Simulating market and environmental impacts of French pesticide policies: a macroeconomic assessment

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SIMULATING MARKET AND ENVIRONMENTAL IMPACTS OF FRENCH PESTICIDE POLICIES: A MACROECONOMIC ASSESSMENT

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Introduction

The application of pesticides is profitable for farmers but generates negative impact on the environment and the human health. These negative impacts call for public actions.

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For French policy makers, the definition of the optimal pesticide policy is not immediate due to scientific uncertainties on health and environmental impacts but also due to the multiple known, but imperfectly measured, tradeoffs. First the optimal pesticide policy must balance environmental and economic objectives. Second French policy makers also have to manage eventual tensions between different environmental objectives. Some lobbies stress that pesticide reduction would be compensate by the increase of other polluting inputs such as fertilizer. Other worries concern the "leakage" effects of such policies at the global level. In particular, the reduction of French agricultural production can lead to land use change (including deforestation) that may increase carbon emissions.

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The existing literature has focused on pesticide taxation scheme, mainly in a microeconomic perspective.

Objective

We perform a macroeconomic quantification of some economic and environmental impacts of two contrasted French pesticide policies: a 50% ad valorem tax in the spirit of the Danish policy (noted hereafter tax scenario) and a technological scenario with new pesticide-saving technologies (noted hereafter R&D scenario), which can arise in the longer term due to the boosting of public/private researches.

Conclusion

We contribute to the debates on the effectiveness of policy instruments targeting pesticide use reduction by estimating French farmers' pesticide demand for the whole diversity of agricultural outputs and simulating the global effects, a task that is rarely (if ever) undertaken jointly.

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We find that French farmers modify pesticide demand, yields and acreage in response to a change in pesticide prices. The CGE simulations highlight that a pesticide taxation scheme of 50% would reduce French farmers' pesticide consumption by 37%. This reduction would however imply some trade-offs: (i) a loss of 899 million euros for French farmers and food industry (ii) an increase of 2 kg/ha of nitrogen and (iii) an additional emission of 8.8 million tons of carbon. We find however that animal production do not contribute to these emissions, as worldwide animal production reduces due to less fodder availability and higher prices of other feeds.

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We find that the R&D policy solves most of these economic and environmental trade-offs but such a policy could only emerge in the longer run.

Empirical strategy

- We develop an original methodology with three distinctive features. First, we perform econometric estimations to identify the economic behavior of French farmers towards their uses of pesticides, fertilizers and their acreage choices. Second, we introduce all farm activities, including the often-neglected fodder crops consumed by livestock sectors.Third, we simulate economic and environmental impacts of the two scenarios at the world level using an original Computable General Equilibrium (CGE) framework, starting from the standard GTAP-Agr model (Keeney and Hertel, 2005).

THE ECONOMIC SPECIFICATION

- Based on Carpentier and Letort (2014), we specify an economic model of a multi-output farm r maximizing its profit using yearly application of variable inputs on each output and the acreage choices of some annual crops. Formally, the program is:

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\begin{aligned}
&\max_{\mathbf{S}_t} \Pi_{r,t} = \sum_{k=1}^{K} S_{k,r,t}\pi^{*}_{k,r,t}\left(\mathbf{x}_{k,r,t}\right) + \sum_{k=K+1}^{\bar{K}} \bar{S}_{k,r,t}\pi^{*}_{k,r,t}\left(\mathbf{x}_{k,r,t}\right) - \left[A + \sum_{k=1}^{K} c_{k,r}S_{k,r,t} + a_r \sum_{k=1}^{K} S_{k,r,t}\ln\left(S_{k,r,t}\right)\right] \\
(1)\quad &\text{s.t.} \sum_{k=1}^{K} S_{k,r,t} + \sum_{k=K+1}^{\bar{K}} \bar{S}_{k,r,t} = UAA_{r,t} \\
&\text{and } \pi^{*}_{k,r,t} = \arg\max_{\mathbf{x}_{k,r,t}} \begin{cases} E\left(p_{k,r,t}\right) y_{k,r,t} - \sum_{i=1}^{I} E\left(w_{i,r,t}\right) x_{i,k,r,t} \\ \text{s.t. } y_{k,r,t} = \alpha_{k,r} + \alpha_{t,k,r}t - \frac{1}{2}\left(\beta^{-1}_{1,k,r}\left(b_{1,k,r} - x_{1,k,r,t}\right) + \beta^{-1}_{2,k,r}\left(b_{2,k,r} - x_{2,k,r,t}\right)\right) \end{cases}
\end{aligned}
$$

- The aim of the statistical approach is to estimate the deep parameters $\left(\boldsymbol{\alpha}_r, \boldsymbol{\beta}_r, \mathbf{b}_r, a_r, \mathbf{c}_r\right)$. In particular, estimations of $\boldsymbol{\beta}_r$ allow determining the elasticities of yields and input demands regarding input and output prices and a_r allows determining the elasticities of area regarding input and output prices for outputs with endogenous areas.

THE ECONOMETRIC PROCEDURE

- We estimate the optimal yields, the optimal pesticide and fertilizer demands and the optimal acreage choices derived from (1) on each French region using naive anticipations for output prices and rational anticipations for input prices.
- We estimate the regional systems using the GME method (Golan et al., 1996), notably because of the limited number of observations.
- We do not observe the crop-specific input demand but only the regional consumption of pesticides and fertilizers $\mathbf{X}_{r,t}$. We thus estimate:

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X_{i,r,t} = \sum_{k=1}^{K} S_{k,r,t}\left(b_{i,k,r} - w_{i,k,r,t}p^{-1}_{k,r,t-1}\beta^{-1}_{i,k,r}\right) + \sum_{k=K+1}^{\bar{K}} \bar{S}_{k,r,t}\left(b_{i,k,r} - w_{i,k,r,t}p^{-1}_{k,r,t-1}\beta^{-1}_{i,k,r}\right) + \varepsilon^{X}_{i,r}
$$

where $\varepsilon^{X}_{i,r}$ is the random term accounting for unobservable heterogeneity and stochastic events.

