Decision analysis for the very long run: optimization vs. scenarios

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Economic issues for natural resource and environment policies

Outline

- 1. Knowledge and ignorance
- 2. Standard expected utility maximization
- 3. The art of scenario making

1. Dimensions of ignorance

- Error
  - Probability (risk)
  - Imprecision (uncertainty)
  - Incompleteness (unknown unknowns)
- Human dimensions
  - Psychologic and social
  - Strategic

1.1 Degrees of error

- The probabilistic model starts with an exhaustive partition of the future into mutually exclusive states, and assign each state a specific weight
- Uncertainty: states are known, weights are imprecise
- Incompleteness: unknown unknowns

Ellsberg's urn

What is the probability of drawing a red ball from a box ?

We know the box contains:

- 3 colored balls
- 1 is yellow
- The other 2 are red or black

The probability is between 0 and 2/3.

A mental experiment

An investor accepted a risky project paying:

4 in the good case (probability p)

-4 in the bad case

Assume that this is a rational investor.

What do we know about *p* ?

Bets and information

$4\,p + (-4)\,(1-p) > 0$ that is $p > ½$

Market choices reveal the information of economic agents.

Application: finance, prediction markets

Imprecision

Intervalls of probability : $[p^-, p^+]$

- Ellsberg's urn
- Coherent bets (De Finetti)

- Belief/plausibility

Special cases [0, p^+] or [p^- , 1]

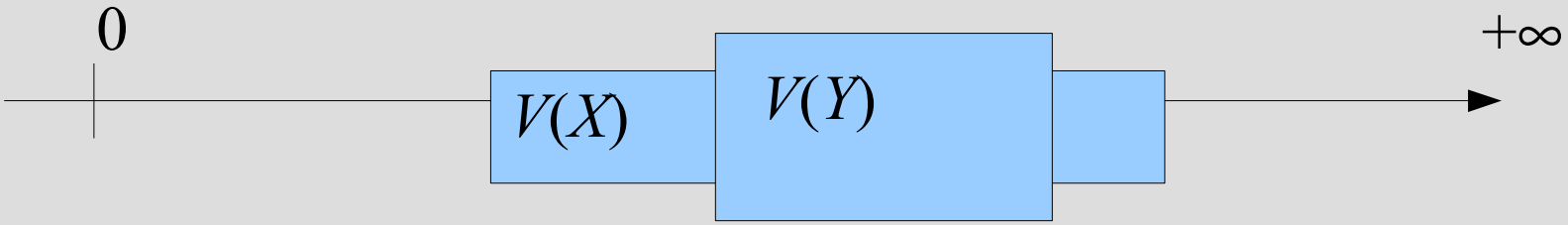
Plausibility level is 0.6 means that
p is lower than 0.6

Scenarios are plausible, not probable.

Imprecision and decision

Expected value is an intervall too

$$V(X)=[\underline{P}(X),\overline{P}(X)]$$



We may not always compare options

1.2 Human dimensions of ignorance

Error: missing information, a desire to get it right

i. Active ignorance

ii. Strategic

i. Active ignorance

Elements excluded from the discourse for psychologic or social reasons

- Surprises
- Metaphysics
- Taboos

Surprise

Unexpected event

Mismatch between a stimulus and pre-established knowledge networks

Surprise ≠ abrupt change

Scenarios can help !

Metaphysics

- Cannot be verified: Faith, values, belief systems
- Parameters of the decision model utility, risk and time preferences, equity

- Warnings
  - Diversity is a source of resilience
  - Dialogue has a role

Taboos

- What the members of a social group must not know or even question
- Essential to the identity of any group, IPCC too
- Plenty of opportunity for interference with Scientific Truth
- Fixes must come from outside

ii. Strategic Ignorance

- Conflicts
- Trust and et coordination

- Example:
  - Free riding
  - Information asymmetries

Conclusions of 1.

Under uncertainty,
use probability intervalls or bounds.

Maximize expected utility
when probabilities are precise

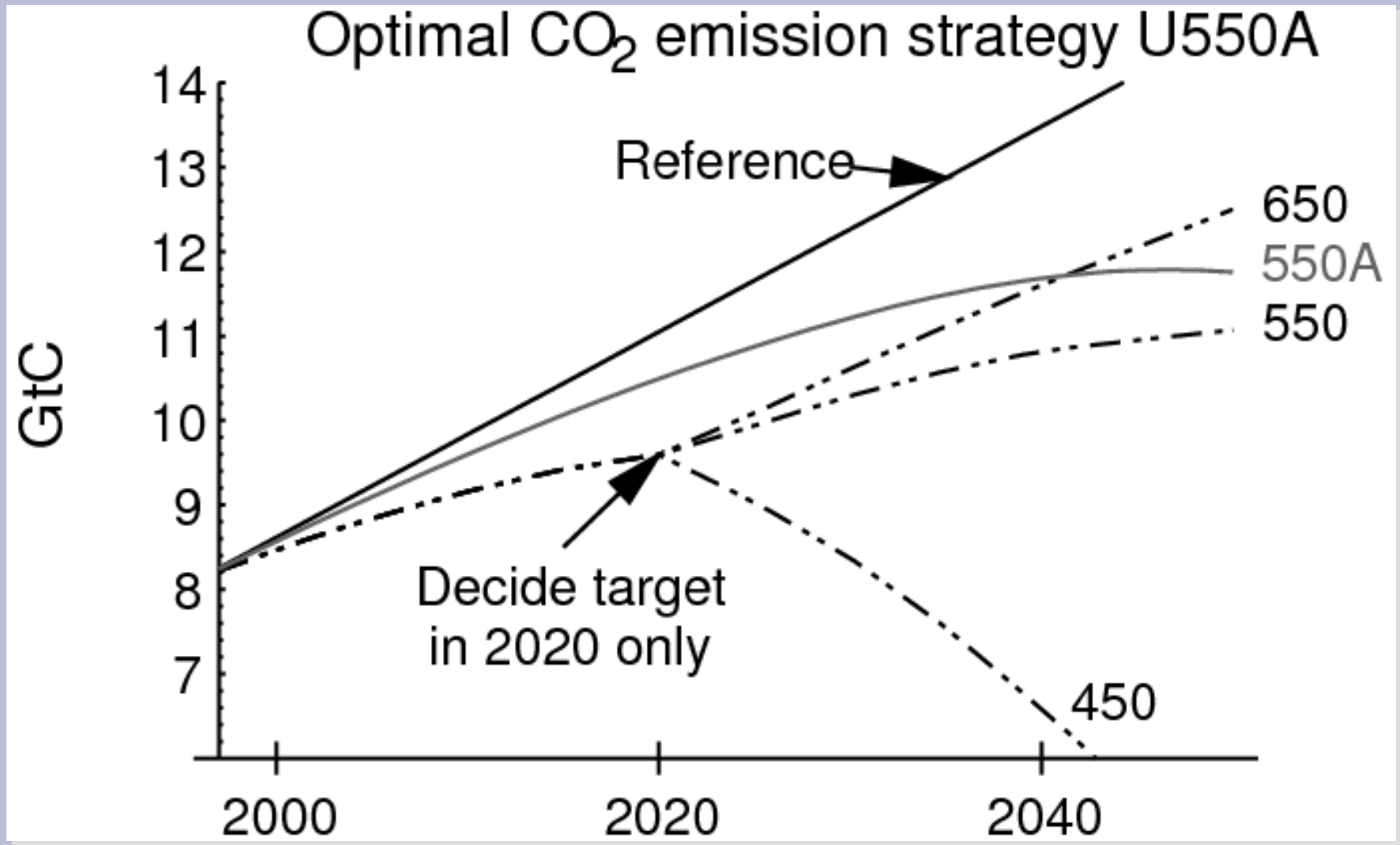
Scenarios are useful tools to analyze the human dimensions of ignorance.

