

Econ 455
Answers - Problem Set 4

1. Consider the case of two large countries:

US: Demand = $300 - 4P_c^{us}$ Supply = $6P_c^{us}$ where P_c^{us} is the price of clothing in **the US**;

China: Demand = $300 - 10P_c^{ch}$; Supply = $20P_c^{ch}$ where P_c^{ch} is the price of clothing in China;

(a) **Find autarky prices:**

US: $S^{us} - D^{us} = 10P_c^{us} - 300 = 0 \rightarrow P_c^{us} = 30$

China: $S^{ch} - D^{ch} = 20P_c^{ch} - (300 - 10P_c^{ch}) = 30P_c^{ch} - 300 \rightarrow P_c^{ch} = 10$

(b) **Assuming free trade (no tariffs), find the equilibrium price and quantities traded.**

World equilibrium requires: $(S^{us} - D^{us}) + (S^{ch} - D^{ch}) = 0 \rightarrow 10P_c^{us} + 30P_c^{ch} - 600 = 0$

Free trade implies: $P_c^{us} = P_c^{ch} \equiv P_c^w$ (world price).

Combining the above two equations implies: $40P_c^w - 600 = 0 \rightarrow P_c^w = 15$

US imports = Chinese exports = $(D^{us} - S^{us}) = 300 - 10P_c^{us} = 150$

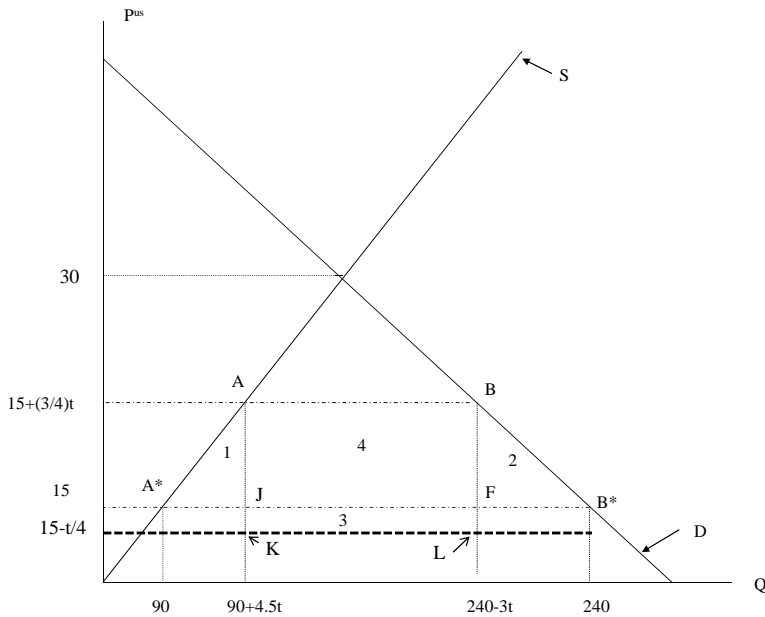
(c) **Show how a US import tariff of t affects the volume of trade, prices in China and the US, and US welfare. Who pays for the US tax? Explain.**

Drop the subscript (c) for clothing; a US import tariff implies: $P^{us} = P^{ch} + t$ if the product is to be sold in both the US and China. This equation, together with the world supply = world demand equation implies:

$$10P^{us} + 30P^{ch} - 600 = 0 \rightarrow 10(P^{ch} + t) + 30P^{ch} - 600 = 40P^{ch} + 10t - 600 = 0 \rightarrow P^{ch} = 15 - (t/4)$$

$$P^{us} = 15 + (3t/4)$$

Even though the US imposes the tax, (1/4) of the tax is paid by Chinese citizens. There is “partial incidence” of the tax on both US and Chinese individuals. To calculate the welfare consequences for the US consider the figure below:



(i) Because the tariff increases US price, consumers lose area $(15, B, B^*, 15 + 3t/4)$ and producers gain area $(15, A, A^*, 15 + 3t/4)$. Calculating these areas gives:

$$\Delta CS = -\left(\frac{3t}{4}\right) \frac{(480 - 3t)}{2} = -180t + \left(\frac{9}{8}\right)t^2;$$

$$\Delta PS = \left(\frac{3t}{4}\right) \frac{(180 + 4.5t)}{2} = \frac{135t}{2} + \left(\frac{27}{16}\right)t^2$$

