Assessing Previously Unassessed Petroleum Provinces Using the Variable Shape Distribution (VSD) Model*

Robert F. Aguilera[1], Edward J. Balistreri[2], and John T. Cuddington[2]

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[1]IIASA (International Institute for Applied Systems Analysis), Vienna, Austria (mailto:aguilera@iiasa.ac.at)
[2]Colorado School of Mines, Golden, CO

Abstract

Earlier size distribution models used to estimate undiscovered petroleum volumes relied mainly on the Lognormal and Pareto (i.e. Fractal) distributions. Historically, all the methods used have been based on an assumed form of the size distribution of nature's endowment of petroleum volumes. Our new Variable Shape Distribution (VSD) model is different in that it allows the actual petroleum data, in this case the province volumes from the U.S. Geological Survey's World Petroleum Assessment (2000), to determine the size distribution relationship of the petroleum volumes.

The USGS (2000) study presents volumes for 409 provinces worldwide. Since the world can be divided into 937 provinces, there are 528 provinces not represented in the study. After using non-linear regression to estimate the parameters of the VSD model that provide the best fit of the data from USGS (2000), the VSD is used to estimate reasonable volumes for all 937 provinces. The estimated volumes suggest that conventional petroleum is more abundant than commonly assumed, since there is a tendency to overlook previously unassessed provinces. The implication is that there is no danger of petroleum depletion over the next several decades.

Assessing Previously Unassessed Petroleum Provinces Using the Variable Shape Distribution (VSD) Model

Dr. Roberto F. Aguilera, International Institute for Applied Systems Analysis (IIASA); and University of Vienna

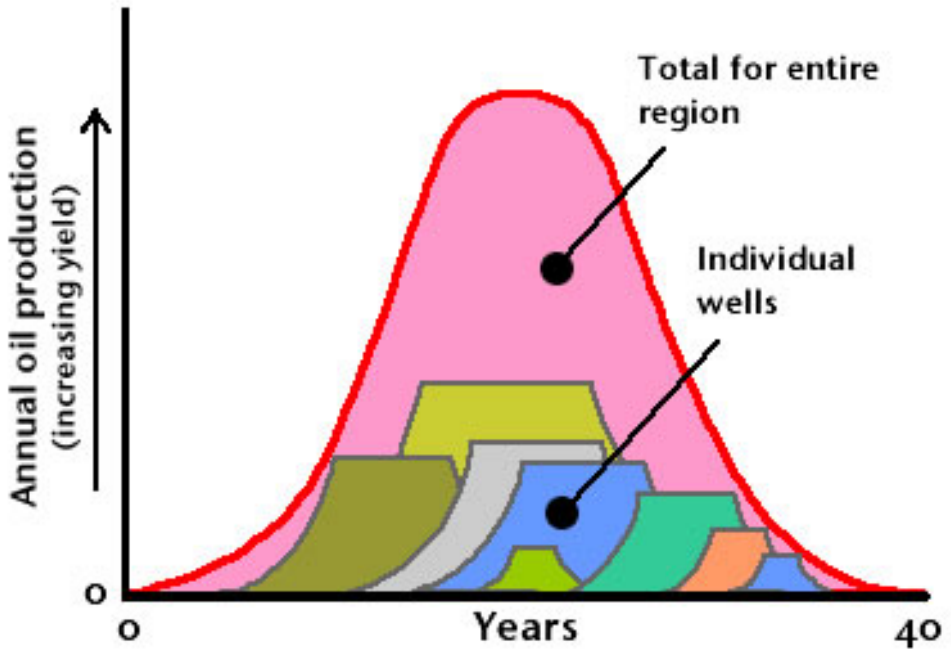
Dr. John T. Cuddington, Colorado School of Mines

Dr. Edward J. Balistreri, Colorado School of Mines

THE DEBATE

SOME EXPERTS PREDICT SCARCITY IN THE NEAR FUTURE

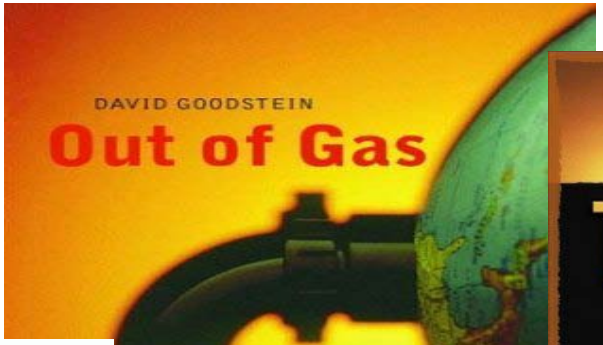
"the pessimists"

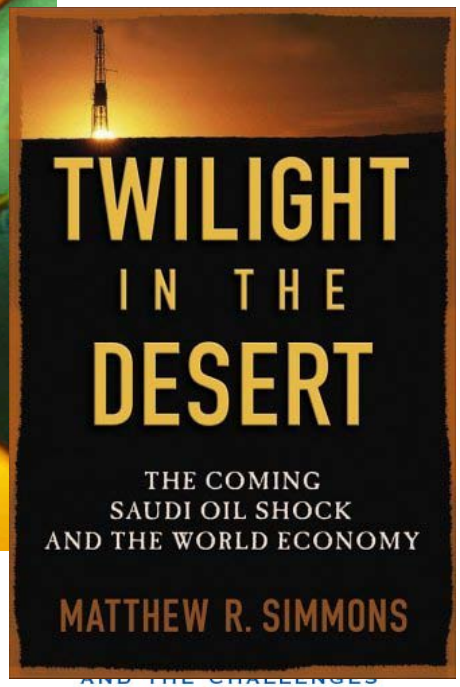


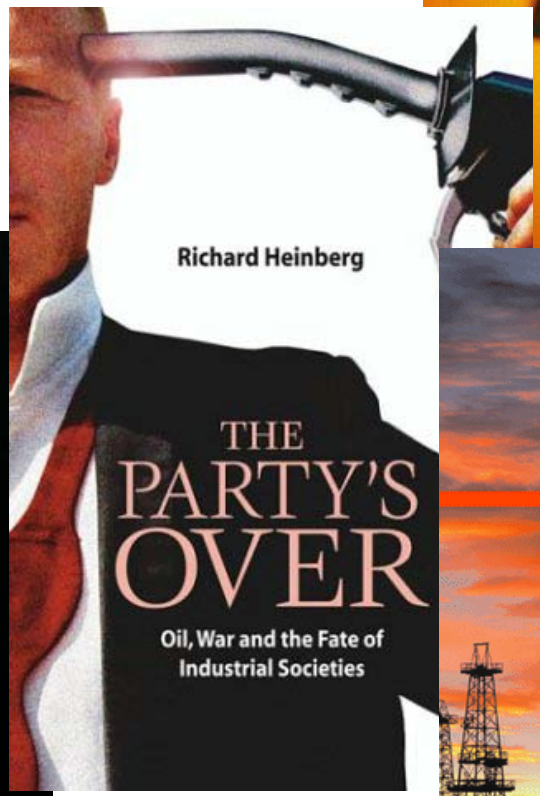
After Colin J Campbell & Jean Laherrere, The End of Cheap Oil, *Scientific American*, March 1998

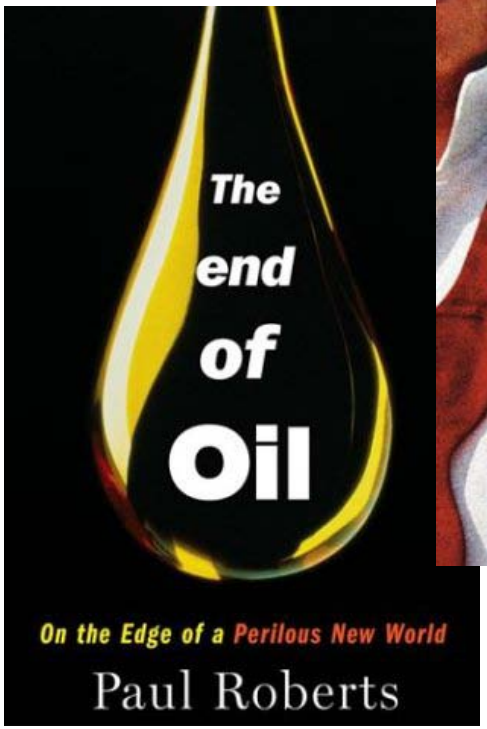
THE DEBATE

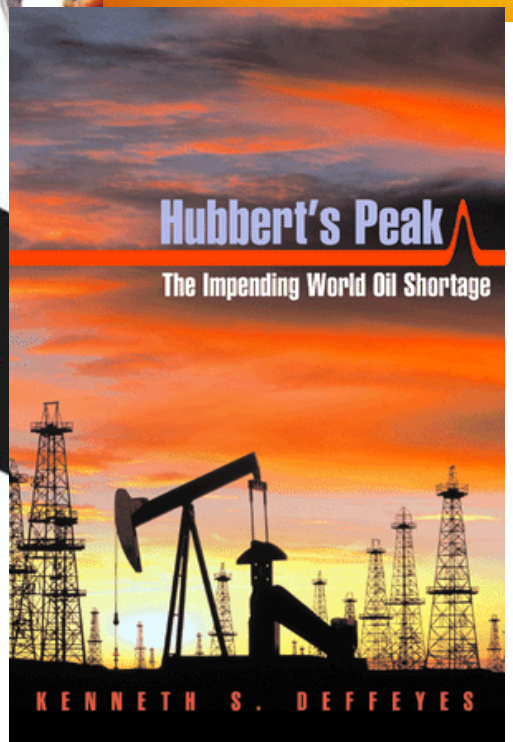
"the pessimists"

