Economics of Risk and Uncertainty

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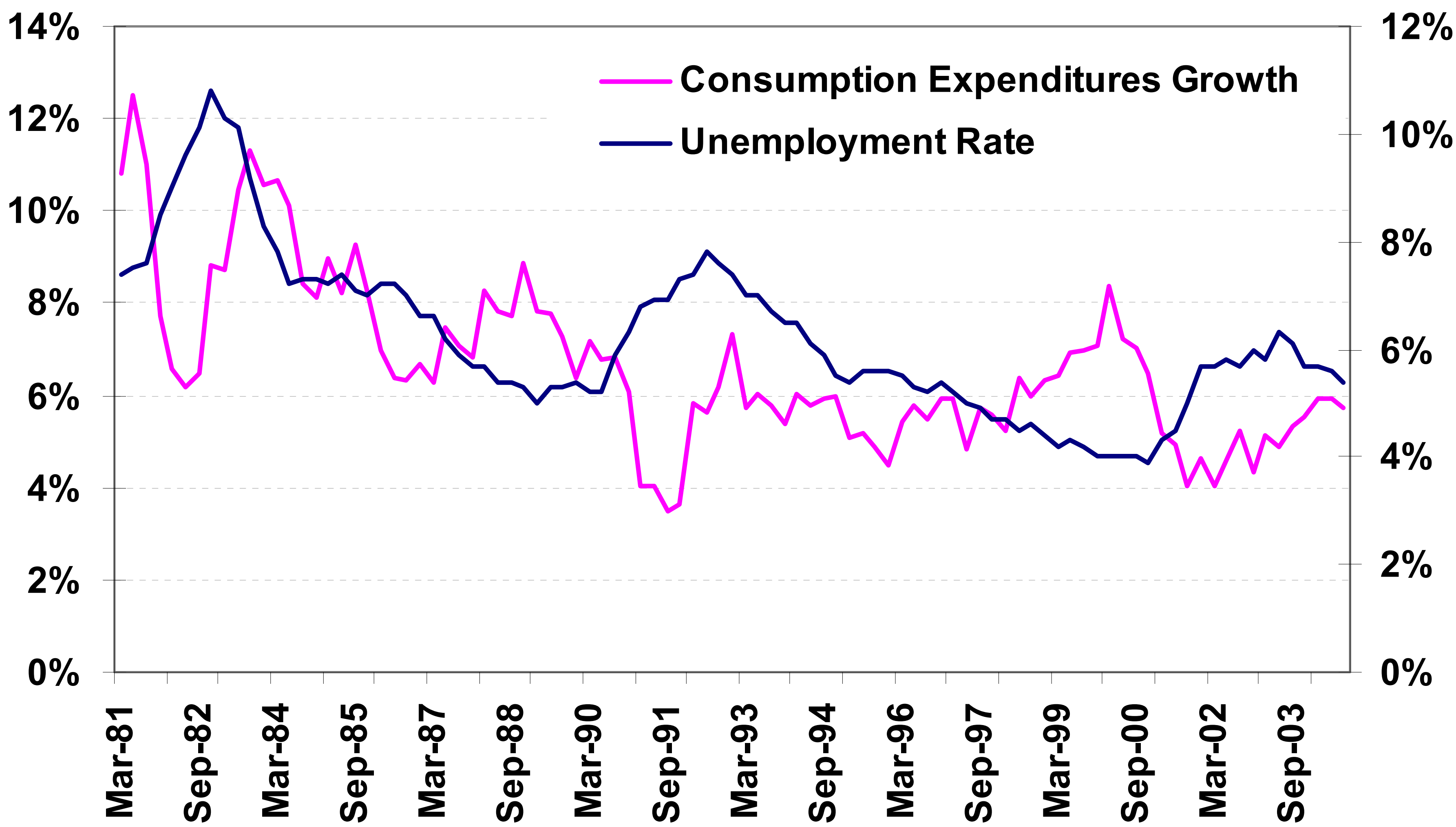
Chapters 4, 5 and 6

4. Consumption and Risk

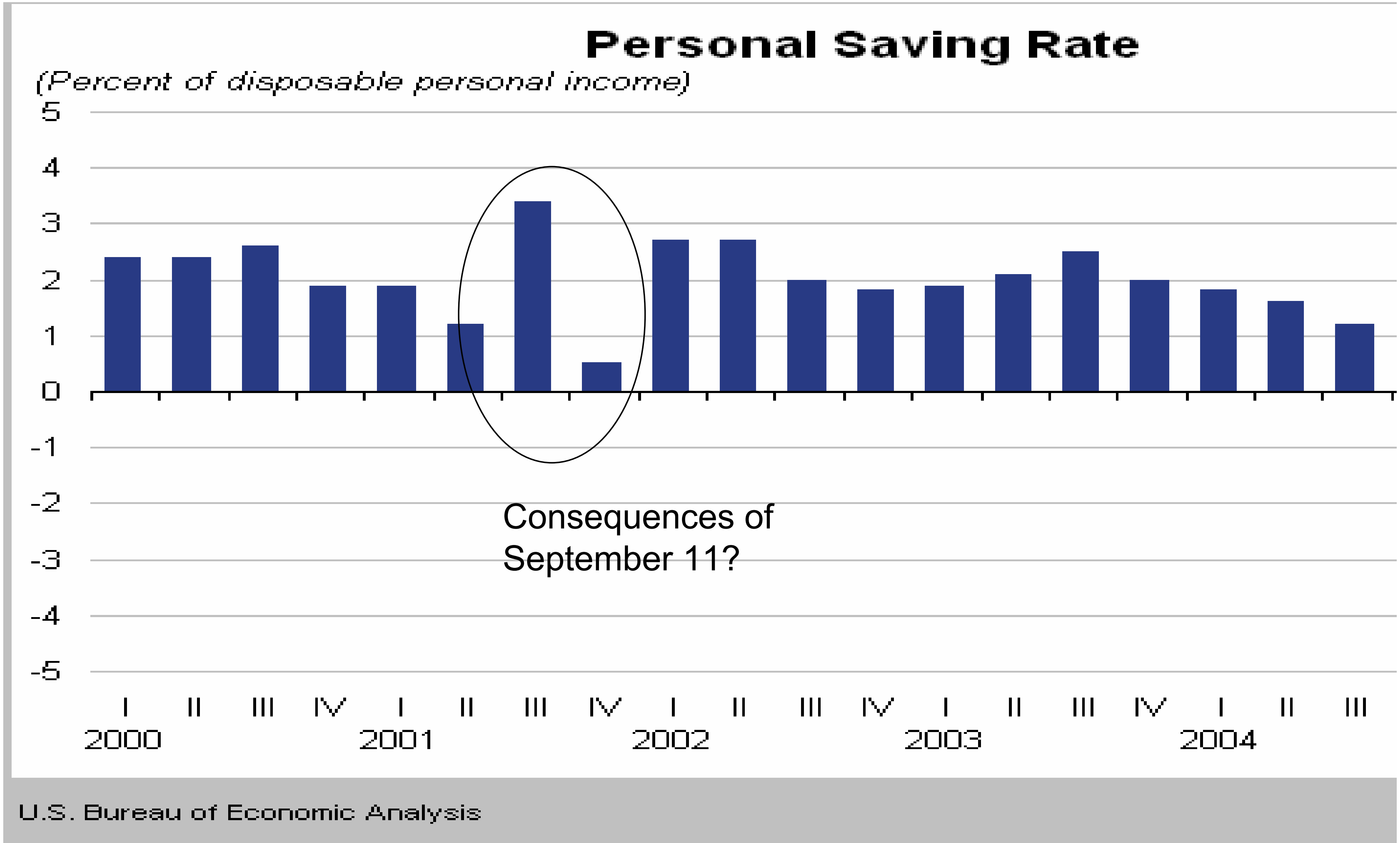
Outline

- A simple two-period model
- The notion of prudence
- How large are precautionary savings?
- Savings and portfolio choices
- Recursive preferences

Consumption vs. Unemployment Rate



Source: Bureau of Economic Analysis, 2004


Personal Saving Rate
(Percent of disposable personal income)
5
4
3
2
1
0
-1
-2
-3
-4
-5
I II III IV I II III IV I II III IV I II III IV I II III
2000
2001
2002
2003
2004
Consequences of
September 11?
U.S. Bureau of Economic Analysis

Objective

- How does risk affect consumption? What is the part of savings that can be attributed to risk?

