3.4 REPORT ON MODELLING CROP MANAGEMENT PRACTICES AND IMPLEMENTATION IN MIND STEP MODEL TOOLBOX

Background and key outcomes/messages towards policy makers

One of the main objectives of the MIND STEP project is to include individual decision making (IDM) unit in policy models. Among these IDM units, are innovative microeconomic models of farmers' production choices that have been developed in task 3.4. Part of these models are micro-econometric models and aim at empirically analyzing crop farmers' choices in terms of yields, chemical input uses, acreages and crop management practices (CMP) and dairy farmers' choices in terms of feeding strategy and land allocation. Those models are primarily specified for exploiting the information contained in available cost accounting datasets and are estimated for two main purposes: being used directly as simulation models, or providing behavioral parameters to – more complex – policy simulation models (e.g., FarmDyn, IFM-CAP, GLOBIOM, CAPRI, MAGNET). Another type of model, based on a Data Envelopment Analysis (DEA) framework has been developed in task 3.4. It investigated the potential of reallocating land use between crop production and livestock production to simultaneously reduce greenhouse gas (GHG) emissions and expand production. As such, it allows a decomposition of environmental inefficiency into components of non-reallocative inefficiency and coordination inefficiency. Non-reallocative inefficiency measures the extent to which GHG emissions can decrease while expanding production for the given land use. Coordination inefficiency assesses the further potential of such sustainability gains through reallocation of land use.
A significant part of task 3.4 builds on the micro-econometric multi-crop (MEMC) models developed in recent years by partner INRAE. These models are random – farm specific – parameter models intended to reflect the heterogeneity of farmers' behaviors, which can be attributed to various factors generally unobserved in economic data (*e.g.*, farmers' skills, soil and climate conditions, etc.). The estimation of these models does not consist in directly estimating the values of the model parameters for each individual farm of the sample, but in estimating the distribution of these parameters among the farmers' population. Once the distributions of the technical and behavioral parameters of these models have been estimated, these parameters can be calibrated at the farm level based on a well-defined statistical background to obtain farm-specific microeconomic simulation models or to obtain farm-specific parameters aimed at calibrating parameters of mathematical programming models (*e.g.*, IFM-CAP, FARMDYN, GLOBIOM, CAPRI). Within task 3.4, these models have been extended to account for the decision of farmers to choose to produce specific subsets of crops among all the crops they could produce. Significant work has also been undertaken during the MIND STEP project to allow the estimation of MEMC models by other partners of the project (see Deliverable 6.2). A first set of work has been carried out to enable the estimation of these models on data available for European member states, i.e. FADN data. Indeed, the estimation of MEMC models requires information on input uses per crop, while the FADN data only contain input expenditures at the farm level. An original procedure has consequently been proposed to allocate input uses at the farm level to input uses per crop based. A second set of work has been done to alleviate the significant estimation burden of MEMC models and enabling their use on a routine basis, as well as for incorporating CMP choice in these models.

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In addition to these works on MEMC models, research has been conducted in Task 3.4 to identify the heterogeneity in the flexibility of dairy farms based on their observed short run responses, in terms of feed concentrate uses and acreage adjustments, to input and output prices. This work aims at providing an economic explanation to the relative rigidity of dairy farms, which may in fact be due to the existence of adjustment costs related, e.g., to the farms quasi-fixed production factors (capital, labor, land,…), and at identifying, among a sample of farmers, those who appear to be most flexible in the short run. For this purpose, an analytical framework, based on random parameter panel smooth transition regression (PSTR) model implicitly accounting for the impacts of input adjustment costs on dairy farmers' production decisions, has been proposed and estimated, as an illustrative purpose, on a sample of French dairy farms. Identification of farmers who appear to be most flexible in the short run is important in explaining differences in marginal abatement costs of emission reductions between farms and related policy design (see also Deliverable 3.3). Finally, partner WU has developed an integrated multi-production technology framework to investigate the potential of land optimization in dairy farms to reduce GHG emissions. Indeed, circular farming has been proposed as a cost-effective way to reduce GHG emissions by the Dutch Ministry of Agriculture in 2019. Dutch dairy farms have already incorporated circular principles in their farming activities, e.g. upcycle manure as crop fertilizers, use crop residuals for animal feed. However, no study until now has quantified the technical and environmental efficiency of dairy farms that incorporates these circularity principles, and explores the potential of land reallocation. The framework proposed by WU combines a by-production approach with a network DEA model to answer these questions.
The key messages of D3.4 are the following:

Methodological developments

First, micro-econometric models of farmers' production choices (like random parameter models, for short run input adjustment costs through panel smooth transition regression models, or embedded technology choice models) can be substantially improved by accounting for unobserved heterogeneity (*e.g.*, farmers' skills, soil and climate conditions, etc.).. Second, mathematical programming models and micro-econometric models are complementary for improving simulation models based on individual farms. For instance, parameter estimates obtained from random parameter micro-econometric models can be used for calibrating mathematical programming models devised at the farm level. One can use either standard procedures for calibrating PMP model parameters against elasticities estimated at the farm level (which can be aggregated at some regional scale) or simple analytical formulas specifically developed in MIND STEP. Micro-econometric multi-crop (MEMC) models can provide information on plausible minimum and maximum ranges of crop rotation shares as e.g. demanded in bio-economic farm FARMDYN. Micro-econometric models of input allocations to crops can be used for estimating input uses at the crop level that can be in turn used to feed mathematical programming models.

Policy implications of obtained empirical results

The empirical results presented in D3.4 show that farmers tend to be efficient from a technical viewpoint given their current production technologies. This result is welcome as famers' efficiency underlies the economic models considered for policy analysis. It also suggests that solving environmental issues implies to solve economic trade-offs that involve changes in production technologies. The results obtained in D3.4 also show that farmers

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respond to economic incentives (even if their responsiveness display significant heterogeneity), implying that economic policy instruments could be useful for achieving the objectives of the EU Green Deal. Finally, some empirical results demonstrate the importance and heterogeneity of farmers' adaptability in response to price variations on agricultural markets. This heterogeneity can mostly be attributed to factors that are specific to each farmers and not observable in economic data (*e.g.*, farmers' skills, soil and climate conditions, etc.). Further investigation, through targeted surveys for instance, could allow to reveal the causes of the heterogeneity we uncovered. This would be useful for identifying relevant instruments for enhancing farmers' adaptation capacities. For instance, survey results might reveal that the choices of less educated farmers and farmers with less broad skills are more rigid, thereby suggesting that education and training could improve farmers' adaptability.

Data needs

The work presented in D3.4 show that public authorities should invest in more accurate data collection. Of course, research regularly complain about data lacking. Yet, the results we obtain document the adverse consequences of these missing data issues on the ability to assess the effects of agri-environmental policies. For instance, the work on input cost allocation tends to show that micro-econometric models allow to obtain reliable estimates of input uses for major crops but much more questionable estimates of input uses for minor crops. Indeed, the fact that FADN data report input uses at the farm level (standard accountancy data) instead of at the crop and farm level (cost accounting data) can only be imperfectly overcome. This provides interesting research topics for micro-econometricians but lead to imprecise inputs to simulation models. Of course, collecting cost accounting data would be costly. A less costly option would be to collect mean input use levels at the NUTS1 or NUTS2 level and to use this information for improving the cost allocation modules proposed in D3.4. This supplementary information would enable the analysts to guide the cost allocation process and, therefore, to ensure the estimates to lie in reasonable ranges. This information, however, is unavailable for many Member States. The same observation holds for innovative production practices, whether agronomic practices (e.g., low input practices, biocontrol techniques) or precision agriculture techniques. This is unfortunate for economists involved in the quantitative assessment of agri-environmental policies but also for farmers interested in changing their production practices. Finally, D3.4 utilized data on farm-level GHG emissions. While feasible, the analysis would improve if the GHG emissions were allocated by activity analogous to cost accounting.

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