Name______________________________ Vorname____________________________

Matrikel-Nr.:________________________ Studiengang:_________________________

☐ Regulärer Versuch ☐ 1. Whlg. ☐ 2. Whlg.

Universität Rostock
Wirtschafts- und Sozialwissenschaftliche Fakultät
Lehrstuhl für VWL – Angewandte Wirtschaftsforschung –

Klausur
Fortgeschrittene Umwelt- und Ressourcenökonomik

SoSe 2024, 2. August 2024

- Beantworten Sie **zwei der drei** gestellten Aufgaben! Unterschreiben Sie die Klausur auf der letzten Seite. Alle Aufgaben sind gleich gewichtet.
- Erlaubte Hilfsmittel: nicht-programmierbarer Taschenrechner.

- *Please answer **two out of three** questions! All questions are equally weighted.*
- *Additional materials allowed: non-programmable pocket calculator.*

Bearbeitungszeit: 90 Minuten
Time limit: 90 minutes

Two (and only two) out of three questions! If you attempt more than two questions, cross out the one you do NOT want counted. Otherwise, we will count the first two.

Question 1. (20 points) Consider a two-period model of optimal resource extraction. There is a fixed stock of $\overline{S} = 40$ tons of the non-renewable resource in the ground. The demand functions for each period are as follows:

$$P_t = a - bR_t$$

where t $= \{0, 1\}$, $a = 20$ and $b = 0.8$.

The cost of resource extraction is:

$$C_t = 3R_t$$

The gross social benefit from extracting and consuming the resource is the area under the demand curve up to the extracted amount, i.e.

$$B(R_t) = \int_0^{R_t} (a - bs)ds$$

The per-period net social benefit is:

$$NSB_t = B(R_t) - C_t$$

Suppose that a central planner maximizes the net social benefit of resource consumption over the two periods:

$$\max_{R_0, R_1} W = NSB_0 + \frac{NSB_1}{1+\rho}$$
$$\text{s.t.} \quad R_0 + R_1 = \overline{S},$$

The planner discounts the future at the rate $\rho = 0.1$.

a) (7 points) Determine P_0 and P_1, the equilibrium prices, and R_0 and R_1, the socially optimal quantities of resource extraction, in each period.

b) (2 points) Are R_0 and R_1 the same or different? Are P_0 and P_1 the same or different? What is the economic intuition for your finding?

c) Now suppose the planner considers a general multi-period model of optimal resource extraction in continuous time. Answer the following questions using a 4-quadrant scheme, in which the price path is projected over a demand curve and a 45-degree line in the quantity dimension of resource extraction. Assume that the demand curve features a "choke price".

c1) (6 points) Show graphically and explain the main elements of the solution of the multi-period model, i.e. the time path of resource prices and extractions, and the determination of the time to resource exhaustion.

c2) (5 points) Now suppose that, contrary to prior expectation, part of the previously assumed resource stock turns out to be non-recoverable due to geological instability. This reduces the amount of the resource stock compared to previous assumptions. Show and explain the effect of this unanticipated change in the resource stock on the price path, time to extraction and the time path of extracted quantities of the resource.

Question 2. (20 points) Suppose a tourism corporation submits a construction project to the government, proposing the construction of a number of holiday bungalows in what is currently a wilderness area. Assume that leaving the wilderness area untouched generates a certain amount of environmental amenity services. With increasing development the amount of amenity services decreases.

The government wants to determine the optimal amount of preservation for society. Suppose that in its analysis the government considers benefits to society from environmental amenity flows of the wilderness area in two periods, periods 1 and 2. The government assumes that discounted net benefits from preservation increase from period 1 to period 2 and that the number of bungalows can be varied from zero to any arbitrarily large number.

In your answers to Question 2 use the tools of graphical analysis and the relevant economic arguments you have studied on this topic.

a) (4 points) Assume that net benefits in both periods are known with certainty and that development is completely reversible. What are the optimal levels of preservation in each period? Show graphically and briefly explain.

b) (6 points) Assume that net benefits in both periods are known with certainty, as in part a). Contrary to part a), assume now that once a bungalow is built, a part of the wilderness area will be lost, i.e. development is irreversible. What are the optimal levels of preservation in each period? Compare and contrast with your solution in part a).

c) (6 points) Assume, as in part b), that development is irreversible. Assume in addition that while marginal net benefits (MNB) in period 1 are known with certainty, marginal net benefits in period 2 are not known with certainty. Instead, assume that one of two MNB curves may realize in period 2, MNB_2^1, with associated probability π_1, or MNB_2^2, with associated probability π_2, where $\pi_2 = 1 - \pi_1$. Assume that for a given level of preservation $MNB_2^2 > MNB_2^1$, and that MNB_2^1 equals the period-2 MNB-curve used in parts a) and b). What are the optimal levels of preservation in each period, assuming risk neutrality for the government? Compare and contrast with your solutions in parts a) and b).

d) (4 points) Suppose that after the analysis in part c) is completed, an economist working for the government realizes that π_2, the probability of MNB_2^2 realizing, was underestimated, i.e. the true π_2 is higher than the value assumed in part c). How do your results change compared to part c)? Assume that, other than the value of π_2, the same setting applies as in part c).

Question 3. (20 points) Suppose you have a one-person, one-good, one-factor, one-period Robinson Crusoe economy. Crusoe gets positive utility from coconuts (C) and disutility from pollution (P):

$$U = U(C, P), \tag{1}$$

where $\frac{\partial U}{\partial C} > 0$, and $\frac{\partial U}{\partial P} < 0$.

Pollution is a function of consumption, C, and abatement effort, E:

$$P = P(C, E), \tag{2}$$

where $\frac{\partial P}{\partial C} > 0$, and $\frac{\partial P}{\partial E} < 0$.

The resource constraint is Crusoe's total time: $C + E = M$.

Now assume the following functional forms for U and P:

$$U = C - P \tag{3}$$

$$P = C - C^{\alpha} E^{\beta} \tag{4}$$

a) (8 points) Solve for optimal consumption (C), abatement effort (E) and pollution (P) subject to Crusoe's resource constraint.

b) Suppose Crusoe would like the optimal pollution path in his economy to be consistent with an Environmental Kuznets Curve (EKC).

b1) (4 points) What is the relevance of returns to scale with respect to the effort spent abating pollution for the EKC to hold in Crusoe's economy? Discuss briefly.

b2) (4 points) Assume that Crusoe discovers a neighboring economy which would be willing to accept any amount of the pollution in his economy for free. Assume also that any amount of pollution can be moved from Crusoe's economy to the neighboring one. Will Crusoe be able to achieve consistency of the pollution path in his economy with the EKC no matter what the returns to scale of the effort spent abating pollution are? Why or why not?

b3) (4 points) Suppose an environmental economist in Crusoe's economy states the following: "With the ability to move pollution to other countries, the EKC is a useless concept for determining whether richer countries get cleaner". Do you agree with this statement? Why or why not? Discuss briefly.