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BRIGHT SPACE

Designing a Roadmap for Effective and Sustainable Strategies for Assessing and Addressing the Challenges of EU Agriculture to Navigate within a Safe and Just Operating Space

D7.1 Report on the functionality and needs to enhance the capacity of the BrightSpace Integrated Modelling Toolbox to better model the EU agricultural just operating space

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Abbreviation/acronym	Meaning
AGMEMOD	AGricultural MEmber State MODelling
CAPRI	Common Agricultural Policy Regionalised Impact Modelling System
CITA	Agri-Food Research and Technology Centre of Aragon
CGE	Computable General Equilibrium
EU	European Union
EuroCARE	EuroCARE GmbH Bonn
DIA	Dietary Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
GLOBIOM	Global Biosphere Management Model
GDP	Gross Domestic Product
HBS	Household Budget Survey
IIASA	International Institute for Applied Systems Analysis
JOS	Just Operating Space
MAGNET	Modular Applied GeNeral Equilibrium Tool
SJOS	Safe and Just Operating Space
SOS	Safe Operating Space
SSP	Shared Socio-economic Pathways
Thuenen	Thünen Institute
UCSC	Università Cattolica del Sacro Cuore
UOXF	University of Oxford
WP	Work Package
WR	Wageningen Research
WU	Wageningen University

EXECUTIVE SUMMARY

The aim of Work Package 7 is to upgrade and expand the BrightSpace model toolbox for an enhanced representation of the Just Operating Space (JOS). This includes technical improvements in the models that are part of the toolbox, the design of new models, and the development of new and/or more detailed indicators that cover one or more of the JOS indicator domains as proposed by the conceptual framework that is developed in WP1. WP7 includes three tasks that each cover a cluster of JOS domains. This deliverable presents an overview of the envisaged improvements in the BrightSpace toolbox across related to (1) Income distribution and employment; (2) health and nutrition and (3) other JOS domains. Finally, it links the planned toolbox improvements and resulting indicators to JOS thematic areas and domains selected in Work Package 1.

1. INTRODUCTION

The aim of Work Package 7 (WP7) is to upgrade and expand the BrightSpace model toolbox (**Figure 1**) for an enhanced representation of the Just Operating Space (JOS). This includes technical improvements in the models that are part of the toolbox, the design of new models, and the development of new and/or more detailed indicators that cover one or more of the JOS indicator domains as proposed by the conceptual framework that is developed in WP1. WP7 includes three tasks that each cover a cluster of JOS domains: (1) Income distribution and employment, (2) health and nutrition, and (3) other JOS domains.

This deliverable presents an overview of the envisaged improvements in the BrightSpace toolbox across these three clusters of JOS domains. It also provides a brief overview of the current state-of-the art in the modeling of JOS domains and indicators, which forms the departing point for the JOS model enhancements. The final section links the planned toolbox improvements and resulting indicators to JOS thematic areas and domains selected in Work Package 1.

