Can taxes and targeted subsidies be effective in limiting the use of pesticides in viticulture?

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Abstract.

The aim of this study is to assess whether market-based instruments of agri-environmental policy such as taxes and subsidies can promote reduced pesticide use in viticulture. Simulations are carried out using VINEPA, a multi-periodic discrete stochastic programming (DSP) model based on panel data from vineyards. We then evaluate how changes in pesticide use would affect the Environment Impact Quotient (EIQ), which evaluates potential impacts of pesticides on farm workers, consumers, and non-target organisms. The results show that reducing their use calls for high tax rates, and EIQ can only be reduced by setting taxes based on levels of toxicity.

Keywords: VINEPA, Viticulture, Pesticides, Taxes, Subsidies

1. Introduction

Extensive use of pesticides by winegrowers has led to greater, more reliable production of grapes, and continues to play an important role in pest management – especially in combating downy (*Plasmopara viticola*) and powdery (*Erysiphe necator)* mildew. In France, a national pesticide reduction program is currently being trialled. However, in viticulture, this reduction is fraught with difficulty. At present, French *appellations* (European Protected Designation of Origin) are governed by strict rules stipulating the grape varieties that can be used for specific wines, making it more or less impossible to replace current grapes with more disease-resistant cultivars. Another possible way to reduce pesticide use is by introducing precision farming technology (PT), which minimises the quantities of pesticide released into the environment. Farmers could potentially be encouraged to adopt such technology through taxes and targeted subsidies.

2. The VINEPA model

Decision making in wine growing protection involves a certain amount of educated guesswork. When growers decide to apply pesticides, they have no way of knowing with absolute certainty what will be the result of that decision on their grape yield. The key question is therefore one of decision theory, involving the maximisation of a given criterion (income or utility)[1], the identification of possible actions, and their associated state of nature probabilities (Rae, 1971; Birge et Louveau,1997). The VINEPA model (Vineyard model for Environmental Policy Analysis) is a multi-periodic DSP model based on the assumption that

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[1] If (Ω, F, P) is a discrete probability space where ω ∈ Ω are events (scenarios), $f_t^{\omega}(x_t, x_{t-1}, y_t, y_{t-1})$ the objective function associated with the completion of the event ω and $p(\omega)$ the probability associated with this event, the objective function used for simulations is: $Max\ Z = E(Y) - \varphi\sigma_Y$ where $E(Y)$ is the expected income defined by:

$$E(Y) = E\left[\sum_t f_t^{\omega}(x_t, x_{t-1}, y_t, y_{t-1})\right]$$

$$= \sum_{\omega\in\Omega} p(\omega) \sum_t f_t^{\omega}(x_t, x_{t-1}, y_t, y_{t-1})$$

φ a risk aversion coefficient and σ_Y the standard deviation of Y defined by

$$\sigma_Y = \sqrt{\sum_{\omega\in\Omega} p(\omega) \times (E(Y) - Y_{\omega})}$$

where Y_{ω} denotes the income obtained over the whole planning horizon for scenario ω.

wine producers maximise their income through two particular decision processes (Lescot, 2014). When protecting wine against main diseases and particularly downy mildew, the first decisions are which pesticide to apply(preventive or systemic), the active ingredient to be used, and when and how often to apply those chemicals within a particular growing season to prevent yield loss. The second is a longer-term choice as to whether or not it is profitable to invest in precision technology to reduce pesticide use (Tisseyre, 2007). Initial results generated by our model show that almost half of the wine estates from our panel data could possibly invest in some basic precision equipment. Some properties even have the capacity to invest in more advanced equipment. Such investments will have a knock-on effect both on pesticide levels (because less will be used), and income (because of the cost of the new equipment). The VINEPA model uses the results from an epidemiologic model called Downy Mildew Potential System (DMPS) to define the relationships between reduced yield, number of treatments, and type of fungicide used. Effectiveness of application is then calculated based on the amount of damage prevented for each case of infection, as estimated by the model.

