Open Questions

Solve no more than 4 questions out of 5. Indicate your choice of questions.

If you provide solutions for all 5 questions, all of them will be commented on by the Jury, but only 4 will add to your score. In this case, if you do not specify which to grade, the maximum grade of 5 will be excluded.

Every open question is worth 30 raw points.

If not stated otherwise, think of all goods, services and assets as of infinitely divisible. Numbers of firms and people may be only integer.

Convey your ideas clearly. Don't skip important logical transitions in your reasoning.

Good luck!

Question 1. "Measuring Inequality" *(30 raw points)*

In most of the tasks about inequality that you might encounter, the data on income or wealth is given and is not questioned. In reality, however, the estimates of these numbers can be biased, and these biases can make an unjustified impression about whether inequality is high or low. Unjustified impressions, in their turn, may lead to unreasonable policy-making. In this task, we will discuss what these biases might be and where they can come from.

(a) *(10 rp)* Ann uses the administrative (tax) microdata to estimate the income inequality in country N. In particular, she takes the amounts of income tax paid by all households per year, calculates incomes dividing tax payments by the tax rates and gets the Gini coefficient based on this income distribution. Bob argues that due to this approach, Anna is likely to overlook a substantial part of the real income distribution. What part is it? Does this bias lead to overestimating or underestimating the extent of income inequality?

(b) *(10 rp)* Bob uses the surveys data to estimate the income inequality in country N. In particular, he refers to the statistics obtained by a sociological service that regularly asks people about their households' consumption spending (income surveys are also available, but Bob doesn't trust how households report their incomes). Ann argues that Bob's results are biased, too. Why is that? Does this bias lead to overestimating or underestimating the extent of income inequality?

(c) *(10 rp)* Carol believes that over time, top 1 percent of incomes in country N are rising more quickly than average incomes. To verify this belief, she has taken Ann's and Bob's estimates at different times. It turned out that one of them does not contradict the belief, but the other one does. Explain which one is which and why it is so.

Solution

(a) People who don't earn taxable income do not pay taxes and don't show up in the tax data. They are generally near the left edge of the income distribution (retirees, people on welfare, etc.), also people working in a shadow economy. Because they are close to the edge, their overlooking will underestimate inequality.

(b) Very rich people are unlikely to participate in surveys (answer the questions in the street, pick up the randomly dialed phone, etc.), so this approach will overlook the right edge. Moreover, the more people earn, the less percentage of income they spend (they save more), so even if there was a chance to ask all of them, income inequality would be underestimated.

(c) If more income goes to the top of the distribution, this won't be seen in surveys (because they overlook the rich) but will be seen in tax data (because the rich pay taxes).

Marking Scheme

(a) 5 points for identifying the overlooked group, 5 points for the explanation why it underestimates inequality.

(b) 5 points for identifying the overlooked group, 5 points for the explanation why it underestimates inequality.

(c) 5 points for correct identification of whose data contradict Carol's observation, 5 points for detailed explanation. If correct identification is likely to be a coincidence (no logical explanation is given), answer is graded with 0 points.

Question 2. "Trade Sanctions and Segmentation"   *(30 raw points)*

There are 100 countries in the World. Demand in country number i for natural gas is given by $D_i(p_i) = 100i - p_i$, while its supply is given by $S_i(p_i) = ip_i$.

(a) *(5 rp)* Find equilibrium prices $p_i^\star$ when countries do not trade with each other.

(b) *(5 rp)* Assume there is a global market for natural gas, in which all countries participate. Find the equilibrium in this market. Determine what countries are net exporters of the natural gas and what countries are net importers.

(c) *(5 rp)* Assume that the world imposes sanctions against country number j and discontinues trade with it. How will this affect the world price? Which agents in other countries will gain and which will lose? What can one say about the change in consumer and producer welfare in country j?

(d) *(15 rp)* Now assume that the global market splits into several blocs (some perhaps consisting of a single country); there is free trade within each bloc but no trade across blocs. Answer the following questions and explain your answers, comparing the results of destruction of the global market to the free trade situation in part **(b)**.

