1. Consider a small country (Thailand) with the following demand and supply curves for oil:

\[
\text{Supply} = 4(P_o^s - 50); \quad \text{Demand} = 1000 - 2P_o^c
\]

\(P_o^s\) is the price producers receive for oil output, \(P_o^c\) is the price consumers pay for oil, and if there are no domestic taxes or subsidies: \(P_o^c = P_o^s\). Thailand can import oil at a given world price of \(P_o = 80\) per barrel of oil. Further, assume that Thailand imposes an import tariff of \(t\) per barrel of oil imported.

a) **Show how: domestic price, consumption and production change as \(t\) increases. Also, calculate how consumer surplus, producer surplus, and government tariff revenue change as \(t\) increases.**

Given the world price, the tariff inclusive price of imports in Thailand is given by: \(P^{d}(t) = 80 + t\); this will be the domestic price if it is less than the autarky price (i.e., if \(t \leq 120\)). Note that for \(t > 120\) the tariff is prohibitive, there are no imports, and the domestic price equals the autarky price of 200. Thus, assuming \(t < 120\), we have:

\[P^{d}(t) = 80 + t; \quad D = 1000 - 2P^{d}(t) = 840 - 2t; \quad S = 4(P^{d}(t) - 50) = 120 + 4t; \quad M = D - S = 720 - 6t\]

Consumption and imports fall, and production rises, as \(t\) increases. The changes in consumer and producer surplus are seen on the diagram on the next page. The increase in producer surplus is given by area \((80, A^*, A, (80 + t))\), whereas the decrease in consumer surplus is given by: \((80, B^*, B, (80 + t))\). Thus:

\[\Delta PS = \frac{1}{2} t \cdot (120 + 120 + 4t) = 120t + 2t^2 \quad \Delta CS = -\frac{1}{2} t \cdot (840 + 840 - 2t) = -840t + t^2\]

\[TR = tM = t \cdot (720 - 6t) = 720t - 6t^2 \] is tariff revenue.

Thus, it is easily seen that producer surplus increases with the tariff, and consumer surplus decreases (for \(t < 120\)), whereas tariff revenue increases with the tariff for \(t < 60\), and then decreases thereafter. Overall:

\[\Delta Welfare = TR + \Delta PS + \Delta CS = -3t^2 \quad \text{so that the tariff lowers overall welfare.}\]

(i) If \(t > 120\), the tariff is prohibitive, no trade occurs and domestic price is 200.

b) **Compare the domestic equilibrium when \(t=70\) to the case where there is no tariff, but there is an import quota of 300 units.**

From part (a), with \(t=70\), domestic price is 150, and imports \(M = 720 - 6t = 300\). Thus, a quota of 300 and a tariff of 70 have identical effects on domestic price, consumption, production and imports. The only possible difference is the tariff revenue (which is 21,000 under the tariff). Under the quota, importers make 70 on each unit imported (the world price is 80 and the domestic price solves for 150).
\[ D - S = 1200 - 6P^d = 300 \] which implies \( P^d = 150 \). Hence, importers will earn excess profits of 300*70=21,000 unless the quota licenses are auctioned off, in which case the two policies are identical.

**Figure 1**

**c) Suppose Thailand subsidizes oil imports at rate \( s \).**

A subsidy is just a negative tariff, so for part (b) just let \( t = -s \) and you get:

\[ P^d = (80 - s); \quad D = 1000 - 2P^d = 840 + 2s; \quad S = 4\left(P^d - 50\right) = 120 - 4s; \quad M = D - S = 720 + 6s \]

(Note if \( s > 30 \) output is zero, not negative). So, as is apparent, the subsidy: (i) reduces domestic price; (ii) raises consumer surplus; (iii) lowers producer surplus; (iv) causes negative tax revenue – i.e., the government must spend money. And it reduces overall welfare. Going through the same exercises as for the tariff:

\[ \Delta PS = \frac{1}{2}(-s)\cdot(120 + 120 + 4(-s)) = -120s + 2s^2 \]

\[ \Delta CS = \frac{1}{2}(-s)\cdot(840 + 840 - 2(-s)) = 840s + s^2 \]

\[ TR = (-s)M = (-s)\left(720 - 6(-s)\right) = -720s - 6s^2 \] is tariff revenue (which is negative)

\[ \Delta Welfare = \Delta PS + \Delta CS + TR = -3s^2 < 0 \quad s \neq 0 \]
i. Since the subsidy increases imports, there is no quota – that is, no restriction on imports – that will have the same effect. Of course, if the government decides how much to import (through a state trading agency, for example), then it can replicate the effects of an import subsidy.

ii. No, as seen above both lower welfare. The point is that for a small country with no market distortions (no inefficiencies) free trade is optimal and any divergence from free trade must lower welfare.