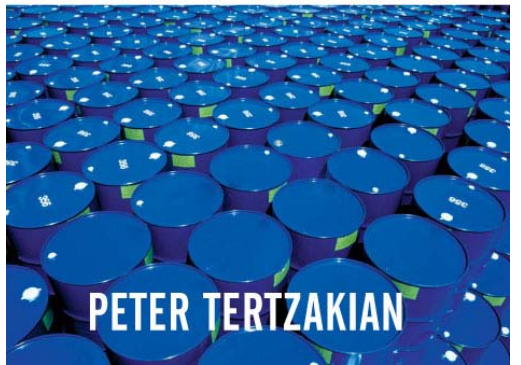








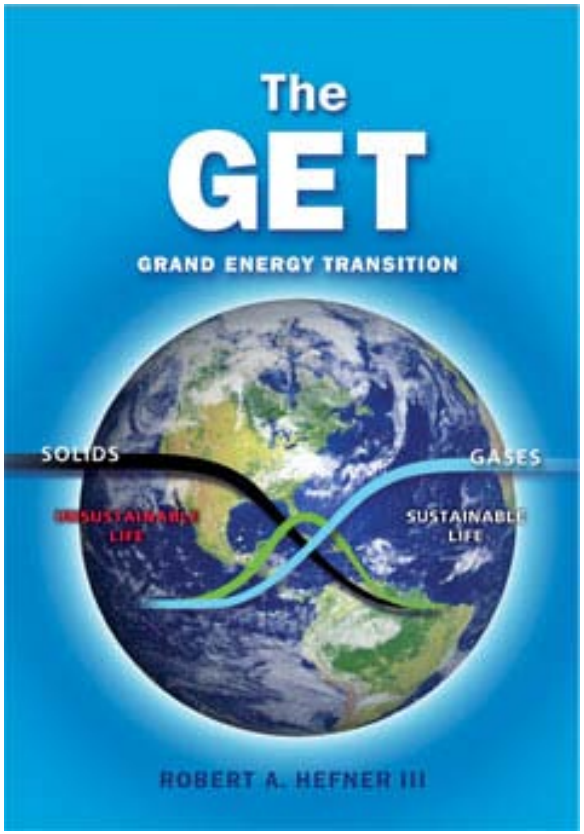


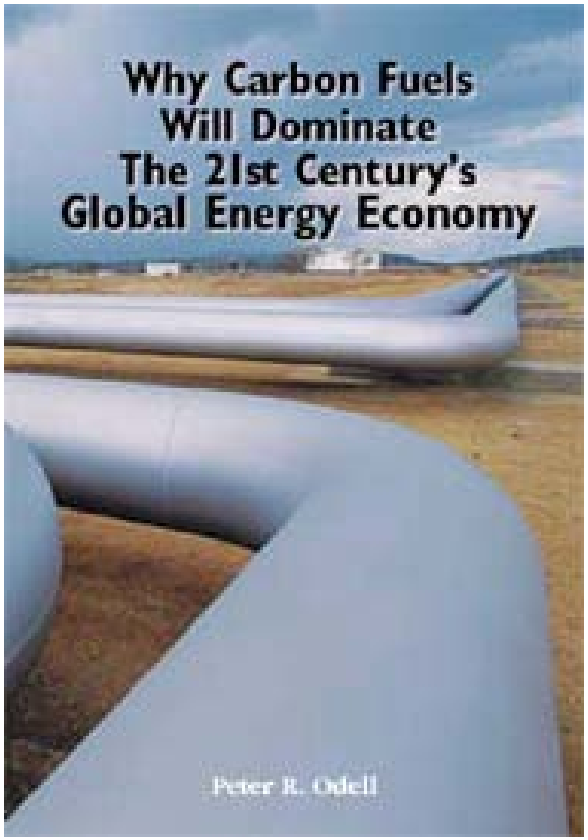


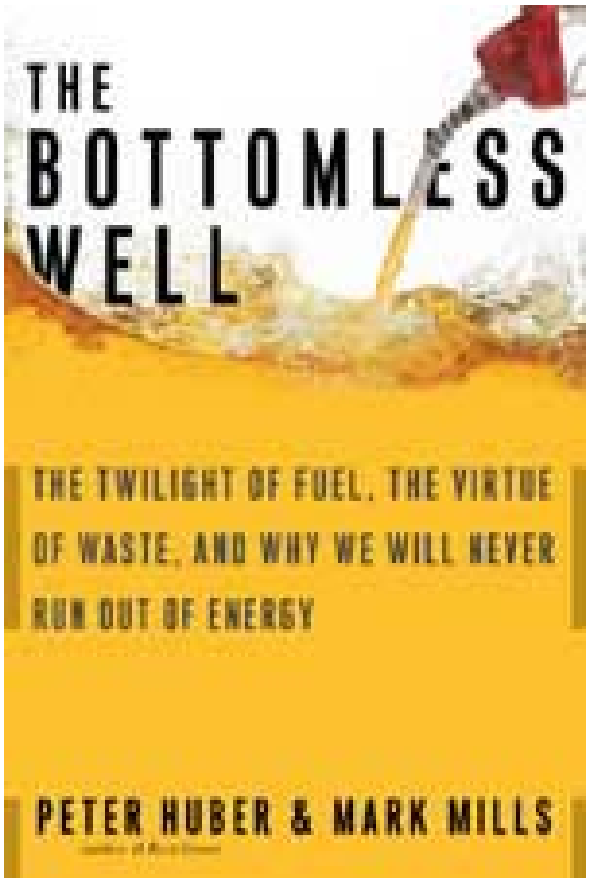
THE DEBATE

OTHER EXPERTS ARE NOT WORRIED

"the optimists"

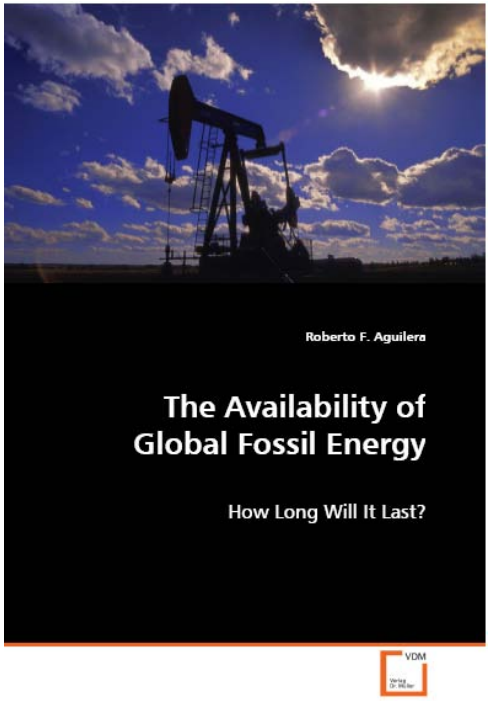






THE DEBATE

"middle of the road"



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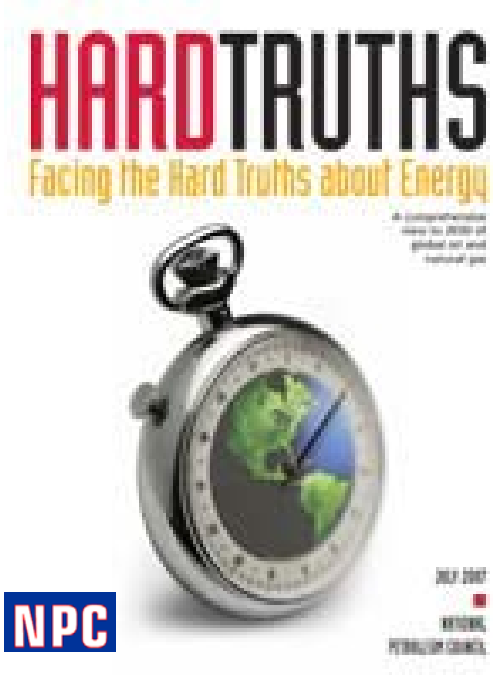
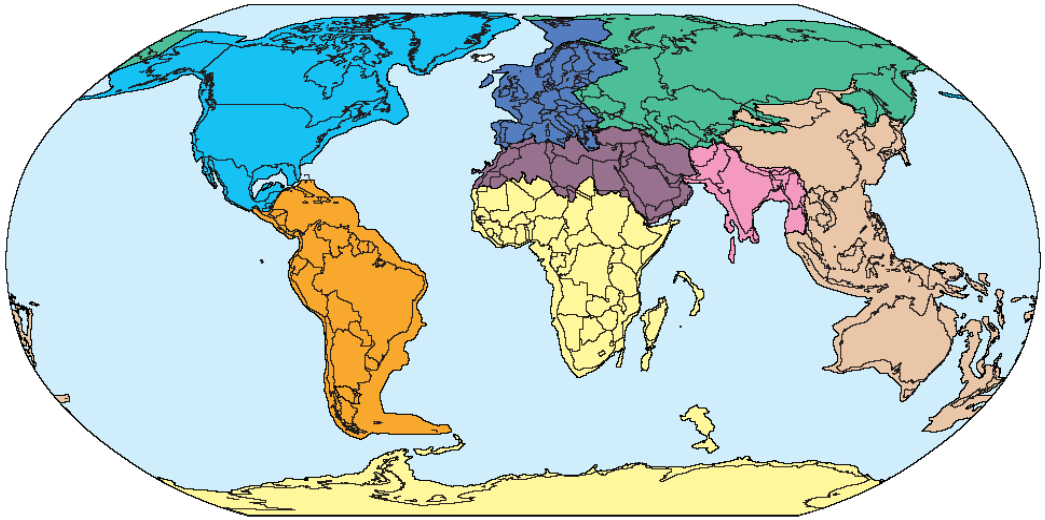


WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ENERGIE

USGS
science for a changing world

USGS World Petroleum Assessment 2000

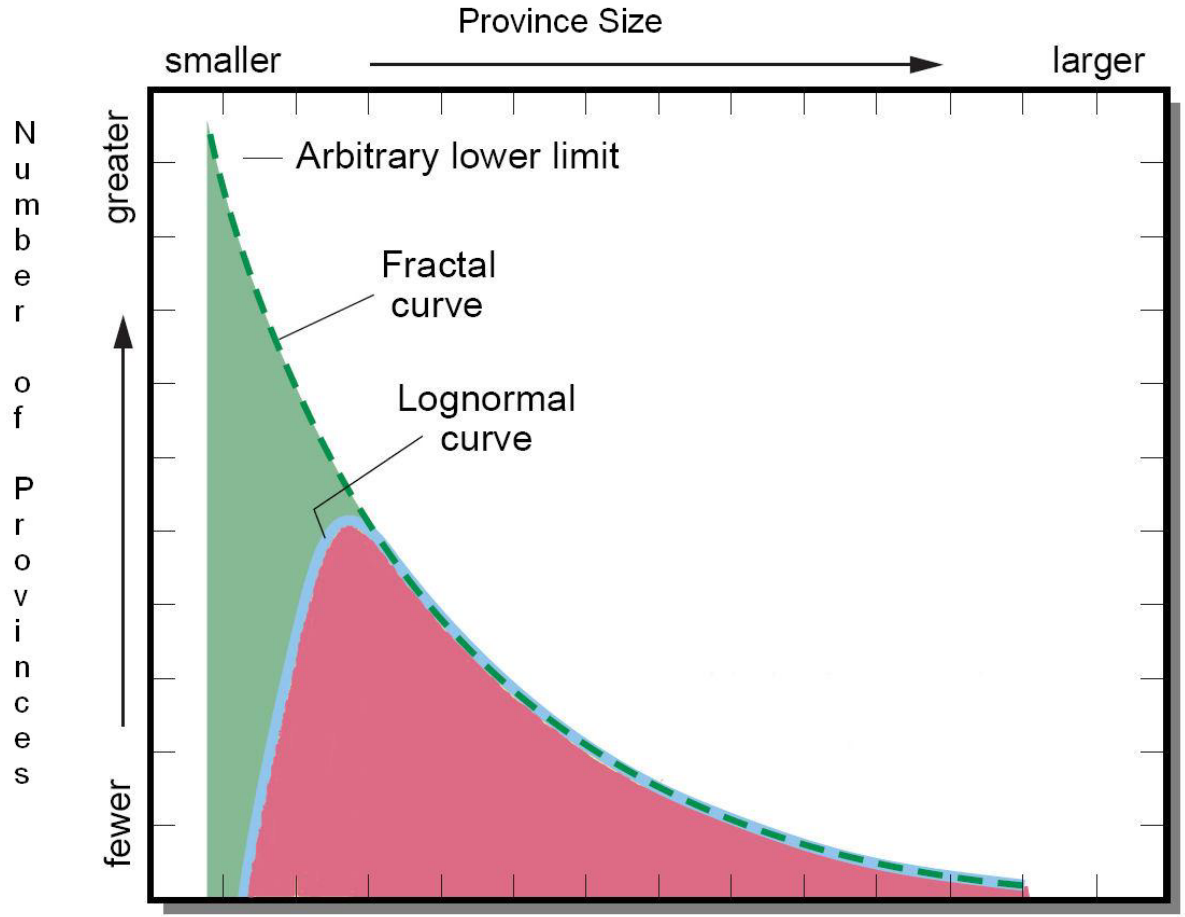


- *USGS (2000) provides estimates for 409 provinces*
  - *Known volumes, undiscovered volumes, reserve growth*
- *937 petroleum provinces in the world*

VSD (Variable Shape Distribution) Model

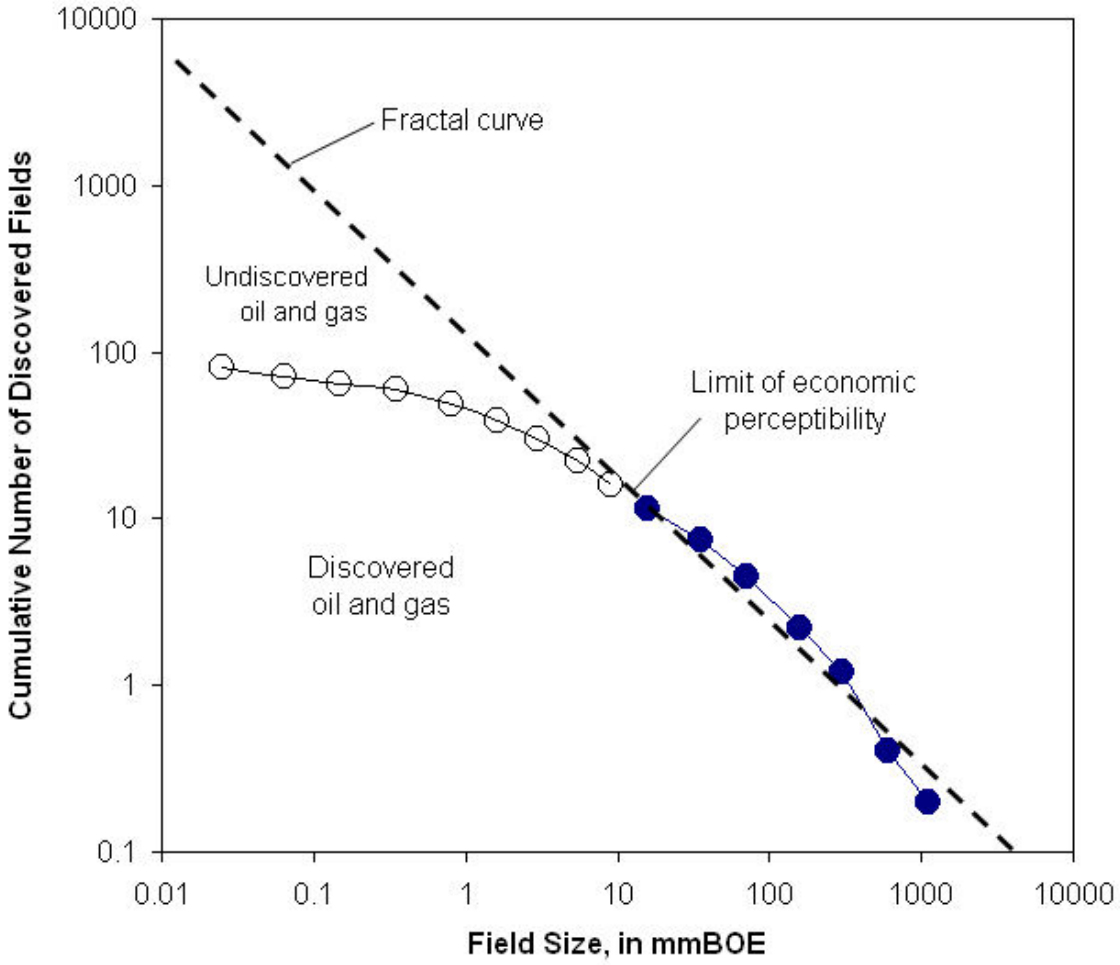
- *New model (VSD) used to estimate volumes of conventional petroleum in all 937 provinces, including previously unassessed provinces*
- *Unlike other models, VSD is not based on an assumed distribution*

Size Distribution Models



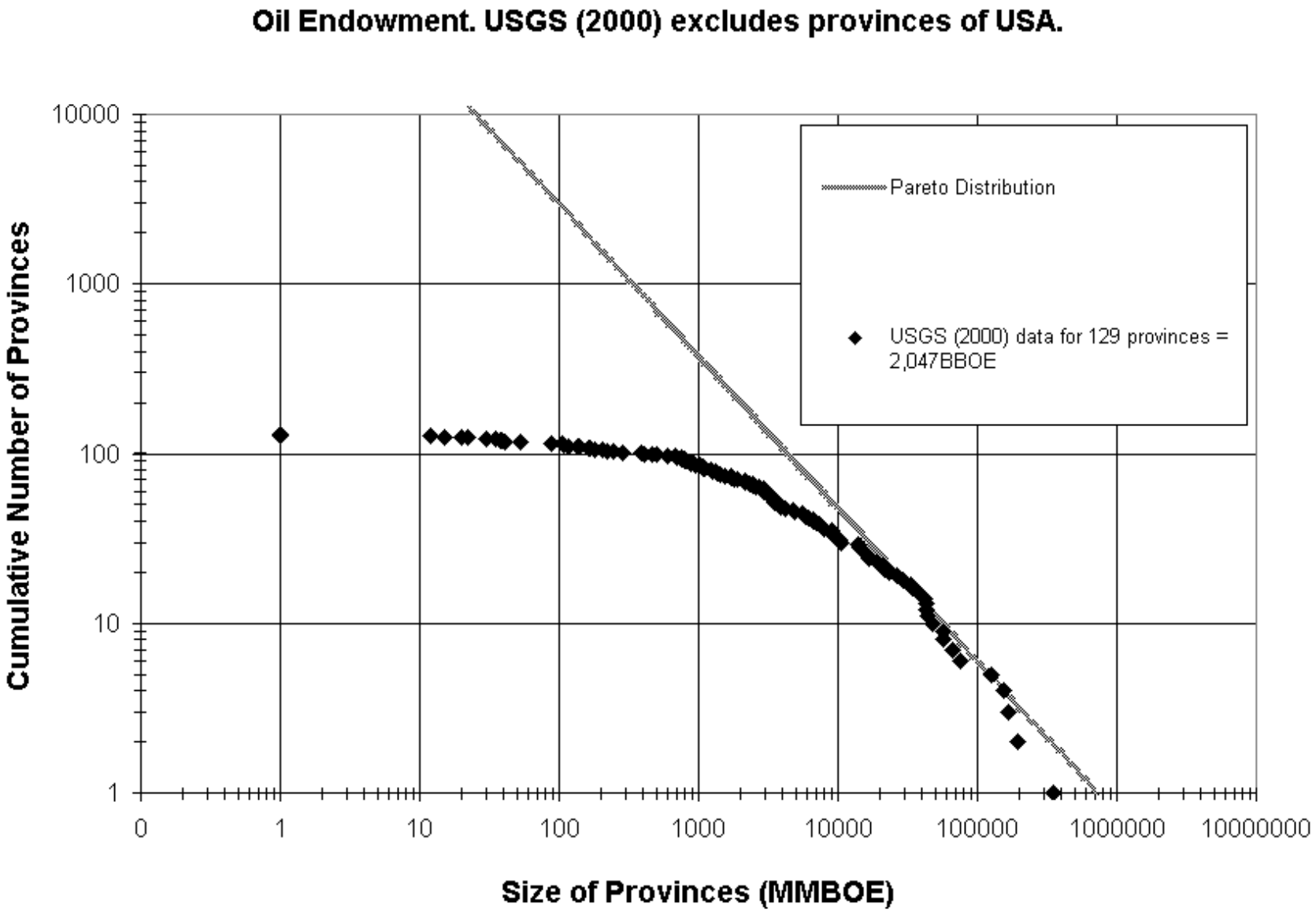
Source: adapted from Barton (1995)