2. Optimization under risk
Maximizing expected “utility”

A short course in decision theory:

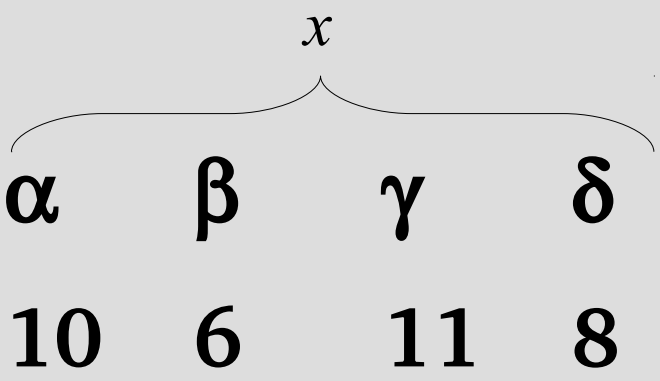
1. Decision criteria
2. Utility maximization
3. Information and option
4. Limits of the standard model

Introductory example
optimal climate policies



2.1 A toy decision problem
The ice cream truck

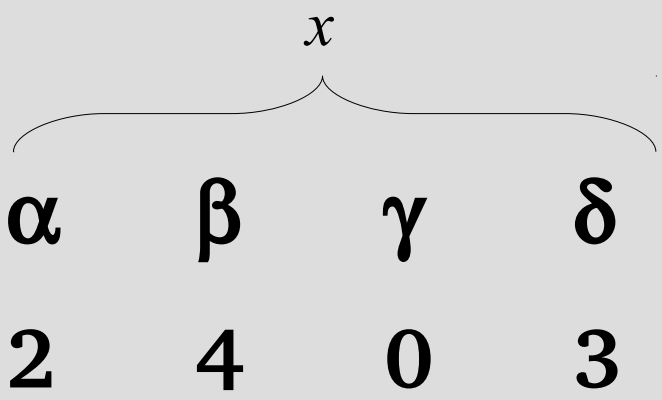
Make a decision x among 4 possible choices $\{\alpha, \beta, \gamma, \delta\}$, given that the profit $\Pi(x)$ is:



Profit $\Pi(s, x)$

2.1 A toy decision problem
The ice cream truck

Another one:



Profit $\Pi(s, x)$

Decide under uncertainty

Profit $\Pi(s, x)$ depends on the weather,

Weather will be Hot or Cold: s = H, C

	x			
	α	**β**	**γ**	**δ**
s=H	**10**	**6**	**11**	**8**
s=C	**2**	**4**	**0**	**3**

Profit $\Pi(s, x)$

Many behavioral rules

- Maximize expected gain
- Maximin (precaution)
- Maximax

Who decides the criteria?

Is there a criteria general enough to represent any “rational” decision maker ?

The Utility of wealth

Increasing

But at a slower rate as wealth increases

2.2 Standard decision model

- Monetary gain $\pi(s, x)$
- Alternative outcomes s with probability $p(s)$
- Utility function $u(\pi)$

Choose the decision *x* maximizing expected utility

$$\Pi^* = \max_x \sum_s p(s) u(\pi(s, x))$$

Pros and cons of the standard economic model

General enough: changing *u* allows to represent the various criteria.

Rationality garanteed

Separes *u*, *p*, and π.

But:

Observing parameters?

Adaptation and irreversibility?

2.3 Information and option

- Contingent strategy
- Information value
- Option value

The ice cream truck again

Expected gain, if we can adapt to s ?

x

	α	β	γ	δ
s=H	10	6	11	8
s=C	2	4	0	3

Profit $\Pi(s, x)$

Value of information

Expected gain of the contingent strategy:

$$\Pi^{\#} = \sum_{s} p(s) \left(\max_{x} u\left(\pi(s, x)\right) \right)$$

Expected value of information

$$EVPI = \Pi^{\#} - \Pi^{*}$$

The value of flexibility (avoiding irreversibility)

Assuming that information will be

- Perfect
- In time to adapt
- Free

Then we can define an option value

$$OV = \Pi^{\#} - \Pi^{*}$$

2.4 Limits of the standard model

- Long term benefits
- Probability is too simplistic
- Real life decisions are not rational

Discounting in the long term

1€ at future time t is worth

only $1/(1+r)^t$ € today

r discount rate

Future generations weighted shockingly low

Hyperbolic discounting

Degrees of ignorance

- The probabilistic model starts with an exhaustive partition of the future into mutually exclusive states, and assign each state a specific weight
- Uncertainty: states are known
- Incompleteness: unknown unknowns

Real decision making

- Rationality is a normative assumption, not a descriptive fact: habits, emotions !
- Society is not a single decision maker: confidence and strategic games

3. Decision with scenarios

1. What to expect from a scenario exercise?
2. A method
3. Using scenarios for action

3.1. Scenarios ≠ simulation

- Multidisciplinary, system-based (holistic)
- Long time (past, present, futurs).
- Uncertainties, tipping points, signposts

A short history of scenarios

- After the war (1950's) : 2 traditions.
  - Rand, SRI, … Delphi techniques and scenario methods for defense et security
  - «French school » : holistic and philosophic analysis (rapport DATAR).
- Popularized by the first oil shock :
  - Royal Dutch Shell & Pierre Wack.

Two kinds of exercises

Exploratory :

- Explore possible futures without limits.
- Look at tendencies, predetermined constants, uncertainties, tipping points, ...

Normative/strategic:

- Focus on choices to be made, the sensitivity of operational results to risks

Specifications ?

- Always : more than 1 or it’s a roadmap
- Simplicity: less than 5
- Exploratory: BAU/central scenario or not ?
- Normative: Wished or feared ?

Co-construction of the future

- « Ni prophétie ni prévision, la prospective n'a pas pour objet de prédire l'avenir – de nous le dévoiler comme s'il s'agissait d'une chose déjà faite – mais de nous aider à le construire. Elle nous invite donc à le considérer comme à faire, à bâtir, plutôt que comme quelque chose qui serait déjà décidé et dont il conviendrait seulement de percer le mystère ».

  Hugues de Jouvenel, « Invitation à la prospective », Futuribles Perspectives, 2004.

- Nous devons « considérer l'avenir non plus comme une chose déjà décidée et qui, petit à petit, se découvrirait à nous, mais comme une chose à faire ».

  Gaston Berger, « L'attitude prospective », Prospective, n°1, 1958.

3.2. Method

- Define problem and time horizon
- System analysis: choose key variables
- Actors
- Microscenarios
- Combination into coherent scenarios
- Dynamic modelisation
- Implications for choices

Problem and time horizon

- Horizon: far enough for structural changes
- Backcast time series at 2 x Horizon
- Literature survey
- Variable of interest

Key variables

- Influence the operational result of interest
- Small number
- Looked at in detail

- Example: Kaya identity

$$CO2 = POP * \frac{PIB}{POP} * \frac{ENE}{PIB} * \frac{CO2}{ENE}$$

Exercice

- What are the key drivers that organize the following set of IPCC climate change scenarios ?

SRES A storylines

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are **convergence** among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

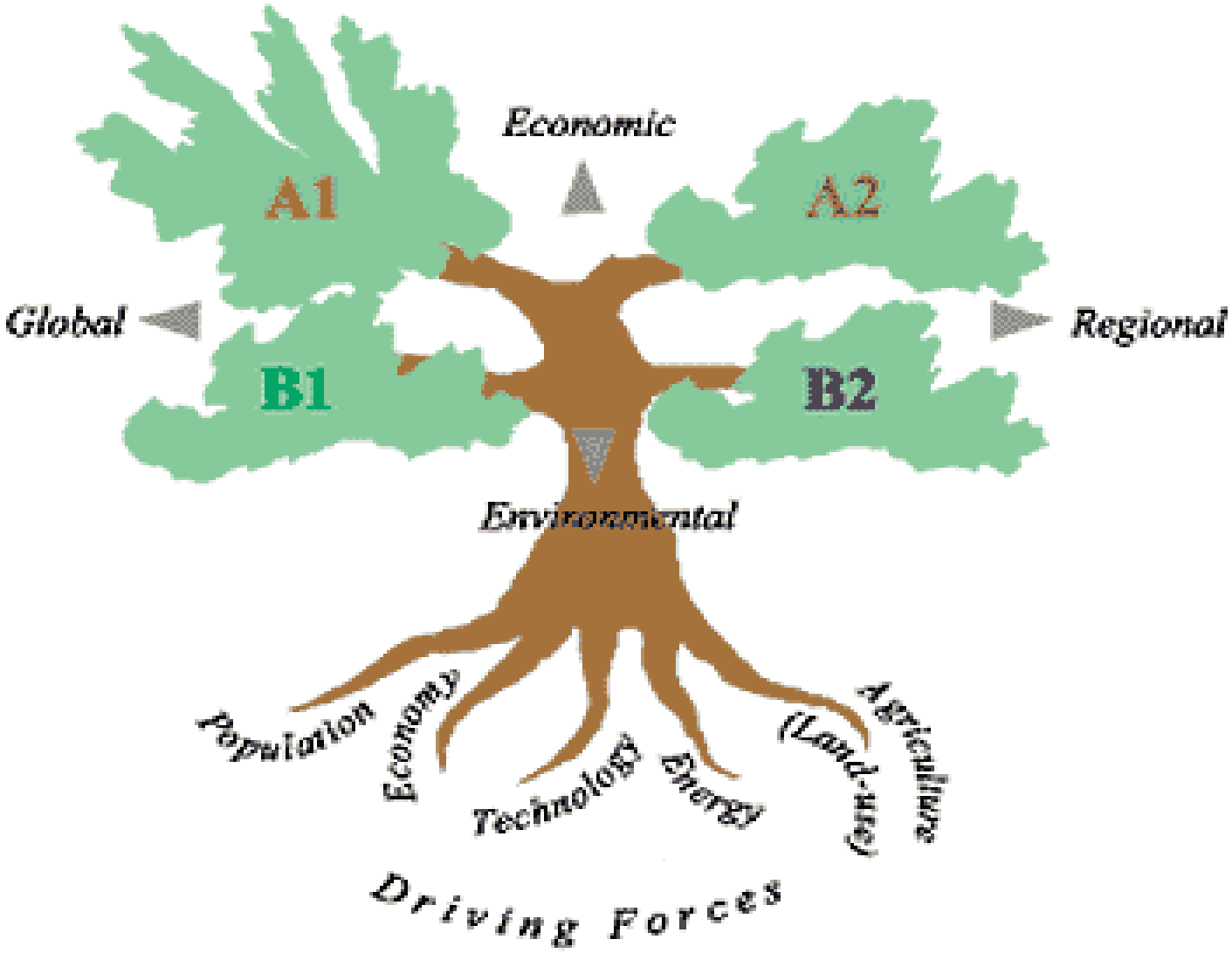
The A2 storyline and scenario family describes a very **heterogeneous** world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

