Robust Decision Making Process under Scientific Uncertainty on Climate Change

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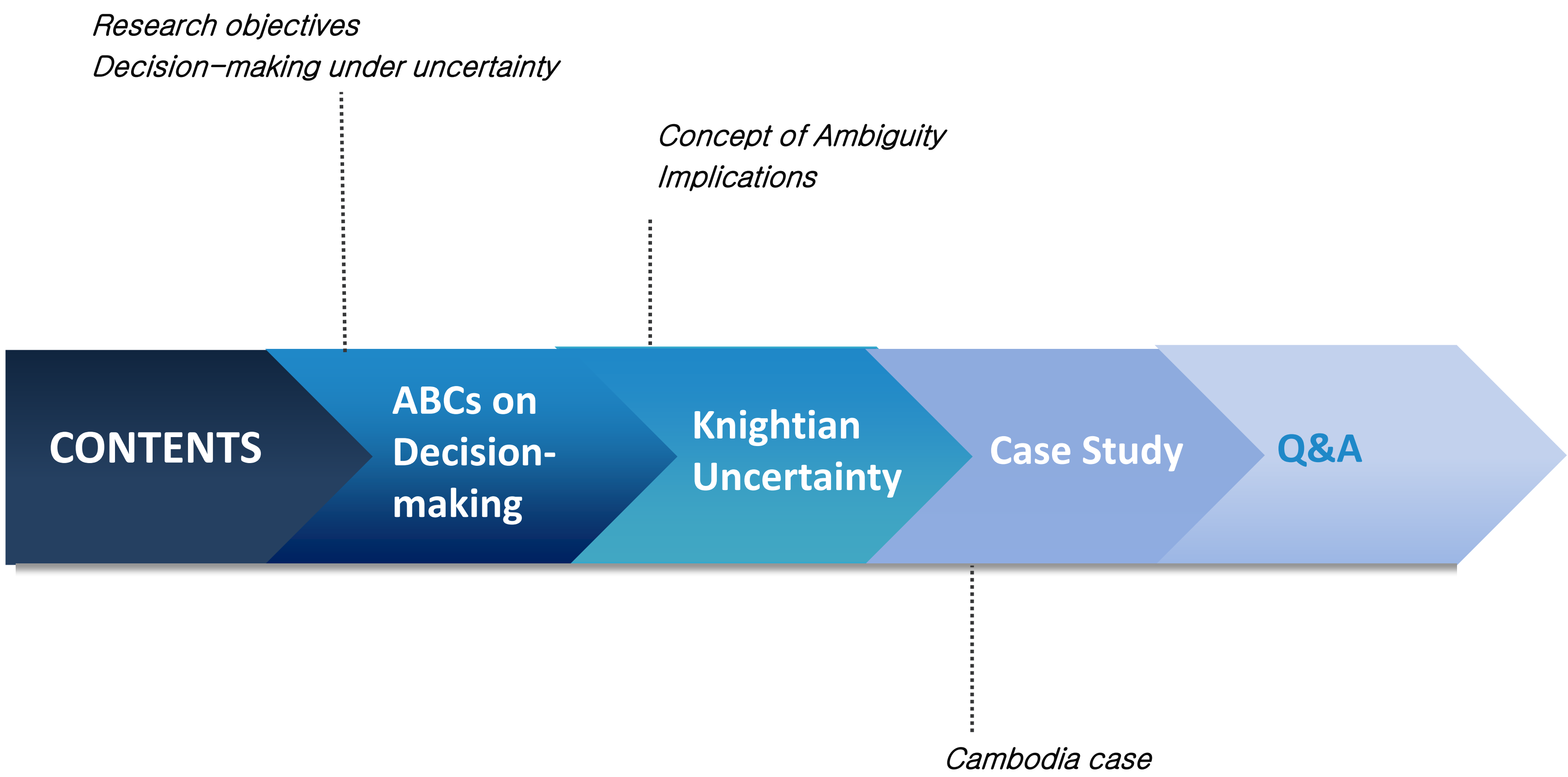

Research objectives
Decision-making under uncertainty
Concept of Ambiguity
Implications
CONTENTS
ABCs on Decision-making
Knightian Uncertainty
Case Study
Q&A
Cambodia case

