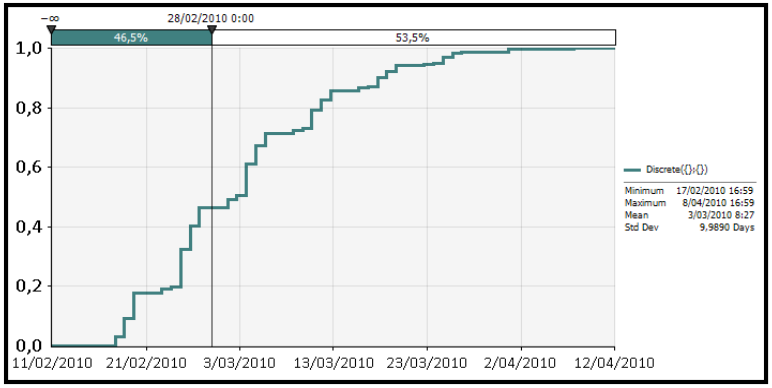


Monte Carlo simulation is used to obtain estimates of project objectives (e.g. cdf of the completion time)



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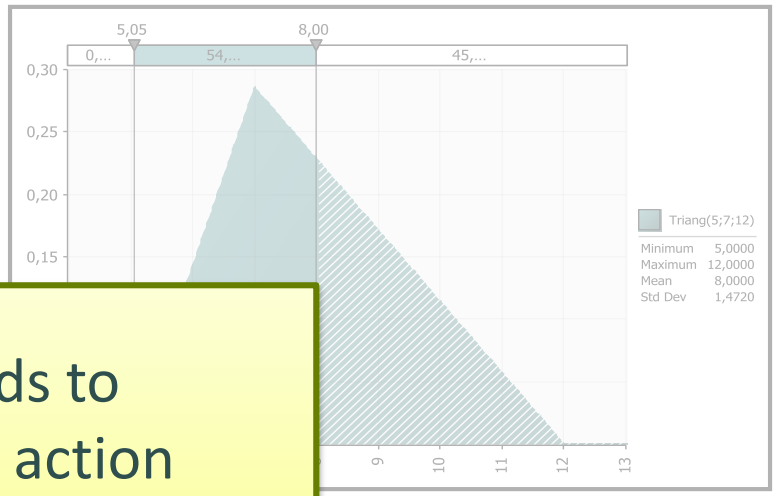
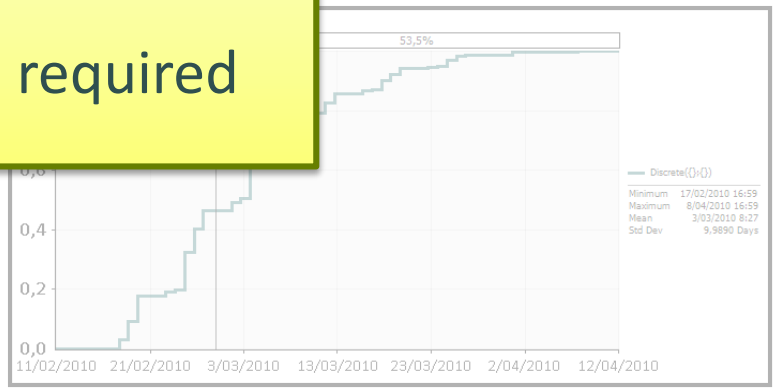


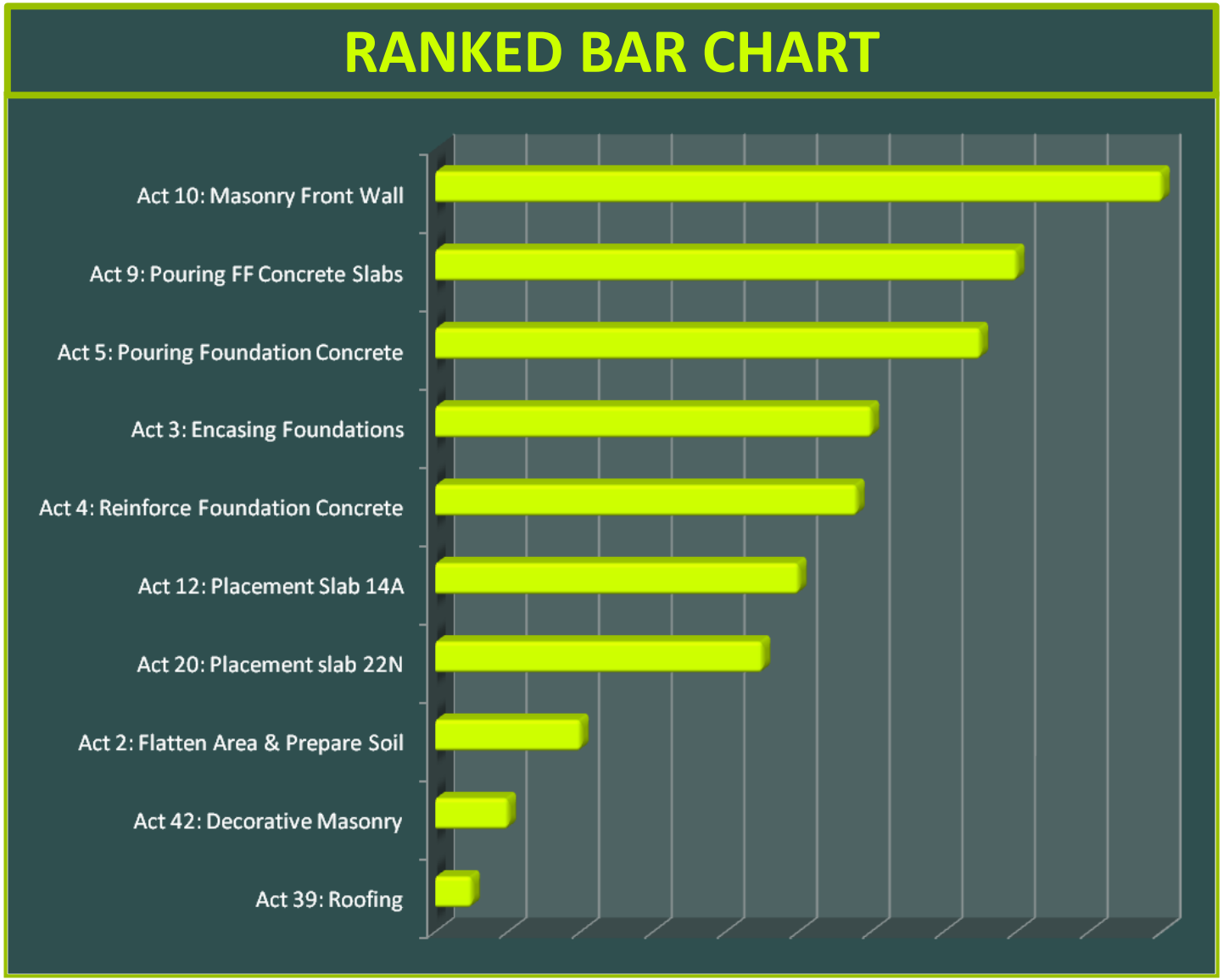


Analysis needs to be followed by action

=>

Risk mitigation is required

RISK MITIGATION: RANKING OF MOST SENSITIVE ACTIVITIES



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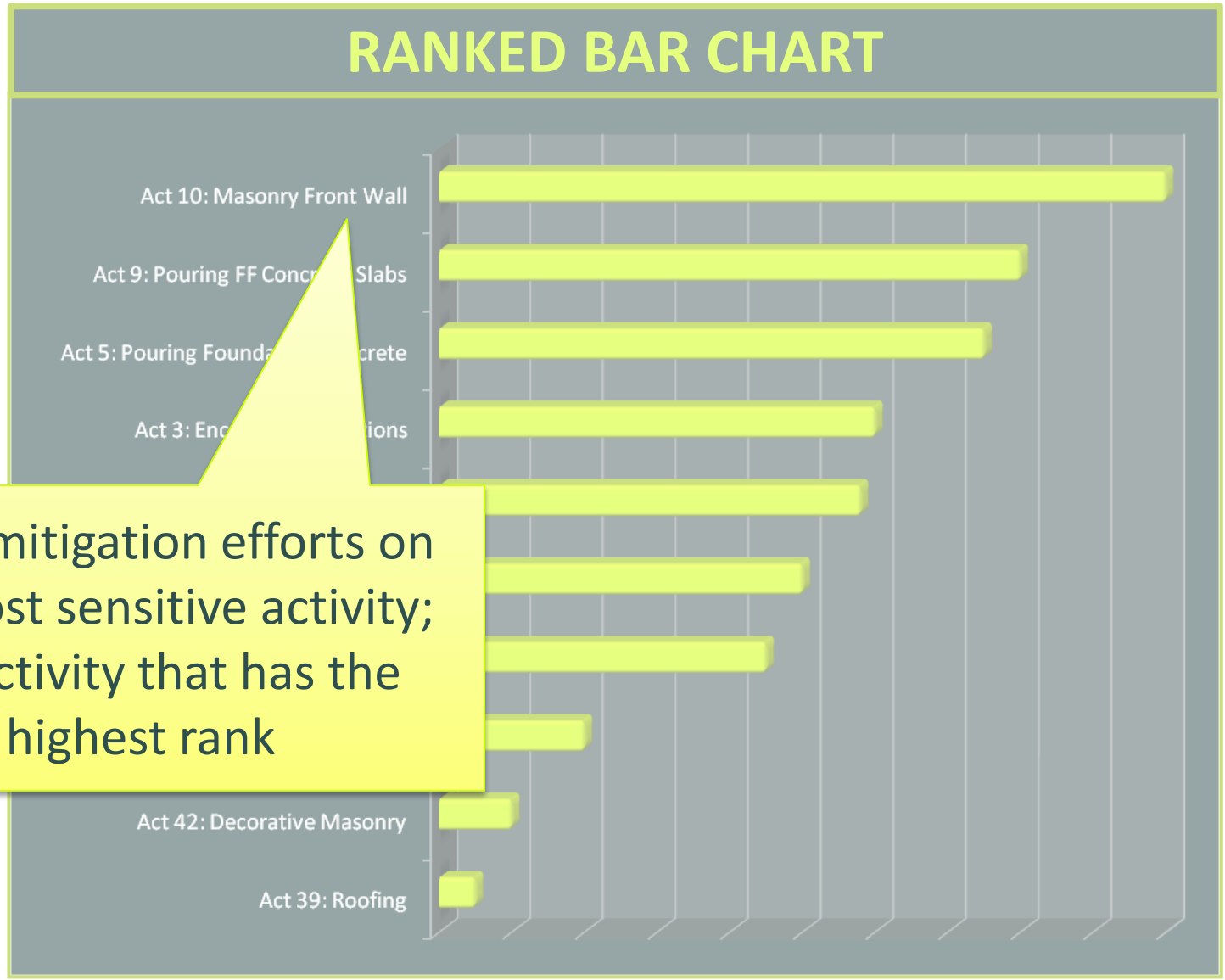


Focus mitigation efforts on the most sensitive activity; the activity that has the highest rank

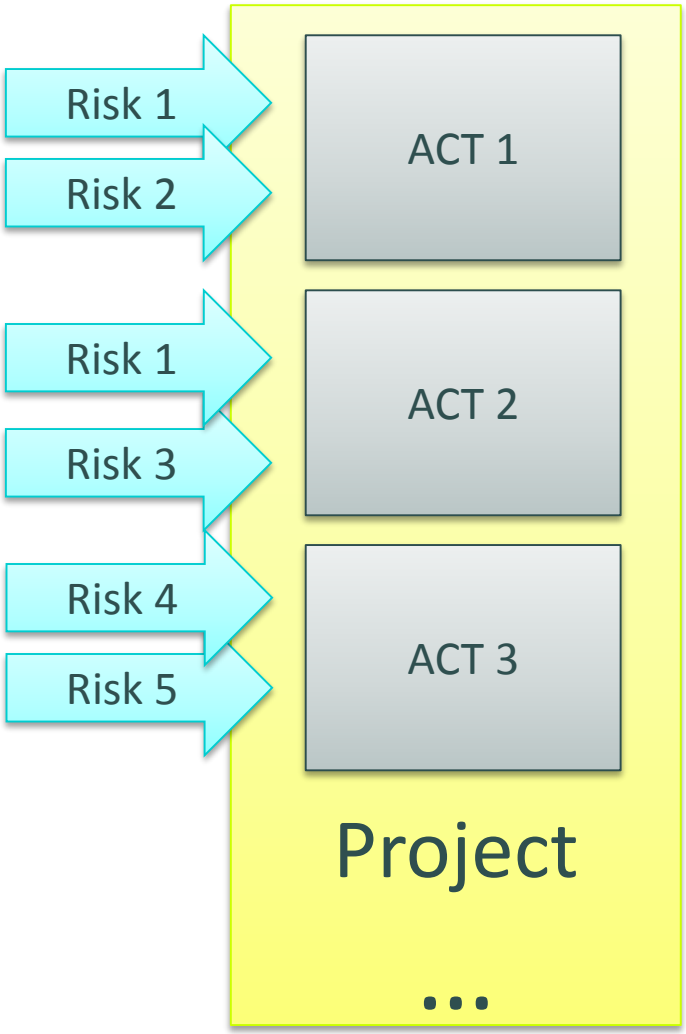
CURRENT RANKING MEASURES

Criticality index	$ACI_j = \frac{1}{q}\sum_{p=1}^{q} \delta_{j,p}$
Significance index	$SI_j = \frac{1}{\sum_{p=1}^{q} c_p}\sum_{p=1}^{q} \frac{d_{j,p}}{d_{j,p} + TF_{j,p}}$
Cruciality index	$CRI_j = \lvert corr(\boldsymbol{d}_j, \boldsymbol{c})\rvert$
Spearman rank correlation	$SRCA_j = \left\lvert corr\left(rank(\boldsymbol{d}_j), rank(\boldsymbol{c})\right)\right\rvert$
Schedule sensitivity index	$SSI_j = ACI_j \sqrt{\frac{var(\boldsymbol{d}_j)}{var(\boldsymbol{c})}}$

