Maurice Huguenin-Virchaux, 18. 01. 2017

Summary for Policy Makers - Natural Resource and Environmental Economics

Chapter

1

Introduction

what it is
- allocation & distribution of scarce resources

why care
- prices reflect scarcity of good & often do not exist (what is price of existence of polar bears?)

economic dimensions
- efficiency & allocation both intertemporal and intertemporal

classification
- renewable & non-renewable resources (regeneration > 1000 a)

classic vs. neo-classical development
- classical: Smith (market allocation), Malthus (convergence of living standard), Ricardo (distribution according to marginal products), Mill (nature's beauty as value)
- neo-classical: Jevons, Menger, Marshall (marginal theory → today's microeconomics & optimal allocation) as well as utilitarianism & externalities

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Ethics, welfare economics and the environment

normative foundations which can be applied to alloc. & distr.
- utilitarianism → individual benefit, welfare, luck & no concept of equality
- liberalism → importance on individual rights & freedoms, property right = legitimate, no/limited gov. intervention

measuring individual & societal utility
- individual utility → $U = U(C)$
- welfare → $W = W(U_1, U_2, U_3, ...)$

discounting affecting future utility/welfare

$$W = \sum_{t=0}^{inf.} \frac{U_t}{(1+r)^t} \; with \; r = discount \; rate$$

- utility today worth more than tomorrow → r allows mapping of conflicts between objectives and requirements of env. & res. economics

fairness according to Rawls
- fair distribution by consensus of free, rational & independent individual
- decisions under 'veil of ignorance' (i.e. choice solely based on moral consideration)
- utilitarian interpretation: max U of worst-off individual
- intertemporal interpretation: max W of generation which is worst-off

how markets failure arise
- markets do not consider from natural resources
  - all individual benefits
  - all central ecological functions
  - all costs of utilisation or exhaustion

correction mechanisms
- policy → often imperfect & often self-serving for politicians
- 'voluntary action' → problem with unequal participation

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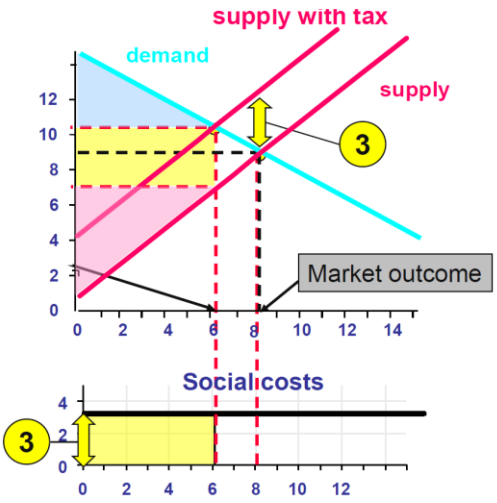
Externalities

most important class of market failure
- + externalities(e.g. bees pollinate nearby orchard)
- - externalities (e.g. pollution)
- negative externalities ≙ supply too high than socially desired (and vice-versa)

internalization of externalities by the government

externalities arise when production / consumption of anyone has impact on someone else's utility & no compensation is made by the generator said effect.

- facilitate voluntary, decentralised internalisation of externalities (campaign)
- Command & Control (C&C) instruments
  - taxation of negative externalities → Pigouvian tax
  - non-transferable emission licences
  - impose minimum technology standard
  - location (move people away from pollution)
  - set cap on allocable number of permits
  - direct production of environmental quality (e.g. wildlife reserve)
- economic incentive (quasi-market) instruments
  - emission taxes & pollution abatement subsidies
  - marketable permit trading system
  - protection of patents



Pigouvian tax and its mechanisms

- tax shifts marginal private cost curve up by amount of tax (e.g. + 3 units)
- producers have incentive to reduce output to the socially optimum level
  - less production → less pollution
  - firm pays price for remaining emissions

private solutions to the externality issues

- moral obligation
- non-profit organizations
- integration of different business models
- Coase Theorem

