Mémoire M2

L'impact des politiques publiques sur les émissions de gaz à effet de serre dans le secteur agricole au travers des échanges commerciaux.

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Chapter 1

Introduction

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We will study in this paper the effect of public policies in agriculture and their effects on greenhouse gaz emissions throughout trade.

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Section 2 will expose a simple two countries model, facing an implementation of two public policies regarding agriculture: the introduction of tariffs and the provision of subsidies to production. The objective will be to see their effects on GHG throughout price equilibrium. This will give use first intuitions as to how these policies can effect total emission.

Section 3 will go beyond these first intuitions, and presents a partial equilibrium model with multiples countries and sector of productions.

Section 4 will expose the model calibration, on FABIO and FAOSTAT data.

Chapter 2

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:

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

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

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.

Chapter 3

Model

Chapter 4

Taking the model to the data

Chapter 5

Results

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Conclusion

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 $\frac{E_H^0}{\eta S_H^0} > \frac{E^0}{(\eta - \epsilon) S^0}$.