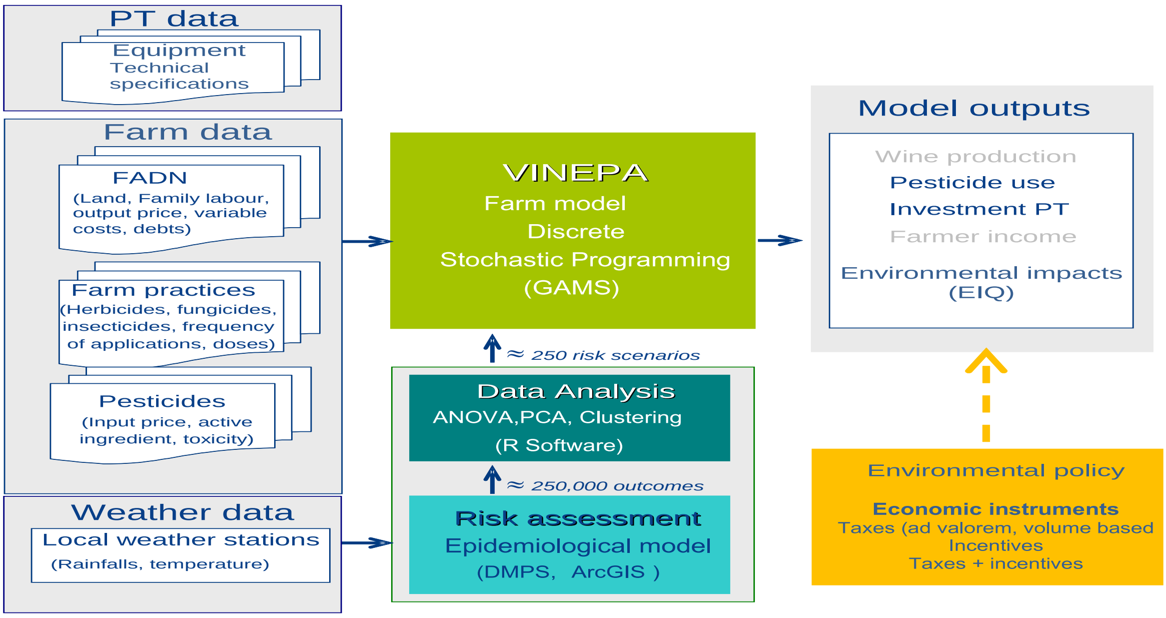

Figure 1. Data used by the VINEPA model

2.1. Data

The VINEPA model uses panel data from around one hundred wine estates representative of the Bordeaux region, drawn from the Farm Accountancy Data Network (FADN), which provides structural, economic, and financial information. Figure 1 gives an overview of all the other data used and how they were obtained.

3. Environmental policy for reducing pesticide use

Different instruments for environmental policies, such as regulation, information-persuasion-awareness, technological and institutional change, bilateral arrangements, market-based instruments, and private law instruments could potentially encourage reduced use of pesticides in viticulture. This study focuses specifically on economic instruments, namely taxes and subsidies.

3.1. Taxes on pesticides

The main aim of taxing pesticides is to reduce their use. The potential impact of a tax depends heavily on the substitution[2] or complementary[3] effect between the pesticides used. In the VINEPA model, the effects of taxation are considered only in terms of substitution, i.e. to what extent farmers will change from using one ingredient to another, rather than a change in the commercial product they spray. Because the design of a tax may play a role in determining its effectiveness, simulations are carried out at different rates for *ad valorem* and volume-based taxes). For *ad valorem* taxes, charges are calculated for active ingredients based on the retail price of the product. Some taxes may be specific to a given type of ingredient, while others may also take into account particular environmental risks. Different rates of taxes are assessed, along with a tax system relating to toxicity classes where the most harmful plant protection product is taxed at the highest rate (table 1).

Table 1. Simulations with taxes

	Toxicity classes	Ad valorem tax					Volume based tax (per kg or litre of active ingredient)								
		uniform			differentiated		no tax	present	x2	x5	x10	x50	x100	x200	
Taxes	simulations	taxV0	taxV50	taxV100	taxVd1	taxVd2	taxWL0	taxWL1	taxWL2	taxWL5	taxWL10	taxWL50	taxWL100	taxWL200	(a)
		i_taxV0	i_taxV50	i_taxV100	i_taxVd1	i_taxVd2	i_taxWL0	i_taxWL1	i_taxWL2	i_taxWL5	i_taxWL_10	i_taxWL_50	i_taxWL_100	i_taxWL_200	(b)
	4	0%	50%	100%	10%	10%	0,00 €	0,00 €	0,0 €	0,0 €	0,0 €	0,0 €	0,0 €	0,0 €	
	3	0%	50%	100%	20%	20%	0,00 €	0,90 €	1,8 €	3,6 €	5,4 €	7,2 €	9,9 €	14,4 €	
	2	0%	50%	100%	30%	40%	0,00 €	2,00 €	4,0 €	8,0 €	12,0 €	16,0 €	22,0 €	32,0 €	
	1	0%	50%	100%	40%	60%	0,00 €	5,10 €	10,2 €	20,4 €	30,6 €	40,8 €	56,1 €	81,6 €	

