5.2 REPORT ON IMPROVEMENTS TO THE CURRENT EU AND GLOBAL MODELS

Background

This deliverable focuses on improving EU-wide and global models (i.e., CAPRI, GLOBIOM, MAGNET) that the European Commission uses for policy evaluation in the agricultural sector. The goal is to enhance the representation of farm-level behaviour and its impact on the environment and climate by linking macro-level models with micro-econometric models. The deliverable highlights various improvements, including harmonising production systems and farm typologies, calibrating behavioural parameters, representing structural changes, improving risk representation, addressing greenhouse gas emissions, and enhancing market power parameters and price transmission elasticities. The achievements are summarised per subtask below.

Subtask 5.2.1 Harmonization of production system, sector and farm type typology used within the MIND STEP model toolbox

The typology of farms, crop types, and production systems was selected using the methodology of intensification classes as proposed by DG AGRI (Indicator C33 – farming intensity). This is based on farm level per hectare crop protection and fertilization expenditure. The typology was compared to existing GLOBIOM classifications and harmonized to GLOBIOM crops and management systems, in terms of per hectare yield and internal consistency of cost indicators. A detailed crop and management system specific bottom-up database was derived from the FADN database by estimating farm-level input-output econometric models. These models provide a full disentangling of variable production costs for cash crops farms across the EU. The cost estimates are spatially differentiated at the NUTS2 level and fully harmonized with the GLOBIOM database. This enables a detailed representation of cost structure, as well as detailed impact analysis of subsidies within the model. The next step is to calibrate the GLOBIOM model with the FADN derived cost estimates. Additionally, the econometric crop estimation technique was compared across approach with multiple modelling groups (JRC, INRAE), using a benchmark of theoretically derived crop costs from national authorities in multiple member states. The advantage and disadvantages of the approaches were highlighted in a draft publication. Concerning the split of animal herds from physical capital in the MAGNET model, the FADN database was used to provide herd shares in total farm assets, aggerated to national level and the animal production sectors used in MAGNET.

Subtask 5.2.2 Improved behavioural parameters for choice of agricultural output and input levels and their substitution

The calibration of relevant behavioural parameters for choice of agricultural output and input levels and their substitution included in the GLOBIOM model was prepared using two steps:

1. Initially, based on the FADN data and the Corine Land Cover database, crop, management system and land use change specific parameters were estimated using econometric models. These empirical estimates of key GLOBIOM parameters allow for a bottom-up calibration of the model dynamics.
2. A validation script comparing GLOBIOM model output in the period 2000 to 2020 to observed FAOSTAT data was prepared. This script benchmarks the models performance in terms of approximating the official statistics within a specific range.
3. Based on the validation script, the performance of the empirically estimated crop-, management-, and land-use change specific parameters were evaluated. Where the parameters improved the model, they were adapted.

In the final reporting period an automatic calibration method integrating the empirical parameter estimates into the GLOBIOM model using machine learning was developed.

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Subtask 5.2.3 Structural change representation in current models

For the GLOBIOM model a prototype structural change estimation model controlling for spatial dependencies was developed. This is based on a multinomial logit formulation and estimates cropping intensity changes at the NUTS-2 level. A draft paper of the model was presented at the 60th Congress of the European Regional Science Association.

From the estimated exit model from deliverable D4.2, coefficients have been transferred to estimate exit probabilities of farms in IFM-CAP. After calculating exit probabilities, the freed land has been distributed according to an empirical distribution of observed land use. With this, no competition about land took place. It is unknown where the FADN farms are located, so they cannot be distributed according to nearby surveying farms from freed land of exiting farms. Although many estimated coefficients from the exit model could be used to model farm exit in IFM-CAP, the most important and predictive one – the age of the farm holder – could not be applied. The results will likely differ according to the distribution of age across FADN farms. Another issue relates to applying productivity parameters derived from all farms in FSS to the sample of farms in FADN. Further research should consider the underlying sample selection of FADN farms compared to the farms observed in FSS data. Further, the distribution process of freed land from the exiting farms to the surveying farms should be simulated by considering shadow values of land, for instance. Additionally, more regionally differentiated exit models could also be estimated for their coefficients with respect to farm characteristics. In the applied model, only the average exit probability is shifted across NUTS2 regions, but the coefficients for the continuous variables are the same for all farms.

Subtask 5.2.4 Risk representation in current models

We developed a methodology to add risk premia to commodity prices in GLOBIOM. This reflects commodity-specific and country-specific farmer risk aversion. A methodological framework with the aim to investigate the impacts of crop-specific insurance on optimal management decisions, considering income and risks in crop production, and subsequently upscale this to consider changes in crop area allocation, prices, and trade in Europe is developed. We show how market-level models such as GLOBIOM can be adapted to deal with increased yield volatility as a consequence of climate change; how crop models such as EPIC-IIASA can be used to assess the impacts of future crop yield volatility; how risk in agricultural decision-making can be included in market-level models, and how this risk can be estimated using stylized farm household modelling. Together, this serves as a proof of concept for future research.