On the other hand government tariff revenue is $tM = t(150 - 7.5t)$, which is area $\{K, L, B, A\}$. Hence, the overall welfare impact is:

$$\Delta W = \text{Area}\{J, K, L, F\} - \text{Area}\{A, J, A^*\} - \text{Area}\{B, F, B^*\} = \text{Rectangle 3} - \text{Triangle 1} - \text{Triangle 2}$$

The last two areas are the familiar losses due to overproduction and underconsumption in the US due to the import tariff. **What is new is the first area** – which represents the gains to the US because China is receiving a lower price for clothing – i.e., the decreased price times the amount imported at that price is like a transfer from China to the US. This gain to the US is a loss to China – a transfer from China to the US because China pays part of the US tax. In terms of the numbers given here:

$$\Delta W^{us} = \text{Tariff Revenue} + \Delta CS + \Delta PS = 150t - 7.5t^2 - 180t + \left(\frac{9}{8}\right)t^2 + \left(\frac{135t}{2}\right) + \left(\frac{27}{16}\right)t^2 = \left(\frac{75t}{2}\right) - \left(\frac{75}{16}\right)t^2$$

The US gains from any tariff such that $\Delta W > 0 \rightarrow 0 < t < 8$.

(ii) For $t=6$, US price rises by 4.5, Chinese price falls by 1.5, US consumer surplus decreases by 1039.5, US producer surplus increases by 465.75, US imports are 105, US tariff revenue is 630 and the change in US welfare is: $\Delta W = -1039.5 + 465.75 + 630 = 56.25$. Clearly the US gains from this import tariff.

(iii) **What would happen if the import tariff of 6 were replaced by an import quota of 105 units?**

With an import quota of 105, if it binds, we have:

US: $D^{us} - S^{us} = 300 - 10P_c^{us} = 105 \rightarrow P_s^{us} = 19.5$ China: $S^{ch} - D^{ch} = 30P_c^{ch} - 300 = 105 \rightarrow P_c^{ch} = 13.5$

Thus, with US imports limited to 105, there would be a price gap of 6 between US and Chinese prices. Whoever had the right to import into the US (the holders of the quota licenses) would make excess profits of 6. Thus, the only difference between the tariff of 6 and the import quota of 105 is that the government revenue under the tariff becomes excess profits for the importers under the quota. If the quota is auctioned off, then the two policies are equivalent.

(iv) Find the US import tariff that maximizes US welfare.

From part (i) above we have: $\Delta W = (75t/2) - (75/16)t^2$

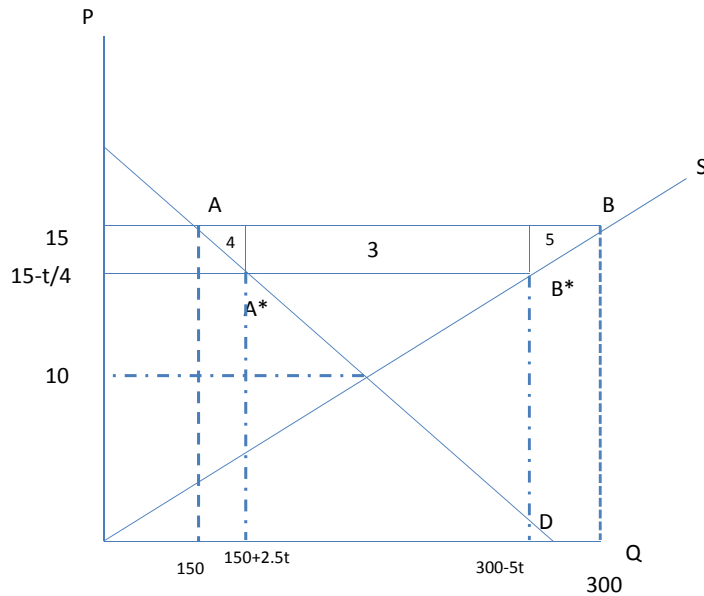
Maximizing with respect to t :

$$\frac{d(\Delta W)}{dt} = \frac{75}{2} - \frac{75}{8}t = 0 \rightarrow t^* = 4$$

As stated above, free trade is not optimal for the US because its policies affect world price. Thus, it has the ability to act like a monopsonist on world markets. But, as with monopsony, even though the monopsonist can increase (its own) welfare by restricting purchases, the loss to sellers exceeds the gains to the buyer – there is a deadweight loss. The same is true of the US import tariff – the loss to the Chinese exceeds the gains to the US, creating a deadweight loss from the tariff.

