ECN 275/375 – Natural resource and environmental economics
12:15-15:15 March 6, 2026

All help aids are allowed except assistance from others.
This test consists of three questions, for a total score of 100 points.
All questions are to be answered. You may answer in English or Norwegian.

In case you find a question that is unclear or you are uncertain about what it means, state the clarifications you need to enable you to answer the question.

This test has been designed to limit the benefits of using artificial intelligence (AI). If AI use is detected beyond reasonable doubt, unreported use leads to a zero-score on that sub-question. Students may use AI if they self-report such use on specific sub-questions at a cost: A question with self-reported AI use reduces the given score by 40%.

When I submit my answers on this test, I confirm that I have worked alone on my answers and not cooperated with others. I am aware that cooperation with others is considered an attempt or a contribution to cheating.
I am aware of the consequences of cheating (cfr. Academic regulations for NMBU).

Your name: NN   (+ ECN 275 or ECN 375)

Question 1 (30 points – 10 points for each part a-c)

Truthful revelation, commonly known as *truth-telling*, is an important feature of modern environmental economics.

(a) (i) Explain what is meant by the term *truth-telling* in environmental economics. Provide an example related to environmental management contract auctions.

  (ii) Connect *truth-telling* to the relevant resource allocation mechanism criteria. Explain briefly for each criterion you choose to include. Illustrate your points linking your answers to the auction example you already provided above.

Answer: (i) Under truth-telling an agent's stated action equals the agent's actual action.

Example: Under procurement contract auctions, the first action is to bid on the contract. Uniform price auctions makes truth-telling in bidding a weakly dominant strategy, that is bidding such that the bid that equals the agent's expected cost of meeting contract terms, i.e. $b_i = \hat{c}_i$, where b_i is the bid and $\hat{c}_i$ is the expected cost of meeting contract terms respectively for agent *i*.

Answer: (ii) Informational viability, participation constraint and incentive compatibility (the latter two are linked, see below).

Informational viability is met as it is feasible to monitor agents' actions to meet contract terms. However, such actions are costly which implies that penalties, *S*, from not meeting contract terms need to be high to drive down the monitoring probability, ρ, according to the basic monitoring and enforcement equation: $\rho \geq (\pi^N - \pi^C)/S$, where π^N and π^C are the respective payoffs of non-compliance and compliance.

The participation constraint and incentive compatibility are treated jointly: Only agents who expect to benefit from engaging in the contract will do so. Probabilistic monitoring regimes of the type $\rho \geq (\pi^N - \pi^C)/S$ do not guarantee that universal compliance among contract holders but would result in a desired level of compliance at a cost to the regulator. The regu-

lator's choice of monitoring probability ρ ensures that expected net benefits to society from monitoring are positive.

(b) The EU recently passed a law that suppliers of environmental goods or services are not allowed to earn rents.

   (i) Explain briefly what is meant by the term *information rents* for supplying environmental goods and services, and why it is difficult to avoid *information rents*.

   (ii) Provide an example where you explain how *information rents* play a role to give incentives for truthful revelation.

Answer: (i) Information rents are extra profits above the true costs agents need to supply environmental goods or services. These rents are difficult to avoid in such cases because the regulator cannot get information on agents' true costs of providing environmental goods or services without offering something back. Allowing agents some rents is one way of achieving this. Why? Because the existence of rents creates an incentive to reveal private information, here marginal costs of delivering the services asked for by the regulator.

(ii) Suppose N contracts are to be awarded in a uniform price procurement auction where low cost contract holders are paid the same price (compensation) as the first non-winning bidder in an $N+1$ price auction. Therefore, in an $N+1$ uniform price procurement auction all agents who get contracts receive a higher compensation than their management costs for meeting contract terms. The difference between the compensation paid and an agent's contract costs are information rents.

In an $N+1$ uniform price auction, the bid size does not influence the compensation paid (the price) – it only determines if a potential provider gets or does not get a contract. This makes bidding truthfully a weakly dominant strategy, i.e. the bid reflects the costs of meeting contract terms.

Remark: Other examples will be evaluated based upon the suitability of the example and the quality of the arguments used.

(c) Explain how an emission tax motivates *truth-telling* for an agent, *i*, under certain conditions. Name these conditions and explain their relevance.

Answer: See graph with arguments in lecture note 5 – covers most of what one needs to answer the question: https://arken.nmbu.no/~eiriro/ecn275/lectures/lec-05.pdf, page 2.

