

cover page for a written examination/test

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Each question should be answered on TiU exampaper, each furnished with the candidate's name and ANR number. If candidates are unable or unwilling to answer a question, they must nevertheless submit a sheet of paper containing details of their name and ANR, together with the number of the question concerned. The 6 digit ANR number is printed on the TiU card.

- Candidates are allowed to use a calculator but no books.
- Candidates are allowed to bring 1 (one) A4 page to the exam with notes.
- This exam consists of 1 question.
- Candidates must write clearly.
- Candidates must convince us that they understand the material of this course. Motivate your answers!
- There is no reason to panic! If you feel that you miss relevant information to answer a question, state this explicitly and assume the information that you need. Then we can see whether we can give points for this.
- If you don't write anything, we cannot give you any points!

Question 1 (25 points)

This exam is based on a paper by Maarten Pieter Schinkel and Yossi Spiegel entitled “Can collusion promote sustainable consumption and production?”. This paper was not discussed in class. But do not panic, we will talk you through the paper.

Some people are concerned that vigorous competition induces firms to produce their products as cheaply as possible. This tendency to reduce costs to remain competitive may go against other public interests like sustainability. In recent years this discussion has flared up in the Netherlands in industries like chicken meat, shrimp fishing and electricity generation. In particular, in the production of chicken meat, people worry about the poor living conditions of chickens in factory farms. Cheap fishing methods destroy the seabed endangering the sustainability of shrimp fishing in the long run. Although coal is still a cheap way to generate electricity, the pollution that comes with it is bad for the environment.

In each of these industries, firms claim that by agreeing to more sustainable production methods, they can improve welfare. Hence, they can decide together to improve living conditions of chickens, invest in more sustainable fishing methods and close down coal plants in favor of green energy production. In order to introduce such agreements among producers, they need an exemption to Article 101.

- (a) (1 point) What are –in your own words– the conditions for an exemption to Article 101?

In order to analyze this question, we introduce a model where firms can invest to increase sustainability. We assume that consumers derive utility from and hence are willing to pay for improved living conditions for chickens, more sustainable shrimp fishing methods and green energy. The question is: how much do firms invest in sustainability under an agreement compared to the competitive outcome. Does the agreement indeed increase such investments?

We assume that there are two firms 1,2 choosing their output levels q_1, q_2 under Cournot competition. The marginal costs of producing $q_{1,2}$ are normalized to 0. Further, firm i can invest in “sustainability” v_i at a cost equal to $\frac{1}{2}v_i^2$ ($i = 1, 2$). We assume that consumer utility is given by

$$u = (1 + v_1)q_1 + (1 + v_2)q_2 - \frac{q_1^2 + q_2^2 + 2\gamma q_1 q_2}{2} + m \quad (1)$$

with $\gamma \in (0, 1)$ and m denotes utility derived from the money spent on other goods in the economy. Let y denote the consumer’s income, then $m = y - p_1 q_1 - p_2 q_2$ with p_i the price of good $i = 1, 2$.

- (b) (1 point) Show that demand for firm i can be written as

$$p_i = 1 + v_i - q_i - \gamma q_j \quad (2)$$

with $j \neq i \in \{1, 2\}$.

- (c) (1 point) For given values of $v_1 = v_2 = v$, show that the total welfare maximizing output levels (first best) are given by $q_1 = q_2 = q = \frac{1+v}{1+\gamma}$.
- (d) (2 points) With prices given in equation (2), show that consumer surplus (CS) can be written as

$$CS = y + \frac{1}{2}(q_1^2 + q_2^2 + 2\gamma q_1 q_2) \quad (3)$$

Hence, if $q_1 = q_2 = q$, we have that $CS = y + (1 + \gamma)q^2$.

- (e) (2 points) Explain why CS in equation (3) does not directly depend on v_i ? That is, why is the only effect of v_i indirectly via its effect on q_i and q_j ?

We consider a two stage game. In the first stage, firms decide on investments v_i . After the investments v_i have been made and are common knowledge, in stage 2 firms compete in output levels (Cournot).

