Presenting:

Oil Market Disruption Risks
by Phil Beccue

DAAG Conference 2017

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Oil Market Disruption Risks

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Decision
Analysis

Agenda

- Motivation
- Approach
- Probability Assessments
- Results & Reflections

The Strategic Petroleum Reserve

- The **Strategic Petroleum Reserve** (SPR) is an emergency petroleum store maintained by the US Department of Energy (DOE). It is the largest emergency supply in the world with current capacity to hold 700 million barrels of crude oil.

- The Reserve contains 60 cylindrical underground salt caverns near the Gulf of Mexico with typical dimensions of 200 ft. in diameter by 2000 ft. deep holding ~10 million barrels each.

SPR Storage Sites

West Hackberry
Bayou Choctaw
Big Hill
Bryan Mound
Gulf of Mexico
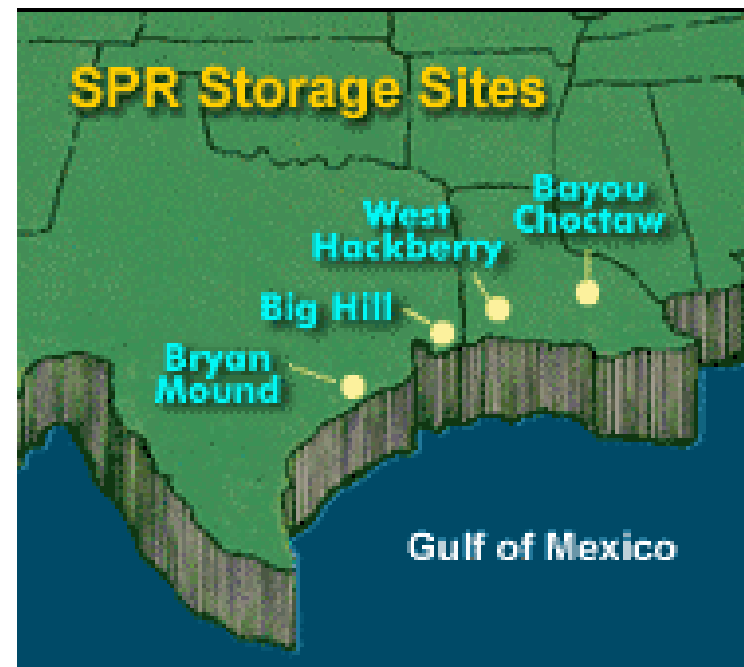
Recent events have led to a renewed interest in oil security risks
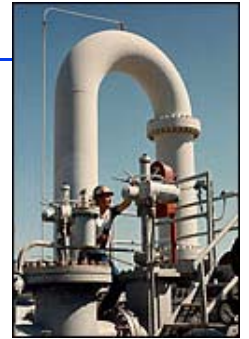
- The probability of the size and duration of another oil disruption is critical to the estimated value of the strategic petroleum reserve (SPR) and its desired size.

- DOE has renewed interest in understanding risk of major oil disruptions:
  - The geopolitical climate regarding oil production has seen significant change in the past 10 years
  - Oil prices have declined in recent years
  - A dramatic surge in North American tight oil supplies from shale formations
  - Interest in understanding the value of the SPR
  - Policymakers have only broad perceptions of how recent events would affect the risk of a disruption
  - Responsible policymaking requires more quantitative and thoughtful evaluations of these important risks

- The DOE asked the Stanford Energy Modeling Forum (EMF) to update the prior risk assessments to reflect current conditions

Why use a decision and risk analysis approach?

- In the past 25 years there have been 5 formal probability assessments for SPR planning

  - DOE/Interagency study (1990): statistical estimation from historical record

  - CIA hosted panel (1990): strategic planning methods from business

  - EMF expert judgment (1996): from an expert panel

  - EMF expert judgment (2005): from an expert panel

  - EMF expert judgment (2015): from an expert panel

- Oak Ridge National Lab published a comparison paper (Leiby, 2003) recommending the EMF approach, highlighting the following advantages:

  - Focused on specific events rather than aggregate distribution shapes

  - Recognized dependencies among events

  - Explored duration as well as size and probability

  - Allowed for an iterative assessment with feedback and refinement

  - Relied on formal protocols to minimize bias and undue influence in a group setting

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The Risk Analysis project was conducted in Washington, D.C. in Fall of 2015

OBJECTIVES

- Develop a risk assessment framework and utilize expert judgment to develop the overall probability of a major oil disruption

- Characterize the likelihood, effective magnitude, and duration of potential supply disruptions

- Clearly document the logic and assumptions driving the risk analyses

IMPLEMENTATION DETAILS

- 2 workshops attended by 30 leading geopolitical, military and oil-market experts

- Experts provided personal judgments, not policy positions of their organizations

# "Risk" is uncertainty regarding future adverse consequences

- Risk assessment has 2 components:
  - Identifying the adverse consequences
  - Determining the likelihood of these consequences

