The CAPRI model

- an overview with a focus on comparison to GTAP

by Wolfgang Britz[1] and Roman Keeney[2]

Draft Version 1 – April 2010
(please do not cite or quote)

Paper to be presented at the Thirteenths Annual Conference Thirteenth Annual Conference on Global Economic Analysis “Trade for Sustainable and Inclusive Growth and Development", Bangkok June 9-11, 2010

[1] Institute for Food and Resource Economics, University Bonn, Bonn, Germany. E-mail address: wolfgang.britz@ilr.uni-bonn.de

[2] Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, USA. E-mail address: hertel@purdue.edu

Introduction

Trade liberalization, changes in domestic supports and other drivers increase market integration for agricultural and food products on a global scale. The recent debate about land-use changes induced by bio-fuel mandates provides a striking example, while again underlying the specific importance of limited natural resources such as soil and water for agricultural supply. Policies impacting on agriculture show therefore a strong bio-physical dimension, with inter-relations to water quality and quantity, to air emissions including gases relevant for climate changes, to soil fertility as well as to habitats and bio-diversity. Analyzing that field thus asks for sufficient detail in describing farming systems, both regarding spatial and technological resolution. At the same time, global coverage should not be lost in the analysis.

The paper analyses complementarities between two established modelling systems for such analysis: GTAP as a global CGE and CAPRI as a specialized agricultural sector model. It is organized as follows. Each of the next two sections offers a short overview of CAPRI and GTAP for those uninitiated to either, with sufficient referencing for those that wish to read more. From there, we offer a discussion of the divergent evolutions of the two model systems, identifying the demand drivers of model and data development on each side and the emergent institutional structure resulting from that demand for analysis.

CAPRI overview

The Common Agricultural Policy Regionalised Impact modelling system (henceforth CAPRI) is an economic simulation tool with a matching data base for analysis of the European agricultural sector (Britz & Witzke 2008). CAPRI functions as a pair of linked partial equilibrium models which iterate to a convergent solution between EU agricultural supplies and global agricultural markets. The supply side maintains prices as exogenous for any particular iteration and is comprised of 280 non-linear regional programming models covering land use for arable cropping, grassland, and animal production in the European Union member states, as well as Norway, Turkey, and the Western Balkans. A recently developed extension of this model allows each region to be disaggregated into a maximum of ten farm types according to their economic size and specialization. Global markets are captured in a spatial Multi-Commodity Model for raw agricultural products and some first stage processing products such as dairy and vegetable cakes and oil.

CAPRI is built in a combined top-down and bottom up approach and thus is rich in information about agricultural technology and physical input use, covering about 50 primary crop and animal production activities and 50 inputs and outputs. This has proven an essential feature in evaluation of the policy influence on environmental indicators. A statistical down-scaling module is appended to the changes in physical quantities in the agricultural sector model which determines estimates for major agronomic variables such as yields, crop shares, fertilizer application rates, and stocking densities at high resolution (1x1 km pixels; Leip et.al.2008) and allows the CAPRI supply model results to be inputted into biophysical models used for determining environmental impacts (Britz & Leip 2009).

Originally developed in EU funded research project in 1996-1999, CAPRI is operational since 1999. Different follow-up projects, again mainly funded by EU research programs, allowed updating the data base, enlarging the model to keep track with the growing EU and improve its methodology. In parallel to expansion and improvement, many policy relevant applications accompanied the process of reforming the Common Agricultural Policy, analyzed impacts of bi- or multilateral trade liberalization scenarios or looked into agri-environmental legislation. Being comparative static in nature, counterfactual analysis is in most cases compared to a future outlook for agricultural market about 10 years ahead. The main client is the EU-Commission, especially its directorates for agriculture and environment.

