ABCD

Guntram Deichsel, Biberach an der Riss

Senn's Game Theoretic Approach to Project Prioritization in the Pharmaceutical Industry

Gambling: Toss three coins - 2 games
A: 3 at once - B: one after the other, stop option

ABCD

Win if three tails turn up	Game A: pay total stake first	Game B: pay stake stepwise
Stake	3	1+1+1 = 3
A priori probability of success	$(1/2)^3 = 1/8$	$(1/2)^3 = 1/8$
Reward	25	20
Net reward if successful	22	17

Which game is the more attractive one?

Game tree - 3 coins, accounts over time

ABCD

Calculating
expected final account

A	B
22/8	17/8
-21/8	-1/2
	-2/4
	-3/8
1/8	**6/8**

Decision analysis

ABCD

Expected reward:
game A: 25/8
game B: 20/8

Expected costs:
game A: 3 = 24/8
game B: 1/2 + 2/4 + 3/4 = 14/8

Expected net reward:
game A: 25/8 - 24/8 = 1/8
game B: 20/8 - 14/8 = 6/8 - **sixfold!!**

Pearson Index: cost & probability architecture

ABCD

Expected reward:

game A: 25/8

game B: 20/8

Expected cost:

game A: 3

game B: 1/2 + 2/4 + 3/4 = 14/8

Pearson Index:

(E(reward) - E(cost)) / E(cost)

Game A: (25/8 -3) / 3, Game B: (20 - 14) / 14

= 0.042 = 0.429

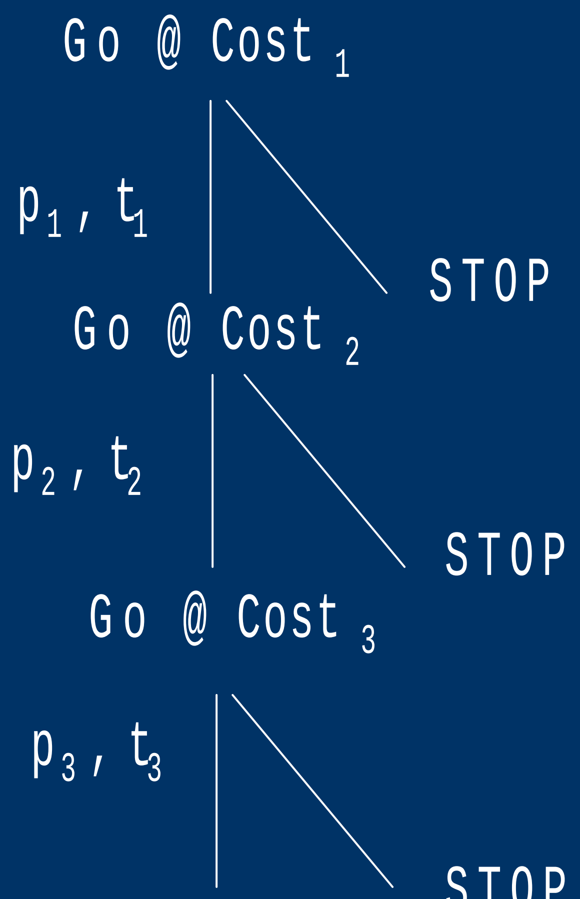
ABCD

Four hypothetical development projects

Stage	A	B	C	D
	--------Project--------			
1: cost | P(success)	3 | 0.8	3 | 0.4	1 | 0.8	1 | 0.4
2: cost | P(success)	2 | 0.6	2 | 0.6	2 | 0.6	2 | 0.6
3: cost | P(success)	1 | 0.4	1 | 0.8	3 | 0.4	3 | 0.8
Total cost	6	6	6	6
overall P(success)	0.192	0.192	0.192	0.192
Reward if successful	28	28	28	28
Expected costs	5.08	4.04	4.04	2.52
Expected reward	5.376	5.376	5.376	5.376
Expected net reward	0.296	1.336	1.336	2.856
Pearson Index	0.058	0.331	0.331	1.133

True 3-stage project - costs & reward to be time discounted!

