Bulgarian Journal of Agricultural Science, 18 (No 5) 2012, 641-650
Agricultural Academy

ESTIMATION OF OPTIMAL TAX LEVEL ON PESTICIDES USE AND ITS IMPACT ON AGRICULTURE[1]

N. IVANOVA, Z. STOYANOVA and P. MISHEV
University of National and World Economy, BG – 1000 Sofia, Bulgaria

Abstract

IVANOVA, N., Z. STOYANOVA and P. MISHEV, 2012. Estimation of optimal tax level on pesticides use and its impact on agriculture. *Bulg. J. Agric. Sci.,* 18: 641-650

The optimal tax level on pesticides use is estimated based on the approach suggested by Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos (2010) as some amendments in the proposed model are done. The period in the analysis is 2002 – 2008, and the optimal tax for each case study is estimated as an average for the period. The optimal tax level is estimated for Bulgaria, Portugal, France, Germany, Poland and Hungary. The optimal tax levels on pesticides use obtained in all analysed cases are generally low, less than 50%, and are highly dependent on the assumption of the effect of pesticide use on the final consumption of agricultural good and not so much dependent on the assumption of the effect of the consumption of the agricultural good on overall utility and to the effect of environmental quality on overall utility. This practically means that consumers would value much more the effect of reduction of pesticides use on final consumption of agricultural goods than other external effects of pest use.

The optimal tax level estimated is used to evaluate the impact of tax introduction on farm level in Bulgaria and Portugal. In both cases, the highest level of the effect on consumption is used. This means that in case of Bulgaria the tax level is established at 14% thus leading to an increase in price of pesticides used by 14% and in Portugal – at 31% leading to an increase in prices of pesticides by 31%. The impact at farm level is evaluated based on the model developed by Skevas, Stefanou, Lansink (2011) and some amendments are done in model due to data availability in both countries.

The study shows that the effect of introduction of tax at farm level is relatively insignificant if the level of the tax is less than 50% in both countries, Bulgaria and Portugal. Impact that is more substantial could be expected in respect to the cost of pesticides in case of tax higher than 50%. The high taxes are needed to achieve significant reduction in use of pesticides. The impact of tax introduction depends on specialization of the farms. It is higher in the cases for farms with orchards and vineyard specialization than on average for all farms.

Having in mind that generally the use of pesticides is relatively inelastic to the price of pesticides which has been proven by the two case studies performed imposing tax less than 50% for Bulgaria and Portugal would not lead to substantial reduction of pest use and as the share of costs for pesticides in total cost on production (8 – 10% though the period 2002 – 2008 on average for agriculture) this increase in price of pest would lead to relatively low increase (less than 2% in case of Bulgaria and less than 3% in case of Portugal) in the total cost of production and that will not lead to a substantial reduction in pest use. Therefore, in two case study regions the effect of the introduction of tax on pesticides use even at highest socially optimal level is doubtful.

Key words: optimal tax level, pesticides, impact on agriculture, Bulgaria

[1] The research leading to these results has received funding from the European Community's Seventh Framework Programme [FP7/2007-2011]) under grant agreement n°212120.

Estimation of the Socially Optimal Tax Level: Short Description of the Model for Estimation of the Socially Optimal Tax Level

The model applied for estimation of the optimal tax rate on pesticide use is given by the following equation Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos (2011):

$$\tau_B = \frac{\alpha \frac{C}{B} + \frac{\gamma}{\beta}\frac{C}{E}\frac{\varepsilon_2}{\rho} + \frac{(\beta_2 - \tilde{\beta}_2)}{\rho}\delta\eta\frac{Y}{H}}{p_B} ,$$

Where:

τ_B - optimal tax; p_B - unit cost of pesticides; Y - agricultural output; C - consumption of agricultural products; H - farmer stock of health; L - labour effort of farmers; δ - quality of labour which depends on health; η - productivity of labour.

The parameters of the model α (effect of pesticide use on the final (consumption) agricultural good), δ (effect of the consumption of the agricultural good on overall utility) and γ (effect of environmental quality on overall utility) are restricted between 0 and 1.

The estimation of the tax is based on the combinations of the parameters α, γ and δ, taking values of 0.1%, 0.5% and 1%.

The environmental quality is measured by the variable stock of the environment calculated as suggested by the following relationship:

$$E_t - E_{t-1} = \varepsilon_1 E_{t-1} - \varepsilon_2 B_t ,$$

Where:

E_t and E_{t-1} are the stock of the environment in the current and previous year, respectively,

B_t is the use of pesticides in the current year; ε_1 is the self-cleaning rate of the environment; ε_2 is the damage rate of the environment due to the use of pesticides.