GTAP overview

The Global Trade Analysis Project at Purdue University has produced global trade, production, and protection data as well as a consistent modelling framework for use with that data since the early 1990s. The impetus for the GTAP undertaking at Purdue was the facilitation of relevant policy analysis in the face of increasingly integrated markets for merchandise, services, and finances (Powell 2007). The core[1] model maintained at Purdue provides a consistent if simplistic view across regions of the world—employing assumptions on returns to scale, competition ,and functional forms that facilitate analytical construction (see Hertel 1997; Hertel and Tsigas 1997). The current version of the database (version 7) fully disaggregated has 113 regions and fifty-seven sectors (Narayanan and Walmsley 2008).

[1] References to a "core" model in this paper indicate the standard GTAP CGE model version 6.2a as documented at https://www.gtap.agecon.purdue.edu/models/current.asp. Note that most research and institutional implementations of CGE using the GTAP database diverge significantly from the assumptions embodied in the core.

Seventeen of the 113 regions are aggregates of multiple countries. The sectors are quite aggregated using standard classifications. Relevant to the current examination of GTAP and CAPRI is the fact that twenty of the fifty-seven sectors are devoted to agriculture, with fourteen of these representing crops (eight primary and six processed) and the remainder representing livestock products (four primary and two processed).

GTAP is built from the top-down, prioritizing complete accounting of economic activity and representation of the intra- and international value flows in a manner consistent with general equilibrium. Equilibrium in the initial data and thus the model structure is assumed to emerge from regional households which own and rent the factors of production to input using constant returns to scale profit maximizing sectors. Regional household behaviour is represented by a non-homothetic demand system, a critical innovation instituted into the core model to deal with heterogeneity of per capita earnings around the world (McDougall 2002). This same regional household and the role it plays in earning income and determining the optimal pattern of expenditure is a boon to theoretically consistent welfare analysis of counterfactual equilibria.

Methodological comparison between GTAP and CAPRI

Representing technology and supply behaviour

The *supply side* in CAPRI builds on the long established tool of aggregate regional programming models. Each region thus features its own, independent supply model which is based on a uniform template so that differences between regions are expressed by parameters. Decisions variables are crop acreages, yields, animal herds, feed composition and fertilization practise. Intermediate input demand is mostly based on Leontief coefficients per head or ha. Explicit constraints ensure that crop and animal nutrient requirements are met and represent policy instruments such as set-aside obligations and sales quotas. Clearly, given that the EU Commission is the main client of the tool, the template offers a highly detailed description of CAP farm subsidies, including major parts of what is called “Pillar II” of the CAP: agri-env supports, payments in so-called “less favoured regions” and in natural reserves. The data base and model comprise 35 crops and 13 animal production processes in different technology variants to render input demands and yields per ha or head endogenous.

Recently, a new module introduces regional land markets, replacing earlier versions where arable and grass land where treated as fixed endowments. In order to overcome aggregation bias inherent in aggregate programming models and to avoid well known problems relating to overspecialization and jumpy behaviour in linear programming, a quadratic dual cost function is introduced into the optimization problem. It represents the effect of labor and capital on allocation decisions and allows calibration to observed behaviour. The parameters of that cost function are econometrically estimated at the regional level from time series in the case of arable crops (Jansson 2007) whereas synthetic elasticities are used to parameterize it for other crops and animal activities. Based on the detailed representation of farm level supply, the supply models allow calculating different environmental indicators such as GHG inventories or nutrient balances.

Summarizing, each supply model can be understood as mixed primal-dual profit maximization problem for the aggregate of farmers in one region at given prices for agricultural outputs and inputs and given policy incentives. However, there are some differences to CGE worth to note: intermediate is not fixed per unit of output, and labour and capital are not explicitly modelled, but shadowed by the cost function.