Coase Theorem and its mechanisms

- i.e. internalization of externalities by bargaining without state interference
- based on heavy assumptions such as
  - no transaction costs
  - perfect communication
  - perfect information, etc.
  - does not make statement about distribution of fairness

public goods may lead to market failure & free-riding

		excludability: yes	excludability: no
rivalry	yes	private goods → swimming pool in July	public resource → beach in July
	no	examples for goods → swimming pool in April	public goods → beach in April

- they are non-excludable & non-rival in consumption
- consumers do not pay
- everyone can use as much as he/she likes → incentive for overuse of resource which creates externality
- impossible (or too expensive) to exclude potential users
- solution: government provides public good which they finance (e.g. wildlife reserve)

provision of public good may result in prisoner's dilemma

- e.g. creation of a road to two homes (if each home owner maximizes his/her own utility, road will not be built)
  - to arrive at equilibrium * → maximize utility of one player while ignoring the other one's (e.g. player A increases its utility if he/she does not pay)
  - Nash equilibrium → A: no cooperation, B: no cooperation

		Player B: pay for road	Player B: do not pay
		A B	
Player A	pay for road	(3, 3)	(1, 4)
	do not pay	(4, 1)	(2, 2)*

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Public Policy

internalisation of externalities by the government

- Command & Control instruments
  - Pigouvian tax
  - licences
  - set technology standard
  - set living location (away from pollution)
  - set cap on allocable number of permits
  - direct production of environmental quality (e.g. wildlife reserve)
- economic incentives

- campaign
- emission taxes & pollution abatement subsidies
- marketable permit trading system
- set ambient pollution standard

- protection of patents

efficient abatement by marketable permit system

$$p_{eq.}(permit) = MC_{abatement}(full\ industry)$$

- if price were higher than MC → all firms would abate which would lead to oversupply & ↓price
- if price were lower than MC → all firms would buy permits which would lead to overdemand & ↑price

double dividends

- achieving better environmental quality & increase efficiency
- tax income (from Pigouvian tax or permits) can be used to lower other taxes
- decreasing those distorting taxes (e.g. 'income tax' which incentivizes you to earn less) leads to efficiency increase
- triple dividend if people innovate more

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Non-renewable Resources

- produced by geological processes over millennia (e.g. oil, coal, gas, minerals, etc.)

crude oil price development

- heavy fluctuations due to political & socio-economic changes
  - conflict over property rights in the 70ies, Yom-Kippur War '73, Iran Crisis '79, 1st Gulf War, 9/11
- newer price fluctuations due to economic growth of India & China → increased demand

potential of energy resources

- technically & economically exhaustible stock: ~40-50 years left
- known & supposed reserves: ~200 years left

the Hotelling Rule

efficient outcome where marginal net benefit of using one unit of output for consumption equals marginal net benefit when it is added to capital stock:

$$\hat{p}_t\ (growth\ rate) = \frac{\dot{p}_t}{p} = r \qquad \rightarrow \qquad p_t = p_0 e^{rt}$$

trade-off: extract more now, put money in bank & get interest rate *r* vs. keep stock underground since price will go up (resource rents increase since overall less stock is available)

limitations

- discount rate constant over time
- extraction costs not considered
- necessary but not sufficient condition for optimality

uncertainties

- total stock unknown
- new discoveries increase known stock
- distinction between known stock & economic viable stock
- R&D can change extraction costs, size of known stock, magnitude of econ. viable stock & estimates of damages from resource use
- about backstop technology → if earlier than expected, resource price lowers, later ≙ price increases

$\frac{\pi^R_1}{\pi^R_0} > 1+r$ → Keep the resource stock fully in the ground

$\frac{\pi^R_1}{\pi^R_0} < 1+r$ → Sell the whole resource stock

$\frac{\pi^R_1}{\pi^R_0} = 1+r$ → Equilibrium (no arbitrage possible)

three choices for resource owner → see picture *(π^R ≙ (per-unit) resource profit ('rent'), r ≙ interest rate)*

