EPFL

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LEURE

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WHY ASSESS ENVIRONMENTAL & HUMAN IMPACTS AND RESOURCES ?

At least three possible applications

1. To decide about projects that involve environmental and human impacts and resources on a costs vs. benefits basis (CBA)
2. True costing
3. Indicators of sustainability

1. Decisions based on cost-benefit analysis

Is environmental protection action α_1 desirable?

D_{bau}	Damage under 'business as usual'
$D(\alpha_1)$	Damage if action α_1 is taken
$B(\alpha_1) = D_{bau} - D(\alpha_1)$	Benefit (or gain) of action α_1
$C(\alpha_1)$	Cost of action α_1

Action α_1 is desirable if

$$D(\alpha_1) + C(\alpha_1) < D_{bau} \Leftrightarrow B(\alpha_1) > C(\alpha_1)$$

NB: there are environmental impacts in D() and C()

1. Decisions based on cost-benefit analysis

Do the environmental benefits justify a costly project?

E.g.:

- 70m bridge for animals over highway costs CHF 4.3 mio.
- Longer railway tunnel between Mattstetten and Rothrist, that reduces impact on landscape and noise costs CHF 16.4 mio.
- Both were built

Contingent evaluation of willingness to pay of concerned population: animal bridge has greater benefits than costs, longer railway tunnel not

In the latter case, political motives outweighed the costs

Strong controversy every time

14-MILLIONEN-PROJEKT

Streit um Wildtier-Brücke: «Jeder Frosch, der über die A1 hüpft, kostet 100'000 Franken»

von Fabian Hägler — az Aargauer Zeitung • Zuletzt aktualisiert am 30.8.2016 um 11:04 Uhr

Die A1 bei Suhr - hier soll für 14 Millionen die Wildtierüberführung Rynetel gebaut werden.
© Sandra Ardizzone

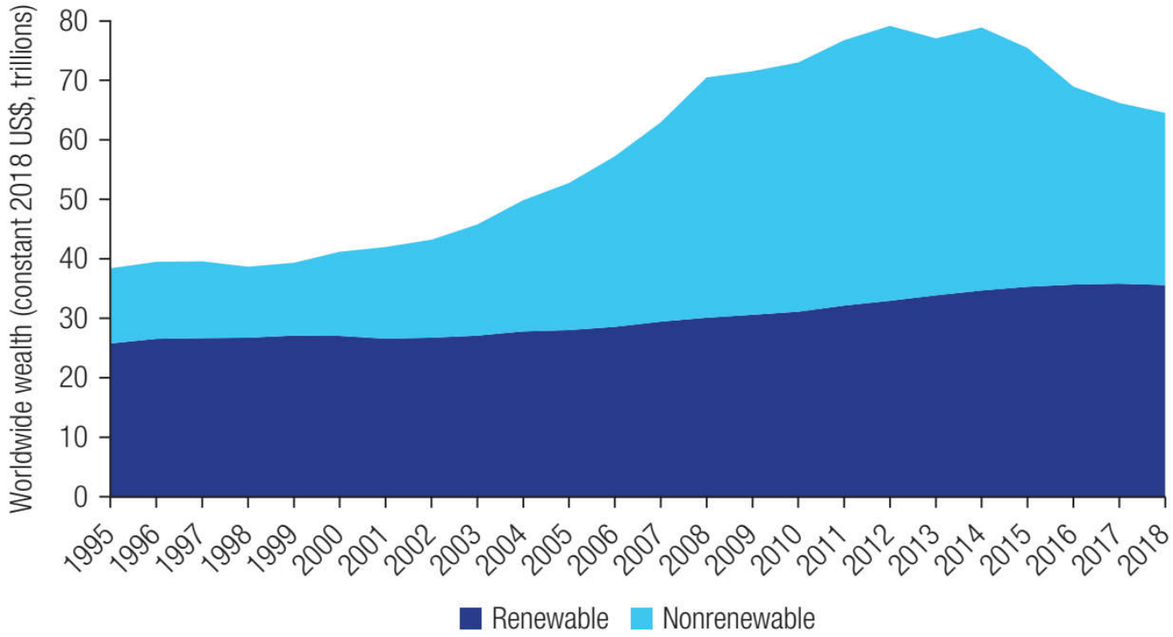
2. True costing

- **Market competition** is only efficient if all competitors bear all the costs and get all the benefits of their actions: level playing field, internalisation of external costs and benefits, true prices

- **Polluter pays** all costs, and not only clean-up costs, only when remaining environmental impacts are adequately priced and billed
- **Compensation of victims** goes beyond coverage of their expenses only when immeasurable damage and losses are estimated

3. Indicators of sustainability

- **Green national accounts**: to show the costs of economic growth (e.g. depletion of natural resources)
- **Natural capital** in wealth accounting
- To **aggregate** various environmental indicators in a common unit



Evolution in natural capital wealth
World, 1995-2018

World Bank (2021) *The Changing Wealth of Nations 2021*, Figure 3.14

Pro and cons

Pro:

- Decisions can be based on encompassing comparison of costs and benefits
- Some value is attached to natural resources and their protection

