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Linking European Science and Society

Linking CAPRI and GTAP

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Executive summary

This deliverable reports on the development of linking of CAPRI and GTAP in a flexible and generic manner (in the sense of not being focussed on a one-off application). The linking aims at combining the strength of CAPRI in detailed modelling of the EU agricultural sector with the economy-wide modelling of GTAP. The combination of the two models allows us to assess in detail the impacts of changes in the overall economy on the agricultural sector in the EU as well as the impact of changes in this sector on the overall economy.

Aiming at a generic link between the two models we started by a formal treatment of establishing a link between a partial equilibrium model like CAPRI and a general equilibrium model like GTAP. We showed that by approximating the partial equilibrium model in the general equilibrium model through (partial) adjustments of the supply curve a fast converging and stable system can be developed. We then further investigated the practical scope for such a linked system by developing a didactic example. Apart from further exploring the foreseen method for linking the example also allowed is start developing the link in practical (software) terms.

We then turned from the didactic models to linking CAPRI and GTAP which required a careful mapping of sectors and regions between the two models. The result was a GTAP model configured for use with CAPRI in terms of having the best possible match in terms of countries/regions and with all agricultural sectors aggregated into a single sector (since CAPRI does the modelling of agriculture in the linked system) except for fibre crops and processed food which have limited coverage in CAPRI. The non-agricultural sectors were further aggregated in four large groups (natural resource extraction, labour intensive manufacturing, capital intensive manufacturing and services), leading to a total of seven sectors in the GTAP model.

The actual implementation of the link requires minimal adjustment to CAPRI and no adjustments to GTAP while making the extent of the link transparent by a dedicated intermediate program calibrating standard GTAP parameters to CAPRI results.

We tested the linked system with a realistic scenario of a tariff reduction for non-agricultural products based on the latest modalities of the WTO multilateral negotiations. The linked system turned out to converge quickly as expected based on the formal development of the link earlier on in this deliverable. The results at first sight are also promising although the size of the impact is limited due to the limited size of shocks in the scenario. A more detailed examination of the results indicate a divergence between the two models for some variables, indicating the current link limited to agricultural production needs to be expanded to include a link of demand for agricultural products in both models.

In retrospect the development of the linked system was most challenging from a technical point of view. Having now achieved a system that converges despite a clear limitation in the extent of the current link indicates that the linking method is robust offering scope for future

extensions of the link. The current results also indicate a clear direction for future work to linking changes at the demand for agricultural products (i.e. linking changes in consumer demand and trade flows).

1 Introduction

This deliverable discusses the linking of CAPRI and GTAP. This linking aims at exploiting the strengths of each model (agricultural sector detail of CAPRI and economy-wide coverage of GTAP) for use in ex-ante policy analysis.

We start in this introductory chapter by outlining the structure of CAPRI and GTAP, the main motivation for linking and an outline of the linking strategy. The second chapter explores in more formal terms the linking of general and partial equilibrium models. Chapter 3 provides an illustration of the proposed linking approach using didactic models. We used the development of this didactic model to design the full scale linked system.

In Chapter 4 we switch the linking of the full-scale models by establishing a mapping between regions and sectors in GTAP and CAPRI. Chapter 5 then describes the technical details of the linking of the two models, comprising both adjustments to CAPRI and GTAP as well as development of auxiliary programs to operationalize the link. Chapter 6 describes results of the linked system of models for simplified version of a trade liberalization of non-agricultural products. Chapter 7 concludes.

Before turning the general discussion on linking of models we set the stage by providing a short description of CAPRI and GTAP, as well as identifying the key considerations of the linking of both models.

1.1 CAPRI

CAPRI is an acronym for Common Agricultural Policy Regional Impact Analysis. This agricultural sector model combines a representation of agricultural supply based on positive mathematical programming with a global trade model for agricultural commodities. The supply module of CAPRI covers the most important agricultural activities in EU27 at a regional level (Nuts1 in the UK, Nuts2 in the rest of the EU). The supply module is able to simulate changes in farmer's behaviour in response to a changed direct payment scheme. The market model provides market feedbacks to farm gate prices for changing farmer behaviour and allows to simultaneously simulate policy changes at the market level (export subsidies, intervention, import tariffs, tariff rate quotas). A joint equilibrium solution of supply and demand is found by a sequential recalibration algorithm, essentially based on iteration between supply and demand, with some technical adaptations to promote convergence.