(d) Consumption depends on the price consumers pay; for an importing country the price consumers pay can be increased either by an import tariff, as above, or by a direct consumption tax. Let \( P^c \) stand for the price the consumer pays; then consumption is \( D = (1000 - 2P^c) \). To get consumption of 700 requires a consumer price of 150: \( D = 1000 - 2P^c = 700 \rightarrow P^c = 150 \).

(i) So, a consumption tax of 70 is required to yield the required consumption since, with free trade, the consumer pays the world price (of 80) plus the tax to the government: \( P^c = 80 + t = 150 \rightarrow t = 70 \). The decrease in consumer surplus is the same as with a tariff of 70, and is the area \( \{80, B, B^*, (80 + t)\} \), with \( t = 70 \), in figure 1. The revenue to the government (taxpayer) from the tax is \( t \cdot Q = 70 \cdot 700 = 49,000 \).

\[
\Delta CS = -\frac{1}{2} t \cdot (840 + 840 - 2t) = \frac{1}{2} (70) \cdot (840 + 840 - 2(70)) = 53,900; \quad \text{Tax Revenue} = 49,000;
\]
\[
\Delta W = -4,900
\]

The deadweight loss due to the consumption tax is due to reduced consumption, which is area BB*F in figure 1. But there is no deadweight loss due to changes in production because the consumption tax does not alter production.

(ii) From earlier, the deadweight loss with a tariff of 70 is: \( \Delta Welfare = -3t^2 = -14,700 \)

Thus, the tariff leads to a larger welfare loss – in order to meet the consumption target – than does the consumption tax. In addition to the deadweight loss due to reduced consumption, with a tariff there is the additional deadweight loss (due to increased production) of area A*EA in Figure 1.

(iii) The point is the policy that directly addresses the noneconomic objective is the best policy; hence, a consumption tax dominates a tariff to decrease domestic consumption because the tariff also affects production. If the goal is to increase production, this can be achieved by an import tariff (that raises domestic price for both producers and consumers) or by a production subsidy. Both increase production, but the tariff has the (unwanted) effect of decreasing consumption, which creates additional inefficiencies. Hence, the production subsidy is the better policy to increase production of oil.

2. Use the same model as in question 1, with \( \text{Supply} = 4 \left( P^* - 50 \right); \quad \text{Demand} = 1000 - 2P^* \).

However, production of oil creates pollution, which damages the environment; the (economic) cost of this pollution is 45 per barrel of oil produced. Thus, the marginal social cost of producing oil exceeds the marginal private cost of producing oil by 45. \{The supply curve reflects marginal private cost (MPC); the MPC of producing oil is thus: \( Q^* = 4 \left( P^* - 50 \right) \rightarrow MPC = 50 + \left( Q^*/4 \right) \}.

Finally, assume the government has no domestic policy to redress the externality (pollution).

a) Suppose world price is 80. Since this is below the domestic price, that means the country will import oil. There are the usual gains from trade (increased consumption because, starting from autarky, the
The value of oil exceeds the world price; decreased production, because private production costs exceed world price) and, in addition, there is the gain from the fact that the presence of pollution – for which there was no government policy – means that oil is overproduced domestically in autarky, and that reduced production reduces pollution damages. Thus, in this case, trade will be beneficial.

i. Calculate the gains or losses from trade in this setting.

![Graph showing demand, supply, and marginal social cost curves.]

The figure above shows the demand curve, the supply curve (marginal private cost) and the marginal social cost curve (MSC), which lies 45 units above the supply curve because of the pollution costs.

The autarky equilibrium is at E, with a price of 200, and output/consumption of 600. This is not efficient because, at that output level, marginal social cost (point G) lies above the marginal value of the additional unit of output. Under autarky, the efficient equilibrium is at R, with a higher price and lower production/consumption.

Starting from E (no pollution tax), the movement from autarky to free trade at a price of 80 reduces domestic price and production, while increasing consumption.

Consumers gain area: 200,E,K,80
Producers lose area: 200,E,A,80
So, ignoring pollution, the gains by moving to free trade is the triangular area AEK, composed of the smaller triangles labeled 1 and 2. This is the usual argument of the gains from trade.

However, because of pollution, the lower output reduces pollution costs by 45*reduced output; this reduction in pollution costs is given by area of parallelogram \{A,A'',G,E\}.
Hence, the total gains from free trade are area $\{EHK\}$ – the gain due to increased consumption; plus area $\{A,A'',G,H\}$ – the gains due to reduced production (i.e., it is the savings in social cost – the area under the MSC curve between 120 and 600, less the cost of importing this quantity – area of rectangle $\{120,A,H,600\}$). The gains from trade are larger than in the case where there are no externalities.