With model coverage extending to all sectors, the GTAP template specification for production is relatively homogeneous relying on cost shares and CES substitution possibilities for differentiation. No regional differentiation of parameters is introduced into the core model meaning that e.g. labor-capital substitution for maize production in the U.S. will differ from that of Mexico only as determined by differences in benchmark cost shares. Substitution in value added (labor and capital as well as land for farm-level sectors) is differentiated across production sectors with substitution possibilities most limited at the farm-level and increasing with the level of processing (i.e. $\sigma^{VA}_{paddy\,rice} < \sigma^{VA}_{processed\ food} < \sigma^{VA}_{textiles}$). Substitution possibilities among intermediates are uniformly set to zero (i.e. Leontief, fixed cost shares) for all sectors in each region, though the use of CES equations allows for this core assumption to be relaxed readily without recalibration or balancing of the database on the supply side. In fact, this practice of updating and introducing regional differentiation on the supply side is essential in many common GTAP applications such as analysing the potential gains from proposed Doha reforms in agriculture (Keeney and Hertel 2005). Regional output in GTAP is limited by the effective quantities of land, labor, and capital. Land is a specific input to primary agriculture with imperfect mobility across uses, while labor and capital are assumed to be perfectly mobile.

Similarities between the two modelling systems are striking. First of all, both systems apply a production function approach, where intermediate demand is Leontief based. However, in GTAP, Leontief coefficients relate to unit of output, whereas in CAPRI, they relate to hectares or heads. Secondly, both GTAP and CAPRI assume profit maximizing behaviour, either expressed by explicit optimization under constraints (CAPRI) or via first-order conditions (GTAP). CAPRI's focus on agriculture allows adding explicit constraints relating to crop nutrient and animal requirements and to express decision variables in physical terms. Unlike GTAP, CAPRI adopts a dual representation for capital and labour, leaving capital and labour use per activity and for the sector as a whole so far shadowed and only modelling their impact on allocation decisions. Equally, with the exemption of intermediates produced inside agriculture such as fodder, young animals or organic fertilizer, only agricultural demand of intermediates at fixed prices is covered by CAPRI, and not their production.

Thus we arrive at one point of significant divergence between the modelling frameworks directly driven by differentiated aims and scope (single region PE vs. Global GE). Off the shelf, GTAP offers a fairly abstract view of the economy (offering ample flexibility for further research input to overcome this). Physical quantities are not represented and thus policy instruments are initialized as ad valorem equivalents working on prices. CAPRI meanwhile overcomes each of these limitations, but at the cost of assuming the irrelevance of inter-sector linkages and feedbacks through input use. Clearly, such a view on primary and intermediate factor markets is reasonably motivated by the small share of primary agriculture in most European countries, while GTAP's global economy coverage demands these linkages be recognized even for small sectors to maintain economy-wide constraints

Commodity markets and demand representation

In order to allow for endogenous prices, CAPRI's supply models are iteratively linked to a *global spatial Multi-Commodity Model* which covers about 40 agricultural commodities including dairy, oils, cakes and by-products from first generation bio-fuels It is globally closed and comprises 27 trade blocks linked by bi-lateral trade flows of which some are further broken down to individual countries with own behavioural function (in total 59 countries or country blocks). As in most CGEs, the CAPRI market model features a gross trade presentation based on the Armington assumption, which allows introducing bi-lateral trade instruments such as preferential tariffs or TRQs. Equally, market instruments of the Common Agricultural Policy (CAP) such as intervention purchases into public stocks or export subsidies are explicitly covered. Equally, flexible levies in cereals markets and the entry price regime for fruits and vegetables for the EU are covered explicitly. Important to note, when comparing CAPRI to other agricultural Multi-Commodity models, are regular, well behaved behavioural functions for supply as well as final, processing and feed demand whose parameter are calibrated against elasticities from other studies and models.

