1. Consider a world of two countries (US, China) with the following demand and supply curves:

US: \[ \text{Demand} = 360 - 10P_s^\text{US} \]; \[ \text{Supply} = 20P_s^\text{US} \]  where \( P_s^\text{US} \) is the price of soybeans in the US;

China: \[ \text{Demand} = 540 - 5P_s^\text{CH} \]; \[ \text{Supply} = 10P_s^\text{CH} \]  where \( P_s^\text{CH} \) is the price of soybeans in China.

a) Find the autarky prices in each country.

US: \[ S_s^\text{US} - D_s^\text{US} = 30P_s^\text{US} - 360 = 0 \rightarrow P_s^\text{US} = 12 \]

China: \[ S_s^\text{CH} - D_s^\text{CH} = 15P_s^\text{CH} - 540 = 0 \rightarrow P_s^\text{CH} = 36 \]

b) Assuming free trade, find the equilibrium world price and quantities traded.

\[ S_s^\text{US} - D_s^\text{US} = D_s^\text{CH} - S_s^\text{CH} \rightarrow 30P_s^\text{US} - 360 = 540 - 15\left(P_s^\text{CH}\right) \rightarrow 45P_s^\text{US} = 900; \quad P_s^\text{US} = P_s^\text{CH} = 20 \]

c) Find how a US export tariff of \( t \) affects the volume of trade and prices in China and the US (your answer should be expressed in terms of \( t \)). Who pays for the US export tax? Explain. {NOTE: under the US export tariff: \( P_s^\text{CH} = P_s^\text{US} + t \).}

US export supply equals China’s import demand, given the tariff, implies:

\[ S_s^\text{US} - D_s^\text{US} = D_s^\text{CH} - S_s^\text{CH} \rightarrow 30P_s^\text{US} - 360 = 540 - 15\left(P_s^\text{CH}\right) \rightarrow \\
45P_s^\text{US} = 900 - 15t; \quad P_s^\text{US} = 20 - \left(t/3\right); \quad P_s^\text{CH} = 20 + \left(2t/3\right) \]

China pays \(2/3\) of the US tax, while US residents pay \(1/3\). The incidence of the tax is on both the buyer (the importer) and the seller (the exporter).

i. Calculate how the US export tariff changes US producer surplus, consumer surplus and government tariff revenue (the answer should be expressed in terms of \( t \)). Use these results to show how the US export tariff changes US welfare. (See figure on next page)

The US tariff causes US prices to fall, and thus consumers gain, producers lose, and the government gains tariff revenue. In terms of the figure:

\[ \Delta CS = Area\left\{20,A,A^*,(20-(t/3))\right\} = \frac{t}{3} \cdot \left\{160 + \frac{5t}{3}\right\} \]

\[ \Delta PS = -Area\left\{20,B,B^*,(20-(t/3))\right\} = -\frac{t}{3} \cdot \left(400 - \frac{10t}{3}\right) = -\frac{400r}{3} + \frac{10r^2}{9} \]

Tariff Revenue = \( t(240-10t) = 240t - 10t^2 \)

Change Welfare = \( \Delta CS + \Delta PS + TR = 160t - 25\left(t^2/3\right) \)

Overall, in terms of the figure below, the US loses areas 1 and 2 because of the changed
output and consumption levels, but gains area 3 due to the improved terms of trade

ii. Provide a numerical answer to (i) for \( t = 15 \). Does US welfare rise or fall?

At \( t=15 \), US welfare increases by 525.

iii. Suppose the US export tariff of \( t = 15 \) were replaced by an export quota of 90 units (no more than 90 units could be exported from the US). What difference, if any, would this change make?

Since exports are 90 when \( t=15 \), the export quota and export tariff have the same effect except, with the quota, the US exporter makes profits \((15\times90=1350)\) equal to the tariff revenue. If the quotas are auctioned off, then the two policies are fully equivalent.

iv. Using your answer to part i above, find the US export tariff that maximizes US welfare (the sum of consumer surplus, producer surplus and government tariff revenue). Why isn’t free trade optimal for the US?

From part (i):

\[
\Delta W = \Delta CS + \Delta PS + TR = 160t - 25\left(t^2/3\right) \quad \Rightarrow \quad \frac{dW}{dt} = 160 - (50t/3) = 0 \quad \Rightarrow \quad t^* = \left(48/5\right)
\]

d) Show how the US export tariff of \( t \) affects Chinese producer surplus, Chinese consumer surplus and Chinese welfare (the sum of producer and consumer surplus). (see figure next page)
In China, 

\[ \Delta CS = -\text{Area}(20 + (2t/3); B, B^*, 20) = -(2t/3)(440 - (5t/3)) \]

\[ \Delta PS = +\text{Area}(20 + (2t/3); A, A^*, 20) = (2t/3)(200 + (10t/3)) \]

\[ \Delta Welfare = -160t + \left(10t^2/3\right) \]

In terms of the figure, China loses areas 1 + 3 + 2

i. Do you think some Chinese import tariff could raise Chinese welfare? Explain why or why not (you do not need to do any calculations).
The same logic applies to China as to the US – China can gain by restricting imports, thereby driving down the world price. To do so China can use an import tariff or an import quota; China gains by an appropriate tariff, but the US would lose more than China gains.

e) Use your answer to parts (c) and (d) to show how the US export tariff affects world welfare.