- Use the simplest microeconomic framework to examine the effect of risk on consumption and savings

- Will explore basic variant versions of this model

Two-Period Model

$U(c_1,c_2)=u(c_1)+\beta v(c_2)$ where β is a discount factor

Assume u, v strictly increasing and concave and thrice differentiable

y_1, y_2 : income in period 1 and 2

Budget constraint:

$\rho y_1+y_2= \rho c_1+c_2$

where ρ is the interest factor (one plus the interest rate)

The Model

Let $w= \rho y_1+y_2$ the future value of total income

The problem is:

1- $Max_c\ u(c)+\beta v(w-\rho c)$

Under a (pure) risk on future income (y_2+X) the problem becomes :

2- $Max_c\ u(c)+\beta Ev(w+X-\rho c)$ where EX=0

Objective: Compare the two maximization problems

FOC,SOC

Certainty:

FOC: $u'(c^*)-\beta\rho v'(w-\rho c^*)=0$

SOC: $u''(c)+\beta\rho^2 v''(w-\rho c)<0$

Uncertainty:

FOC: $u'(c^{**})-\beta\rho Ev'(w+X-\rho c^{**})=0$

SOC: $u''(c) + \beta\rho^2 Ev''(w+X-\rho c)<0$

Precautionary savings= c^*-c^{**}= reduction in current consumption due to a future income risk

(Assume interiority)

Precautionary Savings

Are precautionary savings positive?

Intuitively: Yes, under risk-aversion. Wrong!

Formally: True if for all β, ρ, w and X

$u'(c^*)-\beta\rho Ev'(w+X-\rho c^*) \leq 0 = u'(c^*)-\beta\rho v'(w-\rho c^*)$

Equivalent to: for all z and X, $Ev'(z+X) \geq v'(z+EX)$

Precautionary Savings

For all X, $Ev'(z+X) \geq v'(z+EX)$

By Jensen <=> v' convex, or $v''' \geq 0$

Not risk-aversion, but aversion to downside risk

This condition, $v''' \geq 0$, is commonly known as the condition of « prudence » (Kimball, 1990, Etca)

Early literature: Leland (1968, QJE)

Intuition

What matters is **not** how risk « hurts » utility (risk-aversion) … but how risk « hurts » marginal utility of income (« prudence »)

Prudence: one unit of wealth has more value under uncertainty

⇔ Aversion to a downside risk : uncertainty has more negative impact when less wealthy

Remark: Multiperiod**

Let the indirect utility function:

$U(w)=Max_c\ u(c)+\beta u(w-\rho c)$.

If u risk-averse (resp. prudent) then U is risk-averse (resp. prudent) as well.

This suggests that the results can usually be extended to multiperiod.

See Caroll and Kimball (1996, Etca)

Remark: Increase in Risk**

Can be extended to any increase in risk in the sense of Rothschild and Stiglitz (1970).

Depends on whether $f(x)=u'(c)-\beta\rho v'(w+x-\rho c)$ is concave in x for all the values of the parameters

=> prudence

How Large are Precautionary Savings?

- Controversies

- Dynan (1993, JPE) find little evidence for precautionay savings. Relative prudence - i.e., formally $-xv'''(x)/v''(x)$ - is estimated to be equal to #0.3 => very small and inconsistent with CRRA utility function

- In contrast, Guiso et al. (JME) and Caroll and Samwick (1998, REStat) find significant precautionary savings motive

Exercise

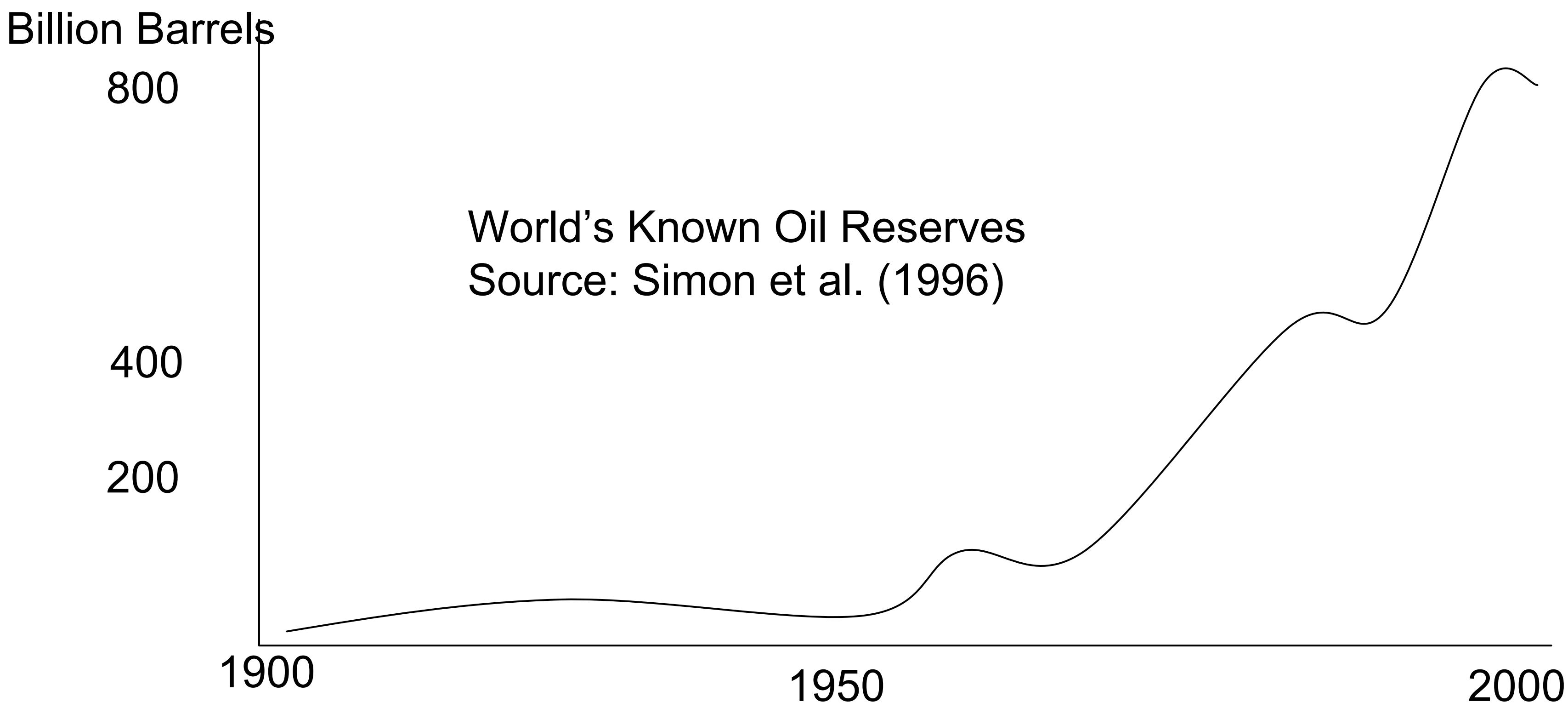
Exercise 1 Let $\text{Max}_c\ u(c)+\beta E_R v(R(y_1\text{-}c))$ where R is random (capital) risk.

i) Examine the effect of more capital risk on consumption

ii) Compare the NS condition to that of prudence. Discuss.