ECO2NOMICS

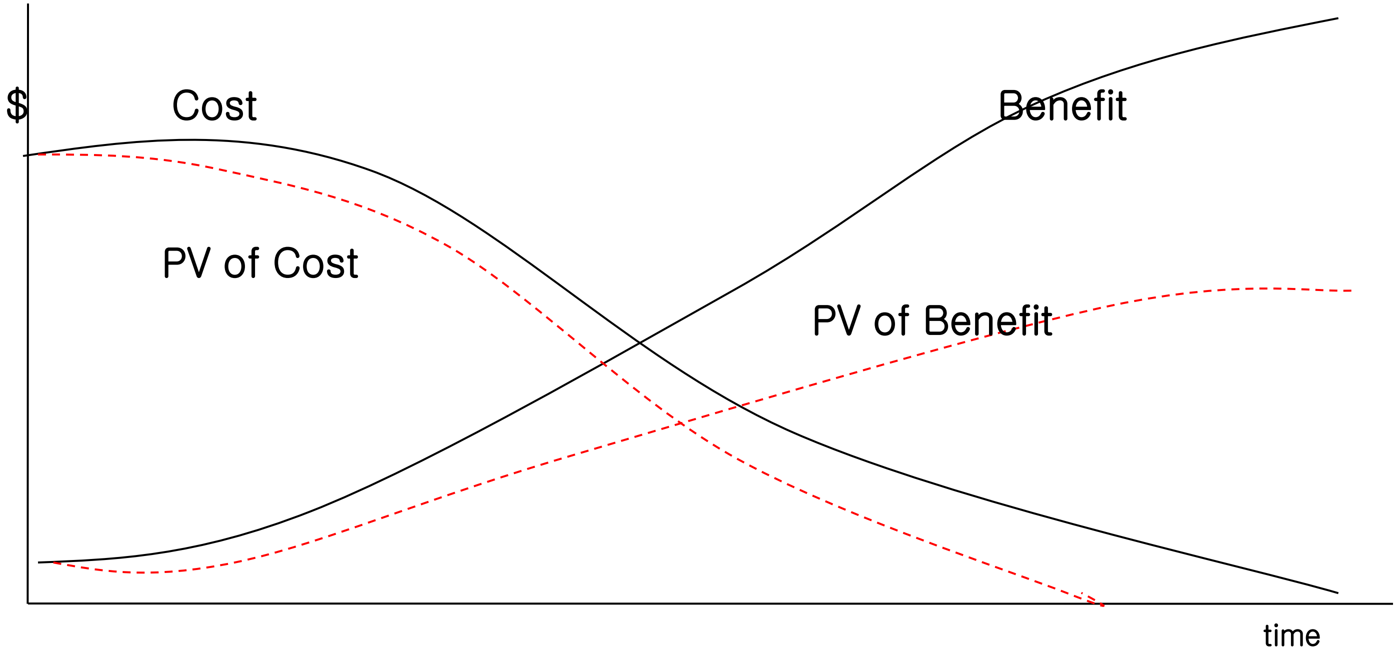
- Identification of problems
- Profiles of strategical policy
- Identification of benefits and costs
- Measuring benefits and costs
- Choice of future values
- Evaluation of uncertainty (and/or risk)
- Overall evalation

Benefit and Cost Analysis on Climate Change

- CO_2 abatement investment

Cost: investment cost of CO_2 abatement

Benefit: Forgone cost of environmental damage



heterogeneous perception in individual discount rate.

Is the world of "IN TIME" possible?

➔ Discount rates must be different across people with different life length.

Decision-making under Uncertainty

1st generation

NPV (Net Present Value) = Discounted Benefit – Discounted Cost > 0

$$NPV = \sum_{t=0}^{\infty} \frac{B_t - C_t}{(1+\rho)^t} - K = \sum_{t=0}^{\infty} \frac{P_t}{(1+\rho)^t} - K$$

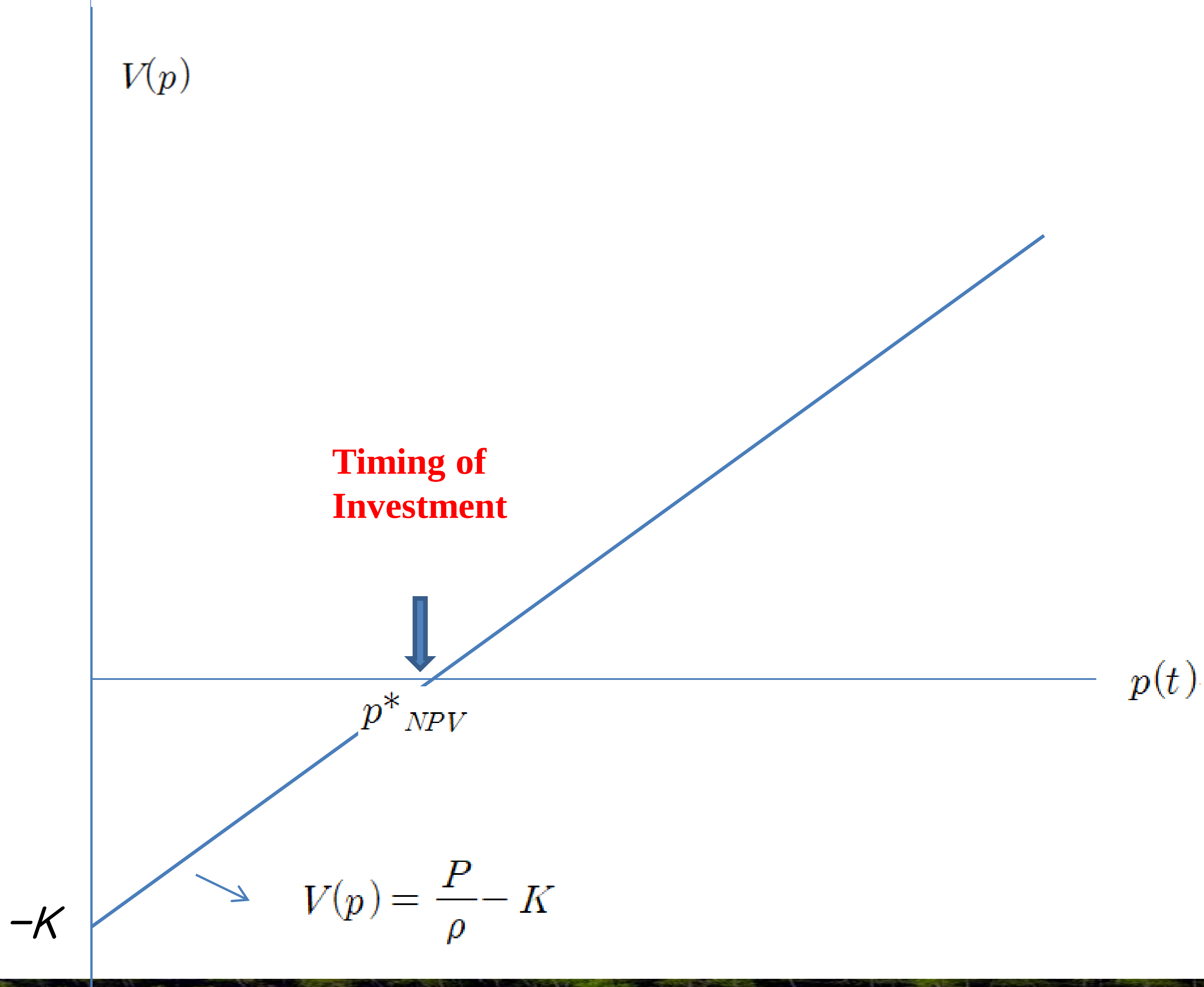
$$NPV = \int_0^{\infty} P e^{-\rho t} dt - K$$