(d1) *(5 rp)* Can there be *a country* where the joint welfare of all consumers and all producers improve?

(d2) *(5 rp)* Can there be *a bloc* where the joint welfare of all consumers and all producers improve?

(d3) *(5 rp)* What happens to the joint welfare of all consumers and all producers in the world?

Solution

(a) Equilibrium in each country can be calculated in a standard way: $D_i = S_i$, that is $100i - p_i = ip_i$ and

$$p_i^\star = \frac{100i}{1 + i}.$$

(b) In the global market, the total demand must equal the total supply under the unified price p, so,

$$\sum_{i=1}^{100}(100i - p) = \sum_{i=1}^{100}(ip).$$

By using $\sum_{i=1}^{n} i = n(n + 1)/2$, we get

$$100 \cdot \frac{100 \cdot 101}{2} - 100p = \frac{100 \cdot 101}{2} \cdot p.$$

Solving for p, we get

$$p_{(b)}^\star = \frac{100 \cdot 101}{103} \approx 98.06.$$

The countries with $p_i^\star < p_{(b)}^\star$ will export (they will prefer to sell to the world market

because it is profitable). That is,

$$\frac{100i}{1+i} < \frac{100 \cdot 101}{103}$$
$$101 + 101i > 103i$$
$$i < 50.5$$

That is, all countries with $i = 1...50$ will be exporters, countries with $i = 51...100$ will be importers.

(c) Country j will disappear from the world market, both supply and demand. Whether it sill shift the world price up or down, depends on whether j was an exporter or importer. If it was an exporter, than under the equilibrium price, more supply will be subtracted from the world S function than demand from the world D function. Thus there will be excess demand, the price in the world will go up. If j was an importer than the world price will go down following similar logic.

This result can also be obtained analytically by subtracting demand and supply of country j and comparing the new equilibrium price with the old one.

$$100 \cdot \frac{100 \cdot 101}{2} - 100p - (100j - p) = \frac{100 \cdot 101}{2} \cdot p - ip$$
$$100 \cdot \frac{100 \cdot 101}{2} - 100j - 99p = \left(\frac{100 \cdot 101}{2} - i \right) \cdot p$$
$$p^{\star}_{(c)} = \frac{505,000 - 100j}{5149 - j}$$
$$p^{\star}_{(c)} > p^{\star}_{(b)} \iff j < 50.5$$

If	$j \leqslant 50$	$j \geqslant 51$
than the world price	↑	↓
consumers in other countries	worse off	better off
producers in other countries	better off	worse off
price in j	↓	↑
consumers in j	better off	worse off
producers in j	worse off	better off

(d1) Yes, it is possible. To construct an example, think of a country which used to be an exporter in the global trade and remains an exporter within a block where equilibrium price is higher than $p^{\star}_{(b)}$. This country is unambiguously better off. E.g., in a block with countries $i = 1, 99, 100$, country 1 will be the only exporter, and the price will be higher than in the equilibrium without blocs.

(d2) No. Assume such a bloc exists. If the price within this bloc is equal to $p^{\star}_{(b)}$, than every agent gets the same welfare. But if it is different, this bloc (all countries in it taken together) used to be a net exporter or a net importer when the free trade was possible. No this bloc is a closed economy, so total welfare of the block must decrease when there is no across-bloc trade.

(d3) Most likely, it will go down, because there will be mutually beneficial transactions between blocs. In a particular case when in all blocs equilibrium prices turn out to be equal to $p^{\star}_{(b)}$, the welfare will be the same (for example, if country 1 trades only with country 100, country 2 trades only with country 99, etc.).

Marking Scheme

(a) 5 points for correctly calculating the prices

(b) 3 points for calculating the world price, 2 points for identifying exporters and importers. It is incorrect to calculate the world price as the average of all autarky prices in the countries, because in the general case this does not lead to the correct result.