(d) Show how the US tariff affects Chinese welfare.

For the Chinese there is no tariff revenue, so the lower world prices they face results in lower welfare. Breaking it down by producers and consumers:



Impact on China of US import tariff

The US import tariff causes world price (and hence Chinese price) to fall from 15 to $15 - (t/4)$. This causes Chinese consumption to rise, production to fall, and exports to decrease. The welfare impact on each group is:

$$\Delta PS = -Area\{15, B, B^*, (15 - (t/4))\} = \frac{-t}{4} \cdot \left(300 - \frac{5t}{2}\right) = -75t + \frac{5t^2}{8}$$

$$\Delta CS = Area\{15, A, A^*, (15 - (t/4))\} = \frac{t}{4} \cdot \left\{150 + \frac{5t}{4}\right\}$$

$$\Delta W^c = \Delta PS + \Delta CS = -\frac{75t}{2} + \frac{15t^2}{16}$$

In terms of the figure, the deadweight loss to China is $Area\{A^*, A, B, B^*\}$

If you compare the figures for the US and China, you see that area “3” is a transfer from China to the US because of lower export prices, while triangles 1 & 2 for the US, and triangles 4 & 5 for China measure the overall inefficiency (or deadweight loss) due to the US policy. In terms of equations:

$$\Delta W^{us} + \Delta W^c = \Delta W = (75t/2) - (75/16)t^2 + \left(-75t/2 + (15/16)t^2\right) = -(15t^2/4) < 0, \quad t > 0$$

(e) **How does the tariff affect world welfare?**

As shown in part (d), it leads to a decline in world welfare because the volume of trade falls and a wedge is driven between production costs in the US and China, and the value to consumers in the two countries of clothing.

i. **Why doesn't the US unilaterally eliminate its tariff?**

The simple point is that what is good for the world as a whole need not be good for the US *without* compensation. Thus, if the US unilaterally eliminates its tariff, the US loses even though China gains even more. Without compensation of some sort, the US will be unwilling to lower tariffs. This is one reason why tariffs are often reduced as a result of international agreements rather than lowered unilaterally by countries (especially for larger countries. Smaller countries, with no ability to affect world prices, do not have the same incentive to maintain trade barriers).

(f) Can China also gain by using an export tariff? Explain.

Yes, the same principle that works for the US works for China – a Chinese export tariff would lower prices in China but raise prices China receives from the US for its exports and some export tariff would benefit China.

i. Return to part (cii). Suppose initially the U.S. has an import tariff of $t=6$ and China has no export tariff. Suppose the U.S. eliminates its import tariff AND China simultaneously imposes an export tariff of $t=6$. How would this affect production, consumption and price in each country? How would it effect the welfare of each country?

Production, consumption and prices would be the same for each country regardless of whether a US import tariff of 6 or a Chinese export tariff of 6 were used. The only difference is who gets

the tariff revenue. With the Chinese export tariff the US unambiguously loses, while China can (and in this case does) gain.

From earlier calculations the change in US welfare – assuming no tariff revenue – is

$$\Delta W^{us} = -1039.5 + 465.75 = -573.75$$

whereas the change in Chinese welfare, counting the tariff revenue, when $t=6$ is:

$$\Delta W^c = \Delta PS + \Delta CS + TR = -\frac{75 \cdot 6}{2} + \frac{15(6)^2}{16} + 630 = 438.75$$

Thus, China gains but world welfare falls.

- ii. Use the arguments above to argue that 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** (no calculations required). {If this happens, it is called a *prisoner's dilemma*}.

Since US and Chinese tariffs have the same impact on total welfare, it is clear that when both countries use tariffs world welfare must fall and hence at least one country must be worse off. It is possible that one country gains in this “trade war” but it is also possible both countries lose. Regardless, neither country has the incentive to unilaterally eliminate its tariff.

2. **Free Trade Area.** Consider the computer industry; Mexico has following Supply and Demand:

$$S = 2p^d; \quad D = 6000 - 2p^d$$

Mexico can import (identical) computers from US at $p^{us} = 600$ or from Brazil at $p^b = 800$

Mexico is small and does not affect world prices. Mexico is contemplating an FTA with either the US or Brazil.

