Mémoire M2

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Intuition

This section seeks to offer preliminary insights into how greenhouse gas (GHG) emissions respond to the implementation of two agricultural public policies: the introduction of tariffs and the provision of subsidies.

To do so, we consider a two-countries market, with a importing country H, and exporting country F.

We denotes the supply and the demand functions for both country $i \in \{H, F\}$:

$$S_i = S_i^0 \left(1 + \eta_i \left(P_i - P_i^0\right) / P_i^0\right)$$
$$D_i = D_i^0 \left(1 + \epsilon_i \left(P_i - P_i^0\right) / P_i^0\right),$$

with S_i and D_i, the quantities produced and demanded by country i, P_i the price, in country i, η_i and ϵ_i are the supply and demand elasticity in country i. X^0 denotes the initial value of X.

Those two countries form the entirety of the economy, hence, the sum of their productions is equal to the sum of their consumptions: $D_H - S_H = S_F - D_F$.

For simplification, we introduce the following aggregate elasticities:
- total demand elasticity $\epsilon = \frac{\partial D}{\partial P_F} \frac{P_F^0}{D^0} = \left(\epsilon_H \frac{D_H^0}{P_H^0} + \epsilon_F \frac{D_F^0}{P_F^0}\right) \frac{P_F^0}{D^0} < 0$,
- total supply elasticity $\eta = \frac{\partial S}{\partial P_F} \frac{P_F^0}{S^0} = \left(\eta_H \frac{S_H^0}{P_H^0} + \eta_F \frac{S_F^0}{P_F^0}\right) \frac{P_F^0}{S^0} > 0$,
- home import demand elasticity $\mu_H = \frac{\partial (D_H - S_H)}{\partial P_H} \frac{P_H^0}{M_H^0} = \frac{\epsilon_H D_H^0 - \eta_H S_H^0}{M_H^0} < 0$,
- foreign export supply elasticity $\chi_F = \frac{\partial (S_F - D_F)}{\partial P_F} \frac{P_F^0}{X_F^0} = \frac{\eta_F S_F^0 - \epsilon_F D_F^0}{X_F^0} > 0$.

For each policies, we will We will examine, for each policies, their effects on total emissions, throughout their effects on international prices (foreign prices), and total production.

2.1 Introduction of a tariff in home country

We consider the first policy, where country H introduce a tariff t, it implies the following relations between prices: $P_H = P_F + t$.

With, the tariff, the price in the exporting country becomes

$$\frac{P_F}{P_F^0} = -\frac{\mu_H (1 - t/P_H^0) - \chi_F}{\eta - \epsilon} \frac{X_F^0}{D^0},$$

and varies negatively with t:

$$\frac{\partial P_F}{\partial t} = \frac{\mu_H}{\eta - \epsilon} \frac{X_F^0}{D^0} \frac{P_F^0}{P_H^0} < 0.$$

Total production from both countries is governed by

$$Q = S_H^0 + S_F^0 + \frac{(P_H^0 - P_F^0 - t)(S_H^0 \eta_H \chi_F + S_F^0 \eta_F \mu_H)}{P_F^0 \mu_H - P_H^0 \chi_F},$$

and thus varies according to

$$\frac{\partial Q}{\partial t} = \frac{S_H^0 \eta_H \chi_F + S_F^0 \eta_F \mu_H}{P_F^0 \mu_H - P_H^0 \chi_F}.$$

The sign of the change is equal to the sign of $S_H^0 \eta_H \chi_F + S_F^0 \eta_F \mu_H$. There is no clear effect of a tariff increase on total production: a first (direct) effect increase home production due to tariff increase, while a second (indirect) effect decreases global production because of lower foreign prices.