- A cumulative distribution function (CDF) is a useful form for representing a probability distribution and summarizing the results of a risk assessment
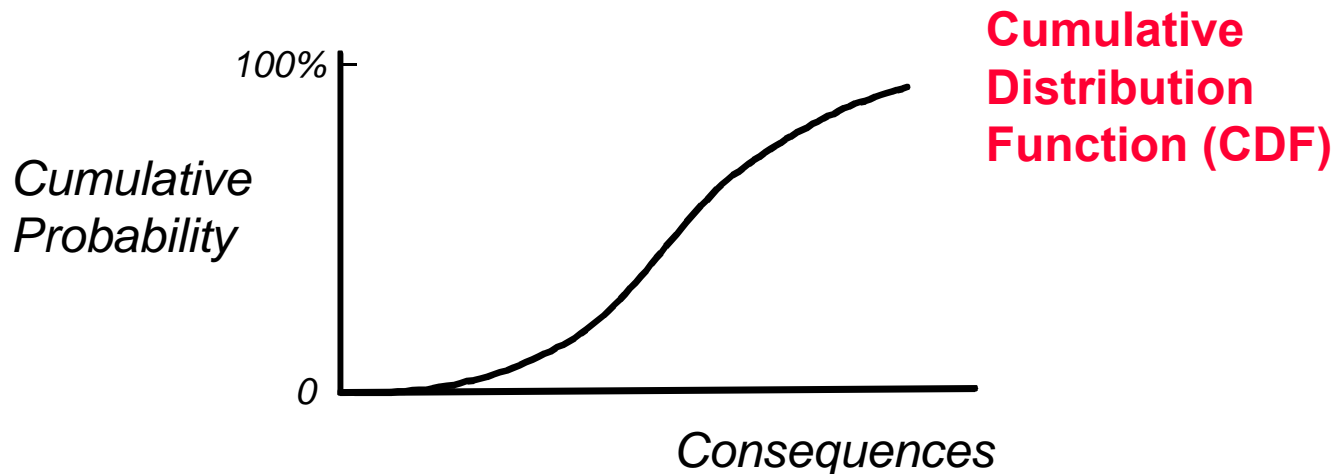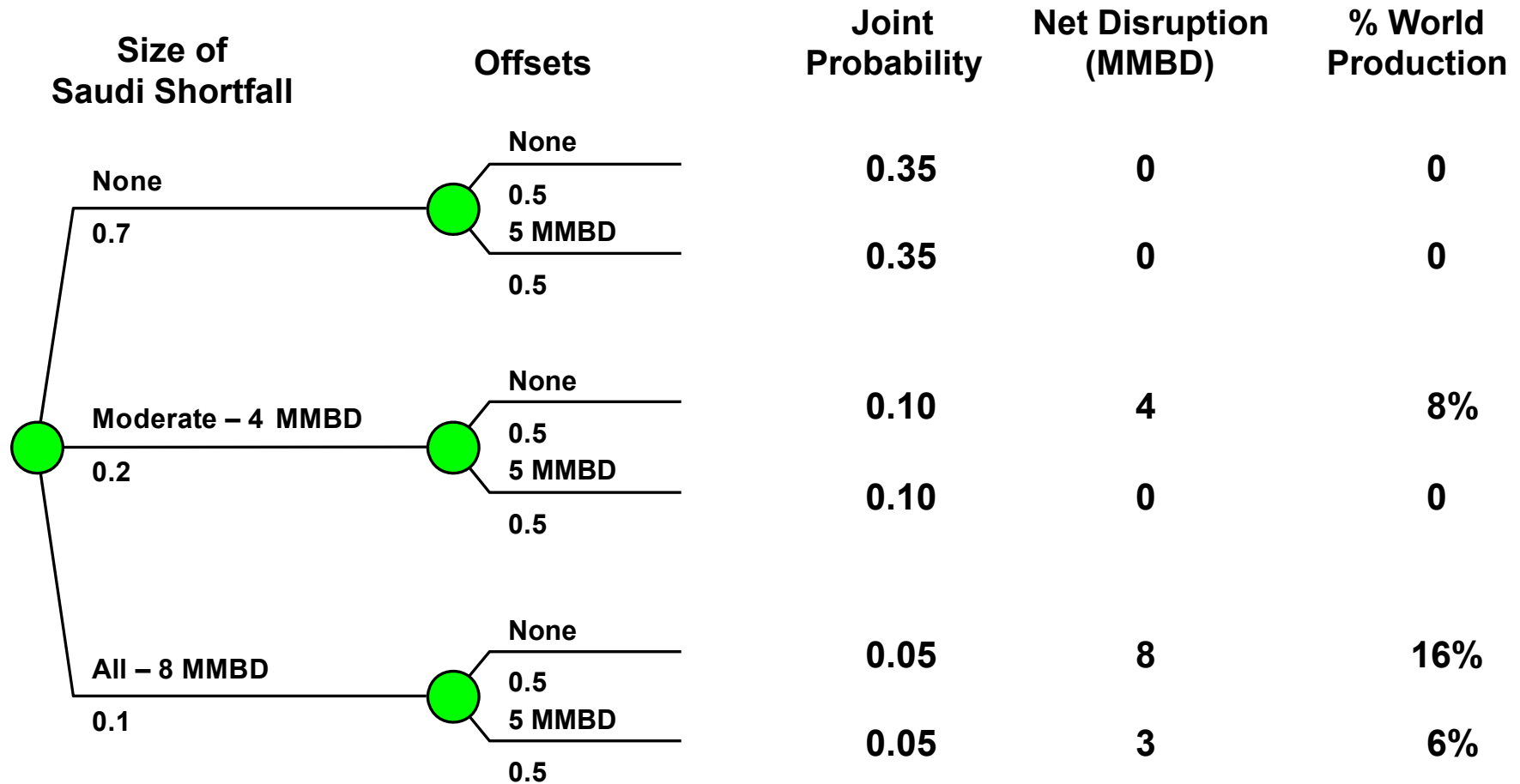
This simple influence diagram shows 2 key uncertainties and the model logic

- For this exercise, the primary variable of interest is Net Disruptions

Net Disruptions = ABS (Saudi Shortfall – Offsets)
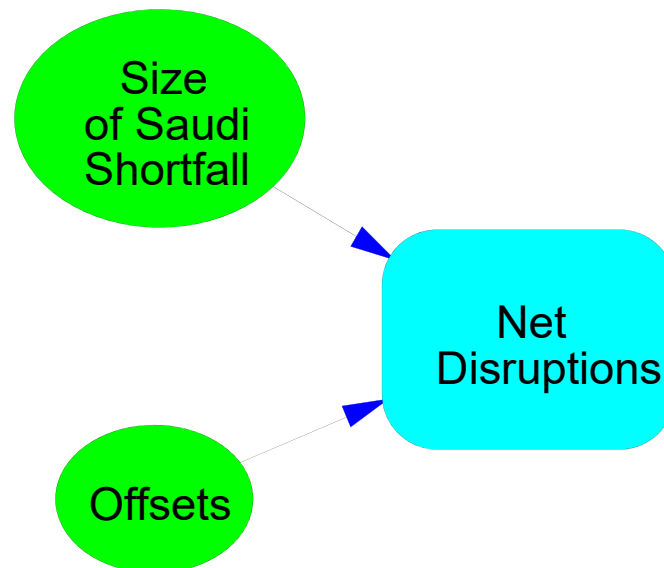
To perform the risk assessment, we examine all possible combinations of states

Size of Saudi Shortfall	Offsets	Joint Probability	Net Disruption (MMBD)	% World Production
None 0.7	None 0.5	0.35	0	0
	5 MMBD 0.5	0.35	0	0
Moderate – 4 MMBD 0.2	None 0.5	0.10	4	8%
	5 MMBD 0.5	0.10	0	0
All – 8 MMBD 0.1	None 0.5	0.05	8	16%
	5 MMBD 0.5	0.05	3	6%

Assumptions: *50 MMBD world production**
No disruptions from other regions
* Illustrative example

Probability distribution graphs summarize the magnitude and likelihood of all possible disruptions

Probability Density Function

Probability

Net Disruption (% World Production)