Remark: Exhaustible Resource

Controversies about the size of resources. Meadows (1972)'s « Limits to Growth »: out of oil in 1992!



Exhaustible Resource Exploitation

- Problem of the optimal exploitation under resource uncertainty

- « How to eat a cake of an unknown size? »

- Similar problem to that analyzed in this chapter

(Formally, assume $w+X$ is the size of the resource, and $\rho=1$)

Consumption and Portfolio

Can save in two assets: a risky asset, and a riskless asset

The amount a is invested in the risky asset with a random return of 1+R; the rest, that is y_1-c_1-a, is invested in the riskfree asset with a return 1+r

$$u(c)+\beta E_R u(y_2+(y_1-c-a)(1+r)+a(1+R))$$

Basically equivalent to

$$u(c)+\beta E_Z u(w-c+aZ)$$

Consumption and Portfolio (cont'd)

$\text{Max}_{c,a}\ u(c) + \beta E u(w - c + aZ)$

FOCs:

$EZu'(w - c^* + a^* Z) = 0$

$u'(c^*) - \beta E u'(w - c^* + a^* Z) = 0$

SOCs satisfied

Assume interiority

Drèze and Modigliani (1972, JET)

Consumption and Portfolio (cont'd)

Exercise 2: Assume u CRRA

Show:

$a^*=k^*(w-c)$ proportional to current wealth $(w-c)$

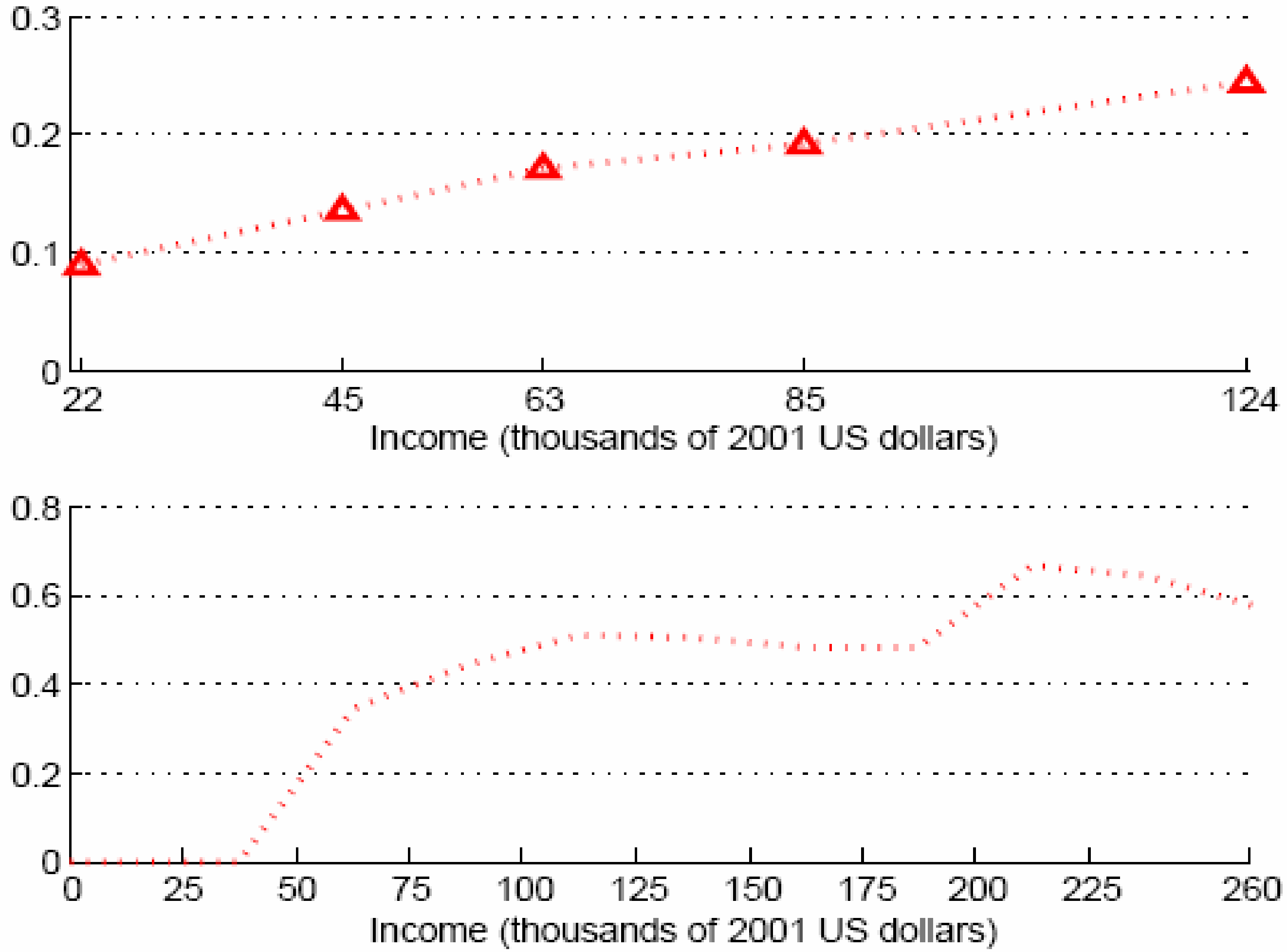
$c^*=m^*w$ proportional to wealth w

with :

k^* defined by $EZ(1+k^*Z)^{-\gamma} = 0$ and

m^* defined by $(m^*)^{-\gamma} - \beta E((1-m^*)(1+k^*Z)^{-\gamma}=0$

Figure 1: Empirical Income Expansion Paths for Saving Rates (Upper Diagram) and Equity Shares (Lower Diagram)



Source: Binswanger (2005) based on data on 17,670 consumers from PSID, and SCF

Horizon Length and Consumption

- Within a consumption model, we can consider different horizon lengths. So we can examine the effect of age.

- Young have a longer horizon, i.e. more periods to live. => Can compare the risk preferences of « young » people to those of « old » people

- Should the young be less risk averse?

A Simple Model**

An individual has only one period to live (the old).

His income in the current period is y, and utility u(y)

The young has two periods to live. Income y in each period. He can smooth consumption

$\Rightarrow$ $v(y)=\text{Max}_c\ u(c)+\beta u(y+\rho(y-c))$

Exercise 3:

i) Show that if $\beta\rho=1$, the young and the old have the same risk-aversion towards risk on income y

ii) Show that under CRRA utility, they have the same risk-aversion as well

A Conceptual Caveat

- The intertemporal expected utility models presented in this chapter combine risk preferences and time preferences

- Conceptual (often overlooked) caveat within these common models; also may explain some puzzles

- To see this, simply consider expected utility $u(c_1)+\beta Eu(C_2)$ where c_1 is certain but C_2 is random

- Then function u captures two aspects of preferences

A Conceptual Caveat (cont'd)

- $u(c_1)+\beta u(c_2)$: the curvature of u captures the desire to smooth consumption across time (elasticity of substitution) under certainty

- $Eu(C)$: the curvature of u captures risk-aversion, i.e. captures the desire to smooth consumption across states of nature in a static model

=> Not clear why these two different concepts are linked through the **same** utility function u(.)