As CAPRI adopts an approach common to multi-region CGEs, it is not surprising that the international trade and demand components are quite similar in the two frameworks. The core GTAP framework does employ a non-homothetic per capita consumer demand system with region specific behaviour. This recognizes the important relationship between budget shares and demand response along the cross-country income distribution. In particular, the demand system parameters represent an area where the GTAP project has invested in econometric work as part of the data package, producing the income elasticity estimates used in the core model as part of the larger data and modelling project (Reimer and Hertel 2004). Another area where project resources have been devoted to econometric investigation is in the international trade elasticities. Armington elasticties which determine the level of substitutability of imports were estimated by project members and first introduced to the core data and model in version 6 of the GTAP database (Hertel, Hummels, Ivanic, and Keeney 2003).

In addition to effort into modelling demand side behaviour, the GTAP project has been at the forefront in advances of trade and protection data. While the GTAP model in its core version relies on ad valorem representations for all instruments regardless of how they are applied, significant progress on tariff data has led to continued improvement in representing policies in ad valorem equivalents. Notably, beginning with version 6 of the GTAP database the MAcMaps approach (introduced by Jean (2004) and further developed in Laborde, Boumellassa, and Mitaritonna (2006)) was used in compiling the regional bilateral tariff data.

Summarizing, *CAPRI's global market component shows many similarities regarding its trade and final demand representation to CGEs, but uses dual representations for production decisions of farmers and some important processing steps of agricultural raw products.*

Data base aspects

Both GTAP and CAPRI use data base concepts which are structured around economic transactions and commodities, with GTAP drawing on the concept of a Social Accounting Matrix (SAM). The basic data base structure in CAPRI resembles a SAM as well:

outputs, inputs and primary factors are shown in the rows, activities and market balances positions in the columns. Transactions reported in the CAPRI data base are restricted to the agricultural sector and/or agricultural commodities. In opposite to a SAM, data cells in CAPRI are expressed both in physical units and values, from which unit values are derived, and are available as time series. The CAPRI data base, similar to a balanced SAM, ensures mutually consistency between quantities, values & prices and across regional levels (globe => country => regions in countries => 1x1 km pixel clusters) as well as completeness over time and regions, achieved by a combination of statistical estimators and rule-based algorithms to fill gaps, detect outliers and ensure consistency.

A distinguishing feature of CAPRI is that the data base (to the largest extent possible) is sourced via official, harmonized statistical data from EuroStat and FAOStat. The challenge consists mainly to combine in a mutually consistent manner sources from different domains such as physical statistics and economic accounts for agriculture, while ensuring completeness in time and space. The data base items are for almost all elements are available as time series since ~1985. The latter is useful and necessary as policy simulations in CAPRI typically run ex-ante against a so-called “outlook” and “baseline”. Especially the parameterisation of the supply models and the underlying activity definitions draws also on engineering knowledge and manifold other data (bio-physical, law book).

Data components in GTAP are significantly more varied. As previously discussed, tariff data is sourced from the MAcMaps teams at CEPII-Paris. Trade data is similarly sourced from a third party. The core data work within GTAP is the reconciliation of multiple data sets including the source SAMs received from contributors worldwide. Data quality management at the GTAP-Purdue is to a large extent focused on these data sets, which by nature are varied in detail though they must meet some common guidelines for consideration (Huff, McDougall, and Walmsley 2000). More recently, the data side of GTAP has seen extension into physical stocks and flows with significant effort on issues like international labor movement (Walmsley, Winters, and Ahmed 2007), global land cover and use (Monfreda, Ramankutty, and Hertel 2008), and energy volumes (McDougall and Aguiar 2007).

In summary, both modelling frameworks are underpinned by significant effort to collect, corroborate, and reconcile economic data. Logical organization and maintenance requires a strong template approach to ensure consistency and replicative capacity with former and future advances in data and modelling as well as demands for analysis. Our next section draws the similarities and distinctions of the template approaches adopted for CAPRI and GTAP.