2nd generation

Risk-adjusted approach

; NPV= Exp(B−C)/(1 + risk-adjusted rate) − K

$$NPV = \int_0^{\infty} P e^{-\rho t} dt - K$$



3rd generation

Real Options Analysis: Uncertainty and Irreversibility

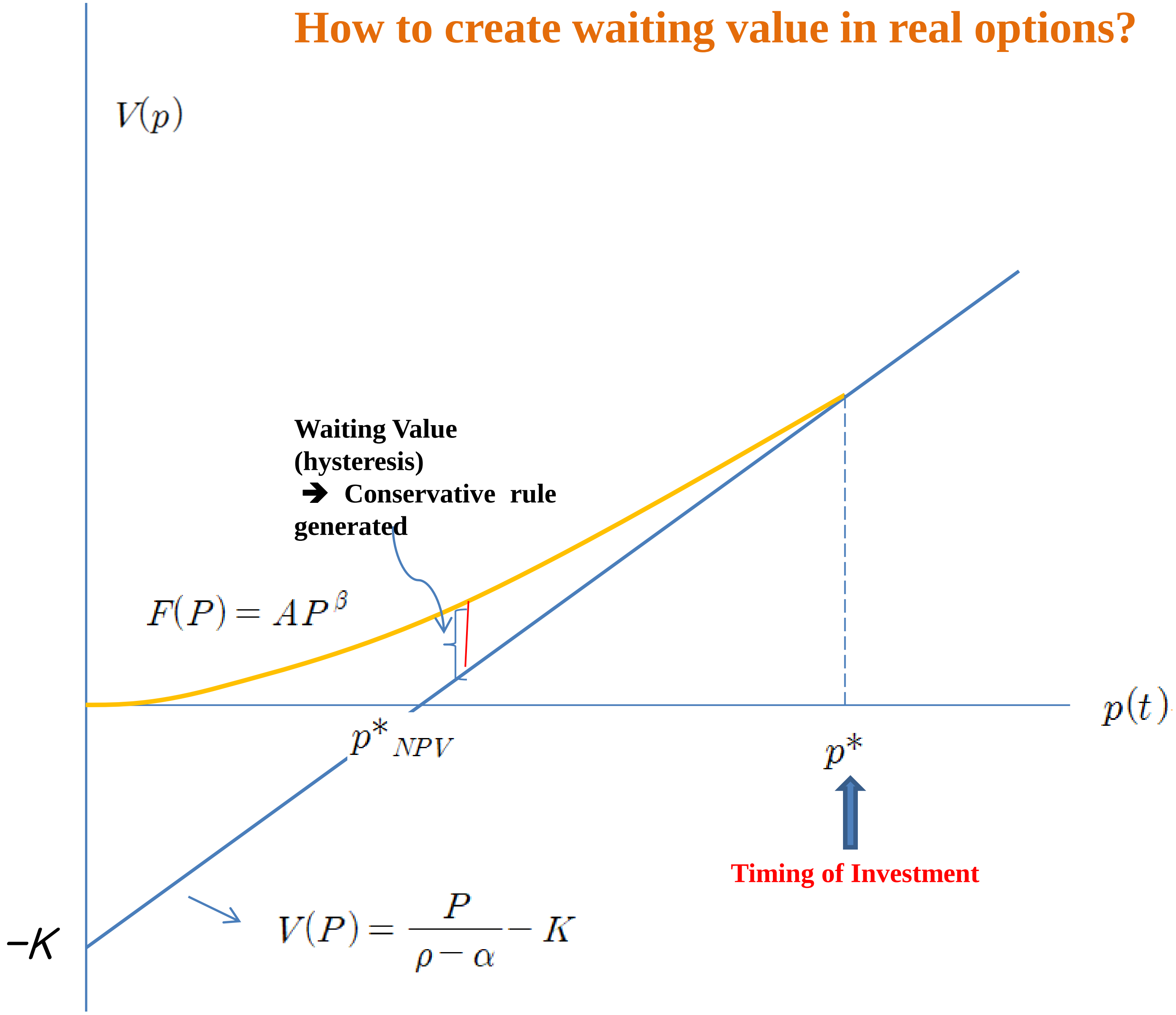
$P(t)$: stochastic process

: $dP(t) = \alpha P(t)dt + \sigma P(t)dW(t)$ 🡐 **Uncertainty**

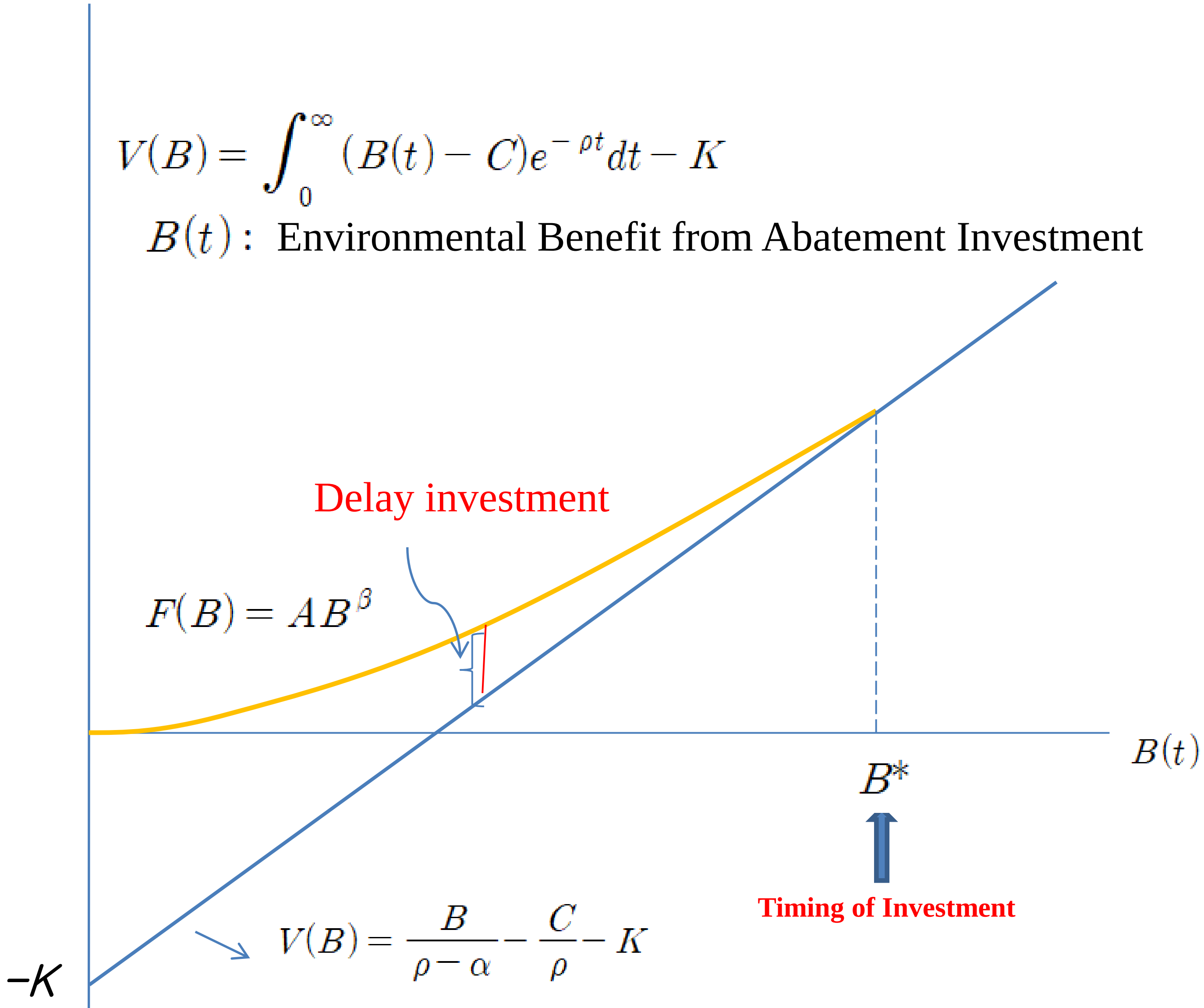
Value Function: $V(P) = \mathrm{Exp}\int_0^\infty P(t)e^{-\rho t}dt$

Option Value: $F(P) = \max[V(P) - K, 0]$ 🡐 **Irreversibility**

How to create waiting value in real options?



Implications on the timing of environmental policy to mitigate climate change impacts



Known and unknown aspects of climate change

	known probability	unknown probability
known event or consequence	(I) 'known knowns' (e.g. increased local temperatures for longer periods will affect crop cycles)	(II) 'known unknowns' (e.g. rising ocean temperatures may increase the intensity of cyclones but the frequency of occurrence is not known)
unknown event or consequence	(III) 'unknown knowns' (e.g. an indigenous person knows of a rare pest that will thrive in a warmer climate but has not told the responsible authorities about it)	(IV) 'unknown unknowns' (ex post only: e.g. corroded sewer pipes due to reduced water flow in adaptation to drought)

Source: http://ccep.anu.edu.au/data/2012/pdf/wpaper/CCEP1201Dobes.pdf

Frank Knight (1921)

- Risk: unknown outcomes whose odds of happening can be measured or at least learned about.
- Uncertainty: uncertain events that we do not even know how to describe.
- Uncertainty on uncertainty: Knightian uncertainty

- Measurement issue of risk
- Probability: Frequentist view vs. Bayesianist view
- Complexity different from uncertainty

4^{th} generation

Decision with Ambiguity (Risk aversion)

$$dB(t) = \alpha B(t)dt + \sigma B(t)dW(t)$$

where $W(t) \in \mathbb{P}$ ← Single measure of probability

We don't know what we know, what we don't know.
→ uncertainty on uncertainty
Only we know 'a set' of probabilities.

Mathematically, Girsanov Theorem is used for the transforming.