1.1.1 Modelling agricultural supply

The CAPRI model includes non-linear programming models for about 200 Nuts2 regions covering the whole EU27. The model differentiates about 30 crop production activities, of which 5 exclusively produce fodder for ruminants. The animal sector incorporates dairy cows, cattle raising, and fattening activities as well as 8 other animal activities.

The objective of the supply model is profit maximisation subject to constraints such as utilisable agricultural area and production quotas. Quadratic cost functions depending on activity levels and originally motivated by the Positive Mathematical Programming approach of Howitt (1995), allow perfect calibration to observed ex-post data on land allocation and herd sizes. In order to reflect regional competitiveness accurately, the calibration approach

also uses additional information on dual values of restrictions — specifically quota rents and land rent — as well as a priori supply elasticities.

The payment scheme for subsidies to farmers under the current legislation is part of the optimization procedure (see Britz and Witzke 2008). The design of the direct payment and single farm payment system adheres fairly closely to the mechanisms defined by the EU regulations. The basic entity of the direct system payment system in CAPRI is the *premium*. With each premium we associate (i) a list of eligible agricultural activities, (ii) a national or regional ceiling in monetary or physical terms, and (iii) information of how the premium amount is computed, i.e. per slaughtered head, hectare harvested or historical or actual yield. The ceilings mentioned under (ii) are used to decrease the payments if the ceilings are overshot.

For the premiums defined in the 2003 CAP reform (single farm payment) there is a special routine that removes premiums that are to be decoupled, and adds a corresponding amount of money to the single farm payment. The single farm payment is modelled as an amount per hectare that is invariant to the cropping choice of the producer. In CAPRI, thus, the single farm payment as well as the single area payment scheme in the new member states influence land rents but not the choice of crop mix.

1.1.2 Modelling of the market for agricultural commodities

The supply side of the CAPRI model is linked to the CAPRI market module in an iterative fashion. This market module is partial, spatial, global equilibrium model for most agricultural primary and important secondary products such as dairy products (see Britz and Witzke 2008).

The partial character refers to exogeneity of non-agricultural variables such as input prices and consumer income. It is spatial as it includes bi-lateral trade flows between countries and country aggregates modelled by the Armington approach. Prices in different regions are linked via price transmission functions capturing multi- and bilateral trade policies of the EU such as import tariffs and export subsidies. Policy instruments of non-EU trading blocks include (bi)lateral tariffs and Producer/Consumer Subsidy Equivalent price wedges (PSE/CSE). Tariff Rate Quotas (TRQs) are also integrated in the modelling system. Within the EU, price linkages between the EU Member States and the EU pool is currently simply one of equal relative changes, not at least to render the analysis of results more tractable. Intervention policies in the EU are implemented for the relevant products.

Behavioural functions derive from flexible forms of the normalised quadratic type apart from human consumption where a Generalised Leontief type indirect utility function is used. Microeconomic consistency is imposed but otherwise flexible forms permit to calibrate to any consistent set of elasticities, if they are available. Typically, parameters are either based on literature research, borrowed from other models or simply set by the modeller (‘synthetic’ parameters).

1.2 GTAP

The framework adopted in this study is the model of the GTAP (Global Trade Analysis Project) consortium, which is a comparative static, multi-sector, and multi-region general equilibrium model. More specifically we use the standard 'plain vanilla' GTAP model Version 6.2a (available from the GTAP website, www.gtap.org). In this model each country (or region) is depicted within the same structural model.

The *regional household* to which the income of factors, tariff revenues and taxes are assigned represents the consumer side. It is assumed that the regional household allocates its income to three expenditure categories: private household expenditures, government expenditures and savings. Consumption of private household is depicted using a Constant Difference of Elasticities (CDE) function, the virtue of which is that budget shares vary with changes in income (e.g., the portion of income spent on food items declines as income rises).