Cumulative Distribution Function

Cumulative Probability

Net Disruption (% of World Production)
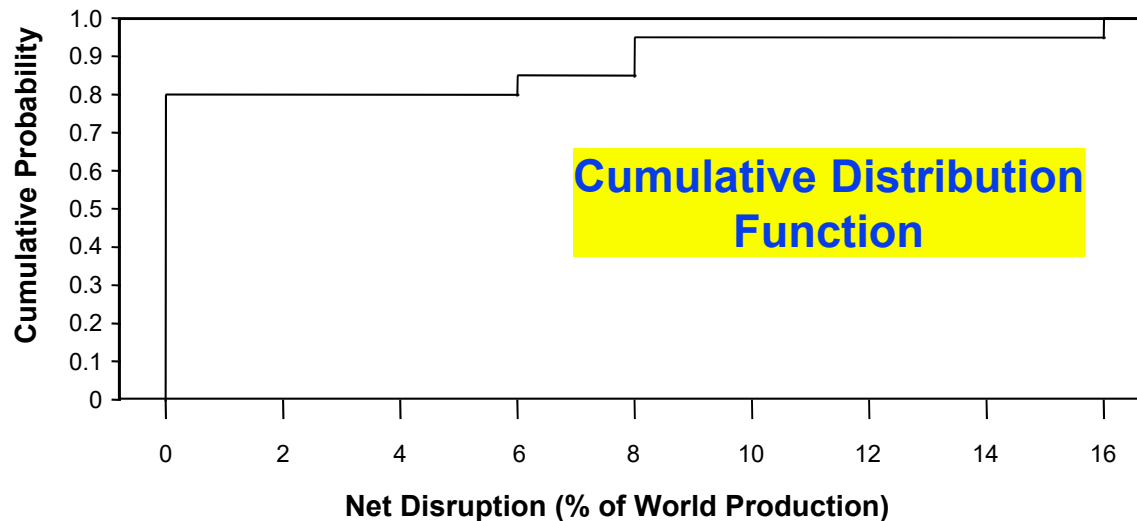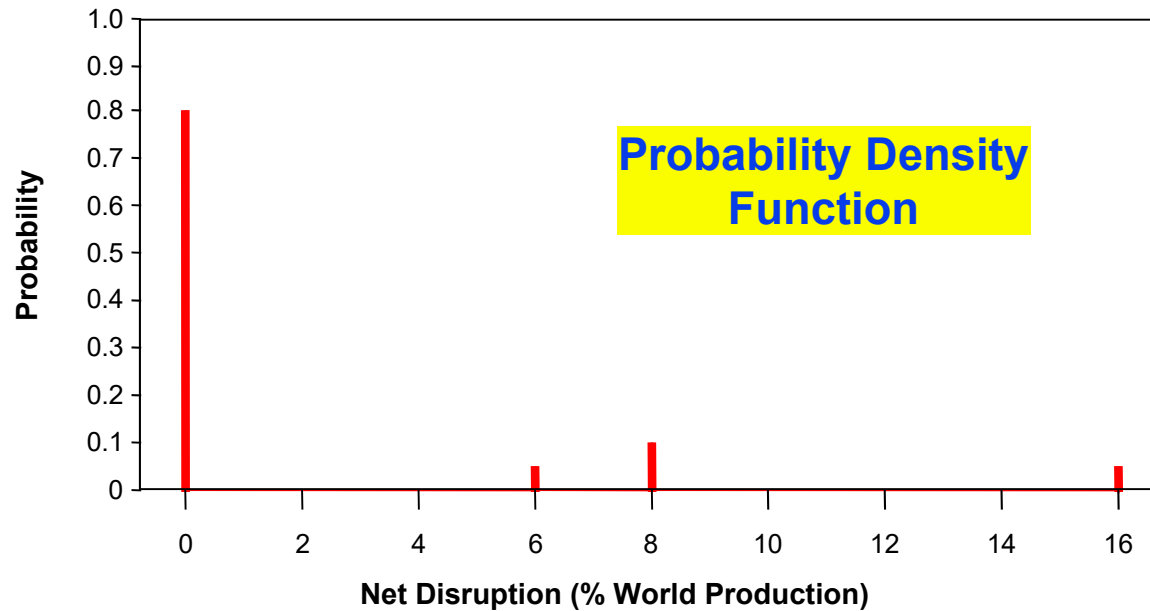
Each point is the probability of observing a disruption less than or equal to the disruption size on the horizontal axis.

We focused on 5 oil supply regions

Russia & Caspian States 13.9 (14%)

Africa 8.8 (9%)

Latin America 3.1 (3%)

Other Persian Gulf 15.5 (16%)

Saudi Arabia 11.6 (12%)
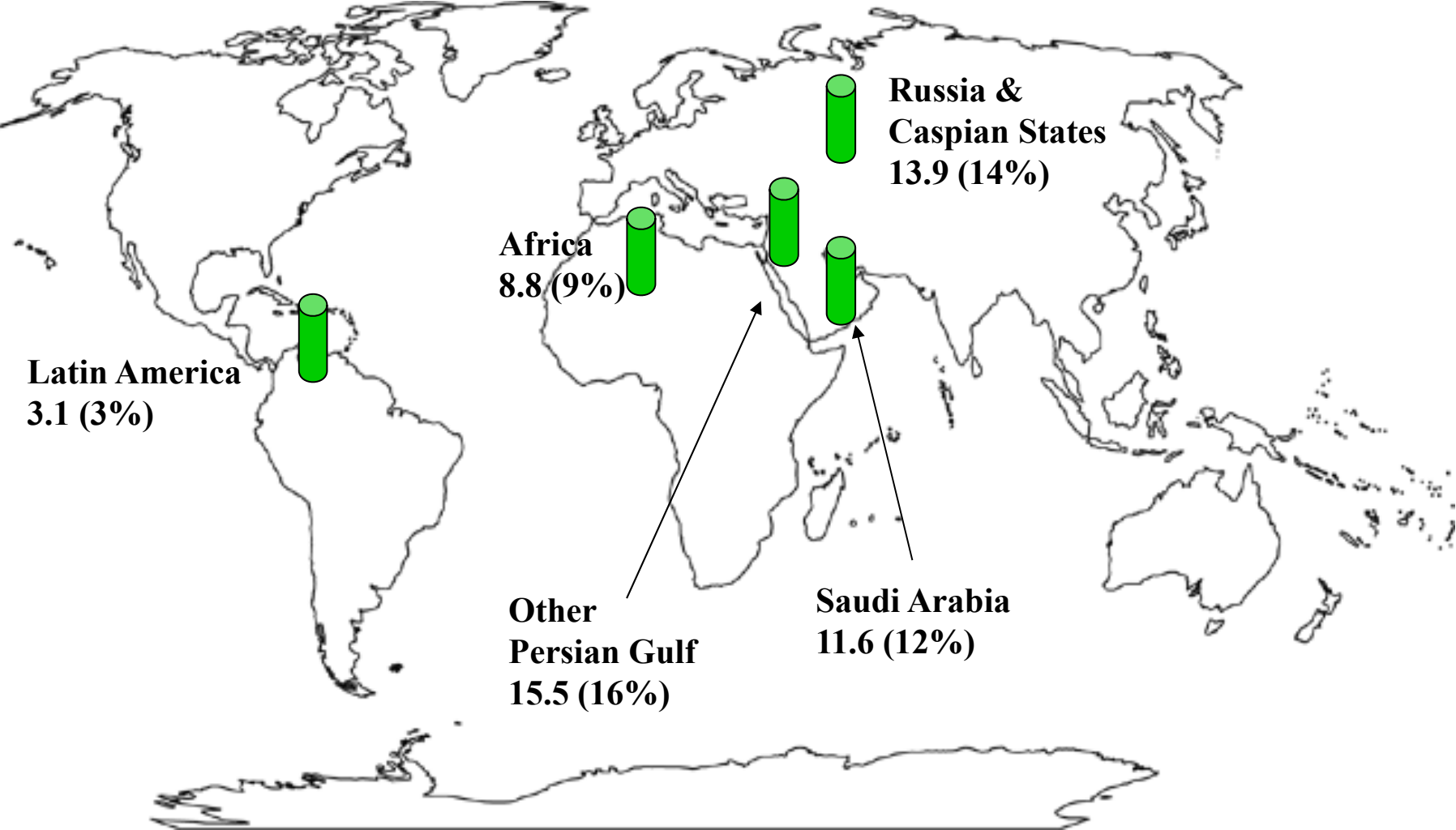
Million barrels per day production in 2020 from EIA projections (% of total market)

Specific steps in developing the risk assessment framework

1. Brainstorm factors

2. Categorize into regional vs. broader underlying events (which impact multiple regions)

3. Develop influence diagrams to identify the relationships between events

4. Develop scales for each region with 2 or more states

5. Assign likelihoods for each state

6. Combine mathematically by analyzing all combination of outcomes and weighting them according to probability inputs from experts

We paid special attention to being precise about definitions and terminology

- "A sudden shortfall in oil production from a world supplier that results in at least 2 MMBD unavailable within 1 month of the beginning of the disruption. The disruption occurs at least one time during the 10-year period 2016-2025."