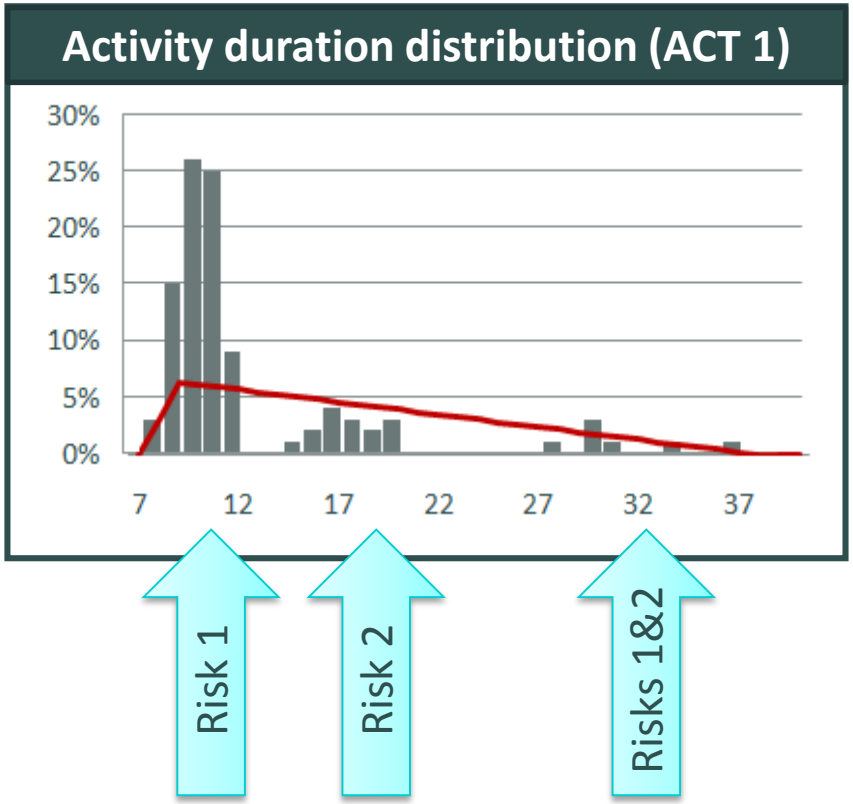
Problems with current approach

- Project managers have a very hard time to model uncertainty
- All of the previous ranking measures have been criticized
- It is not clear where the uncertainty originates from
- It is unclear how to mitigate uncertainty

New approach: risk-driven (instead of activity-based)



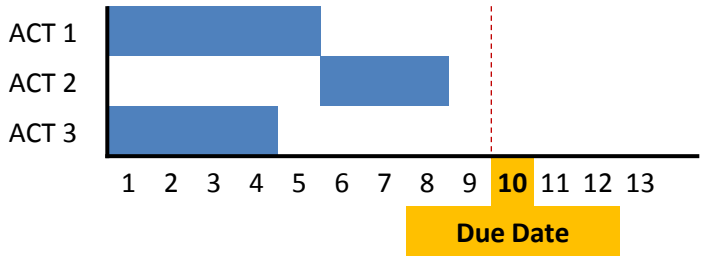
$$\boldsymbol{d}_j = f\left(d_j, \boldsymbol{m}_{j,e}\right)$$



Risk-driven ranking measures

Cruciality index	$CRIR_e = \lvert corr(\boldsymbol{m}_e, \boldsymbol{c}) \rvert$
Spearman rank correlation	$SRCR_e = \left\lvert corr\left(rank(\boldsymbol{m}_e), rank(\boldsymbol{c})\right) \right\rvert$
Critical Delay Contribution (CDC)	$CDC_{j,e} = \frac{1}{q} \frac{\sum_{p=1}^{q} m_{j,e,p} \delta_{j,p} \left(c_p - c\right)}{\sum_{j \in N} \sum_{e \in R} \sum_{p=1}^{q} m_{j,e,p} \delta_{j,p}}$

CRITICAL DELAY CONTRIBUTION (CDC): EXAMPLE



	DUR	DISRUPTION	CDC
ACT 1	**5**		
ACT 2	**3**		
ACT 3	**4**		
PROJECT	**8**		

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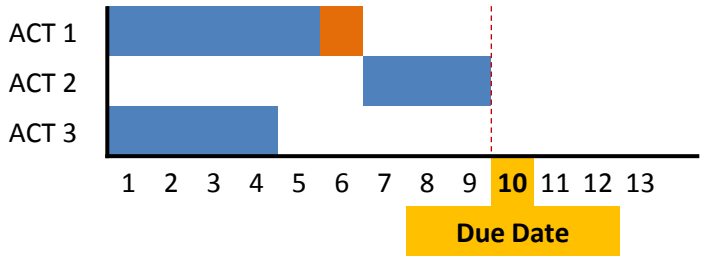
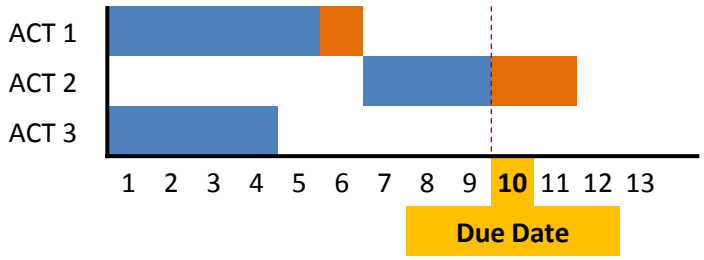


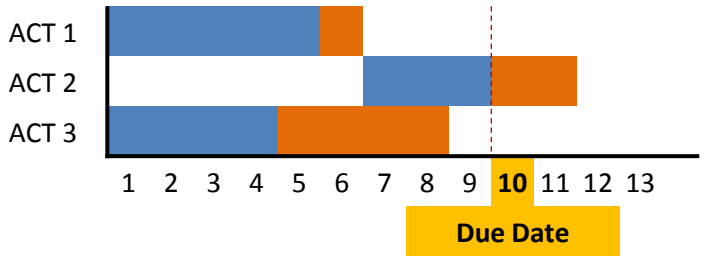
	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**3**		
ACT 3	**4**		
PROJECT	**9**		

CRITICAL DELAY CONTRIBUTION (CDC): EXAMPLE



	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**5**	**2**	
ACT 3	**4**		
PROJECT	**11**		

CRITICAL DELAY CONTRIBUTION (CDC): EXAMPLE



	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**5**	**2**	
ACT 3	**8**	**4**	
PROJECT	**11**	**2**	

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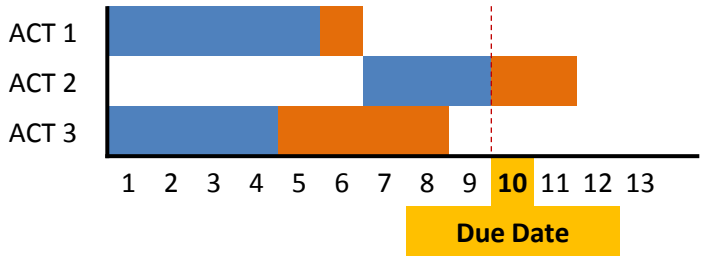

	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**5**	**2**	
ACT 3	**8**	**4**	
PROJECT	**11**	**2**	**2**

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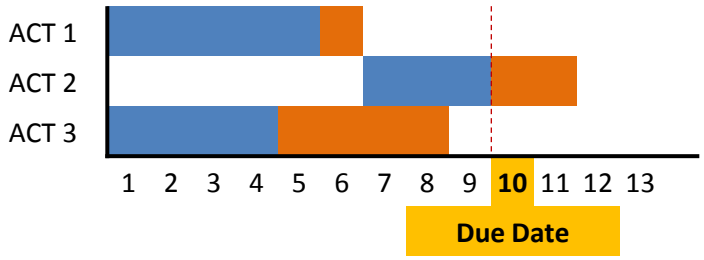
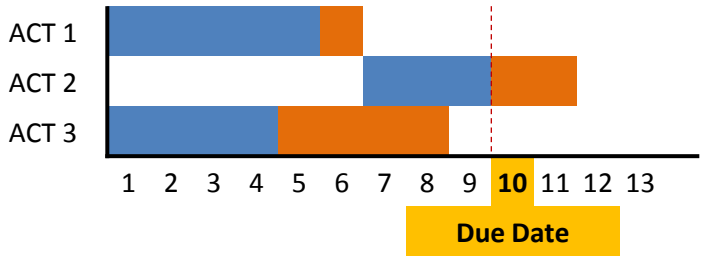


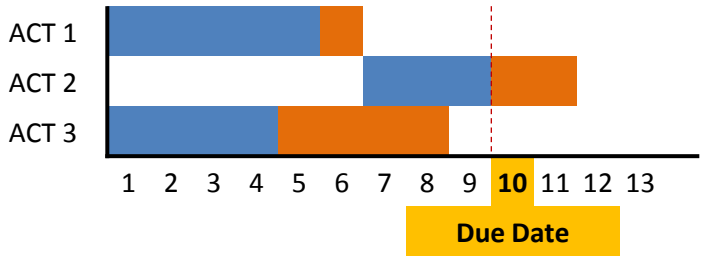
	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**5**	**2**	
ACT 3	**8**	**4**	**0**
PROJECT	**11**	**2**	**2**

CRITICAL DELAY CONTRIBUTION (CDC): EXAMPLE



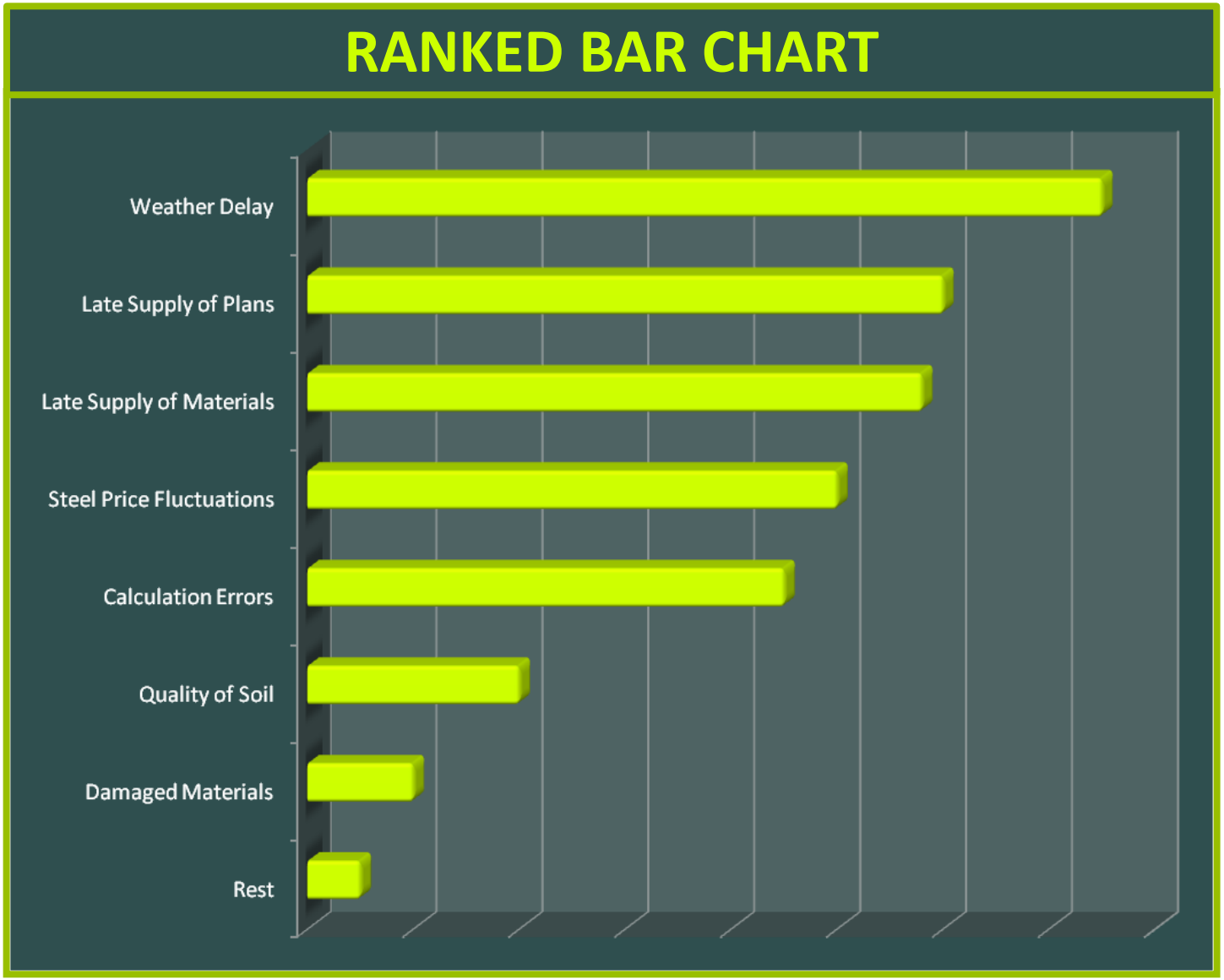
	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	
ACT 2	**5**	**2**	**1,33**
ACT 3	**8**	**4**	**0**
PROJECT	**11**	**2**	**2**

CRITICAL DELAY CONTRIBUTION (CDC): EXAMPLE



	DUR	DISRUPTION	CDC
ACT 1	**6**	**1**	**0,67**
ACT 2	**5**	**2**	**1,33**
ACT 3	**8**	**4**	**0**
PROJECT	**11**	**2**	**2**

RANKED BAR CHART USING RISK-DRIVEN RANKING MEASURES



Advantages of the new approach

- Risks are much easier to predict than uncertainty
- CDC is calculated on risk per activity basis and can be aggregated on the level of risks and activities
- Risks **root** causes are ranked => we know which risk to mitigate!