A *representative producer for each sector* of a country or region makes production decisions to maximize profits by choosing inputs of labour, capital, and intermediates to produce a single sector output. Producers can substitute primary factors for each other, and this substitution possibility is captured using a Constant Elasticity of Substitution (CES) functional form. In addition, it is assumed that intermediate goods are used in fixed proportions (Leontief). In the case of crop production, farmers also make decisions on land allocation. Intermediate inputs are produced domestically or imported, while primary factors cannot move across country. Internationally traded commodities are assumed to be distinguished according to the region of origin. Using this so-called Armington assumption implies that, for example, wheat imported from the US is different from wheat imported from the EU, and trade flows in both varieties have their own price tag. A great advantage of the Armington assumption is that it allows us to model bilateral trade flows and bilateral trade policies. Throughout the present analysis we assume constant returns to scale.

The GTAP model includes two global institutions. All transports between regions are carried out by the *international transport sector*. The trading costs reflect the transaction costs involved in international trade, as well as the physical activity of transportation itself. Using transport inputs from all regions the international transport sector minimizes its costs under the Cobb-Douglas technology. The second global institution is the *global bank*, which takes the savings from all regions and purchases investment goods in all regions depending on the expected rates of return. The global bank guarantees that global savings are equal to global investments.

Taxes are included at several levels. Production taxes are placed on intermediate or primary inputs, or on output. Some trade taxes are modelled at the border. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Trade policy instruments are represented as import or export taxes/subsidies.

A detailed discussion of the basic algebraic model structure of the GTAP model can be found in Hertel (1997), Chapter 2. A complete version history of the model can be obtained from the GTAP website, www.gtap.org.

1.3 Strategy for linking

The motivation of linking models is to exploit their different strengths. In the case of CAPRI and GTAP there is a complementarity in terms of agricultural and non-agricultural sectors. Both models have a global coverage with a different level of country detail (CAPRI has around 53 countries/regions, GTAP Version 7 has 113). The major complementarity between the two models is in their different sector detail. CAPRI has an advantage over GTAP in its detailed modelling of agriculture, both in terms of product details as well as in terms of modelling the different elements of the CAP. GTAP has less detail in agriculture but covers the whole economy, i.e. incorporates general equilibrium feedbacks between all sectors of the economy. GTAP is therefore able to capture the impact of changes in the agricultural sector on the rest of the economy and the resulting feedback on the agricultural sector.

Both CAPRI and GTAP produce results for the agricultural sector (with different levels of detail). Since they are different types of model (partial equilibrium versus general equilibrium) the results will never coincide perfectly, even if scenario assumptions, data, and structural parameters would be made consistent as far as possible. A parallel application of both models would, for example, produce two sets of results on changes of agricultural output values in the EU. Running them in parallel would thus not only imply continuous and tedious work on model specification for consistency purposes, but also require a sophisticated strategy in interpreting and communicating differences in indicator values generated by both models. The preferred option is therefore a full link of both models, making the best use of the comparative advantages of both models in the SEAMLESS context and avoiding conflicting results.

In conclusion we identify three key considerations for developing a link between the two models:

- Exploit the detailed modelling of agriculture in CAPRI.
- Exploit the economy-wide feedbacks of GTAP.
- Avoid different results on the same indicators.

2 Linking general and partial equilibrium models

This chapter develops a link between a general equilibrium (GE[1]) and a partial equilibrium (PE) model, based on a didactic example. In the example, the GE has only the two producing sectors "agriculture" (AG) and "rest" (REST), and a consumer that owns all factors of production. The PE has only the sector AG, but in with two different production activities and an additional technical constraint (land constraint). Thus, the PE displays greater detail for AG than does the GE model and does not model the rest of the economy, as is the case when linking CAPRI and GTAP.