- The sponsors requested us to distinguish between shortfalls of three durations
  - Short: 1–6 months
  - Long: 6–18 months
  - Very Long: over 18 months

After brainstorming sessions with experts, events were classified as external or internal to a region

Examples of External Events
- Well orchestrated terrorist attack
  - Pipeline in Saudi
  - Channel in Venezuela
- Breakdown in political order in Caspian region
- OPEC export embargo (by exporters associated with production drop)
- UN sanctions on Iran (by importers)
- Inter-state conflict (U.S. and Iran – nuclear program)

Examples of Internal Events
- Religious/political domestic conflicts within a particular region
- Nuclear bomb in Saudi facility
- Prolonged Civil War in Saudi Arabia
- Civil War in Iraq
- Spill over into other regions (from Iraq civil war)
- Failed state in a major exporter
- Labor relations in a major exporter

The risk assessment framework followed this skeleton influence diagram

Underlying Events   Shortfall Events   Excess Capacity (Offsets)
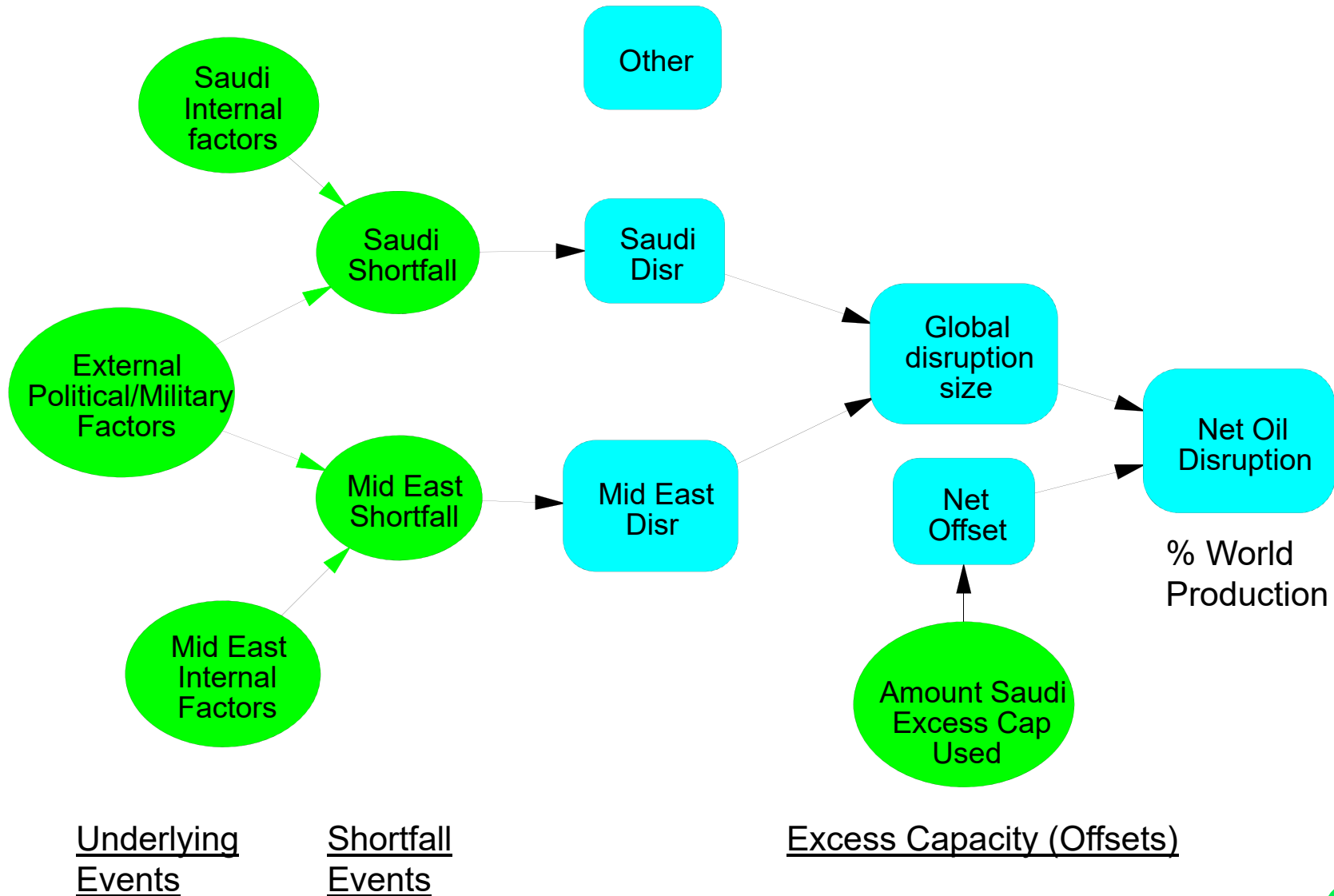
We organized the factors into an influence diagram to show their relationships
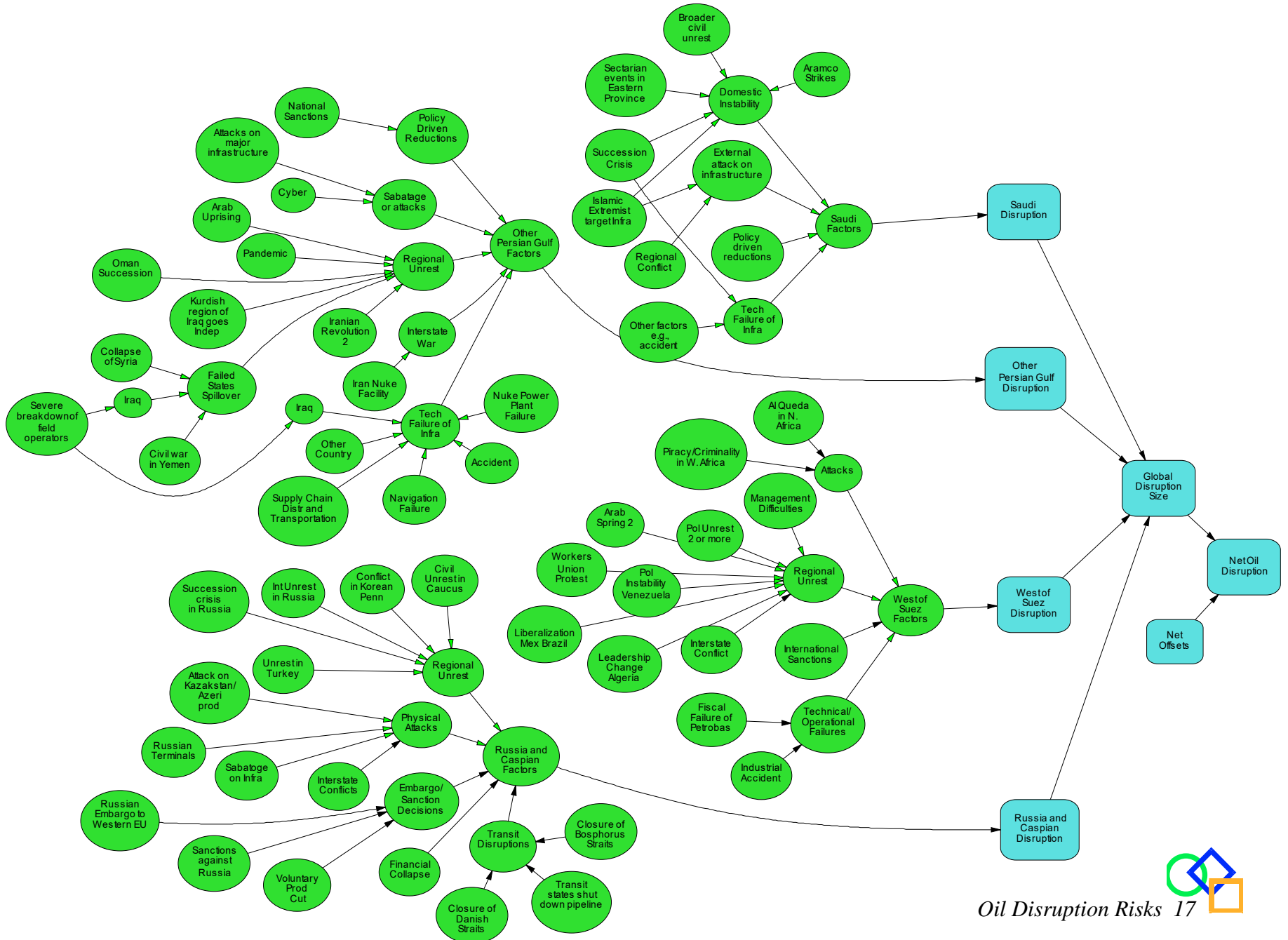
The influence diagrams supported the development of scales for the key uncertainties