(c) All directions are identified correctly, there is an explanation – 5 points

There is intuition of how the prices change, at least one welfare change is specified – 4 points

Only intuition of how the prices change, no specification of welfare changes – 3 points

Answer with correct directions of changes (all of them are present or 1-2 some are missing), no explanation – 2 points

(d1) 5 points for an example

(d2) 5 points for correct proof

(d3) 5 points for correct explanation

If in parts (d1)–(d3) a contestant writes some general intuition on how countries benefit or lose from forming blocs in the market, these ideas are true for the real world but irrelevant to the model in the task, the contestant gets 1 point for a part.

Question 3. "How to Finance Government Spending" *(30 raw points)*

Consider a closed economy where consumption spending depends on output: $C = C_0 + 0.8Y_d$, where $C_0 > 0$ is autonomous consumption and Y_d is disposable income (income after tax). The tax rate is flat at the level of 20% on all income without double taxation. The Short-Run Aggregate Supply (SRAS) is flat at $P = 1$. Investment is given by $I = 7.5 - 4r$, where r is the real interest rate expressed *in percentage points* (for example, $r = 1.12$ means that interest rate is 1.12%, not 112%). The supply of loanable funds is given by $S = 16r$. Initially, the equilibrium level of GDP $Y^\star = 100$, all demand for loanable funds comes from investment, the state budget is balanced. The government wants to reduce unemployment and increases G by 10.

(a) *(10 rp)* Assume that the government just has this money at its disposal, so there is no need to borrow it or find elsewhere. How will the increase in G affect GDP? If the increase in GDP does not equal to the increase in G, explain the difference.

(b) *(10 rp)* Now, assume that the government will finance its new spending through collected taxes, thus adjusting the tax rate. Find the new level of GDP in equilibrium. If it does not equal to the new level of GDP in **(a)**, explain the difference.

(c) *(10 rp)* Assume that instead of raising taxes, the government will borrow 10 in the financial market, affecting the interest rate. How will this affect GDP when the goods market and the loanable funds market are the new equilibrium? If it does not equal the new level of GDP does not equal the new level of GDP in **(a)**, explain the difference.

Solution Please note that since the economy is closed, there are no exports or imports. Moreover, loanable funds are not restricted to savings by consumers. That is, $S = 16r$ as given in the problem and $S \neq Y_d - C$.

Collected taxes are $T = 0.2 \cdot Y = 20$, budget is balanced, so $G = 20$ as well. In the credit market, $7.5 - 4r = 16r$, so $r^\star = 0.375$ and $I = 6$.

In equilibrium, output must equal demand, that is,

$$Y = C + I + G.$$

Let's plug what we know to the output equation: $100 = C_0 + 0.8 \cdot (1 - 0.2) \cdot 100 + 6 + 20$. From this we get $C_0 = 10$. So, the equilibrium condition is:

$$Y = 10 + 0.8 \cdot (1 - t) \cdot Y + I + G.$$

(a) In this part, $t = 0{,}2$, $G = 30$ and $I = 6$. Plugging this into the equilibrium equation, we obtain:

$$Y = 10 + 0.8 \cdot 0.8 \cdot Y + 6 + 30.$$

So, $Y^\star_{(a)} \approx 127.28$, GDP goes up by 27.78. This is greater than $\Delta G = 10$ because of the multiplier effect.

Alternative solution: use the government spending multiplier $1/(1 - mpc(1 - t)) = 1/(0.44)$; $10/0.44 \approx 27.78$.

(b) In this part, t is unknown, $G = 30$, $I = 6$ and $tY = 30$. Plugging this into the equilibrium equation, we obtain:

$$Y = 10 + 0.8Y - 0.8 \cdot 30 + 6 + 30.$$

So, $Y^{\star}_{(b)} = 110$, GDP goes up by 10 compared to the initial state. This is less than in **(a)** because increase in taxes has a partially offseting effect on GDP.