Design aspects

Large-scale modelling systems such as GTAP and CAPRI require a "philosophy" or "design guide" establishing standards for implementation. In agricultural partial modelling, two basic concepts can be found: weak templates with market specific implementation of behavioural equations following some general guidelines (e.g. FAPRI, AGLINK) and strict templates where the same model structure is applied for any region and market (see also Britz & Heckelei 2007 for a recent review of agricultural partial equilibrium models). The strict template approach is incorporated into CAPRIs design and is typically adopted in CGE modelling projects. A template expresses distinctions between commodities/sectors and locations solely by the difference in structural parameters and not by variation in model structure. This approach clearly reduces the cost of model maintenance and provides a clear link between the data base and model structure. Both the CAPRI and GTAP frameworks feature a bevy of exploitation tools that are only possible due to the rigidity of the template structure. The uniformity of model outputs across sectors and regions allows for top level programs to be applied and summarize the vast results as well as lowering the overhead for newcomers trying learning the specifics of model structure.

The constraint of a template approach often leads to simplistic treatment of policy interventions. As previously discussed for GTAP, these are represented as price wedges attached to potential transactions leaving GTAP with a relatively short list of generic intervention variables subsequently indexed to their full dimension of commodity type, purchaser, seller, region etc. CAPRI follows the more traditional approach of explicit and extensive elaboration of policy interventions.

The CAPRI system maintains consistency with EU regulatory frameworks as closely as possible, resulting in a system of policy variables that distinguish between ~30 different subsidy schemes of the CAP which can paid per ha, per slaughtered head or head and year, or per unit of output[2]. Each of these schemes encompasses different lists of activities and can be linked to quantity or value ceilings, and even to intensive or extensive variants for

[2] This coverage of policy instruments in conjunction with the template approach means that CAPRI maintains a very broad template at the modelling unit level (adopting zero interventions for many policy variables).

the production activities. In the CAPRI global market model, specific and ad-valorem tariffs are differentiated. Equally, many bi-lateral TRQs are explicitly modelled, i.e. during simulation runs, the regime switch between quota under-fill, binding quota and over quota imports with the consequence on the tariff applied or the rent is endogenous. Also some, peculiarities of the border protection for agricultural border in EU markets such as flexible levies guaranteeing minimal import prices as long as the bound rates allow for it are captured.

As a consequence from the detailed and explicit policy presentation, policy instruments cannot be easily aggregated over regions or sectors/commodities. Accordingly, aggregation over sectors / regions is not implemented for the simulation model. Indeed, its runs always in same, maximal product and regional dis-aggregation, a distinct difference to CGEs and in particular the flexibility in aggregation afforded by GTAP. Flexible aggregation is a rather unique feature of GTAP in the modelling community and is seldom seen in partial models. Much of this has to do with GTAP not emerging from an institutional driver and setting not geared toward a complete and up to date regular outlook of the latest regime emerging from a policy making body.

The GTAP core model is largely conceived as a starting point rather than an off-the-shelf tool ready for relevant policy analysis. Core model design and maintenance are largely designed to provide a low overhead introduction to the data and global CGE modelling. All exploitation tools (model run interface, summary result viewers, etc.) are available and fully realized for any size aggregation for which the model can be solved. While this ease of introduction is of considerable value in bringing new researchers into the network, it obviously comes with the considerable burden of a full engagement on the limitations of the core framework.

The “standard” representations of CAPRI and GTAP represent an important difference in the two frameworks, largely derived from their institutional drivers (discussed below). GTAP’s standard version has mostly a didactic value, from which a researcher may be led to the rich set of variants which have been produced as extensions offer relevant analysis on a variety of dimensions. In contrast, CAPRI’s “standard” version is a full-fledged tool for policy impact assessment. Indeed, CAPRI master version implements basically all relevant add-ons from past (and sometimes on-going) projects. It can be understood as the latest checked and operational version, and comes along with a matching data base and future outlook as well as parameters. That distinction is clearly the outcome of the much more focused and narrow application domain of a partial sector model such as CAPRI.