By linking the models, the strengths of each model can be utilized. The PE uses endogenous outcomes of the GE for variables that are otherwise exogenous in the PE, and the GE iteratively adapts its agricultural sector to respond precisely as the PE. Furthermore, it is assumed that the PE has a superior market model for agricultural goods, which we wish to utilize in the GE.

2.1 A formal treatment

There are many research projects that attempt to link models in different manners. The subject of the current study is the link from low to high level of disaggregation in terms of spatial and product resolution. It is thus conceptually similar to e.g. Jensen et al. (2004) and Helming et al. (2006) that link a partial to a general equilibrium model. Other possibilities include the linking of physical to economic models, or the horizontal linking of models of similar level of aggregation (e.g. in Fischer et al. 1988, Chantreuil et al 2005).

The work by Fischer et al. comprises a proof that the linked system has a solution. To their aid, the authors make use of a fixed-point theorem. The other publications referred to above contain no or little general and formal treatment of the linking problem. The purpose of this section is to describe the linking problem in general terms, in order to identify the elements involved and introduce a terminology to use in what follows.

In principle, the ideal case of a joint solution of a GE and PE is no different from the solution of a single extended GE. Assuming that the original GE is given in reduced form and the PE as a constrained optimization problem, the extended GE is constructed by merging the original GE equations with the Kuhn-Tucker conditions of the PE. Some of the previously exogenous items (the parameters) of the GE and the PE become endogenous in the new equation system, and new functions are added that map GE variables to PE parameters and vice versa. The problem is thus similar to e.g. the construction of a price equilibrium model by merging microeconomic supply and demand models, where the parameters that are fixed in the individual models (e.g. consumer budget in the consumer model) become endogenous in the linked system, and new equations (e.g. income accounting) are added to the linked system. In practice, it may be difficult to obtain a perfect integration of the models, due to technical as well as theoretical reasons, and special solution methods may be required in order to find an equilibrium solution.

Consider the following simplified case, with one GE linked with one partial (sector) model. Let y and α denote the vector of variables (endogenous) and parameters (exogenous) respectively in the GE, and denote an optimal solution to the GE by the equation system

[1] Throughout the report GE is taken to mean either "General Equilibrium" or "General Equilibrium Model", whatever best fits the context, and similar for PE.

$f(y;\alpha) = 0$, where f is a vector of functions of the same length as y. Similarly for the PE, denote the vector of variables by z, the parameters by β, and the vector of equilibrium conditions[2] by $g(z;\beta) = 0$.

Endogenous results of the GE are mapped to parameters of the PE by the vector valued function Γ, or, with B the set of all possible parameter vectors of the PE and Y the set of all possible solutions (the solution space) to the GE, Γ: Y $\rightarrow$ B. The endogenous results of the PE, which was assumed to be more disaggregated than the GE, are aggregated to the level of the GE by the function h. If the sub-vector of the variables y of the macro model that correspond to aggregated results of the partial model is denoted by subscript p (for "partial") and the rest of y is subscripted by n (for "not partial"), we have that $y = (y_n,y_p)$. With Z denoting the solution space of the PE, we write h: Z $\rightarrow$ Y_p.

If the model chain is solved optimally, then the PE returns exactly the same solution as the GE model when aggregated to the appropriate level, and we may write the following optimality condition for the linked system:

$$y_p = h(z).$$

Consider a "partial closure" of the GE that is obtained by fixing y_n and dropping a corresponding number of equations, so that only y_p is endogenous in the sub-vector of functions f_p (and denote the dropped equations by f_n, so $f = (f_n,f_p)$). Then the smaller model defined by $f_p(y_p;y_n,\alpha) = 0$ is an approximation to the partial model g. This "shift the functions" means re-computing α so that the aggregated outcome of the partial model, i.e. $y_p = h(z)$, solves the approximate partial model.