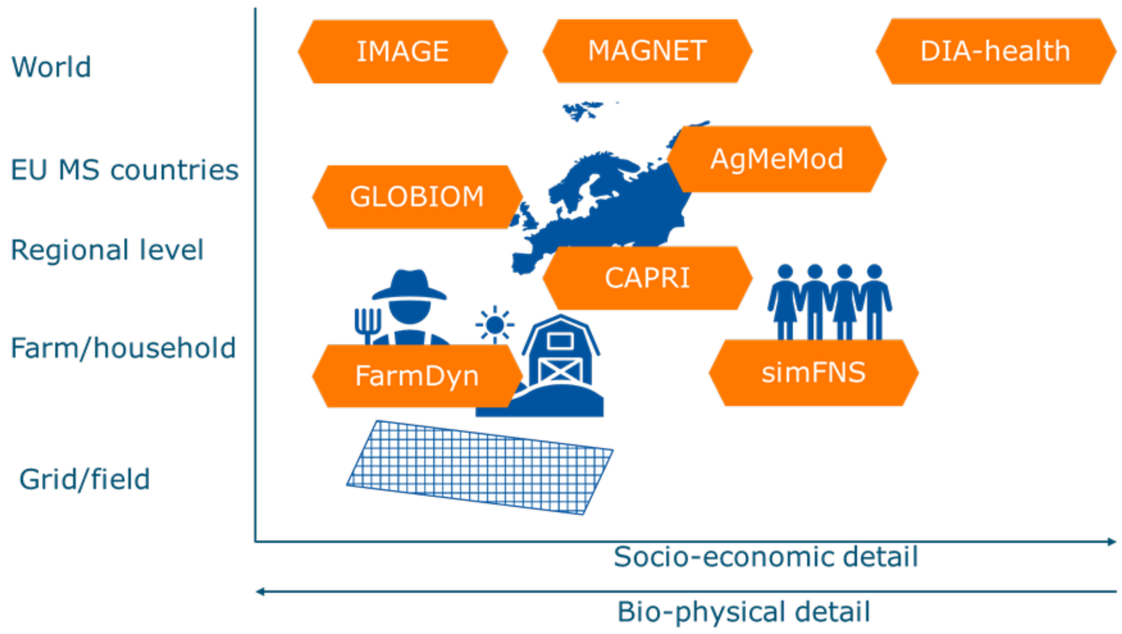

Figure 1: BrightSpace model toolbox across spatial scales and SJOS indicators. Not all models have a JOS component and therefore are not further discussed in this document.

The SJOS concept developed in BrightSpace follows the "Doughnut" concept proposed by Raworth (2017), which combines environmental, economic, and social aspects in a common framework. BrightSpace proposes a set of indicator domains to measure the progress towards or deviation from a Safe and Just operating space for EU agriculture by aligning established indicator frameworks for planetary boundaries (PB) and socio-economic boundaries with policies form the European Green Deal and the Common Agricultural Policy. This SJOS framework is discussed in deliverable 1.1.

One objective of BrightSpace is to provide at set of indicators for the SJOS using the simulation models in the toolbox. With regard to the JOS, considered and modelled indicator domains are shown in **Table 1.** While a large variety of potential indicators of the JOS can already be calculated, some important aspects of the JOS are not yet fully covered and require adjustments and further developments of the toolbox models, which are described in this document.

Table 1: JOS areas, domains and proposed indicators

Thematic area	Indicator Domain	Explanation	Models
Nutrition security	Food availability	Average dietary energy supply	CAPRI, GLOBIOM, MAGNET, AGMEMOD
	Food affordability	Percent of the population that cannot afford a healthy diet. Food price index Agro-food commodity prices, per type per MS	Microsimulation CAPRI, GLOBIOM, MAGNET, AGMEMOD
	Food stability	Import dependency ratio Self-sufficiency rates	CAPRI, GLOBIOM, MAGNET, AGMEMOD
	Food waste	Food waste from harvest losses, food processing, transport and food waste from commodities and food services consumption	MAGNET
	Diet quality/food utilization	Share of calories from fruit and vegetables Share of plant-based protein consumer intake in total protein consumer diet Distance to national dietary guidelines	CAPRI, GLOBIOM, MAGNET AGMEMOD MAGNET
Health	Life expectancy	Diet related mortality	Food & Health model
	Obesity	Prevalence of overweight/obesity	MAGNET, Food & Health model
	Animal welfare	TBD	TBD
	Access to clean water	TBD	TBD
Economy	Sectoral Employment	Number of workers per sector	MAGNET
	Sectoral VAD	Value added per sector	MAGNET
	Sectoral wages	Factor prices labour	MAGNET
	Market organisation	Share of agricultural VA in total VA Agro-food commodity market structure per type and MS Agro-food commodity production volumes per type and MS	MAGNET AGMEMOD AGMEMOD
	Trade	Sectoral trade Agro-food commodity trade	CAPRI, GLOBIOM, MAGNET AGMEMOD
	Energy access	Energy price index	MAGNET
Farm resilience	Farm income	Farm income distribution	FarmDyn, based on samples
	Farm viability	Farm size distribution	FarmDyn, in combination with farm exit model
	Farm structure	TBD	TBD
Social equity	Income distribution (sectoral, spatial)	Gini index/Palma ratio	Microsimulation, MAGNET (indirectly)
	Education	Education levels	TBD
	Gender equality	Gender wage gap	TBD

TBD: To be determined.

The contents of this deliverable were informed by a one-day workshop in the Hague on March 4, 2024, to discuss the further development of the BrightSpace modelling toolbox to assess the EU agricultural Safe and Just Operating Space (SJOS).