Farmer's stock of health is measured as suggested by the following equation:

$$H_t - H_{t-1} = \beta_1 A_{Ht} - \beta_2 B_t ,$$

Where

H_t and H_{t-1} are the current and previous year stock of health of farmers; AH_1 is farmers' health expenditure in the current year; β_1 is the efficiency rate of investment in health protection; β_2 is the health damage rate of pesticide use.

To calculate the initial stock values the suggested approach is used i.e. the following equations are applied:

$$H_0 = \frac{\beta_1 A_{H1} - \beta_2 B_1}{g_H}$$

$$E_0 = \frac{\varepsilon_2 B_1}{\varepsilon_1 - g_E} ,$$

Where g_H and g_E are the growth rate of the farmers' stock of health, and the growth rate of the environment quality both approximated by the growth rate of GDP. The farmer health expenditures are calculated based on the per capita health expenditure and labour employed in agriculture.

The values for the other parameters used in equations in both case studies are the ones suggested by Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos (2011):

ρ = 1% is used as a rate of time preference

ε_1 = 4% is used for self cleaning rate of the environment

ε_2 = 1% is the marginal effect of pesticides used on environmental quality

$\beta_2 - \tilde{\beta}_2 = 0.1\%$ is the marginal effect of pesticides used on farmer's health

β is the marginal effect of consumption of agricultural goods on aver all utility

η is used for farm labour productivity

Amendments of the Model Applied in the Case Studies

Calculation of the initial stock on the environment according to the suggested approach leads to negative value for that indicator in case of GDP higher than 4%, as in case of Bulgaria due to the assumption that the growth rate of the environment quality is approximated by the GDP growth rate. To solve the mentioned problem instead of difference between the self-cleaning rate and GDP growth in the denominator of the equation the absolute value of this difference is used in the considered case studies.

In addition to this amendment since the initial stocks on the environment depends not only on the value of pest used but also depend on the arable land on which the pesticides are applied, we used the value of pesticides per unit of land instead of the value of pesticides used only. Not taking into account the land of application of pest could lead to higher initial values in case of higher application of pest per unit of land, which will mean that in case of higher application of pest per unit of land, we will have better environmental quality or the opposite. This could lead to misleading results or at least to not comparable results. Because of this in the case studies, the initial stock on environment is calculated by the equation shown bellow:

$$E_0 = \frac{\varepsilon_2 B_1 / AL}{\left|\varepsilon_1 - GDP\right|}$$

Where, AL is the land of pest application, which is approximated, by the arable land.

Thus using the suggested equation for calculating the initial stock on the environment, we avoid the problem with receiving negative initial stock on the environment in case of GDP higher than self-cleaning rate of the environment and make the initial values comparable across countries.

Results of Application of the Amended Approach in Bulgarian and Portuguese Case Studies

Data used in estimation the optimal tax in both case studies cover the period 2002 – 2008 and are obtained from EUROSTAT. The indicators used are value of pesticides used, GDP growth rate, total arable land, per capita health expenditure and total number of people employed in agriculture. All data in value terms are in constant prices (2005=100) and measured in thousands of Euros. Since prices of pesticides are not available in both countries, price indices are used as a proxy of price of pesticides (Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos (2011)).

Since the health, expenditures per capita in Bulgaria are available since 2003 data for 2002 are assumed equal to those in 2003. In case of Portugal, data for the last three years are missing. Due to this, data used in calculation are 2005 data adjusted with GDP growth rate.

The parameters of the model used are the same as suggested by the mentioned authors, which practically means that people in all investigated countries treat the environment and health alike and have the same preferences. Thus, the obtained results are comparable among countries examined as well as comparable to the results obtained by the mentioned authors.

The assumption of market equilibrium suggests that Y=C, due to which as a proxy of agricultural output and consumption the gross value added of the agricultural sector (in constant 2005 prices) is used.

Based on the assumptions suggested and amendments done in case of calculation of initial stock on the environment, the optimal tax is estimated over the period 2002 – 2008. Some key variables and the results obtained for the environmental load and stock of health in are shown in Table 1. As seen from the table pesticides use per unit of land and health expenditure per capita differ substantially among the countries. This is the reason caused the mentioned above amendment in the model which makes the results more comparable.