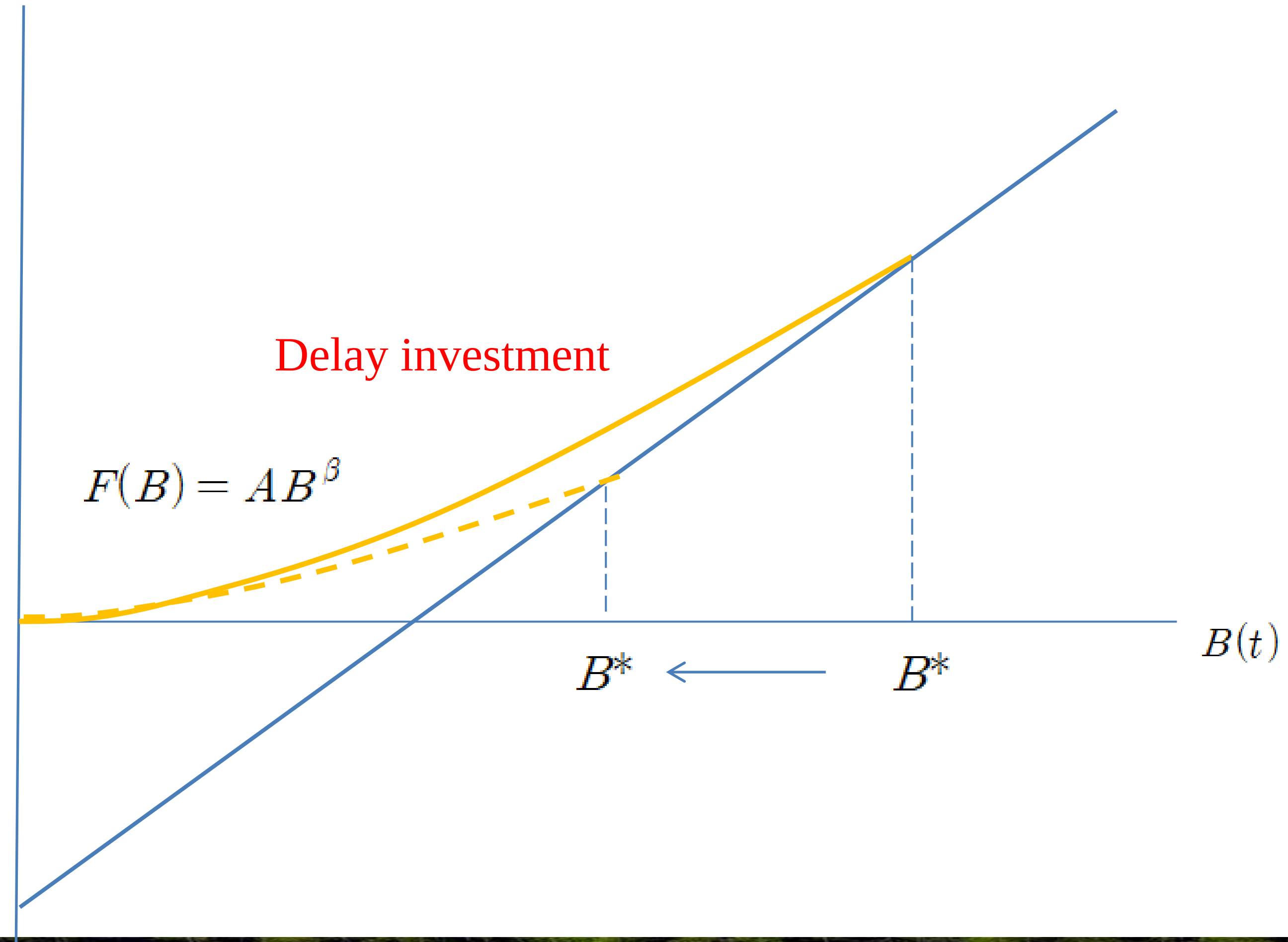
$$Q(A) = \int_A \frac{dQ}{dP} dP(w)$$ Continuous correspondence between P and Q

Transformed process after Girsanov transformation

$$dB(t) = \alpha B(t)dt + \sigma B(t)dW(t)$$

➔ $dB(t) = (\alpha - k\sigma)B(t)dt + \sigma B(t)dW(t)^Q$ where k is an ambiguity aversion.

➔ Earlier investment



Real option model with ambiguity aversion-embedded in the process

Hansen and Sargent (2015): Robustness
Nishimura and Ozaki (2017): Economics of pessimism and optimism
Park(2018): Ambiguous optimism and energy transition policy

Fundamental framework

MinMax strategy: Minimize the Maximum Possible Loss
or equivalently
MaxMin strategy: Maximize the Minimum Possible Gain

ECO2NOMICS!!!

- **No-regret Principle**
  ; Precautionary Principle

: Cost of CO_2 abatement when climate change is not true

(Type 1 error)

➔ opportunity costs exist (but, later opportunity remains)

: Cost of CO_2 non-abatement when climate change is true

(Type 2 error)

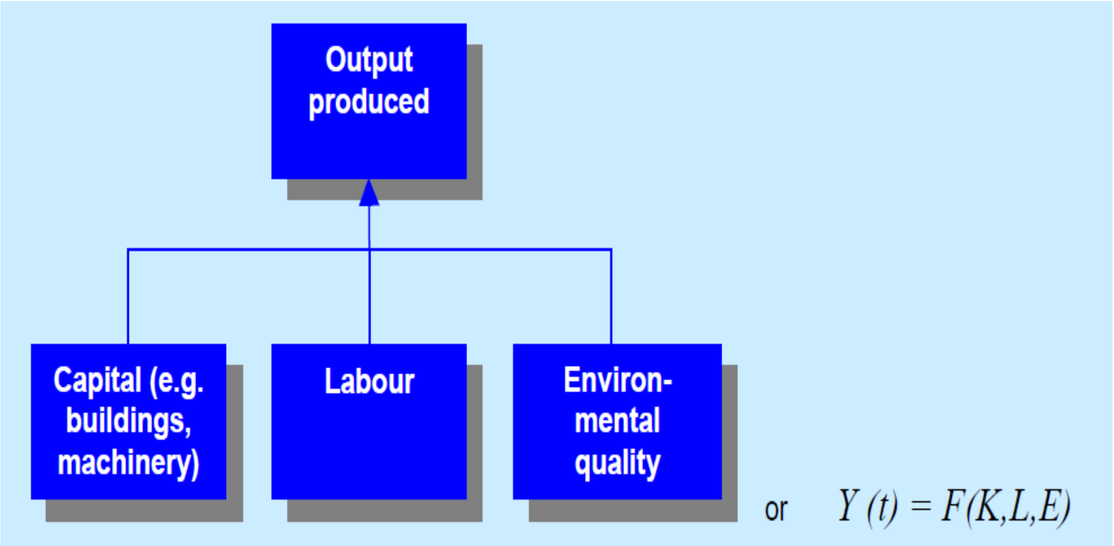
➔ climate damage costs (substantial cost and irreversible cost)