THE DATA

- We use the Agricultural Economic Accounts (AEA) on the 21 former Metropolitan and continental French regions (all Metropolitan regions except Corsica) between 1991 and 2011. In addition to its availability over a relatively large period, this database provides information on the values of fodders, which is usually unavailable in other farm dataset.
- We distinguish five outputs (i.e. $\bar{K} = 5$): cereals, industrial crops (mostly oilseeds and sugarbeet), maize fodder, other fodder (mostly from grasslands) and other crops. This last category is an aggregate of likely pesticide-intensive crops such vegetables, fruits and vineyards. We consider that the acreage of the first three output are determined each year by farmers while the last two types of land are more permanent crops. They are treated as exogenous in the estimation procedure.

THE GTAP-AGR FRAMEWORK

- The GTAP-Agr framework is a comparative static CGE model accounting for a large diversity of goods produced by many sectors (Keeney and Hertel, 2005). It covers the world and consider the heterogeneity of the climatic and topographic conditions, distinguishing between several agro-ecological zones within each country. The GTAP-Agr model distinguishes firms, who maximizes their profits, and households who maximizes their utility. By default, this model assumes that economic agents are price takers.
- We use the last available database of GTAP-Agr who covers the economic flows of 2011, includes 20 agricultural and food products (notably livestock products) and explicitly considers land as a primary factor of production, making it well suited to measure carbon emissions linked to land use changes.
- We explicitly specify the behavior of French agriculture using model (1) and estimated elasticities to perform simulations of French pesticide policies. We rely on the technical literature to give initial value shares of pesticide use because, if we do estimate with sufficient precisions pesticide use responses to pesticide prices, we do not estimate pesticide uses by crops with great precision. In addition, we specify quadratic production function for each animal activity with price responses derived from the literature (Suh and Moss, 2016).

Results

- **47% of the crop-specific parameters of pesticide price responses are estimated with a p-value lower than 0.1.**
  The aggregated estimated elasticities at the national level are provided in Table 1.

Table 1: aggregated estimated elasticities for France

		Cereals	Industrial crops	Maize forage	Other fodders	Other crops	Aggregated
Yield elasticities	Output price	0,07	0,19	0,26	0,17	0,10	
	Pesticide price	-0,04	-0,10	-0,14	-0,09	-0,06	
	Fertilizer price	-0,04	-0,07	-0,11	-0,08	-0,03	
Input own-price elasticities and crop-specific consumption	Pesticide price	-0,34	-1,30	-2,71	-1,01	-0,99	-0,82
	Fertilizer price	-0,23	-0,44	-1,15	-0,54	-0,43	-0,39
	Pesticide repartition	0,13	0,13	0,04	0,04	0,66	
	Fertilizer repartition	0,14	0,15	0,05	0,04	0,63	
Acreage elasticities	Cereal price	0,07	-0,14	-0,14			
	Industrial crop price	-0,05	0,18	-0,04			
	Maize forage price	-0,01	-0,01	0,10			
	Pesticide price	-0,007	0,02	0,01			
	Fertilizer price	-0,01	0,03	0,02			

- **The tax scenario indicates a decrease farmers' use of pesticide by 37%.**
  Table 2 reports the evolution by crops and the main French market impacts.

Table 2: results of TAX scenario in France (in %)

	Area	Yield	Production	Price	Pesticide use
Wheat	-0,8	-2,7	-3,5	0,9	-17,1
Oilseed	0	-9,4	-9,4	1,7	-61,7
Sugarbeet	1,5	-6,9	-5,4	4,2	-56,5
Forage maize	2,7	-11,1	-8,4	13,7	-85,9
Grasslands	0	-2	-2	5,6	-42
Beverages	0	-0,8	-0,8	0,3	-49,6
Vegetables and fruits	0	-1,4	-1,4	0,4	-49,5
Milk			-1,6	1,7	
Cattle meat			-1,9	1,2	
Pork meat			-1,4	1,3	

The farm value added decreases by 638 million euros, mostly supported by a 19% reduction of land prices. The food industry also suffer from the tax (by 261 million euros). On the other hand, the tax receipts for the government increases (by 859 million euros). But French consumers suffer from an increase of food prices.

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We find significant decreases of French exports and significant increases of French imports. These trade impacts favor the farm and food productions in other countries. We obtain the largest production impacts in the other EU member states (productions of oilseeds and sugar increases by nearly 1%), in USA and in Brazil.

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Overall, the world acreage devoted to arable crops increases by 32 thousand hectares. These expansions are made on (Brazilian) sugar cane area (1 thousand), pasture areas (19 thousands) and deforestation (14 thousands). These land use changes lead to 5.7 millions tons of carbon emissions. We also obtain an increase of direct carbon emissions due to higher use of chemicals in other countries (by 0.9 million tons) and reduced carbon stored in the biomass (by 2.1 million tons). Overall carbon emissions increases by 8.8 million tons. The reduction of worldwide animal consumption is not sufficient to counterbalance the carbon emissions related to land use change and crop intensification in other countries.

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At the French level, we also obtain an increase of nitrogen surplus by 2kg/ha due to the completary effects of (i) the reorganization of acreage towards the most fertilizer-intensive crops, (ii) the increase of output price, (iii) the French imports of oilseeds and (iv) the French animal production decreases.

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The technical scenario solves most trade-offs.

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