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IS THE NEW APPROACH BETTER?

Evaluating the new approach: computational experiment

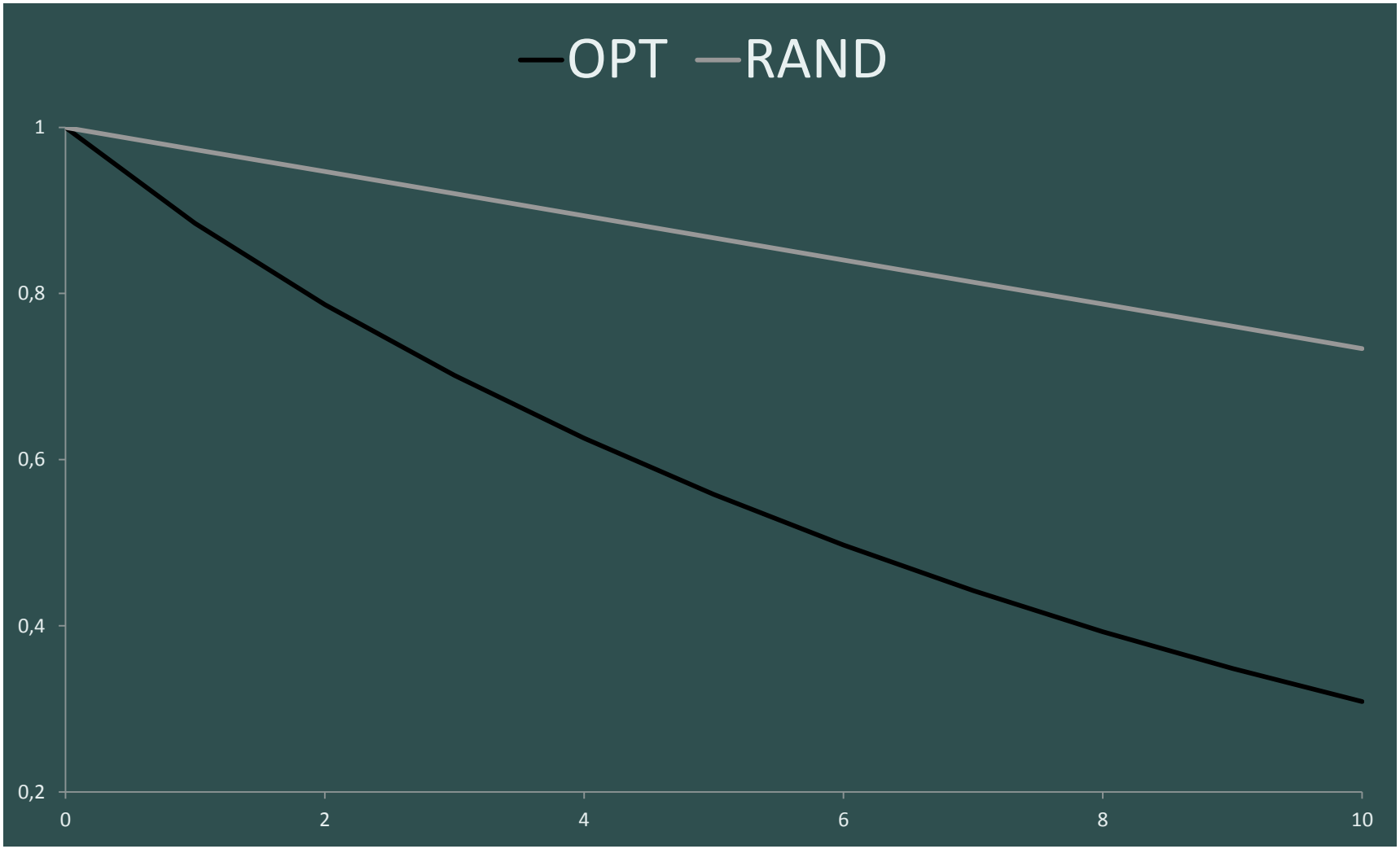
- For a large set of projects (600 projects of PSPLIB 120):
  - Model uncertainty (i.e. define risks, impacts, probabilities…)
  - Simulate the project execution (using 1000 iterations)
  - For each ranking measure:
    - Calculate the highest-ranked risk according to the measure
    - Eliminate the highest-ranked risk (i.e. focus our mitigation efforts on this risk)

How good do the measures
perform when mitigating 10 risks?

COMPUTATIONAL EXPERIMENT: RANKING MEASURES

ACTIVITY-BASED => 1) SELECT THE HIGHEST-RANKED ACTIVITY THAT IS STILL IMPACTED BY RISKS 2) FROM ALL RISKS IMPACTING THE SELECTED ACTIVITY, SELECT THE RISK THAT HAS THE LARGEST EXPECTED IMPACT	RISK-DRIVEN => SELECT THE HIGHEST-RANKED RISK
CDC ACT	CDC RISK
CRI ACT	CRI RISK
SSI	SRC RISK
SI	
ACI	
SRC ACT	

COMPUTATIONAL EXPERIMENT: RESULTS



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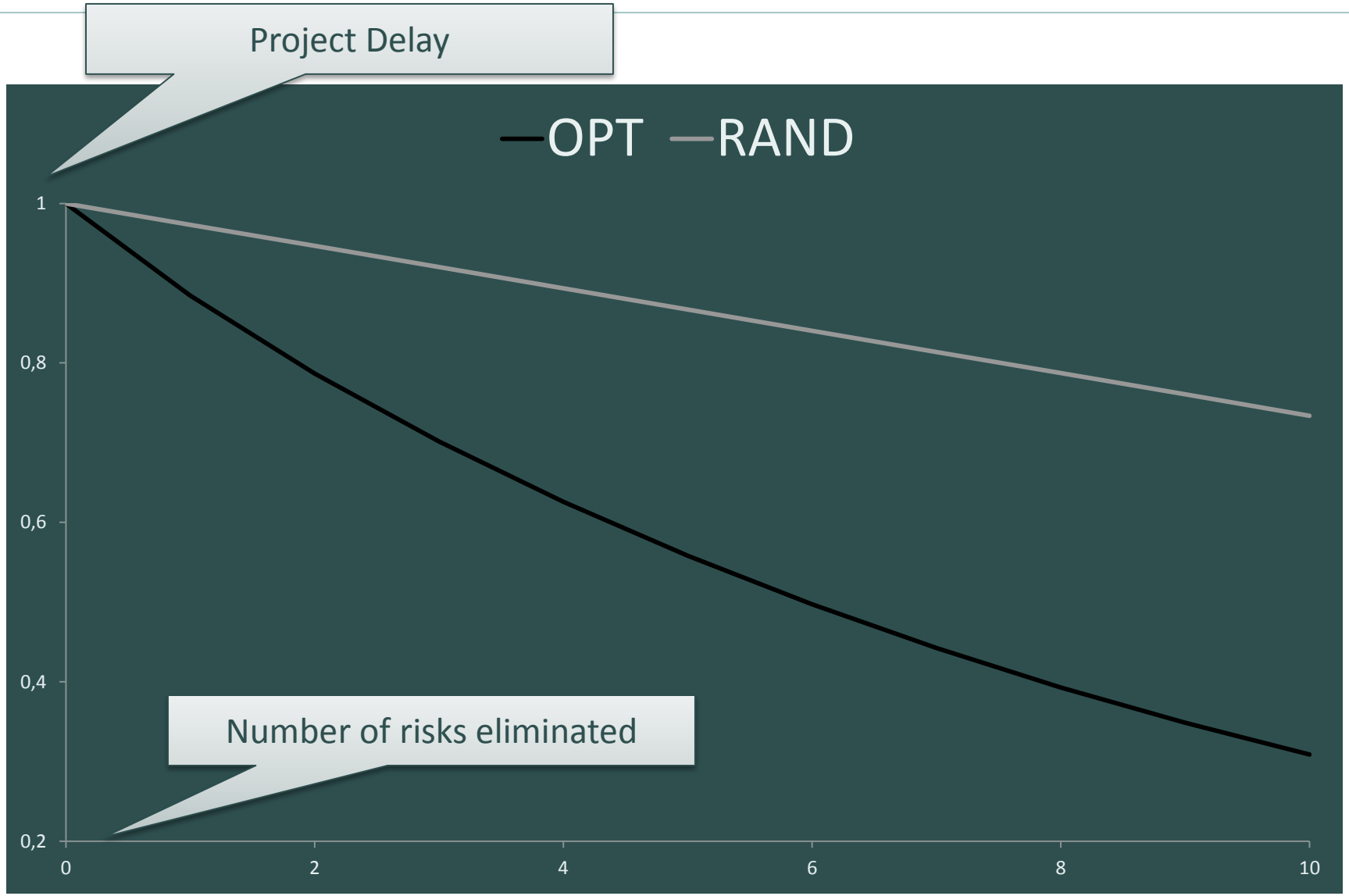

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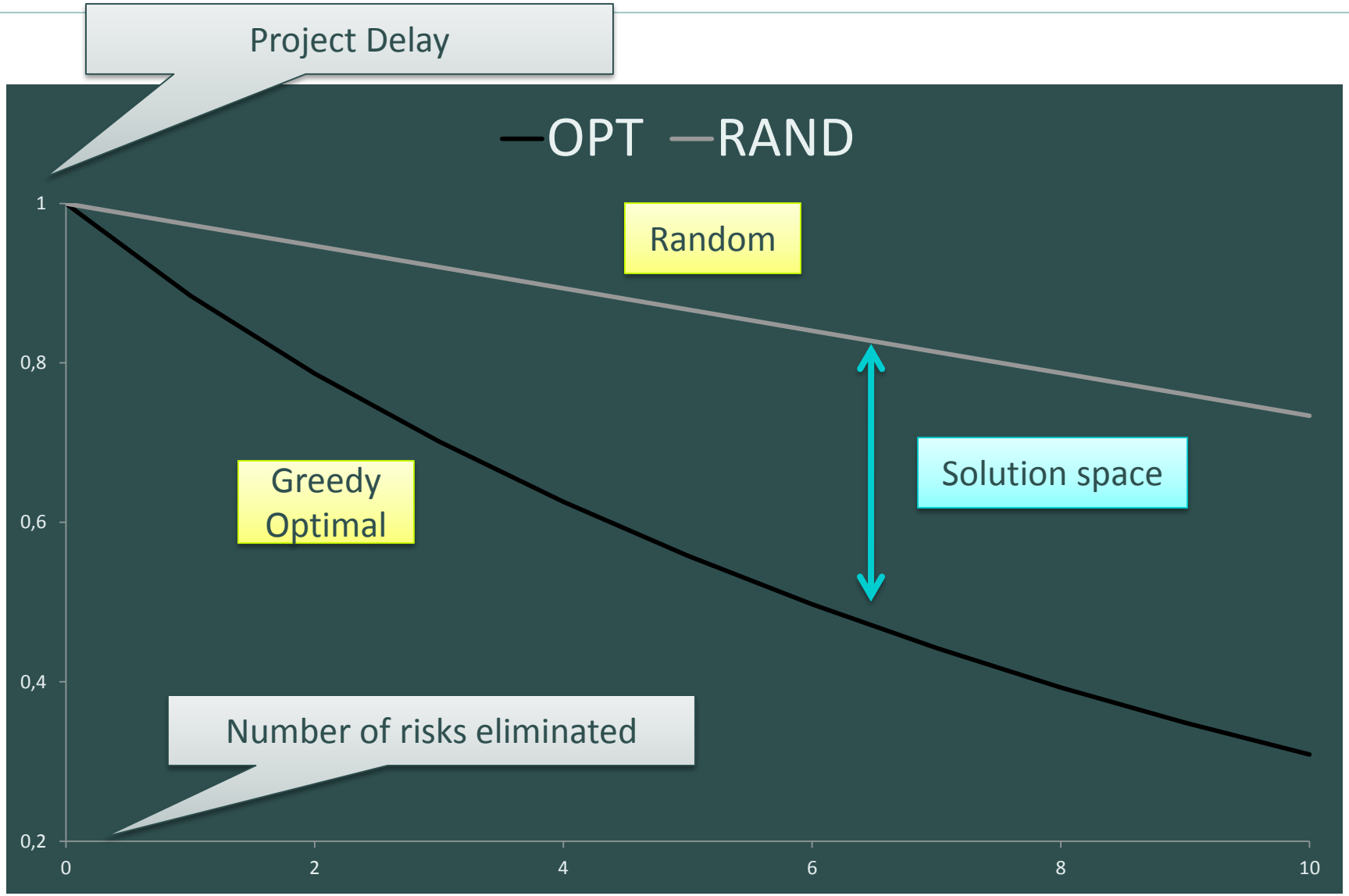