Recursive Preferences

May want to disentangle the two concepts : Kreps and Porteus (1978, Etca), Selden (1978, Etca), Epstein and Zin (1989, Etca)

=> « Recursive preferences »

Built in two different steps:

1) Let $f=v^{-1}(Ev(C_2))$ the certainty equivalent of uncertain period 2 consumption C_2: atemporal context

2) Let $u(c_1)+\beta u(f)$ the intertemporal preferences w/r to the flow of deterministic consumption: certainty context

Recursive Preferences

In the certainty equivalent, i.e. $f=v^{-1}(Ev(C_2))$: the function v controls risk-aversion

Within the intertemporal preferences $u(c_1)+\beta u(f)$: the function u controls the elasticity to substitution

The model thus becomes $u(c_1)+\beta Eu(v^{-1}(Ev(C_2)))$

If u(.)=v(.) => back to the intertemporal expected utility model

Empirical Data

Epstein-Zin (JPE, 1991) examine consumption-portfolio choices under recursive preferences with $v(z)= (z)^{1-\gamma}/(1-\gamma)$ and $u(z)= (z)^{1-\alpha}/(1- \alpha)$

Reject the assumption that $\gamma=\alpha$! (i.e., reject EU)

Elasticity of substitution ($1/\alpha$): α in range [2.4,4.8]
Relative risk-aversion: γ in range [0.4,1.4]

Some Other Estimates

Parameters: References:	γ	α
Weil (1990)	45	10
Giovanni, Jorion (1991)	#1	0.4-1.4
Normandin, St Amour (1996)	0.4-3.6	1.2-3.0
Kocherlakota (1996)	>7	0.5-4.5
Chavas and Thomas (1998)	#1	0.25

5. Physical Risks

Outline:

- State-dependent utility
- A prevention model
- WTP vs. WTA
- Value of statistical life
- Human capital
- Life Insurance

State-Dependent Utility

- Until now, we have assumed that the utility was state-independent: No matter the outcome (or state of the world), same vNM utility u(.)

- Sometimes irrealistic to assume state-independence

- The utility function may depend on the « state of the world »

An Example

- Assume two states of the world: either I will be alive (state 1), or dead (state 2)

- The utility should probably be allowed to be different depending on the state of world

- In other words, being dead or alive do not only have financial consequences, but also may directly affect the utility of wealth

More Generally

- State-dependence may be involved for representing preferences w/r to most « physical » risks, e.g. risks to health

- May also include preferences w/r to the environment (pollution, environmental catastrophes, «intangible» damages..)

- Broader class of events: Success vs. failure at love, life with or without kids, loss of freedom, sports' results..

State-Dependent Utility

Foundations:

Fishburn, P., 1970, *Utility Theory for Decision-Making*, Wiley. New York.

Karni, E., 1985, *Decision Making under Uncertainty*, Harvard UP.

Keeney R. and H. Raiffa, 1993, *Decisions with Multiple Objectives*, Cambridge UP.

For what follows, see e.g. Weinstein et al. (1980, JPE) and the book of Jones-Lee (1982), *The Value of Life and Safety*, North-Holland.

State-Dependent Utility

- Axiomatics:

vNM EU can be generalized to state-dependent EU using similar axioms leading to a representation theorem

- No difficulty with objective probabilities

- However identification problem when subjective probabilities are involved: The subjective probabilities cannot be identified from observable choices (see, e.g., Karni, 1985)**

A Prevention Model

- We will first study a particular case of state-dependent model, that is a model of prevention

- There is a possibility of a bad outcome (e.g., death)

- A way to mitigate this risk is to reduce the probability of occurrence of the bad outcome (prevention)

A Prevention Model (cont'd)

There are two states of the world, the good state and the bad state

- $u(w)$ is utility of wealth w in the good state
- $v(w)$ is utility of wealth w in the bad state (e.g., if sick or dead)

Assume $u(w)>v(w)$ and $u'(w)>0$, $v'(w)\geq 0$ for all w.

A Prevention Model (cont'd)

Let $0 \leq p(e) \leq 1$ the probability that the bad state occurs in which e is the prevention effort (in monetary units)

Assume $p'(e)<0$ and $p''(e) \geq 0$.

Under (state-dependent) EU, we have:

$EU=(1-p(e))u(w-e)+p(e)v(w-e)$

See, e.g., Weinstein et al. (1980, QJE), Viscusi (1993, JEL)

Optimal Prevention

Maximize $EU=(1-p(e))u(w-e)+p(e)v(w-e)$ over e

FOC:

$-p'(e)(u(w-e)-v(w-e))=(1-p(e))u'(w-e)+p(e)v'(w-e)$

Marginal benefit = Marginal cost

SOC satisfied when $u'>v'$, and u and v weakly concave

What is the Shape of v(.)?

Some particular cases:

- v(w)=u(w-L)

monetary loss, state-independent
see, e.g., Jullien et al. (2000, GPRIT)

- v(w)=u(w)-k

additive separability, strong assumption = same marginal utility of wealth

- v(w)=ku(w) with $0 \le k < 1$

e.g., if k=0, utility if dead with no bequest motive
Viscusi and Evans (1990, AER) estimate k#0.7

Prevention and Risk-Aversion

Monetary loss L

Let $EU=(1-p(e))u(w-e)+p(e)u(w-L-e)$

More risk-aversion does not always increase the prevention effort

Dionne and Eeckhoudt (1985, EL)

Intuition?

Prevention and Prudence

- Need condition on u'''
- Eeckhoudt and Gollier (2005, ET) show that a risk averse - and prudent - agent should invest less, and not more, in prevention than a risk-neutral agent!
- Intuition: aversion to a downside risk
- Consider two lotteries:

Same mean and variance

Mortality Risk with No Bequest

Assume $v(w)=0$

$EU=(1-p(e))u(w-e)$

Normalize $u(0)=0$

i) Examine optimal prevention effort under risk-neutrality in wealth (u linear).
ii) Compare to the effort if risk-averse in wealth (u concave).

Financial risk aversion always increases prevention efforts

Valuation of Mortality Risk Reduction

- Important policy issue
- Suppose one wants to implement a public project that is expected to save lives in the society (e.g., reduce pollution)
- What is the social value of this project?
- How to compare this benefit to the monetary cost of the project?

Valuation of Mortality Risk Reduction (cont'd)

- Benefits from mortality risk reductions often dominate benefit-cost analysis
- E.g., represent a large part of benefits from air pollution reduction programs - see Hammitt (2007) for the US and Pearce et al. (2005) for Europe

- Although the « human capital » approach used to be popular, it is now commonly accepted that benefits from mortality risk reduction should be based on an individual willingness to pay approach

Willingness to Pay

- In our context: maximal amount that an individual is willing to pay for a mortality risk reduction

- Theoretically: The amount that keeps constant the level of expected utility

Russian Roulette

- Pure thought experiment: You have to shoot yourself
- The gun has 10,000 chambers, and 5 of them are loaded with bullets
- You are given the opportunity to remove one bullet before shooting. What is your WTP for this removal?