"Saudi" scale

1. Continued acceptance of royal family, and insulation from regional instability, no major policy-driven outages, Aramco maintains high operating standards

2. Major policy-driven reduction

3. Significant but temporary infrastructure problem from attack or technical failure and/or isolated conflict that results in attacks on infrastructure without profound internal implications

4. Regional conflict with neighbors combined with internal political crisis, failed infrastructure and/or sabotage which is difficult to fix

5. Full social revolution resulting in shutdown of exports

The oil disruption risk assessment framework is summarized in 21 probability assessments
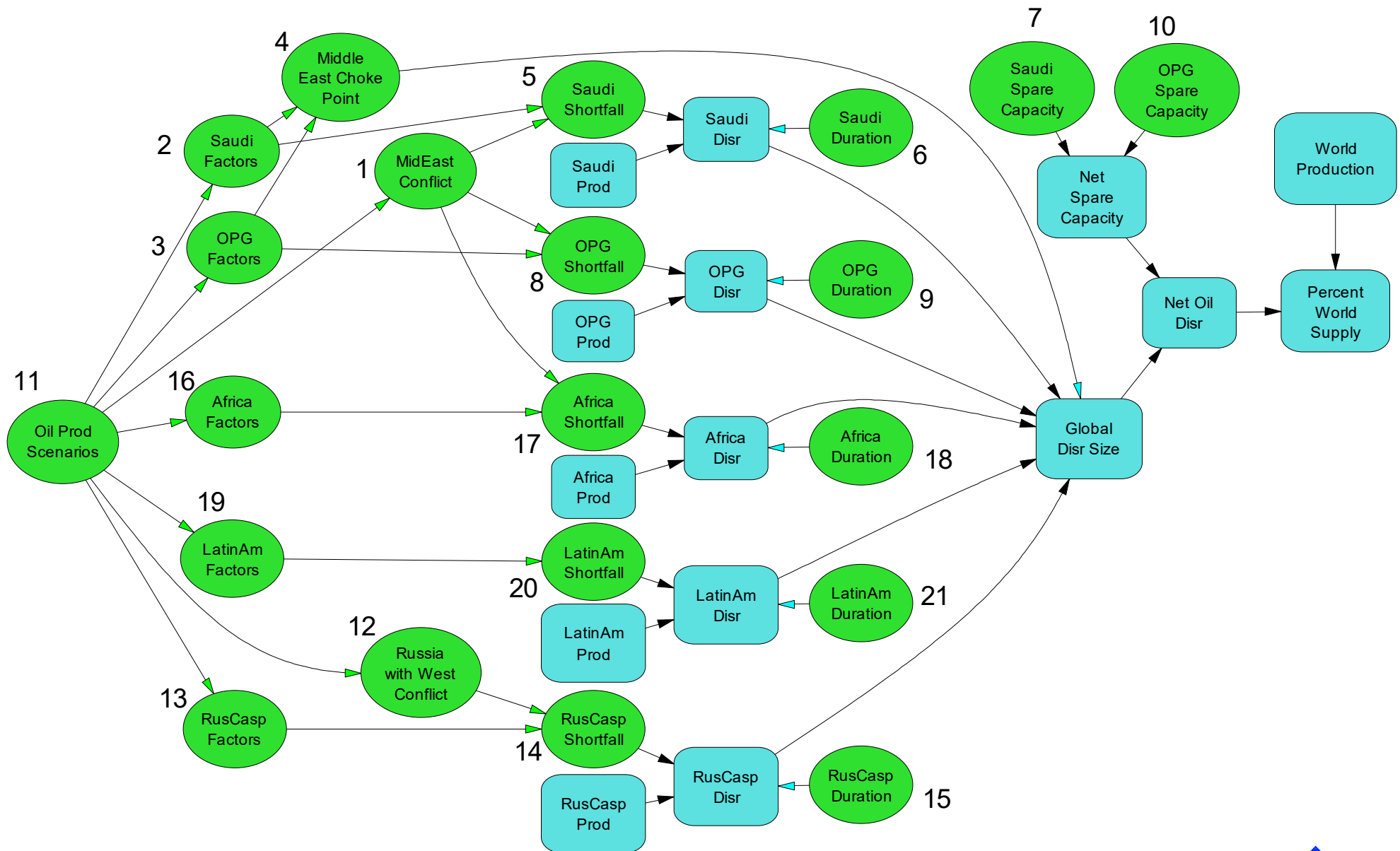
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The risk assessment required probability inputs for 6 variable types

- Global underlying events
- Regional internal factors
- Regional shortfall amounts
- Regional duration
- Future oil production
- Excess capacity

Middle East Conflict: Scale and Probability Assignments

| Oil Price Scenarios				1 **Middle East Conflict**
Ref	**Low Pr**	**High Pr**		
5%	**5%**	**15%**	1.	Minimal conflicts and relatively stable geopolitics (like prior to Arab Spring)
20%	**20%**	**10%**	2.	Domestic persistent unrest (political/religious/ethnic) in many Middle East and North Africa countries
35%	**30%**	**35%**	3.	Unrest in many middle east countries including strife with insurgent groups (like current)
25%	**30%**	**20%**	4.	Growing unrest/strife in many Middle Eastern countries combined with: a) may or may not close key choke points, key facilities and/or b) Coordinated supply reductions across countries (including embargoes or sanctions)
15%	**15%**	**20%**	5.	Interstate military conflict between standing governments in the Middle East a) may or may not close key choke points, key facilities, supply regions b) 2 or more countries: e.g. Saudi Arabia vs. Iran, Iran vs. Iraq, Russia vs. West, possible U.S./Israeli involvement

Saudi Internal Factors

Oil Price Scenarios				2 **Saudi Internal Factors**
Ref Pr	**Low Pr**	**High Pr**		
40%	**30%**	**50%**	1.	Continued acceptance of royal family, and insulation from regional instability, no major policy-driven outages, Aramco maintains high operating standards
20%	**25%**	**15%**	2.	Major policy-driven temporary reduction in oil production
15%	**15%**	**15%**	3.	Significant but temporary infrastructure problem from attack or technical failure and/or isolated conflict that results in attacks on infrastructure without profound internal implications
15%	**15%**	**15%**	4.	Regional conflict with neighbors combined with internal political crisis, failed infrastructure and/or sabotage which is difficult to fix
10%	**15%**	**5%**	5.	Full domestic instability