IT aspects

Even if often neglected in model documentations and scientific papers, IT implementation of large-scale models is a key factor, especially for large-scale models (see Britz 1999). CAPRI is based on a "GAMS only" philosophy, i.e. all working steps are implemented in GAMS: data base generation, baseline development, simulation runs and post-model analysis (including spatial downscaling). GTAP relies mostly on GEMPACK, however, especially in data generation, a higher variety of tool is applied.

Several reasons underlie the decision to maintain model components in the GAMS software. Firstly, GAMS allows for transparent links to powerful numerical solvers able to handle large-scale NLP problems such as CAPRI's global market model, a square system of equations, or explicit optimisation models such as the aggregate programming models on the supply side, or data balancing problems. The current CAPRI version uses only CONOPT to reduce license costs. Secondly, GAMS is based on rather simple programming structures and resembles closely in implementation the notation of scientific papers. GAMS maintains widespread use and an active user and development community within the field of economic optimization making it a low-cost choice for those new to CAPRI or computational modelling. Thirdly, GAMS now comprises an efficient internal data base format to store large, sparsely populated multi-dimensional matrices as they are typically used for large scale models. And last not least, it is still reasonably priced for academic institutions.

However, not every user of CAPRI needs or wants to deal directly with the GAMS code. Accordingly, a Graphical User Interface (GUI) realized in Java allows the user to exploit results or steer the GAMS code underlying the different working steps (Britz 2009). The philosophy differs from the GUI in GTAP, which roots to a larger extent also in institutional differences discuss below. The CAPRI GUI supports different user roles:
(1) exploiters, which only want to look at data or already existing simulation results,
(2) runners, which define and submit counterfactual scenarios (using the GUI) to be solved/simultaed, and (3) administrators, who build the data base and develop the forward baseline.

This means the CAPRI GUI must be functional in steering of all working steps in the production chain including accessing the results which may comprise large numbers of time series. Similar to GTAP, but different in their touch & feel are powerful exploitation tools (tables with hyperlinks, thematic and flow maps, different type of graphs, outlier detection etc.). The GUI also generates and handles ISO standard meta-information from the different working steps and generates HTML based documentation of the GAMS code. The dependencies between the GUI and GAMS are kept to a minimum which eases the use of CAPRI in batch mode or its linkage to other software environments. The latter is especially important for projects where CAPRI itself is used in part of a larger model chain (see e.g. the SEAMLESS project).

GTAP's realization in GEMPACK is largely driven by a close institutional association with the Center for Policy Studies (COPS) at Monash University in Melbourne. GEMPACK is designed explicitly for economic equilibrium modelling such that all components of the software package from model coding to post-simulation analysis are designed by the same team. GEMPACK is at its core a non-linear equation solver such that explicit optimization is not handled by a solver, rather the modeller must write the solution to the system in terms of first-order conditions. This greatly facilitates the ties from analytical to computational modelling and code writing in the system is simplified to a representation of the equilibrium system in its linearized (percentage change) form. The GEMPACK software package includes an appropriate data handling system for large multi-dimensional arrays. All of these facts and the GTAP institutional outreach model of training users new to the community make the marriage between GEMPACK and GTAP rather unique. Short course training in GTAP is fully realized using the same GEMPACK software suite that is used for large scale research modelling.

An important difference to GTAP is how CAPRI is distributed and hosted. As discussed latter, the user community is small, and most users contribute also to code development and maintenance. Accordingly, CAPRI's GAMS code, all data and results as well as the GUI and the underlying Java code are hosted on web-based software versioning system. The latter is a standard tool in software engineering to support the development process. It allows synchronising local copies to web-based master, and stores the history of changes while allowing the definition of access rights to different parts of the repository. In contrast, GTAP is sold by the Center of Global Trade Analysis using a cost of recovery model of pricing for the databases maintenance and development. Thus users wanting full access will pay a license fee to obtain data. To express the data in a model environment, users need only software that is suitable to the task, though full functionality of the model development efforts produced in concert with the data at GTAP would require a separate license for GEMPACK.