Table 2 also shows that that the use of pesticides per unit of land as well as health expenditure per capita differ substantially though the period. Substantial differences in all variables through the observed period reflect in different optimal tax levels through the years of observations (Table 2). To avoid obtaining results that would depend on the base year chosen the averages for the period are used in the study.

In Table 2, the lowest level is obtained in case of α, β and γ equal to 0.001 and highest level is obtained in case of α, β and γ equal to 0.01. The results of estimation show that optimal tax in all countries analysed differs by years quite substantially. The lowest tax level in case of Bulgaria is obtained in 2007 (0.97% - 9.66%) and the highest level - in 2005 (2.14% - 21.43%). In case of Portugal the lowest tax level is obtained in 2008 (2.47% - 24.74%) and the highest level is obtained in 2003 93.52% - 35.21%). In case of France the lowest tax level is obtained in again in 2007 (4.77% - 47.69%) and the highest – in 2002 (5.71% – 57.09%). In Germany the lowest tax level refers to 2008, while the highest – to 2004 when reaches to 59.98% at maximum. In the

Table 1
Descriptive statistics of key variables used

	2002	2003	2004	2005	2006	2007	2008	Average	St. def.
Bulgaria									
Agricultural Gross Value Added (mill €)	1541	1499	1535	1544	1426	824	1424	1399.00	258.73
Total Pesticides Consumption (mill €)	114.11	114.6	122.72	72.34	108	72.07	94.49	99.76	20.68
Calculated stock on environment ('000 €)	456.4	473.5	491.2	510.2	529.5	549.9	571.0	511.71	41.29
Calculated stock of heals ('000 €)	886.2	1129.1	1443.3	1861.9	2398.9	3104.2	4016.6	2120.06	1130.76
pest per 1000 HA	45.6	42.4	47.2	28.9	41.5	26.7	35.0	38.2	7.5
per capita health expenditure	155.0	173.0	186.8	214.0	232.3	260.9	307.0	218.4	49.2
Portugal									
Agricultural Gross Value Added (mill €)	2 638	2 539	2 798	2 389	2 661	2 359	2 515	2 557.00	155.00
Total Pesticides Consumption (mill €)	95.8	86.2	99.1	95.1	95.9	99.4	96.9	95.48	4.41
Calculated stock on environment ('000 €)	563.5	585.2	607.6	630.9	655.2	680.4	706.7	632.82	51.55
Calculated stock of heals ('000 €)	4252.5	4821.4	5465.4	6209.1	7063.8	8043.8	9172.9	6432.75	1771.89
pest per 1000 HA	56.4	53.9	66.1	70.4	77.3	88.8	96.9	72.8	14.8
per capita health expenditure	1219.7	1219.7	1303.3	1367.4	1386.5	1419.8	1419.8	1333.8	80.8
France									
Agricultural Gross Value Added (mill €)	29363.9	25098.8	30575.8	28770.8	28249.1	27612.1	27986.1	28236.7	1699.349
Total Pesticides Consumption (mill €)	2780.6	2579.2	2643.4	2617.5	2547.2	2723.7	2972.9	2694.929	146.8007
Calculated stock on environment ('000 €)	759.7	764.3	768.5	773	778.5	782.4	783.9	772.9	9.2
Calculated stock of health ('000 €)	23980.7	30659	39328.1	50603	65274.4	84312	109011	57595.5	30698.6
pest per 1000 HA	151.9	140.9	144.4	143.0	139.2	148.8	162.5	147.3	7.4
per capita health expenditure	2725.3	2725.3	2840.0	2960.6	3054.2	3170.9	2069.8	2792.3	332.4
Germany									
Agricultural Gross Value Added (mill €)	10825.5	10932.4	14923.5	12811.7	12755.9	12687.4	12315	11071.23	1375.853
Total Pesticides Consumption (mill €)	1054.6	1129.2	1145.9	1338	1337.6	1338.5	1336.8	1240.086	124.9712
Calculated stock on environment ('000 €)	357.5	360.5	363.5	364.6	365.8	367.1	368.4	363.9	3.8
Calculated stock of health ('000 €)	2045.7	3103.7	4794	7469.7	11750.9	18600.7	29560.7	11046.5	9969.3
pest per 1000 HA	89.4	95.7	96.7	112.4	112.4	112.5	112.3	104.5	9.4
per capita health expenditure	2722.3	2722.3	2726.4	2796.0	2871.3	2973.8	3096.8	2844.1	134.8
Poland									
Agricultural Gross Value Added (mill €)	4637.8	4570.7	5972.4	6092.6	5722	6356.3	6537.8	5698.5	792.1
Total Pesticides Consumption (mill €)	381.8	393.4	338.5	338.5	338.5	343.7	486.6	374.4	54.4
Calculated stock on environment ('000 €)	1226	1271.1	1318.5	1367.9	1419.2	1472.5	1526.6	1587.6	108.5
Calculated stock of health ('000 €)	1674.2	2767.5	4637.1	7815.4	13218.5	22402.7	37987.3	64578.3	13181.9
pest per 1000 HA	35.0	35.8	30.4	30.0	29.4	29.3	41.4	33.0	4.2
per capita health expenditure	300.1	300.1	316.8	374.6	417.6	491.5	491.5	384.6	78.3
Hungary									
Agricultural Gross Value Added (mill €)	1368.2	1427.6	2357.1	2206.8	2063.5	1470.6	2682.9	1939.529	519.9601
Total Pesticides Consumption (mill €)	258.9	219.2	273.8	268.8	273.6	294.96	334.6	274.8371	35.03585
Calculated stock on environment ('000 €)	87.5	88.8	89.6	90.5	91.4	92.1	92.4	90.3	1.8
Calculated stock of health ('000 €)	3430	5787.1	9783.3	16577.9	28127.6	47758	81121.7	27512.2	28195.9
pest per 1000 HA	70.0	60.9	76.1	74.7	76.6	83.1	94.3	76.5	9.6
per capita health expenditure	589.7	589.7	630.7	709.4	699.3	722.1	745.7	669.5	60.1