SRES B storylines

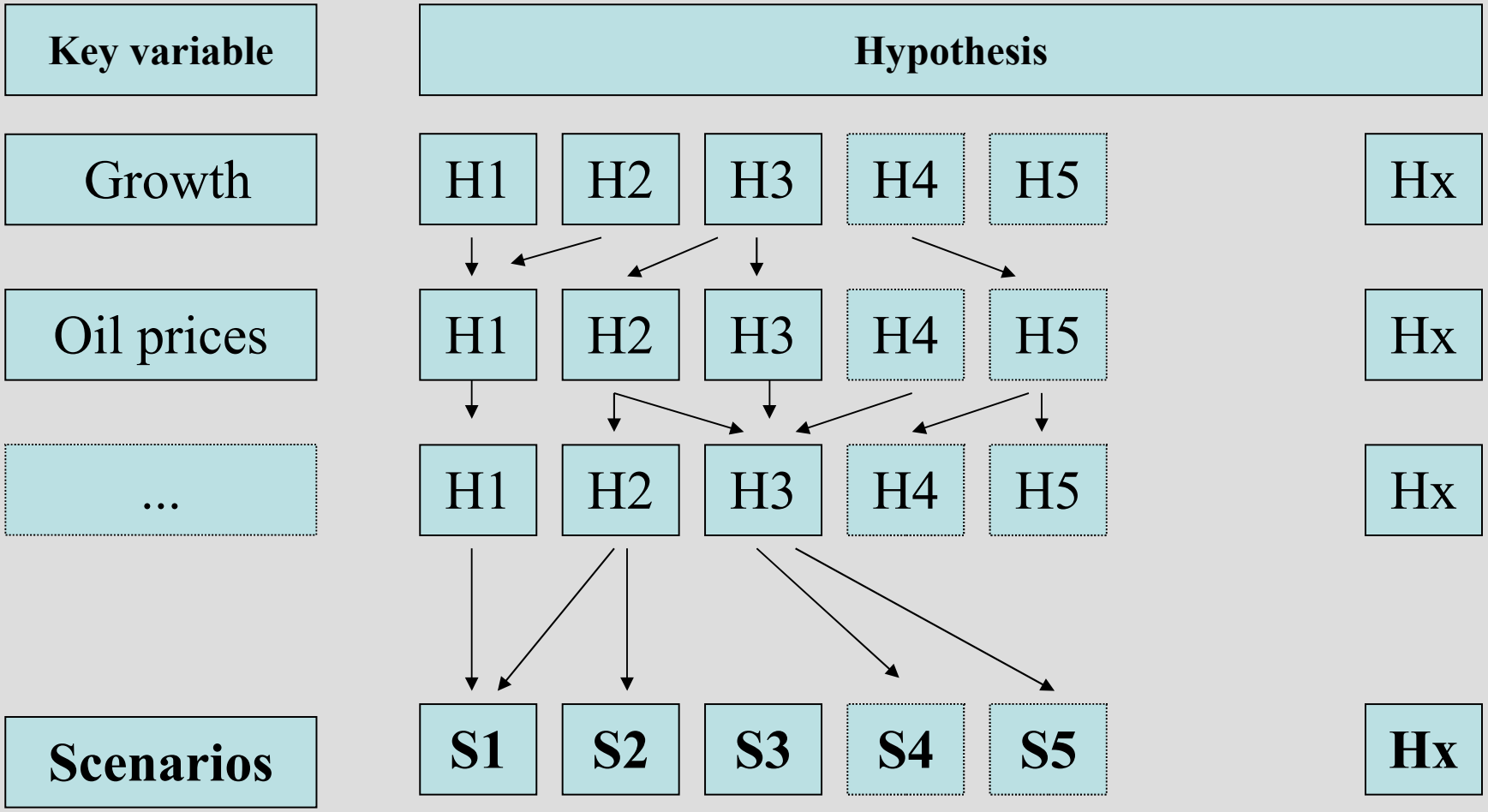
The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a **service and information economy**, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on **global** solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The B2 storyline and scenario family describes a world in which the emphasis is on **local** solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward **environmental protection and social equity**, it focuses on local and regional levels.

SRES Scenarios



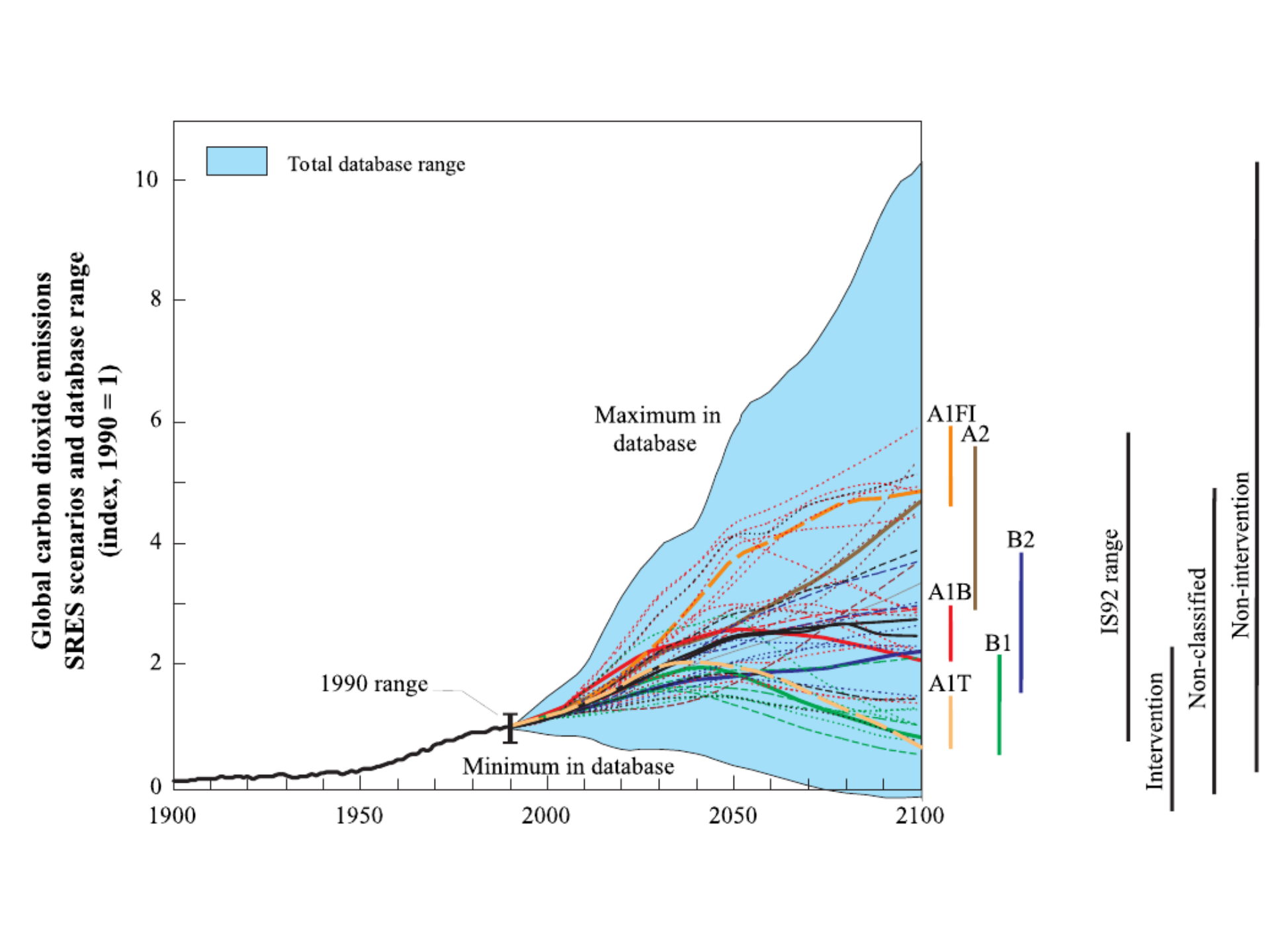
Combine microscenarios seeking coherence and plausibility