$$(1-p+e)u(w-WTP) + (p-e)v(w-WTP) = (1-p)u(w) + pv(w)$$

with $p=5/10{,}000$ et $e=1/10{,}000$

w= initial wealth

$u(.)$ utility if alive; $v(.)$ utility if dead

WTP/WTA

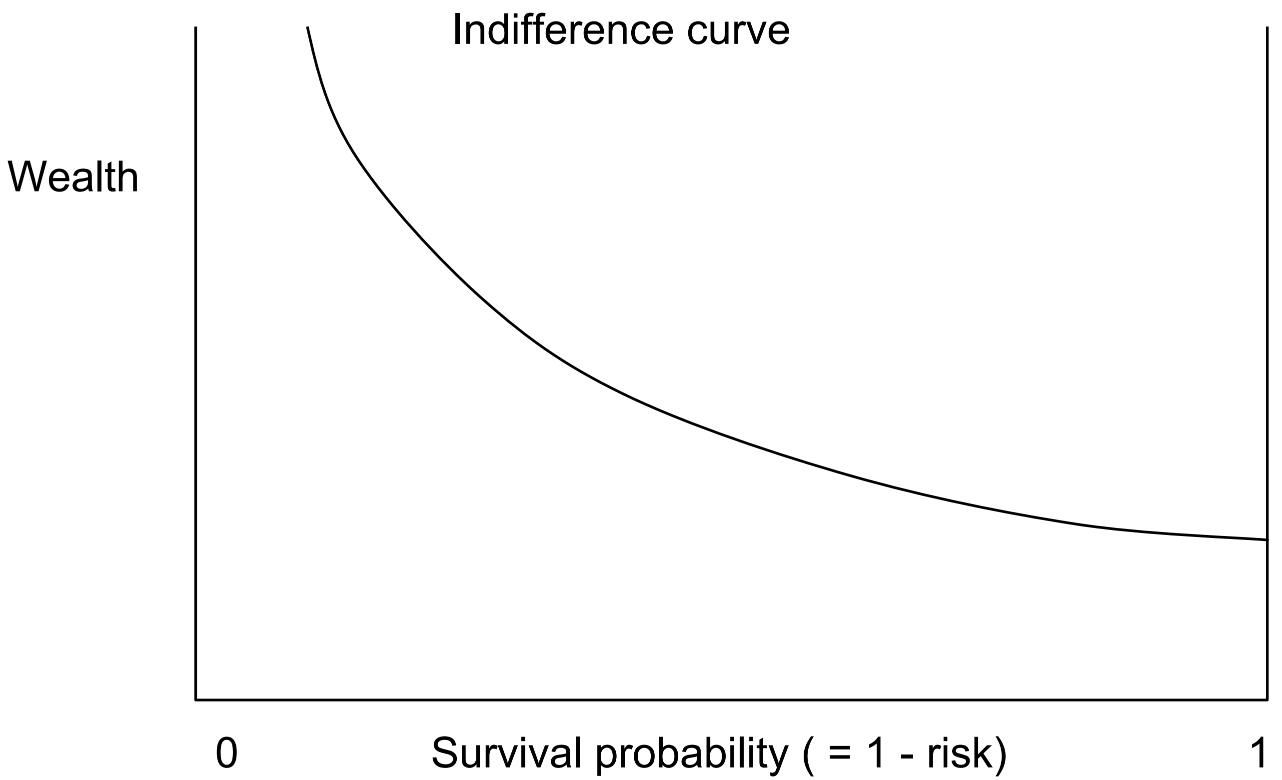
- WTA — Willingness to Accept

(Russian Roulette: Which amount would you accept to add one more bullet?)

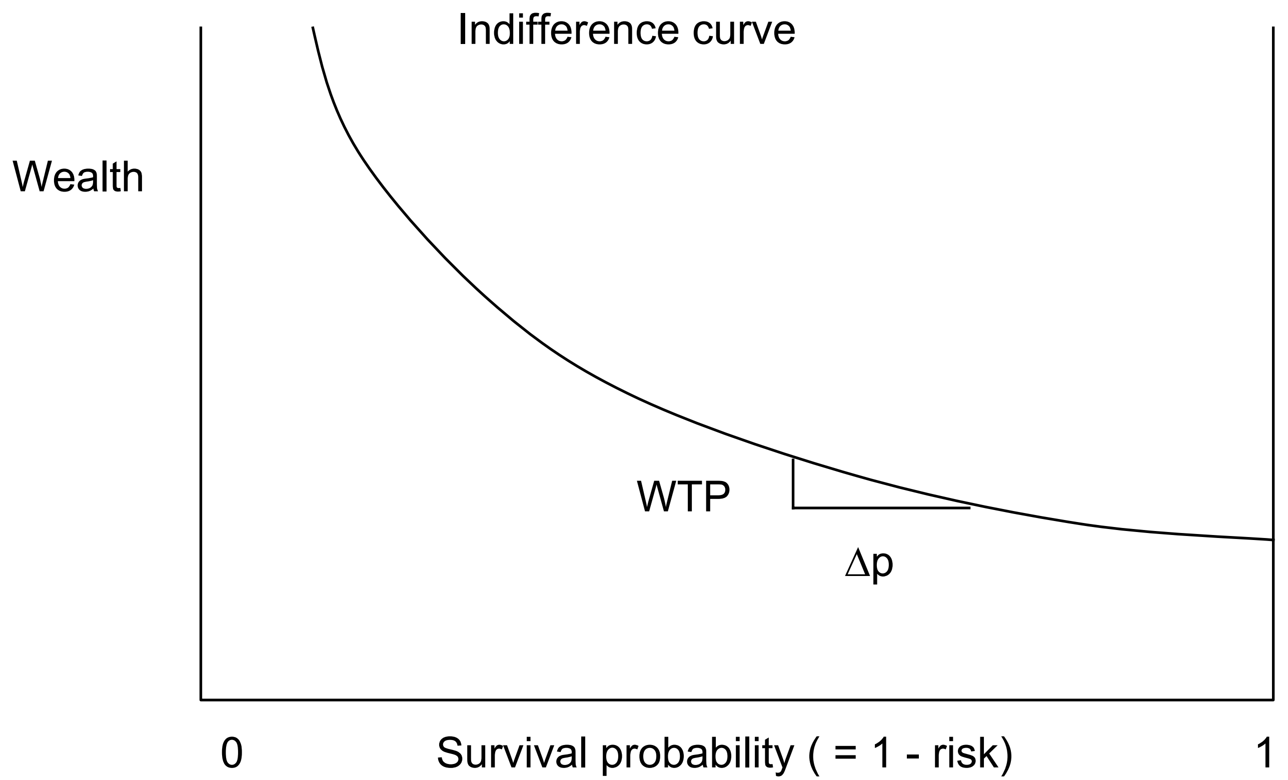
- WTP is limited by available wealth;

WTA not limited
  - Usually WTP $\leq$ WTA
  - For small amounts, WTP $\approx$ WTA

