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# Determinants of pesticide use in Swiss crop and fruit production

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## Context/Theoretical background/Research question

The reduction of pesticide use is on the top of agricultural policy agendas in Europe, with National Action Plans for the sustainable use of pesticides already being in place in the EU member countries and Switzerland planning to follow in 2016. Furthermore some European countries (i.e. Sweden, Denmark, Norway and France) have implemented pesticide taxation schemes. However, the decision rationale of farmers concerning the application of pesticides is not fully understood yet, for example considering the role of risk and risk aversion.

A reduction of pesticide use can be welfare maximizing if external effects of pesticide use (e.g. on human health and the environment) exist (Waterfield & Zilberman, 2012). Apart from not using the socially desirable level of pesticides, farmers have been reported to even deviate from profit maximizing levels of pesticides but over- or underuse pesticides (for an overview see Skevas, 2013).

Deviations from profit maximizing pesticide use might be explained by the existence of groups of farmers with different decision rationales. For instance, Pedersen et al. (2012) show that some Danish farmers aim to maximize crop yields instead of profits. Further, individual pesticide use was found to be determined by farm and farmers' characteristics, such as education, income or farm size (Dasgupta et al., 2001, Rahman, 2003, Galt, 2008). Clearly, also agronomic factors explain pesticide use. For example, Bürger et al. (2012) show that crop management (fertilization, preceding crops, tillage) determines pesticide use. Moreover, climatic and soil conditions explain variations in pesticide use across space and time (e.g. Andert et al., 2015). But, Bürger et al. (2012) could show that indeed the individual farm effect explains more of the observed variability in pesticide use of winter wheat producers in Germany than other determinants. They conclude that this might reflect both routine treatments by farmers and unobserved farm (and farmers') characteristics. We aim to add to this literature by providing additional insights with respect to the latter. More specifically, the existing literature on determinants of pesticide use is limited as in economic studies no distinction between types of pesticides and crop specific analysis are made, i.e. aggregated data is used. In contrast, studies by agronomist do not consider socio-economic aspects. Moreover, the role of risk and risk aversion has not been considered in the above presented studies, although it could be one of the key reasons for deviations from the profit maximizing pesticide use (e.g. Gotsch & Regev, 1996, Horowitz & Lichtenberg, 1994). However, results regarding the effect of farmers risk preferences on pesticide use are ambiguous, as pesticides have been found to potentially decrease but also increase risks and farmers can be risk averse but also risk loving (Horowitz & Lichtenberg, 1994).

Based on this background, we aim to investigate which farm and farmers' characteristics determine the use of different types of pesticide, with a particular focus on risk related aspects. To this end, highly

detailed and high frequency plot-level panel data on pesticide application for Swiss agriculture is employed, controlling for several agronomic factors for pesticide use.

## Methodology

We empirically analyze the above research questions with panel data estimation methods. The data used comes from Swiss ZA-AUI and bookkeeping data (for further details see Spycher et al., 2013, Hoop & Schmid, 2015) and consists of a panel of 302 representative Swiss farmers reporting on their plot wise pesticide use from 2009 to 2013. The data is highly detailed and includes observations for multiple outputs as well as different types of pesticides per farmer, each year. Additionally it provides annual information on spatial and farm characteristics. According to Spycher et al. (2013) the ZA-AUI survey only covers about 1% of the area designated to crop production in Switzerland, but is representative of the pesticides used in Switzerland. For a description of pesticide use in Swiss agriculture and a comparison with other European countries also see Spycher et al. (2013).

As observations for some years are missing the panel is unbalanced. As a dependent variable we use the amount of active ingredient pesticide per hectare in kg (AI kg/ha). This variable is comprised of the amount of yearly pesticide application per plot, expressed in its active ingredient content per hectare. We run separate regressions for accumulated pesticides, insecticides, herbicides and fungicides to capture differences per pesticide type. The non-use of specific pesticides in some years and plots motivates the use of censored regression techniques for special pesticide classes. A multivariate estimation of the different pesticides applied is further tested. We control for farm, spatial and agronomic characteristics by introducing control variables. To also account for the potential effects risk attitudes of farmers have on the pesticides used we use indicators as proxies for risk aversion[1], such as wealth, farm size and age (see e.g. Kondouri et al., 2009, Bar-Shira et al., 1997, Binswanger, 1980). Those indicators might vary over time if risk indicators change. Cross products of culture dummy variables and risk indicators are further used to test for culture specific effects on pesticide use. Local weather conditions or pest pressure, managerial ability as well as effects over time are controlled for. We test for endogeneity, heteroscedasticity, autocorrelation, as well as structural breaks due to policy regimes in Switzerland changing between 2008-2011 (AP 2011) and 2011-2013. Considering the variance in pesticide use per farmer and plot we further test for determinants influencing pesticide over- and underuse.

## Results

Results from Bürger et al. (2012), showing that most variation in pesticide use is due to individual and farm characteristics are confirmed. Our results show significant effects of socio-economic variables (as wealth, education and age), agronomic variables (as soil management) and farm characteristics (as farm type). Higher education, as well as mixed animal and crop farming are shown to be determinants for reduced pesticide use, for example. The effect of proxies for risk aversion on the other hand is difficult to distinguish, due to mixed results in significance and difficulties in interpretation. This might indicate a relatively small effect on pesticide use compared to stable use patterns, which can be site-, management- or weather- specific. Significance of the above determinants further differs for different types of pesticides.

[1] In further research one could explicitly estimate farm specific risk aversion coefficients like in Gardebroek (2006).

## Conclusion

We identify socio-economic-, farm- and agronomic- indicators for pesticide use patterns in the European context, like wealth, education, age, soil management and farm type, and discuss their relative importance. We further extend the literature on agronomic indicators for pesticide use on different cultures and classes of pesticides. With this research we therefore contribute to the understanding of pesticide use and pesticide policy design. This is important especially in the light of a growing number of policy measures taken to reduce pesticide use.

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