2. MODELING THE JUST OPERATING SPACE

2.1. Income and employment

Although there exists a rich literature on the measurement and analysis of income distribution and poverty, there are only a handful of papers (Liu et al., 2022) that assess future income change under different scenarios, and only a few use modeling approaches to analyze the impact of policy shocks on income distribution. Examples of studies that project poverty rates are Crespo Cuaresma et al. (2018), who combined historical estimates of the distribution of income with projections of population changes and GDP to estimate poverty rates by country up to the year 2030 for five different scenarios and Lakner et al. (2022) who used growth incidence curves and machine learning approaches to simulate scenarios for global poverty under various assumptions about future growth and inequality for the same period. Bussolo et al. (2010) and Laborde Debucquet & Martin (2018) combined macro-economic simulation models with microsimulation approaches to project poverty rates. Finally, Soergel et al. (2021), used the output of an integrated assessment model to quantify poverty rates until 2050 and assess how they are affected by mitigation policies.

Future patterns of income distribution will strongly depend on the development of wages, which is one of the main sources of income alongside capital income and land rents. Wages, in turn, are related to sector (agriculture, manufacturing and services) and type of occupation (skilled and unskilled labor). Most partial equilibrium (e.g., CAPRI and GLOBIOM) and computable general equilibrium models (e.g., MAGNET) only have a limited representation of the labor market, which is most likely one of the reasons why there has been limited development in the assessment and modeling of the future income distribution. An exception is Walmsley & Carrico (2013), who presented a framework and database to extend the labor market in the CGE GTAP model. They use detailed information on occupational structures and wages to split skilled and unskilled labor into five major occupation classes. The study includes examples of the impact of trade liberalization and growth on changes in wages and income.

2.2. Food, nutrition and health

Several papers have assessed future trends in food consumption and related impact on nutritional status and health using global modeling approaches. Broadly, the literature can be grouped into two categories. The first one are papers that analyze trends in hunger using forward projections of the FAO prevalence of undernourishment indicator (Cafeiro, 2014; FAO, IFAD, UNICEF, 2023). This approach was popularized by Hasegawa et al. (2015) but has since been adopted by many modelling studies (van Dijk et al., 2021).

The second one are studies that link projections on food intake to diet-related disease incidence and mortality, which rely on comparative risk assessments (Murray et al., 2003). In these, a change in risk is calculated from changes in exposure (diets) subject to relative risk factors, mortality rates, and population numbers. Relative risk factors link dietary risks (e.g., low intake of fruits and vegetables, high intake of red and processed meat) to disease outcomes (e.g., coronary heart disease, stroke, type-2 diabetes, colorectal cancer) and are commonly taken from the epidemiological literature, in particular from meta-analyses of cohort studies (Bechthold et al., 2019; Schwingshackl et al., 2017, 2018). Such burden-of-disease analyses are regularly undertaken, e.g., by the Global Burden of Disease (Afshin et al., 2019), the Global Nutrition Report (Springmann, Mozaffarian, et al., 2021), and the Lancet Countdown on Climate Change and Health (Romanello et al., 2023).

3. INCOME AND EMPLOYMENT IMPROVEMENTS

3.1. Wage and employment projections

This section summarizes extensions that will be developed for MAGNET (Woltjer et al., 2014), CAPRI (https://www.capri-model.org) and FarmDyn (Britz et al., 2016) to provide additional detail on employment and labour income distribution. Computable wage impacts of policy shocks because they explicitely model labour markets. However, most global CGE models, base their employment data on the GTAP database which only provides dollar values of payments to labour but lacks data on the number of people employed or hours worked. As such, these data do not allow an analysis of changes in wages and income distribution, number of jobs nor in the distribution of income across workers in different sectors.

We aim to enhance the MAGNET model in several directions in order to provide better employment, wage and income distributions at the sectoral and occupation level. This includes projections for the agricultural sector and agricultural workers, which can be used to inform JOS indicators, in particular those related to farm income.

We will improve MAGNET with a new labour module that splits skilled and unskilled labour – the standard setup in MAGNET and GTAP - into five types of occupations. To do this, we add two sub-nests to the standard GTAP nested CES production structure, grouping the five labour types into an unskilled (agricultural and low-skilled, service and shop, clerks) and skilled (technicians and professionals, and officers and managers) labour nest. The clustered occupations are comparable in skill level, which supports grouping them in dedicated nests. This setup also ensures the behaviour of the adjusted model remains close to existing model versions distinguishing only unskilled and skilled labour. Base year data on wages and number of workers will be taken from Walmsley & Carrico (2013) and IMPACTECON (https://impactecon.com/downloads/labor-data/).