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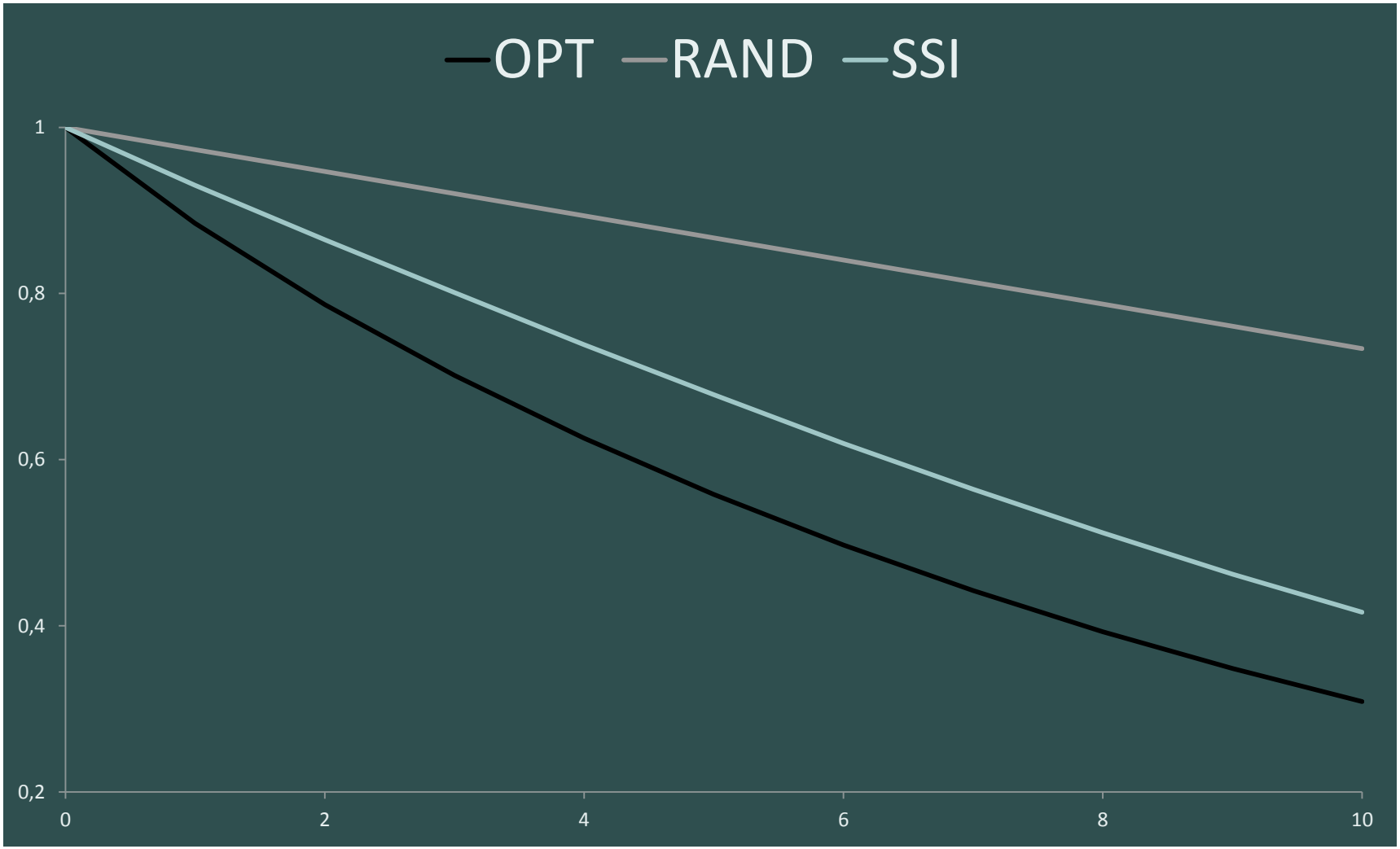

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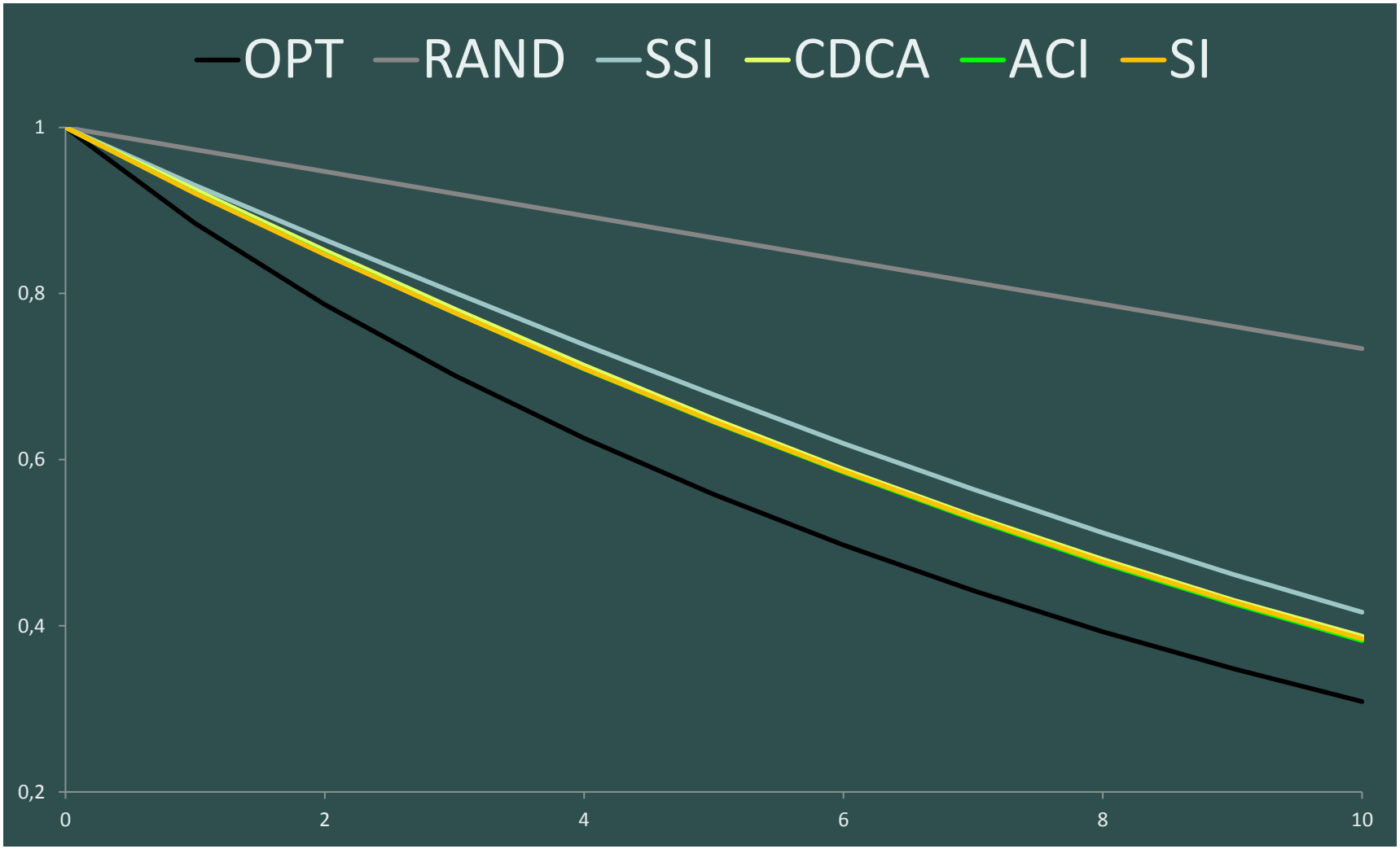

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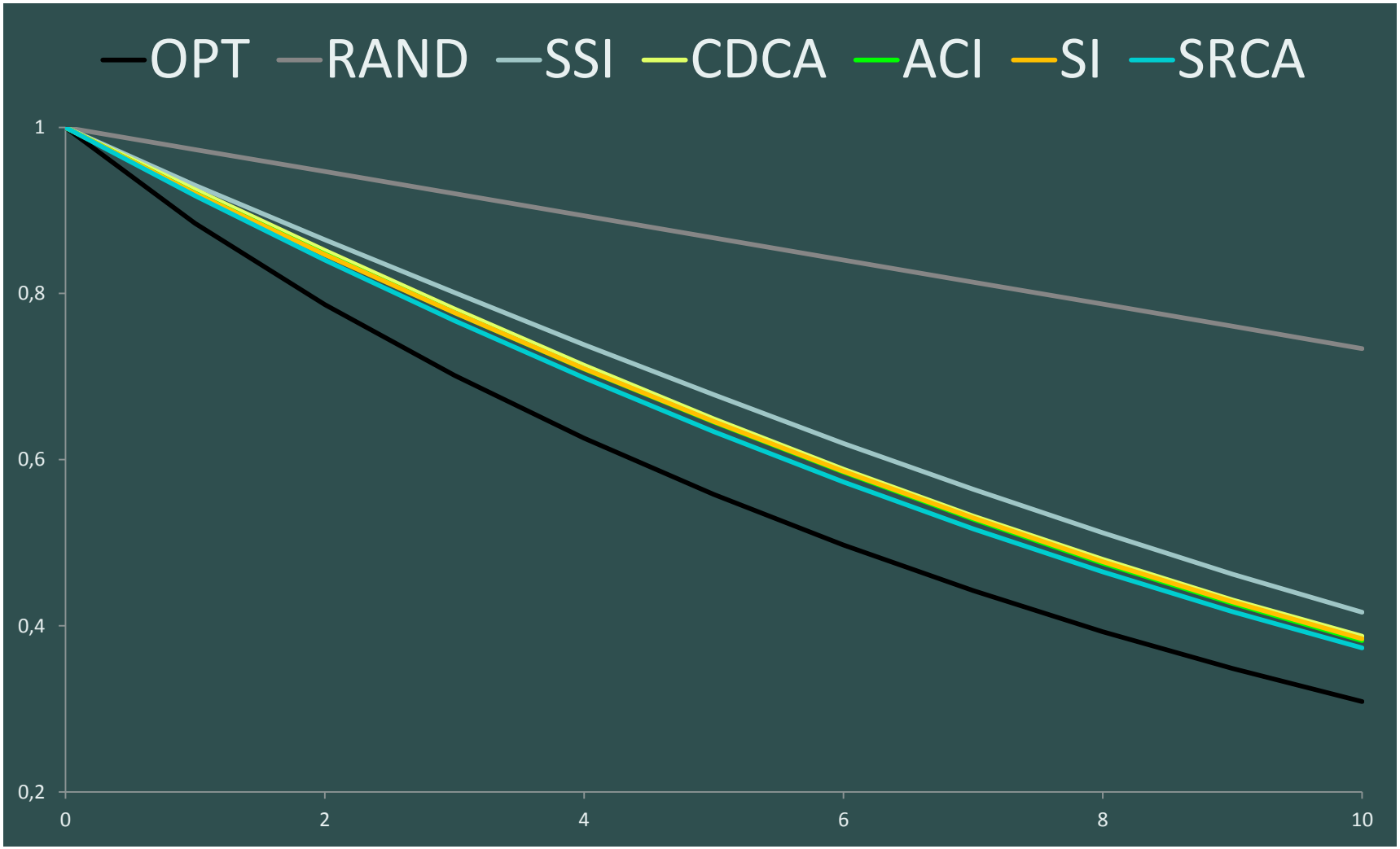