Case study: Cambodia

(collaborated study with APEC Climate Center)

$$y = \bar{y} K^{\alpha} L^{\beta} \left(\theta_0 A\right)^{\gamma}$$

K: capital
L: labor
A: agriculture value-added
$\bar{y}$: total factor productivity

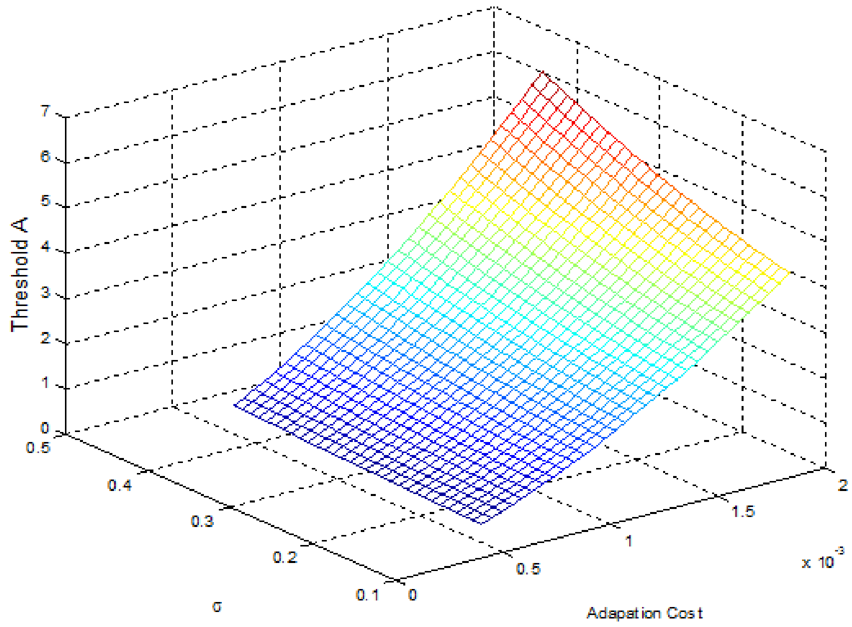


- Economic Feasibility Test for Adaptation Investment (A / A^*)

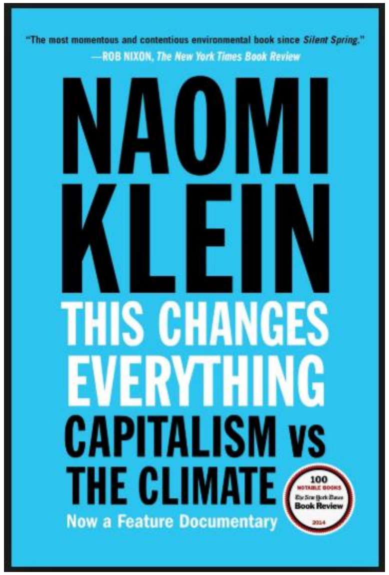
	RCP4.5	RCP8.5	Assumption
Baseline			
-20	0.5411	1.2469	Adaptation cost is 0.001% of GDP
+20	0.4223	0.5525	Adaptation cost is 0.001% of GDP
Irrigation	0.6343	0.8003	Adaptation cost is 0.002% of GDP
CO2 effect			
-20	0.9036	2.4040	Adaptation cost is 0.001% of GDP
+20	0.6449	1.3170	Adaptation cost is 0.001% of GDP
Irrigation	0.5176	0.8166	Adaptation cost is 0.002% of GDP

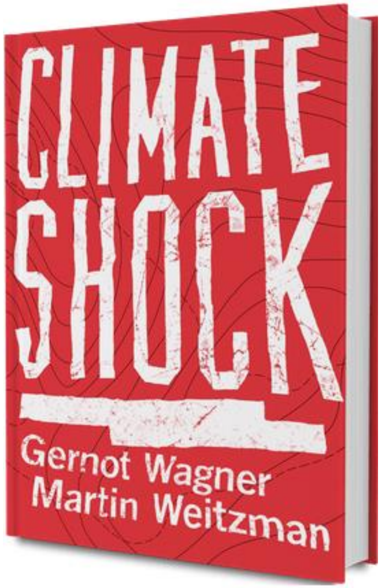
- Implications
  : adaptation investment has positive values
  : adaptation investment values under RCP4.5 > under 8.5
  → needs further study for verifying model results
  : irrigation values > planting dates adjustment

- **Ambiguity aversion** considered
  : A/A*= 0.80 ➔ 0.56
  ➔ **immediate investment is needed**



- Incorporating social costs in market system is necessary to facilitate robust decision making in climate changes.

