sustainability

Supplementary Materials

The use of MAGNET: data, model and scenario description

The Modular Agricultural GeNeral Equilibrium Tool (MAGNET) is a mathematical market simulation Computable General Equilibrium (CGE) model [1]. It employs a fully consistent and academically recognised global database, called the Global Trade Analysis Project (GTAP) [2]. The GTAP database contains a complete record of all economic activities (i.e., production, trade, primary factor usage, final and input demands, taxes and trade tariffs and transport margins) for 57 sectors and 140 regions. In the standard version of the GTAP database, the definition of bio-based activity is confined to eight cropping and four livestock activities; eight processed food and beverages sectors, fishing, forestry, textiles, wearing apparel, leather, wood and paper products.

The MAGNET model has a flexible tree structure that enables the modeller to characterise the substitution possibilities between inputs used within the production technologies of different classes of activities. Given the focus of the current modelling application, the tree structures for the cropping and livestock sectors are presented below in Figures S1 and S2, with the assumed substitution elasticities for each nest, which are garnered from a search of the relevant modelling literature.

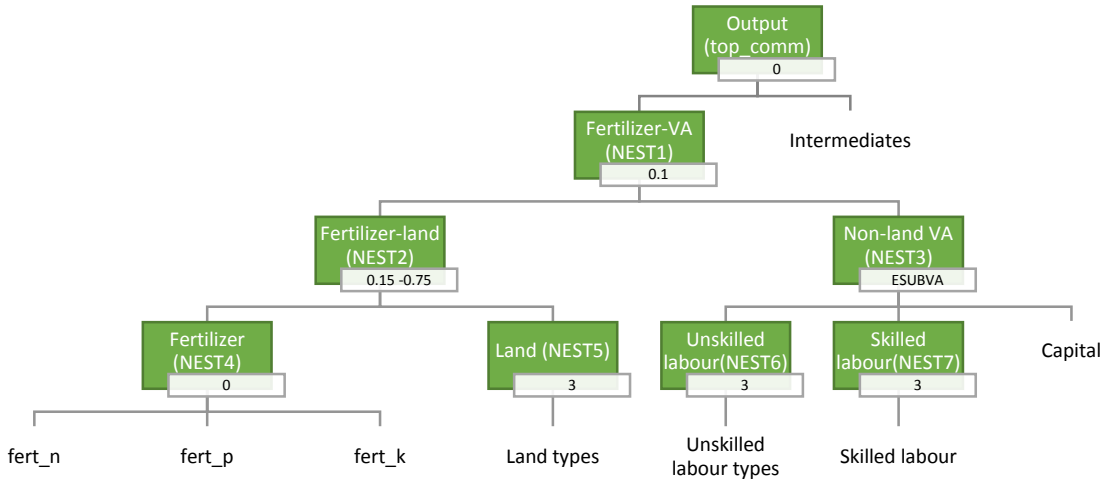

Figure S1: Nesting structure for crop activities in MAGNET
Source: Own elaboration.

In the crop sectors, the top nest captures a fixed proportion technology (Leontief) between intermediate inputs and a composite input of value added and fertiliser usage. The latter nest is subdivided into non-land primary inputs and a land-fertiliser nest.