WTP/WTA

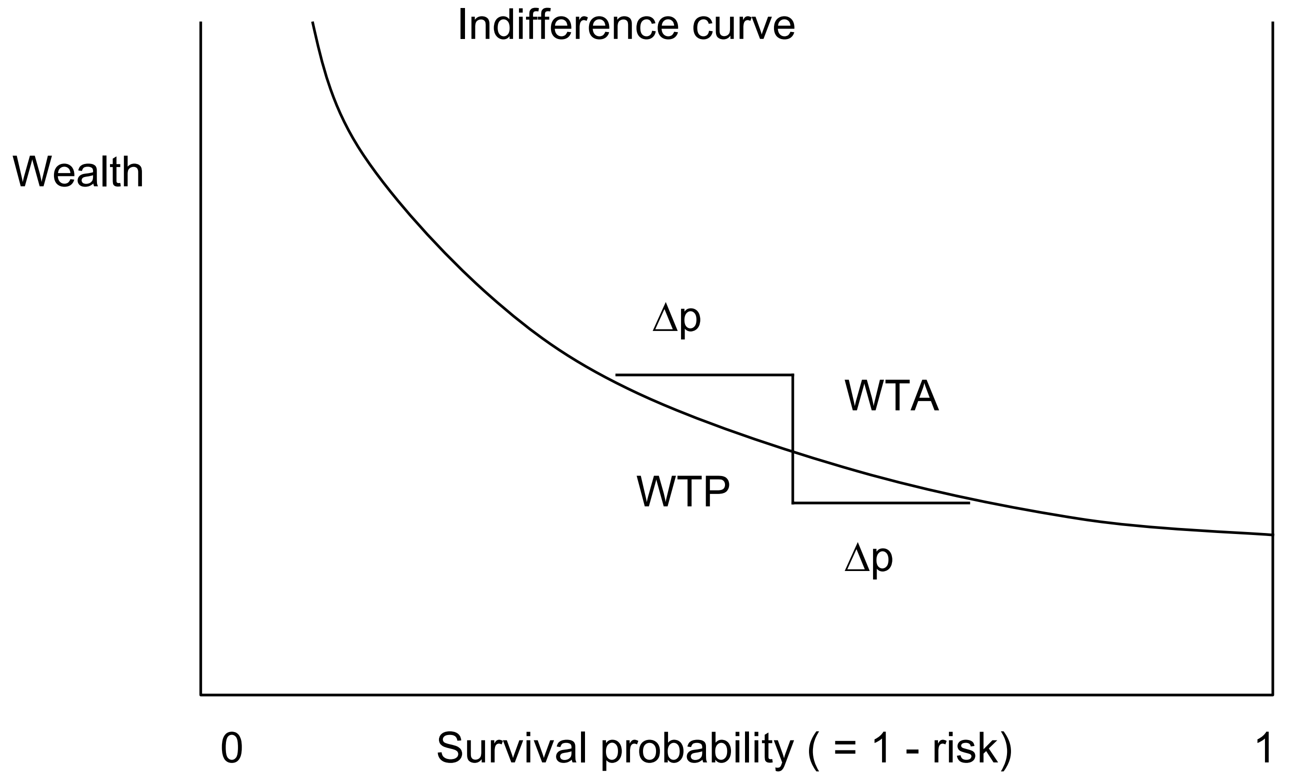


WTP/WTA



Indifference curve
Wealth
WTP
Δp
0
Survival probability (= 1 - risk)
1

WTP/WTA


Indifference curve
Wealth
Δp
WTA
WTP
Δp
0
Survival probability (= 1 - risk)
1

Value of Statistical Life (VSL)

Introduction to the concept:

- N (= 10,000) citizens in a community
- One avoidable statistical death
- WTP equals 500 euros to eliminate this mortality risk of 1/10,000
- VSL is thus 5 million euros total within this community
- $$\mathrm{VSL} = \frac{WTP}{\Delta p} = \frac{N \cdot WTP}{N \cdot \Delta p} = \frac{Total\_WTP}{E\left(Life\_saved\right)}$$

VSL : Theory

Let V=(1-p)u(w) + pv(w)

VSL: marginal rate of substitution between money and risk

$$VSL = \frac{dw}{dp} = \frac{u(w) - v(w)}{(1-p)u'(w) + pv'(w)}$$

VSL

- Does not measure what an individual is willing to pay to avoid his/her own death with certainty
- It measures WTP (resp. WTA) for an infinitesimal risk reduction (resp. increase)

VSL :

i) Increases with baseline risk p (“dead-anyway effect”, Pratt and Zeckhauzer, 1997, JPE)

ii) Increases with wealth w (the sum of two effects) under u and v weakly concave

VSL: Calibration

- Let y=16,500 euros (french yearly income, INSEE 2004)
- Let p=3/1,000 (average yearly death probability for people aged 25-40)
- Let a life expectancy of 45, neglecting changes in income and interest rate, w=16,500*45=742,500
- Assume v=0, no bequest motive
- Assume constant relative risk aversion equals 0.5

$$\text{VSL} = \frac{742{,}500}{0.997*0.5} \# 1.5 \text{ millions euros}$$

Remark: VSL and Consumption

Let $V=\max_c u(c) + (1-p)\beta u(w-\rho c)$

in which (1-p) is survival probability and c is consumption

VSL: (still) marginal rate of substitution between money and risk

$$VSL = \frac{dw}{-dp} = \frac{u(w-\rho c^*)}{(1-p)u'(w-\rho c^*)}$$

In which c* is optimal consumption

Estimations of VSL

- $3 million to $7 million (US and OECD)
  - $6.8 million (used by EPA)
  - $7 million (Viscusi & Aldy, 2003, *JRU*)

- Income-elasticity of VSL positive but usually < 1

Author	Year	Implicit VSL millions US $2000	Country
• JOB-MARKET STUDIES			
• Thaler-Rosen	1975	$1.0	US
• Viscusi	1978-79	$5.3	US
• Dillingham	1977	$3.2-$6.8	US
• Weiss et al.	1981	$3.9-$4.5	Austria
• Marin et al.	1982	$4.2	UK
• Moore-Viscusi	1988	$3.2-$6.8	US
• Berger-Gabriel	1991	$8.6-$10.9	US
• Cousineau et al.	1992	$2.2-$6.8	Canada
• Leigh	1995	$8.1-$16.8	US
• Baranzini et al.	2001	$6.3-$8.6	Switz.
• Kim	1993	$0.8	India
• Liu et Hammitt	1997	$0.2-$0.9	Taiwan
• CONSUMER-MARKET STUDIES			
• Blonquist	1979	$1.0	US
• Atkinson-Alvorsen	1990	$5.3	US
• Dreyfus-Viscusi	1995	$3.8-$5.4	US
• CONTINGENT VALUATIONS			
• Johannesson et al.	1996	$5.0	Sweden
• Corso et al.	2001	$3.1	US
• Ludwig-Cook	2001	$6.0	US

« Official » VSL for Road Safety

Countries	VSL Ecus 1994 millions
• Germany	0.79
• Austria	1.39
• Belgium	0.37
• Denmark	0.72
• Finland	1.21
• France	0.56
• Grece	0.13
• Irland	0.95
• Holland	0.11
• UK	1.01
• Sweden	1.64

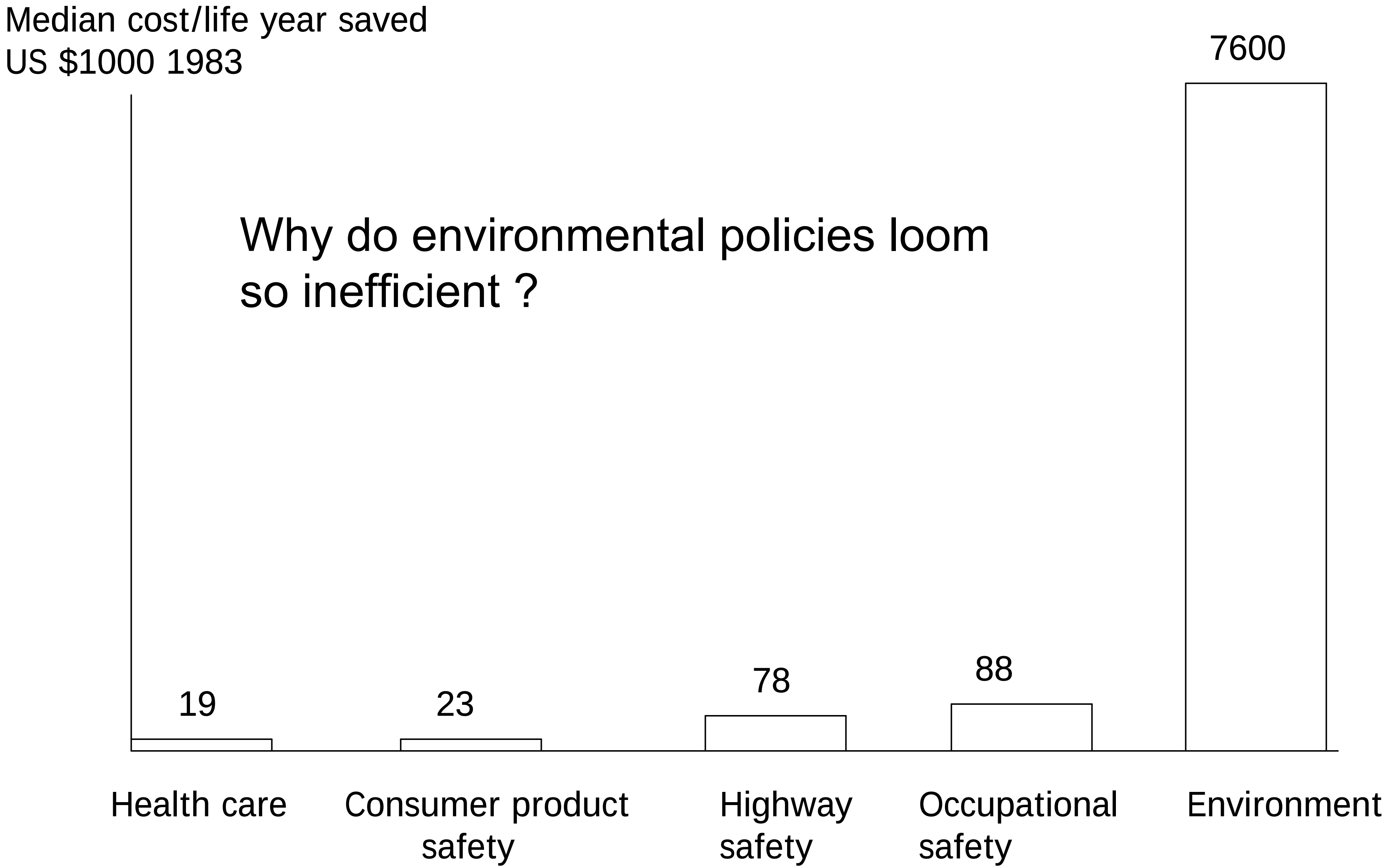
Source: Boiteux (2001)