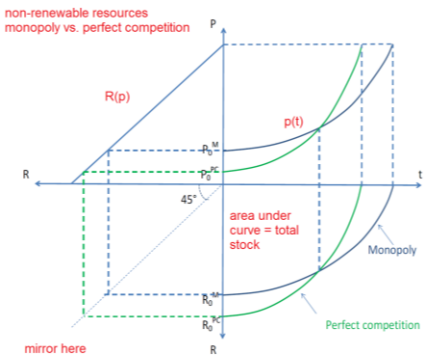
- e.g. 3/2 > 1 + 0.05 → then the profit in next period much higher than the interest rate from the bank & thus keep everything underground

impact of new discoveries on Hotelling price path

- create decrease in price since oversupply & price drop → new discoveries in t_1 & t_2 → ↑S_0

impact of backstop technologies on Hotelling price path

- as heavily used limited resource gets expensive, alternate resources get cheaper, making them econ. viable → at certain price limit, i.e. 'choke price', backstop viable
- if backstop technology arrives earlier than expected → ↓price of old technology since oversupply & vice-versa



monopolistic behaviour (MON) & extraction of non-renewable resources

- initially: price higher than under perfect competition (PC) since supply artificially limited
- if demand linear, extraction path for PC & MON intersect or are identical from the start
- if demand isoelastic (same elasticity coefficient, i.e. how dependent the variable is on the change of another variable): identical exhaustion & price paths
- trade off: MON may be friend of env. when less extraction overall or more spaced out so env. can adapt; definitely friend of environmentalist in beginning since higher price & lower supply

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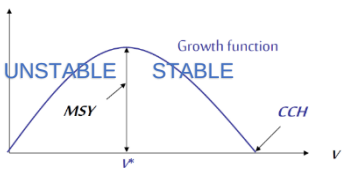
Renewable Resources

regeneration function & factors influencing it

$$F(V) = \frac{dV}{dt} = g\left(1 - \frac{V}{V_{max}}\right) * V - e * E * V$$



- F(V) specific growth rate
- V stock size
- t time
- V_{maxx} carrying capacity of habitat (CCH)

optimal usage of renewable resource

- consider econ. aspects like harvest costs (C), static/intertemporal optimization & open-access problem
- Maximum Sustainable Yield → F'(V) = 0
- **MSY may not be the optimal solution!** → e.g. when interest rate & varying costs of extraction consid.

open-access can lead to over-usage

- public goods problem → increased extraction & market entry of fishers when NB = B – C > 0
- resource extraction is inefficient: equal extraction possible at lower costs
- economic equilibrium only when rents, i.e. NB, = 0 → then no longer entry & exit from the market

solutions for open-access fisheries

- C&C instruments
  - tax on fish caught, subsidisation (help increase efficiency), industrial policy (e.g. prohibition of certain fish species)
- incentive-based instruments
  - landing tax (fixed rate per fish landed), property rights & transferable harvesting quotas → determine total allowable catch, then divide among fishers & allocate permits for trading

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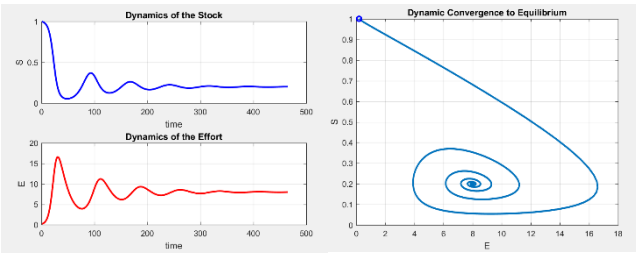
Dynamics of Renewable Resource Harvesting

definitions: Z = e*E*V, C = w*E, E = e*V

open-access model

- stock previously unharvested & at its CCH is opened up to public
- as long as economic profit, fishers enter into market → stock goes down & so does price
- as stock lower, fish harder to harvest → cost per fish rises (harvest cost & the one from the market)
- typical boat makes less profit & exits market → stock goes down & everything in reverse
  - stock & effort levels have oscillatory behaviour & system adjusts to **bioeconomic equilibrium**



private-property fishery

- management by single entity → either firms control or institutions enforce
- harvesting & pricing behaviour competitive rather than monopolistic
- like above, costs depends on both harvest Z = eES & effort E = eV

- now: choosing not to harvest equivalent to capital investment (next period same fish + some growth)
- if costs independent on stock then private property maximizing steady-state eq. where stock maintained at a level where rate of growth = market return on investment
  - keep stock growth at level where it equals interest rate → similar to Hotelling rule

$$F(V) = i$$

- if interest rate goes up, profit maximizing stock size decreases → fish a lot & put money into bank

I still do not fully understand this last part with interest rates.