Models vs. scenarios

- Models
  - Cartesian division in subsystems
  - Quantitative, (falsely) precise
  - Convincing
  - Must be parametrized

- Scenarios
  - First a narrative
  - More vague (more right ?)
  - Can use models
  - Base + Trajectory + final image


Global carbon dioxide emissions
SRES scenarios and database range
(index, 1990 = 1)
Total database range
Maximum in database
1990 range
Minimum in database
A1FI
A2
B2
A1B
B1
A1T
IS92 range
Intervention
Non-classified
Non-intervention
0
2
4
6
8
10
1900
1950
2000
2050
2100

3.3 Scenarios and decision making

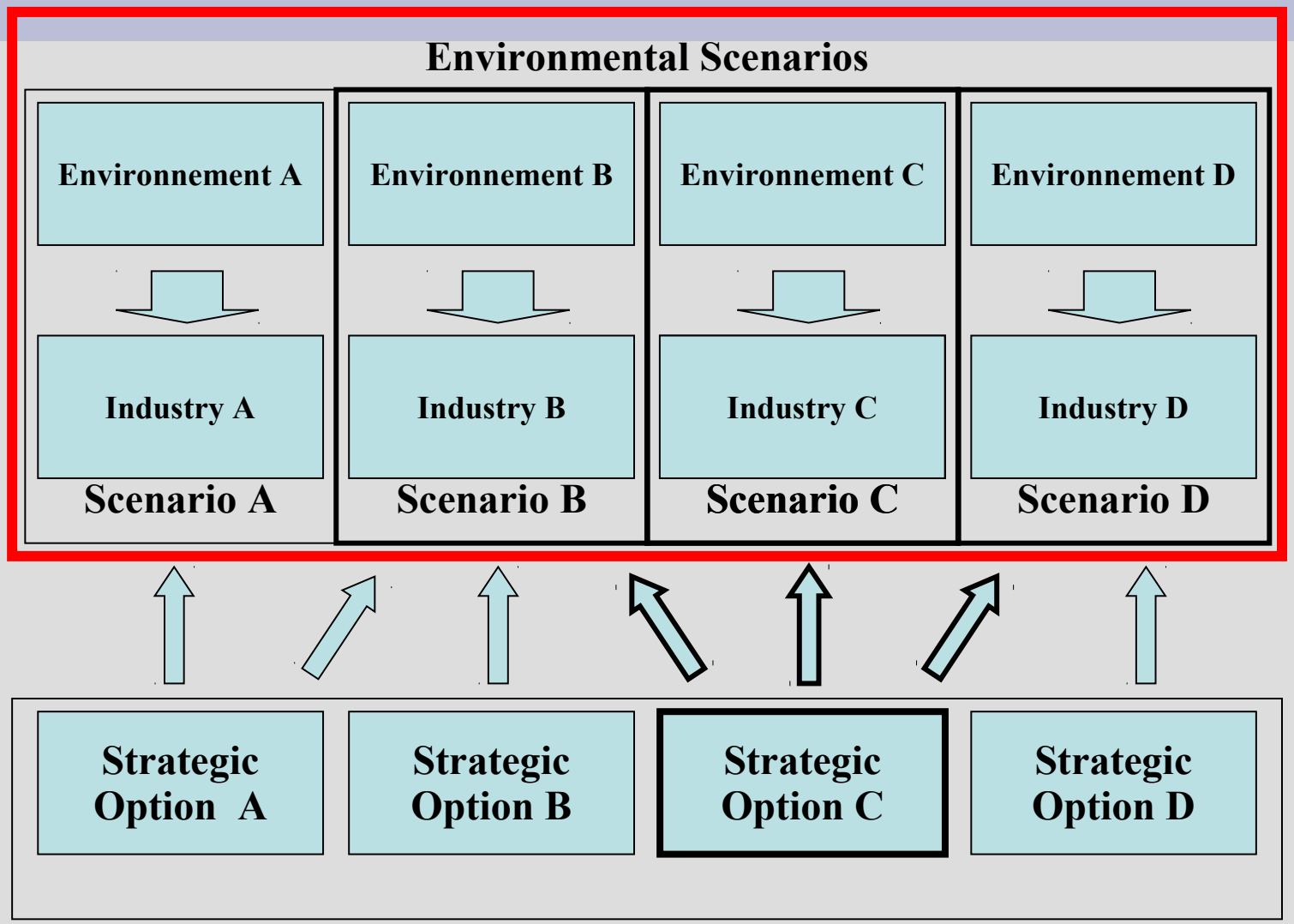
- Analysis tool for strategic decisions
- Provides a common langage
- Warn about possible surprises
- Increase sensitivity to early warnings

☠ Paralysis by analysis ☠

Necessary balance between:

- Reactivity and anticipation
- Strategic planning and execution

Prospective & Strategy



Conclusion

- « Scenarios are attempts to describe in some details a hypothetical sequence of events that could lead plausibly to the situation envisaged ».

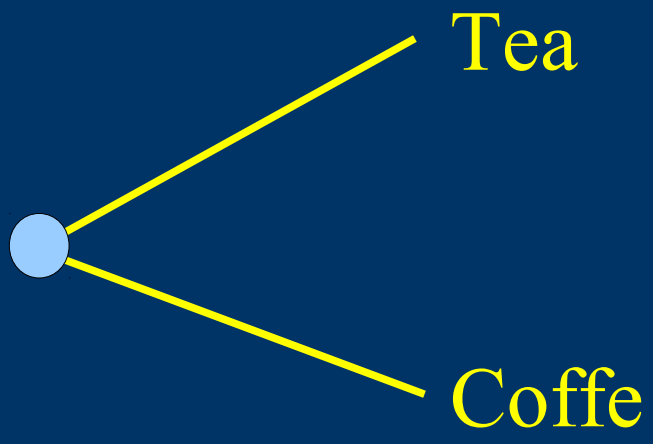
  Herman Kahn.

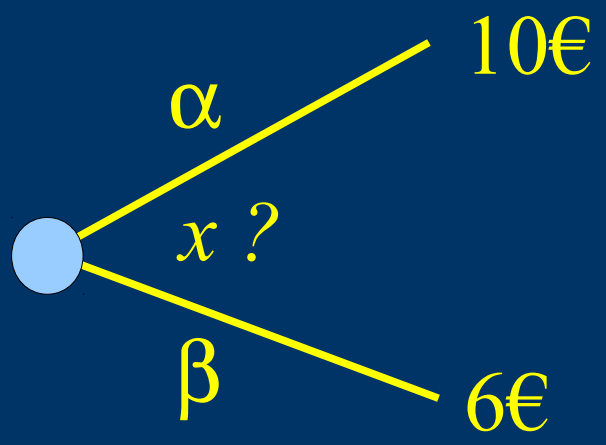
- « Scénarios are stories about the way the world might turn out tomorrow, stories that can help us recognize and adpat to changing aspects of our present environment ».

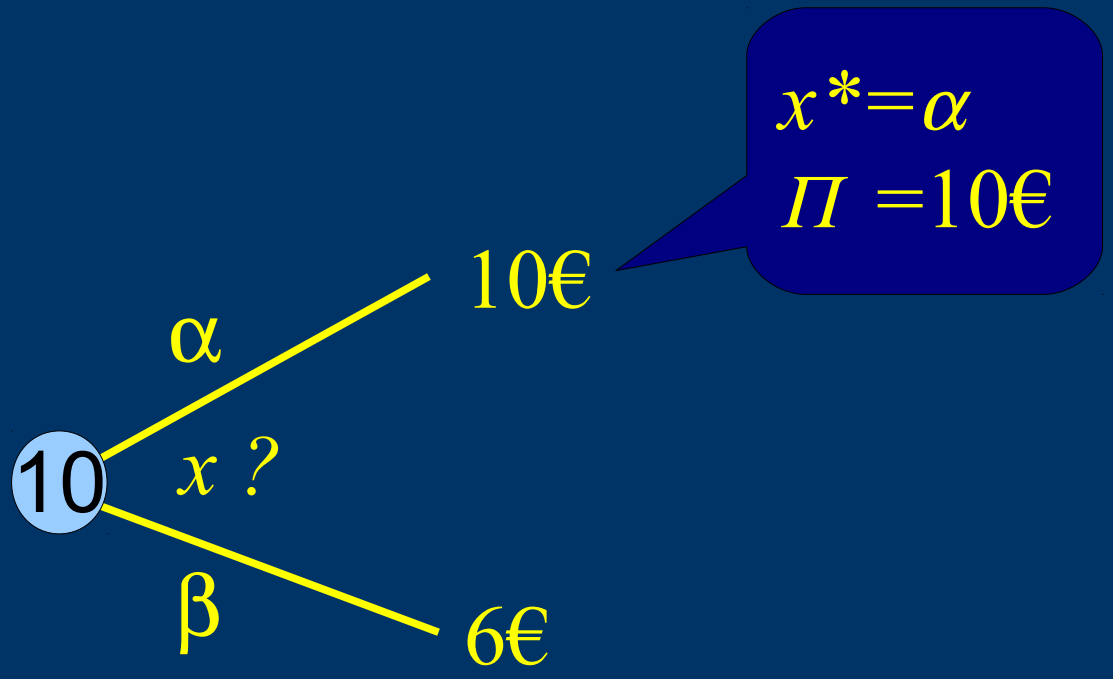
  Peter Schwartz.