Size Distribution Models

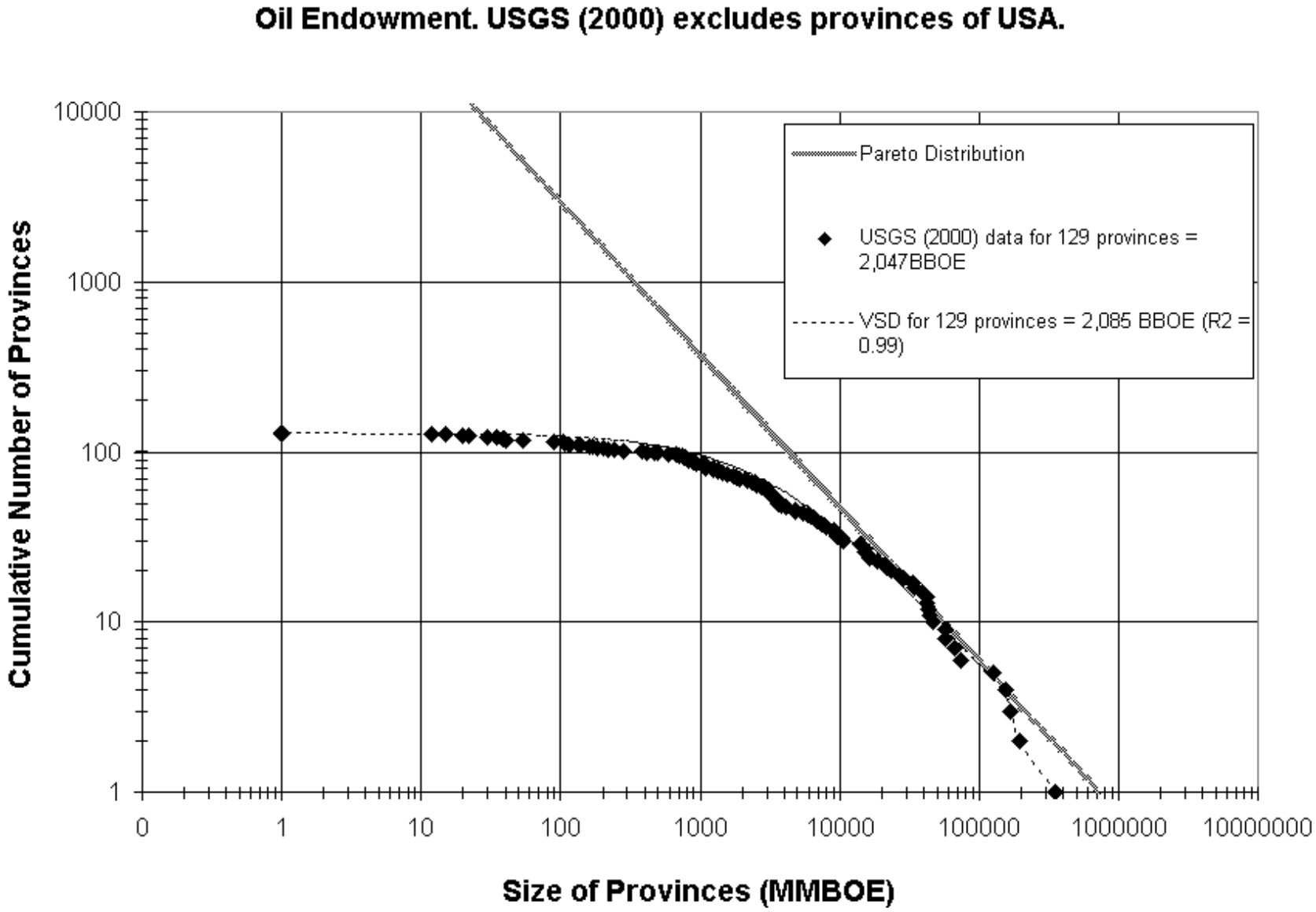


Source: adapted from Barton (1995)