- a) Initially, with $t = 400$ regardless of origin of imported computers:

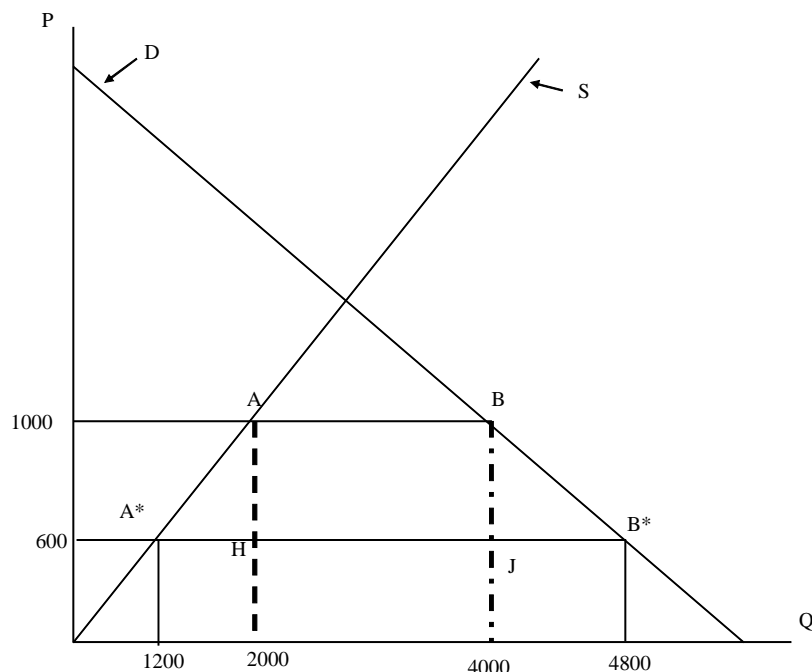
$$\text{Mexico imports from US; } P^{mex} = P^{US} + 400 = 1,000$$

$$\text{Hence: } Q^{mex} = 2p^d = 2000; \quad D = 6000 - 2p^d = 4000; \quad M^d = D - S = 2000$$

- b) Mexico forms FTA with US. Since there are no taxes on US computers, imports from US cost Mexican consumer 600, those from Brazil 1200. **Hence, imports come from US as in (a).**

$$P^d = P^{us} = 600; \quad S^m = 1200; \quad D^m = 4800; \quad M^m = 3600$$

Mexican production falls, consumption increases, imports increase. Volume trade increases by 1600 – this is trade creation. There is no trade diversion since imports come from US with or without the tariff. Welfare must rise – see figure below



Consumers **gain**: Area {1000,B*,B,600} = 400*4400 = 1,760,000
 Producers **lose** Area {600,A*,A,1000} = 400*1600 = 640,000
 Government **loses** tariff revenue = 400*2000 = 800,000 (Area A,B,H,J)
Net Gain = 320,000

This net gain is the gain from trade creation (triangles {A*,A,H} and {B,B*,J})

(c) If Mexico forms the FTA with Brazil now Brazilian computers in Mexico cost 800 (no tariff) while US computers (still subject to the tariff) cost 1,000. Hence, Mexico will import from Brazil and there will be trade diversion (see figure below)

Mexican production falls to 1600, consumption increases to 4400 and imports are 2800. Thus, there is trade creation (imports increase by 800), but also trade diversion (imports from US fall from 2000 to 0). The gains from trade creation are areas 1 and 2 in figure below, while the losses from trade diversion are rectangle 3 – due to the fact that on the 2000 units of imports originally from US Mexico is paying Brazil 800 instead of US 600. Changes in CS, PS, tariff revenue and Mexican welfare are:

$$\Delta CS = \text{Area}\{1000, B, E, 800\} = 200 * 4200 = 840,000$$

$$\Delta PS = -\text{Area}\{1000, A, D, 800\} = -200 * 1800 = -360,000$$

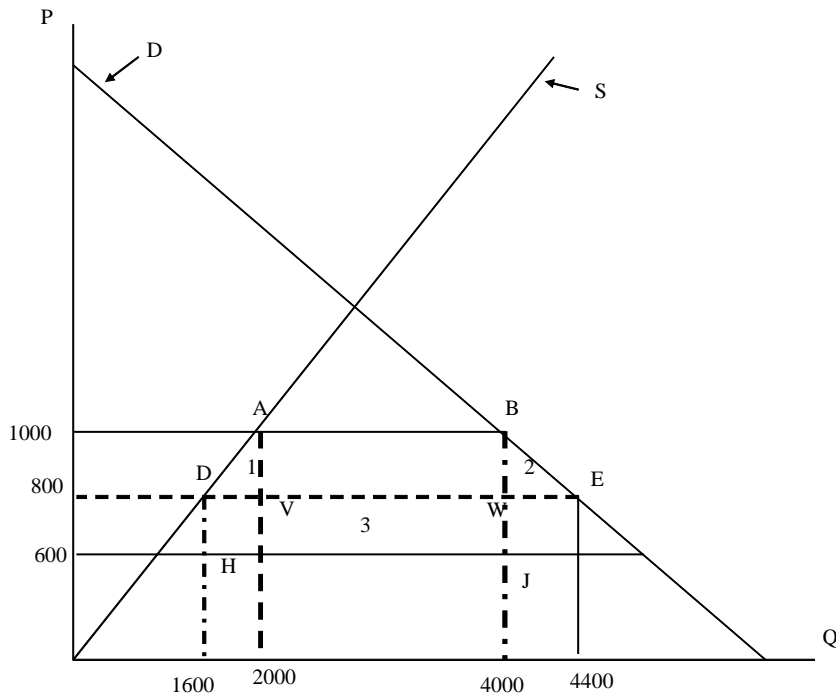
$$\Delta \text{Tariff Rev} = -\text{Area}\{A, B, J, H\} = -400 * 2000 = -800,000$$

Thus, overall Mexican welfare falls by -320,000.

Gains from trade creation – triangles 1 and 2 = $200 * 400 / 2 + 200 * 400 / 2 = 80,000$

The loss from trade diversion – rectangle 3 = $200 * 2,000 = 400,000$

Hence, the overall loss is 320,000 (the same as calculated using CS, PS and tariff revenue)



- d) If the original tariff had been 600, imports from US would cost 1200 and imports would be 1200. If FTA is formed with US, as earlier Mexico must gain – trade creation is larger than with $t=400$, and there is no trade diversion. If FTA were formed with Brazil, the losses from trade diversion will be smaller than when $t=400$ (since there is less trade pre-FTA) and the gains from trade creation will be larger so it is possible in this case there are gains from forming the FTA with Brazil. The figure below shows what happens with the tariff of 600, and the welfare gains can be calculated as:

$$\Delta CS = \text{Area}\{1200, B, E, 800\} = 400 * 4,000 = 1,600,000$$

$$\Delta PS = -\text{Area}\{1200, A, D, 800\} = -400 * 2,000 = -800,000$$

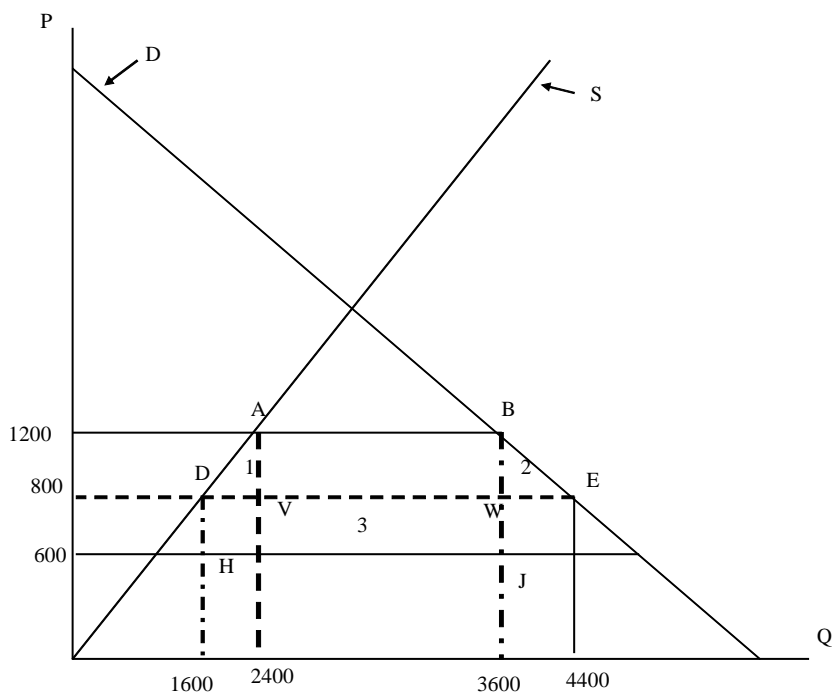
$$\Delta \text{Tar Rev} = -600 * 1200 = -720,000$$