There is still debate about how the risk, as estimated by farm household models such as FarmDyn, can best be transferred to market-level models. Task 3.5 developed the curvature of the value function on risk preference and statistically determined the risk preference of farmers. However, it has not been possible to translate the outputs of task 3.5 to a risk premium that can be incorporated into GLOBIOM. Generating changes in risk premiums in a farm(household) model with risk preferences is not straightforward. The changes in the risk premiums are in the dual domain (a kind of “shadow price” change), while we observe changes in the cropping pattern in the simulations. To estimate the risk parameters, information on the variability of the prices and yields can be obtained from EPIC-IIASA, as well as costing from FADN. A second issue exists around translating a farm-specific risk premium to a per-crop and per-hectare risk premium. Further research could analyze whether an econometric approach could be better suited. Using a revealed preferences approach, one could econometrically estimate country average risk aversion coefficients based on FADN data and explore possibilities to integrate these into GLOBIOM to assess impacts on production, consumption, trade, and agricultural markets.

For IIASA, GLOBIOM has been further adjusted to be run in a non-stationary fashion with the aim to assess the impact of extremes such as climate-induced yield shocks on producer behaviour and their aggregate effects on e.g. agricultural markets and land use. Using the best available CMIP6 climate data and crop model outputs from estimations by EPIC-IIASA we assess the impacts of future extreme yield losses on consumption and markets.

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Subtask 5.2.5 Improved representation of mitigation technologies adoption in current models

The primary objective of this task was to explore options to improve the representation of mitigation measures in macroeconomic models using the single-farm level model FarmDyn. Based on the findings of farmers' adoption behaviour of mitigation measures in Task 3.3, this task assesses the impact of the mitigation measure portfolio extension in the explicit representation (single add-on technologies) in GLOBIOM and the implicit representation (MAC curves) in MAGNET, respectively. Regarding GLOBIOM we developed a streamlined simulation procedure starting with the simulation setup in FarmDyn for the generation of new add-on technologies in GLOBIOM. First, one has to build a farm sample, which can include multiple or single farms. Second, this farm sample is run in FarmDyn for each mitigation measure once. Third, FarmDyn produces a customized output file which reports the relevant variables including total global warming potential (CO2-eq.) per farm and per on-farm source, number of cows and heifers per farm, profit per farm, and milk output per farm. Fourth, in a post-processing step we transferred the information in the required format for the add-on technology in GLOBIOM, which includes relative reduction of CO2-eq. per cow and costs per cow. In this exercise, we refrained from parameterizing the productivity change of a cow for each mitigation measure. Regarding MAGNET we identified the required functional form to build the marginal abatement cost curve. The same farm sample as presented in the GLOBIOM was used to simulate changes in CO2eq emissions at different CO2eq taxation levels, applying all available mitigation technologies simultaneously. In Task 6.4 the approach is extended to country specific MACC in MAGNET using data from NUTS2 average dairy farms in EU-FADN.
In conclusion, this task offered valuable insights into the potential to extend the portfolio of mitigation measures implicitly and explicitly in macro-scale models using single-farm level models. Foremost, the wide range of simulation options in single-farm level models allows to establish loose linkages to multiple macro-economic models such as partial equilibrium models and computable general equilibrium models. This proof of concept allowed us to extend the initial differentiation of mitigation technologies by farm heterogeneity, farm intensity, and nationally specific GHG accounting schemes. However, it should be noted that this linkage also highlights the challenge posed by limited data availability, which hampers the accurate representation of diverse cost structures and marginal abatement costs within the single-farm level model. Eventually, further research is warranted to increase the coverage of single-farm level models to provide macroeconomic models with a wider range of spatial coverage to produce more robust policy assessments of mitigation potential in the agricultural sector.

Subtask 5.2.6 Improved market power parameters and price transmission elasticities in current models

This task gives an extensive literature review how market power could be represented in large scale models. From the literature, it emerges that this can be done by splitting by heterogeneous firm values and then calibrating through perceived price elasticity (PPE) estimates. Therefore, we expect to adopt the methodology described in Deliverable 4.4 as an empirical basis for estimating the price differentiation factor to introduce heterogeneity in the model in the future. Currently the market power parameters obtained from task 4.4 only concern a few selected supply chains in Germany and Italy. Results obtained in the selected supply chains cannot be automatically extended to other products and regions. This actually means that although conceptually feasible, the upscaling to CAPRI and/or MAGNET would not be very promising.

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