(a) standard equipment
(b)investment in PT possible

For volume based taxes, we use as a reference the National Water Law (Loi n°2006-1772) that sets a tax on pesticides based on active ingredients and their respective toxicity classifications[4]. This tax, first devised in 2006, has been levied on pesticide retailers since 2008. From 2010, category 1 pesticides are taxed at 5.10 € per KG, category 2 at 2 € per KG, category 3 at 0.90 € per KG. Category 4 pesticides are exempt from the tax. When products have two or more active ingredients, the rate related to its most harmful active substance is retained.

Table 2. Simulations with subsidies

	rates	No taxing			ad valorem tax (differentiated Vd2)		
		ceiling			ceiling		
		30 000 €	60 000 €	no ceiling	30 000 €	60 000 €	no ceiling
subsidies	40%	sub40_tax0_lim3	sub40_tax0_lim6	sub40_tax0_lim0	sub40_taxVd2_lim3	sub40_taxVd2_lim6	sub40_taxVd2_lim0
	60%	sub60_tax0_lim3	sub60_tax0_lim6	sub60_tax0_lim0	sub60_taxVd2_lim3	sub60_taxVd2_lim6	sub60_taxVd2_lim0
	100%	sub100_tax0_lim3	sub100_tax0_lim6	sub100_tax0_lim0	sub100_taxVd2_lim3	sub100_taxVd2_lim6	sub100_taxVd2_lim0

In this particular study, we used VINEPA's mean-standard deviation objective function to run a number of simulations. In some of those simulations, farmers kept their standard equipment. In others, they were given the possibility to invest in PT equipment, which can be paid for

[2] In the case of substitution, a higher tax on one active ingredient will make other active ingredients relatively cheaper and more attractive. This will have a positive impact on the effects of a differentiated tax.

[3] There is complementarity when the use of one pesticide has a clear connection with the use of another pesticide (particularly pesticides including two or more active ingredients like contact + systemic fungicides usually applied against downy mildew). In this case, tax on active ingredients may have little impact.

[4] There are four categories according to this Law: category I (toxic, very toxic, carcinogenic, mutagenic or toxic for reproduction), category II (Harmful for the environment), category III (Mineral substances harmful for the environment) and category IV (other active substances).

either in cash or by taking out a loan. For the ad valorem tax type, we first tested uniform tax rates (0%, 50% and 100% of the retail price), for all ingredients, irrespective of toxicity. Two differentiated rates (*taxVd1* and *taxVd2)* were then applied according to their toxicity classification (Table 2).

Table 3. Simulations with taxes and subsidies

subsidies	rates	Volume based tax (per kg or litre of active ingredient)								
		present			x 2			x 5		
		30 000 €	60 000 €	no ceiling	30 000 €	60 000 €	no ceiling	30 000 €	60 000 €	no ceiling
simulations	40%	sub40_tax WL1_lim3	sub40_tax WL1_lim6	sub40_tax WL1_lim0						
	60%				sub60_tax WL2_lim3	sub60_tax WL2_lim6	sub60_tax WL2_lim0			
	100%							sub100_ta xWL5_lim3	sub100_ta xWL5_lim6	sub100_ta xWL5_lim0

4. Results - Impacts of taxes on pesticides use and spraying applications

The outcomes of our simulations show that fungicide use is more or less completely unaffected by increases in the price of pesticide. This confirms the findings of a number of studies, which demonstrate the low price elasticity of demand relating to agricultural pesticides (Hoevenagel et al., 1999). Our results are in line with previous studies showing that there are few viable ways of reducing pesticide use in viticulture without compromising profit. This means that growers are restricted in the extent to which they can change their agricultural practices.

4.1. Advalorem tax (taxV)

On the basis that farmers still use their standard spraying equipment, taxes of 50% and 100 % (*taxV50, TaxV100*) have a significant effect in reducing the number of treatments (respectively -0.7 and -1.3) affecting mainly application of contact pesticides. Differentiated taxes (*taxVd1, Vd2*) have a non-significant effect in reducing the number of treatments because of substitution between active ingredients. While half of the wine estates studied could invest in basic precision equipment, increasing the tax rate makes it profitable for them to adopt more advanced equipment. However, investing in precision technology does not lead to a reduction in the number of treatments – indeed, a slight increase can be seen.

