Why individual farm decision model can better capture the effects of CAP post 2013? Insights from the Greening measures using the IFM-CAP model

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1. Introduction

Over the last two decades, the Common Agricultural Policy (CAP) has evolved from market intervention instruments (e.g. price support) to more farm-specific and multifunctional instrument designed to satisfy a diverse portfolio of EU policy objectives including rural development, preserving the environment and promoting the competitiveness of European agriculture. This became more evident in the last CAP reform of 2013 with the introduction of: (i) the three 'greening' measures (crop diversification, maintenance of permanent pasture, and respect of ecological focus areas) with the aim of supporting agricultural practices beneficial to the climate and environment, (ii) the new system of direct payments aimed to create a more equitable support system through the use of the redistributive payment, voluntary capping and degressivity (reduction) of payments, and (iii) the targeted income support to farmers most in need, particularly small and young farmers, farmers in low-income sectors and farmers in areas with natural constraints (DG AGRI, 2013).

The uptake and economic effects of these farm-specific measures differ significantly between farms depending, among others, on their size, specialisation, resource endowment, location and socio-economic characteristics. Current aggregate agent models (representative farm, regions, countries, groups of countries) are not able to deliver impacts of such measures for individual farms without imposing strong ad hoc assumptions. Although representative farm models can assess to some extent the farm-specific policies, they are subject to some limitations. They cannot model policies for which eligibility depends on individual farm characteristics and location as they are subject to significant aggregation bias. This can easily be illustrated through the crop diversification measure which states that farmers must cultivate at least two crops when their arable land is between 10 and 30 hectares and at least three crops when their arable land exceeds 30 ha. The main crop should cover at most 75% of the arable land, and the two main crops at most 95% of the arable land. Modelling such measure with an aggregate agent model (e.g. representative farm model) is challenging because by construction, the cropping pattern is much more diversified for a representative farm than it is for the real individual farms on the basis of which the representative farm was created. As a result, the crop diversification requirements will usually be respected (not binding) at the level of the representative farm, although the restriction may be binding at the level of individual farms.

Another drawback of existing farm models is that most of them are developed for a specific purpose and/or location and, consequently, cannot easily be adapted and reused for other applications and contexts. Out of a large number of EU-based representative farm models, only two have full EU coverage: CAPRI-FT (Gocht and Britz, 2011) and AROPAj (De Cara and Jayet, 2011). The other models cover either a specific Member State (MS) or a selected set of MSs/regions. To our knowledge there are no individual farm-level models with a full EU coverage available in the literature. Probably the main reasons for this gap relate to the computational complexity of solving an individual farm-level model at the scale of the EU. These types of models are also very data intensive (and this may not be available or easily accessible) as well as demanding in terms of parameterisation and calibration compared with aggregate agent models.

The main aim of this paper is to present the first EU-wide individual farm level model (IFM-CAP) designed to support decision making in agricultural and environmental policies. Based on behaviour of the individual farmers, IFM-CAP seeks to improve the quality of policy assessment upon existing aggregate agent models and to provide assessment of distributional effects over the EU farm population.

2. The IFM-CAP model

The IFM-CAP model is a farm-level model designed for the economic and environmental analysis of the European agriculture. Rather than providing forecasts or projections, the model aims consists in generating scenarios – or 'what if' – analyses. It simulates how a given scenario, for example a change in environmental and agricultural policies, might affect a set of performance indicators important to decision makers and stakeholders. Performance indicators include changes in crop allocation, input use, crop and animal production, farm income, livestock density and CAP expenditures.

The main advantage of IFM-CAP compared to other models used for CAP impact analysis is that it models in detail farm-specific measures introduced by last CAP reform (greening, capping, targeting, etc.) and their distributional effects. The second advantage of IFM-CAP is its EU-wide geographical coverage that allows simulating policy impacts across all EU farming systems and regions. Further, IFM-CAP (i) provides a very detailed representation of farm production processes in terms of commodities coverage and land heterogeneity; (ii) permits a flexible assessment of a wide range of farm-specific policies at EU-wide scale and (iii) allows capturing farm behaviour related to risk.

IFM-CAP is a comparative static Positive Mathematical Programming, which solves a set of microeconomic models reproducing the behaviour of a large sample of individual farms. The main data source, on which the model is built, is the EU-wide farm survey data, the FADN (Farm Accountancy Data Network). To guarantee the highest representativeness of the EU agricultural sector, the model is applied to every individual farm available in the FADN - around 83,292 farms.