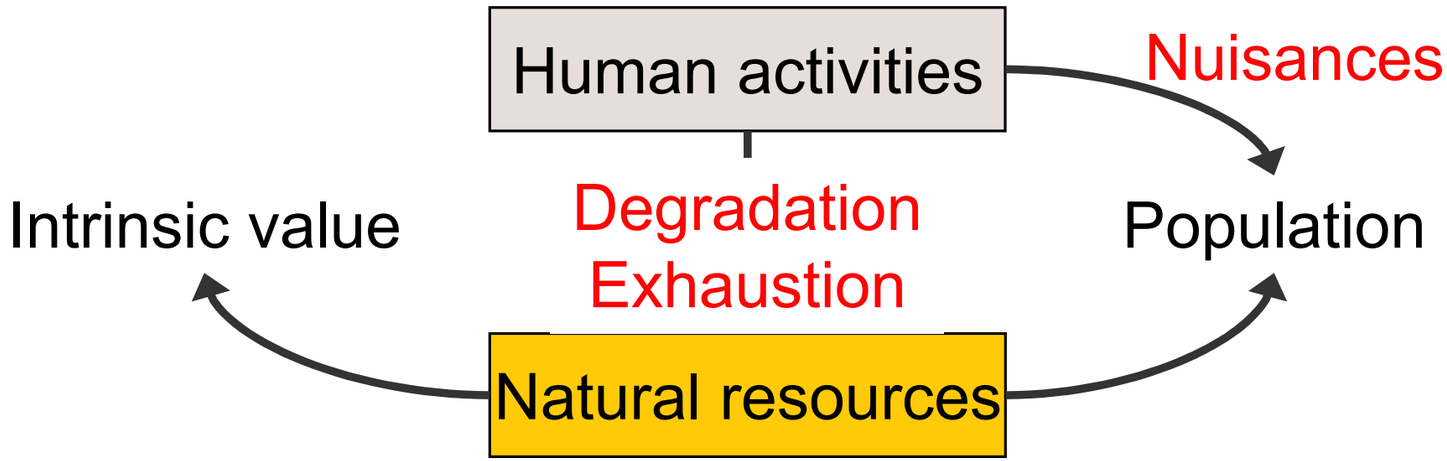
Contra:

- The first stage of listing and analysing environmental effects already increases awareness
- Monetarisation: natural resources and people are treated like commodities
- The valuation of environmental goods is necessarily people-centred

PRINCIPLES OF IMPACTS AND VALUES

Environmental & human impacts and resources

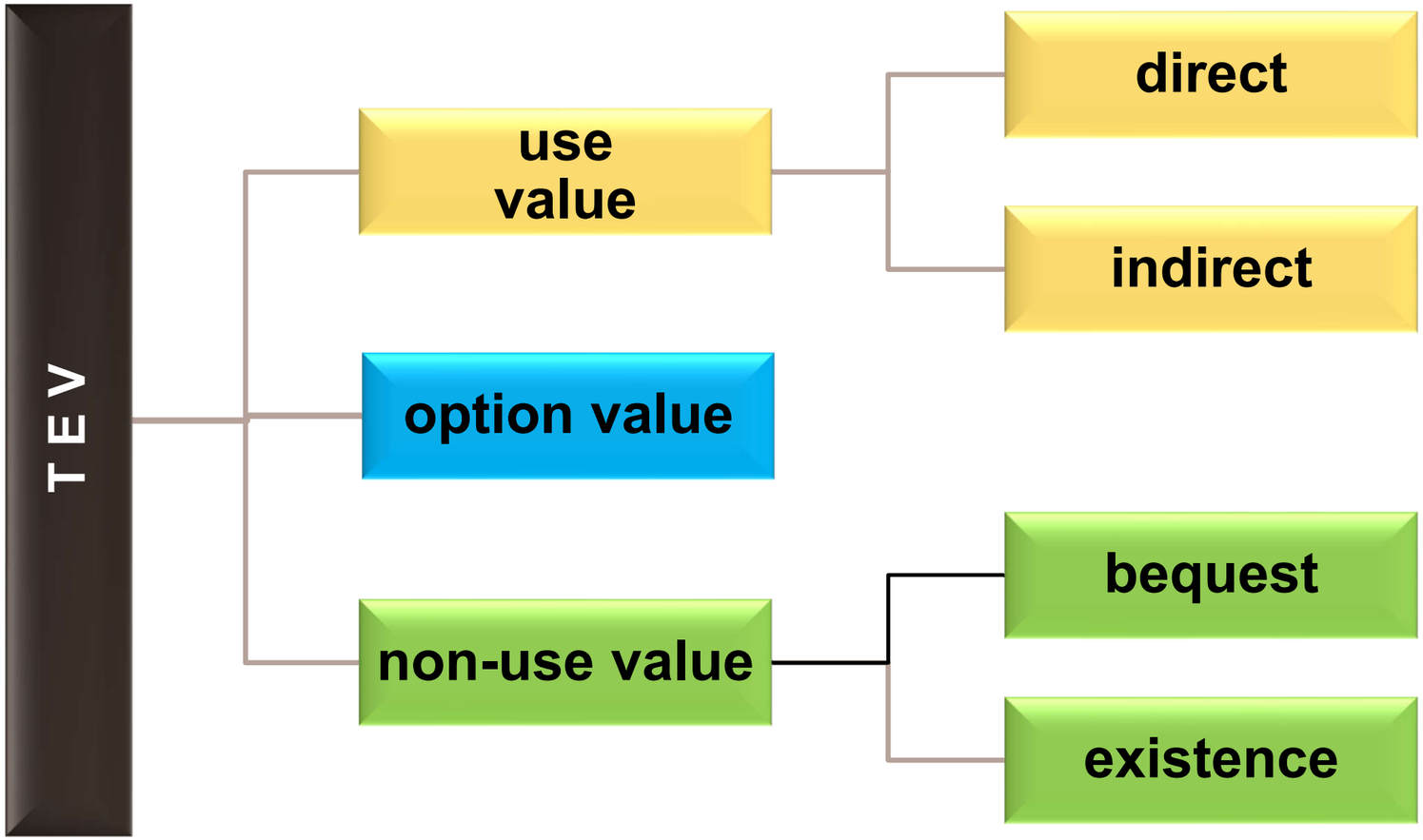
- **Value** of natural resources: air, water, plants, animals, landscapes, minerals
- **Cost** of environmental & human impacts:
  - Degradation of natural resources
  - Health risks for populations
  - Nuisances for populations
  - Impacts on productivity (indirect effects)



Why is someone willing to pay to preserve, e.g., a forest ?

- She can use the forest (walks, mushrooms, branches, or just looking at it): **direct consumption use value**
- She can exploit the forest (logging): **production use value**
- The forest provides services she would otherwise have to pay for (eco-system services): **indirect production value**
- She might benefit from the plants and animals in the forest in the future (biodiversity): **option value**
- She might be happy to know that the forest exists: **existence value**, a part of **non-use value**
- She might also take into account the value of the forest to **other people** and **future generations**, another part of **non-use value**

Classification proposed in many textbooks



Source : Soguel N. (1994), *Evaluation monétaire des atteintes à l'environnement : une étude hédoniste et contingente sur l'impact des transports.* Neuchâtel: EDES-Editions de la Division économique et sociale, p.6.