Decision theory 101, in a different language

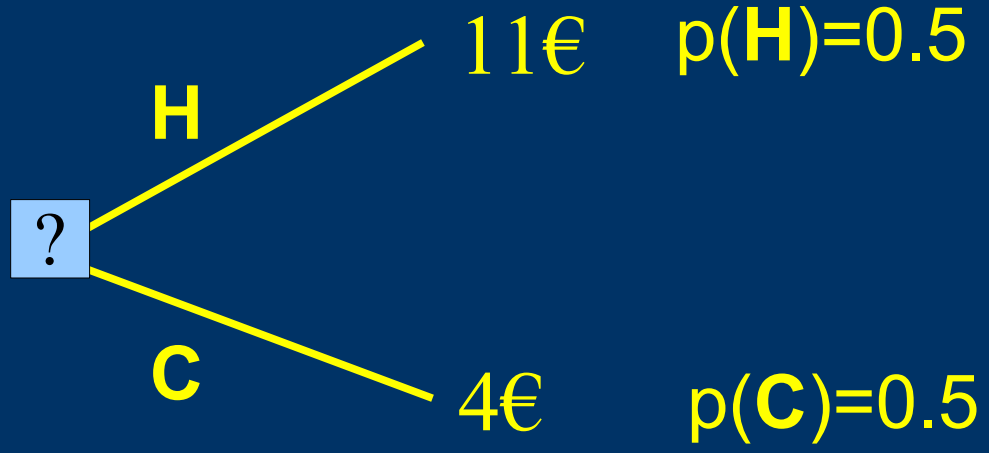
Decision


Tea
Coffe

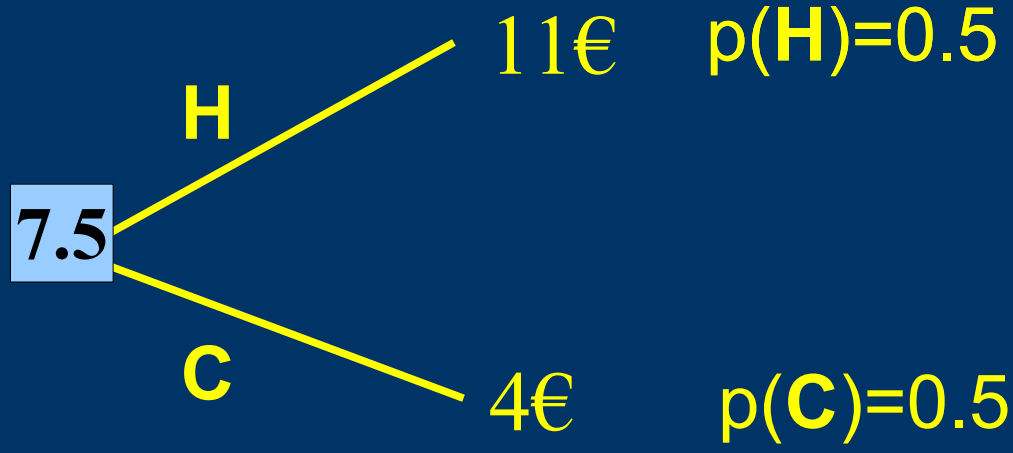

10€
α
x ?
β
6€


$x^*=\alpha$
Π =10€
10€
α
10
x ?
β
6€

Uncertainty

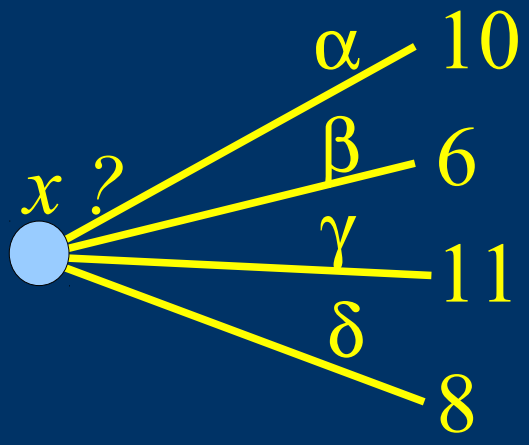

11€
p(H)=0.5
H
?
C
4€
p(C)=0.5

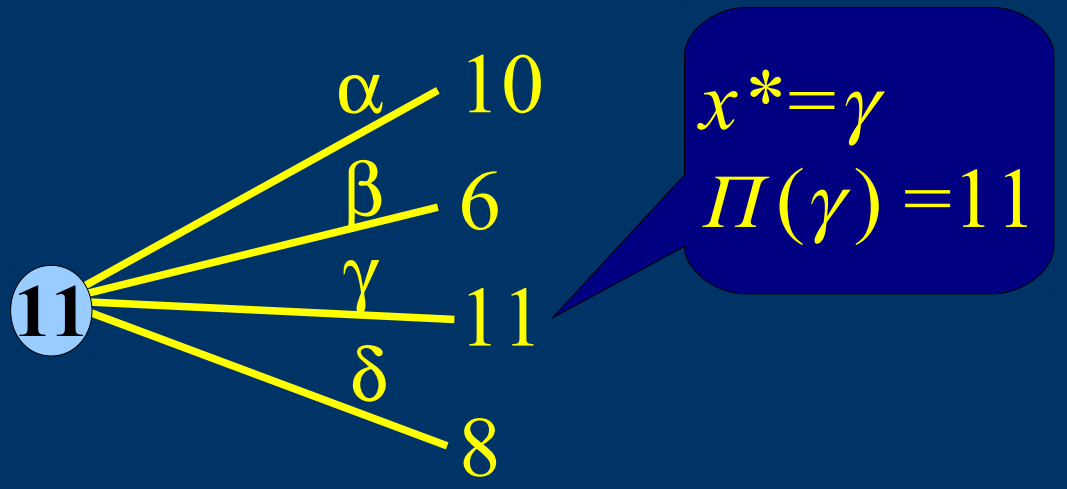
$0.5 * 11 + 0.5 * 4 = 7.5$