Source: EUROSRTAT and own calculations other two countries the lowest tax level is obtained in 2008 (Poland) and 2007 (Hungary), while the highest level is calculated in 2004 in both countries.

Due to the large differences in the tax levels obtained over the period in all cases and high dependence of the tax level on the base year chosen the average tax level over the whole period is calculated. In estimation the average tax level the simple averages for the pesticides consumption and agricultural gross value added, weighted average for the health expenditure are used. The average tax levels obtained on average for the period 2002–2008 are presented in Table 3. The optimal tax levels on pesticides use obtained in all analysed cases are generally low less than 50% and are highly dependent on the assumption of the effect of pesticide use on the final consumption agricultural good and practically not so much dependent on the assumption of the effect of the consumption of the agricultural good on overall utility and to the effect of environmental quality on overall utility. This practically means that consumers would value much more the effect of reduction of pesticides use on final consumption of agricultural goods than other external effects of pest use.

As seen from the table the obtained tax levels varied among the countries as the lowest tax level is obtained in case of Bulgaria (1.41% - 14.10%), and the highest in France (5.11% - 51.10%). These tax levels estimated correspond to the results obtained by Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos (2011) for Cyprus, UK and Netherlands, but as seen from the table and the results presented, although the equal treatment of the health and environment the tax levels differ quite substantially.

In order to find the reasons for the observed differences in tax levels obtained a comparison of the pest used per unit of land and per capita health expenditure are compared (Table 1). The results show that the higher is the quantity of pesticides used per thousand of hectare and health expenditure higher is the estimated tax level. This practically means that under the same preferences of the consumers the tax level should be higher in case of agriculture that is more intensive and the opposite lower in case of less intensive agriculture.

Table 2
Lowest and highest levels of optimal tax obtained over the period

	2002	2003	2004	2005	2006	2007	2008
Bulgaria							
Lowest	2.07%	1.89%	1.72%	2.14%	1.49%	0.97%	1.48%
Highest	20.65%	18.90%	17.15%	21.43%	14.87%	9.66%	14.77%
Portugal							
Lowest	3.43%	3.52%	3.37%	2.94%	3.18%	2.53%	2.47%
Highest	34.28%	35.21%	33.69%	29.36%	31.80%	25.33%	24.74%
France							
Lowest	5.71%	4.82%	5.69%	5.24%	5.05%	4.77%	4.06%
Highest	57.09%	48.24%	56.89%	52.39%	50.48%	47.69%	40.58%
Germany							
Lowest	4.64%	4.53%	6.00%	4.87%	4.75%	4.60%	3.83%
Highest	46.39%	45.25%	59.98%	48.74%	47.50%	46.02%	38.33%
Poland							
Lowest	1.76%	1.67%	2.33%	2.30%	2.11%	2.24%	1.50%
Highest	17.64%	16.65%	23.27%	23.00%	21.14%	22.43%	15.05%
Hungary							
Lowest	2.42%	2.58%	3.87%	3.53%	3.22%	2.19%	3.33%
Highest	24.20%	25.83%	38.69%	35.32%	32.22%	21.87%	33.29%