TEV of Wetlands

DIRECT VALUES	INDIRECT VALUES	OPTION VALUES	NON-USE VALUES
Production and consumption goods such as: Water, Fish, Firewood, Building poles, Thatch, Wild foods Medicines, Crops, Pasture, Transport, Recreation, *… etc …*	**Ecosystem functions and services such as:** Water quality and flow, Water storage and recharge; Nutrient cycling; Flood attenuation, Micro-climate, *… etc …*	**Premium placed on possible future uses or applications, such as:** Agricultural, Industrial, Leisure, Pharmaceutical, Water use, *… etc …*	**Intrinsic significance of resources and ecosystems in terms of:** Cultural value, Aesthetic value, Heritage value, Bequest value, *… etc …*

Source : Emerton L. (2005), *Values and Rewards: Counting and Capturing Ecosystem Water Service for Sustainable Development*, IUCN Water, Nature and Economics Technical Paper N.1, Cambridge (UK): IUCN-The World Conservation Union. P.4

Different components of value

- Some benefits from natural resources are easier to measure than others
- Ideally, the easier to measure benefits are sufficient to justify protection
- E.g.: the value of the blue whale is certainly greater than the commodities derived from it, but if those commodities justify limiting whaling until a stable population is restored, that makes the proof easier (Spence, 1974)

FIRST DISTINCTION BETWEEN ASSESSMENT METHODS

First distinction

Not based on individual preferences	**Based on individual preferences**
Damage function	Stated (expressed) preferences
Production function	Revealed preferences

DAMAGE FUNCTION METHOD

Principles

1. Impact: measure physical or health relation between some environmental attribute (e.g. pollution) and some damage (e.g. sickness, damage to buildings, lost crop)
2. Cost: apply unit price to working days lost, cleaning up, lost crop

Not individual avoidance expenditure, because that would be a revealed preferences approach

Example (1)

Costs of traffic congestion, 2014:

- Light vehicles (cars + light trucks) lost 27.85 million hours/year in traffic jams and heavy vehicles (heavy trucks + buses) 1.09 million hours
- Estimate: 1h lost = 41.6 CHF for light vehicles, 80.8 CHF for heavy vehicles
- Source: SN 641 822a (Zeitkosten Personenverkehr), SN 641 823 (Zeitkosten Güterverkehr) and SN 641 827 (Betriebskosten von Strassenfahrzeugen)
- Cost = 27.85×41.6 + 1.09×80.8 = 1245 MCHF
- Add costs for congestion related accidents, additional fuel use and air pollution

Mario Keller (MK Consulting) u. Philipp Wüthrich (Infras), “Neuberechnung Staukosten Schweiz", Schlussbericht zH des Bundesamtes für Raumentwicklung, Juni 2016

Example (2)

Impacts of road-traffic related air pollution on buildings (2010):

- Inventory of effects on building facades: additional cleaning costs, additional renovation costs, shortened life-expectancy
- Identification and measurement of immissions: PM10 dirties inside rooms, darkens facades and corrodes materials
- Distinction by source of PM10, type of agglomeration, type of facade and building use
- Data: surfaces affected (m^2) and costs per m^2
- E.g. cleaning costs: 166 million m^2 of windows and glass and metal facades, of which 11.4 million m^2 are exposed to PM10 and commercially cleaned; additional cleaning: 1/year at 5.25 CHF/m^2 cleaning costs; total cost = 11.4 x 5.25 = 59.9 million CHF

Ecoplan/Infras, “Externe Effekte des Verkehrs 2010. Monetarisierung von Umwelt-, Unfall- und Gesundheitseffekten”, Schlussbericht zH des Bundesamtes für Raumentwicklung, 14.06.2014

Limits of this method

- Often based on actual clean up and remediation, even when it is only partial
- Victims are often assumed to be perfectly passive: no self protection, no change in activity (e.g. replacing crops)
- Prices are assumed to be unaffected

PRODUCTION FUNCTION METHOD

Principles of production function method (1)

- Augment a production function with environmental factors; when environmental factors change:
  - by how much is output reduced?
  - or by how much must other inputs be increased to maintain production?

Output Q = f(K,L,M,E,P,T)

K = capital, L = labour, M = intermediate goods, E = energy,
P = precipitations, T = temperature

Principles of production function method (2)

- Consider all alternatives
- Take the change in prices triggered by the change in production into account (output loss is partly offset for producers by price increase)
- The error from omitting this market effects is of second order for total damage, but the allocation of gains or losses between producers and users (consumers) is wrong

Impact on agricultural output and land value

Estimation of impact of global warming on agricultural land values:

- Estimate an econometric land value function by regressing the average price of agricultural land in US counties on soil characteristics, temperature and precipitations
- Allow for changes in crops
- Simulate a uniform increase of temperatures by 5°F and precipitations by 8%
- Some northern counties will have higher land values, most southern counties will have lower land values
- Global effect is slightly positive, thanks to gains on the irrigated western and southern lands (sunbelt)

Mendelsohn, Robert, William Nordhaus et Daigee Shaw (1994) "The impact of global warming on agriculture: A Ricardian analysis", *American Economic Review* 84(4)