Question 2 (30 points – 10 points for each part a-c)

A major source of SO_2 and NO_X in the atmosphere is burning of fossil fuels to generate electricity. Two thirds of SO_2 and one fourth of NO_X in the atmosphere come from fossil fueled electric power generators. Particles of SO_2 and NO_X bind to water in the atmosphere lowering atmospheric pH (make atmospheric water more acid). The resulting rainfall is therefore more acid, which is the origin of the term *acid rains*.

Winds can carry SO_2- and NO_X-particles for long distances, and in some cases even across country borders, i.e. to different jurisdictions. The latter implies that acid rains may also cause problems not covered my national laws which could prevent affected citizens suing to

receive compensation from damages. Moreover, citizens in other countries may not be compensated in kind for damages, for example through lower electricity prices.

Suppose we have three countries, *Origin* (where emissions originate but damages are perceived acceptable due to high smokestacks allowing most SO_2 and NO_X to drift downwind) to *Close* (the closest downwind country to *Origin*), and *Next* (the next downwind country after *Close*). Marginal damages from acid rains gradually decline with the distance from *Origin*, implying that marginal damages are higher in *Close* than *Next*.

(a) Side-payments is one possible way to break the deadlock agreeing on how to pay for reducing *Origin* emissions.
   (i) Why are side-payments difficult to implement in general?
   (ii) Why is it particularly challenging to agree on side-payments in this case?

Answer: (i) Side-payments are difficult to implement in general because there are advantages waiting for the other parties to take the first initiative (last mover advantage).

(ii) There are two challenges here. First, unknown size of the payment for *Origin* to reduce its emissions.

Second, *Close* and *Next* must decide how to split the compensation paid for *Origin* to agree to reduce its emissions. Suppose *Close* decides to pay to reduce damages of acid rains in *Close* to its optimal level. Then *Next* can free-ride on the payment C*lose* makes to achieve optimal damages in *Close* due to the decline in the acidity of the rains with distance from *Origin*.

Information for sub-question (b) below: An alternative to building higher smokestacks in Origin is to switch to lighter fuels containing less sulfur (S). A tradable permit regime requiring reductions in S-emissions would create incentives for such a fuel switch or replacing fossil fueled power generations with other energy sources like wind or solar. Allowing foreigners to buy permits could enlarge the funding base for such a transition of *Origin's* electric energy supply infrastructure.

(b) Explain why such a tradable permit regime for emissions in *Origin* is a viable and more efficient solution in this case than side-payments.

Answer: Under a tradable permit scheme in *Origin*, *Origin* polluter would reduce emissions until their individual marginal costs, $MC_i(q_i)$ to reduce emissions by, q_i^0, equal the permit price, i.e. $MC_i(q_i^0)=P_Q^0$, where P_Q^0 is the permit price for any aggregate quota given by the formula $\sum_{i=1}^{I} q_i^0 = Q^0$.

This opens for *Close* (hereafter *C*) and *Next* (hereafter *N*) to jointly buy *Origin* permits for retirement until the optimal emission level is reached in *C*. At first sight, the initial problem of *C* and *N* agreeing seems to remain. However, in the beginning of joint buying permits for retirement, total emissions are so high that some damages also take place in *N*. This provides incentives for *N* to join *C* in buying permits for retirement until marginal damages in *N* equal the quota price $P(Q_N^*)=MD_N(Q_N^*)$. For *N* the initial low quota prices also make it easier for *N* to start buying permits together with *C*.

Once the optimal emission reductions are reached in N, i.e. $P(Q_N^*)=MD_N(Q_N^*)$, the incentives for *N* to continue buying permits together with *C* disappear. However, this has enabled *C* to have parts of its bill to reach its optimal emission level: $MD_C(Q_C^*)=P(Q_C^*)>P(Q_N^*)$. Hence, complete free-riding by *N* is removed.

Both *C* and *N* know that trading will be gradual. This opens for *C* to condition their partial payment of reducing acid rains in *N* on *N* committing to sponsor some of the extra acid rain reductions needed in *C* for optimality, i.e. $MD_C(Q_C^*) = P(Q_C^*)$.

Another way to make *N* contribute for emissions reductions beyond Q_N^* is that *C* has split the cost with *N* of achieving Q_N^* . A fairness perspective or future cooperation with C on other issues may induce *N* to pay a share of the expenses of further reductions in *C* to Q_C^* .

Remark: The above approach may not be optimal in a strict sense (welfare is maximized for all involved), but it is a large improvement over full side-payments which are unlikely to be accepted by *Close*, which could render welfare losses in *Close* and hence less revenues for *Origin.*

(c) Suppose that an agreement on any mechanism (policy) that entails payment from *Close* and *Next* to *Origin* were to be made to reduce environmental damages.
   (i) Why would some environmental groups still oppose this agreement?
   (ii) What are the welfare implications of not implementing a side-payment agreement to induce *Origin* to reduce its emissions compared to doing nothing?