Source: own calculation

Sensitivity Analysis of the Obtained Results

Due to the large number of the assumed parameters used in the model the sensitivity analysis of the tax levels estimated in the study regions is performed. The sensitivity analysis is done based on 10% change in the assumed parameters. Results of the analysis show that the results are the most sensitive to the parameter rate of time preference (parameter connected to the short run gains and the long run losses from pesticide use), as 10% increase in it leads to changes in tax levels between minus 0.17% (α=1%, δ=0.1%, γ=0.1%) and minus 6.01% (α=0.1%, δ=1%, γ=1%). Quite sensitive are also the results to the change in the effect of the consumption of the agricultural goods on overall utility (β) as the change varies from minus 0.17% (α=1%, δ=0.1%, γ=0.1%) to minus 5.96% (α=0.1%, δ=0.1%, γ=1%). Results are practically not sensitive to all other parameters used in the model since 10% increase in all of them have led to a change in the tax level less that 1% .

The sensitivity analysis showed that the obtained tax levels are relatively stable in respect to the assumed parameters in the model with exception of the two parameters mentioned above but as seen from Table 3 the tax levels estimated depends highly on the assumption of the parameters α, γ and δ.

Estimation of the Effect of the Established Tax Levels on Farms

The model applied for the estimation of tax level's effect on farm is the model developed by Skevas et al. (2011). According to the theoretical model, farmers are maximizing their profit taking into account their production possibilities and pesticide impacts given by following equation:

$$\max_{x_t, z_t} \; p_t y_t - w_{p_t} x_{p_t} - w_{z\,t}(Z_{l\,t} + Z_{h\,t}) + \beta[p_{t+1} y_{t+1} - w_{p_{t+1}} x_{p_{t+1}} - w_{z_{t+1}}(Z_{l_{t+1}} + Z_{h_{t+1}})]$$

where

$$y_t = e^{(c_0 + \sum_i^{N-1} c_i * id_i)} x_{1_t}^{\alpha_1} x_{2_t}^{\alpha_2} q_{1_t}^{\beta_1} q_{2_t}^{\beta_2} q_{3_t}^{\beta_3} .(1 - e^{-(\gamma_1 Z_{l_t} + \gamma_2 Z_{h_t} + \gamma_3 Z_{l_t} Z_{h_t} + \gamma_4 PI_{w_t})})$$

y: output; p: output price; w_p: price of variable inputs; w_z: price of pesticides; c: farm specific dummies; x: variable inputs (i.e. fertilizers, other inputs); q: fixed inputs (i.e. labor, capital land); β: discount factor; Z_l: low toxicity pesticides; Z_h: high toxicity pesticides; Z_{lh}: interaction term of the two pesticide categories; PI: pesticide impacts on different organisms and the health of the farm operator.

The solution to this optimization problem leads to the optimal x_1 and x_2 (variable inputs).

According to the available FADN data in both countries some changes in the model were done. Since the pesticide's impacts, data do not exist for Bulgaria and some of the Bulgarian and Portuguese FADN data are more aggregated than these for Netherlands the maximization function used for both cases are:

$$\underset{y_t, x_{p_t}, Z_t}{Max}(p_t y_t - w_{p_t} x_{p_t} - w_{Z_t} Z_t)$$

where

in the case of Bulgaria

$$y_t = e^{(c_0 + \sum_i^{N-1} c_i * id_i)} x_{1_t}^{\alpha_1} q_{1_t}^{\beta_1} q_{2_t}^{\beta_2} (1 - e^{(\gamma_1 Z_t)})$$

and in the case of Portugal

$$y_t = e^{(c_0 + \sum_i^{N-1} c_i * id_i)} x_{1_t}^{\alpha_1} x_{2_t}^{\alpha_2} q_{1_t}^{\beta_1} q_{2_t}^{\beta_2} q_{3_t}^{\beta_3} (1 - e^{(\gamma_1 Z_t)})$$

z – pesticides

The variable inputs in Bulgarian case are calculated as a difference between the value of total inputs and pesticides. The variable inputs in the case of Portugal consist two types of inputs. The first one is called other inputs calculated as a sum of expenditures for energy and seeds, other specific cost and other direct inputs. The second type is fertilizers. Variable inputs for both cases are denoted as x. Variable inputs were measured in euro.

Fixed inputs (q) in the case of Bulgaria include land (q2) and labour (q1). Fixed inputs in the case of Portugal include land (q2), labour (q1) and capital (q3). Land is measured in hectares and labour is measured in annual work units (AWU). Pesticides were measured as expenditures in euro.