To project employment and wages into the future we will combine the model with exogeneous projections for the number of workers in each of the five occupation classes, which are consistent with the common scenario drivers (e.g., population and GDP change) that are used in MAGNET. To project the number of workers per occupation class, we combine projections for the working-age population, which is defined as all persons aged 15 and older from the SSP Database (2016), with new projections for the labour force participation rate, defined as the number of persons in the labour force as a percentage of the working-age population, and the share of workers per occupation class. We will use an econometric framework to relate historical information on GDP growth and education with data on labour force participation and the share of workers per occupation. The results will subsequently be combined with the SSP database to create forward projections for the number of workers in each of the five occupation classes.

Finally, these labour projections are then applied as exogenous shocks to MAGNET with the new labour module, together with other exogenous drivers of a scenario. The MAGNET simulation then provides the number of workers by sector as well as their payment. We thus exogenously set the total number of workers by occupation but leave the allocation of these workers over the sectors and the associated wages endogenous in the MAGNET model simulation. These data on workers and wages provide a range of new employment and distribution indicators, such as the poverty headcount, poverty gap index and Palma ratio.

CAPRI has a very simple approach of estimating agricultural labor use based on "labor requirements" for agricultural activities estimated in the context of the baseline preparation. These labor requirements must be updated and aligned with recent data on agricultural labor use. During scenarios, these requirements are typically held constant such that changes in agricultural labor use are (so far exclusively) derived from changes in activities. We aim to compare the CAPRI labor projections based on labor requirements with the updated MAGNET labor projections, which are derived from a labor market module. Where possible, we will tailor the CAPRI labor input to new labor projections.

The bio-economic farm model FarmDyn is a simulation model for agricultural production at farm level. Input requirements for farm activities, including labor requirements, are an integral part of the model. The challenge is to scale the results from farm-level to regional or sector levels to permit interactions with market- and sector models. In the MIND STEP project (Helming et al., 2023; Krisztin et al., 2023; Perez-Soba et al., 2023), this was done by constructing model farms for NUTS2 regions across the EU based on data from the Farm Accountancy Data Network (FADN). Results for marginal abatement cost in the FarmDyn models were then upscaled to national levels, which permitted the parameterization of the respective equations in the MAGNET model. At the same time, commodity and input classification in CAPRI, GLOBIOM, and MAGNET were mapped to the corresponding categories in FarmDyn to permit including market price changes for alternative scenario specifications in FarmDyn.

The workflow between market- and farm-level models in BrightSpace follows a similar approach with regard to wages and employment. FADN data were received in April 2024 and will be used to construct a set of regionally representative farms across the EU. This includes the labor endowments at farm level and the on-farm as well as off-farm activities of the farms' labor force. Scenario-based wage changes from the MAGNET model will then directly be taken over by the FarmDyn model to evaluate changes in farm-level labor use across the farm types. Aggregation to regional or national levels is in principle possible, using the weights of the representative farm types from FADN. However, this implies that the distribution of farm types remains constant. Alternatively, the impact of scenarios on farm income and hence the likelihood of certain farms to remain in the sample can be used to adjust these weights. This procedure was used in MIND STEP (Krisztin et al., 2023; Perez-Soba et al., 2023) and the potential for applications will be further explored in BrightSpace.

3.2. Income distribution

A new microsimulation model will be developed to assess the impacts of EU agricultural and food policies on incomes. Following the approaches developed by Bussolo et al. (2010) and Laborde Debucquet & Martin (2018), we will combine output from MAGNET on wage changes with detailed micro-level data on income from EU statistics on income and living conditions (EU-SILC) to project changes in income distribution (WR, WU, Thuenen, IIASA and UCSC have already obtained access to EU-SILC microdata for EU27 countries).