US Public Prevention Programs

Programs (Agency)	Estimated cost per avoided death ($1990)	
• Underground construction (OSHA)	0.1	
• Trihalomethane drinking water standards (EPA)	0.2	
• Crane suspended personnel platform (OSHA)	0.7	
• Children's sleepwear flammability ban (CPSC)	0.8	
• Low altitude windshear equipment (FAA)	1.3	**Efficient?**
• Hazard communication (OSHA)	1.6	
• Arsenic/copper smelter (EPA)	2.7	
• Grain dust explosion prevention standards (OSHA-S)	2.8	
• Radionuclides/uranium mines (EPA)	3.4	
• Ethylene dibromide drinking water standard (EPA)	5.7	
• Abestos occupational exposure limit (OSHA-S)	8.3	
• Ethylene oxide (OSHA)	20.5	**Inefficient?**
• Uranium mill tailings (EPA)	31.7	
• Abestos ban (EPA)	110.7	
• Diethylstillbestrol cattlefeed ban (FDA)	124.8	
• Hazardous waste land disposal ban (EPA)	4,190.4	

Source: Viscusi (1998), Sunstein (2001)

Why do environmental policies loom so inefficient ?



Source: Tengs and Graham (1996) and Lomborg (2001)

Human Capital

- Traditionally, two conceptual approaches
  - Human Capital
  - VSL
- Human Capital: Opportunity cost of early death, or say earning ability
  - In practice: proportional to net income over lifetime
- What is the link between the two approaches?

Human Capital Table

($1,000, in the US, updated from Hartunian et al., 1981)

Age	Male	Female
0-14	448	306
15-24	776	525
25-34	868	538
35-44	730	476
45-54	492	370
55-64	199	212
65-74	24	85
75 +	3	31

WTP vs. Human Capital

- In general, WTP per unit of change in risk is higher than human capital

- Let the WTP to eliminate a mortality risk

$$u(w-WTP) = (1-p)\, u(w) + p\, v(w)$$

- Show that if $v(.)=0$ and $u(0)=0$, then $WTP/p > w$ under $u(.)$ concave
- For small p (risk change), VSL>w

Implication

- Consider a population of N people, in which Np will die

- Using the WTP approach, we collect ex ante N*WTP to eliminate this mortality risk
- Using the human capital approach, we collect Npw

(number of people who die times their human capital w)

- The human capital approach undermines the value of preventing death. It does not take into account preferences (typically financial risk-aversion)

Life Insurance

- Why do people buy life insurance?

- Consider a simple model in which an individual chooses to receive I if he dies:

  $F(I)=(1-p)u(w-(1+\lambda)pI) + pv(w-(1+\lambda)pI+I)$

  where $(1+\lambda)pI$ is the insurance premium

FOC: $F'(I)=-(1-p)(1+\lambda)pu'() + p(1-(1+\lambda)p)v'()=0$

SOC satisfied

Life Insurance

FOC: $F'(I) = -(1-p)(1+\lambda)u'() + (1-(1+\lambda)p)v'() = 0$

- Assume that insurance is actuarilly fair, $\lambda=0$.

FOC: $-u'(w-pI)) + v'(w-pI+I) = 0$

- But by assumption $u'(z)>v'(z)$ for all z, and v' decreasing => I negative is optimal
- "Selling" life insurance is optimal! What's going on here? Is there something missing?

Life Insurance

Exercise: Find the optimal insurance policy for u(x)=Logx and v(x)=kLog(x); assume that the financial loss is Hw if death; and assume λ=0.

I*= (H+k-1)w/(1+(k-1)p)

If k=1 => I*=Hw: full insurance under risk aversion

I* increases in k, I*>0 when k>1-H

I* (if positive) increases in w (despite DARA!)

Prevention Models: Final Remarks

- Need a general model of prevention with:
- Individual actions that affect the probability of a loss, but also the loss itself
- Possibility to purchase life and health insurance contracts
- Early reference is Ehrlich and Becker (1972, JPE), but few general prevention models exist
- Need a better understanding of the shape of utility in the case of sickness or death

6. Option Values

Outline

- The Concept of Information
- Information Value
- The « Irreversibility Effect »
- The Precautionary Principle

Information

- Information is another, important, way to cope with risk – Allows the decision-maker to better adapt decisions to the knowledge of risk

- Information is obtained from: information search, the passage of time, scientific progress, education, media, social interactions…

Assumption

Information will be

- exogenous (e.g., no learning by doing..)
- non-strategic
- free

Example: Investment Decision

Cost: c, Benefit: X (uncertain). Risk-neutrality.

Investment rule: invest if EX>c ; Expected profit: **max(EX-c, 0)**

Suppose now perfect information.
Investment rule: invest if X=x>c ; Expected profit: **Emax(X-c,0)**

Information Value: **IV=Emax(X-c,0) - max(EX-c, 0) ≥0**

Take: c=100, X=(50%, 200, 50%, 50). IV= 50-25=25
Take: c=100, X=(50%, 140, 50%, 50). IV= 20-0=20

The Concept of Information

- Information, as defined in economics, means that the decision-maker will receive a message about the realisation of X

- The value of information is computed ex ante., i.e. before any message is received. Hence, the decision-maker does not know which message (about the realization of X) will come.

=> The information value is always positive

Positive Information Value

- Let u(d,X) any decision problem in which d is the decision and X a random variable

- Value of information

$IV = E \max_d u(d,X) - \max_d Eu(d,X)$

Show that IV is always positive

Intuition?

Remark: Information Value

- Value of perfect information: full information versus no information
- Information can be less than perfect
- In economics and statistics: « Better information » is characterized using the Blackwell (1951)'s notion of the comparison of information structures
- Imperfect information not done here.

Determinants of Information Value

- (Small) literature on the determinants of the information value
- The effects of wealth, risk, risk-aversion etc. are all ambiguous. Depends on the decision problem.
- See Hirshleifer and Riley (1992, chapter 5) for a simple and excellent overview

Information and Time

- Information is important in a sequential decision-making framework
- What should I do today given that I will have better information in the future?
- Should I wait? Should I delay decisions? Should I be more cautious?