Institutional aspects

Large-scale economic models need a business model to ensure sustainability. With the latter we mean securing the necessary resources to update the data base underlying the modelling systems in a regular manner, to adjust the tool to user needs and develop it further while maintaining the necessary network of experienced user which can respond timely to clients' demand for policy impact assessment. Here, CAPRI shows some distinct differences from GTAP. These differences are mainly due to two interlinked factors: a much smaller market and more or less continuous funds from one major sponsor.

The smaller market compared to GTAP is clearly linked to CAPRI's geographic focus on Europe in combination with coverage of the agricultural sector, only. CAPRI responds thus to demands for a less general and more specialized tool operating in it's a smaller market only supporting a limited number of users. GTAP, however, can be used for economic wide analysis, and thus allows targeting a much broader field of policy questions. Equally, country specific impact assessment in a global concept is now possible for the nearly 120 countries covered by their own SAMs.

Major funds for CAPRI stem from projects in the so-called "EU research framework programs", based on EU wide thematic calls to which consortia from different EU Members states can respond. These calls are often closely linked to demands for scientific support from the policy scene. Selection of successful tenders is based on a peer review process with competition between competitors for one call, but also across calls in one thematic field. The team around CAPRI has produced a successful track record in attracting funds from that program. The projects allow for relatively high freedom in the scientific aspects while still ensuring an applied policy perspective. Besides the larger projects from EU research funds, the domain of support now includes an increasing number of smaller projects focused on counterfactual analysis (often linked to some targeted development). Almost any project so far had been funded by EU and national agencies. Equally, all teams involved in CAPRI stem from institutions which are directly or indirectly state owned or financed, so that also any co-financing of projects was paid for by the tax payer.

It was therefore decided very early to handle CAPRI basically as a "controlled" open source project: nobody is refused access to the tool, but users have to ask for access and are registered. It remains to be seen if that business model will be sustainable in future. Currently, funds are available at least until 2013 for maintenance and updates.

GTAP has a different history in that respect as that a sponsoring program such as the EU framework program was not available in a phase critical for the continuation of the activities. Therefore, a consortium of key institutions realizing the strategic importance of a global set of harmonized SAMs was brought together. The consortium members finance part of the centre in Purdue, but also give research directions. In order to generate an incentive to contribute a national SAM, the GTAP data base was not made freely available. Instead, the data set can either be bought, or

As for most large scale models, there is a centre with some key researchers. In the case of CAPRI, a core group is based at the chair for economic and agricultural policy at the agricultural faculty of Bonn University. The still small CAPRI network active today has to a large extent developed from phd students working in Bonn on CAPRI related research projects. As a consequence, the core group of users and developers interacts intensively together, linked by long-standing successful working relations and often also by friendship. Together with success in attracting funds which also contributed to updates and maintenance work, so far no formal consortium was needed and funded.

A drawback from the somewhat small market is the fact that development of training activities such as the GTAP short course is less inviting. However, given that currently more applications or project contributions based on CAPRI would be feasible if staff experienced in its application would be available, some steps towards standard course material are undertaken.

Summary and conclusions

There are some obvious similarities between CAPRI and GTAP: high continuous investments in data base work, longer history of continuous improvements and policy relevant applications combined with a strong market position. Both systems are also strictly based on optimisation behaviour rooting in micro-theory.

Equally obvious are the distinct differences. CAPRI is linked to a much smaller and more focused market: the complex Common Agricultural Policy and its impact on farm income and management, food prices, land use and environmental impacts. That focus asks for a high dis-aggregation in sectors/products and space, while coverage of land-use/management and environmental aspects introduces a lot of physical data in the system. Especially the latter two features render a link between GTAP & CAPRI interesting for specific applications.

References

Britz, W. & Witzke P. (ed.) (2008): CAPRI Modelling System Documentation. URL: http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/capri-documentation.pdf, University of Bonn.

