Estimating Sequential Multi-Choice Demand : An Application to Pesticides Utilization in France.

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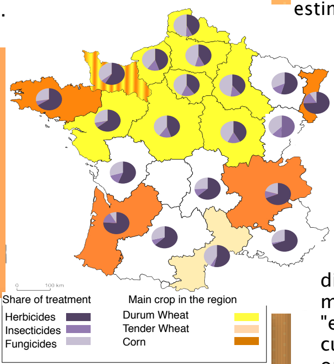
Introduction

France is the third largest consumer of pesticides in the world. This country has developed systems of production based on the use of these products. So, it appears very dependent on them. The use of pesticides is often the only way for farmers to maintain their yields. In this context, we will focus on products choosen by farmers considering firms' supply throught the estimation of their demand function. To introduce differentiated choices of products, i.e. introduction or the removal of a product influence farmer choices, we consider discrete modeling for demand function and precisely discrete choice models when multiple treatments are applied.

Our goal is to estimate an aggregate demand in the pesticide market for farmer considering differentiated products and heterogenous farmers in order to explain their choice of products.



Empirical Background

Previous studies have worked on the use of pesticides by estimating elasticities of demand by farmers, or impact of pesticide use on productivity (see). They were mainly interested in explaining the quantity without taking into account the diversity and the characteristics of the pesticides product that are used.

When consumers purchase heterogenous products, the common approach is to consider brand choice models specifying a multinomial logit approach, total demand for one brand is computed aggregating all purchase probabilities by brand times the whole market size of a market segment.

Introduction of multi-products is provided by Hendel (1999) (Following by Dubin and McFadden, 1984). He focuses on "task" characteristic for a purchase, and consumer maximize their profits by choosing the number of units of each brand. Augereau et al. (2006) consider bivariate probit to estimate the demand of one type of product, thus it could exist correlations between choices.

Model specifications

Considering the number of treatment and the probability that a farmer reach the last treatment, we estimate a **sequential logit demand**. Treatment are ranked on the basis of the growth stage of the crop at the date of application. Individual farmers characterics are introduced to explain the probability that a farmer reach the last treatment. We suppose that farmer maximize their utility function by choosing the products and treatments to apply. The estimation is provided on each sample for which farmer applied at least "s" treatments.

Now, we consider the type of treatment, and we estimate the probability that a farmer apply one type of treatment knowing its own characterics. We set different assumption for the distribution of errors which led us toe estimate different class of models. First estimates are provided considering **multinomial logit** (Model1), setting independence between two types. The introduction of farmer individual characteristics is provided through the estimation of a **mixed logit** (Model 2 and 3) specification.

Finally, we want to test correlation between two types of treatment. Indeed, intensive treatment in one category should be correlated with the other one. The previous model is estimated through a **multivariate probit** specification (Model 4).

Data and Descriptive Statistics

We use 3 differents datasets. Our main data source is the "enquêtes pratiques culturales", a French survey on farmers agricultural practices*. This dataset provides informations on farmers and their individual characteristics. Moreover, it gives informations on pesticides use providing details on each product applied : date or growth stage application, doses and name. This data on farming practices are merged with regulation dataset on products authorisation to consider its characteristics, like doses, firm holder, or age. Finally, we introduce prices of products by merging the previous data with PCIA's survey.

Our final sample has 9355 plots for 6 crops, and we focuse on the largest type of treatment (herbicides, insecticides and fungicides). Because farmers apply more than one product we get 15 583 observations. Finally, we define the market size as sum area of all products applied, and we consider 18 market segments illustrated in Figure 1. This Figure also illustrates the fact that more than one treatment is applied by plot, because the total area is often smaller than the applied product area.

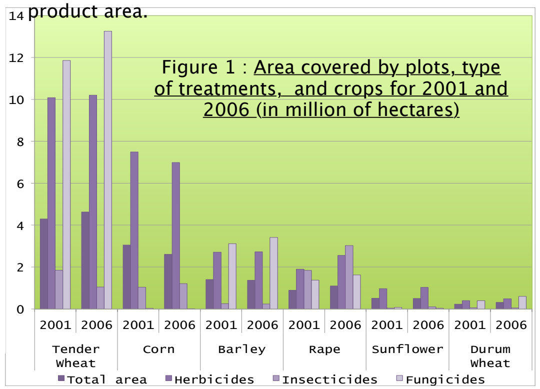


Figure 1 : Area covered by plots, type of treatments, and crops for 2001 and 2006 (in million of hectares)

Results

The first results of our estimates on treatment choices highlights that the effect of the doses is more important on the first applications, and smaller when the number of treatments increase. Besides, whatever the rank of treatments, products' age is negatively related to the probability of application on some categories, like herbicides, but positively for others, like fungicides. Our estimates on farmers' yields follow approximately an inverse u-shaped curve, and it could exist an optimal number of treatments that leads to the final yield objective, but this optimum is not known by farmers at the moment of the treatment.

The reference category for our estimation is insecticides treatments (k=2), and results are provided in table bellow for 2001. Where "k" denotes the type of treatment, so k=1 and k=3 are respectively herbicides and fungicides. We control for region (regionk) and type of crop (cropk). The covariates are the price of the product (pk), the intensity of treatment (tfik), computed by the ratio between applied doses and legal doses of application. The age of the product (agek) is also introduced in Model 3 which referes to mixed logit specification. Finally to allow the random components of the utility function to be nonidentical, multivariate probit specification (Model 4) is estimated.

	Model1	Model2	Model3	Model4
c1	**1,545** *	**1,545** *	**1,493** *	**-1,624** *
	0,145	0,146	0,162	0,022
c3	**2,290** *	**2,290** *	**5,020** *	**-0,576** *
	0,133	0,138	0,195	0,043
p1	**0,007** *	**0,007** *	**0,004** *	**0,004** *
	0,001	0,002	0,001	0,000
p3	**0,002**	**0,024**	**-0,004**	**0,001** *
	0,001	0,002	0,002	0,000
tfi1	**-2,958** *	**-2,958** *	**-2,701** *	**-0,406** *
	0,135	0,099	0,100	0,030
tfi3	**-2,021** *	**-2,021** *	**-2,010** *	**-0,284** *
	0,117	0,090	0,008	0,023
crop1	**0,130** *	**0,139** *	**0,090** *	**0,095** *
	0,012	0,012	0,012	0,002
crop3	**0,046** *	**0,046** *	**0,110** *	**0,005** *
	0,011	0,011	0,011	0,001
region1	**0,023** *	**0,023** *	**0,019** *	**0,002**
	0,003	0,003	0,003	0,001
region3	**0,021** *	**0,021** *	**0,028** *	**0,001**
	0,003	0,002	0,003	0,000
age1	-	-	**0,024** *	-
			0,008	
age3	-	-	**-0,291** *	-
			0,008	
theta1	-	-	-	**3,7195**
				0,2353
theta3	-	-	-	**34,248**
				3,1256
McF R2	0,218	0,218	0,341	-
LL	-5816	-5816	-4897	-5592
LL0	-7438	-7438	-7438	-
AIC	11652	11652	9819	11291

Standard error besides estimates, * significant at 1%,

Conclusion and Perspectives

More generally, estimating the demand is the preliminary step to analyse market power. This could lead to measure variation of welfare for farmers after a modification of competition structure, such as mergers or acquisition of firms, or measure the existence of tying sales in the market. In term of public policy, this allows us to measure the effects of products taxation or suppression by measuring the substitution between different characteristics of products or welfare variation.

References

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Notes

* The "enquêtes pratiques culturales"s dataset is collected by the statistical department from the French Ministry of Agriculture (SSP)