US: \[ \Delta W^{us} = 160t - 25(t^2/3) \]

China: \[ \Delta W^{ch} = -160t + \left(10t^2/3\right) \]

World: \[ \Delta W^{us} + \Delta W^{ch} = -5t^2 \]

i. Assuming the US export tariff reduces world welfare, why doesn’t the US want to unilaterally lower its tariff? Explain.
Because the US gains from its own tariff.

f) Can China also gain by using an import tariff? Explain.
Answered above.
i. Return to part (ii). Suppose initially the U.S. has an export tariff of \( t=15 \) and China has no tariff. Assume the U.S. eliminates its export tariff AND China simultaneously imposes an import tariff of \( t=15 \). How would this affect production, consumption and price in each country? How would it effect the welfare of each country?

If the US removes its tariff of 15, and China imposes an import tariff of 15, then production and consumption in each country are unchanged, but the tariff revenue now accrues to China instead of the US. Hence, for each country, from earlier results:

\[
\begin{align*}
\text{US:} & \quad \Delta CS = \frac{t}{3} \cdot \left( 160 + \frac{5t}{3} \right) \quad \Delta PS = -\frac{400t}{3} + \frac{10r^2}{9} \quad \Delta W^{us} = -80t + \left( \frac{5t^2}{3} \right) = -825 \text{ at } t=15 \\
\text{China:} & \quad \Delta CS = -\left( \frac{2t}{3} \right) \left( 440 - \left( \frac{5t}{3} \right) \right) \quad \Delta PS = \left( \frac{2t}{3} \right) \left( 200 + \left( \frac{10t}{3} \right) \right) \quad TR = t \left( 240 - 10r \right) \text{ At } t=15: \\
& \Delta W^{ch} = 80t - \left( 20r^2 / 3 \right) = -300
\end{align*}
\]

The loss in world welfare is the same as earlier but in this case both countries lose. China, though, could benefit from a lower tariff. Using the results above China’s optimal tariff, if the US does not use a tariff, is \( * \frac{6}{t} = 6 \). The reason China’s optimal tariff is lower than for the US is that more of the tax falls on China because China’s import demand is less elastic than US export supply.

ii. Use the above to argue both countries can gain from their own tariff but are hurt by the other country’s tariff. Is it possible to have an equilibrium where both the US and China have tariffs, both are worse off than under free trade and yet neither country wants to unilaterally eliminate its tariff? Explain (this is called a prisoner’s dilemma).

As explained in class, each country has an incentive to restrict trade. Since world efficiency falls, at least one country must lose from this practice. If the countries are of fairly similar size and have similar elasticities of import demand or export supply, then it is quite likely that both countries lose. However, neither country has the unilateral incentive to remove its tariff.

2. Consider a small country (VietNam) with the following demand and supply curves for coal:

Supply = \( Q^s = 3P_e^s \); Demand = \( D^s = 800 - 2P_e^c \)

\( P_e^s \) is price producers receive for coal output, \( P_e^c \) is the price consumers pay, and if there are no domestic taxes or subsidies \( P_e^s = P_e^c \). VietNam can trade world price: \( P_e^w = 80 \) per ton of coal.

Domestic consumption (burning) of coal in VietNam creates pollution, which damages the local environment, with cost of 100 per ton of coal consumed. Hence, the marginal social value of consuming coal is less than the marginal private value of consuming coal by 100. Finally, assume the government has no domestic policy to redress the externality (pollution).

a) Suppose the world price of coal is 80. Is it possible that allowing coal imports could lower domestic welfare? How does the presence of the externality affect the gains from trade?

Yes, since imports of coal lower domestic price (from 160 under autarky to 80), consumption increases and hence pollution increases.
i. **Calculate the gains (or losses) from trade in this setting.**

\[ \Delta CS = \text{Area} \{160, E, A, 80\} = 80 \times 560 = 44,800 \]

\[ \Delta PS = -\text{Area} \{160, E, B, 80\} = 80 \times 360 = -28,800 \]

\[ -\Delta \text{Pollution Cost} = -100 \times 160 = -16,000 \]

\[ \Delta \text{Welfare} = 0 \]

Main point is that free trade may not improve welfare because it increases pollution costs; in this numerical case the increased pollution costs offset the conventional gains from trade, so there is no net increase, or decrease, in welfare at this world price. But there could be a loss or gain, depending on world price.