Concerning the global emissions E, if we consider emissions as the product of quantity product with a factor of emission, we find:

$$E = E^0 + \frac{(P_H^0 - P_F^0 - t)(E_H^0 \eta_H \chi_F + E_F^0 \eta_F \mu_H)}{P_F^0 \mu_H - P_H^0 \chi_F},$$

and

$$\frac{\partial E}{\partial t} = \frac{E_H^0 \eta_H \chi_F + E_F^0 \eta_F \mu_H}{P_F^0 \mu_H - P_H^0 \chi_F}.$$

The sign is the same as $E_H^0 \eta_H \chi_F + E_F^0 \eta_F \mu_H$. Here, again, the effect of increasing tariff on global emissions is ambiguous. The formula is the same as for production except supplied quantities are replaced by emissions. The higher are domestic emissions E_H^0, the more likely is a tariff increase to increase emissions.

See Appendix A.1 for proofs, and particular cases.

2.1.1 Provision of a subventions to production in home country

In this subsection, we consider the provision of a subventions to production in the home country, this implies a change in our supply functions, we now have $S_F = S_F^0 \left(1 + \eta_F \left(P_F - P_F^0\right)/P_F^0\right)$, and with the subvention s $S_H = S_H^0 \left(1 + \eta_H \left(P_H + s - P_H^0\right)/P_H^0\right)$. For simplification, we consider $P_H = P_F = P$.

Providing a subvention leads to the following price expression and derivate:

$$\frac{P}{P^0} = 1 + \frac{\eta_H}{\mu_H - \chi_F} \frac{s S_H^0}{P^0 X_F^0},$$

$$\frac{\partial P}{\partial s} = \frac{\eta_H}{\mu_H - \chi_F} \frac{S_H^0}{X_F^0} < 0.$$

This means that introducing a subvention to production in the home country will lower prices, in the home and foreign countries.

Total supply becomes:

$$S = S^0 + \eta_H S_H^0 \frac{s}{P^0} \left[1 - \frac{\eta}{\chi_F - \mu_H} \frac{S^0}{X_F^0}\right],$$

$$\frac{\partial S}{\partial s} = \frac{\eta_H S_H}{P^0} \left[1 - \frac{\eta}{\chi_F - \mu_H} \frac{S^0}{X_F^0}\right].$$

Since $X_F^0(\chi_F - \mu_H) = \eta S^0 - \epsilon D^0$, and $\epsilon < 0$, we have $1 > \frac{\eta}{\chi_F - \mu_H} \frac{S^0}{X_F^0}$, which means that a subvention to the production will increase total production.

With linear emission to supply, we have:

$$E = E^0 + \eta_H \frac{s}{P^0} \left[E_H^0 - \frac{\eta_H E_H^0 + \eta_F E_F^0}{\chi_F - \mu_H} \frac{S_H^0}{X_F^0}\right],$$

hence

$$\frac{\partial E}{\partial s} = \frac{\eta_H}{P^0} \left[E_H^0 - \frac{\eta_H E_H^0 + \eta_F E_F^0}{\chi_F - \mu_H} \frac{S_H^0}{X_F^0}\right].$$

This time, the sign of the derivative is more ambiguous: it depends on the relation between $(\eta - \epsilon)E_H^0 S^0$ and $(\eta_H E_H^0 + \eta_F E_F^0)S_H^0$, if the former is higher than the later, then the subvention will lead to more emissions.

See Appendix A.2 for details.

Appendix A

Intuition

A.1 Tariff

First let's expresse P_F as a function of t and the elatsicities.

Starting from $D_H - S_H = S_F - D_F$ and the supply and demand definitions, we have:

$$D_H^0\left(1+\epsilon_H\frac{P_H-P_H^0}{P_H^0}\right)-S_H^0\left(1+\eta_H\frac{P_H-P_H^0}{P_H^0}\right)=S_F^0\left(1+\eta_F\frac{P_F-P_F^0}{P_F^0}\right)-D_F^0\left(1+\epsilon_F\frac{P_F-P_F^0}{P_F^0}\right).$$

We then factorize by $P_i - P_i^0/P_i^0$, for $i = H, F$

$$\frac{P_H-P_H^0}{P_H^0}[D_H^0\epsilon_H - S_H^0\eta_H] + D_H^0 - S_H^0 = \frac{P_F-P_F^0}{P_F^0}[S_F^0\eta_F - D_F^0\epsilon_F] + S_F^0 - D_F^0.$$