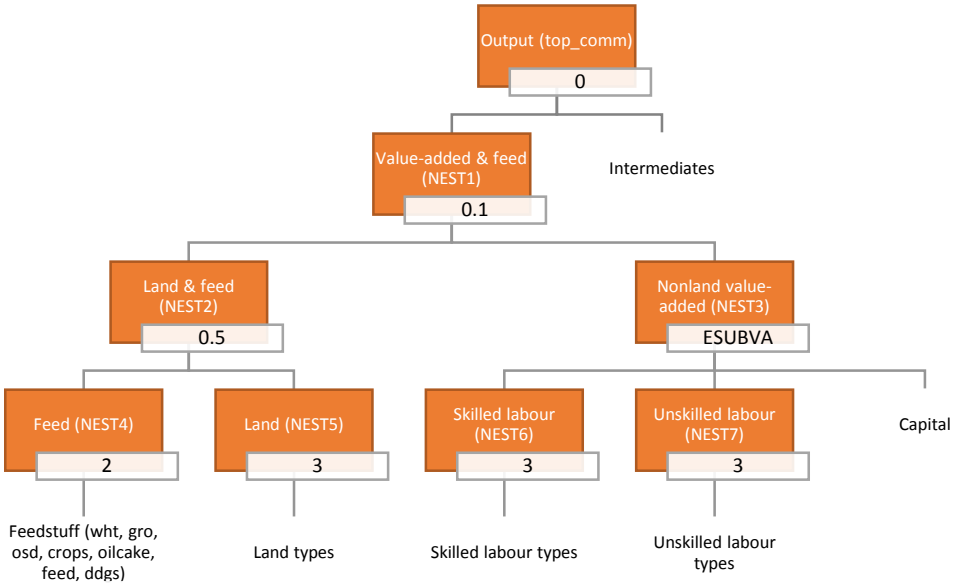

Figure S2: Nesting structure for livestock activities in MAGNET
Source: Own elaboration.

In the livestock sectors, the top nest captures a fixed proportion technology (Leontief) between intermediate inputs and a composite input of value added and animal feed. The latter nest is subdivided into non-land primary inputs and a land-animal feed nest to characterise substitution possibilities between natural pasture and feed supplements.

In this paper a detailed model variant of MAGNET is used. It captures the specifics of agricultural markets, such as heterogeneous agricultural land usage by activity; a regional endogenous agricultural land supply function; the immobility of capital and labour transfer between agricultural and non-agricultural sub-sectors with associated wage and rent differentials; the inclusion of explicit substitution possibilities between different feed inputs in the livestock sectors; and additional behavioural and accounting equations to characterise EU agricultural policy mechanisms.

Following [3] and [4] a greenhouse gas (GHG) module is added to the MAGNET model code. In essence, this module incorporates an GHG emission accounting system filtered by (i) GHG type; (ii) emission source (combustion or process); (iii) emitter (i.e., producers consumers) and (iv) region. In addition, the model is further parameterized to implement emission reduction targets or carbon tax changes. Finally, additional environmental tax equations (which link to the standard tax equations in the MAGNET model) and endogenous slack equations are incorporated.

To solve the model, the number of equations and (endogenous) variables within the system must be equal (known as the model 'closure'). Additional variables under the direct control of the modeller (i.e., 'exogenous' variables), typically capture market distortions (tax rates),

factor endowments and technological change, can be manipulated or 'shocked'. In addition, a medium- to long-term neoclassical model closure is chosen, where fixed regional savings rates drive regional investment demands and imbalances on the capital account (i.e., regional savings less investment) are compensated by current account adjustments (exports minus imports), such that the balance of payments nets to zero.

As a global benchmark, the Agricultural Model Intercomparison and Improvement Project (AgMIP) [5] considers a range of narratives or socio-economic pathways (SSPs) projecting up to 2050 with the objective of identifying how variation in the underlying macroeconomic, technological and biophysical drivers under different future pathways lead to differing market developments in the long-run (2050) and very long run (2100) [6]. The MAGNET simulations employ SSP2, which reflect a status quo vision of the world. Labour projections are assumed to follow regional population trends, capital endowment shocks are equal to regional macro growth forecasts (i.e. assuming a fixed medium to long-run capital-output ratio) and natural resources are projected to grow at one quarter the rate of the change in the capital stock. Under these assumptions, MAGNET is used to project the world economy to the years 2020, 2025 and 2030. Using these three databases as counterfactual reference points, three levels of carbon taxes are imposed in each reference year corresponding to the scenarios run in the Aglink-Cosimo model.

In the Aglink-Cosimo model carbon taxes are phased in, beginning in the year 2020 and gradually increasing to $50, $100, and $150 per ton of CO2 equivalent respectively, in the year 2030 for the three scenarios modelled (nominal prices). Since MAGNET is a model working with real prices (2011 USD), carbon taxes are deflated to 2011 USD using an assumed 2% global inflation rate.

Table S1. Carbon taxes in Magnet, 2011 USD/t CO2eq

Scenario	2020	2025	2030
Baseline	0	0	0
Tax50	4	21	34
Tax100	8	41	68
Tax150	11	62	102

Source: Own elaboration

Then equivalent carbon tax scenarios are imposed as counterfactual simulations in the years 2020, 2025 and 2030 in MAGNET. The resulting percentage changes in the price of energy (i.e. aggregated price change of crude oil, gas, coal) as well as changes in the price of chemicals (i.e. proxy for pesticides) and fertiliser are transmitted to the Aglink-Cosimo model together with changes in real GDP.

References

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