4.2. Volume based tax (taxWL)

While increasing tax rates up to tenfold has only a limited effect in reducing spraying applications (-0.6), significant changes can be seen once the tax rate is multiplied by 50 (*taxWL50, taxWL100, taxWL200*). This is accompanied by a switch from systemic to contact fungicides, leading to an increase (+3) in the total number of treatments (+10 for contact, -5 for systemic) to an average of 12.5 applications. The tax therefore does not have the desired effect, as the results show. A relative decrease in the number of spraying applications is achieved at the highest tax rates of 100 and 200 times the base rate (12.1 and 12 applications respectively). When growers are given the possibility of investing in PT (*i_taxWL*), the number of treatments does not fall, but actually goes up (+0.2 on average).

4.3. Subsidies

The effect of targeted subsidies to help winegrowers invest in PT equipment is analysed with different rates ranging from 40% up to 100 % of the investment cost (sub40, sub100) with no ceiling and two levels of upper bounds (lim0, lim3 and lim6). Increasing support promotes adoption of PT. By raising subsidies and raising the ceiling for funding, growers are eventually encouraged to invest in advanced equipment. Whatever the rate, subsidies have no effect in reducing the number of applications. One explanation for this could be that losses are reduced through the use of this new technology, therefore resulting in less pesticide expenditure.

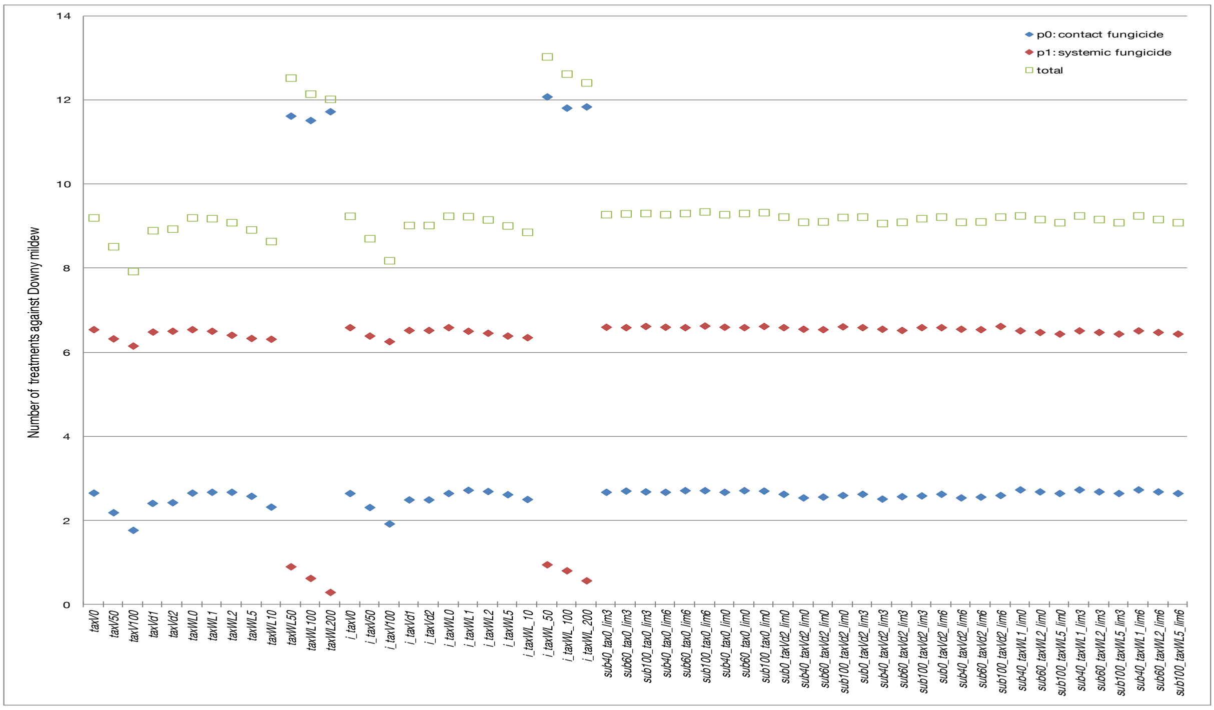

Fig2. Effects of taxes and subsidies on the number of treatments against downy mildew

4.4. Combination of taxes and subsidies

We examined the extent to which a combination of taxes and subsidies could impact the reduction of pesticides applications while generating additional public funds that can be earmarked for subsidizing farmers who wish to purchase precision technology. While increasing subsidies promotes the adoption of PT equipment, taxes (whatever the type and the rate) have no significant effect in reducing the number of treatments.