“Wait and See” Arguments

- DuPont spoken-person (CFC regulation, 1981): *“We are going in a very long way into the regulatory process before scientists know what’s really going on”*

- White House Conference (1990) (CO_2 regulation): *“An aggressive strategy to address possible global change based on today’s knowledge may be wholly inappropriate within a decade”*

The Precautionary Principle

- Precautionary Principle at Rio Conference (1992)*"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"*

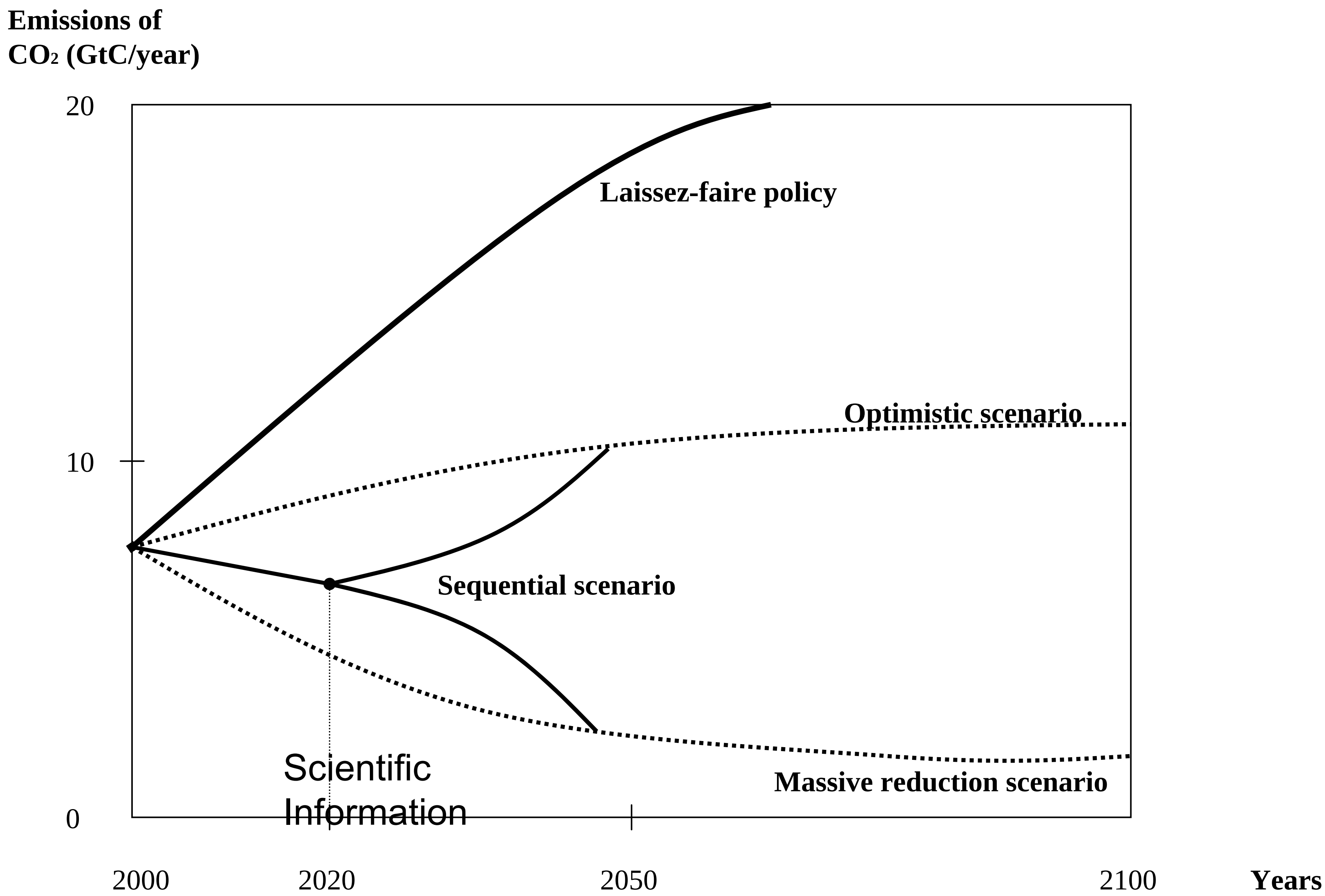
- Equivalent Definitions: Loi Barnier (1995), Convention on climate change (1992), Maastricht treaty (1995), Protocol on Biodiversity (2000)...

Over-Cautious?

- Greenpeace: *“Do not admit a substance unless you have proof that it will do no harm the environment”*

- Scientific uncertainty=>refuse any risk-taking

- Inconsistent with economic efficiency and the development of innovations



See: Intergovernmental Panel on Climate Change (IPCC), www.ipcc.ch

Sequential Decision Making

Climate change:

« *The challenge is not to find the best policy today for the next 100 years, but to select a prudent and flexible strategy and to adjust it over time* » (IPCC, 1995)

« *Measures should be periodically reviewed in the light of scientific progress, and amended as necessary"* » (European Commission, 2000)

=> Bayesian framework

Prevention vs. Precaution

Prevention	Precaution
Reduce the probability of occurrence of damages	Select flexible and temporary actions to wait for better scientific information
Static framework	Framework : Sequential
No information arrival	Information arrival

See Gollier and Treich (2003, JRU)

Development Project

- A project of development of a forest is considered.
- Total cost c. Current benefit b.
- Future discounted cash-flow X is unknown (e.g., loss of biodiversity)
- Investment Rule: Invest if $b-c+EX>0$
- Is it the best investment rule?

Alternative Rule

- One may want to wait until we know X.
- An alternative rule may be: « Do nothing today and invest in the future if $X=x>c$ »
- Expected profit of the alternative rule:

$0+ E\max(X-c,0)$

Alternative Rule

- Reminder: Alternative rule brings 0+ Emax(X-c,0)
- To be compared to Max(b-c+EX,0)

- Alternative rule: Loose b but gain the information value

- No info: There is no value of waiting
- With information, the alternative rule may be optimal
- Coined the (quasi-) option Value (Henry, 1974, AER)

- Key features: Information + Irreversibility
- Once the project is developed, cannot be stopped

Modelling the Decision Problem

- Decision Problem- No Information

$V0= Max_{d1}\ b\ d_1 + Max_{d2}\ (EX-c)\ d_2$

- Decision Problem- Perfect Information

$V1= Max_{d1}\ b\ d_1 + EMax_{d2}\ (X-c)\ d_2$

with d_1 in $D_1=\{0,1\}$ and d_2 in $D_2(d_1)=\{d_1,1\}$

The Decision Problem

Hence we retrieve:

V0= Max (b + (EX-c), 0)

V1= Max (b + (EX-c), EMax(X-c,0))

Modelling irreversibility constraints:

D_2(d1) represents irreversibility

If d_1=0 then d_2 in {0,1}

If d_1=1 then d_2=1 => irreversible choice

The « Irreversibility Effect »

- Assume that an *increase* in d_1 shrinks the decision set $D_2(d_1)$ - Does better information leads to *decrease* d_1?

- In other words, does it make sense to have more flexibility if better information is forthcoming?

Henry (1974, AER): Yes

Epstein (1980, IER): It depends

The Decision Problem

- Previous payoff (Henry): v(d1,d2,x)=bd1 + (x-c)b2

- General approach (Epstein): unspecified payoff v(d1,d2,x)

- Epstein (1980) showed that v must have a « separable form » for the irreversibility effect to hold

A Consumption-Resource Model**

- Illustration of non-separable payoff
- A cake can be consumed over three periods. The size of the cake is unknown.
- What is the effect of getting perfect information at date 2 on the consumption at date 1?

Eeckhoudt, Gollier and Treich (2004, EER)

The Consumption Model**

No Info

Max u(c1)+u(c2)+Eu(X-c1-c2)

u'(c2*)=Eu'(X-c1*-c2*) =u'(c1*)

Perfect Info

Date 2: Max u(c2)+u(x-c1-c2) => c2**=0.5(x-c1)

Date 1: Max u(c1)+2Eu(0.5(X-c1))

u'(c1**)=Eu'(0.5(X-c1**))

The Consumption Model**

=>under prudence, $c1^{**}>c1^{*}$: Perfect information increases, and not decreases, consumption!

Intuition:

- Perfect information: perfect smoothing in the future, less risk in the future => less precautionary savings today under prudence
- More information => less « cautious » in the short-run!