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Cost – Benefit Analysis

Net Present Value

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

- problem: often no correct price or one at all for environmental goods (e.g. how to assess price of wildlife reserve?)

steps in Cost-Benefit (C&B) analysis

i. specify projects & programs
ii. quantify inputs & outputs
iii. ascertain social C&B
iv. compare C&B

problems

- how to measure, correct discount rate *r*, how to deal with uncertainty, ethical considerations

assessing C&B

a) indirect expression of preferences
   - avoidance cost approach (how much people willing to pay to avoid negative externalities)
   - travel cost approach (how much tourists to pay to spend time at beach)
   - Hedonic prices (measure value which people accord to diff. features of a good, e.g. lake view)
b) direct expression of preferences
   - contingent evaluation method (ask people about their willingness to pay for certain env. good)
   - political decisions (allows for direct assessment of people's preferences)

cost assessment of environmental project

- fixed costs (of construction)
- variable costs (of maintenance & operation)
- implicit costs (non-monetary costs, e.g. jobs lost due to new env. laws)

consideration of risks

- first step: risk assessment → stochastic (depending on chance) & systematic (on circumstance) risk
- for assessment you need probability of event & severity of event
- probability estimated on basis of historical data & analogy

assessment of future C&B

- either weighted (i) equal, (ii) more or (iii) less than today
- problem: effects of env. project has impact on multiple time periods → **how to weigh future C&B?**
- discounting → choice of correct factor crucial!

$$NPV = \frac{100\ CHF}{1+0.05} = 95.24\ CHF$$

- 100 CHF worth more today than in a year since you can put it in bank and get 5% interest

objection of C&B analysis for environmental issues

- travel cost approach is weak
- are consumer preferences the correct benchmark?
- right only considering human preferences? what about animals, plants, ecosystems?

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Sustainability

- development is sustainable if it meets needs of present without compromising ability of future generations to meet their own needs (Brundtland Report, 1987)

stock-based definitions

- weak sustainability → constant productive capacity
- strong sustainability → constant natural capital

flow-based definitions

- constant yield
- non-declining utility / consumption

weak sustainability → **economic concept**

- close to Brundtland → constant satisfaction of needs
- preservation of opportunities
- substitution between different types of capital

strong sustainability → **ecological concept**

- no substitution between accumulated capital (K) & natural capital (N) but between natural res. types
- prevention & precaution with respect to nature but not with economy

criteria for sustainable resource use

- *performance assessment with PER index: (AP-CP)/(OP-CP)*
- *substitution possibilities (increase in efficiency with other technology?)*
- *defining thresholds (do not cross in order to be sust.)*
- *flow-concepts & non-declining utility (utility must always increase)*
- *efficiency & sustainability* $W_2 \geq W_1$ (welfare increase)
- *yield constancy (sust. if harvest is as high as last period)*

different sustainability indicators

- Genuine Savings → comprise savings in an economy (net investment in physical capital but also in R&D, human capital, social capital, etc.)
- Environmental Performance Index (EPI) → multidimensional index with focus on ecology
  - consists of two parts each weighing 50%: economic health & ecosystem vitality & natural resource management
  - no economy included
- Index of Sustainable Economic Welfare (ISEW) → index of personal consumption
  - – inequality index → issue: care about equality within a generation?
  - + welfare improving contributions
- Ecological Footprint Index → how much nature it takes to sustain human activity
  - is an ecological accounting system, attempts to translate ecological impact into space needed
  - overshoot day → 2016: August 8th
- Multidimensional Indicators → ecological, economic & social aspects included
  - problem: weighting
  - conversion of different metrics
  - explanatory power of heterogeneous indicators