Definition of groups to facilitate assessment of Saudi duration probabilities
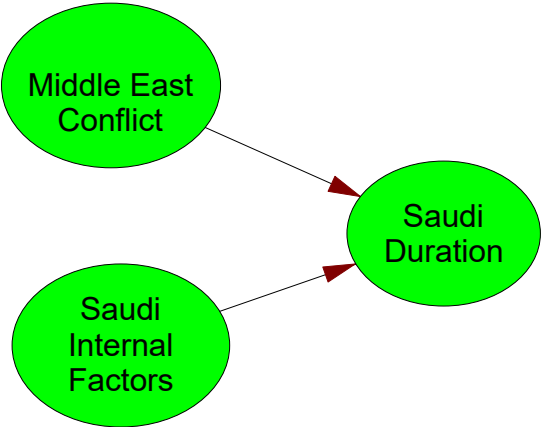
Saudi Internal Factors

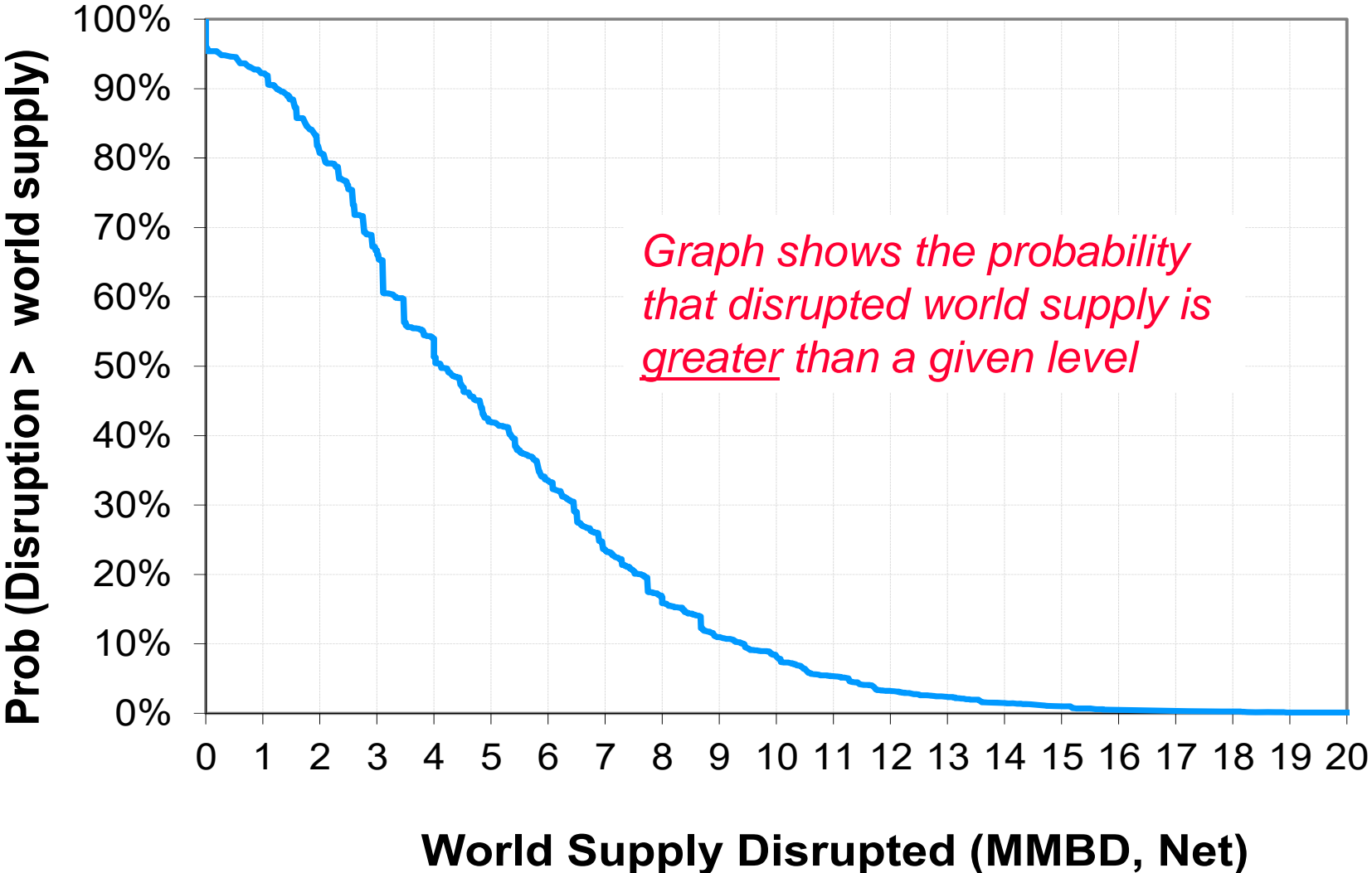| Middle East Conflict	Stable	Major policy-driven reduction in oil production	Tech Failure or Isolated Conflict	Regional Failed State	Regional Conflict w/ Internal Crisis
1. Minimal conflicts and relatively stable geopolitics (like prior to Arab Spring)	Group A	Group A	Group A	Group A	Group C
2. Domestic persistent unrest (political/religious/ethnic) in many Middle East and North Africa countries	Group A	Group A	Group A	Group B	Group C
3. Unrest in many middle east countries including strife with insurgent groups (like current)	Group A	Group A	Group B	Group C	Group C
4. Growing unrest/strife in many Middle Eastern countries combined with: a) may or may not close key choke points, key facilities and/or b) Coordinated supply reductions across countries (including embargoes or sanctions)	Group B	Group B	Group C	Group C	Group C
5. Interstate military conflict between standing governments in the Middle East a) may or may not close key choke points, key facilities, supply regions b) 2 or more countries: e.g. Saudi Arabia vs. Iran, Iran vs. Iraq, Russia vs. West, possible U.S./Israeli involvement	Group B	Group B	Group C	Group C	Group C