Shifting crops

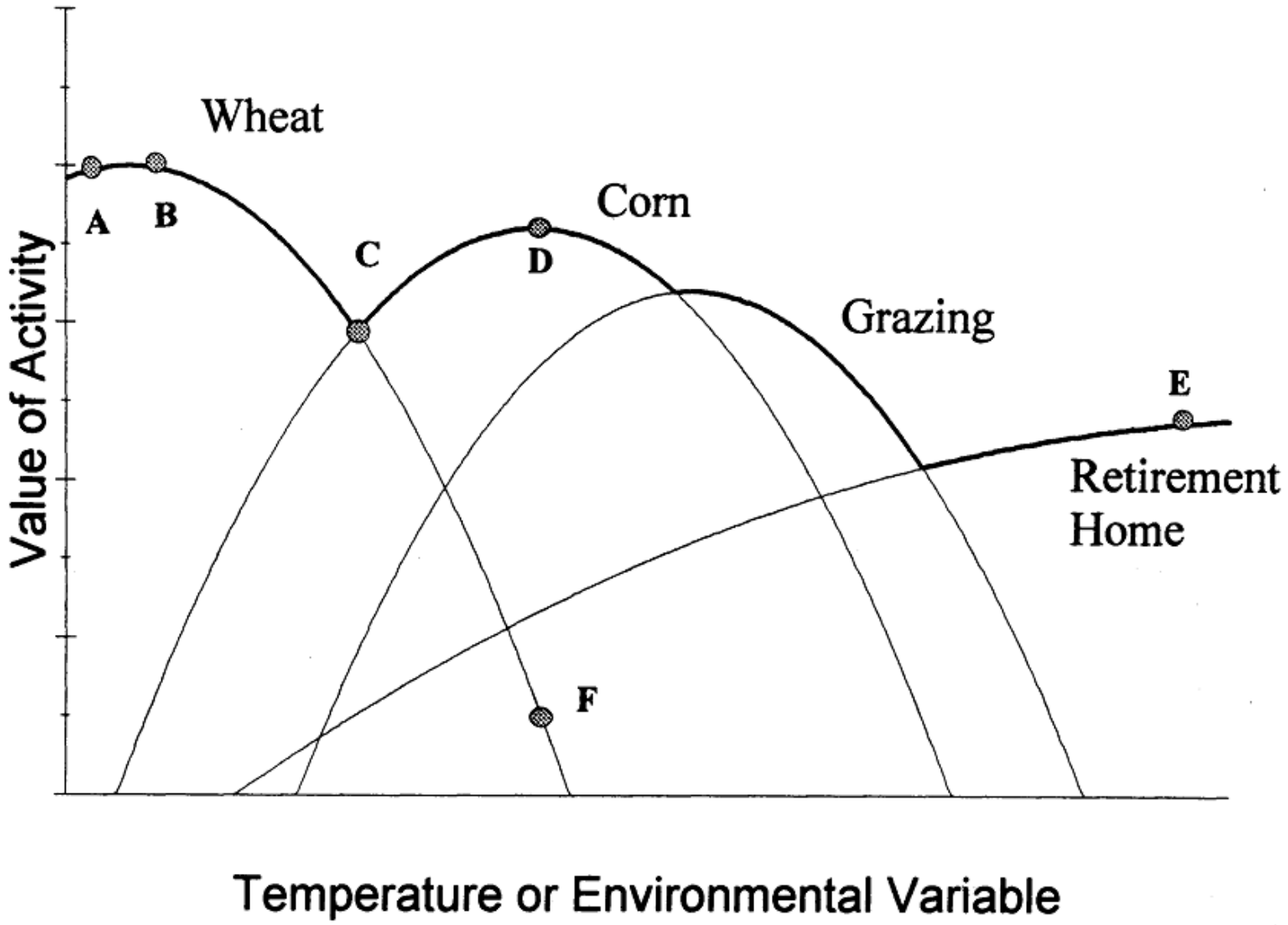


FIGURE 1. BIAS IN PRODUCTION-FUNCTION STUDIES

Mendelsohn, Robert, William Nordhaus et Daigee Shaw (1994)

