ECN 275/375 summary: Natural resource economics

Eirik Romstad
School of Economics and Business
Norwegian University of Life Sciences
eirik.romstad<at>nmbu.no WEB: www.nmbu.no/hh/

The basics

Natural resource economics

Objective: maximize net present value of rents (or utility) from utilizing natural resources or recipient services with a set of choice variables. Formulation depends on the problem specifics.

Subject to: A set of resource constraints. Could be a quantity constraint (non-renewables) or properties of the growth function (renewables).

Discounting: (below discount rate *r* (real interes), choice variable(s) $\boldsymbol{x}_t$ and payoff $\pi_t(.)$ in time period *t*):

- continuous time: e^{-rt} with net present value $NPV = \left\{ \begin{matrix} MAX \\ \boldsymbol{x}_t \end{matrix} \right\} \int_{t=0}^{T} \pi_t(.) e^{-rt} dt$
- discrete time: $(\frac{1}{1+r})^t = (1+r)^{-t}$ with present value $NPV = \left\{ \begin{matrix} MAX \\ \boldsymbol{x}_t \end{matrix} \right\} \sum_{t=0}^{T} \pi_t(.)(1+r)^{-t}$

Specific formulations depend on the type of problem.

Production and utility

Natural resources usually termed *N* or *R* in formulations, and man-made *K*. Production may involve natural resources alone, $Q_t = Q_t(R_t)$ or joint with man-made capital, $Q_t = Q_t(K_t, R_t)$. The time index in the production function indicates the production processes change over time (no time index on the production function → no assumed technological progress in production, but captured by investment in man-made capital *K*. This is then captured by a production constraint (see lectures 13-14 for examples).

If utility is maximized in sted of profits (resource rents), the objective function is $U(C_t)$ (in economics, utility comes from consumption which has positive but declining marginal utility, $U_C(C_t) > 0$ and $U_{CC}(C_t) < 0$.

In models with consumption, the link to production is via the production constraint where production can be used for two purposes, consumption *C* or investment (= savings, see macro linkage: households can consume or save) in production capital *K* at the price *r*, the real interest rate.

Key production issue: weak and strong sustainability. Strong: No substitution possibilities in production → some natural resource essential for production (no resources → no production). Note: a resource may be essential in production, but that is of limited importance if consumers can change consumption habits and consume other goods that circumvent the limited substitutability in production (possibly at increased costs.

Topics covered

See the schedule of lectures (http://arken.nmbu.no/~eiriro/ecn275/schedule.html) for list of topics (for natural resources from lecture 11). Risk (lecture 3) form the foundation for risk inclusion in models. Handouts/lecture notes cover the essentials. The book and additional reading materials provide additional materials and insights that it is worth reading. Reading guide for each lecture/gathering.

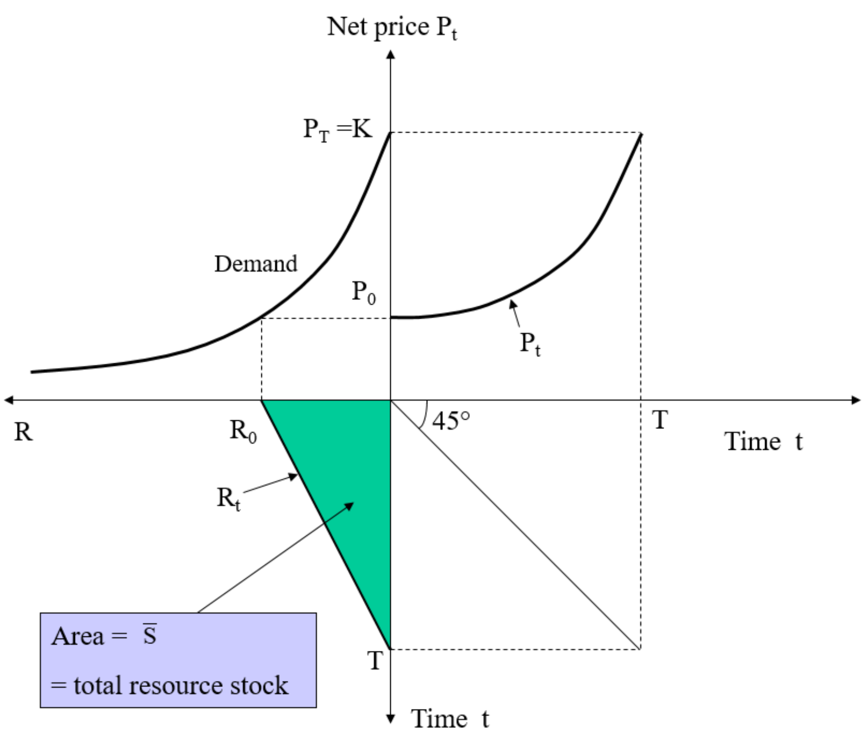
Non-renewable resources

Objective function: maximize discounted resource rents or discounted utility from consumption subject to constraints (see lecture notes 13-14). The utility (modification if a direct negative utility impact of pollution), and production function, and constraint equations can be modified to include accumulated pollutants (lecture 14)