IFM-CAP is a constrained optimisation model which assumes that farmers maximise their expected utility subject to resource (arable and grass land and feed) endowments and policy constraints such as CAP greening restrictions (Louhichi *et al.,* 2018). Farmers expected utility is defined following the mean-variance (E-V) approach (Markowitz, 2014) with a CARA (Constant Absolute Risk Aversion) specification (Pratt, 1964). According to this approach, expected utility is defined as the expected income and the associated income variance. Effectively, it is assumed that farmers select a production plan which minimises the variance of income caused by a set of stochastic variables for a given expected income level (Arribas *et al.,* 2017).

Farmer's expected income is defined as the sum of expected gross margins minus a non-linear (quadratic) activity-specific function. The gross margin is the total revenue including sales from agricultural products and direct payments (coupled and decoupled payments) minus the accounting variable costs of production activities. Total revenue is calculated using expected prices and yields assuming adaptive expectations (based on past three observations with declining weights). The expected accounting costs include costs of seeds, fertilisers and soil improvers, crop protection, feeding and other specific costs (following the same approach as with expected revenues). The quadratic activity-specific function is a behavioural function introduced to calibrate the farm model to an observed base year, as usually done in positive programming models. This function intends to capture the effects of factors that are not explicitly included in the model, such as farmers' perceived costs of capital and labour, or model misspecifications (Heckelei, 2002). Regarding the income variance, we opted for considering uncertainty in revenues, but without differentiating between sources of uncertainty (Arribas *et al.,* 2017).

The general mathematical formulation of the IFM-CAP model can be written as follows (Louhichi *et al.,* 2018a):

$$\underset{x\geq 0}{\text{Max}} \quad \text{E}\left(\text{U}\right) = \mathbf{E}\left[\mathbf{p}\circ\mathbf{y}\right]'\mathbf{x} + \mathbf{s}'\mathbf{x} + et - \mathbf{Cx} - \mathbf{d}'\mathbf{x} - 0.5\mathbf{x}'\mathbf{Qx} - \frac{\varphi}{\mathbf{2}}\mathbf{x}'\mathbf{\Sigma x} \qquad (1)$$

S.t

$$\mathbf{Ax} \leq \mathbf{b} \qquad [\boldsymbol{\rho}] \qquad (2)$$

where E(U) is the farm expected utility to be maximized, **x** is the (N×1) vector of unknown activity levels, **p** is the (N×1) vector of activity prices, **y** is the (N×1) vector of activity yields, **s** is the (N×1) vector of coupled payments, **C** the (N×K) matrix of average observed variable costs, e is the constant decoupled payment per eligible hectare, t is the constant eligible area for decoupled payments, **d** is the (N×1) vector of the linear part of the behavioural activity function, **Q** is the (N×N) symmetric, positive (semi-) definite matrix of the quadratic part of the behavioural activity function, φ is the farmer's constant absolute risk aversion coefficient and $\mathbf{\Sigma}$ is the (N×N) symmetric, positive (semi-) definite matrix of the variance-covariance activity revenues, **A** is the (M×N) matrix of technical coefficients, **b** is the (M×1) vector of available resources and upper bounds to the policy constraints and $\boldsymbol{\rho}$ is the (M×1) vector of their corresponding shadow prices.

IFM-CAP is calibrated for the base year 2012 using individual farm-level data and the Highest Posterior Density (HPD) approach with prior information on NUTS2[1] supply elasticities and dual values of resources (e.g. land rental prices). The calibration to the exogenous supply elasticities is performed in a non-myopic way, i.e., we take into account the effects of changing dual values on the simulation response (for more details see Louhichi *et al.,* 2018).

The main limitation of IFM-CAP is that prices are set exogenously and thus, it does not model the interaction between farm production decisions and agricultural markets. To capture the price effects of simulated scenarios, we interlink IFM-CAP with CAPRI partial equilibrium model. However, this link is performed only for some specific case studies. A second limitation is that we assume a fixed farm structure, implying that we do not consider farm exit and entry (neither re-specialisation) as a response to the policy changes. Model robustness should also be re-checked and improved through sensitivity analysis or/and ex-post validation using second reference-year or independent sample.