Table 3
Tax levels obtained under different assumption for the parameters α, β and γ

Bulgaria									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	1.41%	1.43%	1.45%	7.02%	7.04%	7.06%	14.03%	14.05%	14.07%
γ=0.005	1.42%	1.44%	1.46%	7.03%	7.05%	7.07%	14.04%	14.06%	14.08%
γ=0.01	1.44%	1.45%	1.48%	7.05%	7.06%	7.09%	14.06%	14.08%	14.10%
Portugal									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	3.13%	3.14%	3.15%	13.84%	13.85%	13.87%	27.23%	27.24%	27.26%
γ=0.005	4.93%	4.94%	4.95%	15.64%	15.65%	15.66%	29.03%	29.04%	29.05%
γ=0.01	7.17%	7.18%	7.20%	17.88%	17.89%	17.91%	31.27%	31.28%	31.30%
France									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	5.11%	5.12%	5.14%	9.30%	9.32%	9.33%	14.54%	14.55%	14.57%
γ=0.005	21.35%	21.36%	21.38%	25.54%	25.55%	25.57%	30.78%	30.79%	30.81%
γ=0.01	41.64%	41.66%	41.67%	45.83%	45.85%	45.87%	51.07%	51.09%	51.10%
Germany									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	4.28%	4.31%	4.34%	7.85%	7.88%	7.91%	12.32%	12.34%	12.38%
γ=0.005	17.80%	17.83%	17.86%	21.37%	21.40%	21.44%	25.84%	25.86%	25.90%
γ=0.01	34.70%	34.73%	34.77%	38.27%	38.30%	38.34%	42.74%	42.77%	42.80%
Poland									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	1.99%	2.00%	2.01%	8.07%	8.09%	8.10%	15.68%	15.70%	15.71%
γ=0.005	3.83%	3.85%	3.86%	9.92%	9.93%	9.95%	17.53%	17.54%	17.56%
γ=0.01	6.14%	6.15%	6.17%	12.23%	12.24%	12.26%	19.84%	19.85%	19.87%
Hungary									
	α = 0.001			α =0.005			α=0.01		
	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01	β=0.001	β=0.005	β=0.01
γ=0.001	3.09%	3.09%	3.10%	5.92%	5.92%	5.92%	9.44%	9.45%	9.45%
γ=0.005	12.64%	12.64%	12.64%	15.46%	15.46%	15.47%	18.99%	18.99%	18.99%
γ=0.01	24.57%	24.57%	24.57%	27.39%	27.39%	27.40%	30.92%	30.92%	30.93%

Source: own calculations

The parameters to be estimated are α, β, γ, c. The coefficients α, β, γ are interpreted as elasticity and parameters c are farm specific dummies that eliminate the influence of some factors that are not accounted for in the model such as stochastic events and measurement errors.

Results of Application of the Micro Model in the Case of Bulgaria and Portugal

The effect of imposing tax on pest use on farms is estimated in the case of Bulgaria and Portugal. Having in mind that generally the use of pesticides is relatively inelastic to the price of pesticides (Kalaitzidakis, Mamuneas, Nicholas, Stefanou, Stengos) imposing tax less than 50% (as estimated in all considered countries) would not lead to substantial reduction of pest use and having in mind the share of costs for pesticides in total cost on production (8 – 10% though the period 2002 – 2008 on average for agriculture) this increase in price of pest would lead to relatively low increase (less than 2% in case of Bulgaria and less than 3% in case of Portugal) in the total cost of production. Due to this we have considered the highest level of tax on pest consumption estimated, i.e. α = 1%, or in other words the tax level in Bulgaria established at 14% and thus increasing the price of pesticides used by 14% and in Portugal – at 31% leading to an increase in prices of pesticides by 31%.

Data used for estimation of the tax level's effect on farm in Bulgarian case cover two years - 2005 and 2007. Data from the farm accountancy data network of the Bulgarian Ministry of Agriculture were used. The data for calculation of estimated parameters - α, β and γ used in Bulgarian simulation model are for years 2005 and 2007. Bulgarian FADN data for 2007 was used to estimate the model.

To find out whether the production pattern has impact on model results two data sets were used. The first data set covers all the data for the country (i.e. 209 observations). The second one covers only data for the farms specialized in orchards (19 observations).