Winners and losers

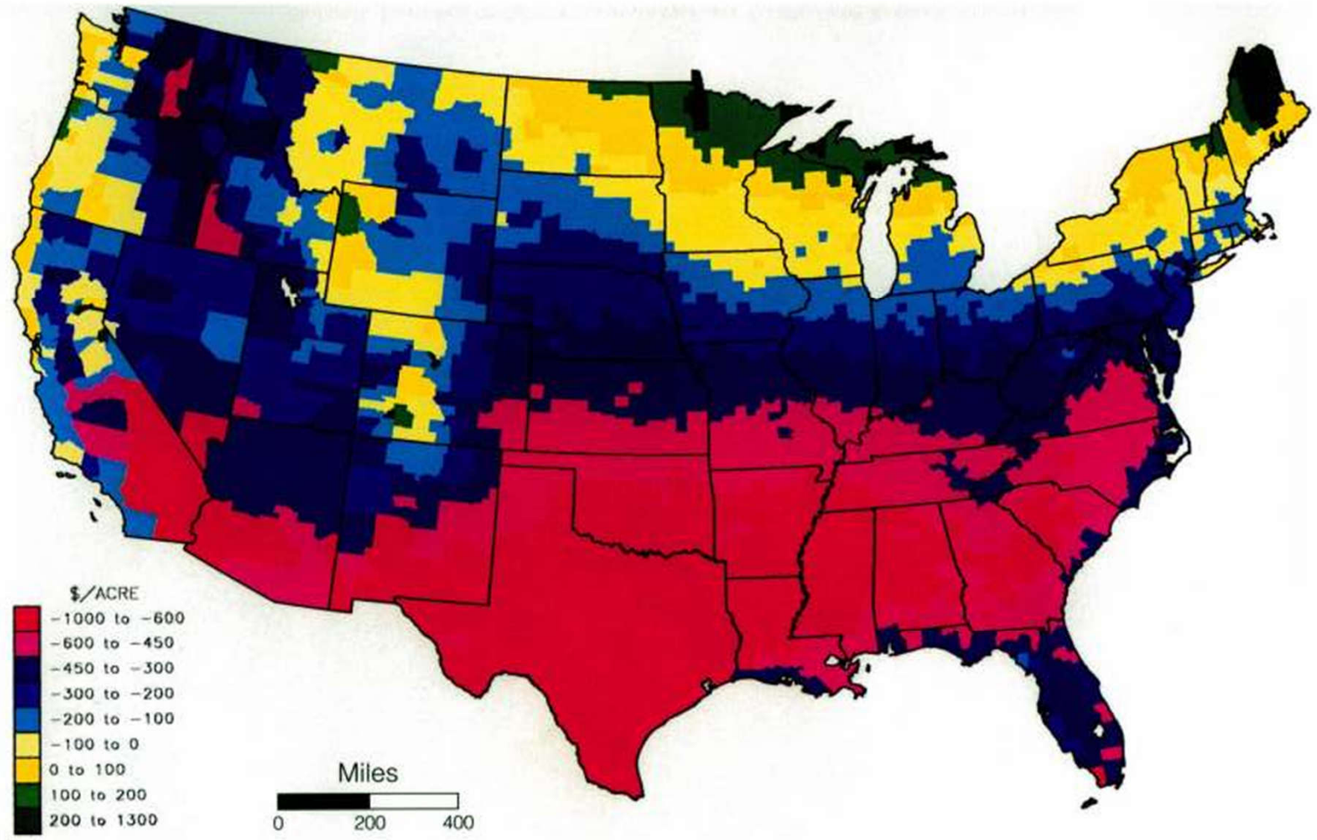


FIGURE 4. CHANGE IN FARM VALUE FROM GLOBAL WARMING: CROPLAND WEIGHTS
Note: The map shows the change in terms of dollars per acre for a 5°F uniform warming and an 8-percent increase in precipitation, 1982 prices.

Mendelsohn, Robert, William Nordhaus et Daigee Shaw (1994)

PREFERENCE-BASED ASSESSMENT METHODS

Principles

Assessment is

- centred on people
- based on their preferences
- monetary

Key concepts for translating preferences into money are

- willingness to pay (WTP) and willingness to accept (WTA)
- *similarly, compensating variation (CV) and equivalent variation (EV)*

WTP and WTA

"good" environment — *deterioration* → "bad" environment

WTP to avoid this
WTA in compensation for this

"good" environment ← *improvement* — "bad" environment

WTP to get this
WTA in compensation for not getting this

In general, these WTP and WTA are close, but they need not be equal, because paying and accepting money are not equivalent, and because the starting point is not the same

Personal improvements and deteriorations

Improvement	Deterioration
To enjoy more of a natural resource	To be deprived of part of a natural resource
To be better protected from pollution	To be exposed to more pollution
To be allowed to discharge more	To be forced to clean up

In green: environmental "goods", in orange: environmental "bads"
This shows that for every “bad” there is a “good”

Two families of assessment methods

- **Revealed Preferences** approach
  - Observation of people buying or selling on a market
  - Observation of people in a controlled experimental setting
- **Stated Preferences** approach
  - Asking people about their willingness to pay or willingness to accept a compensation for a change in the state of the world (environmental change, policy change, etc.)

Further decomposition of methods

	Indirect	Direct
Revealed Preferences → Surrogate Market	▪ Household Production Function (HPF) Approach: • **Averting Costs (AC)** • **Travel Costs Method (TCM)** ▪ **Hedonic Price method (HPM)**	▪ Replacement Costs Method (RCM)
Stated Preferences → Hypothetical Market	▪ Contingent Ranking (CR) ▪ Choice Modelling (CM)	▪ **Contingent Valuation Method (CVM)**

Bold faced = methods that will be presented hereafter

REVEALED PREFERENCES

Revealed preferences

- There is no market for environmental goods, but there are markets for related products. Hence these methods:
  - Avoidance or averting costs
  - Market price of related products
  - Travel cost method
  - Hedonic method
- Revealed preference methods generally get their data at much lower costs than stated preference approaches, so they use much larger data sets

Averting costs

- E.g. spending on double-glass windows against noise
- Buying bottled water when tap water is contaminated
- Limitations
  - there may be many ways to avoid suffering from a nuisance
  - the measure taken to avoid a nuisance can have other positive effects (e.g. double-glass windows reduce heating energy need, bottled water can be sparkling)

Travel cost method (TCM)

- In the 1940s, the US National Park Service asked eminent economists to help value its parks
- Harold Hotelling outlined the travel cost method in 1947
- This method only estimates a **use value**
- It uses travel costs as prices paid for use of service and estimates a demand function; WTP for use of site is **consumer surplus**
- E.g.: individual A who lives close to the site spends $10 to visit once and B who lives far away spends $100; if we may assume that A and B have the same preferences, then A would have been willing to spend $100; his surplus is $100 – $10 = $90

HEDONIC PRICE METHOD (HPM)