Key concepts non-renewable resources:

- Hotelling's rule (Hotelling price path): which states indifference between utilizing the resource across time periods (over time) = the capitalized net price over time (the inverse of discounting)
  - continuous time: $P_t = P_0 e^{rt}$
  - discrete time: $P_t = P_0 (1+r)^t$
- Lagrange formulation of constraints:
  - Understand difference between equality and inequality formulations
  - Two period constraints (discrete time constraint most meaningful): $\bar{S} = R_0 + R_1 = \sum_{t=0}^{1} R_t$
  - Multiple period constraints: (discrete time: $\bar{S} = \sum_{t=0}^{1} R_t$, continuous time: $\bar{S} = \int_0^T R_t \, dt$

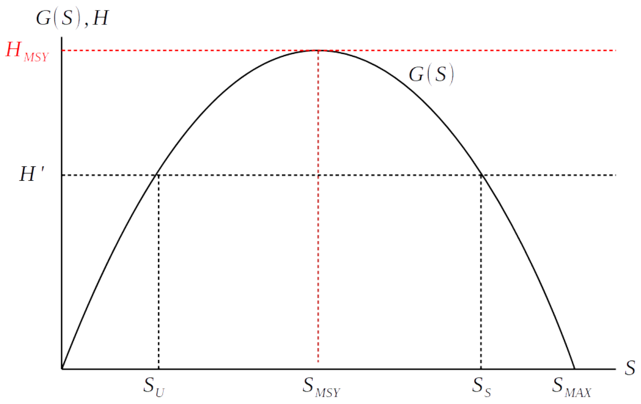
Graphical analysis: four corners (quadrant graph). Example of basic figure (from lecture 13):



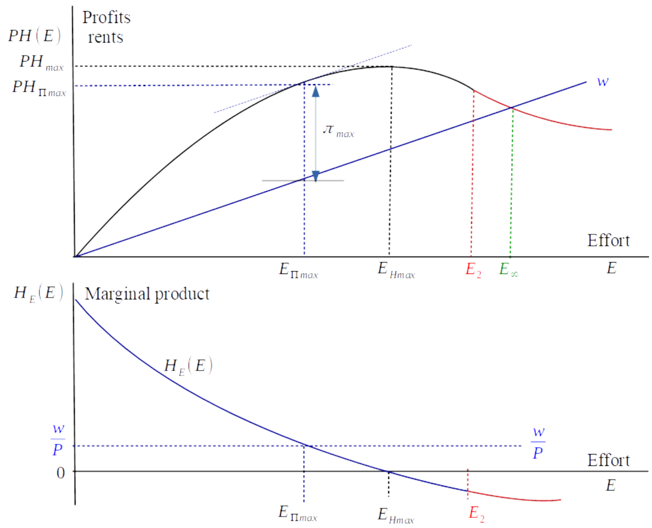
Renewable resources 1: Fisheries (lecture 15-16)

Two types of models:

Growth as a function of stock size



Resource rents as a function of effort



Growh as a function of the stock size $G(S)$ essential. Link stability discussions to left figure (= understand unstable and stable equlibria). Exercise and discussion 6 essential.

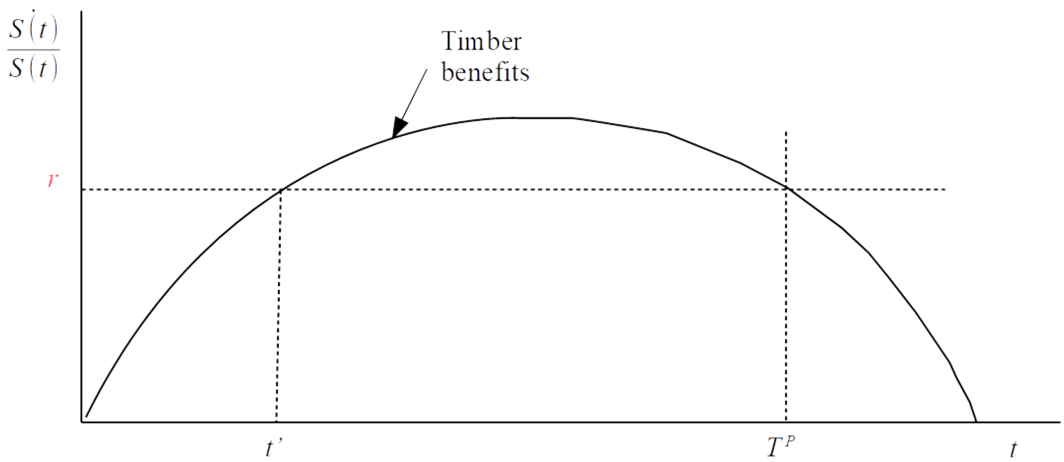
Harvest as a function of effort. Understand open access equilibrium and rent maximization. Able to formulate the relevant profit functions and solve (OA = rents equal zero, profit max ← FOC)