5. Results - Environmental effects of changes

In terms of the impact of these changes on the value of the EIQ environmental indicator, only taxes set based on levels of toxicity have a significant effect in reducing EIQ, and then only if the level of tax is high enough. The best results are obtained with the differentiated ad-valorem tax *(taxVd2)* and the volume-based tax set at 5 and 10 times the base rate (*taxWL5, taxWL10*) for fungicides used for downy mildew. Of all the fungicides used to combat fungal diseases, significant reduction of EIQ is obtained only for volume-based taxes (whatever their rate). Where PT technology is employed, smaller quantities of pesticides are applied per hectare, while still achieving the same level of grape protection. However, subsidizing PT equipment without adequately taxing harmful pesticides does not have any noticeable effect in reducing EIQ.

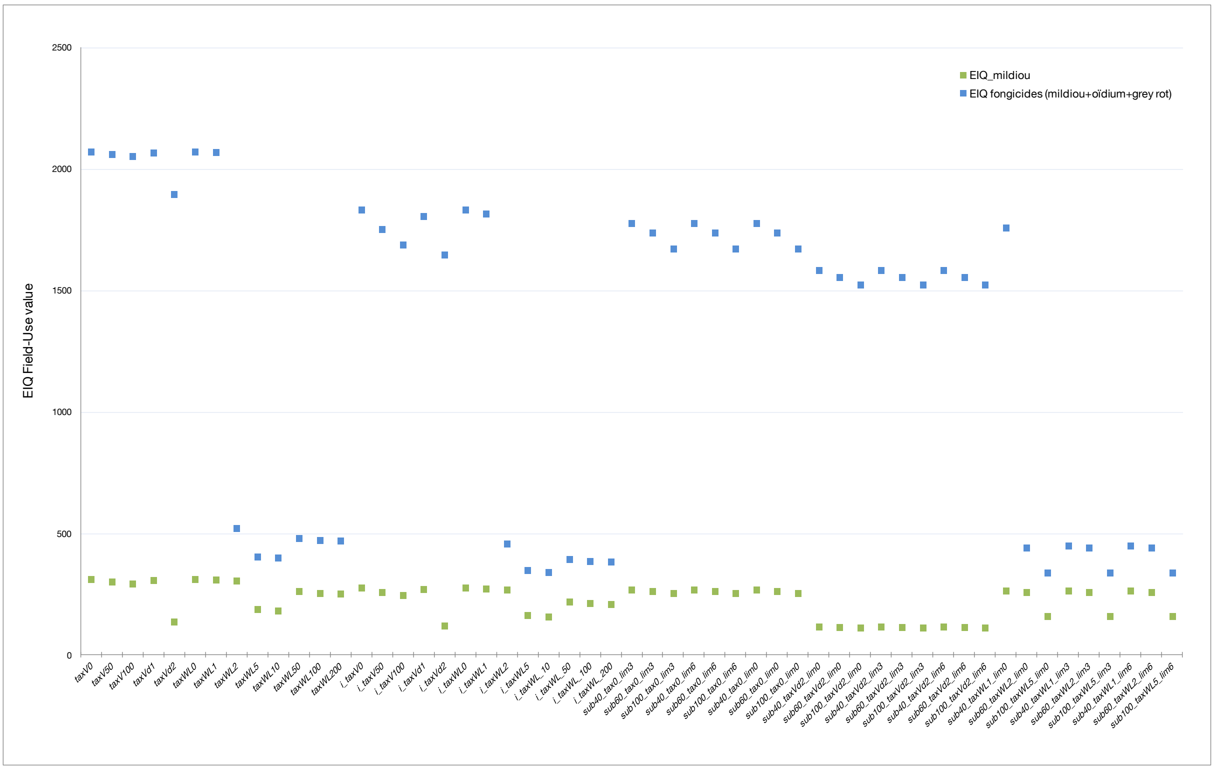

Fig 3. Effect on the Field-Use EIQ

6. Conclusion

The results of this study show that managing reduction of pesticide use in viticulture through economic instruments is a complicated and challenging enterprise. In the short run, the only way of effectively altering winegrowers' behaviour is through greater taxation, but such increases may prove politically sensitive. Nevertheless, in order to reduce environmental impact, tax bands should be set based on the toxicity of different active substances. While the introduction of precision technology does not by itself lead to a reduction in the number of treatments, the savings achieved by investing in such equipment could help to reduce spray drift, therefore limiting the unwanted side effect of pesticides being transferred into the natural environment.

7. References

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