Basic idea

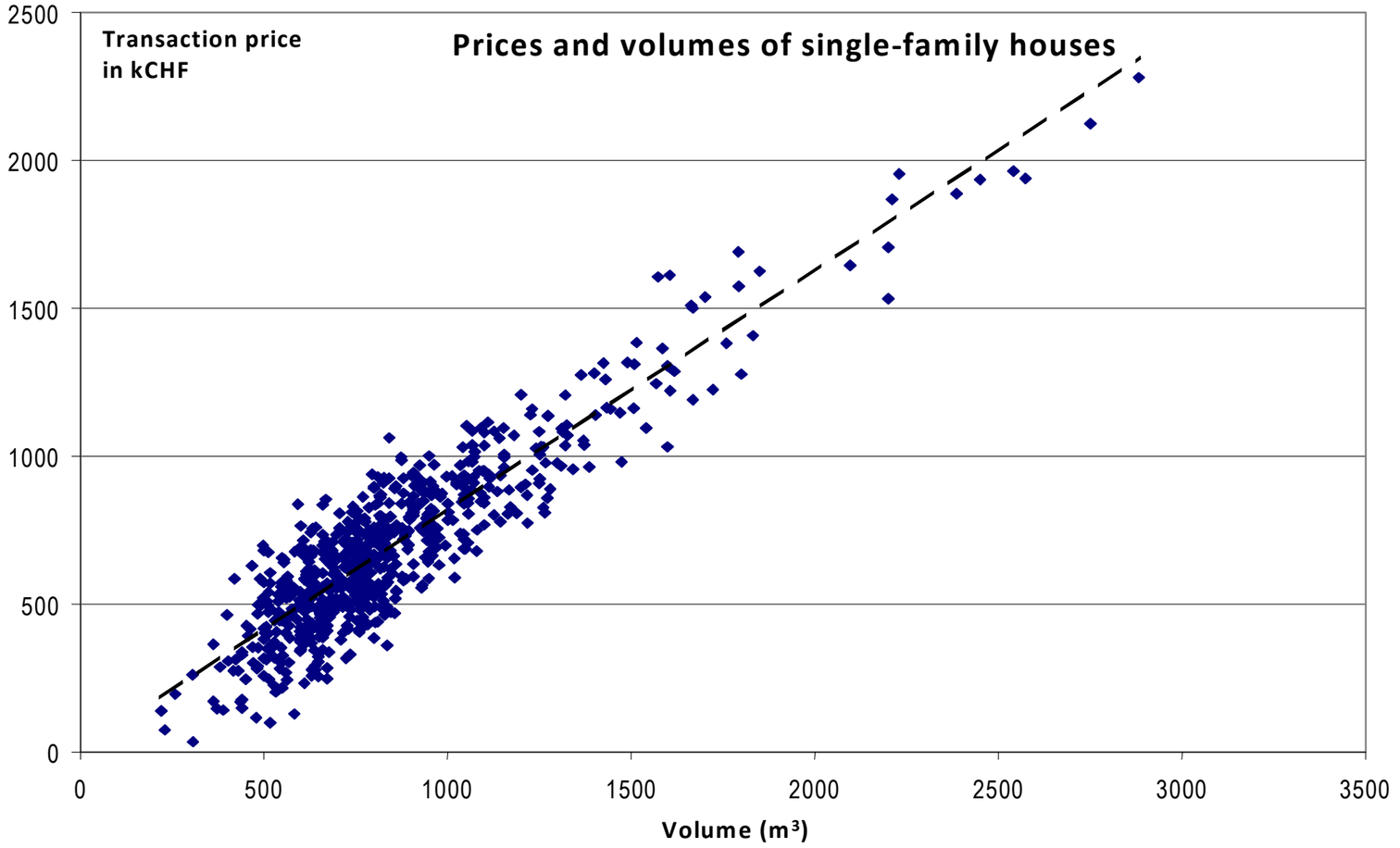
- Real estate markets: nuisances are compensated by lower prices or rents or hotel room rates (WTA); nice locations command a premium (WTP)
- Labour market: risks of sickness, injury or loss of life are compensated by higher wages (WTA)
- Challenge: to separate the premium from the other determinants of rent, price or wage

Basic method

- When we buy a heterogeneous good, we buy a **bundle of attributes** or characteristics
- Our willingness to pay reflects the value to us of these attributes
- The production cost also depends on these attributes
- Hence the price of the good is a combination of the implicit (shadow) prices of the various attributes
- The HPM is a statistical method designed for identifying the relevant attributes of heterogeneous goods and for estimating the implicit prices of these attributes

Example (1)

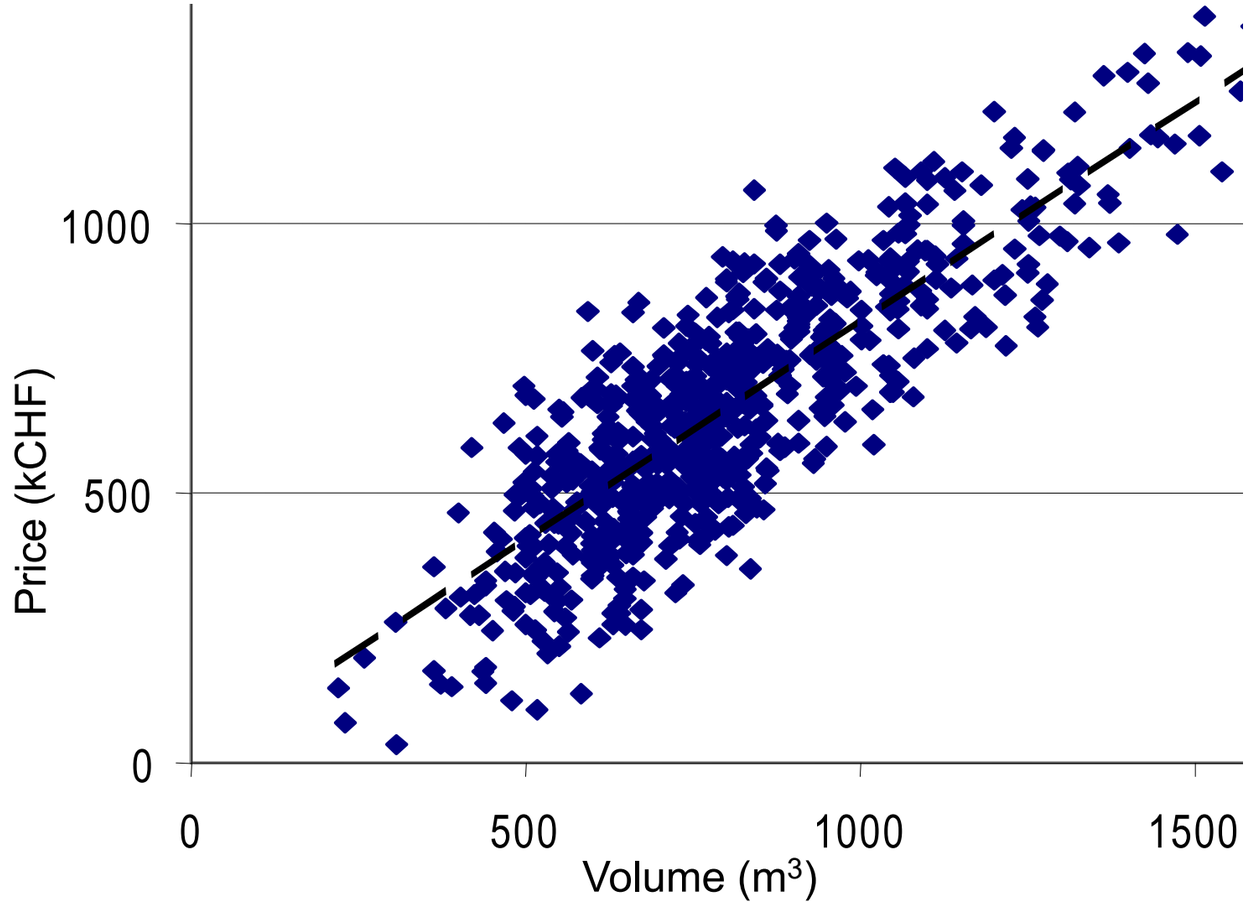
The price of single-family houses explained by their volume:
price = 814 CHF × volume



