Extended Abstract

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Paper/Poster Title	Exploring the pesticide trap: Persistent and Transient pesticide inefficiencies in Swiss winter wheat production

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Abstract	***200 words max***
We explore the matter of pesticides trap in the case of Swiss winter wheat producers. Our analysis is grounded on the assumption that self-reinforcing mechanisms that are the main features of a trap or path dependency place farms in a sub-optimal state characterized by persistent inefficiency in pesticide use. We first estimate an input requirement technology. After correcting for potential endogeneity issues, persistent and transient inefficiency are estimated using maximum simulated likelihood (MSL). The results in the case of Swiss winter wheat producers reveal that persistent inefficiency is the major component (86%) of the total inefficiency (35% and 27% in the case of pesticides load index – LI – and treatment frequency index – TFI –, respectively).	

Keywords	persistent inefficiency, transient inefficiency, path dependency, load index, Swiss wheat
JEL Code	Q12, Q15, Q50 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

The substantial reduction of pesticide risks for humans and the environment are key policy goals in the EU and other European countries. For example, the Farm to Fork strategy requires a 50% reduction of the use and risk of pesticides by 2030. A general hypothesis is that the efficacy of pesticides reduced over time, e.g. due to a diminishing toolbox of products available. The decrease in pesticide efficacy should lead to adopting alternative practices that prevent crop losses with minimal-to-zero external costs. However, modern agriculture creates a strong path dependency on pesticides once established. As a result, modern agriculture does not always exploit underuses opportunities of sustainable practices and still highly depend on chemical controls. In the literature, the concept of path dependence is the dominant explanation of pesticide use persistency (Cowan and Gunby, 1996, Wilson and Tisdell, 2001, Vanloqueren and Baret, 2008). While most of this literature is based on reviewing and documenting cases in light of theoretical constructs around path dependence, our contribution in this paper is to provide another look through the lenses of inefficiency. With this in mind and using ideas from production economics (Aigner et al., 1977, Aigner and Chu, 1968), we hypothesize that two types of inefficiencies characterize pesticide use at the farm level: one transient and the other persistent (Kumbhakar et al., 2014). The transient inefficiency is the most flexible component and can change from one period to another. At the same time, the persistent part expresses the rigidity in inefficiency or a long-term suboptimal technology due to all the mechanisms maintaining in the state of path dependency. Overall, we argue that persistent inefficiency is the resulting consequence of path dependency.

Methodology	***100 – 250 words***

We operationalize our idea by representing the production technology considering a stochastic input requirement frontier model following Guan et al. (2009). Pesticide use is expressed as a function of all other inputs and outputs. We adopt a two-step method due to the endogeneity accrued to this representation. In the first step, consistent estimates of the production technology parameters (elasticities) are obtained using the generalized method of moments (GMM). In the second step, the residuals from the first step are used to disentangle the inefficiency components using maximum simulated likelihood (MSL) following Filippini and Greene (2016) and Badunenko and Kumbhakar (2016).

The production technology can be summarized by the pesticides (Z) requirement function, which can be expressed as

$$Z_{it} = F(Y_{it}, \mathbf{X_{it}})e^{a_i+b_{it}+c_i+w_{it}}$$

Where $u_{it} = c_i + w_{it}$ is the overall pesticides inefficiency with c_i be the persistent part and w_{it} the transient part, and $v_{it} = a_i + b_{it}$, where a_i is the farm unobserved effects and b_{it} is the random noise, Y is the output, and $\mathbf{X}$ the vector of all other inputs (the production area, nitrogen fertilizer and work-machinery).

The model is applied to data of a sample of intensive Swiss winter producers over the period 2009 and 2019 (Möhring et al. 2020). The unbalanced panel data contains 235 different farms present for about five years on average. The total number of observations is 1,062.

Two indicators are considered to assess pesticides volumes: the load index (LI), i.e. an indicator for toxicity, and the treatment frequency index (TFI), i.e. an indicator for intensity of applications (Möhring et al. 2019).

Results	***100 – 250 words***

The first step GMM reveals that the input “labour and machinery costs” is related positively and significatively to pesticides use. This implies that the two input variables are complement rather than substitute as suggested in the production theory. A potential reason for this complementarity is that farm machinery use alleviates potential constraints (e.g. physical conditions) associated with pesticides spray. In other words by making pesticides spray easy, farm machinery can actually increases pesticide use. On the other hand, mechanical weeding appears to be a substitute for pesticides. All the other variables are nonsignificant. It seems that the level of wheat production, the quantity of nitrogen use, or the area planted with wheat does not influence pesticide use. We posit that most of the effects of these variables are captured by the unobserved farm heterogeneity.

In a second step, the remaining parameters of the technology frontier are estimated and the different efficiency components evaluated. First, the overall efficiency is on average 65% and 73% in the case of LI and TFI, respectively. This implies that pesticides can be reduced in total by about 35% and 27% as measured in LI and TFI, respectively. Second, as mentioned in the methodology section, the overall efficiency has two components: a transient and persistent efficiency. In our case, the results reveal very high level of transient efficiency (94% and 96% in the case of LI and TFI respectively), while the persistent efficiency is quite low (68% and 77% respectively). In terms of inefficiency, the results show that the persistent inefficiency is actually the dominant component of the total pesticides inefficiency. The share of the persistent inefficiency in the total inefficiency distribution mounts to 86%

Discussion and Conclusion	***100 – 250 words***

Persistent inefficiency features path dependency of pesticides. Our results clearly confirm that this is highly relevant for pesticide use in Swiss winter wheat production. Moreover, the persistent inefficiency share in the overall inefficiency reflects a high "degree of entrapment." An interesting avenue for future research is to assess the influence of pesticides lock-in features, as described in the literature, in explaining these levels of inefficiency. Finally, future research shall identify possible public and private policies to break this pesticide dependence.