Understand the formulation of dynamic fish and wildlife harvesting problems, and adjustments that take place from the harvests towards steady state haverst, $H^{\delta=r}(S^*)$, and the impacts of knowledge about the species in question on the speed of reaching the steady state.

Understand how safe minimum standards can be developed when the growth function $G(S)$, may be influenced by external factors (like the "el Niñinjo" effect).

Renewables resources 2 – Forestry

Forest production is a long term undertaking. The discount rate is therefore essential. Understand the figure below (lecture 17 for explanation). Exercises 17 and the Exercise/Discussion 6 provide extensions of the models.



Understand the derivation and meaning of the optimal rotation age is T such $\frac{\dot{S}(T)}{S(T)}$.

Understand the difference between the single rotation and multiple rotation forests models (the Faustmann equation), and their implications on extensions into multiple use forestry. For example, hunting benefits do not change the optimal rotation in a single rotation framework, but does in a multiple rotation setting.

Ability to formulate alternative explanations of the appropriate profit function if for example thinning is added (Exercise/Discussion 6).

Remark: Mathematical understanding of Faustmann or its derivation, not exam relevant.

Clarity in writing and figures

The importance of being accurate in notation. If that is not the case, it is very difficult for readers to understand what is meant. This implies that:

1. Basic definitions like *cost effectiveness* and (*cost*)*efficiency* (*optimality*) is used properly.
2. Mathematical notation is clear, and terms are defined so that readers are able to know what goes on.
3. Graphs and figures have the proper names (variables suffice some times) on axes, and curves/functions are written in such a way that it is clear which are the independent and dependent variables. It is still OK for curves that are changed to drop the detailed notation to make the figure/graph less cluttered.
4. Equilibrium solutions, which usually involve both prices and quantities in some form, are properly written. For example, the basic commodity marked equilibrium is written $\{p^*, q^*\}$ where the asterix is used to denote that the equilibrium is a specific (usually optimal) combination of prices and quantities. Other chosen values are marked, for example as $\{p', q'\}$.

In brief: the basics are there to set a standard for communication with other economists and academics. Note that if one communicates with non-economists/-academics, the use of specific terms in economics is a two-edged sword: scientific language serves a purpose when one communicates with members of one own's tribe (like economists), but that some of these terms may be unknown to non-academics or -economists. If that is the case and a term is frequently used, explain it in long hand the first time it is used, f.ex. "the subsidy (*S*)".

Overarching perspective on models

The core issue in natural resource economics is the maximization of utility or resource rents. The analysis may be influenced by our knowledge on the resource to be used/harvested (see Exericise/-Discussion 6 for an example on fisheries).

Models used to stylize a case/situation have several purposes:

1. To make the analysis more focused and tractable
2. To put the case at hand in a setting so that useful simplifications can be made to make the analysis more focused. Recall: models are (often) simplifactions of the case to be studied.
3. Natural-resource economics models are complicated. Use models to analyze parts of the totality, and assess if changes in some of the parts may influence other parts of the total model.

The take home test

Overall purpose: to facilitate learning →.the tests cover what is important. Getting the basics right, and being able to extend the basics to more complicated settings is at the core of ECN 275/375.

The duration of each of the take home tests is 3 hours.

From a student-taking-test perspective there will be some focus on the basics, your topical knowledge, and *ability to reason as an economist*. However, parts of the analysis will require that you are able to extend the basics to stylized applied settings. As always on my tests, computations are likely to be simple – this is a course in *environmental and natural resource economics*, not your knowledge of advanced mathematics or your computation skills.

2-3 hours after the tests are completed (= all have handed in their answers with a good "safety cushion", my suggestions for answers are posted on the course web page to facilitate your learning.