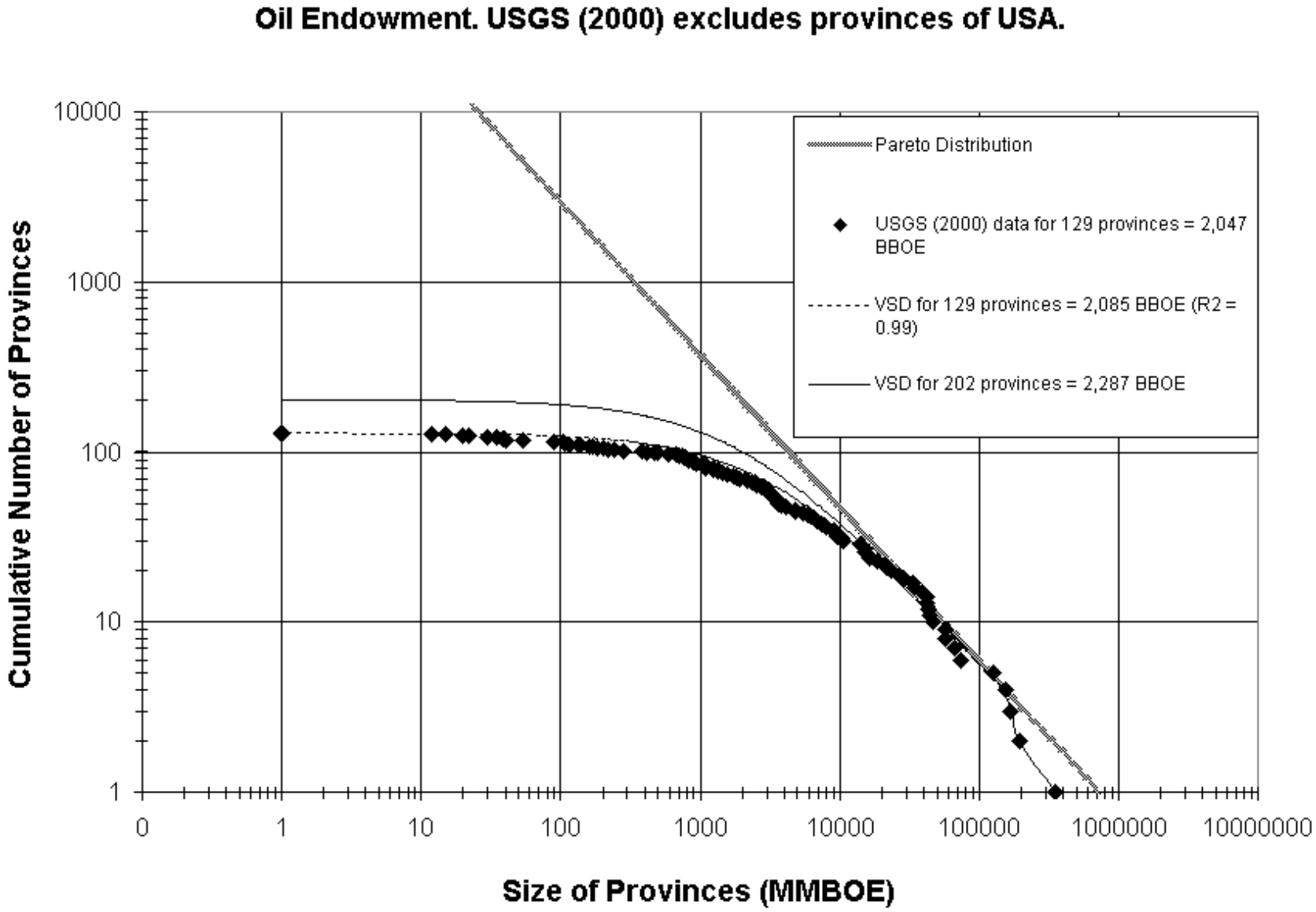
VSD Model - Variable Shape Distribution



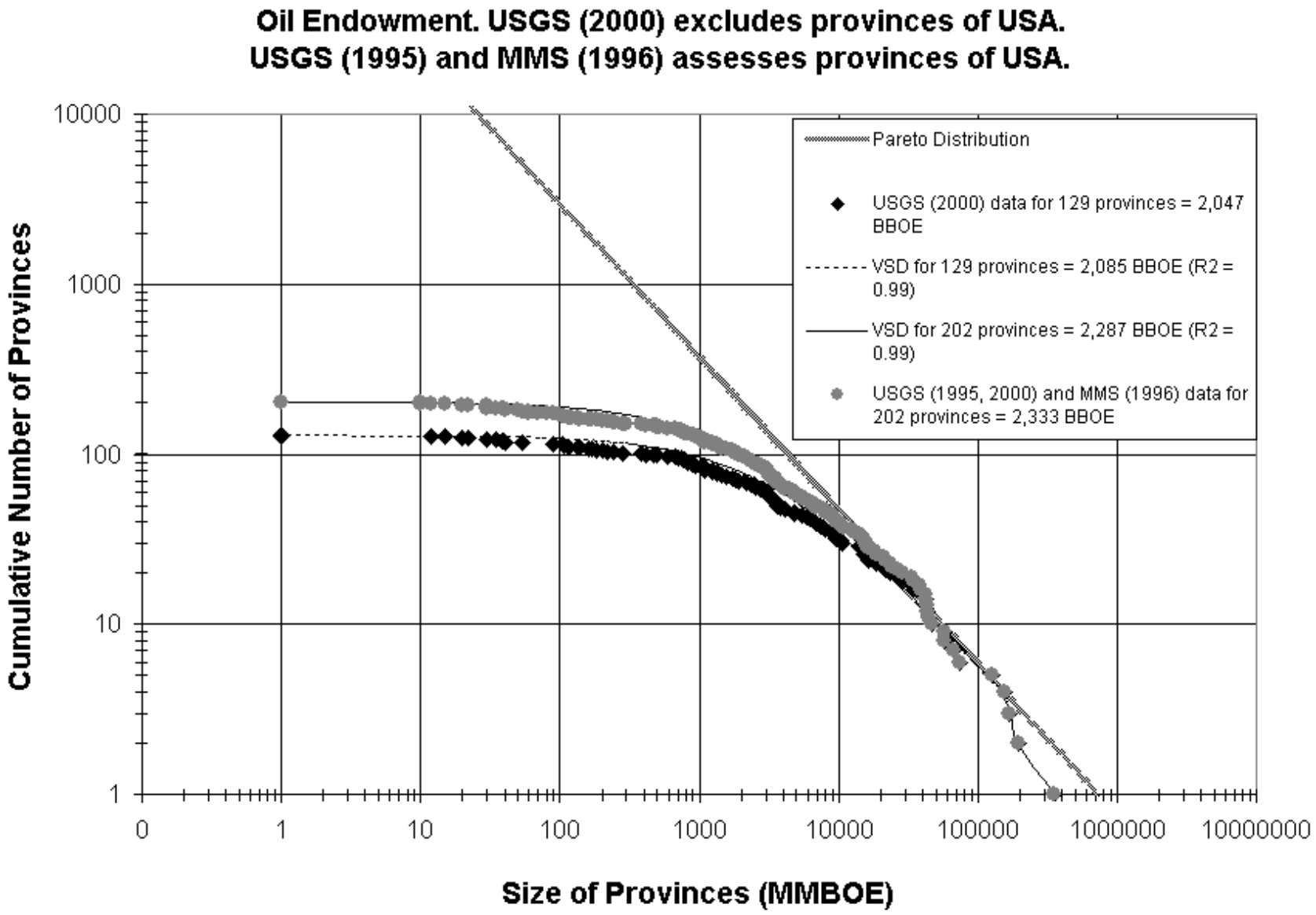
VSD Model - Variable Shape Distribution



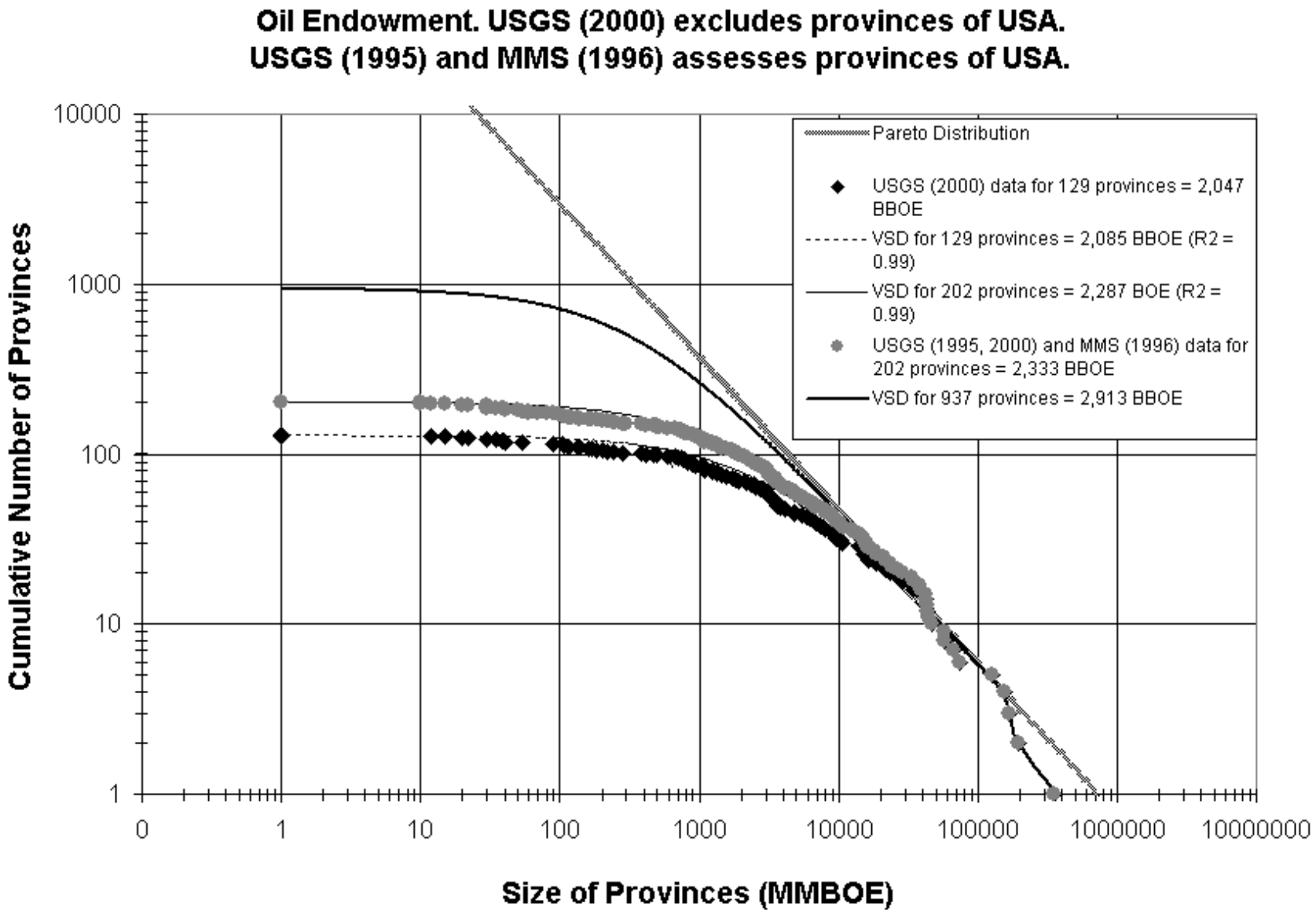
VSD Model - Variable Shape Distribution



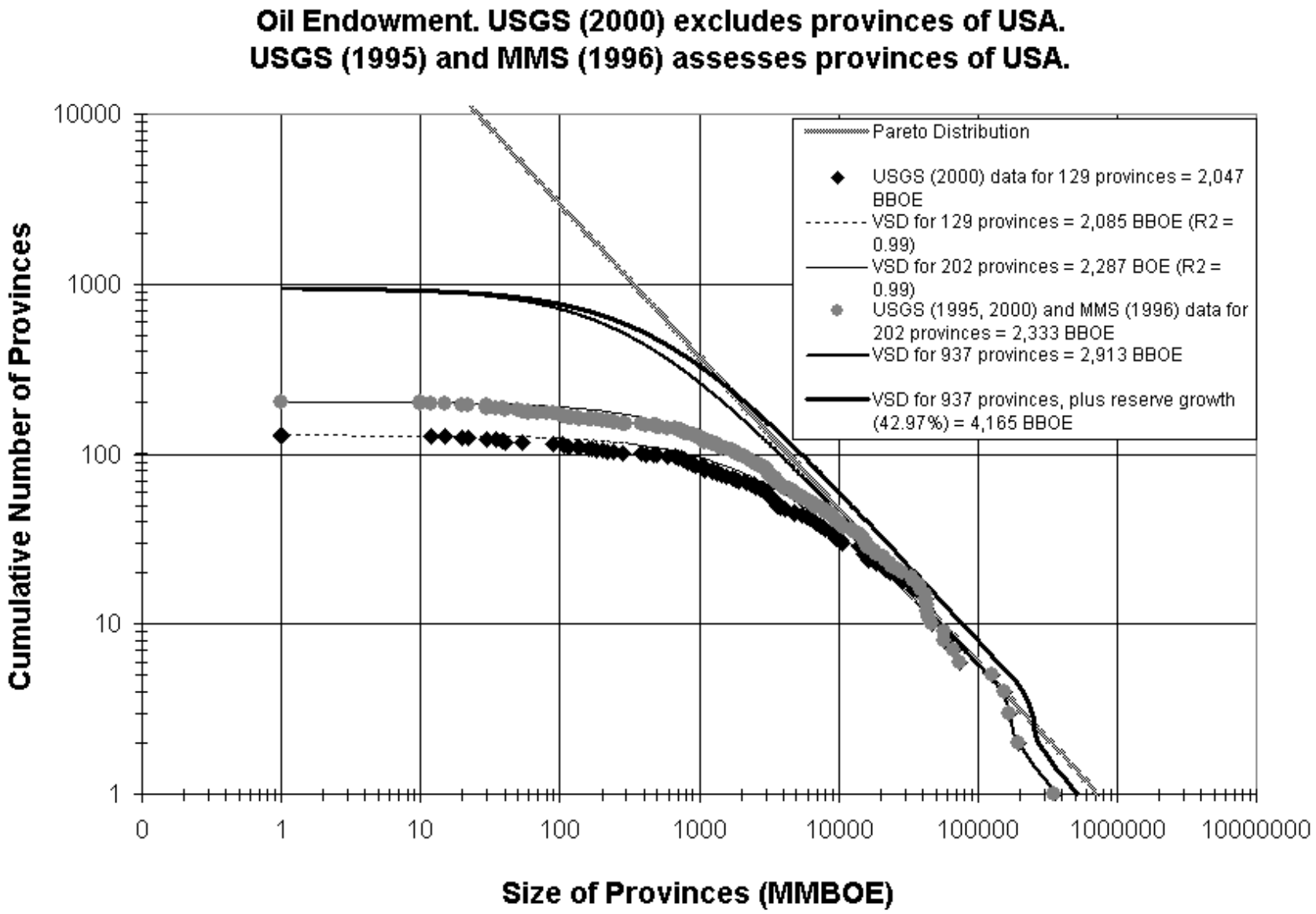
VSD Model - Variable Shape Distribution

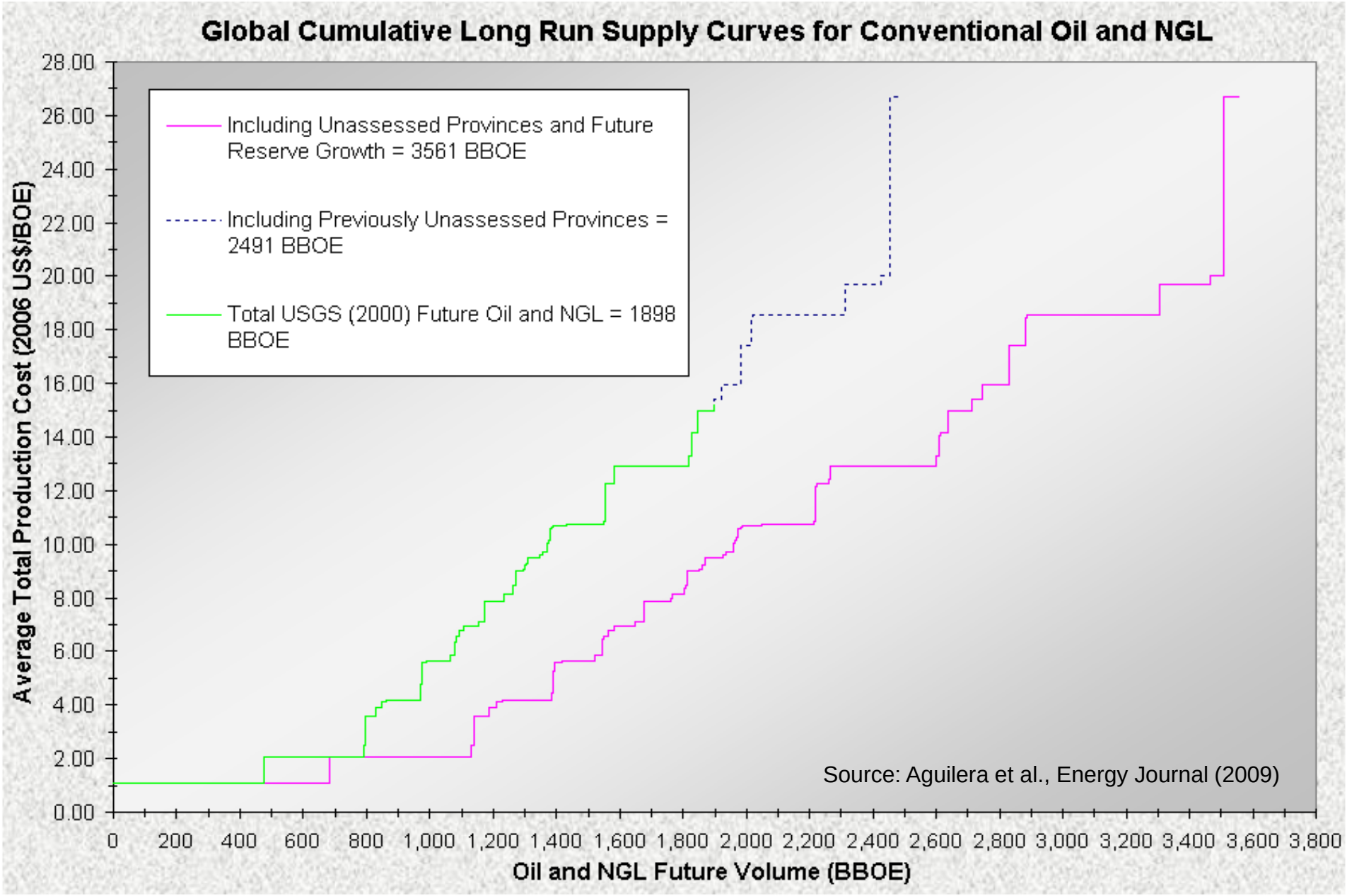


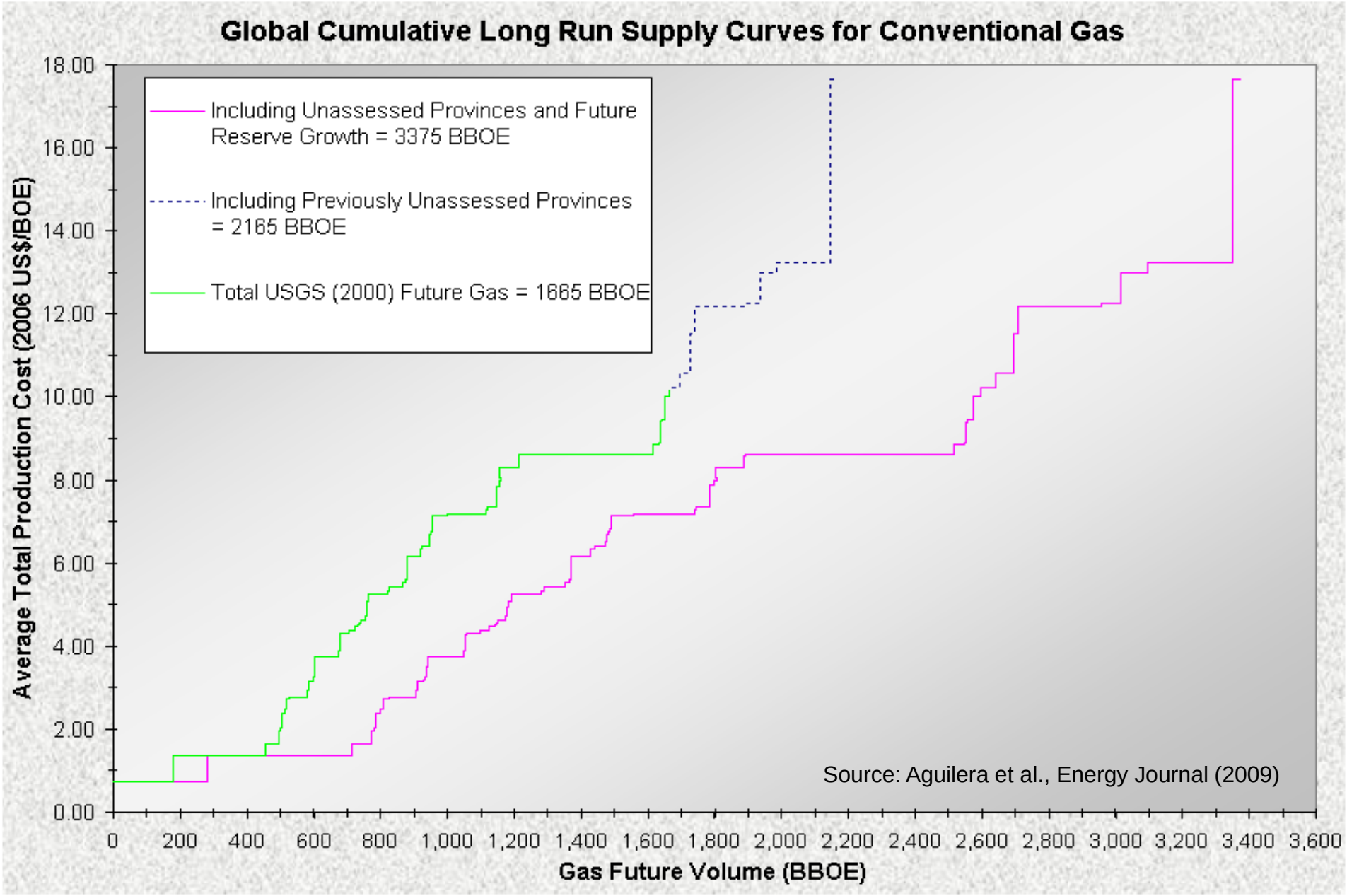
VSD Model - Variable Shape Distribution

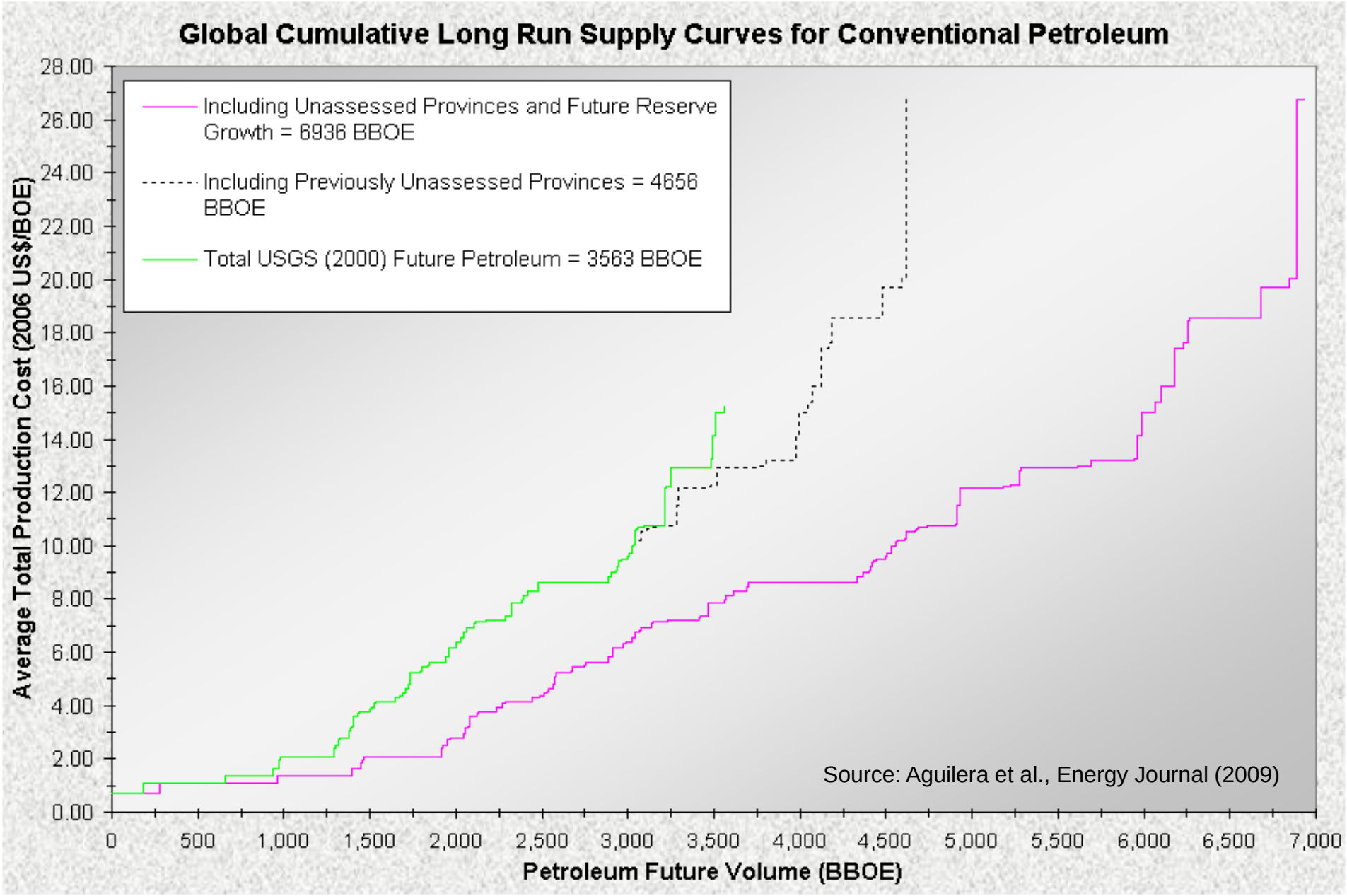


VSD Model - Variable Shape Distribution




Global Cumulative Long Run Supply Curves for Conventional Oil and NGL
Including Unassessed Provinces and Future Reserve Growth = 3561 BBOE
Including Previously Unassessed Provinces = 2491 BBOE
Total USGS (2000) Future Oil and NGL = 1898 BBOE
Average Total Production Cost (2006 US$/BOE)
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000 2,200 2,400 2,600 2,800 3,000 3,200 3,400 3,600 3,800
Oil and NGL Future Volume (BBOE)
Source: Aguilera et al., Energy Journal (2009)


Global Cumulative Long Run Supply Curves for Conventional Gas
Including Unassessed Provinces and Future Reserve Growth = 3375 BBOE
Including Previously Unassessed Provinces = 2165 BBOE
Total USGS (2000) Future Gas = 1665 BBOE
Average Total Production Cost (2006 US$/BOE)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
2,600
2,800
3,000
3,200
3,400
3,600
Gas Future Volume (BBOE)
Source: Aguilera et al., Energy Journal (2009)


Global Cumulative Long Run Supply Curves for Conventional Petroleum
Including Unassessed Provinces and Future Reserve Growth = 6936 BBOE
Including Previously Unassessed Provinces = 4656 BBOE
Total USGS (2000) Future Petroleum = 3563 BBOE
Average Total Production Cost (2006 US$/BOE)
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
Petroleum Future Volume (BBOE)
Source: Aguilera et al., Energy Journal (2009)

LIFE EXPECTANCIES

Product	Future Volume (boe)	Average Annual Production, 2004 – 2006 (boe)	Life in Yrs 0%	Life in Yrs 2%	Life in Yrs 5%	Average Annual Production Growth 1976 – 2006 (%)
Conventional Oil and NGL	3561×10^9	2.96×10^{10}	120	61	39	1,04
Conventional Gas	3375×10^9	1.64×10^{10}	206	82	48	2,82
Heavy Oil	4000×10^9	4.59×10^{10}	87	50	34	-
Oil Sands	5000×10^9	4.59×10^{10}	109	58	37	-
Oil Shale	14000×10^9	4.59×10^{10}	305	98	56	-

IMPLICATIONS

- *Conventional oil and gas more abundant than commonly assumed*
- *Tendency to overlook volumes from unassessed provinces and reserve growth*
- *Conventional oil and gas likely to last far longer than many now claim*
- *Production costs lower than current market prices*

VSD Equations

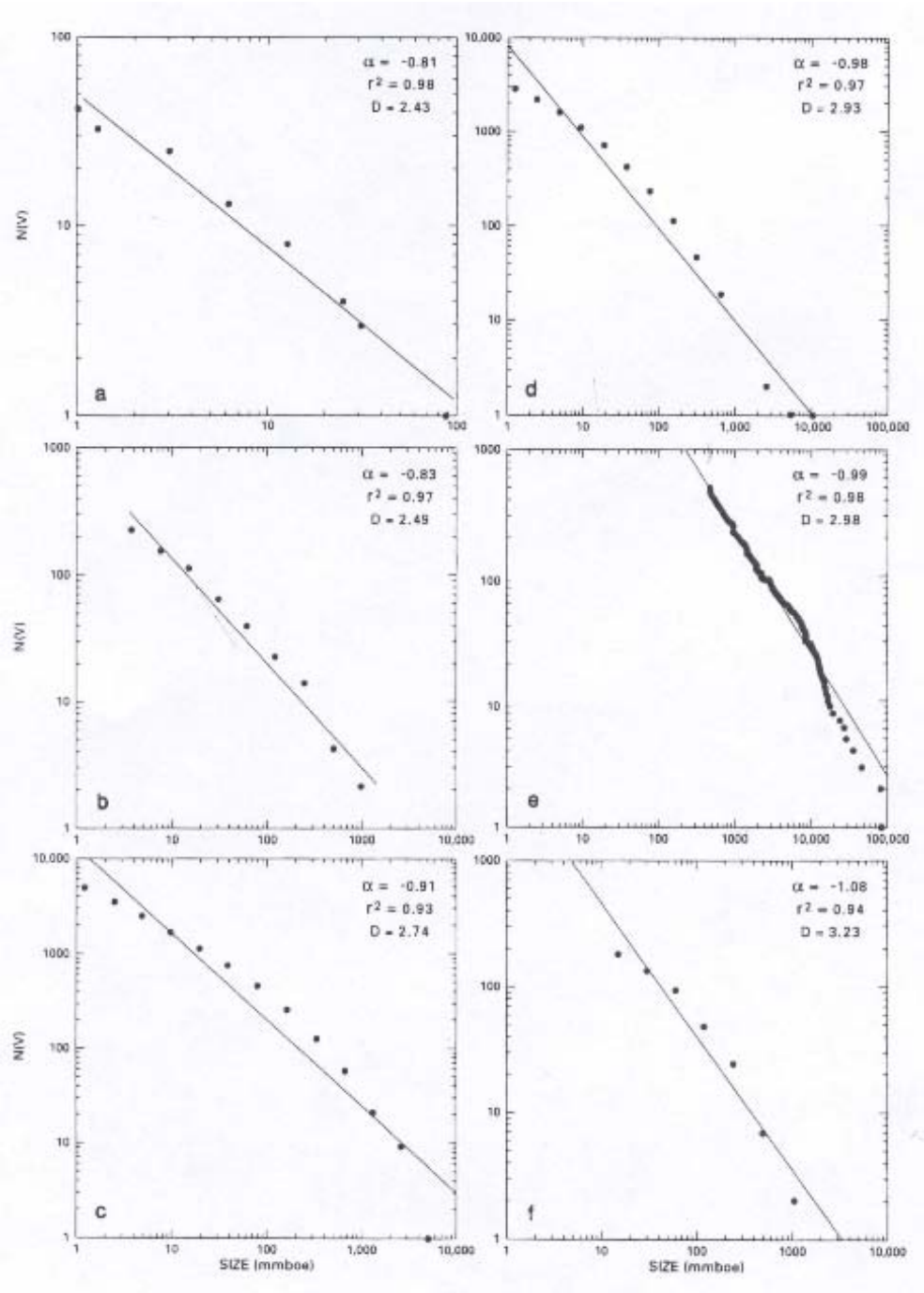
$$V_e = \frac{V_t \times \psi}{\psi + (1-\psi)\cdot(1-\exp(-V_t/V_s))^S}$$

where:

$$V_t = \left[\left(\frac{1}{N_t} - \left(\frac{V_m}{V_x}\right)^{\left(\frac{\log N_x - \log N_m}{\log V_x - \log V_m}\right)}\right)^{\frac{1}{a_p}} + \frac{V_m}{V_x}\right]\cdot V_x$$

Parameters:

- V_x
- a_p
- ψ
- V_s
- S

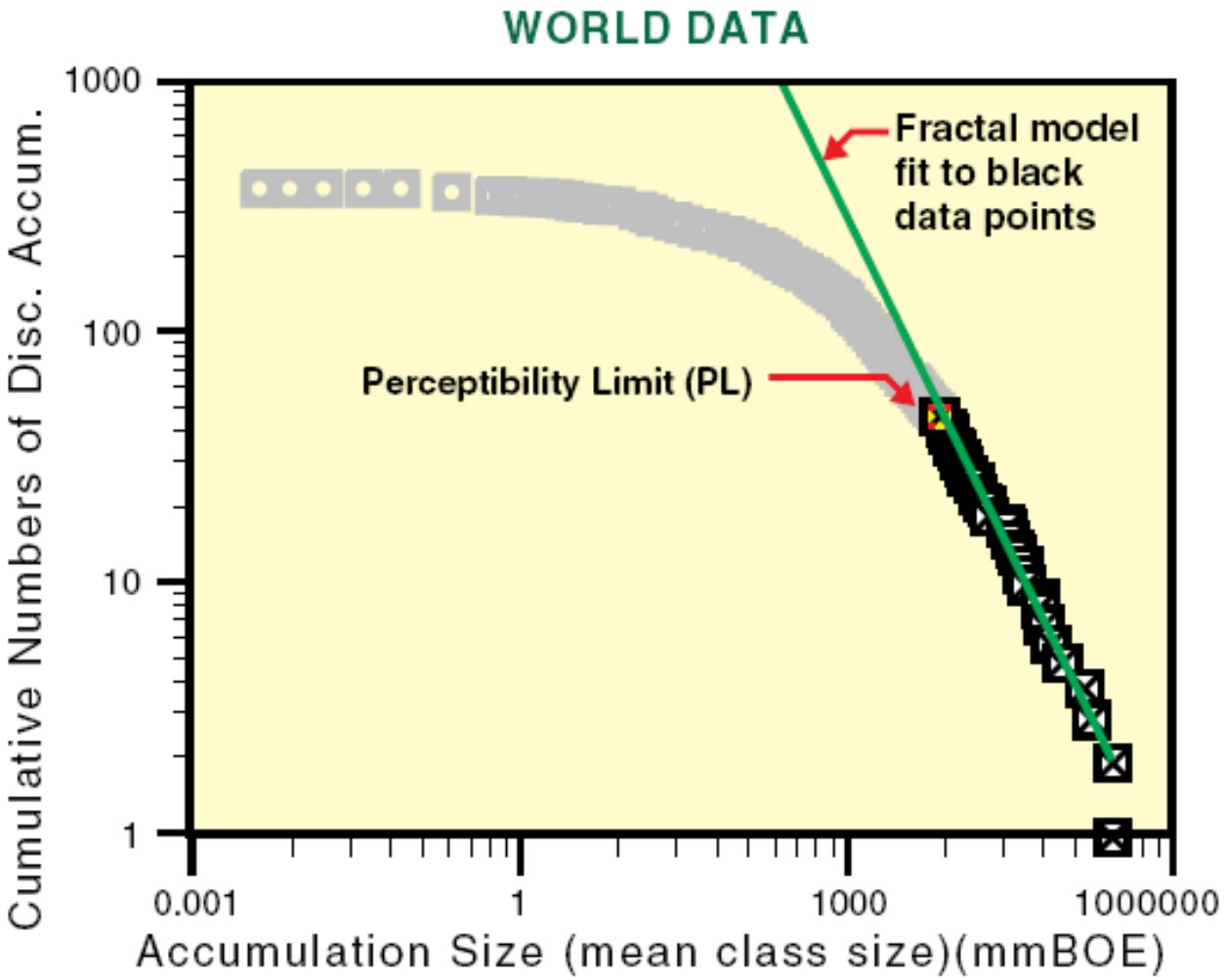


Log-log plots of cumulative number of pools, N(V), versus pool size (MMBOE) for:

(a) Cardium Scour oil play of central Alberta, Canada, through 1982
(b) Frio Strand Plain oil and gas exploration play, onshore Texas, through 1985;
(c) oil fields in the conterminous 48 states through 1984;
(d) gas fields in the conterminous 48 states through 1984;
(e) giant oil and gas fields, worldwide, through 1980;
(f) oil and gas fields in the western Gulf of Mexico through 1976

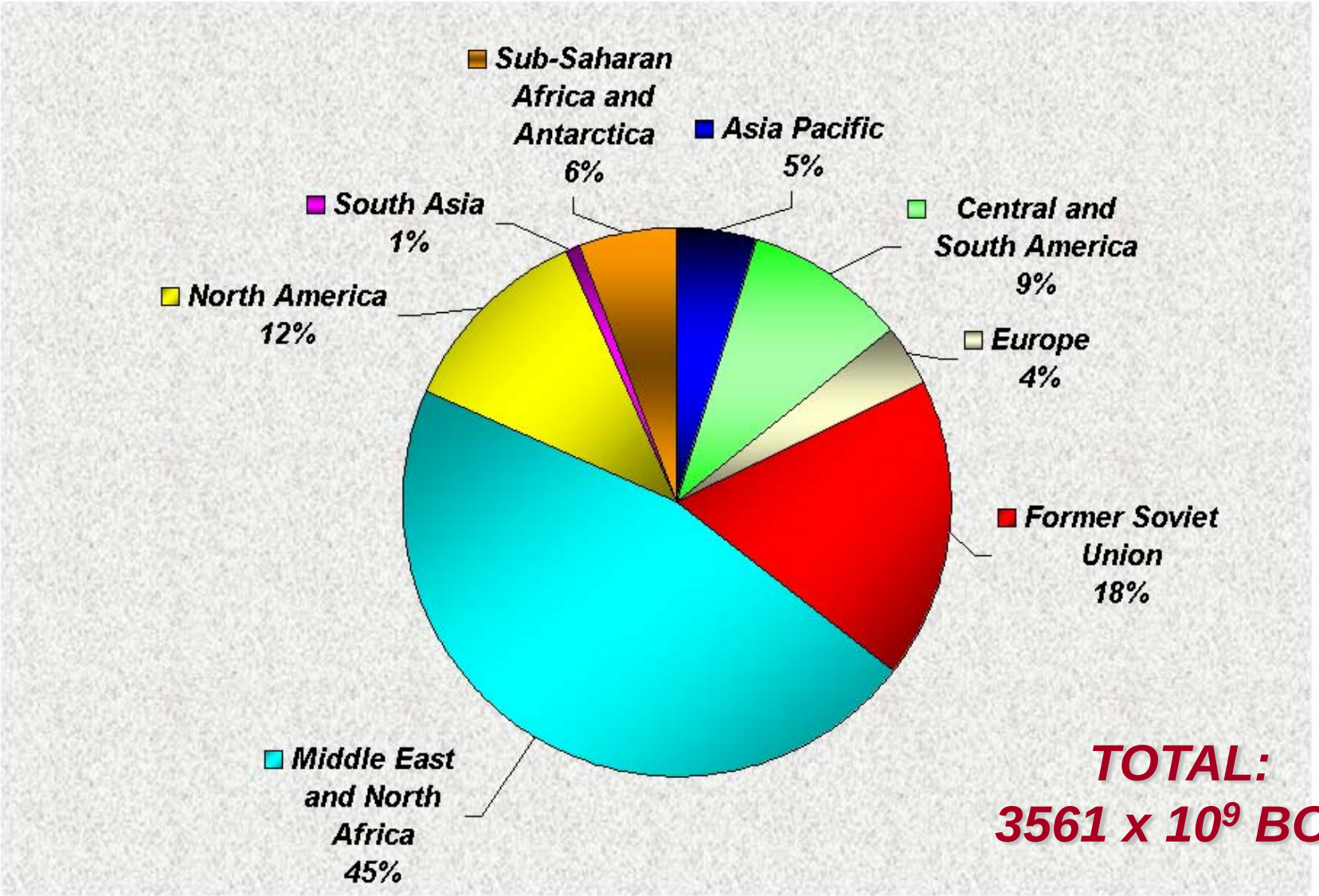
Source: Barton and Scholz, 1995

Pareto (aka fractal) Distribution

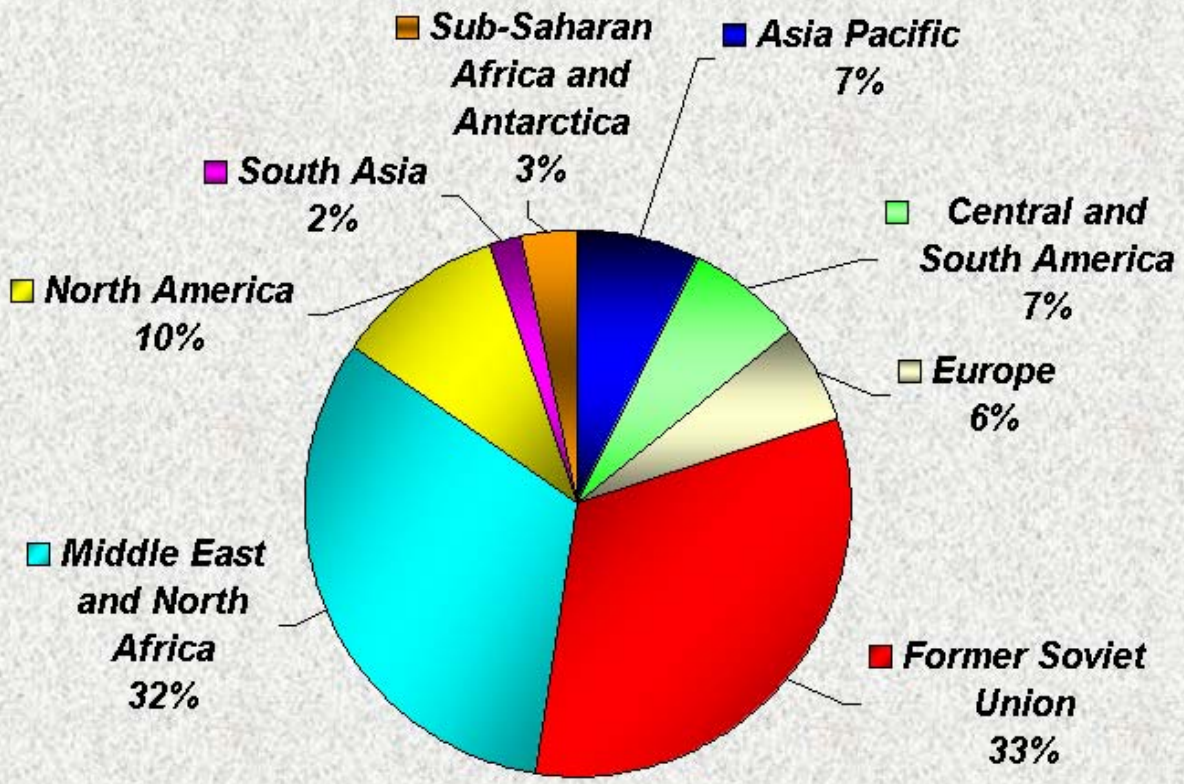


Source: Barton, 1995

Distribution of Future Oil Volume



Distribution of Future Natural Gas Volume



TOTAL:
3375×10^9 BOE

ASSESSING PREVIOUSLY UNASSESSED PETROLEUM PROVINCES USING THE VARIABLE SHAPE DISTRIBUTION (VSD) MODEL

THANK YOU

Dr. Roberto F. Aguilera
International Institute for Applied Systems Analysis (IIASA);
and University of Vienna

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