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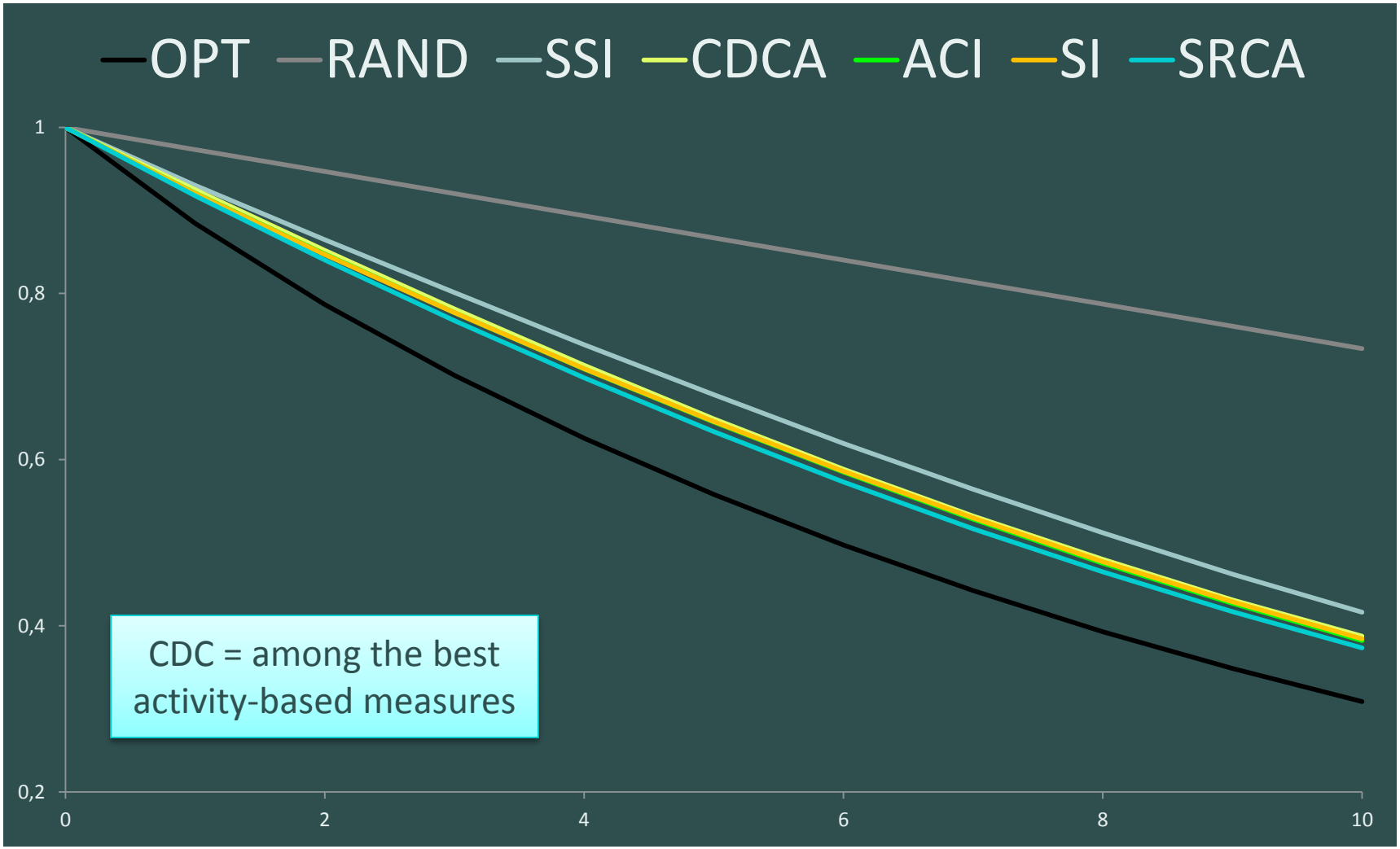

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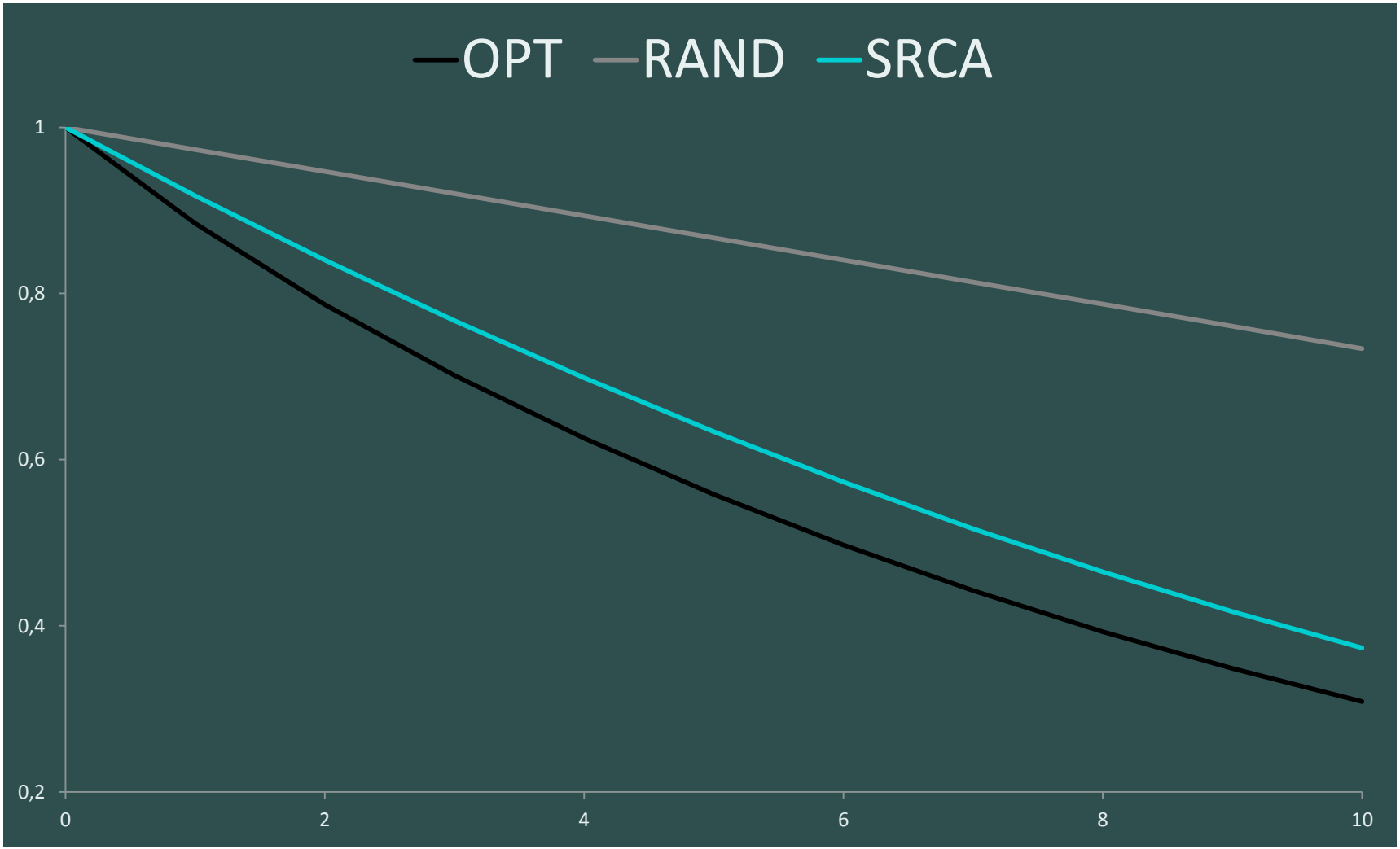

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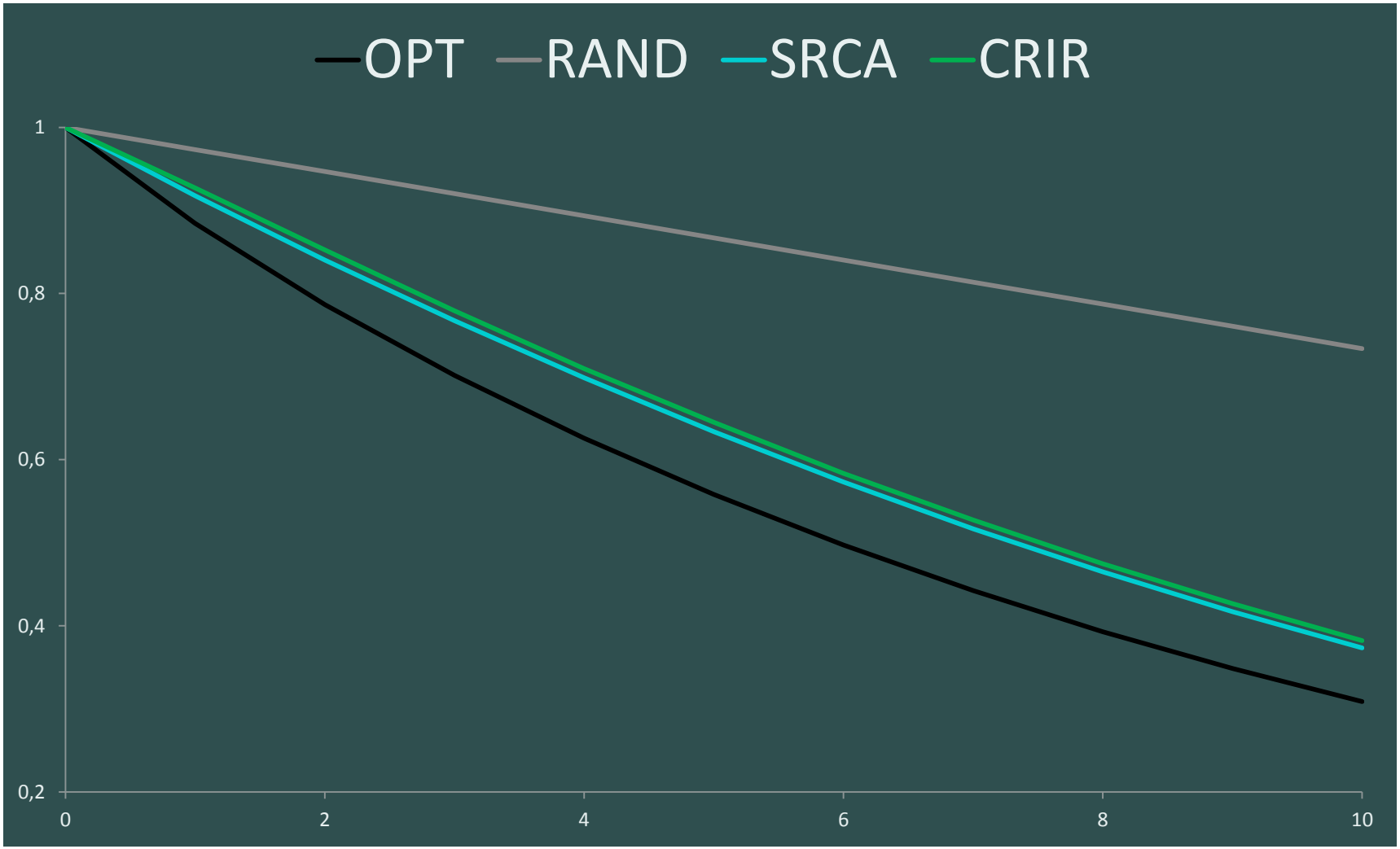

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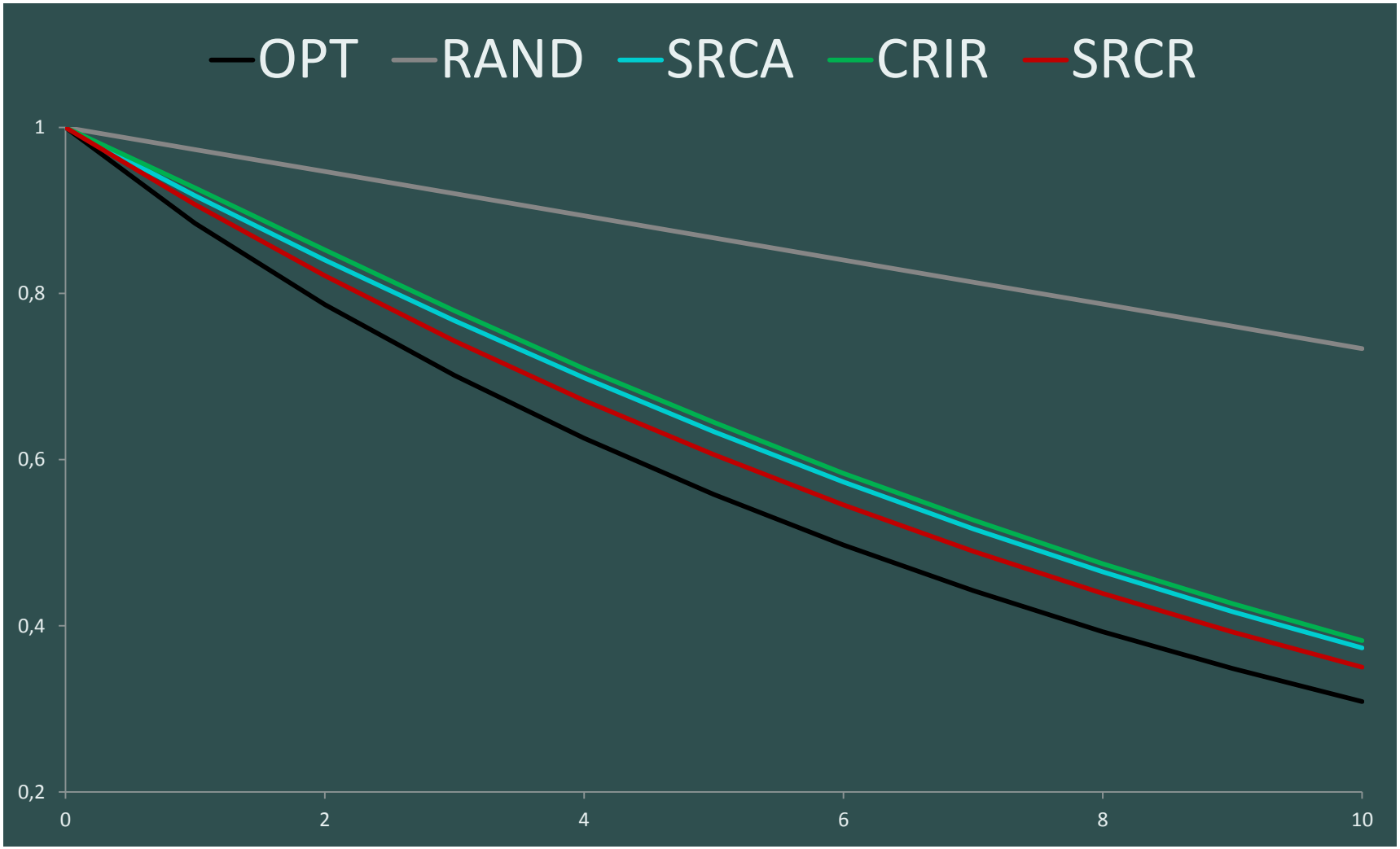