3. Selected results

The IFM-CAP model has been applied to assess the economic impacts of various CAP measures such as the crop diversification (Louhichi *et al.*, 2017), the greening (Louhichi *et al.*, 2017), the direct payments (Espinosa *et al.*, 2018), the abolishment of CAP support (Mbarek *et al.*, 2018), etc.

In this paper we briefly present some illustrative results of model application to analyse the EU farmers' responses to the greening requirements introduced by the 2013 CAP reform (Louhichi *et al.*, 2018)[2]. The main finding from this model application is that the CAP greening effect on farm income is rather small at the aggregate level. Although the proportions of farms and UAA subject to CAP greening are sizeable (55 per cent of all farms and 86 per cent of UAA) in the EU-27, the area reallocated as a result of the adoption of CAP greening measures represents only 4.5 per cent of UAA and agricultural income decreases by around 1 per cent. These results are explained by the fact that many farms subject to CAP greening comply with the greening requirements in the baseline (i.e. in the absence of the greening).

The results by production specialisation and farm size aggregated at EU level reveal a more significant income effect for certain farm specialisations, but they remain below 2 %. Farms that specialise in livestock experience the biggest drop in income because they are affected by both the permanent grassland and the crop diversification measures. By farm size, the most affected are farms with a large economic size, followed by small farms. Middle-sized farms are less affected by CAP greening. This is due to the relatively minor impact of CAP greening on land use and production for these farms.

At the individual farm level, the impact could be more pronounced (e.g. a decrease of production and income of more than 30 per cent), although the number of farms affected by the measures remains relatively small (around 29 per cent of the total farm population). The most constraining measure appears to be the EFA measure, followed by the crop diversification measure.

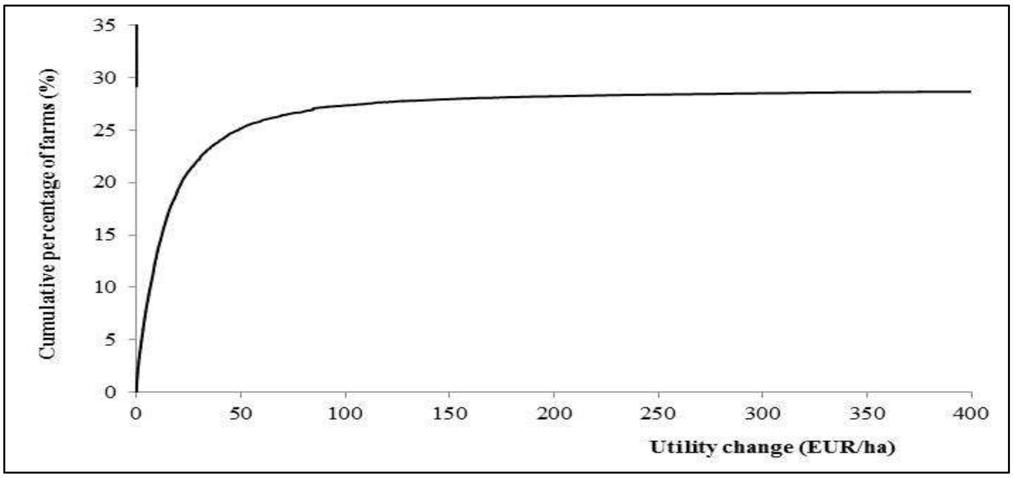
In terms of the distribution of compliance costs across agricultural area affected by CAP greening, 51 % of all agricultural area is not affected by greening at all and incurs no related compliance costs. Of the 49 % area affected, around 80 % of this area incurs compliance costs below EUR 25/ha. For more

[1] NUTS2 refers to regions belonging to the second level of the Nomenclature of Territorial Units for Statistics of the European Union.

[2] For more details on model results see Louhichi *et al.* (2018).

than 50 % of the affected area, these costs are below 10 EUR/ha. However, around 5 % of total agricultural area (or 10 % of the 49 % affected area) has costs exceeding EUR 50/ha, while around 2.7 % of total agricultural area (or 5.6 % of the 49 % affected area) has costs exceeding EUR 100/ha in EU-27 (EUR/ha).

Fig. 1. The distribution of compliance costs of CAP greening across farm population (*Source: Louhichi et al., 2018*).



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