"the aggregate area of land and water in various ecological categories that is claimed by participants in the economy to produce all the resources they consume, and to absorb all wastes they generate on a continuing basis, using prevailing (übliche) technology" (Wackernagel and Rees, 1997)

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International Environmental Issues and Global Warming

- international externalities unintended & uncompensated
- national & environmental resources do not respect borders, thus we have exploitation & persistent emissions

instruments

- Pigouvian tax
- subsidies & protection
- permit trading system

decision problems

- cooperation problems between conflictual regimes → **contractual environment**
  - global problem (no unitary solution)
  - intergenerational problem (benefits manifest later)
  - requires changes in billions of people
- lack of authority to enforce → capacity
- time-dependence → concern

manifestation of international environmental externalities

- GHG concentration globally uniform, thus global goods problem with everyone both perpetrator & victim
- rich countries emit more & are more responsible
- poor countries more affected

- two solutions: mitigation & adaptation

internalization of externalities with the Kyoto Protocol

- goal: Annex-1 reduce their emissions by 2008-2012 by 5.2% relative to 1990 level
- no binding contract for developing countries
- entered into force 2005 since two requirements were fulfilled (more than 55% of nations signed & ratified as well as 55% of global GHG emission countries did it)

mechanisms in the Kyoto Protocol

- Bubble Provision → countries of state-community, i.e. EU, regarded as one country
- Joint Implementation → Annex-1 can pay in another Annex-1 country
- Clean Development Mechanism (CDM)→ Annex-1 country can pay in developing country if otherwise project would not be implemented

why Kyoto cannot be regarded as success

- fails to meet enforcement problem
- missed to include major emitters in meaningful way (Russia didn't have to abate much)
- did not include developing countries, e.g. India's emissions are big today
- uncertainty about C&B from abatement
- not enough scientific knowledge (SO_2 cooling potential was not in the IPCC report)
- efficiency of CDM unknown

costs and benefits from Climate Change

costs	benefits
rising seas, increased extreme events, changes in ocean circulation, increase in health issues (outbreaks of diseases), endangerment of ecosystems, crossing of thresholds, etc.	agriculture may benefit from increased precipitation, less heating in winter (although more air conditioning), decreased winter mortality, etc.

open markets & 'Race to the Bottom'

- deregulation of business environment or taxes in order to attract or retain economic activity in one country's jurisdiction → works in short-run: plan of Trump to 'make America great again'
- one country gains competitive advantage and others follow suit → leads to all eventually adopting the standard of the lowest country
- counter-arguments
    - there are gains from national env. policy such as increase in ind. welfare (health, air, etc.)
    - env. protection often only percentage of national GDP
    - env. taxes are revenue in government budget constraint → double or even triple dividend

change in international environmental politics with the Paris Agreement

- mitigation → INDCs
- transparency system & global stock take → accounting from 2023 onwards
- adaptation mechanisms → strengthening ability of countries to deal with the issues
- loss & damage → strengthening ability to recover from impacts
- support → financial aid for developing countries & mitigation there counts for industrialized countries' INDC
- principle of equity & fair burden-sharing → all countries included (in contrast to Kyoto)
- compliance mechanism → Article 15, overseen by committee of experts

two crucial aspects for Climate Policies

- efficiency → achieve temperature goal at lowest marginal abatement cost for the economy
    - could implement uniform carbon tax
    - an emission trading system (ETS) with permits
- equity → fair burden-sharing according to principles
    i. Ability To Pay Principle → rich pay more
    ii. Polluter Pays
    iii. Egalitarian Principle → everyone contributes
    iv. Policy Cost Sharing Principle → if country has low MC of abatement, it should do more
    v. Merit Principle → bigger efforts should reward more
    vi. Comparing Like With Like Principle → abatement when few alternatives available should be weighted differently than when a lot of substitutes are on the market

Equity Principles: → i.e. who pays for Climate Change for it to be fair for both rich & poor?

i. Ability To Pay Principle
ii. Polluter Pays Principle
iii. Egalitarian Principle
iv. Policy Cost Sharing Principle
v. Merit Principle
vi. Comparing Like With Like Principle