Noting that $D_H^0 - S_H^0 = S_F^0 - D_F^0$, it leads to:

$$\frac{P_H-P_H^0}{P_H^0}[D_H^0\epsilon_H - S_H^0\eta_H] = \frac{P_F-P_F^0}{P_F^0}[S_F^0\eta_F - D_F^0\epsilon_F].$$

Using the aggregated elasticities defined in the the chapter 2.1, we have

$$\frac{P_F}{P_F^0} = -\frac{\mu_H(1-t/P_H^0)-\chi_F}{\eta-\epsilon}\frac{X_F^0}{D^0}.$$

Multiplying both sides by P_F^0, a simple derivation gives:

$$\frac{\partial P_F}{\partial t} = \frac{\mu_H}{\eta-\epsilon}\frac{X_F^0}{D^0}\frac{P_F^0}{P_H^0} < 0.$$

Now if we assume the initial tariff to be zero, i.e. $P_F^0 = P_H^0$, we have:

$$\frac{P_F}{P_F^0} = -\frac{(1-t/P_H^0)\mu_H-\chi_F}{\chi_F-\mu_H} = 1 + \frac{\mu_H}{\chi_F-\mu_H}\frac{t}{P_H^0} < 0.$$

Assuming initial tariff is zero, and elasticities are the same across countries gives the following price and derivate.

$$P_F = P_F^0 + t\frac{\mu_H}{\eta_i-\epsilon_i}\frac{X_F^0}{D^0},$$
$$\frac{\partial P_F}{\partial t} = \frac{\mu_H}{\eta_i-\epsilon_i}\frac{X_F^0}{D^0} < 0.$$

Regarding total production Q, when initial tariff is zero and when we have:

$$Q = Q^0 + \frac{-t/P_H^0 \eta_i (S_H^0 \chi_F + S_F^0 \mu_H)}{\mu_H - \chi_F},$$
$$\frac{\partial Q}{\partial t} = \eta_i \frac{S_H^0 \chi_F + S_F^0 \mu_H}{\chi_F - \mu_H} \frac{1}{P_H^0}.$$

For emissions, we consider $E_i = e_i S_i$, which leads to the results in 2.1. We also find, when initial tariff is zero and when we have equality of elasticity ($\eta_H = \eta_F = \eta_i$, and $\epsilon_H = \epsilon_F = \epsilon_i$):

$$E = E^0 + \frac{t/P_H^0 \eta_i (E_H^0 \chi_F + E_F^0 \mu_H)}{\chi_F - \mu_H},$$
$$\frac{\partial E}{\partial t} = \eta_i \frac{E_H^0 \chi_F + E_F^0 \mu_H}{\chi_F - \mu_H} \frac{1}{P_H^0}.$$

A.2 Subvention

Rewriting the equilibrium equation, with the new supply functions

$$D_H^0 \left(1 + \epsilon_H \frac{P - P^0}{P^0}\right) - S_H^0 \left(1 + \eta_H \frac{P + s - P^0}{P^0}\right) = S_F^0 \left(1 + \eta_F \frac{P - P^0}{P^0}\right) - D_F^0 \left(1 + \epsilon_F \frac{P - P^0}{P^0}\right),$$

we have the price and derivate of section 2.1.1.

When elasticities are the same across countries, then $\epsilon_i = \epsilon$ and $\eta_i = \eta$, and

$$\frac{P}{P^0} = 1 + \frac{\eta}{\mu_H - \chi_F} \frac{s S_H^0}{P^0 X_F^0}, // \frac{\partial P}{\partial s} \qquad = -\frac{\eta}{\chi_F - \mu_H} \frac{S_H^0}{X_F^0} < 0.$$

Regarding the supply, we have:

$$S = S_F + S_H = S^0 + S^0 \eta \frac{P - P^0}{P^0} + S_H \eta_H \frac{s}{P^0},$$

which leads to the results in 2.1.1.

For the emissions, we use again the $E = e_H S_H + e_F S_F$. When the elasticities are the same across countries, then adding the subvention leads to more emissions only if $\frac{E_H^0}{\eta S_H^0} > \frac{E^0}{(\eta - \epsilon) S^0}$.