(c) The government enters the loanable funds market as a borrower aiming to borrow 10, so it is now $7.5 - 4r + 10 = 16r$, and $r = 0.875$. With this rate, $I = 4$; also $t = 0.2$, $G = 30$. Plugging this into the equation, we get:

$$Y = 10 + 0.8 \cdot 0.8 \cdot Y + 4 + 30.$$

So, $Y^{\star}_{(c)} \approx 122.22$, GDP goes up by 22.22 compared to the initial state. This is less than in **(a)** because by entering the loanable funds market, the government forces the interest rate higher, which reduces investment (this is called the crowding out effect).

Marking Scheme

(a) 5 points for correct calculations, 5 points for explanation. For intuition/explanation it was important to explain multiplier effect.

Correct comparison of ΔG and ΔY with correct calculations, but missing explanation of the multiplier effect [7/10].

Common mistake - calculating multiplier without tax rate, which makes it 5 and leads to $\Delta Y = 50$. [7/10 with correct intuition.]

(b) 5 points for correct calculations, 5 points for explanation.

For intuition/explanation needs to mention effect of taxes on disposable income.

Common mistake - assuming that the new tax rate is 30%. It is actually too high and leads to $Y = 22.73$ and tax collected of 36.82, which is more than 30. [8/10]

(c) 5 points for correct calculations, 5 points for explanation.

For intuition/explanation needs to explain crowding out of private investments.

Common mistake - calculate correctly effect on I, i.e. reduction from 6 to 4, but then do not account for the multiplier effect and conclude that effect on Y is -2. [7/10] With an attempt to calculate an effect on Y through some sort of a multiplier, but incorrect. [8/10]

Question 4. "Shadow Economy"   *(30 raw points)*

One of the problems with the GDP indicator is its inability to account for the production of goods and services in the underground (shadow) economy. By this we mean not only illegal production of forbidden goods and services but also housework, helping friends, etc. — everything that is not observable for official statistics, but would have to be included in GDP if it were observable.

Clearly state two different approaches for estimating the size of the shadow economy of a country. Explain why your approaches may work to achieve this goal. Also explain why they might not work (the disadvantages).

Solution The three approaches that are mostly used are the following.

1. Survey data; one can ask people how much they earn, or spend, or how busy they are with housekeeping etc. and compare it with the official statistics of income and consumption. Since people may take their unofficial activities into account when answering surveys, the comparison with the official statistics may to some extent reveal the unobserved part of the economy. The main disadvantage are common for surveys: the samples can be biased (it's unlikely that people who are rich and heavily engaged in tax evasion will take part), some people will refuse to respond, some of them will respond, but will not mention their unofficial earnings in fear that they can be investigated.

2. Using indirect (proxy) indicators of overall economic activity like electricity consumption, percentage of cash in the money supply, etc. This can work, because people inevitably leave 'fingerprints' when participate in the unofficial transactions, and they can be traces with this proxies. On the other hand, *quantifying* the shadow economy with these proxies is very difficult, so estimates can be way off.

3. Calculating GDP by definition, i.e., looking at the costs of production for the economy. It should work because even products sold illegally and unofficially are produced at the initial stages. The disadvantage of this approach is that we are missing most services.

Marking Scheme

15 points for each method: 5 for identification + 5 for why it works + 5 for disadvantages.

Question 5. "Going Green" *(30 raw points)*

There are two groups of consumers of solar panels in country S: 150,000 households who consider purchasing them because they care about the environment and 200,000 households who consider purchasing them because it is trendy (this is sometimes called the bandwagon effect). The demanded quantities of the solar panels are given by:

$$Q_{c(\text{are})} = 150{,}000 - p, \qquad\qquad Q_{b(\text{andwagon})} = 40{,}000 - 5p + 500\sqrt{N},$$

where p is the price of a solar panel (in USD) and N is the total quantity of solar panel users (in equilibrium, $N = Q_c + Q_b$). For simplicity, assume that Q_c, Q_b, and N can be non-integer. The supply of the solar panels is perfectly elastic, $p = 25{,}000$.