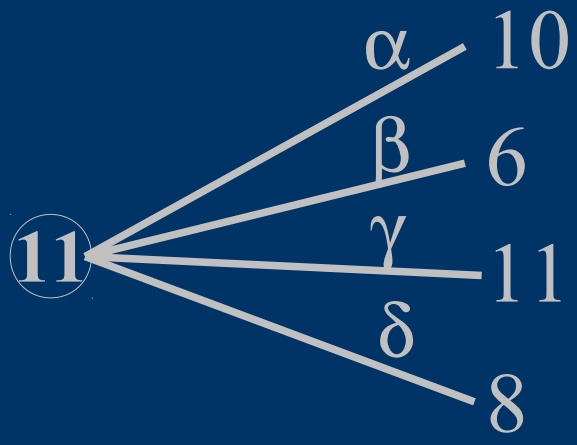


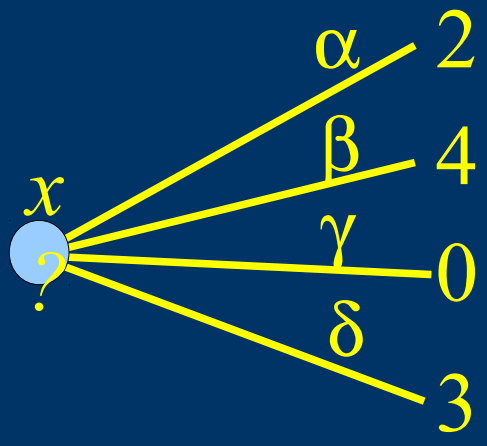
Decision node

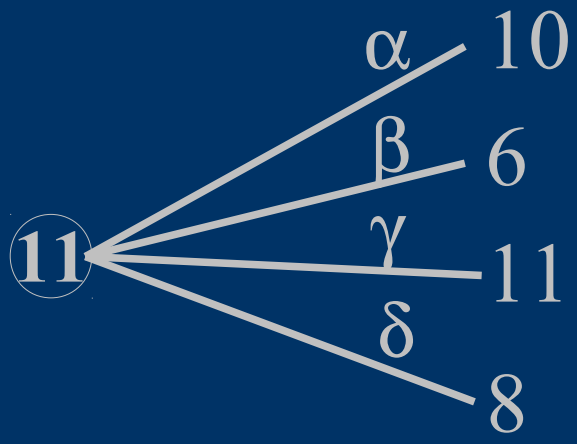
Chance node

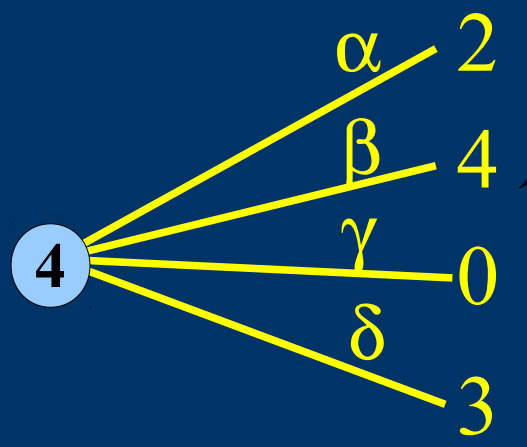

α
10
β
6
x ?
γ
11
δ
8


α
β
γ
δ
10
6
11
8
11
x*=γ
Π(γ) =11


α
β
γ
δ
10
6
11
8
11

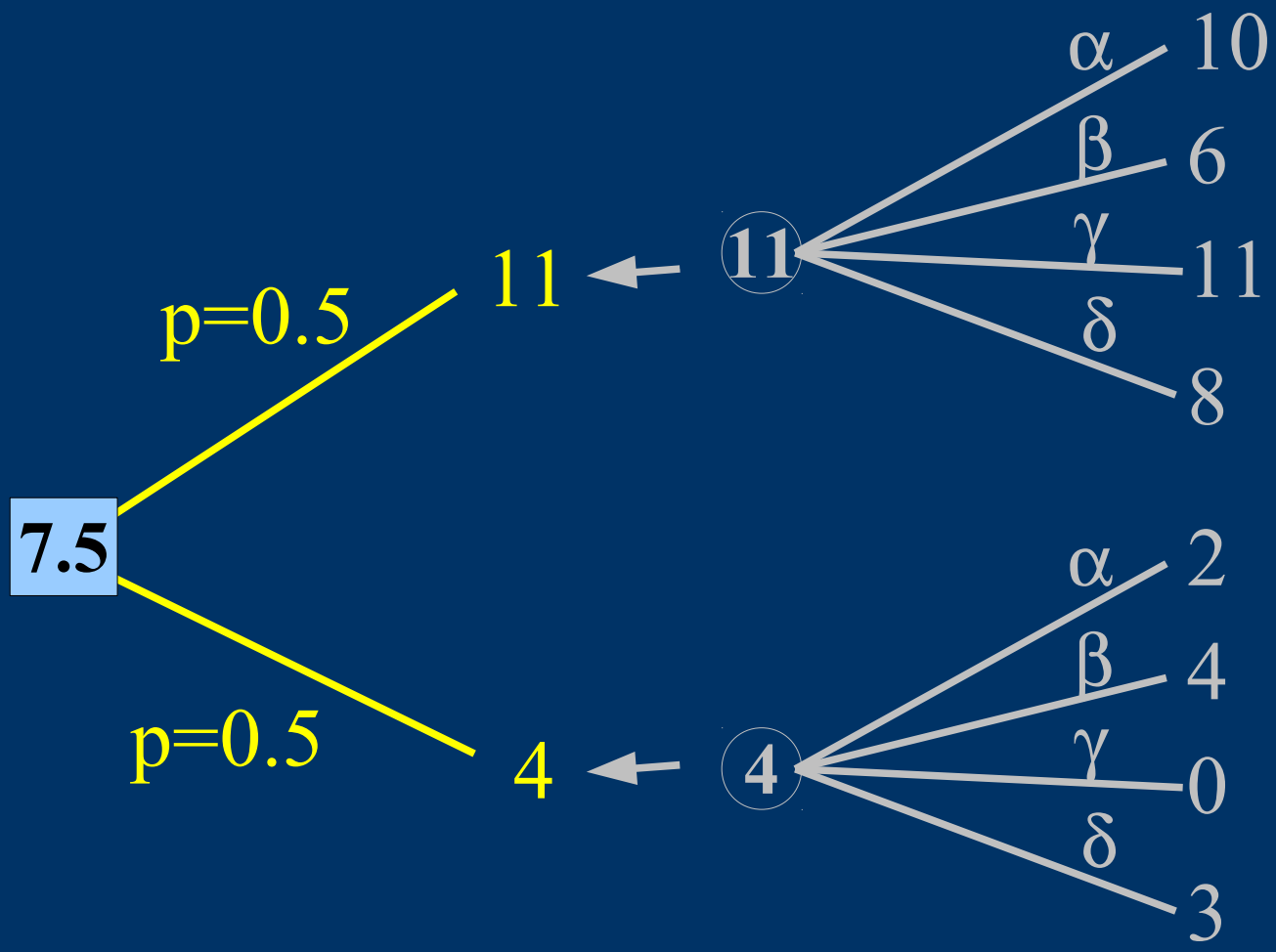

α
β
γ
δ
2
4
0
3
x
?