So, overall welfare increases by 80,000 in this case. In terms of trade creation and trade diversion:

$$\text{Gains trade trade creation} = \text{Areas triangles 1 \& 2} = (1/2) * 400 * 800 + (1/2) * 400 * 800 = 320,000$$

$$\text{Loss from trade diversion} = \text{Area rectangle 3} = 200 * 1200 = 240,000$$

Overall gain is 80,000, same as above.



Impact FTA with Brazil when tariff was 600 originally.

e) **General conclusion:** the larger is trade creation and the smaller trade diversion, the more likely the FTA is to increase welfare. Thus, when tariffs are initially high (on all countries) the FTA is more likely to raise welfare. Also, the larger the share of initial trade was with the other countries entering the FTA, the more likely the FTA is to raise welfare (as trade diversion will be smaller).

3. Thailand has following demand and supply curves for steel:

$$\text{Supply} = Q^s = 6P_s^s ; \text{ Demand} = 5000 - 4P_s^c$$

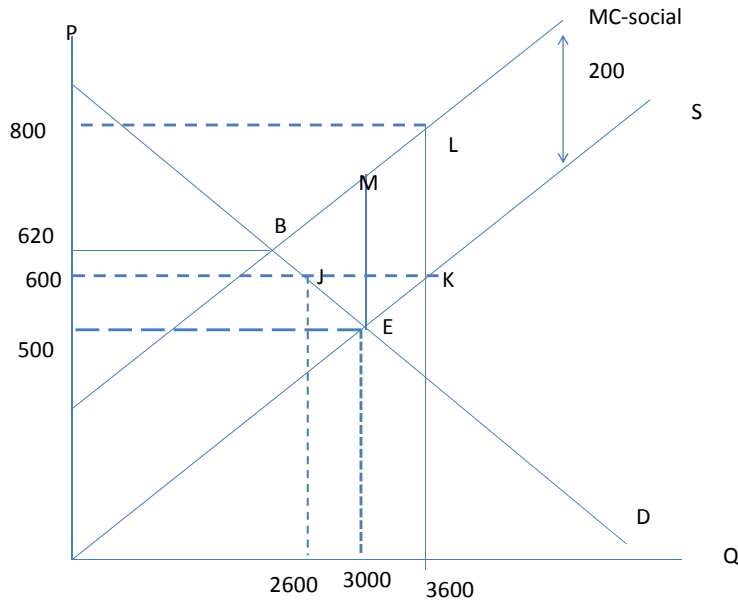
P_s^s is the price producers (sellers) receive for steel output, P_s^c is the price consumers pay for steel, and if there are no **domestic** taxes or subsidies, then: $P_s^c = P_s^s$. Thailand can trade (import or export) steel at a **given world** price of: $P_s^w = 600$.

Domestic **production** of steel in Thailand creates pollution, which damages the local environment. Suppose the estimated (economic) cost of this pollution is **200** per ton of steel produced. This means that the **marginal social cost** of producing steel **exceeds** the marginal private cost of producing steel by **200**. {Since the supply curve comes from equating marginal private cost to price, the marginal private cost (MPC) of producing steel is: $Q^s = 6P_s^s \rightarrow MPC = (Q^s / 6)$ }. Finally, assume the government has no domestic policy to redress the externality (pollution).

a) The autarky price of steel in Thailand is 500, so at a world price of 600 Thailand will export steel. However, this autarky price is too low because it does not reflect the true social cost of producing steel in Thailand. To make firms internalize the pollution externality, they should be subject to a tax of 200 per ton of steel. If that were the case, the supply of steel and autarky price would be:

Supply = $Q^s = 6P_s^s = 6(P_s - 200)$; Demand = $5000 - 4P_s$ so autarky price, with pollution tax, is $6(P - 200) = 5000 - 4P \rightarrow 10P = 6200 \rightarrow P = 620$. Thus, Thailand should, on efficiency grounds, be importing steel not exporting steel and hence it is possible (likely) that Thailand loses from trade.