The market adjusts to the equilibrium in the following way. First, customers who care about the environment decide whether they will have solar panels. At every step after that, customers from the 'trendy' group observe the quantity of solar panels around and decide whether they will have solar panels based on this observation. This goes on until everyone is happy with their choice.

(a) *(5 rp)* How many solar panels will be purchased?

(b) *(15 rp)* The government introduces a per-unit subsidy $s = \$5{,}000$. Calculate the quantity of solar panels in equilibrium.

(c) *(10 rp)* After the equilibrium from **(b)** is reached, the government surprisingly eliminates the subsidy. Customers have the opportunity to return the once-purchased solar panels and get $25,000 refunded (and indeed do this if their willingness to pay is below 25,000 per panel). Find the new equilibrium quantity of installed solar panels. Is your answer the same as in **(a)**? Why or why not?

Solution

(a) Quantity demanded by those who care is $Q_c = 150{,}000 - 25{,}000 = 125{,}000$. The number of panels to be purchased by the second group in the first period: $Q_b = 40{,}000 - 5 \cdot 25{,}000 + 500\sqrt{125{,}000} \approx 91{,}776$. With this, N becomes approximately $125{,}000 + 91{,}776 = 216{,}776$ and should increase further: $40{,}000 - 5 \cdot 25{,}000 + 500\sqrt{216{,}776} \approx 147{,}796$. The process will continue until the equilibrium is reached. In equilibrium, $N = Q_c + Q_b$, so

$$N = 125{,}000 + 40{,}000 - 5 \cdot 25{,}000 + 500\sqrt{N}.$$

One can rewrite it with $x = \sqrt{N}$ and get $x^2 - 500x - 40{,}000 = 0$. This is a quadratic equation solved by $(x_1, x_2) = (50 \cdot (5 + \sqrt{41}), 50 \cdot (5 - \sqrt{41}))$. The second one is negative; the first one will result in $N = x_1^2 \approx 325{,}078$. $Q_c = 125{,}000$, so Q_b is 200,078, but there are only 200,000 households in this group, so actually $Q_b = 200{,}000$ and $N^\star_{(a)} = 325{,}000$.

(b) Now the price for consumers is 20,000, and $Q_c = 150{,}000 - 20{,}000 = 130{,}000$. There are even more consumers at the initial stage, so the 'bandwagon' segment will be even more willing to join, everyone there will join again. So, $N^\star_{(b)} = 330{,}000$.

(c) According to the described mechanism, those who care will adjust first and return back to $Q_c = 125{,}000$. So, the equilibrium condition will be the same as in **(a)**, so as the result.

Marking Scheme Since the questions and the results of parts are very similar, they are graded together.

- 6 points for making sure that under the calculated Q_c, Q_b is positive, so the equilibrium condition can be applied. This should be done at least for $p = 25{,}000$ (then, for the case with subsidy the result will follow).
- 10 points for specifying the equilibrium condition with all parameters plugged in.
- 6 points for solving for equilibrium values of N (2 points for each from **(a)**, **(b)**, **(c)**).
- 3 points for noticing that Q_b is too big and correcting it to 200,000 (1 point for each from **(a)**, **(b)**, **(c)**).
- 5 points for pointing out that the result in **(c)** is the same as in **(a)** because nothing changed.

Comment. Because of the typo in the students' version of the task, this question turned out to be much simpler and less interesting than it was initially designed. This also explains why the maximum points for parts do not reflect their difficulty. The corrected version provided below encompasses an interesting phenomenon: the introduction and removal of the subsidy can change things compared to the initial state due to the bandwagon effect.

Question 5. "Going Green (corrected)" *(30 raw points)*

There are two groups of consumers of solar panels in country S: 150,000 households who consider purchasing them because they care about the environment and 200,000 households who consider purchasing them because it is trendy (this is sometimes called the bandwagon effect). The demanded quantities of the solar panels are given by:

$$Q_{c(are)} = 150{,}000 - 5p, \qquad Q_{b(andwagon)} = 40{,}000 - 5p + 500\sqrt{N},$$

where p is the price of a solar panel (in USD) and N is the total quantity of solar panel users (in equilibrium, $N = Q_c + Q_b$). For simplicity, assume that Q_c, Q_b, and N can be non-integer. The supply of the solar panels is perfectly elastic, $p = 25{,}000$.