Disruption Duration Probabilities for Saudi

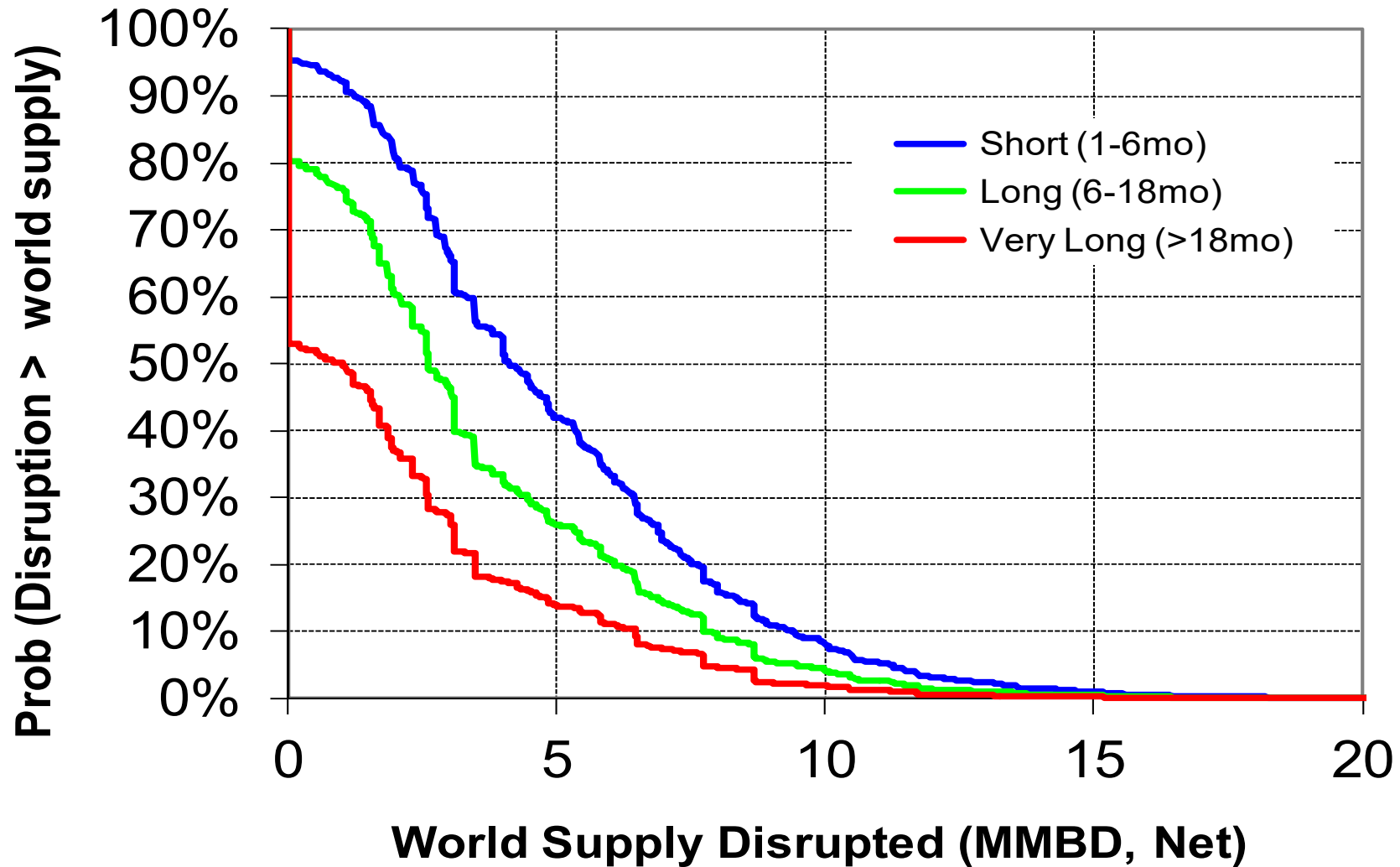| SAUDI	Group A	Group B	Group C
Short (1-6mo)	80%	20%	10%
Long (6-18mo)	10%	60%	20%
Very Long (>18mo)	10%	20%	70%

Duration

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Probability of an Oil Disruption Lasting 1-6 Months

Graph shows the probability that disrupted world supply is <u>greater</u> than a given level
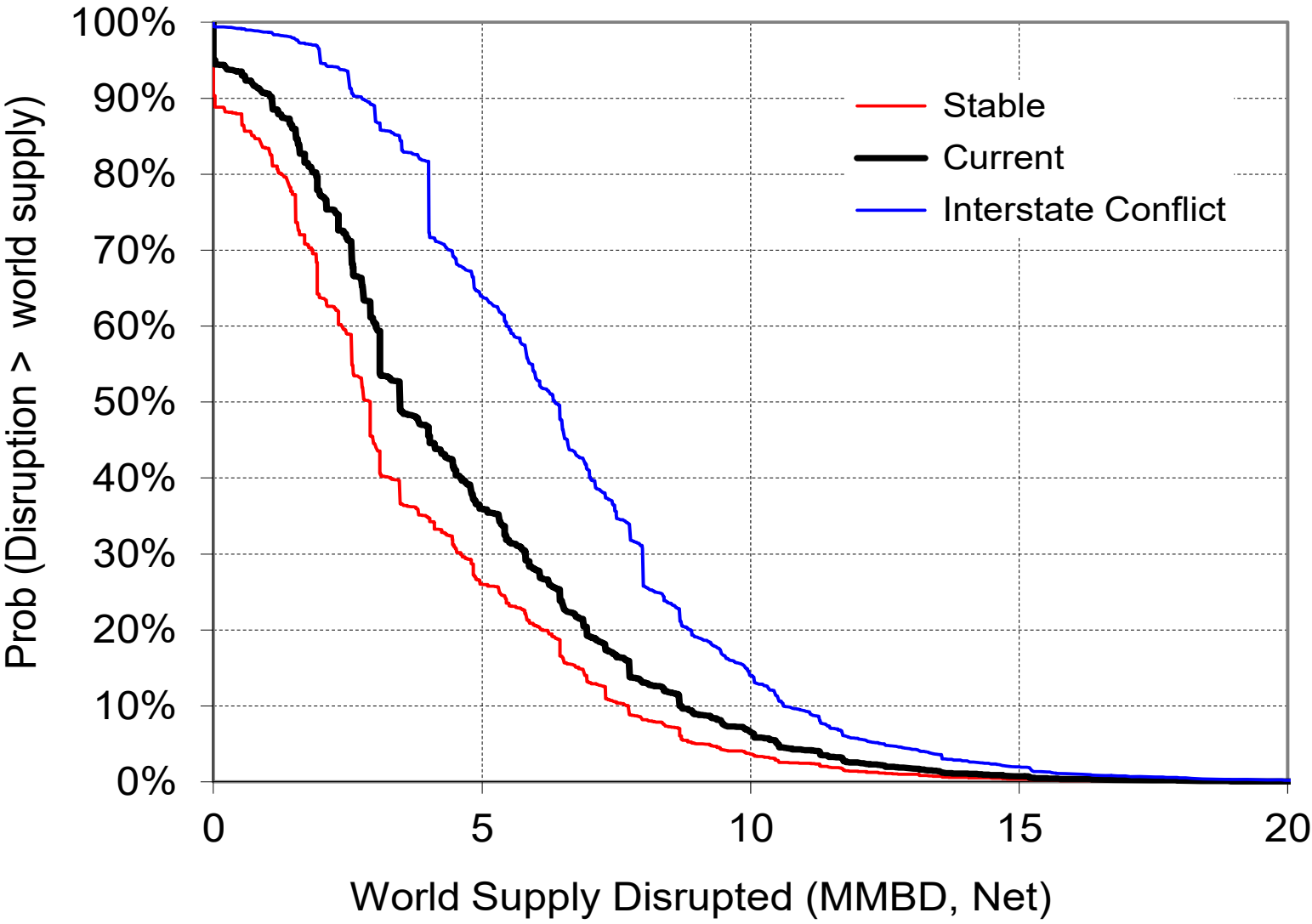
Oil Disruption Risks 28