- (f) (1 point) Show that the first order conditions for output $q_{1,2}$ under Cournot can be written as

$$1 + v_1 - q_1 - \gamma q_2 = q_1 \quad (4)$$

$$1 + v_2 - q_2 - \gamma q_1 = q_2 \quad (5)$$

- (g) (1 point) For given values of $v_{1,2}$, derive that the Cournot output levels are given by

$$q_1 = \frac{2 - \gamma + 2v_1 - \gamma v_2}{4 - \gamma^2} \quad (6)$$

$$q_2 = \frac{2 - \gamma + 2v_2 - \gamma v_1}{4 - \gamma^2} \quad (7)$$

assuming that $q_1, q_2 \geq 0$.

- (h) (1 point) Show that firm i 's profits can be written as $\pi_i = q_i^2 - \frac{1}{2}v_i^2$. [hint: equations (4) and (5) are written in a way to help you with this question.]
- (i) (2 points) Moving back to stage 1, show that firm i 's first order condition for v_i in Nash equilibrium can be written as

$$q_i \frac{4}{4 - \gamma^2} = v_i \quad (8)$$

Equation (8) gives an expression for the investments in sustainability v_i in case firms compete in the first stage. We will compare this to the investments (i) under second best and (ii) when firms have an agreement between them to choose $v_{1,2}$ to maximize joint profits.

Under second best, the planner chooses $v_{1,2}$ to maximize total welfare

$$(1 + v_1)q_1 + (1 + v_2)q_2 - \frac{q_1^2 + q_2^2 + 2\gamma q_1 q_2}{2} - \frac{1}{2}v_1^2 - \frac{1}{2}v_2^2 \quad (9)$$

taking into account how $v_{1,2}$ affect output in the second stage as given by equations (6,7).

- (j) (1 point) Show that the first order condition for v_i in second best can be written as the sum of two effects (denoted α and β in the following equation):

$$\underbrace{q_i + (1 + v_i - q_i - \gamma q_j)}_{\alpha} \frac{\partial q_i}{\partial v_i} + \underbrace{(1 + v_j - q_j - \gamma q_i)}_{\beta} \frac{\partial q_j}{\partial v_i} = v_i \quad (10)$$

Hence the first order condition for v_i under second best is comparable to the competitive outcome in equation (8). We have v_i on the right hand side in both equation (8) and (10). The left hand sides are different. The higher the left hand side in equation (8), the higher v_i is. [hint: this statement may not be totally obvious to you –as q_i depends on v_i as well– but you can take it to be true.] Hence, if the left hand side of (10) is higher than the left hand side of (8), second best v_i exceeds v_i under competition.

The left hand side of equation (10) consists of two parts α and β . First, consider part α .

- (k) (2 points) Using the expressions in equations (4,5) –or otherwise– show that the first part of equation (10) can be written as

$$\alpha = q_i + (1 + v_i - q_i - \gamma q_j) \frac{\partial q_i}{\partial v_i} = q_i \frac{6 - \gamma^2}{4 - \gamma^2} \quad (11)$$

How does this compare to the left hand side of equation (8)? What is the interpretation of this?

- (l) (2 points) Does the term $\beta = (1 + v_j - q_j - \gamma q_i) \frac{\partial q_j}{\partial v_i}$ tend to increase or decrease investment v_i compared to equation (8)? What is the interpretation of this?

Now we compare the investments $v_{1,2}$ under competition –as given by equation (8)– with the investments that firms choose when they have an agreement in the first period. We assume that the agreement allows the firms to coordinate investments such that total profits are maximized:

$$\max_{v_1, v_2} q_1^2 + q_2^2 - \frac{1}{2}v_1^2 - \frac{1}{2}v_2^2 \quad (12)$$

where $q_{1,2}$ are given by equations (6,7); that is, the agreement does not allow firms to collude in the second period.

- (m) (2 points) Show that in the symmetric outcome of equation (12), we find that $v_1 = v_2 = v = q \frac{4}{4+2\gamma}$. How does this compare to the expression for v under competition in the first stage?
- (n) (2 points) If the firms get an exemption from Article 101 –and are allowed to coordinate investments in the first stage– does this increase output q compared to first stage competition? Why (not)? [hint: the first question is about math, the second about economic intuition.]
- (o) (2 points) What is the effect of an exemption from Article 101 on consumer surplus CS ? [hint: use the expression for CS derived under (d).]

- (p) (2 points) Think of the examples given to motivate this analysis –animal welfare, sustainable fishing, green energy. Why does *CS* not capture all relevant consumer welfare? Does this work in favour or against an exemption from Article 101? [hint: in the first example, we are *not* thinking of chickens as consumers.]