CIFI-Centre d'Information et de Formation Immobilières SA

Example (2)

The price of single-family houses explained by their volume:
price = 814 CHF × volume

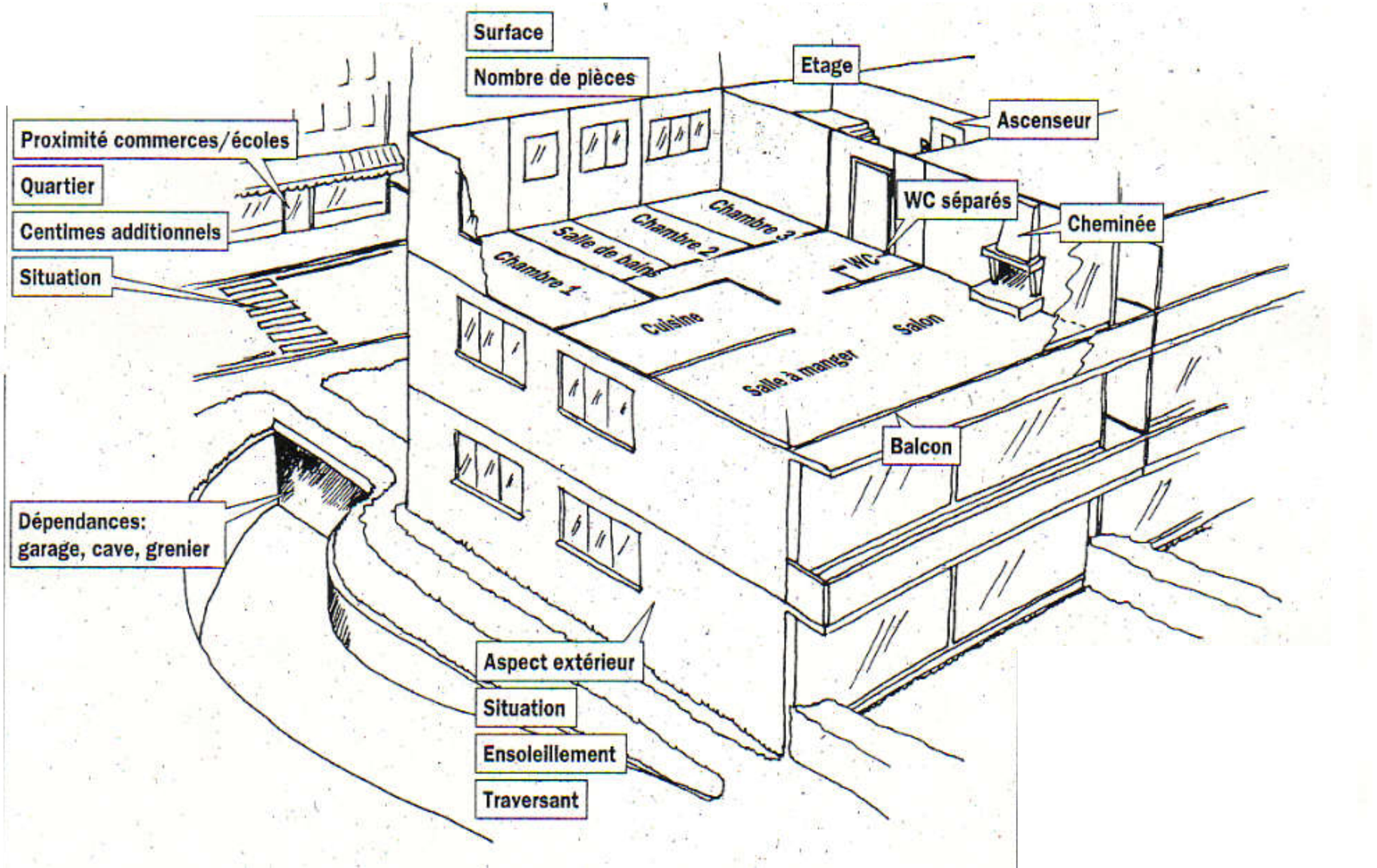


A closer look shows:
The fit is not that good!

Example (3)

- Price explained by the volume of each house
  - ► Price = 814 CHF × volume
- Price explained by the volume and the age of each house
  - ► Price = 843 CHF × volume – 8'730 CHF × age
- Price explained by the volume and the age of each house and by the surface of land
  - ► Price = 468 CHF × volume – 8'560 CHF × age
    + 662 CHF × surface of land
- Etc.

More generally, for housing



Basic Model – fundamental assumptions

- The quality of a market good can be described by a set of measurable characteristics
- These characteristics are the explanatory variables of the hedonic price function that explains the (relative) prices of the different varieties of this market good:

$$P_j = \alpha_0 + \alpha_1 X_{1j} + \alpha_2 X_{2j} + \ldots + \alpha_n X_{nj} + \varepsilon_j$$

$$P_j = \beta_0 X_{1j}^{\beta_1} \times X_{2j}^{\beta_2} \times \ldots \times X_{nj}^{\beta_n} \times (1 + \varepsilon_j)$$

- P_j is the price of variety j of the good, X_{ij} is the value for variety j of characteristic i, and α_i is the implicit price of that characteristic to be estimated using econometric techniques (regression analysis)
- In the multiplicative model, β_i measures the proportional change in the price of the good for a 1% change in X_i
- ε_j is the part of the price of variety j that cannot be explained by the model; the statistical analysis aims at minimizing ε_j

Estimated housing hedonic price function (Neuchâtel 1989)

