MATS
making agricultural trade sustainable

DISCUSSION BRIEFS
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Synthesis of model-based studies

A discussion on computational models applied in agricultural trade-related work.

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Introduction

The paper summed upon this discussion brief presents computational models used in previously published agricultural trade-related academic journal articles. The study analyses the results of models that were used to assess the relation between trade and sustainability (environmental, social, and economic dimensions). A detailed description of the models and information about their characteristics, goal, type, regional coverage, time frame, and applications can be found in MATS project DEL2.2.

A synthesis of results is depicted in tables to highlight important information about the models investigated, which might provide the basis for a proposal for a model framework within MATS. This approach allows a comparison between the various models based on their basic characteristics and their application, their regional coverage, and the sustainability dimensions they are capable of covering. Furthermore, this study assesses how methods and models are complementary to one another. This study's primary method of analysis was a literature review of previous work focused on agricultural trade and sustainability matters in terms of trade dynamics, agricultural production, and agricultural production output. The present discussion paper presents over 200 international agricultural articles with an equivalently great variety of trade and sustainability-related subjects.

Highlights

TRADE DYNAMICS

Six broad types of computational models are distinguished – all commonly used in analysing trade dynamics:

1. Computable General Equilibrium (CGE) models
2. Partial Equilibrium models
3. The Gravity Approach
4. Regression Models
5. System Dynamics (SD) Models

6. Integrated Assessment Models (IAMs)

CGE models are mostly used in the analysis of the global trade system. They differ from Partial Equilibrium models because these models limit themselves to a single industry or a narrow number of industries. The Gravity Approach has been frequently used to describe worldwide or regional trade. Compared to other models, it has simple mathematical structure and intuitive assumptions. Regression models are widely utilised in impact evaluation, causal analysis, and forecasting as statistical tools. Moreover, System Dynamics modelling frameworks have been widely employed in agricultural land, soil, and water resource management research, and in the study of food system resilience to handle complex and nonlinear feedback systems. Finally, Integrated Assessment Models (IAMs) focus on issues relating to the future development of environmental and sustainability topics by looking at the interactions between human activities and environmental factors. The main attributes of each model type are presented in the following table.

Table 1. Trade Dynamics – Models' Summary Table

Model	Models	Sustainability Dimension	Static/ Dynamic	Regional Coverage	Forecasting Time Frame	Degree of Aggregation	Perfect or Imperfect Competition
Computable General Equilibrium (CGE) models	GTAP, GTAP extensions, MIRAGE, OECD ENV-Linkages, GEM-E3, GTEM-C	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	~2050, up to 2100	National, Regional, Household level	Both (Standard version of the model has the perfect competition hypothesis)
Partial Equilibrium models	IMPACT, GLOBIOM, Latent Class Stochastic Frontier Model, CARD model, TRIMAG, Aglink-Cosimo	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	~2050, up to 2100	National, Regional, Household level	Both (Standard version of models has the perfect competition hypothesis)
The Gravity Approach		**Strength**: Economy	Dynamic, Static	Global, National, Regional	The forecasting horizon is relatively short; the exact length depends on the hypothesis of the study.	National, Regional, Household level	Both
Regression Models		**Strength**: Economy	Dynamic, Static	Global, National, Regional	The forecasting horizon is relatively short; the exact length depends on the hypothesis of the study.	National, Regional, Household level	Both
System Dynamics (SD) Models	SD Modelling Approach, National Water-Food (NWF)	**Strength**: Economy, Environment, and Society	Dynamic	Global, National, Regional	Depends on the setup of the experiment.	National	Depends on the setup of the model

	model						
Integrated Assessment Models (IAMs)		**Strength**: Environment	Dynamic	Global, National, Regional	~2100	National, Regional, Household level	Depends on the setup of the model.

AGRICULTURAL PRODUCTION

Seven types of models used in agricultural production studies are being described in the paper and these types are:

1. Computable General Equilibrium (CGE) models
2. Partial Equilibrium Models
3. Optimal Crop Allocation Models
4. Calibrated programming Models
5. Regression Models
6. System Dynamics Models
7. Spatial Models

CGE, Partial Equilibrium, Regression, and System Dynamic models are also described and analysed previously in Trade Dynamics. Optimal Crop Allocation models are utilized to solve diverse types of optimization matters. Calibrated programming models are empirical analysis tools that allow the use of all available information. Finally, spatial models such as InVEST can utilize map and value key ecosystem services to answer local, regional or global inquires. The main attributes of each model type are presented in the following table.

Table 2. Agricultural production – Models' Summary Table

Model	Models	Sustainability Dimension	Static/ Dynamic	Regional Coverage	Forecasting Time Frame	Degree of Aggregation	Perfect or Imperfect Competition
Computable General Equilibrium (CGE) models	National Computable General Equilibrium model, Dynamic CGE (DCGE) model, MAGNET model, MyGTAP model	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	~2050	National, Regional, Household level	Both (Standard version of the model has the perfect competition hypothesis)

Partial Equilibrium models	IMPACT, CAPRI, UKAMM, AGMEMOD	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	~2050, up to 2100	National, Regional, Household level	Both (Standard version of the model has the perfect competition hypothesis)
Optimal Crop Allocation models	Flower Pollinated Algorithm, Linear Programming Models, Stochastic and Math Algorithm	**Strength**: Economy and Environment	Dynamic, Static, Stochastic	Global, National, Regional	Depends on the setup of the experiment.	National, Regional, Household level	Depends on the setup of the model.
Calibrated programming models		**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	Depends on the setup of the experiment.	National, Regional, Household level	Depends on the setup of the model.
Regression models		**Strength**: Economy	Dynamic, Static	Global, National, Regional	The forecasting horizon is relatively short; the exact length depends on the hypothesis of the study.	National, Regional, Household level	Both
System Dynamics (SD) Models	The Green Economy Model (GEM)	**Strength**: Economy, Environment, and Society	Dynamic	Global, National, Regional	Depends on the setup of the experiment.	National, Regional, Household level	Depends on the setup of the model.
Spatial models	InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs)	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	Depends on the setup of the experiment.	National, Regional, Household level	Depends on the setup of the model.

