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***

Despite the high volumes of pesticides, a large amount of crop production is still lost to pests (Oerke, 2006, Pimentel et al., 1993, Sharma et al., 2017), and yields have even stagnated or declined in some areas (Liu et al., 2014). The decrease in pesticide efficacy should lead to adopting alternative practices that prevent crop losses with minimal-to-zero external costs. This implicitly raised the question of why modern agriculture, in general, would not adopt sustainable practices and still highly depend on chemical controls. This question directly stems from the evidence that modern agriculture creates a strong path dependency on pesticides once established. In the literature, the concept of path dependence is the dominant explanation of pesticide use persistency (Cowan and Gunby, 1996). 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.

Methodology | ***100 – 250 words***

Practically, our idea is operationalized by representing the production technology considering a stochastic input requirement frontier model following Guan et al. (2009). In this new representation, 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 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 model is applied to a sample of Swiss winter producers surveyed between 2009 and 2015.

The production technology can be summarized by the pesticides 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).

Results | ***100 – 250 words***

Using the logarithmic transformation and a Cobb-Douglas function, we consider the following model

$$z_{it} = \lambda y_{it} + \boldsymbol{\beta}' \mathbf{x_{it}} + a_i + b_{it} + c_i + w_{it}$$

Where $z_{it} = \ln Z_{it}$, $y_{it} = \ln Y_{it}$, $\mathbf{x_{it}} = \ln \mathbf{X_{it}}$, and $\boldsymbol{\beta}$ is a parameter vector. The estimation of this model may be flawed because of the endogeneity of the output and some of the input. To deal with the endogeneity, we consider a two-step approach procedure. In the first step, a transformation is used to eliminate the time-invariant components $(a_i + c_i)$. After eliminating the time-invariant component, we consistently estimate the parameters $(\lambda, \boldsymbol{\beta})$ in the frontier function using the GMM approach. Given the consistent estimates of $(\hat{\lambda}, \widehat{\boldsymbol{\beta}})'$, in a second step the remaining parameters are estimated using the maximum simulated likelihood (MSL).

Two indicators are considered to assess pesticides volumes: the load index (LI) and the treatment frequency index (TFI). Our preliminary results reveal lower levels of persistent pesticide efficiency with an average of 68% and 77% in the case of LI and TFI, respectively. In both cases, the overall efficiency is on average 65% and 73%. This implies that pesticides can be reduced by about 35% and 27% in the case of LI and TFI, respectively. Moreover, the persistent part of the inefficiency is the most important component of the overall performance, and is on average about 86%.

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

As we argue in the Introduction section, if persistent inefficiency features path dependency, our results clearly confirm that this is the case 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, looking at the parallel in the "poverty trap" literature, an exogenous chock (e.g. in terms of stringent policy regulation) may be necessary to break this pesticide dependence.