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



So, prior to trade and without any pollution policy, the autarky price in Thailand is 500, production is 3000, the marginal value of another ton of steel to buyers is 500, the private marginal cost to steel firms of production steel is 500 BUT the social marginal cost of producing steel – due to the solution – is 700. Too much steel is produced and the price is too low. IF Thailand can buy or sell steel on world markets at the price of 600, Thailand will export steel, consumption falls to 2600, production increases to 3600. Consumers lose area {600,J,E,500}, producers gain area {600,K,E,500} and pollution costs increase by $200 \times \text{increased production} = \text{area } \{E,M,L,K\}$. Thus the net welfare effects:

$$\Delta CS = -100 \times 2800 = -280,000$$

$$\Delta PS = 100 \times 3300 = 330,000$$

$$\Delta \text{Pollution Cost} = 200 \times 600 = 120,000$$

Thus, not counting the pollution cost, welfare increases by 50,000 but counting the pollution costs welfare actually falls by 70,000. This is because steel is overproduced relative to the efficient level in autarky, so trade just worsens this problem. In terms of areas, the gains to producers exceed the loss to consumers by area of triangle {E,J,K} but pollution costs increase by trapezoid {L,M,E,K}. In theory, country can gain or lose from trade – in this

example it loses.

- 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 would be a tax of 200 on steel production so that firms internalize the costs they impose on society. With this tax, the autarky price would go to 620, Thailand would import steel and it would definitely gain from trade.

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

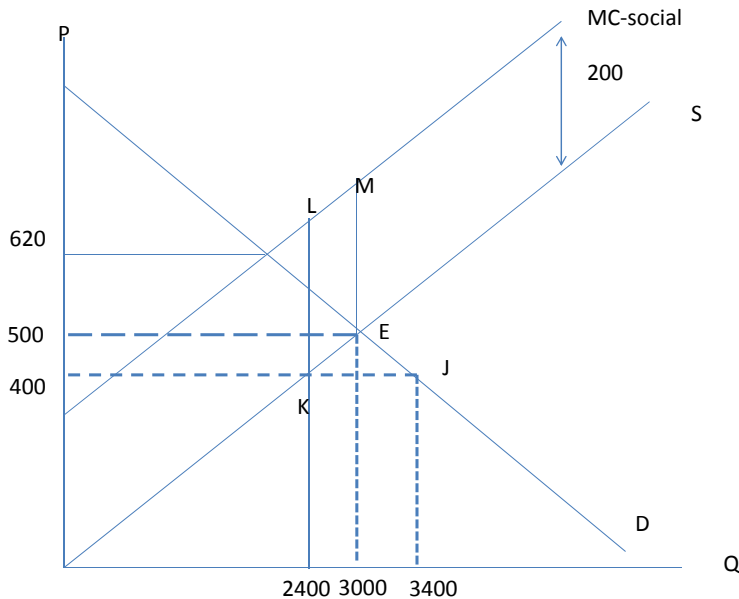
If only trade policy is possible, the country wants to discourage exports so it should tax steel exports. Indeed, if feasible, it should subsidize imports.

- b) Suppose now that the world price of steel is **400** so that, with no government policy, the country will import steel. Is it possible that free trade could lower domestic welfare in this case? Why does this case differ from part (a)?

In this case, the country must gain from trade. You have the usual gains from trade (for imports, increase in consumer surplus exceeds loss in producer surplus). In addition, you have the gains from reduced pollution costs.

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

With a world price of 400:



Due to trade, domestic production falls to 2400, consumption increases to 3400, and 1000 units are imported. Consumers gain area {500,E,J,400}, producers lose area {500,E,K,400} so the net gain – excluding pollution costs – is triangle EJK. **In addition**, since domestic production falls, pollution costs

fall by area {L,M,K,E}. Numerically:

$$\Delta CS = +100 * 3200 = 320,000$$

$$\Delta PS = -100 * 2700 = -270,000$$

$$ReductionPollutionCosts = 200 * \Delta Q = 200 * 600 = 120,000$$

Hence, welfare increases by 170,000.

- 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.

If any policy can be used, then again taxing pollution – which is equivalent to taxing steel output – is the optimal policy (tax of 200 per ton of steel).

- iii. If only trade policy is possible, the government wants to reduce steel production, so an import subsidy on steel would be the “second best” policy.