AGRICULTURAL PRODUCTION OUTCOME

The Agricultural Production Outcome section is dedicated to six types of models. These types are the following:

1. Computable General Equilibrium (CGE) Models
2. Sustainability Assessment Models
3. Regression Models
4. Agricultural Production Growth Models
5. System Dynamics Models
6. Economic and Financial analysis

The CGE, Regression, and System Dynamics models are found in all sections of this paper since they are widely used in studies. In the agricultural production outcome studies, additional types of models are presented.

Sustainability assessment models evaluate dimensions and subjects concerning farm management strategies. Furthermore, Agricultural Production Growth Models Examine the relationship between agricultural production and necessary production inputs such as physical capital stock, labour, and land. Finally, economic and financial models can be developed to analyse investments in the agriculture sector. The main attributes of each model type are presented in the following table.

Table 3. Agricultural production output – Models' Summary Table

Model	Models	Sustainability Dimension	Static/ Dynamic	Regional Coverage	Forecasting Time Frame	Degree of Aggregation	Perfect or Imperfect Competition
Computable General Equilibrium (CGE) models	CGE models, Dynamic CGE-Water model	**Strength**: Economy and Environment	Dynamic, Static	Global, National, Regional	~2050, up to 2100	National, Regional, Household level	Both (Standard version of the model has the perfect competition hypothesis)
Sustainability Assessment Models	Sustainability Assessment of Food and Agricultural Systems (SAFA), Sustainability Standard of the German Agricultural Society (DLG), Sustainable Farming (KSNL), Multi-Objective Decision Support Model for Agri-Ecosystem Management Model (MODAM), Model for Nitrogen and Carbon Dynamics in Agro-Ecosystems (MONICA), Agricultural Production Systems sIMulator (APSIM), Agricultural sustainability assessment framework, SALCAsustain methodology, Sustainable food profiling models	**Strength**: Economy, Environment, and Society					

Regression Models		**Strength**: Economy	Dynamic, Static	Global, National, Regional	The forecasting horizon is relatively short; the exact length depends on the hypothesis of the study.	National, Regional, Household level	Both
Agricultural Production Growth Models		**Strength**: Economy	Dynamic, Static	Global, National, Regional	The forecasting horizon is relatively small; depends on the setup of the experiment.	National, Regional, Household level	Both
System Dynamics (SD) Models	System Dynamics models for food-energy-water (FEW) nexus, Integrated Sustainable Development Goal (iSDG) model	**Strength**: Economy, Environment and Society	Dynamic	Global, National, Regional	Depends on the setup of the experiment.	National, Regional, Household level	Depends on the setup of the model.
Economic and Financial Analysis		**Strength**: Economy	Dynamic	National, Regional	Forecasting ability is relatively short; depends on the setup of the experiment.	National, Regional	Depends on the setup of the experiment

Discussion points

After a thorough review of the presented models, it is notable that although most models address a wide variety of sustainability dimension issues, specific models provide modelling frameworks that are technically more flexible than the others. Such models are mostly the Sustainability Assessment models, the IAM models, and the System Dynamic models. To exemplify, a state-of-the-art modelling framework that is currently being used, to address economic, environmental as well as societal issues is the System Dynamics (SD) modelling approach. Compared to other models, the respective framework introduces the element of non-linearity in developing efficient Decision Support Tools (DST). Thus, the corresponding framework provides additional complexity to the calculation about to most of the participatory, deterministic, and probabilistic approaches. However, it can be

linked or coupled to those different approaches to improve the emphasis regarding the complexity of issues connected to natural as well as agricultural resources. Moreover, the SD modelling approach is adequately designed for policy prospection and scenario testing at a regional, national and global scale and allows multi-method and multi-disciplinary integration. Although a primary difficulty in the SD modelling is validation, the respective approach is appropriate for the reproduction of agricultural systems' organisation, and for designing and experimenting with new strategies and management/policy scenarios respectively.

However, the thorough investigation regarding the available modelling approaches considering the synthesis of model-based studies indicated the lack of an important feature that is not being addressed. Regarding the sustainability dimension of the models, few of them address the social aspect of the sustainability dimension. Most computational models don't address measures such as unemployment, human development, household welfare, living standard, population dynamics, gender productivity gap, and labour market that refer to issues of vital importance for the society. Hence it is suggested that future research address them more extensively.

For more information

Link to website and MATS research document: https://sustainable-agri-trade.eu/

Link to request for more information about MATS/leave a message or reaction: Corresponding author, Anthony Rezitis, arezitis@aua.gr

Anthony Rezitis, Spyridon Karytsas, Anna Stefani Siettou, Efthymios Xylangouras (2022). Synthesis of model-based studies. Geoponiko Panepistimion Athinon (AUA), Department of Agricultural Economics and Rural Development, Greece. MATS Deliverable number D2.2.
https://sustainable-agri-trade.eu/deliverables/
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