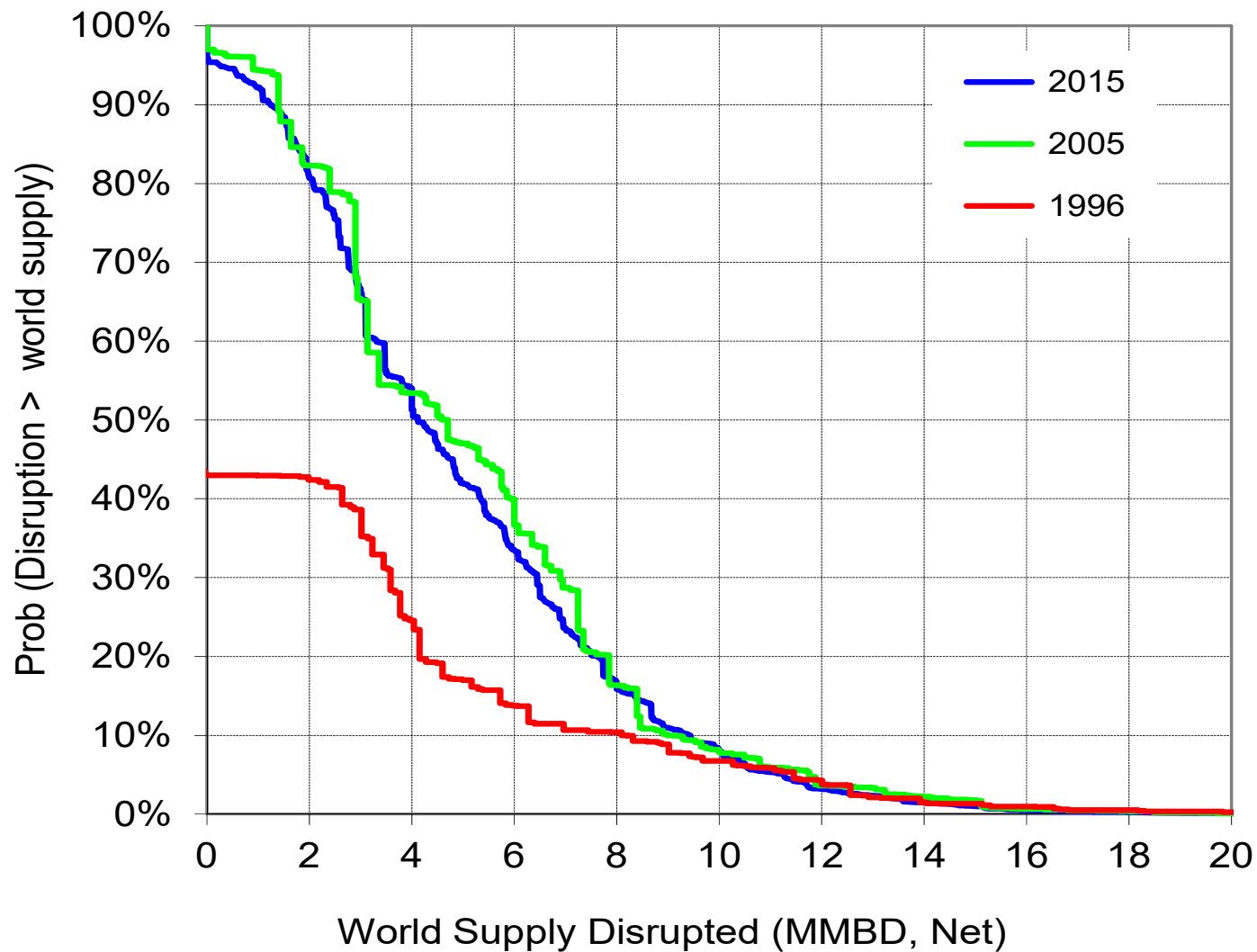# Probability of a Disruption for All Durations

Comparison of Duration Probabilities by Region
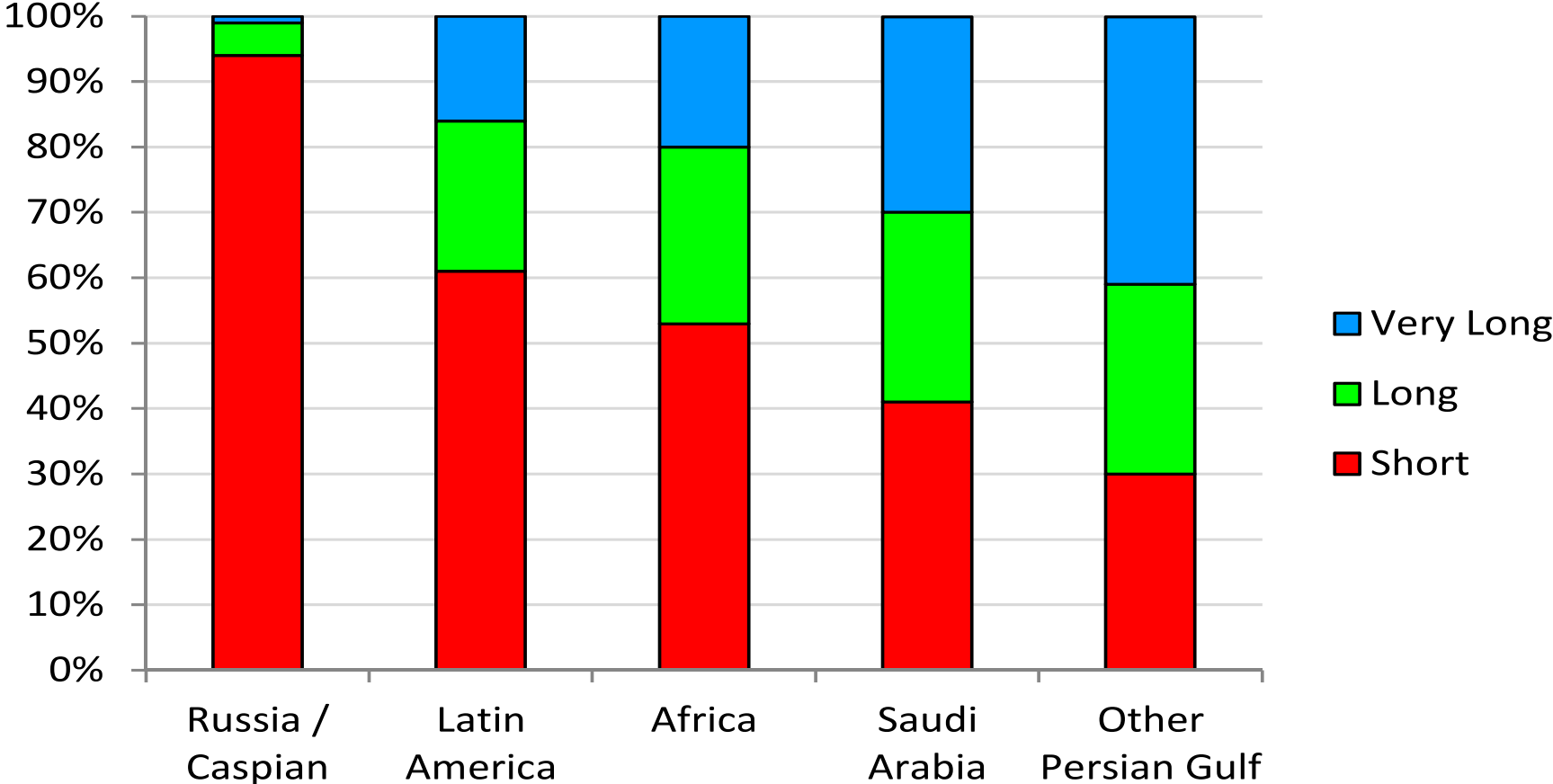
Sensitivity to Middle East Conflict Event

The risk assessment showed very few changes in the last two studies compared to 1996

Reflections on the risk assessment approach

- In two workshops with 30 geopolitical, military, and oil market experts we developed an oil disruption model structure and assessed over 300 inputs for 21 key parameters, employing DA tools and techniques

- The influence diagram framework allowed for an efficient synthesis of complex issues from multiple sources

- We calibrated results via an appropriate interaction among experts

- Simulation runtimes were fast, allowing for numerous sensitivities and straightforward updates

- We demonstrated that the framework is repeatable; we saved time by building on earlier studies