In shifting the functions, it is not desirable to change the *behaviour* of the fixed sectors (the behaviour of elements of y_n), since the partial model does not (by definition of "partial") deliver any information about the behaviour of those sectors. Thus, we want to be able to split also the parameter vector α in two parts, where one part is specific to the sub-vector of functions f_p (the partial closure of the macro model). This is always technically possible (but potentially economically meaningless or worse[3]), by introducing an additional parameter vector δ of the same dimension as y_p such that the new system of equations is $f_p(y_p - \delta;y_n,\alpha) = 0$. Since δ only occurs in f_p but not in f_n, the rest of the macro model will behave (ceteris paribus) as before the shift, and setting $\delta = 0$ recovers the original model formulation. Denote the extended parameter vector (δ,α) by γ, and denote the shifting operation that maps y_n,y_p and α into δ by $\Phi(y_n,y_p;\alpha) = \{\delta: f_p(y_p - \delta;y_n,\alpha) = 0\}$.

By shifting the equations f_p, the macro model is adjusted to approximate the partial model. There are several alternative methods of making that approximation. For example, the equations f_p can be removed and replaced by a new set of equations that are simpler to shift and provide a better point approximation to the partial model. An almost trivial such substitution is to replace f_p by a vector of constants, given by the solution of the partial model $h(z)$, i.e. by using the shifting function $\Phi(y_n,z;\alpha) = \{\delta: \delta = h(z)\}$ and re-defining f_p as $\delta - y_p = 0$ (which is equivalent to dropping f_p from the system f and fixing y_p to $h(z)$. Such a simple approximation may, however, lead to convergence problems in the iterative solution algorithm, as we will see below.

[2] For the moment, we ignore inequality constraints and complementary slackness conditions.
[3] Take for example a general equilibrium (GE) model linked to a partial model of demand for a specific kind of goods. If the parameters of the demand system of the GE model contains fixed budget shares, those share parameter become meaningless, or at least not shares anymore, by the introduction of a demand shift term δ as shown above.

When the models are linked, the parameter vectors δ and β become endogenous to the model system, and we then seek a joint optimal solution in terms of (y,z,δ,β) to both models characterized by

$$\begin{aligned} &f(y_n,y_p,\delta;\alpha) = 0 \\ &\Phi(y_n,y_p;\alpha) = \delta \\ &h(z) = y_p \\ &g(z,\beta) = 0 \\ &\Gamma(y) = \beta. \end{aligned} \qquad (1)$$

The *differential* baseline calibration approach implies calibrating the function h and the mapping Γ so that for the "standard" parameter sets α^* and β^*, it holds that

$$\begin{aligned} &\Gamma(y^*) = \beta^* \\ &h(z^*) = y_p^* \end{aligned}$$

where y^* is the solution of the macro model parametrized by α^*, i.e. the vector that solves $f(y^*;\alpha^*) = 0$, and z^* similarly solves $f(z^*;\beta^*) = 0$.

The *harmonizing* baseline calibration approach, given that the partial results z^* are to be respected by the GE model implies computing (y_n,α,δ) such that $f(y_n,h(z^*),\delta,\alpha) = 0$, while keeping the variables y_n that are still free "close" to the original level, i.e., for some metric F that measures the deviation of y_n from y_n^*, solving

$$\begin{aligned} &\min_{y_n,\alpha|y_p^*} && F\left(y_n, y_n^*\right) \\ &\text{subject to} && f(y_n,y_p,\alpha) = 0 \\ &&& y_p = h(z^*) \end{aligned}$$

In the application at hand, the metric F takes the full vectors y and y^* as arguments, with higher weights for the partial sub-vectors, i.e. acknowledging that there is a trade-off between a perfect fit to the partial results and the rest of the solution vector.