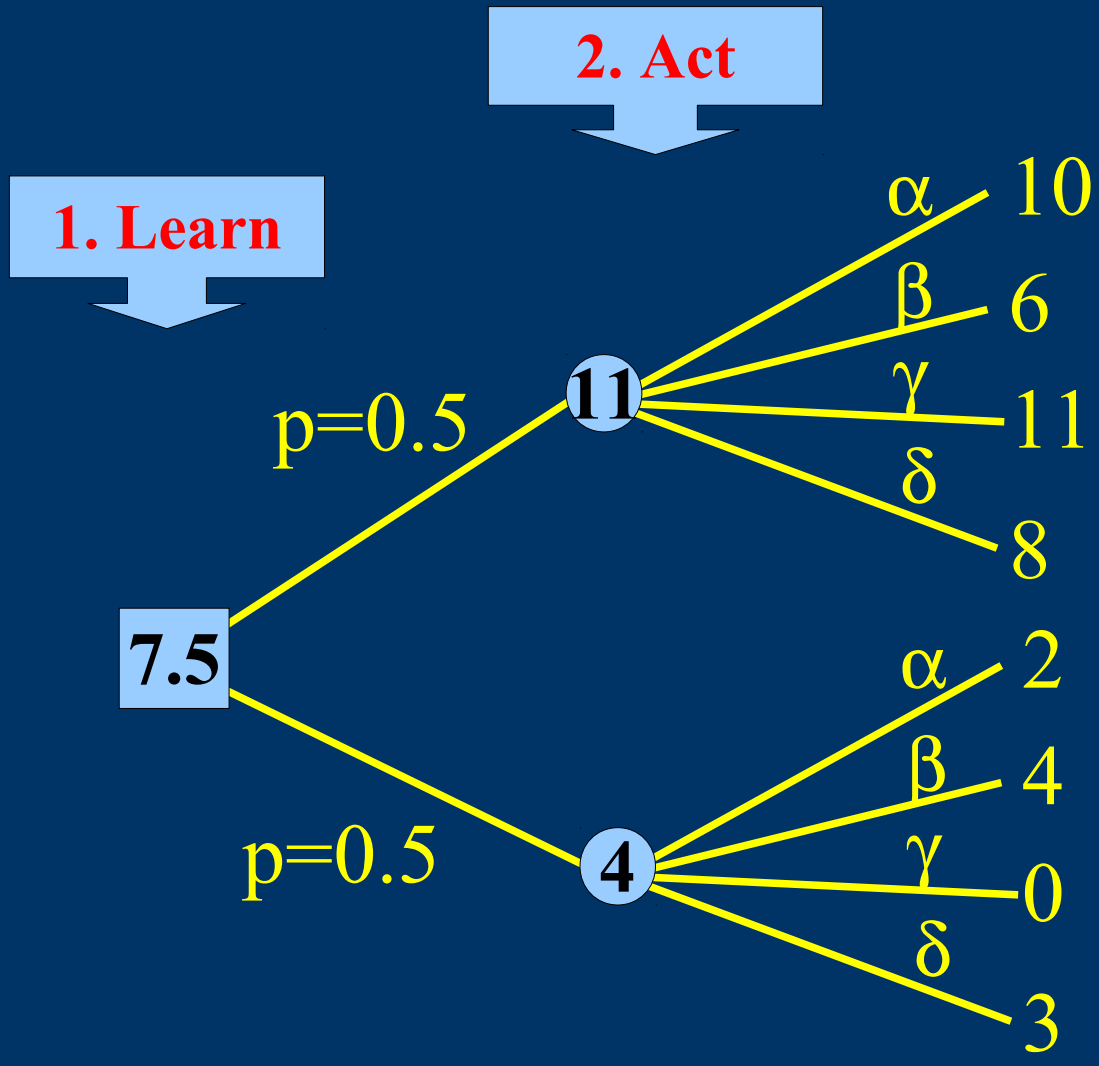


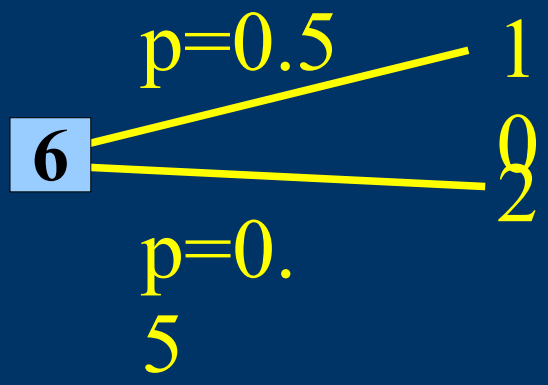


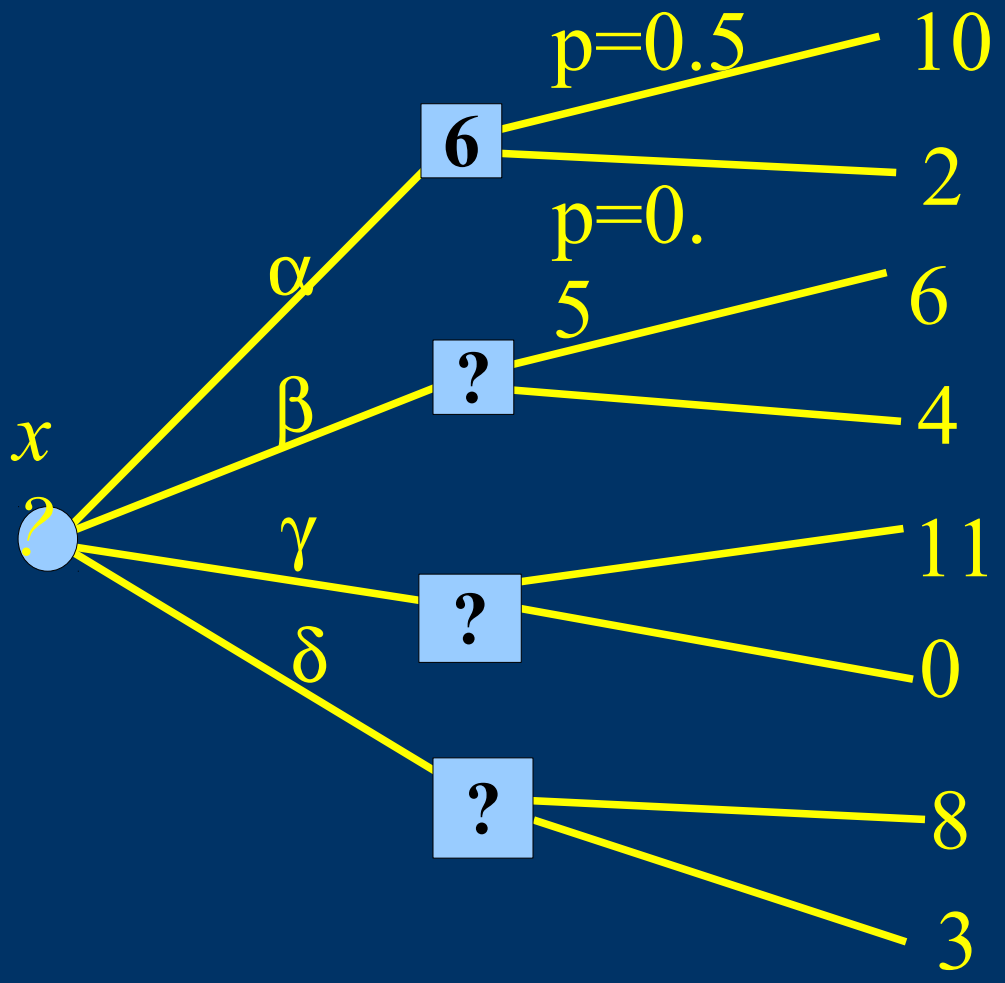
$x^* = \beta$

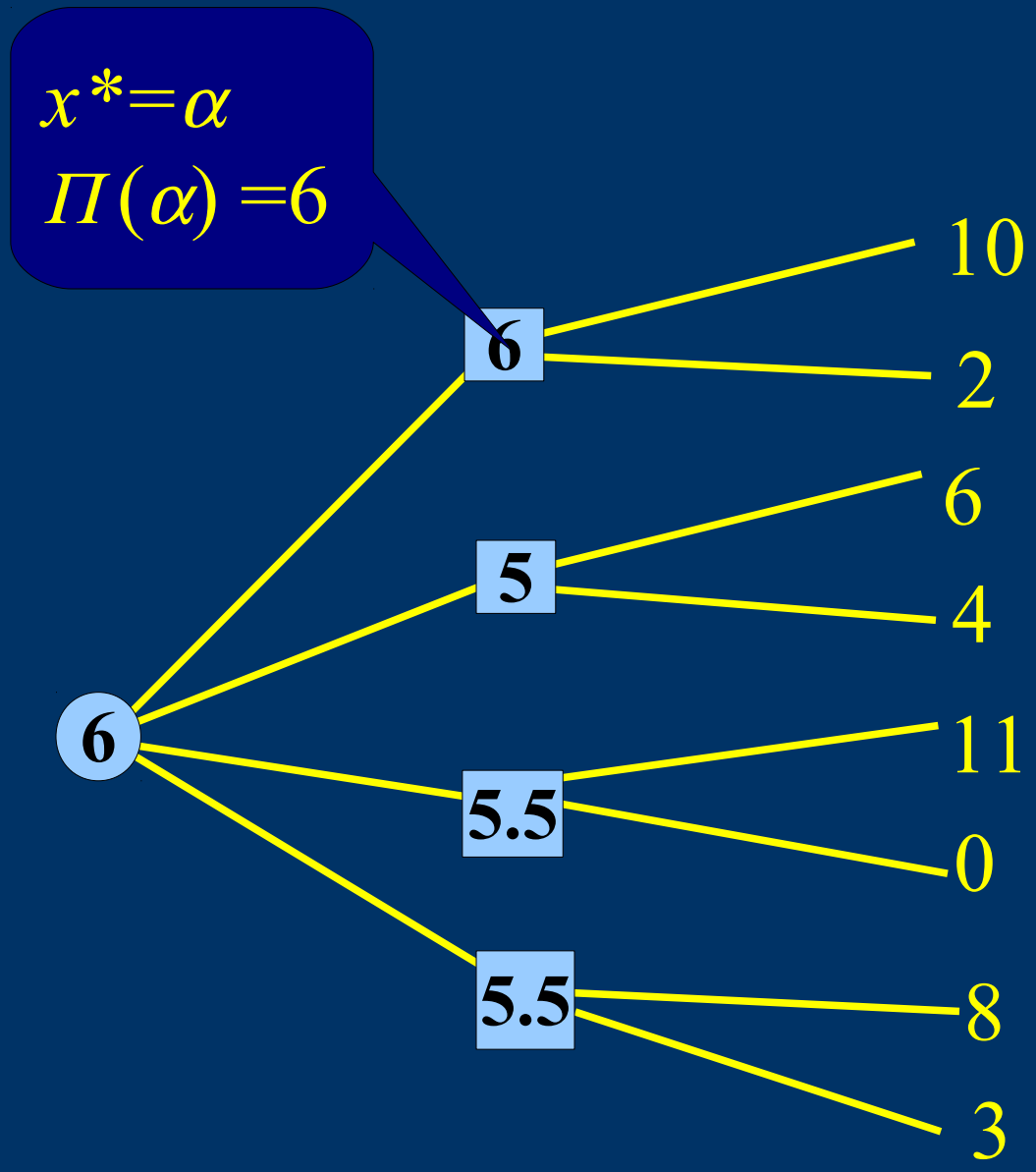
$\Pi(\beta) = 4$

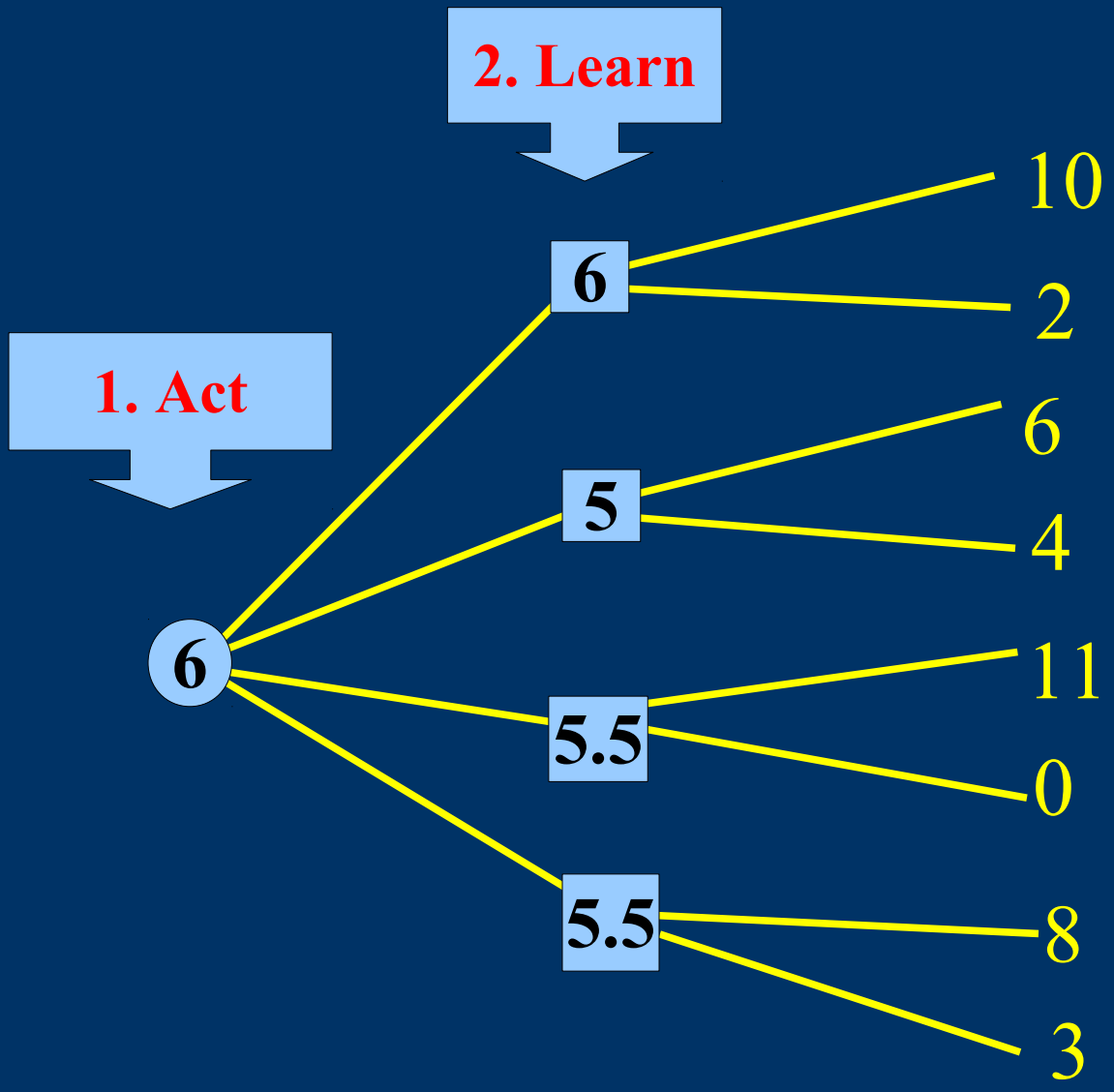

α
10
β
6
γ
11
δ
8
11
11
p=0.5
7.5
p=0.5
4
4
α
2
β
4
γ
0
δ
3


2. Act
1. Learn
α
β
γ
δ
10
6
11
8
11
p=0.5