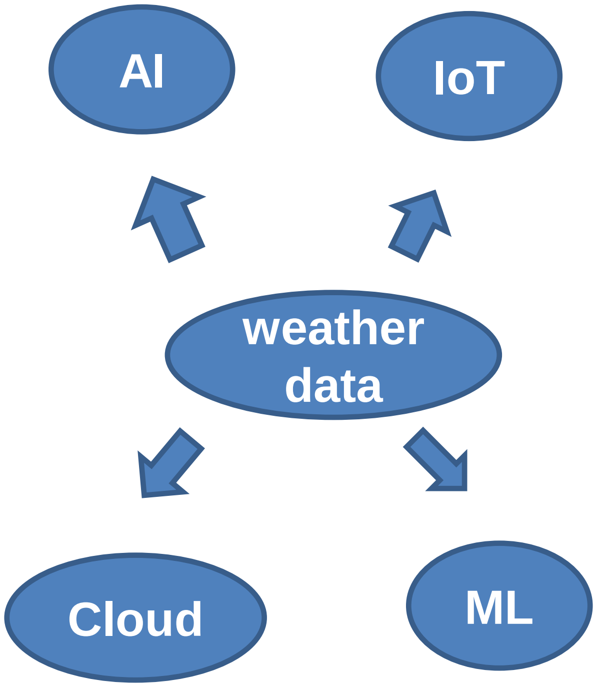




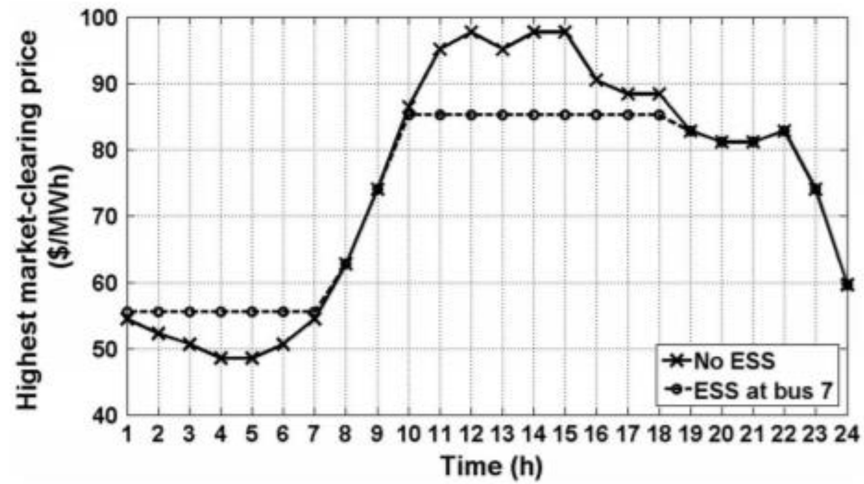
Institutionalism vs. Market-oriented

Ursus Wehrli

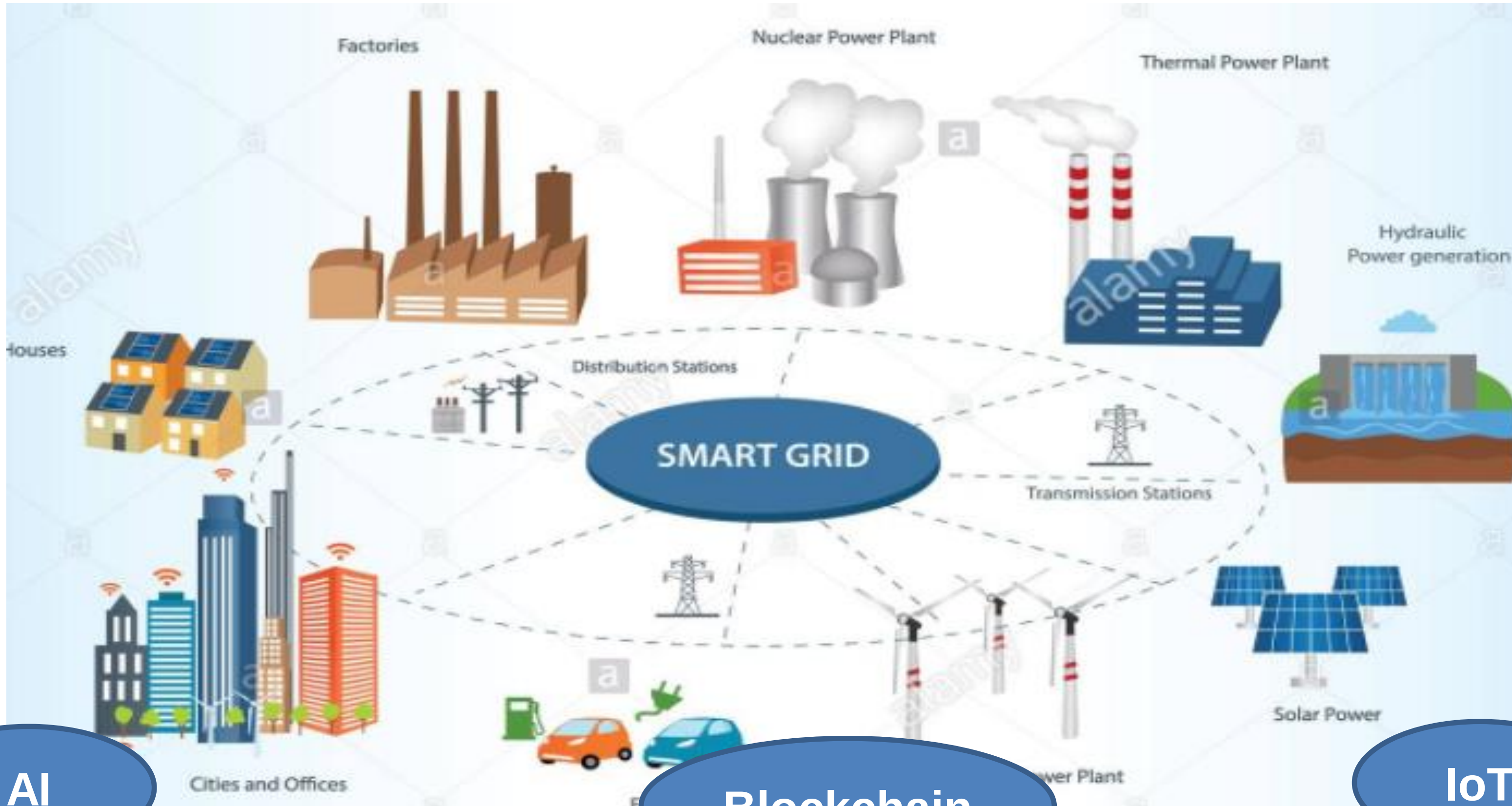
Platform: $dS/dt=0$ ← role of market



ESS (Energy Storage System)