2.2 Iterative solution and some potential problems

For technical reasons, the system (1) generally cannot be solved simultaneously. The models f and g are potentially implemented in different software, and the parameters δ, α and β are exogenous each time a model is solved. Instead of a simultaneous solution, the system can be solved iteratively. In its simplest form, an iterative solution algorithm involves the following steps:

Step 0: Set $i := 1$, $y^0 = y^*$, $z^0 = z^*$ (stars now indicating calibrated baseline values)

Step 1: Compute $\delta^i = \Phi(y_n^i, h(z^{i-1}), \alpha)$

Step 2: Solve $f(y^i,\delta,\alpha) = 0$ with respect to y^i given (δ,α)

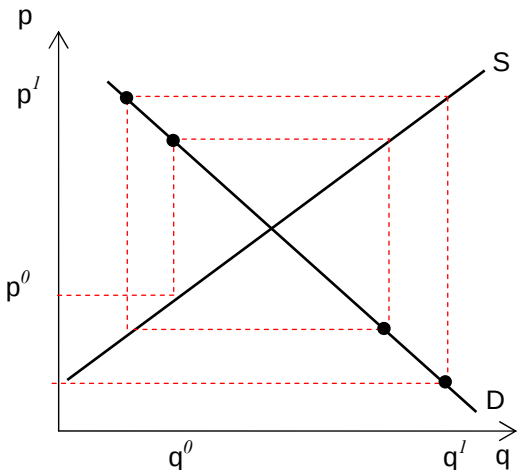
Step 3: Compute $\beta = \Gamma(y^i)$

Step 4: Solve $g(z^i;\beta) = 0$ with respect to z^i given β.

Step 5: Using some metric d, compute $DEV = d(z^i,z^{i-1})$. IF DEV < tolerance, THEN terminate, ELSE set $i := i + 1$ and go to step 1.

The simple algorithm outlined above need not converge even though a solution exists (which is assumed to be the case). One case when it may happen is when f_p are dropped and y_p fixed to $h(z)$ as discussed above. In that case, the familiar divergent cobweb model may result. That case is depicted in figure 2.1. The simple GE model in the figure contains only the demand schedule D and a market balance, and is solved for market clearing price at an exogenous supply quantity q, or D(p) = q. The supply quantity q is the result of the iteratively linked partial model, represented in the figure by the supply schedule S. Let p^0 be an initial price that enters the partial model, resulting in quantity q^0. That quantity in turns enter as fixed supply into the GE model, which is solved for price p^1, and so on. In the case shown by the figure, the model system will not converge, even though a unique equilibrium obviously exists. The black dots show the sequence of solutions to the GE model, and the dashed line shows the iterative solution path. One can see that the system only will converge if the slope of the supply schedule is greater than the (negative of the) slope of the demand schedule.

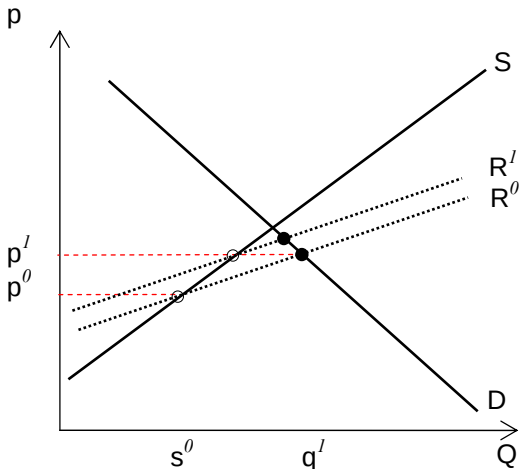
Figure 2.1: Cobweb with diversion. Demand schedule d symbolizes the GE model, supply schedule s the partial model, and the dashed line the iterative solution path.



In figure 2.1, the partial model was approximated inside the GE model by a constant supply, iteratively adjusted to the result of the true partial model. Those implicit *vertical supply schedules* were left out in the figure for clarity. There are better approximations than vertical lines. In figure 2.2 the partial model is iteratively approximated by a line R with finite positive slope *(dotted line)*, and this line is iteratively shifted to account for the last outcome of the partial model. The GE model now consists of D(p), R(p) and the market clearing condition $D(p) = R(p)$. Solid dots denote solutions to the GE model and empty dots solutions of the partial model.

Again, let p^0 be the initial price, inserted into the partial model S and resulting in the quantity $q^0 = S(p^0)$. The linear approximation R is shifted to run through the point (q^0,p^0) by re-computing the intercept of R. The operation of re-computing the intercept is the implementation of the function Φ previously mentioned. The GE model $D(p) = R(p)$ is solved, and the resulting equilibrium price p^1 is submitted to the partial model to start a new iteration. The reader can verify that the algorithm will converge under a wider range of slopes for R, i.e. in the figure the sequences of filled and empty dots will approach a common equilibrium.