Britz W. & Heckelei T. (2008): Recent Developments in EU Policies - Challenges for Partial Equilibrium Models , Invited paper prepared for presentation at the 107th EAAE Seminar "Modeling of Agricultural and Rural Development Policies". Sevilla, Spain, January 29th-February 1st, 2008

Britz W. (1999), IT - An Unimportant Ingredient of Large Scale Models? Agrarwirtschaft JG 48, Heft 3/4, Frankfurt

Britz (2009), The Graphical User Interface for CAPRI version 2009, URL: http://www.capri-model.org/docs/Gui2009.pdf

Britz W. and Leip A. (2009): Development of marginal emission factors for N losses from agricultural soils with the DNDC-CAPRI meta-model, Agric. Ecosyst. Environ. 133 (2009), pp. 267-279, doi:10.1016/j.agee.2009.04.026

Hertel, T.W. (ed). 1997. *Global Trade Analysis: Modeling and Applications*. Cambridge University Press.

Hertel, T.W., and M. Tsigas. 1997. "Structure of GTAP." GTAP Resource # 413. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=413

Jansson T. (2007): Econometric specification of constrained optimization models, Dissertation (doctoral thesis)

McDougall, R. 2002. "A New Household Demand System for GTAP." GTAP Technical Paper No. 20, Center for Global Trade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=942

Leip, A., Marchi, G., Koeble, R., Kempen, Britz W. and Li, C. (2008): Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen losses from cropland soil in Europe, Biogeosciences, 5(1): 73-94

Narayanan, B.G., and T.L.Walmsley. 2008. *Global Trade, Assistance, and Production: The GTAP 7 Data Base*. Center for Global Trade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/databases/v7/v7_doco.asp

Powell, A.A. 2007. "Why, How, and When did GTAP Happen?" GTAP Working Paper No. 38, Center for Global Trade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2467

Table 1: Comparison between CAPRI and GTAP from a methodological / coverage perspective

	CAPRI	**GTAP**
Coverage	Only agricultural sector and some important first processing stages (oil & cakes, dairy, bio-fuels) Global, but focus on and detailed representation of Europe	All sectors No specific regional focus
Agricultural Supply	Europe: Explicit optimisation under constraints, sub-national resolution Mostly Leontief demand for intermediates (as far as possible in physical quantities, expressed per ha/head); exceptions: feed & fertilizer Capital & labour shadowed in dual cost function, land as physical balance Non-Europe: dual; normalized non symmetric quadractic profit function	Implicit optimisation (FOC in MCP), nation & group of nations Leontief demand for intermediate (constant values, expressed per unit of output) CES GVA nest
Final demand	Generalized Leontief; expressed in raw product equivalent	Different functional forms; directly linked to sectors/commodities
Feed demand	Based on explicit nutrient requirements (energy, crude protein, dry matter corridor ..) of herds –supply model; composition of bulks such as cereals based on CES - handled in market model	Leontief as other intermediates
Fertilizers	Substitutions between mineral & organic fertilizers; based on N,P,K nutrient requirements of crops, farming practise and location factors	Leontief as other intermediates
Processing demand	Dual; normalized not symmetric quadratic profit function; only for cakes, oils, dairy, bio-fuels	Same structure as all other sectors (Leontief + GVA nest via CES)

Trade	Armington; physical quantities; ad valorem & specific tariffs separated; explicit TRQs and some trade instruments of EU; no CET	Armington; constant values; ad valorem equivalents (encompassing TRQs); CET
Consumer prices	Linked to raw products prices with fixed margin	Linked to producer prices of relating sectors (food industry etc.)
Spatial resolution	280 regional units in Europe; 59 countries / country blocks worldwide	~180 nations world wide (maximal, typically aggregated in applications)
Commodity resolution	ca. 40 products (agriculture and first stage processing of agriculture)	Ca. ? products covering all economic activities
Sectors	Multiple outputs per sector (= production activity), 35 crop and 13 animal activities	Typically symmetric to one commodities