The market adjusts to the equilibrium in the following way. First, customers who care about the environment decide whether they will have solar panels. At every step after that, customers from the 'trendy' group observe the quantity of solar panels around and decide whether they will have solar panels based on this observation. This goes on until everyone is happy with their choice.

(a) *(5 rp)* How many solar panels will be purchased?

(b) *(15 rp)* The government introduces a per-unit subsidy s = $5,000. Calculate the quantity of solar panels in equilibrium.

(c) *(10 rp)* After the equilibrium from **(b)** is reached, the government surprisingly eliminates the subsidy. Customers have the opportunity to return the once-purchased solar panels and get $25,000 refunded (and indeed do this if their willingness to pay is below 25,000 per panel). Find the new equilibrium quantity of installed solar panels. Is your answer the same as in **(a)**? Why or why not?

Solution

(a) $Q_c = 150{,}000 - 5 \cdot 25{,}000 = 25{,}000$ solar panels purchased by the first group. As for the second (bandwagon) group, in the first period $Q_b = 40{,}000 - 5 \cdot 25{,}000 + 500\sqrt{25{,}000}$. This is negative, so, no panels will be purchased by the second group. So, $N^\star = 25{,}000$.

(b) The price for customers is now $p - s = 20{,}000$. Quantity demanded by those who care is $Q_c = 150{,}000 - 5 \cdot 20{,}000 = 50{,}000$. This allows for positive number of panels to be purchased by the second group: $Q_b = 40{,}000 - 5 \cdot 20{,}000 + 500\sqrt{50{,}000} \approx 51{,}803$. With this, N becomes approximately $50{,}000 + 51{,}803 = 101{,}803$ and should increase further: $40{,}000 - 5 \cdot 20{,}000 + 500\sqrt{101{,}803} \approx 99{,}533$. The process will continue until the equilibrium is reached. In equilibrium, $N = Q_c + Q_b$, so

$$N = 50{,}000 + 40{,}000 - 5 \cdot 20{,}000 + 500\sqrt{N}.$$

One can rewrite it with $x = \sqrt{N}$ and get $x^2 - 500x + 10{,}000 = 0$. This is a quadratic equation solved by $(x_1, x_2) = (50 \cdot (5 + \sqrt{21}), 50 \cdot (5 - \sqrt{21}))$. From this we get $N_1 = x_1^2 \approx 229{,}564$ and $N_2 = x_2^2 \approx 436$. Given the process that leads to the equilibrium, the answer must be greater than 101,803, so we conclude that $N^\star \approx 229{,}564$ (alternative explanation: N cannot be equal to 436 because $Q_c = 50{,}000$ and it is a part of N).

(c) According to the described mechanism, those who care will adjust first and return back to Q_c = 25,000. The equilibrium condition is now the following:

$$N = 25{,}000 + 40{,}000 - 5 \cdot 25{,}000 + 500\sqrt{N}.$$

One can rewrite it with $x = \sqrt{N}$ and get $x^2 - 500x + 60{,}000 = 0$. This is a quadratic equation solved by $(x_1, x_2) = (300, 200)$. From this we get $N_1 = x_1^2 = 90{,}000$ and $N_2 = x_2^2 = 40{,}000$. Given the process that leads to the equilibrium, the answer must be the greater one, so we conclude that $N^\star$ = 90,000. Even though there is no subsidy anymore, the number is different from **(a)**, because of the equilibrium dynamics: the 'bandwagon' customers immediately saw a lot of solar panels around, so they did not want to get rid of them. So, if the government or a producer wants to make something of this kind popular, they can firs stimulate buying it, and after some time remove the incentive.