Final Exam – Guidelines

Resource Economics - ECON4925
Department of Economics, University of Oslo

December 18, 2023

This exam has 3 questions. The points x of each question are mentioned in brackets as [x p]. The exam sums to a total of 100 points. Provide well-motivated answers that are as concise as possible. If you get stuck in algebra or discover a mistake, explain how you would proceed, what you would expect, or why you think there is a mistake.

1. **Forestry Economics:** In this question, choose only "True" or "False". Do not explain your answer. [15p]

   In a forestry model, assume that the growth function is increasing and concave, forest management is profitable and the optimal Faustmann rotation length is smaller than that of the maximum sustainable yield. Then, under the Faustmann rotation

   (a) when suppliers become more patient, timber supply decreases in the short run but increases in the long run. [3p]

   (b) when the price of timber rises, timber supply increases in the short run but decreases in the long run. [3p]

   (c) timber supply increases in both the short and long run when cost of production falls. [3p]

   (d) land rent increases when costs fall, and thus more land is devoted to forestry. [3p]

   (e) the average annual harvest decreases when suppliers become more patient. [3p]

2. **Fishery Economics:** Consider a fishery where the biomass of some fish S_t in international waters evolves according to the equation of motion

$$\dot{S}_t = g(S_t) - H_t,$$

where time is continuous, $H_t \geq 0$ is the size of harvest, and

$$g(S_t) = 2r\left(\sqrt{S_t} - \frac{S_t}{\sqrt{M}}\right),$$

gives the dynamics of the fish population in the absence of harvesting, where $r > 0$ and $M > 0$ are parameters defined by the biological conditions of the marine ecosystem. Initial fish stock is positive $S_0 > 0$. (Observe that the derivative of the function $f(x) = \sqrt{x} = x^{0.5}$ is $f'(x) = \frac{1}{2\sqrt{x}}$.) [50p]

(a) Find the maximum sustainable yield S^{MSY}. [3p]

(b) Find the carrying capacity of the fish population S^{CC}. [3p]

A social planner (a state or government) will choose the optimal sizes of harvest H_t over an infinite time horizon. The population receives some immediate utility $2\sqrt{H_t}$ from the harvest, plus some recreational utility from deep-sea diving $2\alpha_S\sqrt{S_t}$ ($\alpha_S \geq 0$), which decreases the less fish remains in the sea. As a result, the total immediate utility is given by $u(H_t, S_t) = 2\sqrt{H_t} + 2\alpha_S\sqrt{S_t}$. Moreover, the utility stream is discounted at some interest rate $i \geq 0$.

(c) Formulate the dynamic optimization problem that the social planner faces, and identify the control and state variables. [5p]

(d) Formulate the current-value Hamiltonian and derive the first-order conditions. [5p]

(e) Show that the Euler equation is given by [4p]

$$\frac{\dot{H}_t}{H_t} = 2\left(\left[\alpha_S\sqrt{\frac{H_t}{S_t}} + \frac{r}{\sqrt{S_t}} - \frac{2r}{\sqrt{M}}\right] - i\right).$$

(f) Provide an economic interpretation for the Euler equation in the steady state. [12p]

(g) Find the equation that provides the optimal steady state level of fish stock S^{stst} resulting from this optimization problem. (Hint: You do not need to find the steady state level itself, just the equation that would produce it in terms of all of the parameters in the model.) [6p]

(h) We can use the equation you found in (g) to show the following result:

1. $S^{stst} > S^{MSY}$ when $\frac{\alpha_S}{i} > Q$,
2. $S^{stst} < S^{MSY}$ when $\frac{\alpha_S}{i} < Q$, and,
3. $S^{stst} = S^{MSY}$ when $\frac{\alpha_S}{i} = Q$,

where $Q > 0$ is determined by parameters in the model. Provide an interpretation of this result in economic terms, and explain why you think it holds. (Hint: Take the result stated as given. You do not need to show that the result holds or what the value of Q is.) [12p]

3. **Fossil Fuel Extraction and Climate Economics:** [35p]

(a) Explain the core insights of Hotelling's rule in economic terms for the extraction of a non-renewable resource such as fossil fuels. [5p]

(b) List the three key assumptions for the derivation of the Hotelling rule, and explain in words how the insights of the rule is impacted if these assumptions are violated. [20p]

(c) Provide examples of fossil fuels with low and high royalties. The use of which fossil fuel type reacts more strongly to an (unannounced) increase in carbon tax for CO_2 emissions? Explain intuitively. [10p]