Calculating the gains:

$$\Delta CS = (1/2) \times 120 \times [600 + 840] = 86,400$$

$$\Delta PS = -(1/2) \times 120 \times [600 + 120] = -43,200$$

Reduction in pollution costs: $45 \times (\Delta Q) = 45 \times 480 = 21,600$

Total Welfare Gain = $86,400 - 43,200 + 21,600 = 64,800$

ii. The best policy to attack the market failure is to “internalize the externality” – i.e., to make firms take in to account the costs they impose on others. Specifically, this means taxing their output based on pollution emissions (and damages done), or for this specific case a 45 tax on oil output.

iii. What to do if only trade policy can be used? In this case, since the problem is firms produce too much (even at the lower world price, the marginal social cost of producing oil is above the cost of getting oil from the world market), then the optimal policy is to subsidize imports, reducing domestic price, thus domestic output and pollution. {You do not have to do a calculation here but I will}. If the subsidy is $s$, then domestic price is $(80-s)$, domestic production is $4(P^d - 50) = 120-4s$; domestic consumption is $1000 - 2P^d = 840+2s$, and imports are $720+6s$ (see problem 1c). The changes in surplus are (again, see 1c) and in pollution costs

$$\Delta PS = \frac{1}{2} (-s) \cdot (120 + 120 + 4(-s)) = -120s + 2s^2$$

$$\Delta CS = -\frac{1}{2} (-s) \cdot (840 + 840 - 2(-s)) = 840s + s^2$$

$$TR = (-s) M = (-s)(720 - 6(-s)) = -720s - 6s^2$$ is tariff revenue (which is negative)

ReductionPollutionCost = $45 \times (\Delta Q) = 45 \times (4s) = 180s$

Thus, the overall welfare change is:

$$\Delta W = \Delta CS + \Delta PS + TR - ReductionPollutionCost = -3s^2 + 180s$$

$$\frac{dW}{ds} = 180 - 6s = 0 \rightarrow s^* = 30$$

So, the second best policy is an import subsidy that reduces domestic price to 50 and lowers domestic output. The best solution, a tax of 45 on oil output would – under free trade – would lead to no domestic output of oil.

b) If the world price is 220, above the autarky price (without a pollution tax), the country will export, rather than import, oil and thus trade will increase domestic production and pollution. Hence, it is quite possible that for this case trade reduces welfare. First, note that while the autarky price is 200, the efficient autarky price (point R in the figure) is found from imposing a tax of 45 on production so:
Thus, if a pollution tax were imposed on firms, the country should import, rather than export, oil.

\[ S = D \rightarrow 4 \left( P_o^s - 50 \right) = 1000 - 2P_o^c \rightarrow 4 \left( (P_o^c - 45) - 50 \right) = 1000 - 2P_o^c \rightarrow P_o^c = 230, \quad P_o^s = 185. \]

Due to trade, domestic price increases from 200 to 220, domestic consumption falls from 600 to 560 and domestic production increases from 600 to 680. The welfare effects are as follows:

\[ \Delta CS = -area\{200, E, K, 220\} = -11,600 \]
\[ \Delta PS = +area\{200, E, A, 220\} = +12,800 \]

Increase Pollution Costs \( = 45 \cdot \Delta Q = +3,600 \)

\[ \Delta Welfare = -11,600 + 12,800 - 3,600 = -2,400 \]

Thus, trade lowers welfare. Overall, the gain is area \{K,H,E\} less area \{H,G,A''\,A\}.

As in part (a), since the market failure is that marginal private production costs are lower than marginal social costs, the optimal policy is to tax pollution, which in this case is synonymous with a tax of 45 on production of oil. If that were done the autarky price would be 235, and the country would – under free trade – import oil rather than export oil.
iii. If only trade policy is possible, then export restrictions – or export tariffs – would be the appropriate policy. Let the export tax be \( t \); then the domestic price would be:
\[
P^s_0 = P^c_0 = P^d = 220 - t, \quad t \leq 20; \quad D = 1000 - 2P^d = 560 + 2t; \quad S = 4 \left( P^d - 50 \right) = 680 - 4t
\]

\[\text{Exports} = S - D = 120 - 6t\]
\[\Delta CS = + \left( \frac{1}{2} \right) \cdot t \cdot (560 + 560 + 2t) = 560t + t^2\]
\[\Delta PS = - \left( \frac{1}{2} \right) \cdot t \cdot (680 + 680 - 4t) = -680t + 2t^2\]
\[TR = t \cdot \text{Exports} = 120t - 6t^2\]
\[\Delta CS + \Delta PS + TR = -3t^2\]

So, from the above, we see that if there were no pollution, then the export tariff would lower welfare. However:

Decrease in Pollution Costs = \[45 \cdot (-\Delta Q) = 45 \cdot (4t) = 180t\];

Thus, change in welfare:
\[\Delta W = \Delta CS + \Delta PS + TR + \text{Decrease in Pollution Costs} = 180t - 6t^2\]

So, welfare increases for \( t \leq 20 \) and for \( t = 20 \) we return to autarky.

The optimal export tax:
\[
\frac{dW}{dt} = 180 - 12t = 0 \rightarrow t^* = 15
\]