Answer: (i) Paying polluters to reduce emissions conflicts with the *polluters pay principle* (here victims end up paying) which many environmental groups deem to be important.

(ii) This follows from the *participation constraint* in RAMS: All parties who accept an agreement will only do so if they perceive the agreement to improve conditions over their current situation, and they see no other feasible welfare enhancing solution that works better.

Question 3 (40 points – 10 points for each part a-d)

Since the turn of the century, there has been increased concerns on micro particles from plastics (MPPs). These concerns have so far been particularly large for MPP emissions to water: MPPs negatively affect aquatic organisms by accumulating in their digestive systems and serving as attractors for various toxic substances that further increase negative impacts on aquatic life. Increased awareness on these issues has contributed to increase collection of plastic waste in many countries.

Styrofoam (polystyrene) is a plastics derivative. It is frequently used for insulation, packaging protection of high value products like consumer electronics, and to keep certain foods like burgers, warm. Styrofoam is high in volume and often contaminated, which makes recycling particularly costly. In many countries, including Norway, large shares of styrofoam therefore end up as residual waste or are not even collected. Recent protest against establishing fast food sale outlets is one example of styrofoam waste not collected.

Consider a small, open and affluent economy (not unlike that of Norway). Evaluate the following policies to reduce emissions of MPPs from styrofoam:

   (1) Forbidding the domestic (inland) use of styrofoam.

   (2) A tax on the use of styrofoam to reduce the relative profitability of styrofoam use.

   (3) A subsidy on the use of styrofoam substitutes to reduce the relative profitability of styrofoam use.

When answering, keep in mind that small and open economies import many consumer products.

(a) Discuss the advantages and disadvantages of a ban on domestic use of styrofoam (1).

Answer:

Advantages: easy to monitor.

Disadvantages: Could be costly, in particular for uses of styrofoam where there currently are no good substitutes. A possibility here is to exempt certain uses from the ban. One example of a possible exemption is the use of styrofoam for insulation purposes. This could be justified if the release of MPPs is low (which it is in this case as insulation between the concrete plate/building base and the ground is not exposed to light).

(b) What are the main advantages of price instruments like (2) and (3) in the above list compared to forbidding domestic use of styrofoam (1 in the above list).

Answer:

Advantages: For some uses there exists low-cost substitutes implying that price instruments would lower costs compared to bans. A high elasticity of substitution further enhances these advantages (see https://arken.nmbu.no/~eiriro/ecn275/lectures/lec-02-multi-input-production.pdf, page 1).

Disadvantages: For some uses there are currently few good substitutes. Hence, for these uses the reduction in styrofoam use would be low, at least until good substitute products become available. See the answer above to (a) for a possible example of such use and why that is not critical in the short run.

(c) What are the main advantage of taxes (2) compared to subsidies (3) to reduce the domestic use of styrofoam.

Answer: First, subsidies increase government expenditures. Second, they create incorrect entry-exit incentives. Taxes have the opposite impacts: increased government revenues and correct entry-exit incentives.

Supporting information to sub-question (d) below: Some countries have suggested to internationally reduce the use of styrofoam and other plastics based materials. The experiences with international agreements are mixed. One example of a highly successful international agreement is phasing out the use of freon and other hydrofluorcarbons (HFCs) to reduce damages to the ozone layer (the Montreal Protocol, 1987). Since its inception the ozone layer has gradually recovered. Important reasons for the success of the Montreal Protocol are that substitute products for HFCs were available, and that the protocol's general negative impacts on profits were small. For some uses of HFCs the elasticity of substitution is high, which partly explains the low costs of the protocol's policies.

(d) Based upon the above information, would you advocate an international ban on styrofoam or the use of economic instruments, primarily taxes or tradable permits on using styrofoam? Please provide the reasoning behind your answer.

Answer: The existence of substitutes and high elasticity of substitution for some uses of styrofoam (see the answers in b), support the use of economic instruments. A key issue to reach agreements between countries is that expected benefits exceed expected costs – the lower expected costs are, the easier it becomes to meet this criterion.

Moreover, economic instruments make it easier to sanction countries that have not implemented appropriate policies as tradable permit prices or tax rates in exporting countries are often easy to observe. This makes it easier for importing countries to levy tariffs on exporting countries not having proper policies in place according to the WTO-agreement (see https://arken.nmbu.no/~eiriro/ecn275/lectures/ex-disc-3-international.pdf).

Please note that the performance of tradable permits or taxes also depend on how rules are enforced. To some extent this may also be observable/possible to model when looking at styrofoam use compared to aggregate styrofoam residues found.