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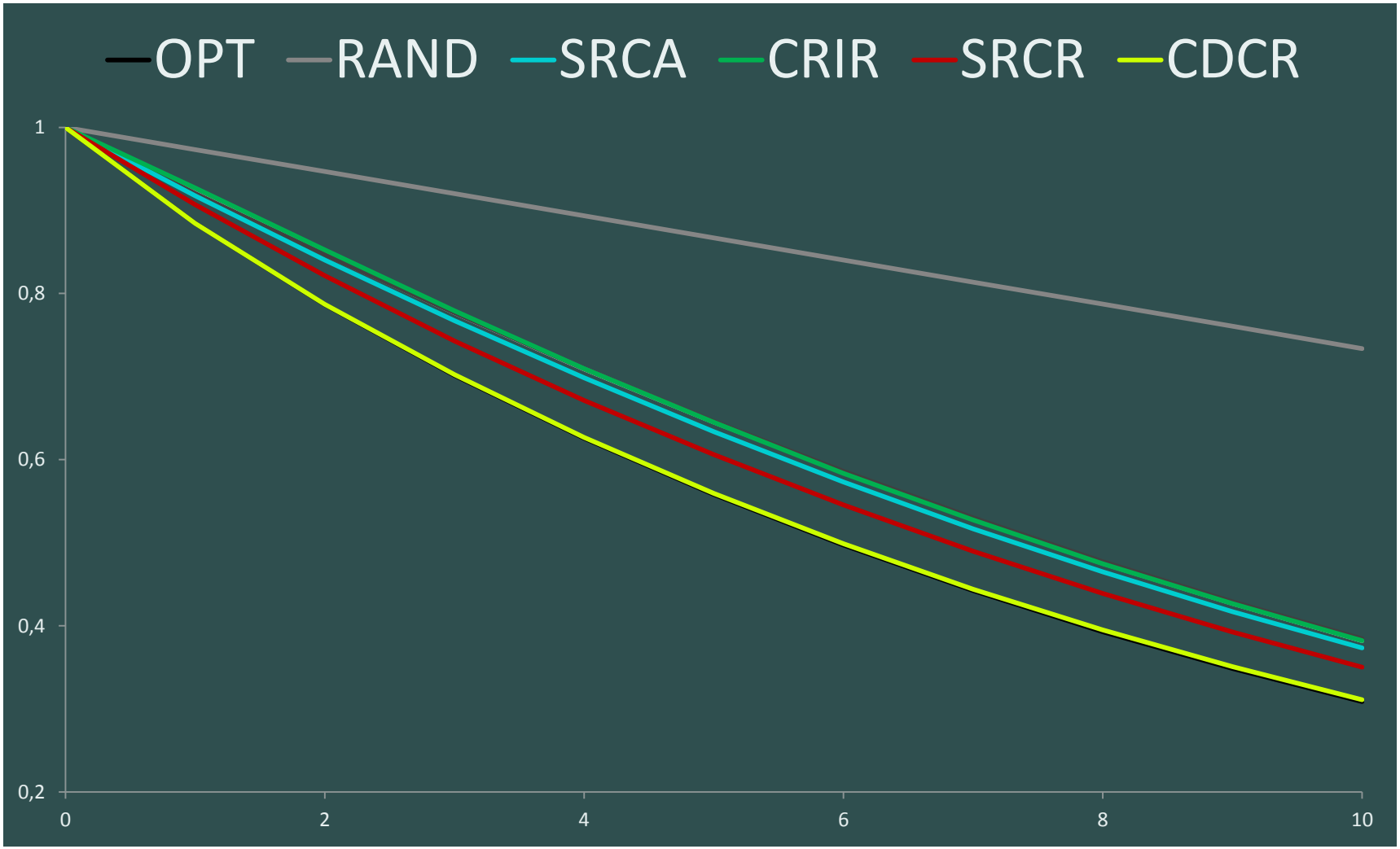

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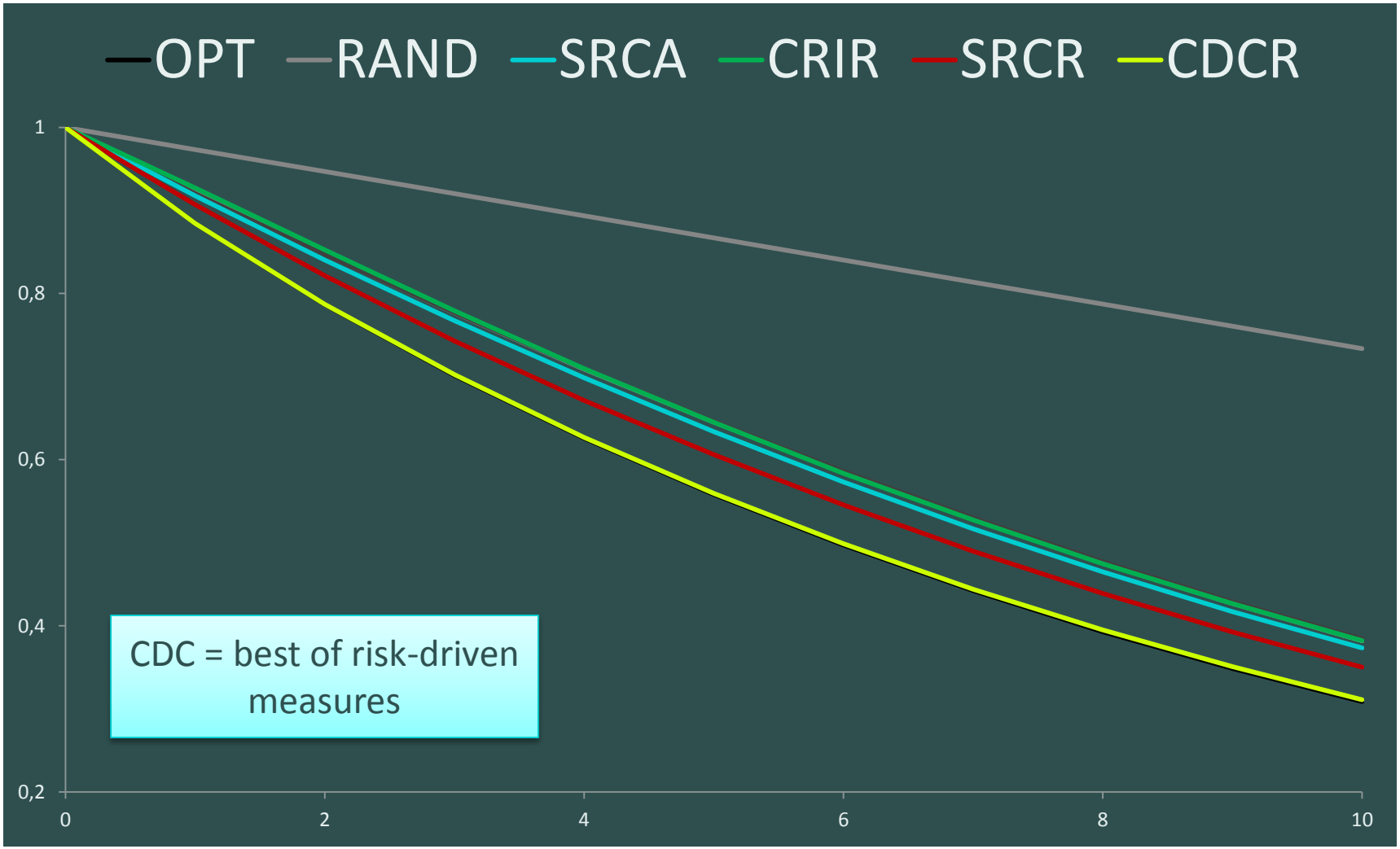

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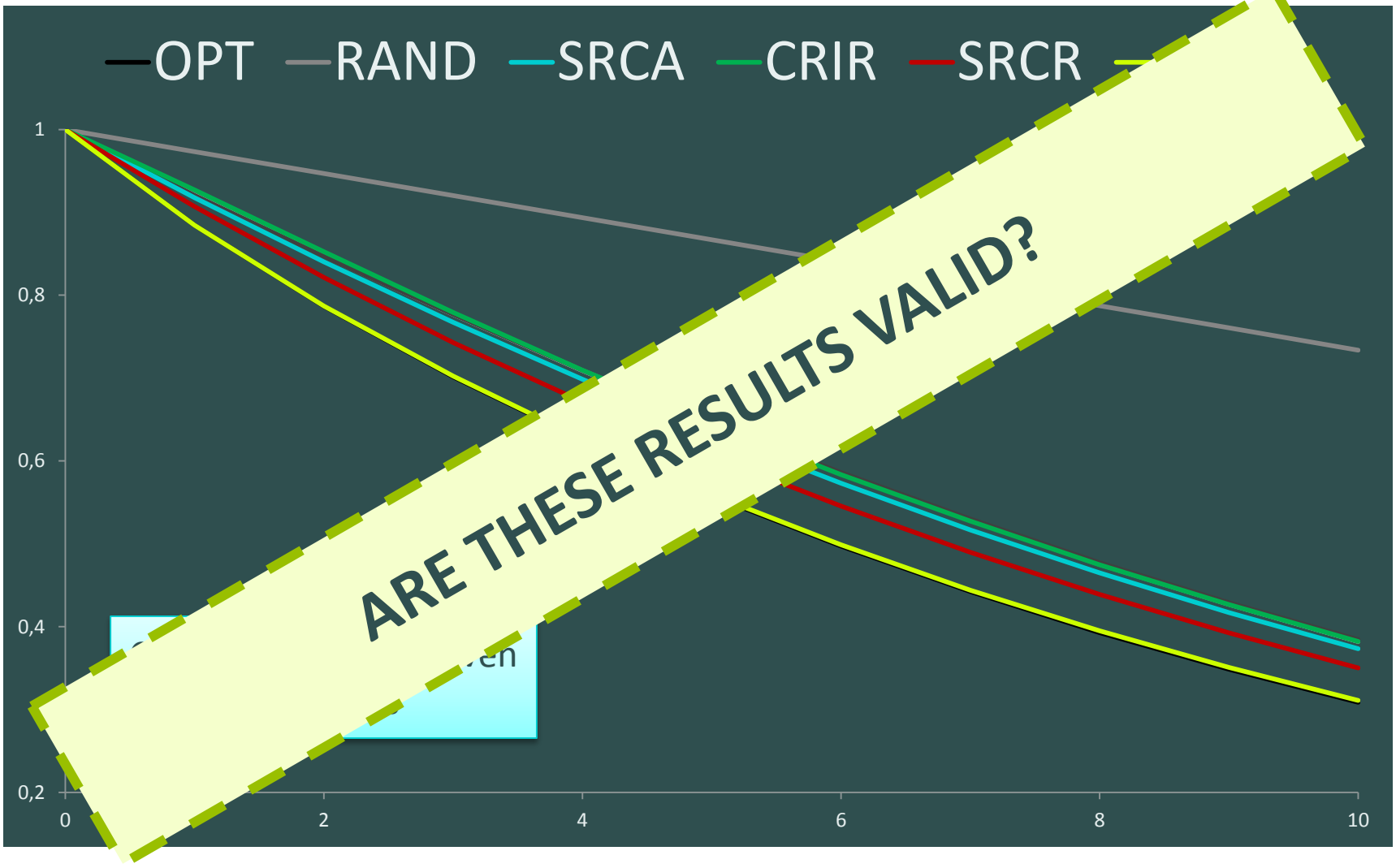

Model validity

Question: how many simulation iterations are required to obtain convergence in project completion times?