To project household income distribution over time, the microsimulation model updates the weight and income level of each household into the future. For each country, the household weights are adjusted so that the population totals are in line with age, sex, occupation and urban-rural projections that are prepared as part of socio-economic scenarios (Lovelace & Dumont, 2016), which can be considered as main drivers of change in income distribution. Apart from changes in the composition of the population, which are captured by the reweighing procedure, changes in income distribution will also be affected by changes in the level of household income over time. To account for this, macro-level projections on wage changes from the new labor module in MAGNET will be linked to household-level information on wages. Finally, the updated weights and household income are combined to project the simulated future income distribution at the country level. Given the innovative nature of the proposed model and challenges with the availability and quality of the EU-SILC data, the emphasis will be on developing a proof of concept that will be applied to one to three EU countries for which sufficient data is available.

As in the case of wage and employment projections (previous section), the FarmDyn model will be used to assess the impact of alternative scenarios on farm income across different types of farms across the EU. FarmDyn can be parameterized to a large extent using the FADN datasets, which were received in April 2024. Based on these datasets, model farms will be constructed and the statistical farm income and its components (revenues, variable input cost, taxes and subsidies, cost of fixed inputs and wages) will be tested against the model results in the base scenario. The potential to use FarmDyn income results in a statistical farm-exit model has been explored in MIND STEP to assess which farms may give up farming due to low incomes and more attractive opportunities outside of farming (Krisztin et al., 2023; Perez-Soba et al., 2023). This approach will also be further explored in BrightSpace.

4. FOOD, NUTRITION AND HEALTH IMPROVEMENTS

4.1. Body Mass Index (BMI) indicator

To improve the assessment of changes in food and agriculture policies on health, MAGNET will be extended with a module that generates a Body Mass Index (BMI) indicator. Data from the European Health Information Survey (EHIS), with information on individual heights and weights, will be used to generate BMI population distributions for each of the European Union member states. Two waves of data are available, corresponding broadly to the years 2014 and 2019. This data has already been attained by the partner CITA. A key challenge relates to the representativity of the sample EHIS data such that it is consistent with Eurostat reported classifications of weight distributions. This involves removing certain BMI outliers and experimenting with representative sampling weights for each of the individuals to closely approximate the starting BMI classifications reported in EUROSTAT.

Once prepared, the data will be inserted into MAGNET. The model code will be modified to include distribution functions by EU member states with fixed cut-off intervals that delineate different BMI classifications (i.e., normal weight, obesity class I, etc.). Changes in the 'representative' mean BMI in each EU member state will be driven by changes in per capita calorie intake from the nutrition module of MAGNET. This endogenous relationship is based on an econometric specification taken from the literature (Springmann et al., 2016). In the first instance, one will assume a fixed standard deviation for the population distribution, such that rightward/leftward shifts in the mean BMI in each country, coupled with fixed weight classification cut-off points, will determine changes in the assumed areas within each of the BMI weight classifications. Later, the intention is to examine whether there is a tentative association between how economies develop over time and the standard deviation of the BMI distribution with a view to testing the prospect of having endogenous standard deviation changes in the simulation baseline.

4.2. People at risk of hunger indicator

MAGNET will be extended with a people at risk of hunger indicator, which measures the number of people whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life. This indicator is already generated by GLOBIOM based on the approach developed by Hasegawa et al. (2015). To ensure consistency and comparability between the two models, the GLOBIOM implementation, which is coded in GAMS will be recoded in GEMPACK to be incorporated in MAGNET.

4.3. Modelling of food consumption

We will improve consumer representation in GLOBIOM by capturing differences in food demand between various consumer groups defined by sex and age. As a result, we will use the information existing in the SSP database on population composition projections to design richer demand scenarios that take into account the change in population demographic structure. A more detailed consumer representation will enable, on the one hand, a more targeted design of healthy diets that will capture heterogenous needs of different groups of people. On the other hand, this will allow for improved assessment of undernourishment and overconsumption in these groups as a result of consumption deviations from those dietary targets (McNaughton et al., 2008). Furthermore, this development will allow for improved impact assessment of dietary interventions, such as school meals or gender-targeted interventions, on different socio-economic and environmental outcomes that link directly to several SJOS domains (Custodio et al., 2021).

We will use EFSA data. It is open-access survey-based data covering the EU27 countries. Consumption is reported in g/day/capita, split by sex (M/F) and age classes (Other children, Adolescents, Adults, Elderly, Very Elderly, Pregnant women, Toddlers, Infants, Lactating women, Vegetarians). Survey years between 1997 and 2019. We are currently mapping the food products to the food groups in GLOBIOM. Consumption of each food group will be divided across consumer groups by age (4-5 age groups) and sex (2 groups) in each EU27 country. These shares will be assumed to be constant over time. Next, the food demand function in GLOBIOM will be calibrated to reflect these differences in consumption levels. We will assume that income growth is proportional across all the distinguished consumer groups and all have the same income and price elasticity.