Figure 2.2: Cobweb model with iterative linear approximations. Lower case s denotes quantity in the partial model.



Under some circumstances, the iterating system will not converge even with the linear approximation. That may happen if, in the example above, the demand schedule is close to vertical and/or the slope of the approximation *R* is very big. In such cases, some other/additional mechanism is required in order to find the equilibrium. One such mechanism is to work with partial adjustments[4]. If partial adjustment is implemented in the partial model, then the function Γ computing the parameter β (= p) is not, as in the figures above, just $p^i = p^{i-1}$ (as was the case in both the previous examples), but $p^i = \sum_{j=1}^{i-1} a_j p^{i-j}$, where a_j are weights that sum to one. For example, choosing $a_1 = 0.5$, $a_2 = 0.5$ and all other $a_j = 0$ implies taking the simple average of the last two iterations. The reader may try this on the cobweb model in figure 2.1, and will find that the system in that case would converge very quickly.

Both convergence methods—the iterative approximations and the partial adjustments—may be used simultaneously, and are then capable of handling a great range of possible situations.

[4] Partial adjustments in the sense that only a fraction of the current solution of the GE model is going into the new parameters of the partial model. Alternatively, this could be expressed as a "lagged expectation" in the partial model, though that term is loaded with too much economic content and suggests a misleading interpretation of iterations as "time".

3 A didactic example

General equilibrium as well as partial models can be set up in a multitude of ways. Thus, the current study is limited to models of a specific structure, as exemplified by didactic size GE and PE models, which are used throughout the paper.

The GE, with an initial SAM displayed in table 3.1, contains the producing sectors AG and REST, the factors *L* and *K*, and a final consumer C who owns all *L* and *K*. All prices are scaled to be "1" in the baseline. See appendix for behavioural equations. As can be seen in the SAM, the sector AG uses more labour in relation to capital than REST does, and constitutes a relatively minor share of the whole economy. The good AG is used directly by final consumers as well as by the sector REST.

Table 3.1: Social accounting matrix in baseline

	AG	REST	L	K	C	Revenues
AG	1	1			3	5
REST	1	5			70	76
L	2	20				22
K	1	50				51
C			22	51		73
Expenditures	5	76	22	51	73	227

The PE model contains a more detailed description of the agricultural sector, and also of the final demand for agricultural goods. The didactic model does this by splitting the GE good AG into two different goods called MAIZE and BEANS, for production as well as for consumption.

Table 3.2: Baseline data for the PE model

	A_BEANS	A_MAIZE	S	D	P
BEANS	5		15	15	0.15
MAIZE		4	28	28	0.1
REST			0	64.95	1
LAB	-3	-2	-23		0.05
LAND	-3	-7	-10		1
INCOME	2	2	20	70	

Baseline data for the PE model is given in table 3.2. The first two columns contain information for the production *activities*, and the first four rows contain information about the five *inputs or outputs*. Thus, in the upper left 4 × 2 matrix we have the I/O coefficients a_{ij}, where one hectare of the activity A_BEANS yields five tons of BEANS and requires three units of labour. In the row LAND, we see the number of hectares planted (its negative, for technical reasons). The column S contains the gross production or use for each of the rows obtained by multiplying the coefficients by LAND, except in the case of LAND itself, where it is the sum. Thus, 15 tons of BEANS and 28 tons of MAIZE were produced. The column D contains the demand for each good, and P the prices. In the row INCOME, the gross margin

per activity is shown in the first two columns. The consumer budget is shown in the intersection of the row INCOME with the column D, 70 money units.

The reader can compare this to the GE SAM in table 3.1, and see that the data is slightly inconsistent. For example, the consumer income in the PE is lower, and there is no use of intermediate agricultural products as is the case in the GE. The inconsistencies are deliberate, and serve to exemplify inconsistencies that are bound to occur in the case of real models. Those inconsistencies are handled by a joint baseline calibration procedure described below.