ABCD



Success - Reward

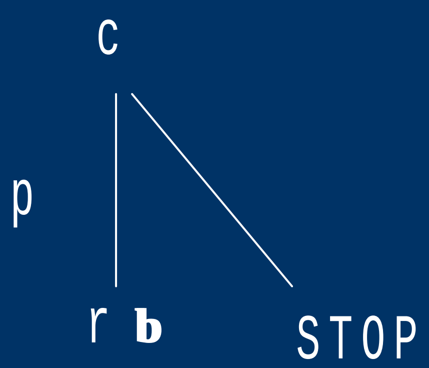
N.B. net present value!

A model for a 1-stage and a 2-stage project

ABCD

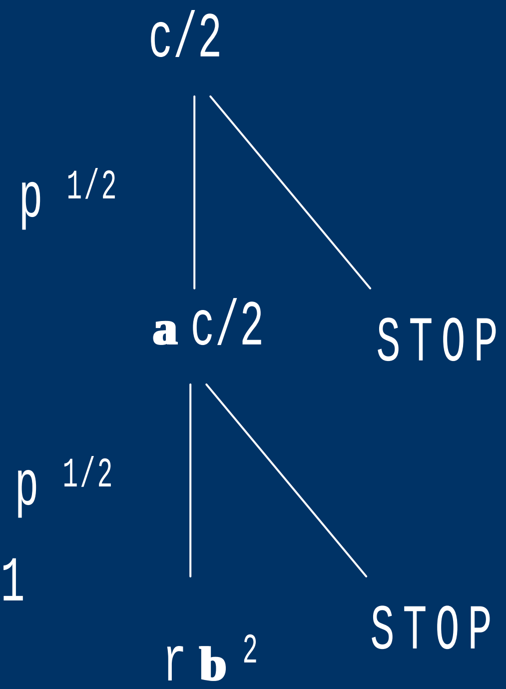
t year per stage, equal P(success) & cost per stage,

α = exp(-a t) - cost, β = exp(-b t) reward discount factor



$E(r) = pr\beta$

$E(c) = c$



$E(c) = c/2 + p^{1/2}\alpha c/2$

$E(r) = pr\beta^2$

Pearson Index $D_n = E(r)/E(c) - 1$

With (realistic) t=2, p=0.1

c=1, r=15, a=0.06, b=0.09

$D_1 = 0.253$

$D_2 = 0.634$

Time "penalties" in an n-stage project - reflected in the Pearson Index

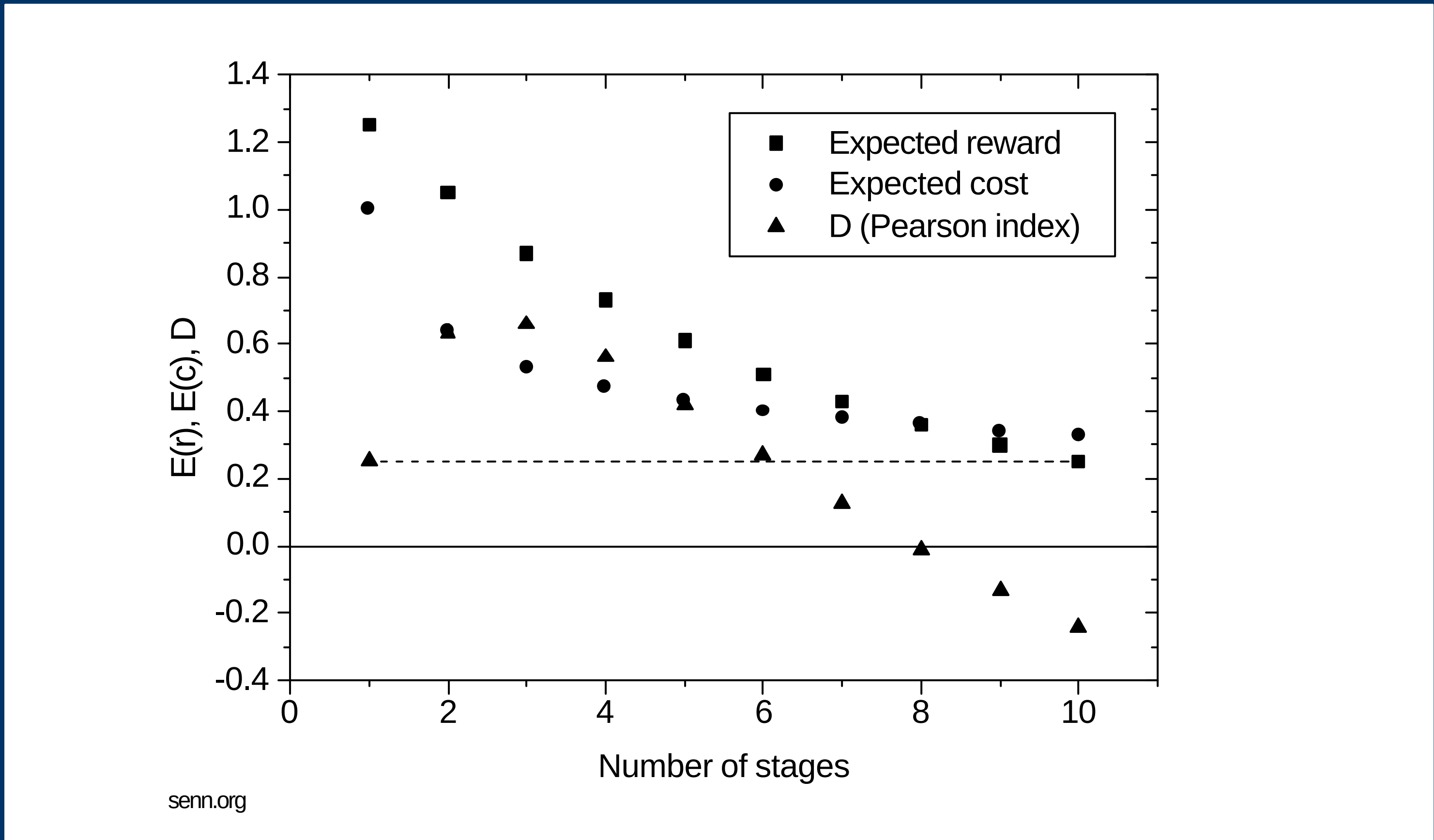
$$D_n = pr\,\beta^n / \left[(c/n)\,(1 - \alpha^n p) / (1 - \alpha\, p^{1/n}) \right] - 1$$

(cost term gained via geometric series summation formula)

Stages	Expected reward	cost	D (P.I.)
1	1.25	1.00	0.2529
2	1.05	0.64	0.6346
3	0.87	0.53	0.6585
4	0.73	0.47	0.5605
5	0.61	0.43	0.4209
6	0.51	0.40	0.2714
7	0.43	0.38	0.1259
8	0.36	0.36	-0.0099
9	0.30	0.34	-0.1336
10	0.25	0.33	-0.2446

Faster is not always better

ABCD



Regulatory hurdles can be in sponsor's interest

Statisticians: "What - more work?"

ABCD

Cf. **Put Option** - sell stocks @ purchase price in case of falling value.

Pearson Index: captures *a priori* the value of such an option.

This value is to be made available to
R&D portfolio managers for planning considerations.

Conclusion:
Statisticians can add value to strategic R&D planning
by "speaking the language of managers".

Suggested readings

ABCD

Senn S (1996): Some Statistical Issues in Project Prioritization in the Pharmaceutical Industry. Statistics in Medicine **15:** 2689-2702
(source of this presentation)

Bergman S, Gittins J (1985): Statistical Method for Pharmaceutical Research Planning.
New York (Dekker)

Enas GG, Andersen JS (2001): Enhancing the value delivered by the statistician throughout drug discovery and development: putting statistical science into regulated pharmaceutical innovation. Statistics in Medicine **20:** 2697-2708