Test: proportion of projects for which the means are not equal for different numbers of simulation iterations if risks are ranked randomly

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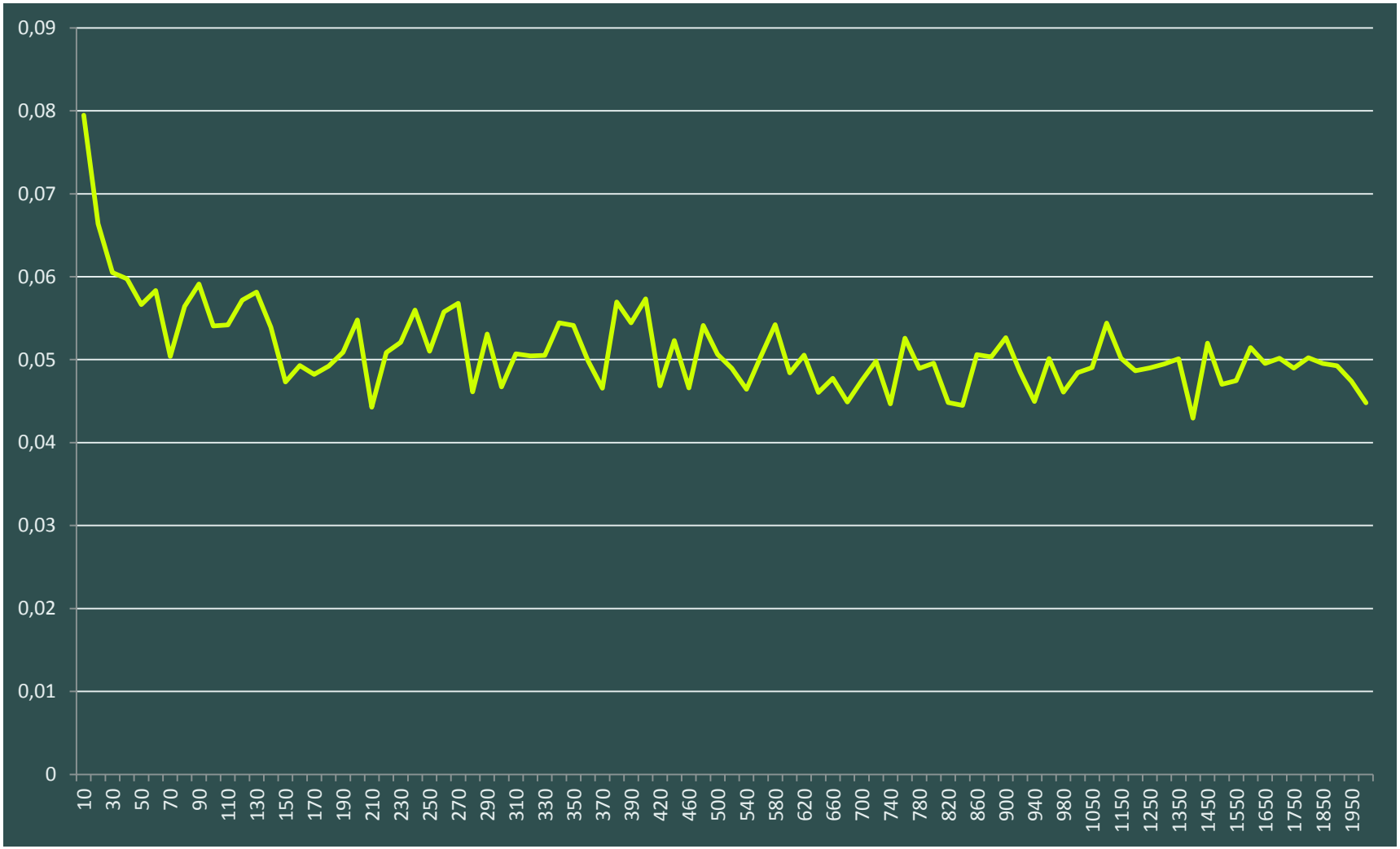

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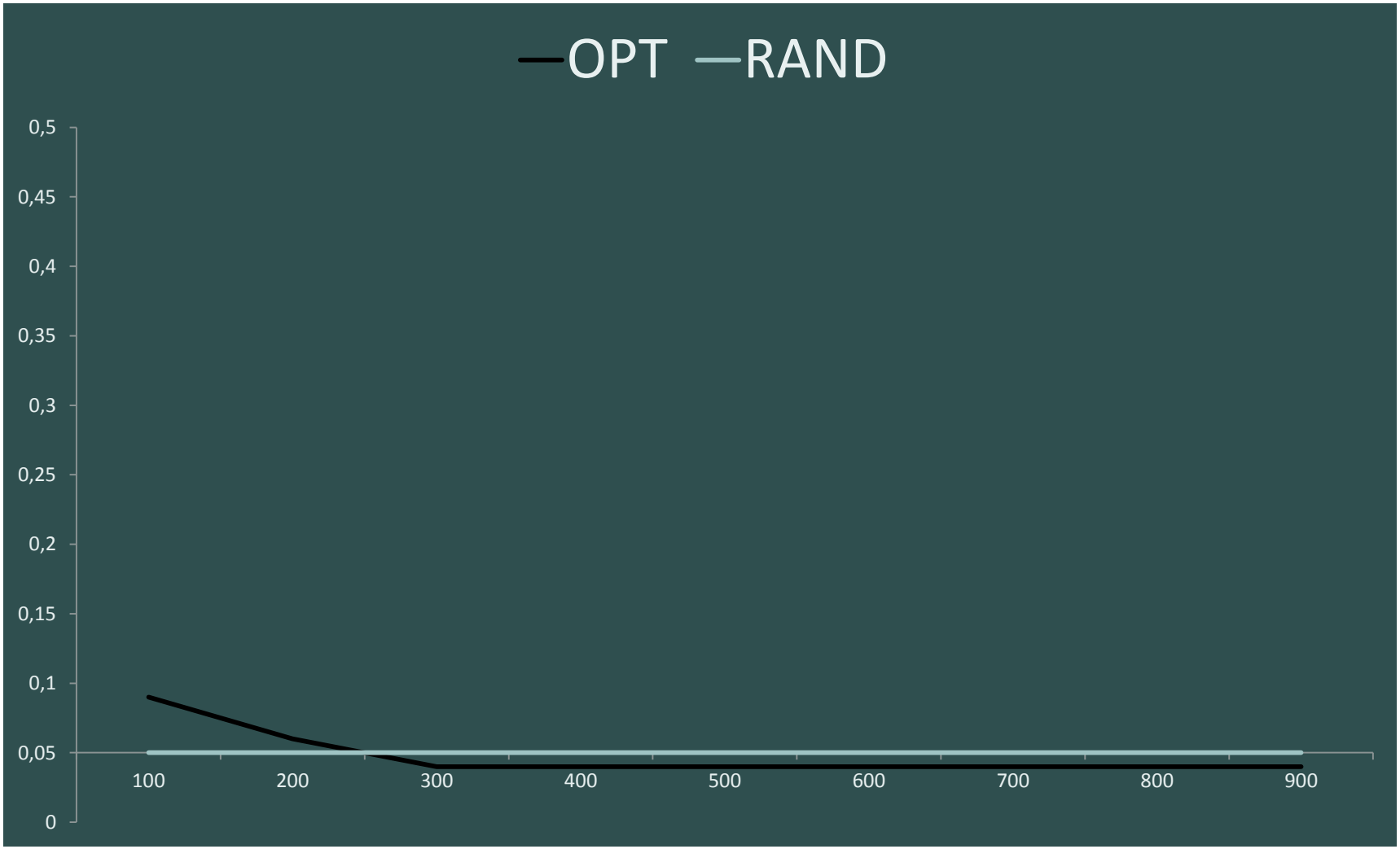
Question: for a given ranking index, does the ranking of risks converges as well?
Test: proportion of projects for which the means are not equal for different numbers of simulation iterations used to determine the ranking of risks

Model validity: proportion of projects for which means are not equal for different numbers of simulation iterations used to determine risk ranking



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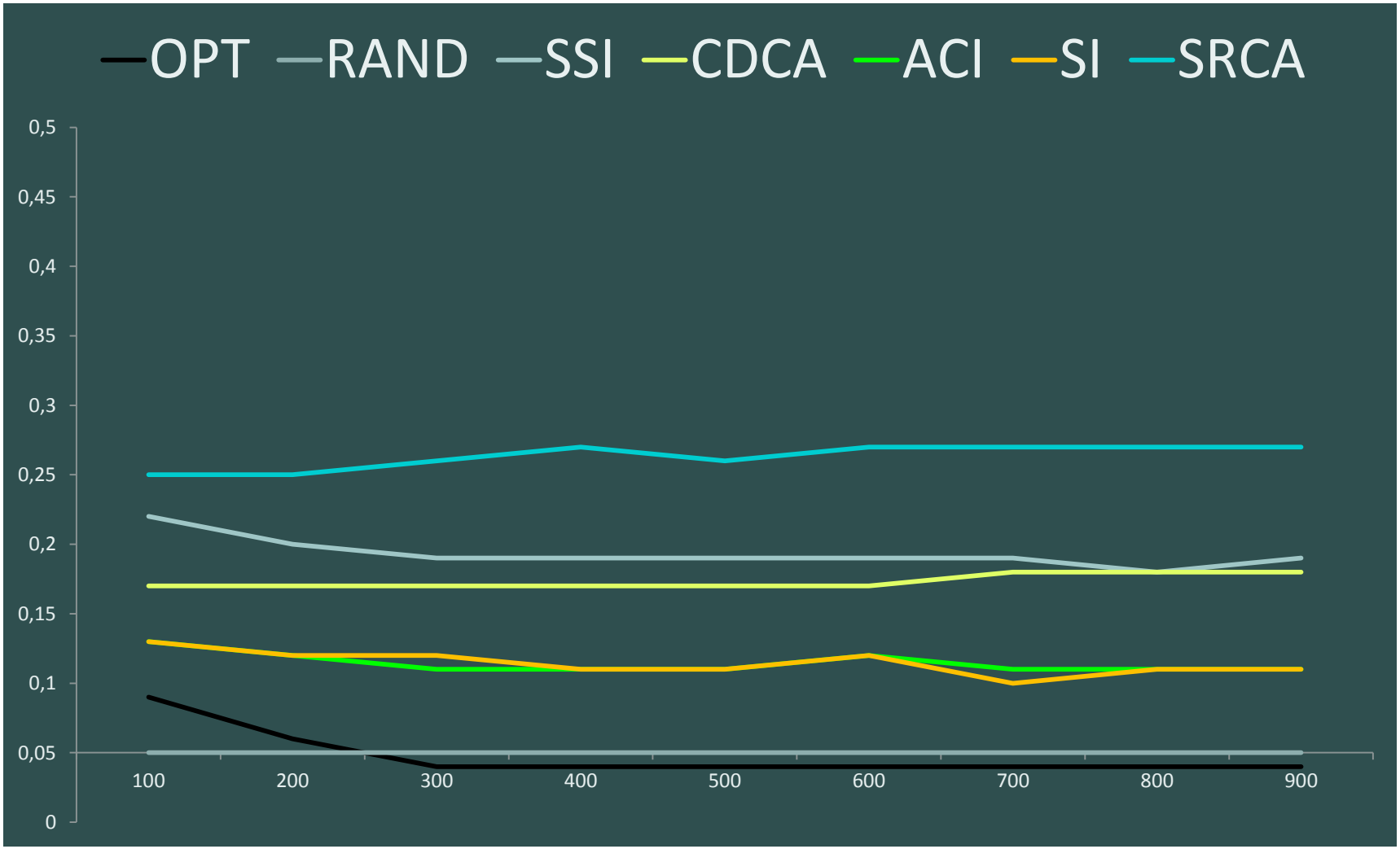