4.4. Food affordability

The microsimulation model described above will simulate how food affordability in the EU will change with different food and agricultural policies. We start by determining the cost of a healthy diet. The composition of a healthy diet will be taken from national dietary guidelines available for most EU countries. The guidelines will be coded and standardized to be compared across countries and linked to detailed price information from the OECD (obtained) to determine the costs of a healthy diet (Springmann, Clark, et al., 2021). Finally, the costs will be compared with household income information and fixed costs (housing, energy, etc.) from the EU-SILC to shed light on food affordability (Penne & Goedemé, 2021).

4.5. Food and health model

Building on our work with comparative risk assessments, we will couple the outputs of the agriculture-economic models of the BrightSpace toolbox to the health module of the Dietary Impact Assessment (DIA) model (Springmann, 2023). The DIA-health model is a global comparative risk assessment model with country-specific resolution and eight diet and weight-related risk factors, including low intake of fruits, vegetables, nuts, and legumes, and high intake of red meat, and being underweight, overweight or obese. We will develop algorithms linking the food group and regional aggregation of CAPRI, MAGNET and GLOBIOM to the DIA model by using population-based mapping for the regions and consumption-based mapping for food groups. We will also update the databases of the DIA-health model to account for new data on food intake, relative risk factors, and weight distributions.

4.6. Update of food price and income elasticities

Price and income elasticities are core parameters in CAPRI, GLOBIOM, MAGNET and the new microsimulation model to assess changes in future food demand and the impact of demand-side policy changes. We will estimate new price and income elasticities to improve the models using EU household survey data. The main source for estimating such elasticities are the Eurostat household budget surveys (HBS) (access granted). Unfortunately, the quality of the HBS differs widely, and for many EU countries, quantity data on food purchases is missing, which makes the estimation of elasticities tedious.

As a proof of concept, a detailed study will be presented for Italy, for which additional food purchase data for a representative sample of Italian households augmented with information on the nutritional characteristics of foods was obtained from the national statistics. We will estimate a demand model that is flexible enough to allow price sensitivities to vary across different socio-economic groups. The estimated results will then be used to derive price and income elasticities, which can be used to simulate potential changes in food purchase patterns, and so in population-wide nutritional outcomes after the introduction of different fiscal policies affecting food prices (e.g., environmental-related or health-related taxes on foods). As price sensitivities vary with socio-economic groups, the distributional implications of fiscal policies across population sub-groups can also be derived.

Parallel to the Italian case study, we will further investigate the HBS data to determine if comparable but potentially less detailed studies can be undertaken for other EU countries using the Eurostat HBS data.

5. OTHER JOS DOMAINS IMPROVEMENTS

We will explore if it is possible to construct model indicators that cover gender and education dimension of the JOS domain. This task will be split into five stages. The first stage involves the identification of relevant candidate indicators of gender and education. As an official database for the monitoring of human development in the European Union in all of its domains, a trawl of the official Eurostat SDG panel database will be performed to pinpoint two to three 3 relevant candidate indicators that can be used to illustrate gender and education outcomes in the EU member states (e.g., early leavers from education by gender, tertiary education attainment by gender). A second stage will involve a search of the empirical (econometric) literature to identify the macro drivers of education and gender changes. A third stage will involve the construction of a database of these relevant explanatory variables for the time period and space dimension corresponding to the availably dependent variable observations from the Eurostat SDG database. In the fourth stage, a panel data econometric analysis will be carried out to assess the drivers' relevant strengths and statistical significance.

Drawing on the education literature, a possible theoretical framework for the econometric specification is based on the education production function that posits that educational performance can be assessed in terms of a production function influenced by a series of 'input' drivers (Hanushek, 1979). In a final stage, the ex-post part-worth elasticities of the econometric specification will be inputted into the ex-ante MAGNET model to provide future projections of these just indicators for medium-term simulations conducted within the Brightspace model toolbox. This may involve using forward-looking projections from the econometric analysis to aid baseline calibrations with MAGNET drivers.

6. ACKNOWLEDGEMENTS

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