7.5
p=0.5
4
α
β
γ
δ
2
4
0
3

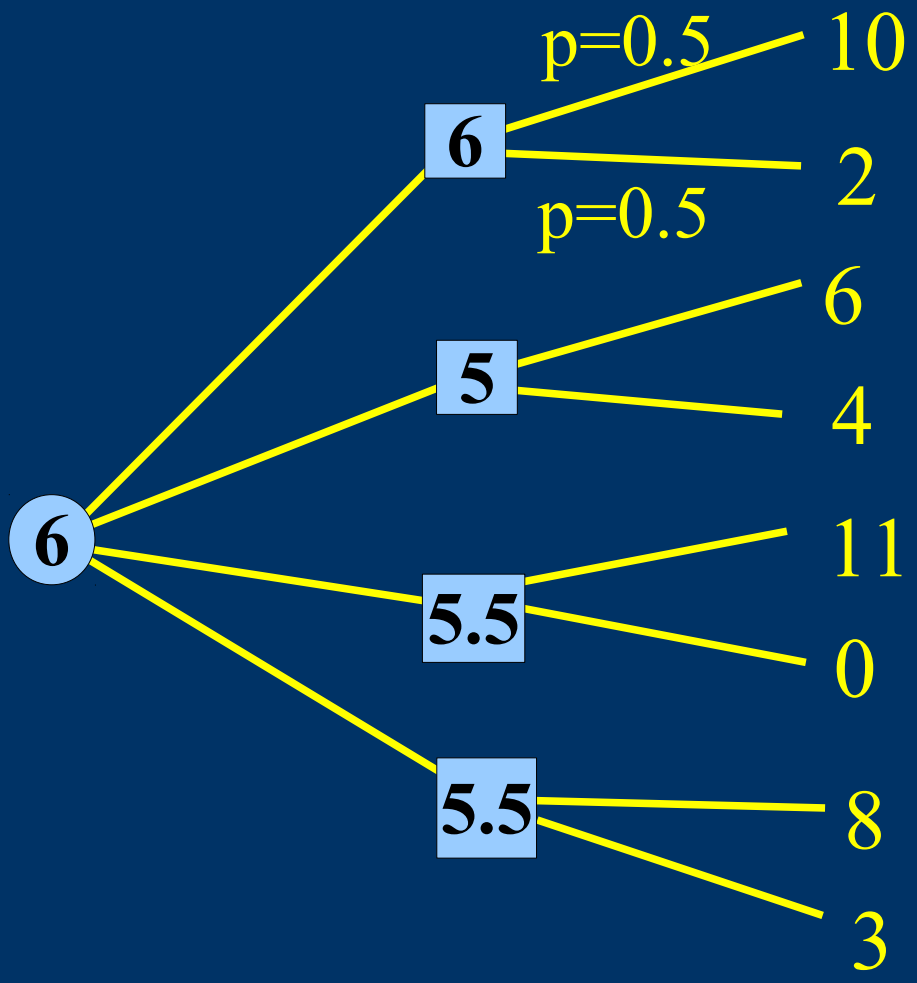

p=0.5
1
0
6
2
p=0.
5


p=0.5
10
6
2
p=0.
5
6
α
β
?
4
x
?
γ
11
?
δ
0
?
8
3

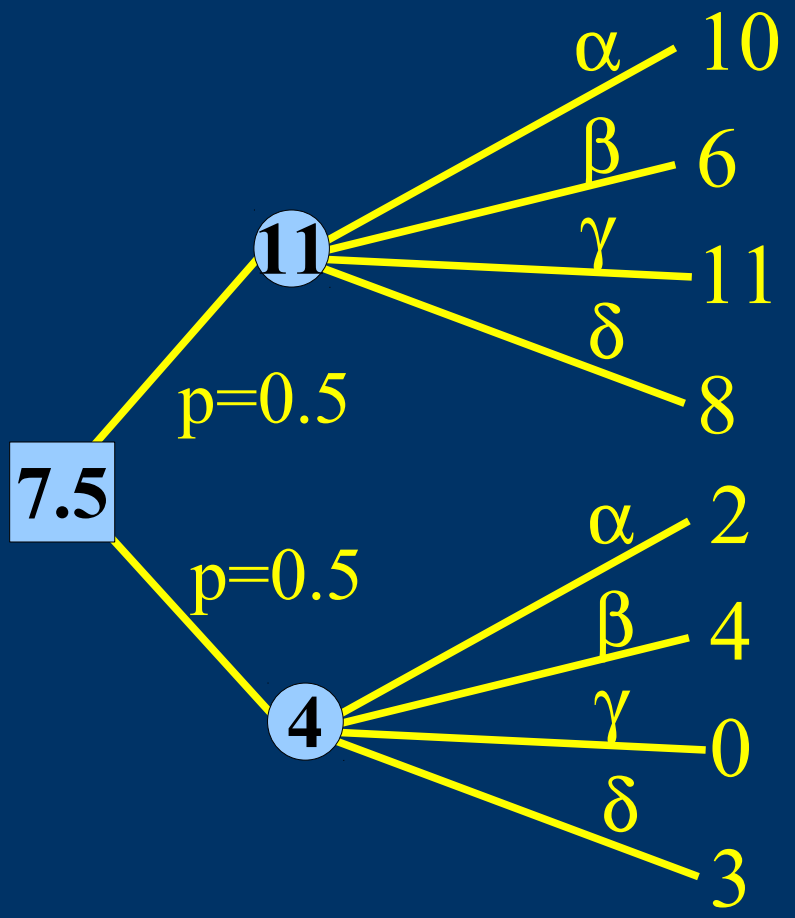

$x^*=\alpha$
$\Pi(\alpha)=6$
6
6
5
5.5
5.5
10
2
6
4
11
0
8
3


2. Learn
1. Act
6
6
5
5.5
5.5
10
2
6
4
11
0
8
3

Act then learn



Learn then act



Cám ơn !