

Annual Rice Global Forum for Engineering & Construction

October 11, 2005

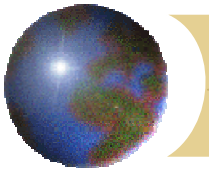
Uncertainty, Risk, and “Expected” Profits
Or, “What can I *really* expect?”

Ben Ball

Phone 281/494-0396

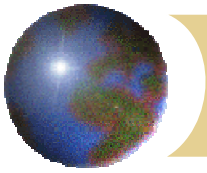
benball@alum.mit.edu

www.benball.com



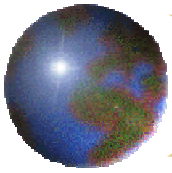
Note

In all numerical examples,
please multiply each figure by
 10^X , where X is whatever size
it takes to make it applicable to
your business.



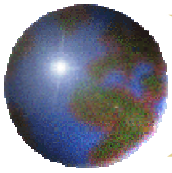
An example

- You own a petroleum reservoir which contains *exactly* 1,000 barrels.
- The marginal out-of-pocket cost of production is *exactly* \$9.50/bbl.
- You forecast oil price to average \$10/bbl. at your wellhead.
- What do you expect your net cash flow to be?

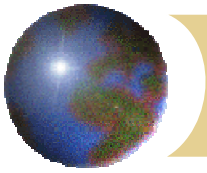


\$500, because there are 1,000 barrels
at 50¢/barrel margin.

Right?



WRONG!!

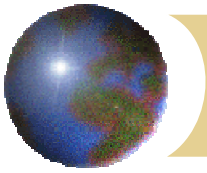


Correct answer

✚ \$1,000

✚ Why?

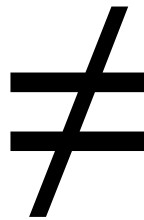
- The price of oil is forecast to be normally distributed with a mean of \$10 and an standard deviation of 1.8.
- You would not produce when the price is below your marginal cost.



“The flaw of averages”

With credit to Prof. Sam Savage, Stanford University

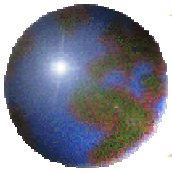
The value of a
function evaluated at
its average value



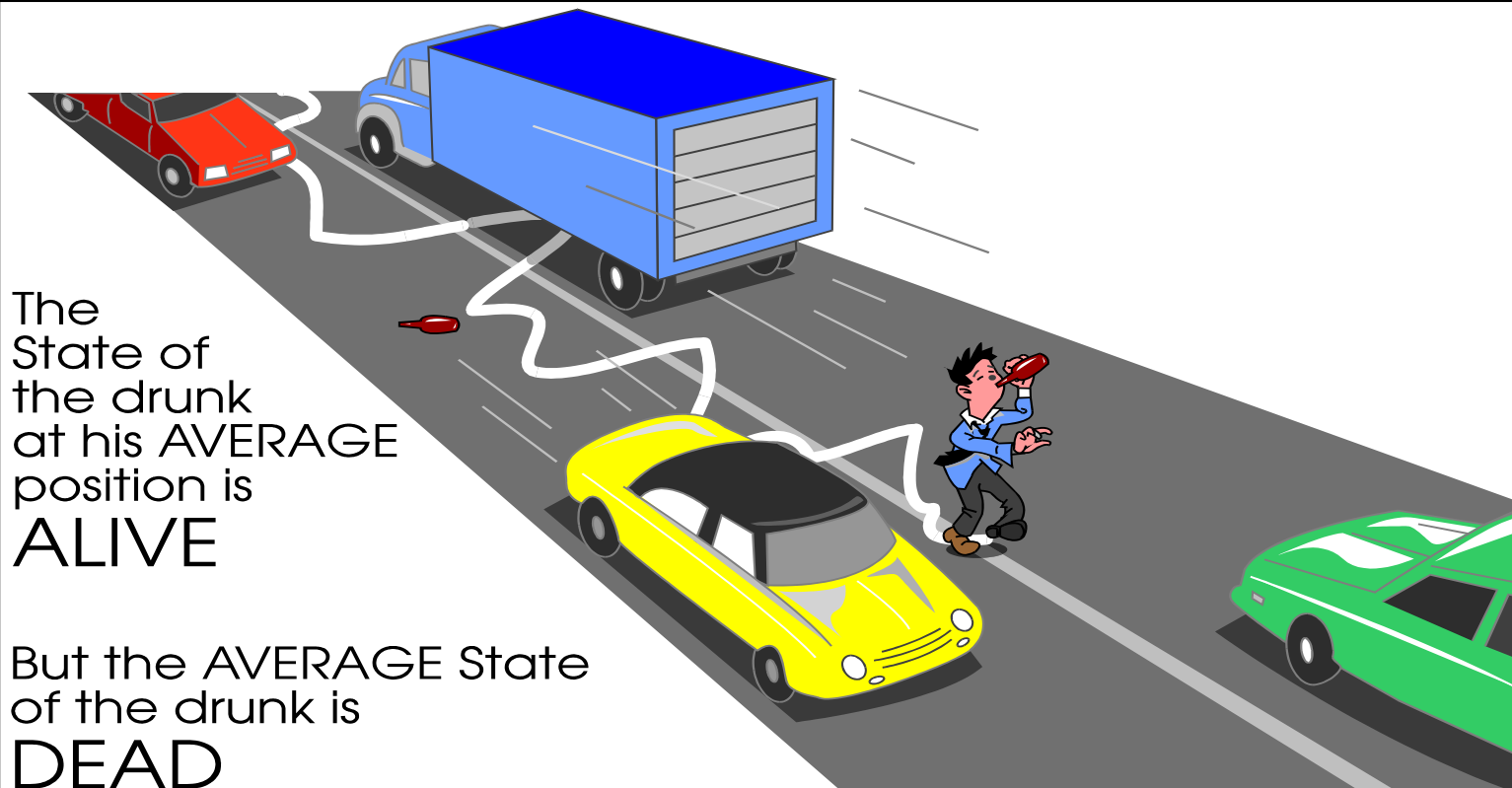
The average value of
the function*

- Unless the function is linear. (Jensen's inequality)

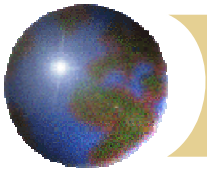
P.S. Very little in this world is linear.



A sobering example

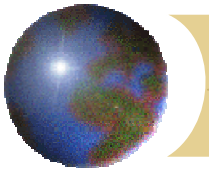


Used by courtesy of Prof. Sam Savage, Stanford University



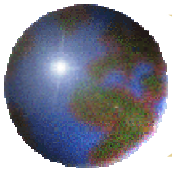
A more interesting example

- ✚ You operate a warehouse out of which you sell widgets at a margin of \$2/widget.
- ✚ You can replenish your inventory every morning.
- ✚ Overnight charges for any inventory left over from the day's activity = \$1/widget.
- ✚ Average sales = 5 widgets/day.
- ✚ Therefore, you daily inventory 5 widgets.
- ✚ What is your expected daily profit?

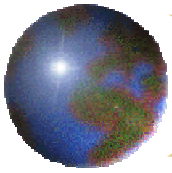


\$10, because average sales of 5/day times a \$2 margin equals \$10/day, with no inventory leftover charges.

Right?



WRONG!!

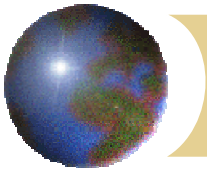


Correct answer

✚ \$5.91

✚ Why?

- ▣ Because the sales are equally distributed between 0/day and 10/day.

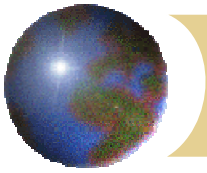


Sales distribution!

	Sales	Cost	Margin	Profit
	0	5	0	-5
	1	4	2	-2
	2	3	4	1
	3	2	6	4
	4	1	8	7
	5	0	10	10
	6	0	10	10
	7	0	10	10
	8	0	10	10
	9	0	10	10
	10	0	10	10
Average	5			\$5.91

Equally likely

Inventory = 5



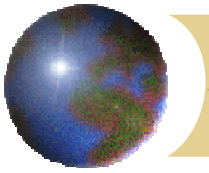
The right input

⊕ Not

▣ What are the *average* sales?

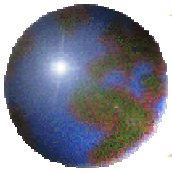
⊕ But

▣ **How are the sales distributed?**



Distributions as input

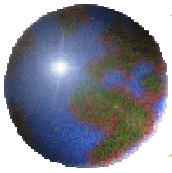
- ✚ Use the same distributions for all applications of the same parameter.
- ✚ Avoid “normal distributions,” “standard deviations,” etc. (These are stone-age relics.)
- ✚ Triangular distributions may be the most useful, at least for starters.
 - ▣ Use what you know about what you don’t know.
 - ▣ E.g.
 - <10% probability of <40
 - Mean of 50
 - <10% probability of >60
 - ▣ This avoids the flaw of averages and illuminates the risks.
- ✚ Use historical data.



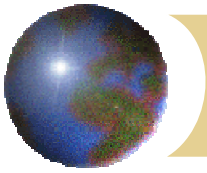
Sales distribution

	Sales	Cost	Margin	Profit
	0			
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
Average	5			

Equally likely



Welcome to Monte Carlo Simulation!



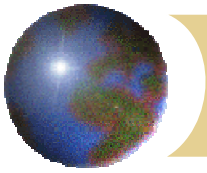
The right question

✚ Not just

- ▣ What is the expected profit (margin, cash flow, return, etc.)?

✚ But

- ▣ What is my risk?
 - E.g., What is the probability of losing money?



Some Definitions

✚ Uncertainty

- ✚ Objective

- ✚ Independent variables, the value of which are unknown.

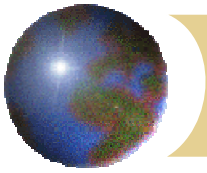
- E.g., future oil price

✚ Risk

- ✚ Subjective. In the eye of the beholder.

- ✚ Whatever you worry might happen to you.

- E.g., the probability of negative cash flow



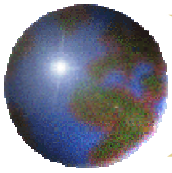
Definitions, cont'd

✚ Mean

- ✚ Average. Expected value.
- ✚
$$\frac{(\text{Each possible outcome}) \times (\text{its probability})}{(\text{number of possible outcomes})}$$

✚ Mode

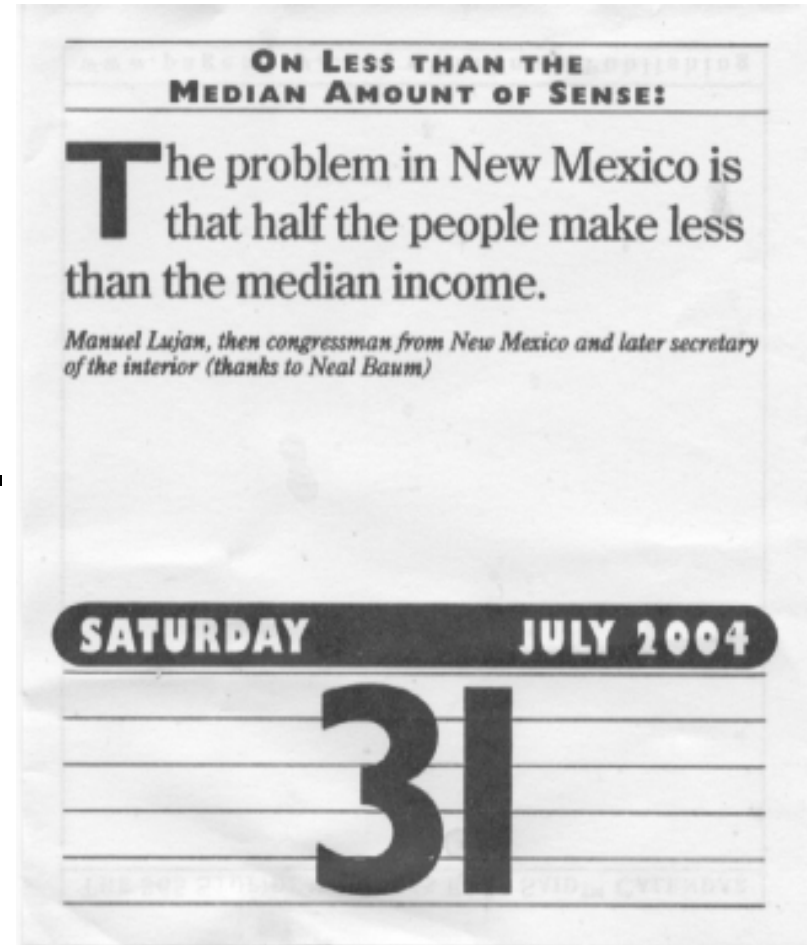
- ✚ The most likely outcome. Not very useful.
- ✚ Usually not even very likely.
 - E.g., the most likely outcome for a roll of die is 7, but its probability is only .17, i.e., 1 chance in 6.

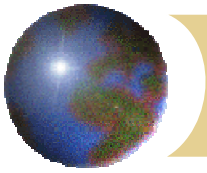


Definitions, cont'd

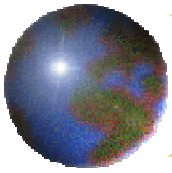
Median

- The middle value in a distribution.
- Not very useful in our work.



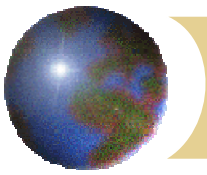


What is my risk at an inventory level of 5?

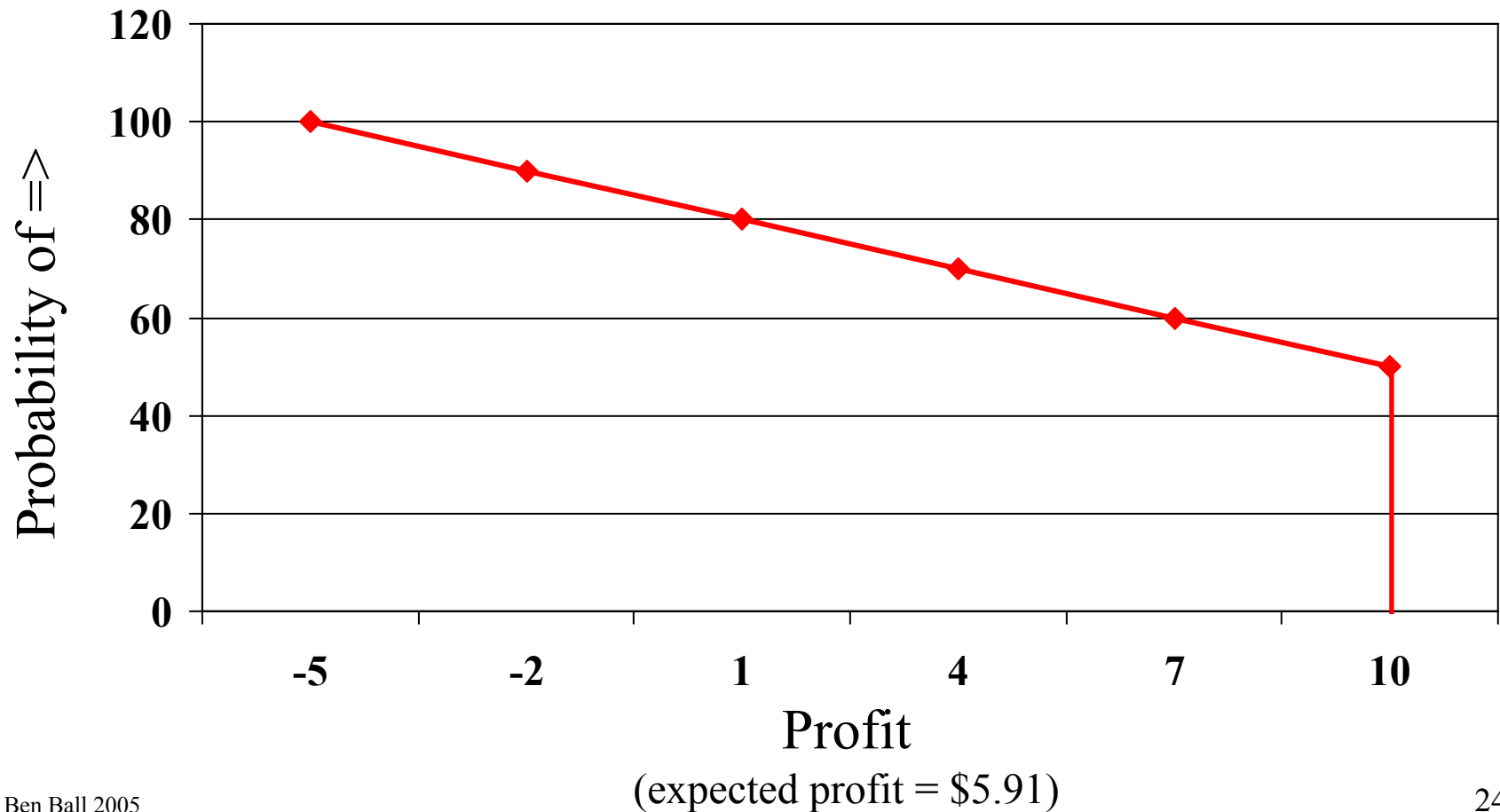


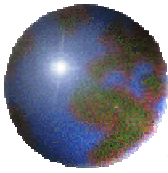
Sales distribution

	Sales	Cost	Margin	Profit
Equally likely	0	5	0	-5
	1	4	2	-2
	2	3	4	1
	3	2	6	4
	4	1	8	7
	5	0	10	10
	6	0	10	10
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Average	5			\$5.91

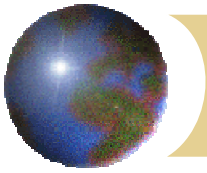


What is my risk at an inventory level of 5?



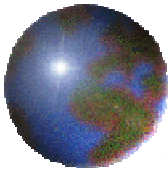


Risk is a probability distribution!



Another good question

⊕ How can I maximize my expected profit?

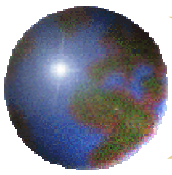


Sales distribution

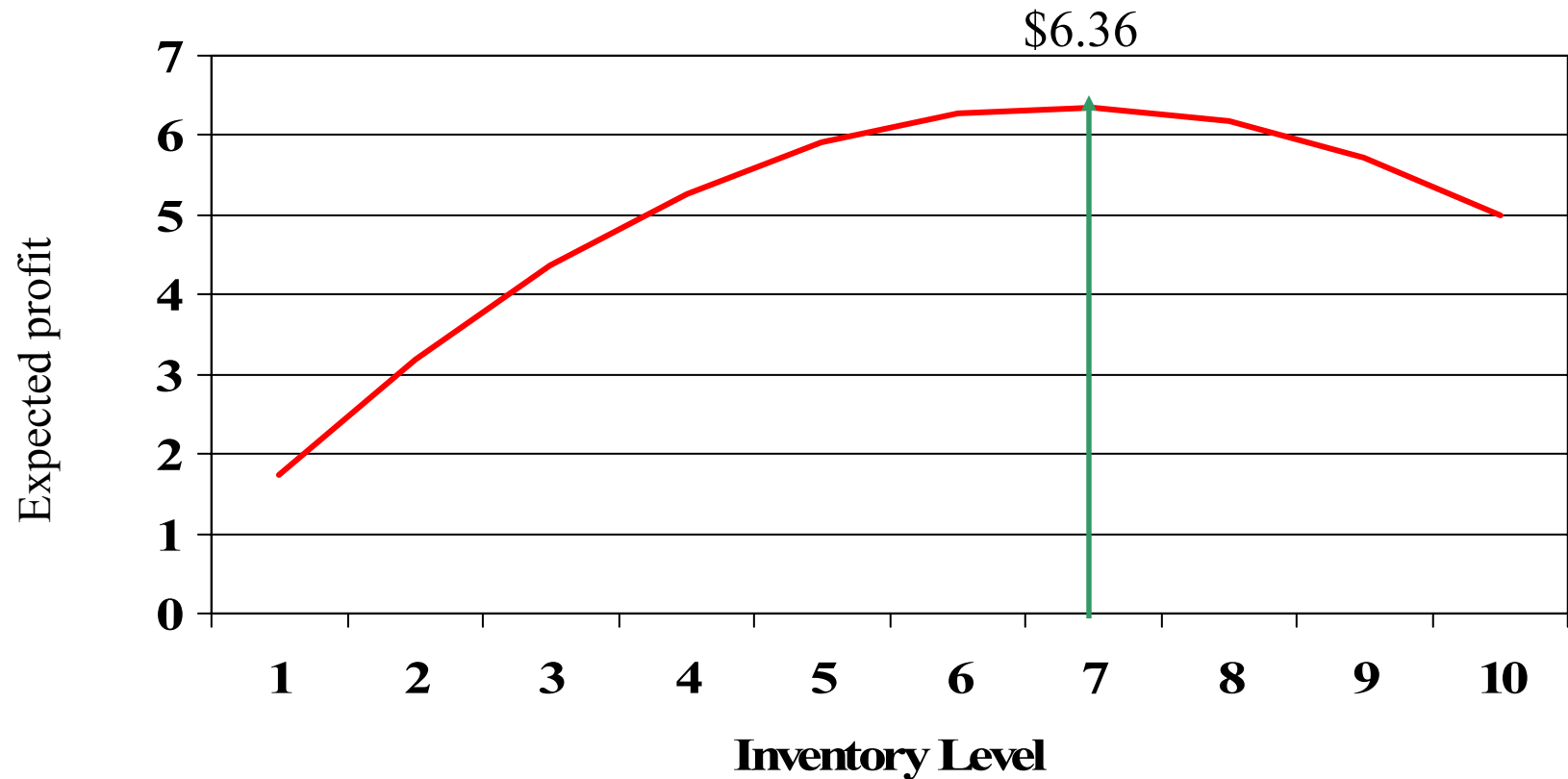
	0	Cost	Margin	Profit
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
Average	5			Y

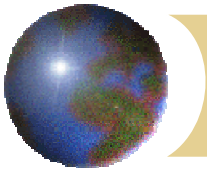
Equally likely

Inventory = X



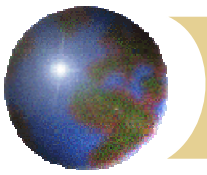
Expected profit vs. inventory level





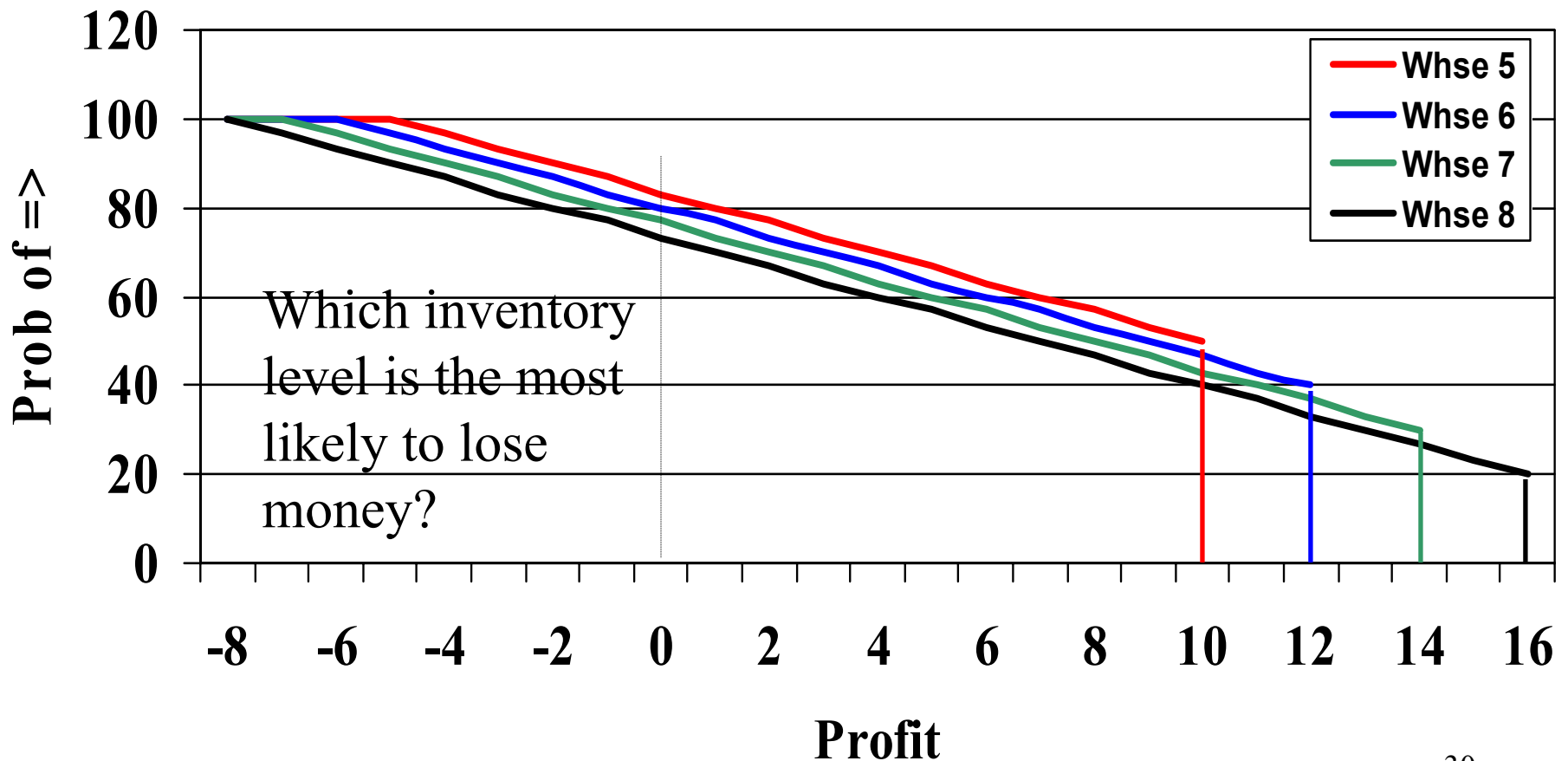
Another good question

⊕ How can I minimize my risk?



How can I minimize risk?

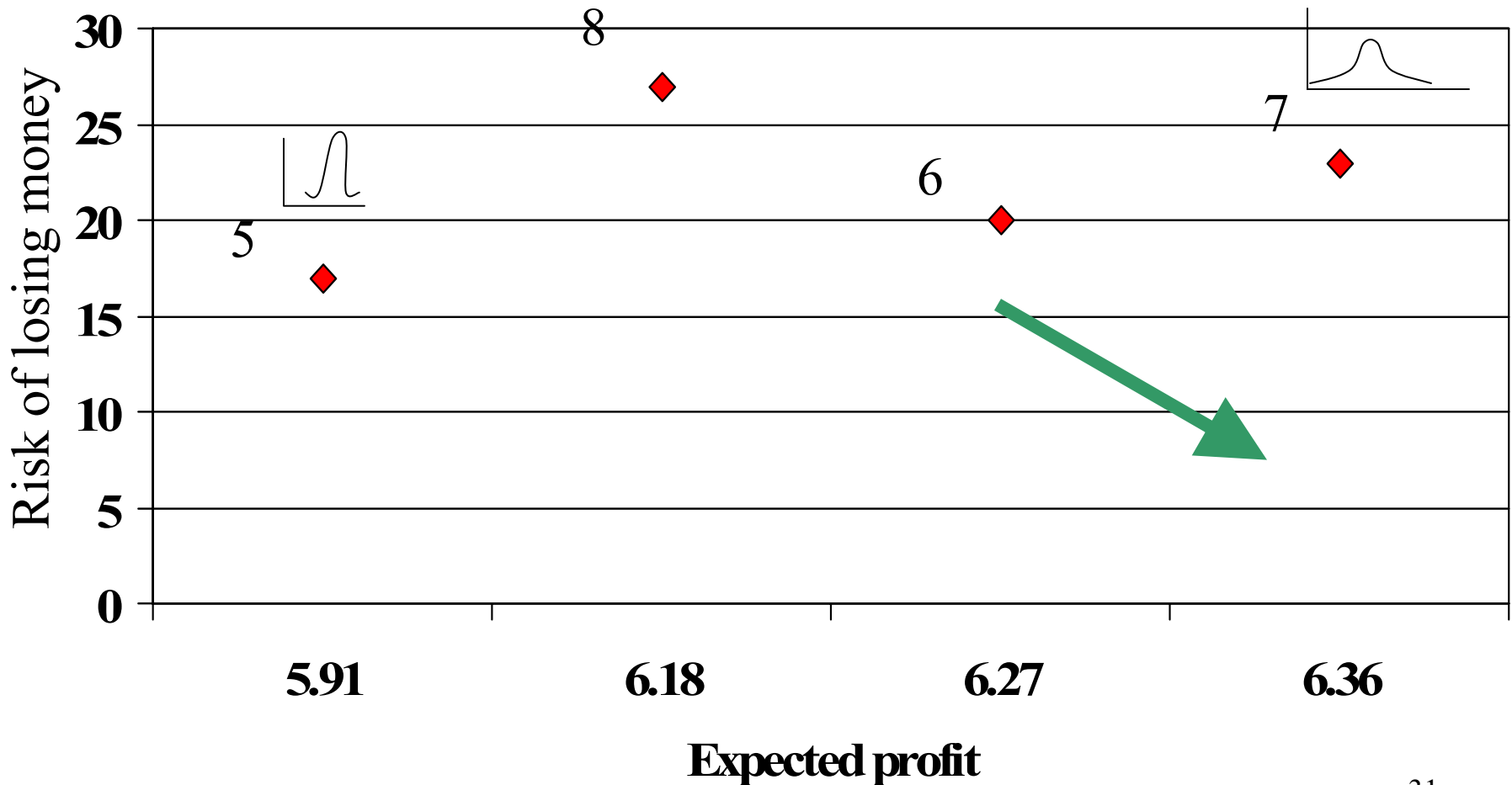
Cumulative risk profiles

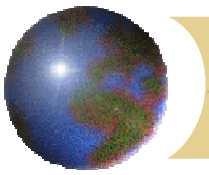




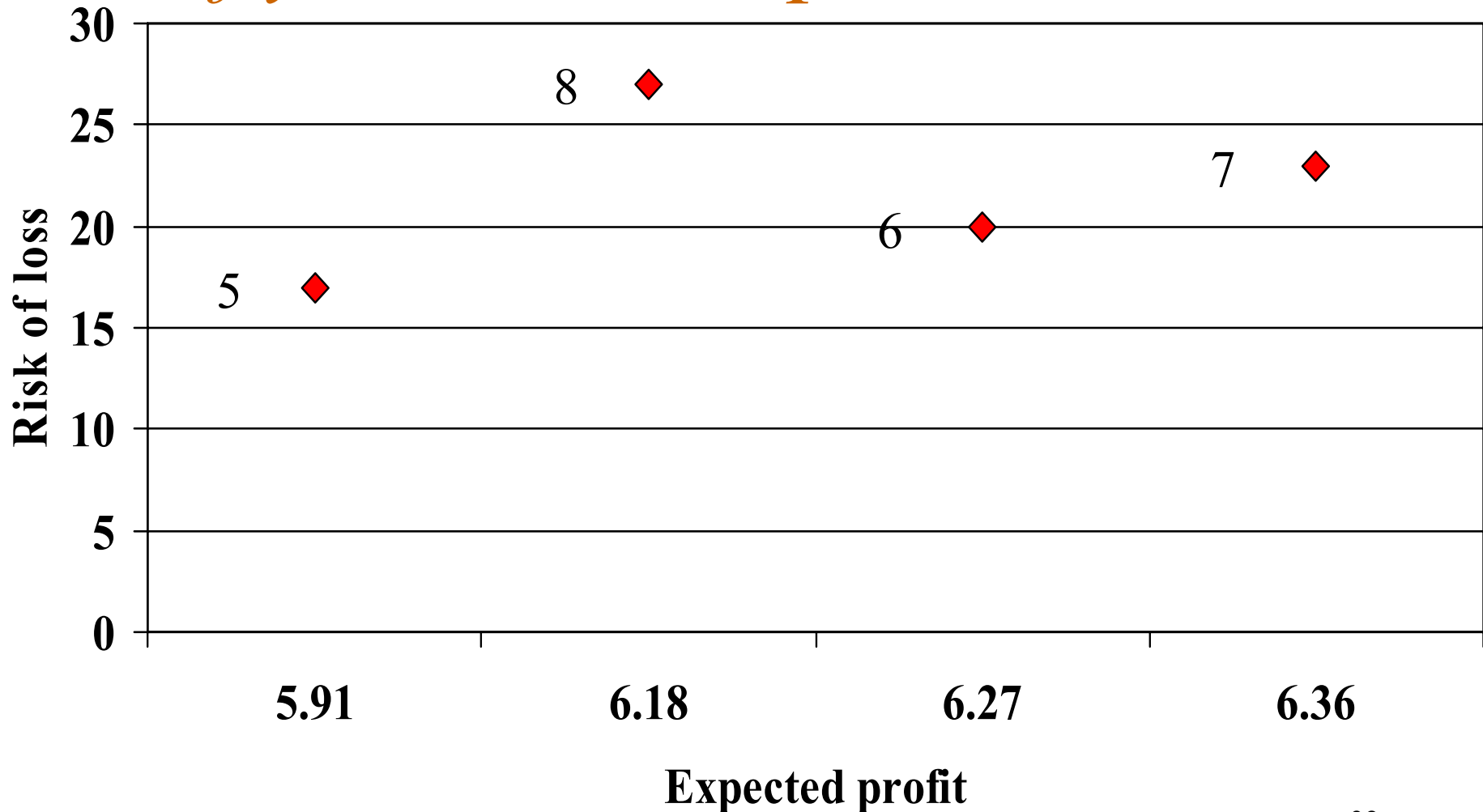
The best question:

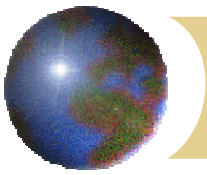
What is the optimum strategy?



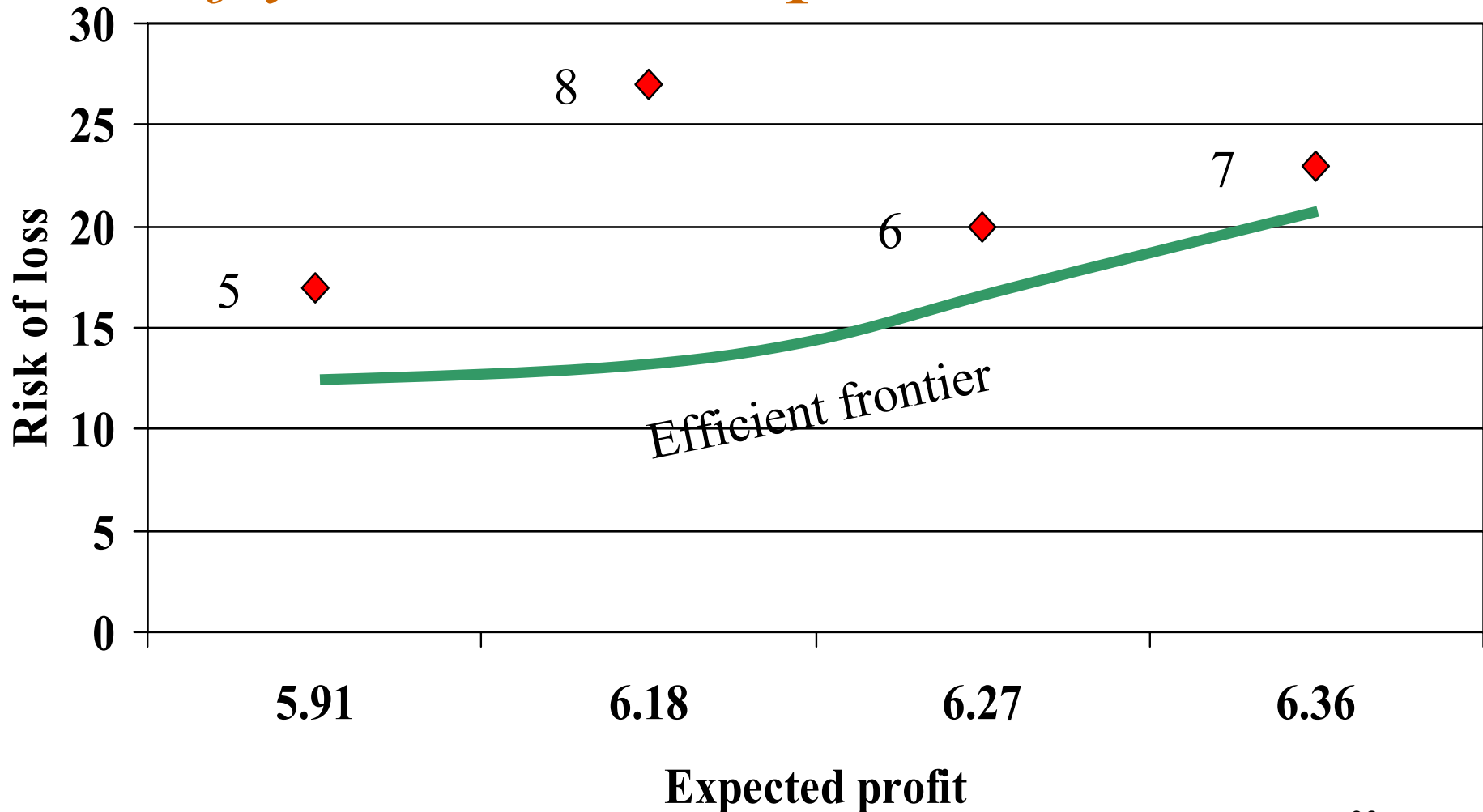


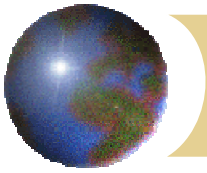
What if you had multiple warehouses?





What if you had multiple warehouses?





Correlations among projects

⊕ Negative correlations

- (When one goes up, the other goes down.)

⊞ are preferable to

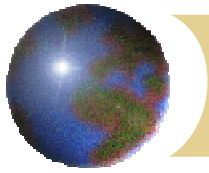
⊕ Zero correlations

- (All inputs are independent of each other.)

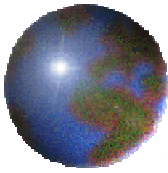
⊞ which are preferable to

⊕ Positive correlations

- (All move in the same direction.)



Welcome to Portfolio Optimization!



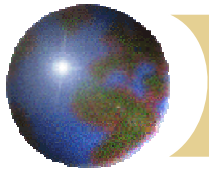
See:

“Holistic vs. Hole-istic E&P Strategies,”
Journal of Petroleum Technology

By Ben Ball & Sam Savage

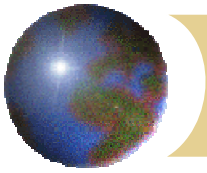
September 1999, pp. 74- 82

SPE Paper № 57701



Summary

- ✚ Avoid the flaw of averages
- ✚ Use input independent variables as distributions, not averages.
- ✚ Use the same distributions for each independent variable in all applications.
 - ✚ I.e., Manage your “distribution of distributions.”
(Thanks again to Sam)
- ✚ The answer is not “a number,” but a distribution.
- ✚ Make decisions using risk/return trade-off.
- ✚ Seek negatively correlated projects.
- ✚ Optimize your portfolio of projects for maximum return at minimum risk.



Ben Ball
President, Ball & Associates
10 Rainford Court
Sugar Land, TX 77479-2909
Phone 281/494-0396
Fax 281/494-0517
E-mail benball@alum.mit.edu
Website www.benball.com