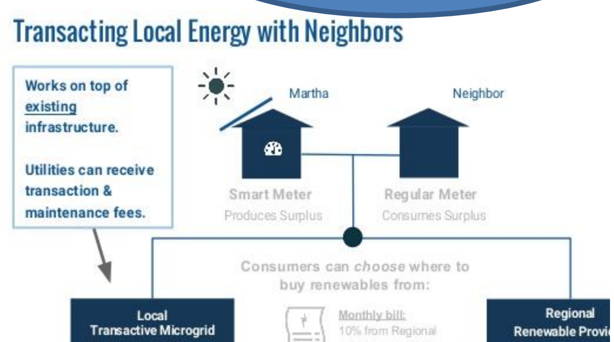
Flexible rates system

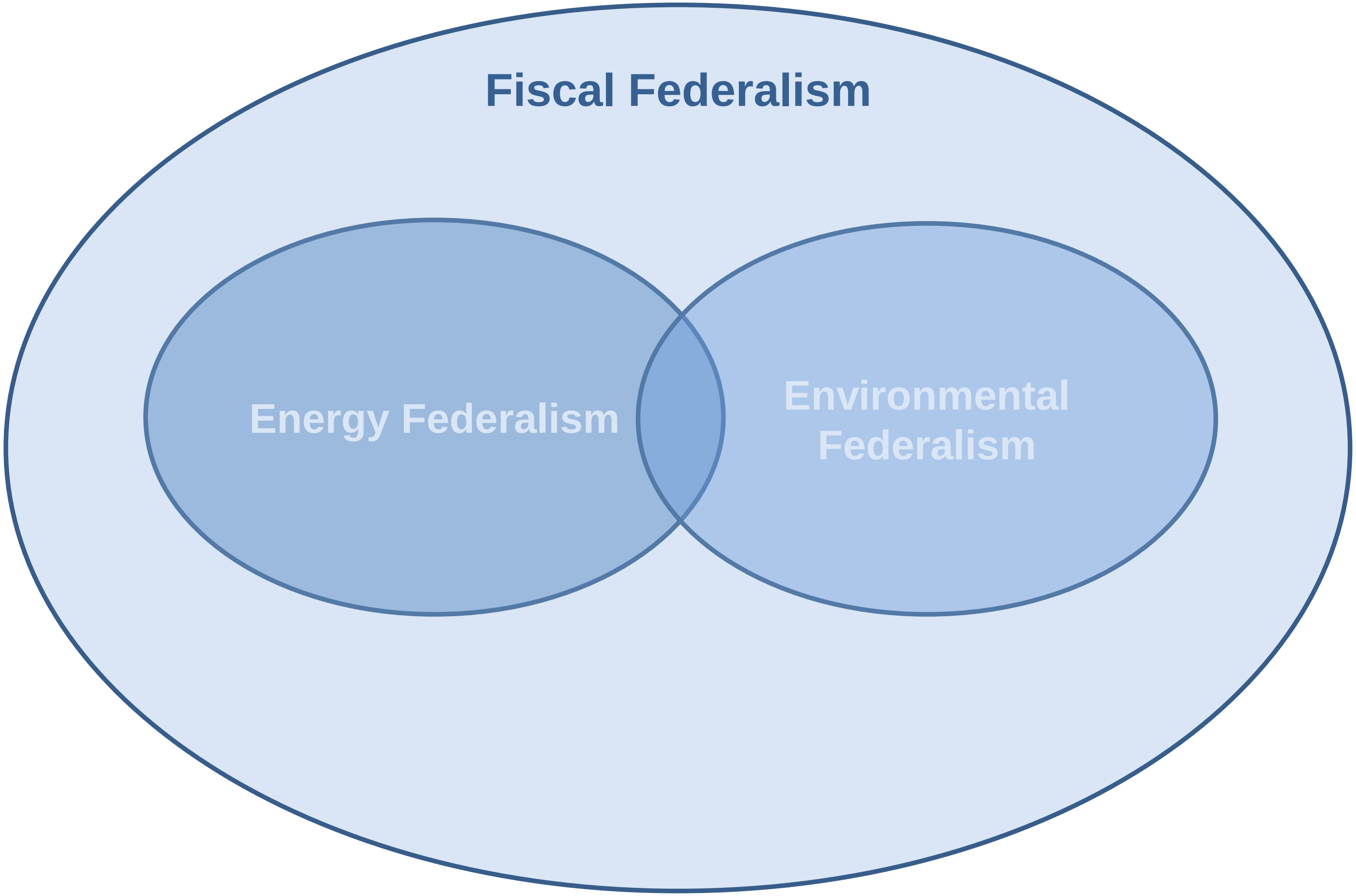


AI

Blockchain

IoT




Fiscal Federalism
Energy Federalism
Environmental Federalism

Findings

- Uncertainty is a key factor to be considered in climate change study

- Uncertainty is a key factor to increase tendency of investment hysteresis

- Uncertainty is not simply measured with single probability distribution because of ambiguity in scientific uncertainty

- The presence of ambiguity calls for earlier investment to minimize the maximum possible loss from climate change