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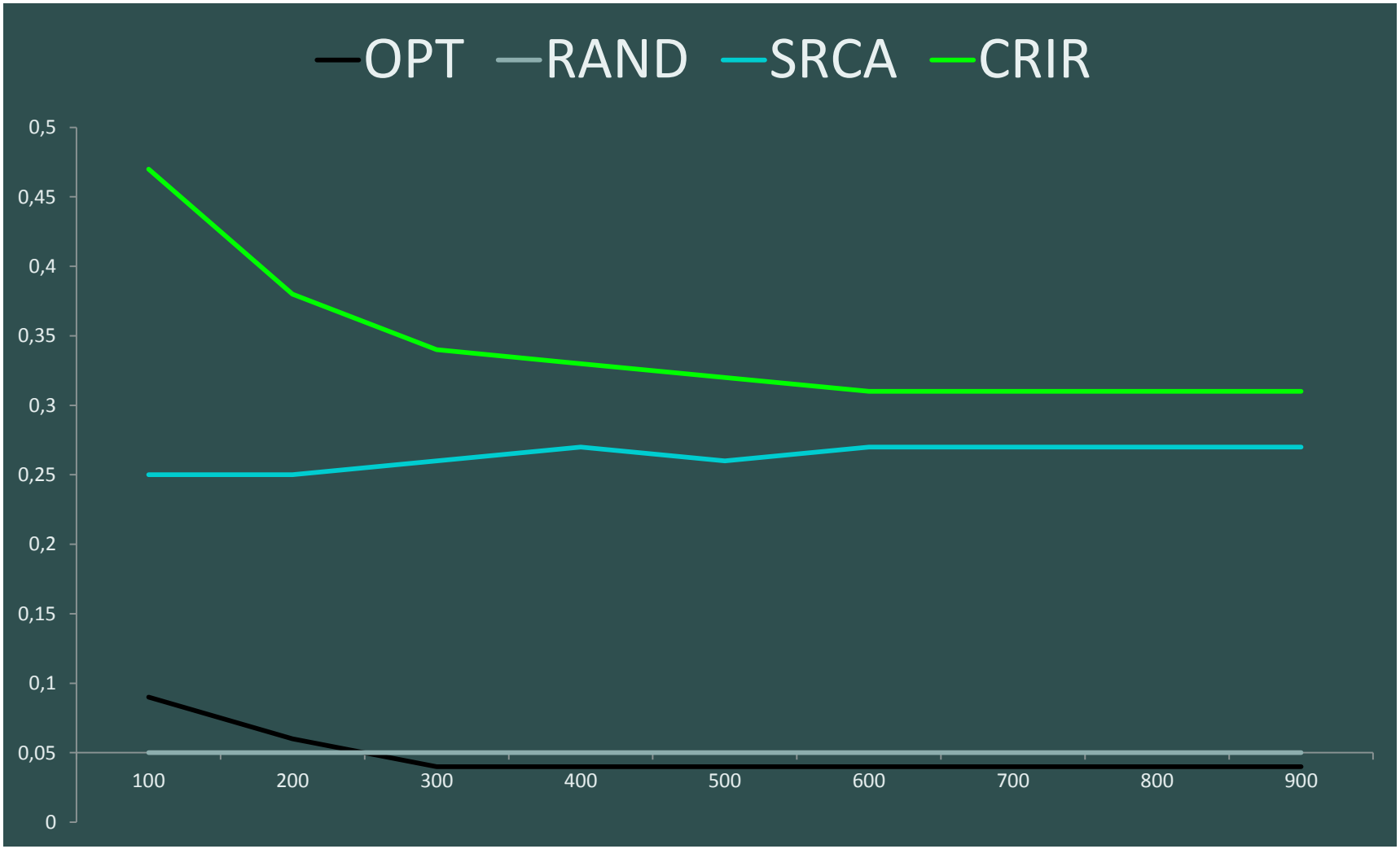

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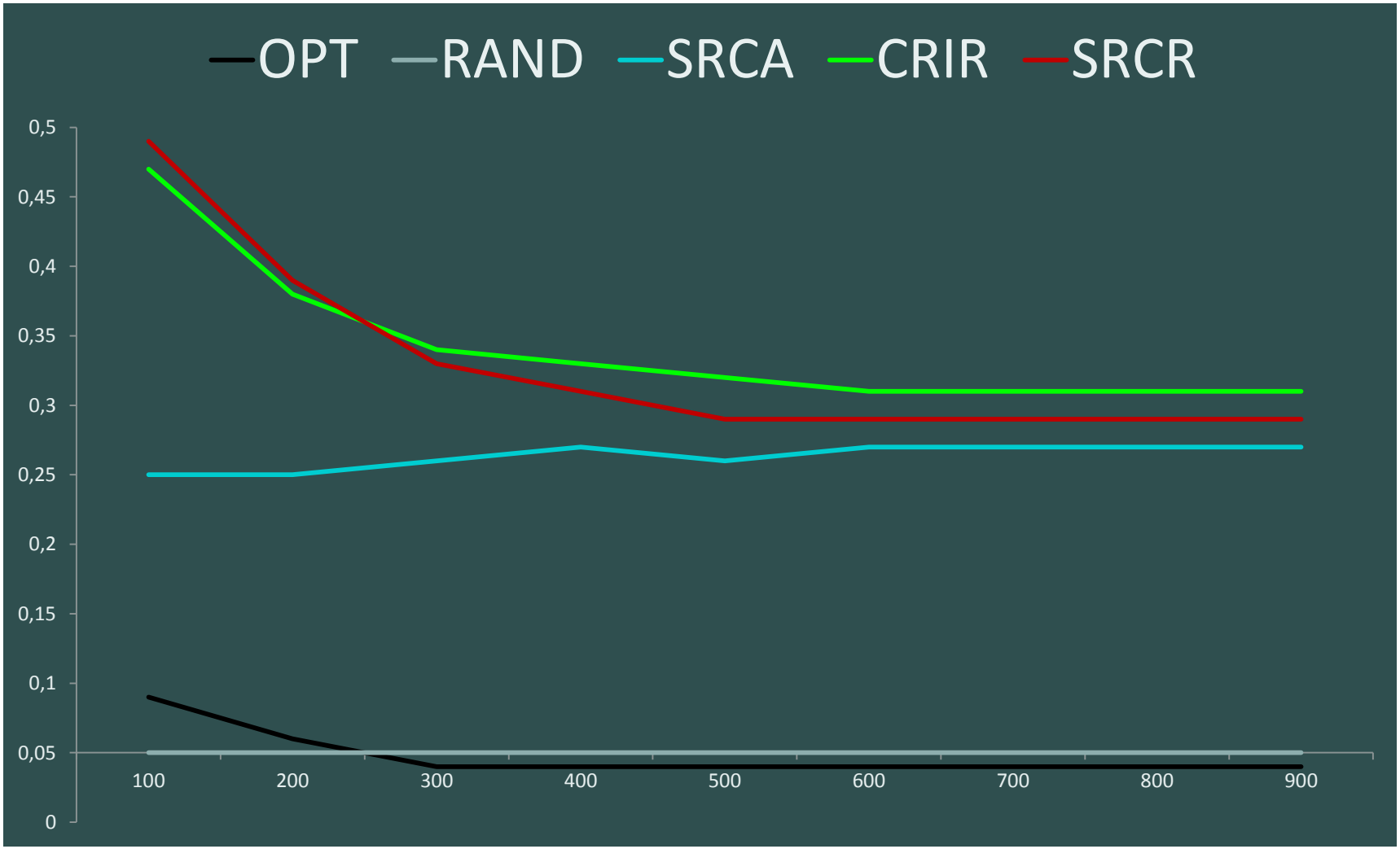

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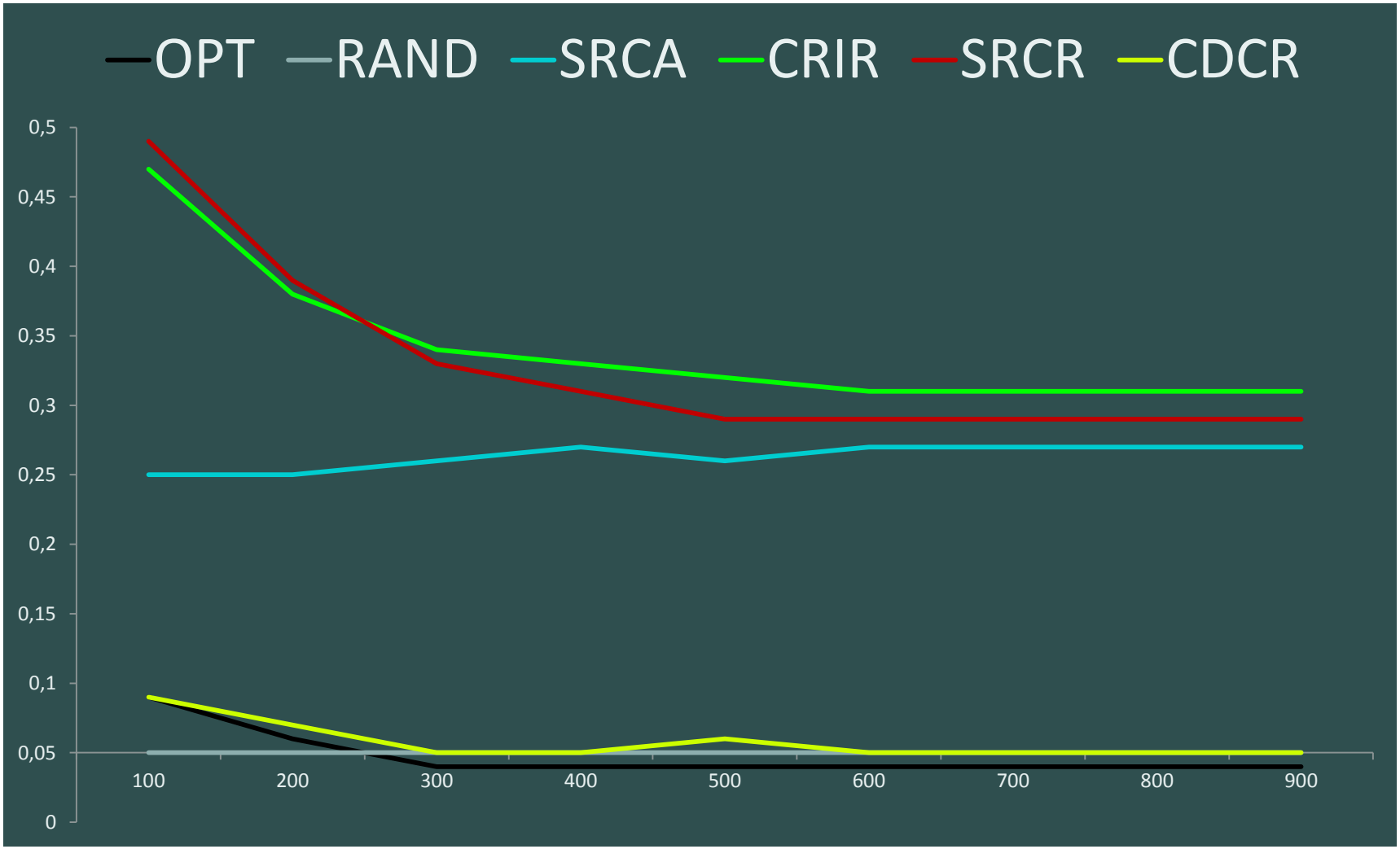

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Question: for a given ranking index, does the ranking of risks converges as well?
Test: proportion of projects for which the means are not equal for different numbers of simulation iterations used to determine the ranking of risks
Conclusion: only for CDCR the ranking of risk converges!

Conclusions

- A risk-driven approach to project risk analysis is preferred
- CDC is able to outperform current best practice measures (activity-based AND risk-driven)
- CDC is very close to greedy optimal
- Recommendations are insensitive to parameter settings:
  - Different settings of risk probabilities and impacts
  - Risk occurrences correlated or not?
- Future research: Optimal approach is future research

Questions?

Risk profiles

Risk profiles

- We consider 48 risk profiles using 5 risk parameters:
  - Risk uniformity (high/low)
  - Risk quantity (high/low)
  - Risk probability (high/low)
  - Risk impact (high/low)
  - Risk correlation (no/random/perfect)

Limited mitigation potential

LIMITED MITIGATION POTENTIAL (75% MITIGATION POTENTIAL)

	BASE CASE	LIMITED MITIGATION POTENTIAL
RAND	0,000	0,001
OPT	0,697	0,538
CA	0,619	0,395
ACI	0,640	0,482
SI	0,639	0,463
CRI	0,636	0,424
SRCA	0,677	0,444
SSI	0,614	0,465
CDCA	0,644	0,49
CRIR	0,638	0,433
SRCR	0,684	0,446
CDCR	0,695	0,537

Multiplicative risk impacts

MULTIPLICATIVE RISK IMPACT

	BASE CASE	MULTIPLICATIVE IMPACT
RAND	0,000	-0,002
OPT	0,697	0,728
CA	0,619	0,596
ACI	0,640	0,632
SI	0,639	0,655
CRI	0,636	0,678
SRCA	0,677	0,7
SSI	0,614	0,682
CDCA	0,644	0,687
CRIR	0,638	0,679
SRCR	0,684	0,708
CDCR	0,695	0,725

Risk impacts subject to noise

Risk impact is subject to noise (25% noise)

	BASE CASE	RISK IMPACT SUBJECT TO NOISE
RAND	0,000	0
OPT	0,697	0,698
CA	0,619	0,62
ACI	0,640	0,642
SI	0,639	0,641
CRI	0,636	0,612
SRCA	0,677	0,657
SSI	0,614	0,615
CDCA	0,644	0,645
CRIR	0,638	0,639
SRCR	0,684	0,673
CDCR	0,695	0,696

Risk uniformity / activity groups

Risk uniformity / activity groups

Index	$\text{MEI}^{(\cdot)}$			
$RAND$	-.006	-.006	-.006	-.008
OPT	.019	.073	.167	.338
CA	.000	.001	.001	.002
ACI	.001	.003	.004	.002
SI	.001	.002	.006	.005
CRI	.001	.005	.021	.070
$SRCA$	.001	.006	.025	.074
SSI	.002	.010	.036	.107
$CDCA$	.002	.009	.036	.111
$CRIR$	.001	.046	.146	.326
$SRCR$	.000	.050	.149	.329
$CDCR$	.017	.072	.167	.338
Risk profile	1	2	3	4

EQUAL RISK RANKING

EQUAL RISK RANKING