Data used for estimation of the tax level's effect on farm in Portuguese case cover the period 2000-2007. Data from the farm accountancy data network in Portugal are used. The data used for the calculation of estimated parameters - α, β and γ used in the simulation model in Portuguese case cover the period 2000-2007 and to estimate the model Portuguese FADN data for 2007 are used. As in case of Bulgaria, two cases are considered: all farms (81 observations) and vineyard farms only (104 observations).

Six scenarios with different taxes applied are developed. The tax is achieved by increasing the price of pesticide with 5, 20, 32, 50, 80 and 120% in case of Bulgaria and 10, 20, 50, 55, 80 and 110 % in case of Portugal.

The effect of introduction of a tax on profit and other variable inputs at farm level in the case of all farms in Bulgaria (Table 4) is relatively insignificant in all analysed tax levels. The reduction in profit is between 0.013% at 5% tax level and 0.31% at 120 % tax applied. The expected change in other variable inputs is from 0,003% to 0.05%.

The only sensitive indicator is the value of pesticides. The expected reduction in pesticides use is between 0.58 and 10.3% in the case for all farms (Table 4). As seen from the table if the tax level is below 50% the expected reduction on pesticides use is less than 5%, and the reduction is slightly above 10% in case of tax equal to 120%. This practically means that in case of Bulgaria the tax level should be at minimum 50% to be able to expect at least 5% reduction in pesticides use. Since 50% tax is highly above the socially optimal tax estimated in case of Bulgaria we could conclude that introduction of tax at its optimal level will not lead to reduction of pesticides use.

The analysis shows that the effect of introduction of tax in the case of farms with orchards specialization in Bulgaria is more significant than for all farms but generally the effect on other variable inputs and on profit is low. The reduction in profit is insignificant for all levels tax applied with only exception of tax level 120%, when the change in profit is "-2.04" %. The expected change in other variable inputs vary from "-0.01"% for 5 % tax applied to "-0.39" % for level 120 % tax applied. As in case of all farms, impact that is more substantial could be expected in respect to value of pesticides as the change in the case the orchard's case the expected reduction in pesticides use is between 0.72 % and 14.49 % (Table 5). Again relatively reasonable reduction in pest use could not be expected if the tax level is below 50% or at least 32% (with reduction of pest use by 4.9%) which is highly above the socially optimal tax estimated.

The results in the case of all the farms as well as for the farms with orchards specialization show that there is a reduction in profit, other variable inputs and pesticides under all scenarios tested (Tables 5 and 6). The reduction of the profit and other variable inputs is relatively insignificant for most tax levels applied. Value of pesticides proofed to be the most sensitive indicator as for the case of all farms as well as for the case of farms with orchards specialization in Bulgaria.

The results of the analysis in both cases in Bulgarian case study lead to a conclusion that in the case of Bulgaria the introduction of a tax on pesticides within the socially optimal tax level will not cause really reduction of pest use.

The results of farm level model application in case of Portugal for all farms as well as for the farms with vineyard specialization also show that the reduction in profit, other variable inputs, fertilizers and pesticides for all levels of the taxes applied are more sensitive to the tax level than in the case of Bulgaria. The reduction of profit is relatively insignificant for tax level up to 50%. The negative impact of tax introduction on profit is sensible at tax levels 50% and above. Variable inputs and fertilizers are practically insensitive for the dataset of all the farms (reduction less than 1.3% is estimated) and for the farms with vineyard specialization (reduction below 2%) at all tax levels applied. As in case of Bulgaria value of pesticides is the most sensitive indicator for both data sets among the indicators analysed.

For agriculture as whole (based on all farms) the change of pesticide's use is between 2.22 and 17.59 % (Table 6). Reduction in pest use higher than 5% could be expected at 50% tax level or higher which as in case of Bulgaria is above the socially optimal tax levels estimated.

The effect of introduction of tax at farm level for the case of farms with vineyards specialization in Portugal is also relatively more significant than on all farms (Table 7). The reduction in profit is insignificant for the tax levels below 50% as the change of profit is "-0.74" and "-1.43"%. The change in profit for the other tax levels

Table 4
Change in profit, other variable inputs and pesticides under the tax scenarios applied, Bulgaria –all data (base 2007 year)

	Tax applied					
	5%	15%	32%	50%	80%	120%
Profit , %	-0.013	-0.067	-0.1	-0.13	-0.21	-0.31
Other variable inputs, %	-0.003	-0.012	-0.024	-0.027	-0.03	-0.05
Pesticides, %	-0.58	-1.94	-3.87	-5.8	-7.74	-10.3

Source: own calculations

Table 5
Change in profit, other variable inputs and pesticides under the tax scenarios applied, Bulgaria – orchards (base 2007 year)