3.1 Linked items

The establishment of a model link requires two principle issues to be addressed. Firstly, *interfaces*, containing lists of items that are delivered as output of one model and used as inputs by the other, need to be defined. There will be one such interface for the link GE→PE (here termed "downward") and another for the opposite direction PE→GE (upward). Secondly, *algorithms* that incorporate the information sent over the link must be developed. This section establishes the interfaces, whereas the algorithms that convert information sent over the interface into the recipient models are developed in the following section.

With the hierarchical structure assumed here, where the PE is superior to the GE for everything that relates to the sector studied in the PE, the *downward* interface is the easier to implement: All items which are *exogenous* in the PE but endogenous in the GE are fixed in the PE to the outcomes of the GE. For items which are *endogenous* in the PE, any related GE results are ignored.

Table 3.3 lists all items that are required for establishing the downward interface. In this case, the GE has an endogenous price of labour, whereas the PE supply model treats the price of labour as fixed. The same holds true for the price of REST, the demand (but not supply) of which is modelled in the PE, and consumer income.

Table 3.3: Downward interface (GE→PE).

Interface item	GE variable	Linked PE parameters
Price_L	Price of L	Price of LAB
Price_REST	Price of REST	Price of REST
C_Revenues	Consumer income	Consumer income

Note: The left column lists the positions in the interface, sent by the GE, whereas the right column indicates the use of the information in the recipient model.

Note that the PE also computes demand for REST, which is better done by the GE. The only information concerning REST that is included in the downward interface is its price, but not its quantity. The reason for ignoring the quantity is that *its complement* is included in the upward link in the form of the aggregated output of AG, as described below.

The *upward* interface contains the input and output quantities, demand and prices of agricultural goods in the PE model, aggregated to a level comparable to that of agriculture in the GE model. In the example models, this implies total quantity of labour used, total supply and demand of the agricultural good, and the price index of all agricultural goods. Since there is no external trade, no government and no processing sector, and consumer prices are identical to producer prices, the distinction between supply and demand quantities and prices for agriculture becomes trivial. The distinction between demand and supply quantities is

maintained here for clarity and generality. The upward interface is summarized in table 3.4, where the last column indicates the use of the linked information in the GE.

Table 3.4: Upward interface (PE→GE).

Interface item	PE variable	Use in GE
AG_TOOU	Value of all agricultural outputs (price * quantity of maize plus beans)	Shift supply of AG sector
AG_DTOT	Total value of demand of agricultural goods	Re-calibrate demand and supply functions with respect to AG
AG_PRIC	Laspeyres price index using baseline quantities as weights	Re-calibrate demand functions with respect to AG
LAB_DEM	Total use of labour	Re-calibrate input demand of AG sector

3.2 Algorithms: how to use the linked information

In an ideal situation, the models would rely on identical drivers[5], yielding identical baseline forecasts for items that are common. Then the agricultural sector in the GE model would develop exactly as the aggregate agricultural sector in the PE model and so on. Unfortunately, the models are so different, including different functional forms, starting data, and a multitude of assumptions and auxiliary data sources, that a fully consistent baseline projection may not be feasible to obtain. The first problem is thus to devise a way of calibrating the models so that simulation of the baseline without a shock also delivers a stable solution.

Since the models, as will be described below, rely on the outputs of one another, the baseline calibration is not a trivial task. On the one extreme, the models could be coerced to reproduce fully identical solutions. This is here termed the harmonization approach. For reasons indicated above, full harmonization is not feasible in all cases. On the other extreme, the difference between the models could be accepted and interpreted as differences in definition of the underlying data. In the latter case, the ratio between the linked items (here termed the link ratio) is computed in the baseline and maintained in simulations. This is here termed the divergent approach. The divergent approach is easy to implement, and can be used in combination with harmonization. It is not desirable to chose the divergent solution for all positions, since that would obscure true data problems and errors. