Recovering cropping management practices specific production functions: clustering and latent approaches

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Extended Abstract

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Paper Title	Recovering cropping management practices specific production functions: clustering and latent approaches

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Abstract	***200 words max***
Reducing the use of pesticides and more generally of chemical inputs is a topical issue for governments. Economists generally advocate taxation for reducing polluting input uses. While econometric models tend to show that the pesticides price elasticity is low, these models mostly consider short-term adjustments. Mid-term adjustments of variable input uses are expected to be larger as reducing such uses require farmers to change their cropping management practices (CMPs). CMP is a notion closely related to the economists' production functions and used by agricultural scientists for characterizing crop production technologies. Yet, data lacking on farmers' CMPS prevents direct empirical analyses of CMPs' performances and adoption processes. The main objective of this paper is to propose original approaches for identifying farmers' CMPs in farm accountancy panel datasets with cost accounting. We consider that each CMP is characterized by a specific production function and propose approaches for identifying farmers' CMPs and the related production functions either sequentially or simultaneously. We demonstrate the relevance of our approaches through an empirical application based on a French arable crop farm accountancy unbalanced panel dataset covering the 1998-2014 period. Albeit preliminary, our empirical results demonstrate that our approaches perform relatively well. For instance, they enable us to identify three wheat CMPs used by farmers.	

Keywords	Cropping management practices, Production Function, Finite Mixture Models, Clustering Analysis
JEL Code	Q12, Q16, C51 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***
Negative effects of pesticides and chemical fertilizers on biodiversity and more generally on the environment and on human health have been demonstrated (Pimentel, et al., 1992) (McLaughlin & Mineau, 1995) (Wilson, 1998). Economists generally advocate public policies relying on market-based instruments (*e.g.* taxation) for reducing polluting input uses. However, pesticide price elasticity is found to be low in most econometric (Skevas, Oude Lansink, & Stefanou, 2013) (Böcker & Finger, 2017). Such inelasticity of pesticides quantities to price changes is based on short-term models whereas a significant reduction in pesticide uses are expected to occur	

in the mid-term. Indeed, agricultural scientists argue that farmers need to change their cropping management practices (CMPs) to diminish significantly their chemical input use levels.

Introducing the agronomic notion of CMP in micro-econometric agricultural production choice models would enable economists to investigate medium run effects of policies targeting chemical input use reductions (Femenia & Letort, 2016). Yet, farmers' CMPs are not documented in most datasets available to agricultural production economists. The main objective of this paper is to propose original approaches for identifying farmers' CMPs in farm accountancy panel datasets with cost accounting. Considering that each CMP is characterized by a specific production function, we propose approaches for identifying farmers' CMPs and their congruent production functions either sequentially or simultaneously.

Methodology

100 – 250 words

We hypothesize CMPs can be interpreted as production functions that are valid on limited ranges of variable input use levels. According to this hypothesis, farmers consistently choosing different levels of inputs uses – and, consequently, obtaining different yield levels – can be considered as using CMPs differing with respect to their targeted yield levels.

We propose two approaches for identifying CMPs and their congruent production functions. The first one sequentially recovers farmers' CMPs and CMPs' production functions. In a first step, farmers' CMPs are identified non-parametrically using unsupervised learning methods. These methods aim to detect clusters in the data (*e.g.* partitioning clustering or hierarchical clustering). In our case, farmers are classified in clusters according to the patterns of their input use and yield levels sequences. In a second step, the farm clusters obtained in the first step are used for defining sub-samples of farmers using the same CMP. Then, we estimate micro-econometric production choice models on these sub-samples to recover CMP specific production functions.

The second approach aims to simultaneously recover farmers' CMPs and the congruent production functions. It consists of estimating a mixed micro-econometric production choice model that allows farmers to use different production technologies. The considered technologies are latent in the data in the sense that the technology actually used by a given farmer is unknown *a priori*. Estimating this model enables us to recover the parameters of the production technologies identified from the data and to estimate the probability of each sampled farmer using any of the identified technologies. The considered micro-econometric production choice model is a finite mixture (or latent class) parametric model (McLachlan & Peel, Finite mixture models, 2000). Maximum likelihood estimators of finite mixture parametric models are typically estimated by using expectation-maximization algorithms (McLachlan & Krishnan, The EM algorithm and extensions, 2007).

Results

100 – 250 words

Our empirical application is based on a large farm accountancy unbalanced panel dataset with cost accounting. This dataset considers French arable crop farms (around 800 per year) and covers the 1998-2014 period. Being located in a small geographical area (the Marne *département*) and specialized in the same grain and industrial crop set, the considered farms have similar soil quality, face similar climatic conditions and have access to the same extension services.

We analyse farmers' production choices on a crop per crop basis and consider three chemical inputs: herbicides, pesticides and fertilizers. We apply our clustering and estimation approaches by considering four years crop production choice sequences and assuming that farmers stick to the same CMP along the considered period. Applying our approaches while considering longer time spans and allowing for changes in CMPs is more challenging, and is only subject to ongoing research work.

Albeit preliminary, our empirical results demonstrate that our approaches perform relatively well. For instance, they enable us to identify three wheat CMPs used by farmers. As expected, these practices are mostly characterized by their chemical input use intensities. "Intensive" farmers obtain very high yields by using large levels of chemical input uses while "chemical input saving" farmers rely on significantly lower input use levels and achieve lower yield levels. Other farmers use an intermediate CMP. Importantly, identification of these three CMPs based on four year sequence is robust along the 1998-2014 period.

The share of farmers using each identified CMPs varies along this period. As wheat prices dramatically varied along the 1998-2014 period, our results suggest that economic incentives significantly impact farmers' CMP choices. We are currently investigating this topic.

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

The main contributions of this article are twofold. First, we provide a link between the CMP notion used by agricultural scientists and the production function used by economists. Second, we propose and of two approaches aimed to identify farmers' CMPs in farm accountancy panel datasets. Our empirical results are promising, albeit still preliminary, and demonstrate the empirical relevance.

Importantly, accounting for CMPs in crop production choice models allows disentangling two effects of economic incentives on chemical input uses. Economic incentives impact inputs uses within a given CMP (in the short run) as well as through changes in CMPs (in the medium run). The short run effects have been demonstrated to be small. The medium run effects are expected to be larger.

This article focuses on the identification of CMPs and on the related production functions. The next step consists of modelling the effects of economic incentives on farmers' production choices and, as a result, of investigating effects of agro-environmental policy instruments, such as chemical input taxation, on farmers' production choices – CMP, input uses and yield levels – through simulation exercises.

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