	Tax applied					
	5%	15%	32%	50%	80%	120%
Profit, %	-0.09	-0.33	-0.61	-0.91	-1.43	-2.04
Other variable inputs, %	-0.01	-0.035	-0.08	-0.14	-0.25	-0.39
Pesticides, %	-0.72	-2.89	-4.88	-7.19	-10.63	-14.49

Source: own calculations

Table 6
Change in profit, other variable inputs and pesticides under the various tax scenarios applied Portugal–all data (base 2007 year)

	Tax applied					
	10%	20%	50%	55%	80%	110 %
Profit , %	-0.54	-1.05	-2.55	-2.99	-3.67	-5.32
Fertilizer, %	-0.12	-0.25	-0.61	-0.95	-0.96	-1.3
Other variable inputs, %	-0.13	-0.26	-0.61	-0.95	-1	-1.34
Pesticides, %	-2.22	-4.43	-9.7	-11.21	-13.99	-17.59

Source: own calculations

Table 7
Change in profit, fertilizer, other variable inputs and pesticides with various tax scenarios applied in case of vineyards (base 2006 year)

		Tax applied				
	10%	20%	50%	55 %	80%	110%
Profit, %	-0.74	-1.43	-3.55	-3.89	-5.53	-7.4
Fertilizer,%	-0.1	-0.3	-0.8	-0.9	-1.3	-1.82
Other variable inputs,%	-0.18	-0.33	-0.84	-0.91	-1.35	-1.86
Pesticides, %	-2.31	-4.41	-9.82	-11.59	-14.31	-17.92

Source: own calculations

applied varies between “-3.55” at 50% tax and “- 7.4” at 110% tax. These results shows that vineyards production will be affected much more than on average for all farms in case of introduction of tax on pesticides use.

The expected change in other variable inputs and fertilizers as in case of all farms is insignificant in farms specialized in vineyards in Portugal. The change in other inputs varies from “-0.18”% for 10 % tax applied to “-1.86” % for level 110 % tax applied. The change in fertilizers varies from “-0.1”% for 10 % tax applied to “-1.82” % for level 110 % tax applied. Both results show that other inputs and value of fertilisers will not be affected much if the tax on pest is introduced.

Results of the analysis of the impact of introduction of tax on pesticides use show that it could be expected relatively significant reduction in the value of pesticides in the vineyard case in Portugal. The expected reduction in pesticides use is between 2.31 % at 10% tax and 17.92 % at 110% tax (Table 7). Again, the tax should be at least 50% to expect really reduction in pest use.

The results obtained at macro- and micro levels in the two case studies show that it is unlikely to expect that introduction a tax on crop protection would result to a decrease in the use of crop protection products or a significant change in the way high input farmers’ farm. It is also very unlikely these farmers to move from high input crop protection systems to low input or organic systems.

Conclusions

Sustainable use of pesticides in European agriculture is a task with high priority for future development of EU agriculture. The designed socially optimal tax and levy scheme applied reveals two important issues:

- In all countries, analysed consumers value much more the effects of reduction of pesticides use on final consumption of agricultural use than other external effects of pesticides use.
- Although the costs of pesticides are important in the cost structure of agricultural production in Bulgaria and Portugal, increase of price of pesticides (through tax imposing) would lead to relatively low increase in the total cost of the production as well as in insignificant reduction in profit of the farmers with exception of vineyards farmers in Portugal. Thus in the case of both countries effects of tax introduction even on upper limit of obtained optimal tax level is quite doubtful.

References

Kalaitzidakis, P., Th. Mamuneas, Ph. Nicholas, S. Stefanou and Th. Stengos, 2010. WP 6.2: A Dynamic Macroeconomic Model of Effective Pesticide Use and Effective Tax and Levy System.

Kalaitzidakis, P., Th. Mamuneas, Ph. Nicholas, S. Stefanou and Th. Stengos, 2011. WP6.4: Empirical Investigation of Policy Effects on Optimal Pesticide Use with Emphasis on Constructing an Effective Tax and Levy Scheme.

Skevas, T., S. E. Stefanou and A. Oude Lansink, 2011. WP:5.4. An empirical and theoretical evaluation of the impacts of pesticide levy and tax schemes on agriculture and the environment.

D6.4 Empirical Investigation of Policy Effect on Optimal Pesticide Use with Emphasis on Constructing an Effective Tax and Levy Scheme

Received March, 2, 2012; accepted for printing July, 2, 2012.