Variables indépendantes		*Paramètres estimés*	
Structure de l'immeuble			
BUAN	variable binaire : buanderie commune = 1, sinon = 0	0,209 *	(2,026)
ln CHPRO	nombre d'années depuis le dernier changement de propriétaire	-0,132 **	(-6,663)
CONC	variable binaire : service de conciergerie = 1, sinon = 0	0,0824 *	(2,340)
COOP	variable binaire : l'immeuble appartient à une coopérative = 1, sinon = 0	-0,202 **	(-3,008)
GER	variable binaire : immeuble administré par une gérance = 1, sinon = 0	-0,155 **	(7,314)
LIFT	variable binaire : ascenseur = 1, sinon = 0	0,216 **	(8,291)
MAIN	variable binaire : maintenance de l'immeuble au cours des 10 dernières années = 1, sinon = 0	0,0919 **	(3,463)
ln NBAP	nombre d'appartements	-0,210 **	(-8,442)
Structure de l'appartement			
ATTIQ	variable binaire : appartement en attique = 1, sinon = 0	0,485 **	(4,316)
BALC	variable binaire : balcon ou terrasse = 1, sinon = 0	0,0875 *	(2,533)
ln CHLOC	nombre d'années depuis le dernier changement de locataire	-0,0568 **	(-5,241)
ISOL	variable binaire : isolation particulière des fenêtres contre le bruit = 1, sinon = 0	0,105 *	(2,407)
ln NIV	niveau sur lequel se situe l'appartement, rez-de-chaussée = 1	0,0555 **	(3,074)
ln PIECE	nombre de pièces, sans cuisine, ni salle de bain ou toilettes	0,577 **	(18,986)
RENOV	variable binaire : appartement rénové au cours des dix dernières années = 1, sinon = 0	0,0836 *	(2,536)
Localisation			
BRUIT	niveau de bruit diurne, en *dB(A)*	-0,00914 **	(-5,183)
ln CEN	distance jusqu'au centre-ville, en mètres	-0,0682 **	(-3,978)
Constante		7,334 **	(36,796)
R^2 corrigé		0,797	

Soguel N. (1994), *Evaluation monétaire des atteintes à l'environnement : une étude hédoniste et contingente sur l'impact des transports.* Neuchâtel: EDES-Editions de la Division économique et sociale, p.6.

Hedonic assessment of WTA risk in wages

Estimate equation of individual wages with characteristics of:

- employee (education, experience, nationality, gender)
- employer (size, region, public sector)
- job (responsibility, stability, schedules, overtime)
- and a measure of risk of death (#death/10 000 employees)

Estimated coefficient suggests wage premium of CHF 600 at mean risk of one dead/15 600 employees

⇒ **Value of statistical life = CHF 9.4 mio** (= 600×15 600)

Baranzini, Andrea et Giovanni Ferro Luzzi (2001) "The economic value of risks to live and health: Evidence from the Swiss labour market", *Swiss Journal of Economics and Statistics* 137(2): 149-170

CONTINGENT VALUATION METHOD (CVM)

Basic Idea (1)

- Can serve to estimate use value & non-use value
- Wide fields of application and flexible tool
- Survey people and ask them directly about their WTP or WTA
- Create hypothetical (contingent) situation in which the environmental good or bad exists or does not exist anymore

The wording of the elicitation question

	Change in the state of the world, in the quality or in the quantity of the good	
	Reduction	**Improvement**
WTP	«How much would you be willing to pay to avoid a reduction in the quality or quantity of the good?»	«How much would you be willing to pay to obtain an improvement in the quality or quantity of the good?»
WTA	«In exchange for which compensation would you accept a reduction in the quality or quantity of the good?»	«In exchange for which compensation would you accept to forgo an improvement in the quality or quantity of the good?»

Basic Idea (2)

- Value revealed in monetary terms: "how much would you be willing to **pay** to benefit from this service or this investment?"
- Hence, the CVM allows us to know directly (i.e. without econometrics) the price of the characteristic of interest
- However, econometrics are used to **explain** the WTP or WTA
- This makes it possible to test whether people answered carefully and truthfully or randomly, or even with bias

Different formats

- Open-ended question: ‘what is the maximum amount you would be willing to pay?’
- Auction format: ‘would you accept to pay 10 €? 20 €? etc.’
- Random numbers: ‘would you accept to pay x €?’, then construct distribution of x
- Referendum format: ‘if policy is implemented, your tax bill would go up by x € : would you accept this?’

Problems of the method

- Designing the contingent scenario to be truthful and complete yet understandable and unbiased
- Can people estimate non-use values, i.e. their WTP for preserving something they will never use?
- WTP may depend on the payment model used
- Inclusion bias if not all the components of the policy are included in the assessment
- Sampling and administration
- Analysis and inference
- Free riders

Problems of the method

- People have difficulty assessing a hypothetical situation
- Strategic answering
- Influence of how questions are phrased and who asks the questions
- Influence of how payment would be made

Sneezing in Times of a Flu Pandemic: Public Sneezing Increases Perception of Unrelated Risks and Shifts Preferences for Federal Spending

The interviewer sneezed and coughed while conducting a survey on federal budget priorities (i.e. should the government spend money on vaccine production or on green jobs?). Participants were more likely to favor federal spending of $1.3 billion on the production of flu vaccines rather than the creation of green jobs when the experimenter sneezed.

Lee, S. W. S., Schwarz, N., Taubman, D., & Hou, M. (2010). Psychological Science, 21(3), 375–377. https://www.jstor.org/stable/41062217

Respondents to the CVM study may have overvalued the bug in order to block the highway they did not like

Le scarabée pique-prune
Osmoderma eremita
Hermit beetle

Le scarabée pique-prune bloque l'autoroute A-28

Ouest-France - 14/15 août 1999

L'autoroute A-28
Alençon - Le Mans - Tours

Vote on minarets:
2 weeks before vote, 37% say no to minarets, on day of vote (29.11.2009), 57%!

Referenda

- People vote on some environmental protection measure: if they accept it, they value the benefits more than the costs
- Limitations
  - What understanding of benefits and costs?
  - Low and non-representative participation rates
  - Reveals only an upper or lower bound