![Graph of market demand and supply](image)

ii. **If the government were to use some policy to attack the market failure (the pollution), what policy should it use? Be as specific as possible.**

The optimal policy is a pollution tax, which is the same in this case as a consumption tax of 100 per ton coal used.

iii. **If only trade policy is possible, should the government tax or subsidize coal imports? Calculate the value of the second-best import tariff or subsidy.**

The goal is to reduce coal consumption; if only trade policy can be used, then you want to reduce imports (raise domestic price) to reduce consumption. If a tariff of \( t \) is used, compared to free trade:
\[ P^d = 80 + t; \quad C = 640 - 2t; \quad S = 240 + 3t; \quad \text{Imports} = 400 - 5t \]
\[ \Delta CS = -t[640 - t]; \quad \Delta PS = t[240 + (3/2)t]; \]
\[ \text{Tar. Revenue} = t[400 - 5t]; \quad \Delta \text{Poll. Costs} = 100(\Delta C) = -200t \]
\[ \Delta \text{Welfare} = -5\left(t^2/2\right) + 200t \]

If there is no pollution, then of course the tariff lowers welfare. In this case with pollution, the constrained optimal tariff is:
\[ \frac{dW}{dt} = 200 - 5t = 0 \rightarrow t^* = 40 \]

b) Suppose now that the world price of coal is 240 so that, with no government policy, the country will export coal. Is it possible that free trade could lower domestic welfare in this case? Why does this case differ from part (a)?

If the country exports coal, domestic consumption falls, which reduces the externality. Thus, if the country exports coal it must gain from trade.

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

Autarky: \( P = 160; \quad C = S = 480 \)
Free trade: \( P = 240; \quad S = 720; \quad D = 320 \)
\[ \Delta PS = 80\left(\frac{480 + 720}{2}\right) = 48,000 \]
\[ \Delta CS = -80\left(\frac{480 + 320}{2}\right) = -32,000 \]
\[ \Delta \text{Poll. Costs} = 100\Delta C = -16,000 \]
Thus, welfare rises by 32,000; 16,000 being the conventional gains, and 16,000 because of reduced pollution costs.

ii. If the government were to use some policy to attack the market failure (the pollution), what policy should it use? Be as specific as possible.

As earlier, the optimal policy is to tax pollution, which is equivalent to taxing consumption. The tax should be 100 per ton of coal consumed.

iii. If only trade policy is possible, should the government tax or subsidize coal exports?

If only trade policy is possible, the goal is to reduce consumption; hence an export subsidy would be the second-best policy in this case.

3. (Free Trade Area) Consider a simple partial equilibrium model of the clothing industry. Belgium has the following supply and demand curves:

\[ S = 3p^d; \quad D = 250 - 2p^d \]
Belgium can import (identical) clothing from China, at exogenous price $p_c = 10$, or from Italy, at $p_I = 20$. Belgium is contemplating forming a Free Trade Area with Italy, which would eliminate tariffs on imports from Italy, but leave Belgium’s tariffs on imports from other countries (China, in this case) unchanged.

a) Suppose initially Belgium has a common tariff of $t=20$ on imports from either country. From which country would Belgium import, and what would domestic price, production, consumption and imports be under this tariff?

With a tariff of 20 on imports from Italy and from China, Belgium will import from China and the domestic price will be 30 ($P^e + t = 10 + 20 = 30$).

At this price $S=90$, $D=190$, Imports $=100$

b) Belgium forms a FTA with Italy; Chinese goods are subject to the tariff. How does this FTA affect from whom Belgium imports, domestic prices, production, consumption, and welfare?

The FTA with Italy causes domestic price in Belgium to fall to 20; at this price, $D=210$, $S=60$, Imports $=150$

$\Delta CS = Area\{30, B, E, 20\} = 2,000$;  $\Delta PS = -Area\{30, A, D, 20\} = -750$

$\Delta Tar Rev = -Area\{ABJH\} = -20*100 = -2,000$;  $\Delta Welfare = -750$
Overall, in the figure above, triangles 1 & 2 represent the gains due to trade creation, whereas rectangle 3 represents the loss due to trade diversion—Belgium pays 10 more per import (now from Italy) than it paid China. Overall, in this case, the country loses from the FTA.

i. Suppose Belgium establishes a quota that allows Chinese clothing imports duty free into Belgium, but these imports are limited to the amount (100) that was previously imported. Given this quota, calculate Belgium’s imports from each country (China and Italy) and calculate the change in welfare due to the FTA and the quota (compare to welfare in part a). Can the FTA make Belgium worse off in this case? Explain.

In this case, the domestic price still falls to 20 (as we can import freely from Italy), 100 units are imported from China, and the balance (50 units) from Italy. Belgium pays 10 for the imports from China (the domestic quota holders make profits of 10 per import or, if the quotas are auctioned off, the price will be 10 each, and this becomes government revenue), and 20 for the imports from Italy. There is no trade diversion—just trade creation and Belgium must gain in this case. Of course, free trade with China would yield even more benefits.

c) Repeat part (a) under the assumption the original tariff had been 30; that is, calculate the change in Belgian welfare due to the FTA. Does your answer as to whether joining the FTA is beneficial change? Explain your result in terms of trade creation and trade diversion.

If the tariff had originally been 30 (see figure), then eliminating the tariff would have resulted in more trade creation (triangles 4 and 5) and less trade diversion (rectangle 6) because the original volume of trade would have been lower. For this case, the net welfare gain is:
Trade creation: Area 4 = 600 and Area 5 = 400; Trade diversion Area 6 = -500.
Net welfare gain = 500.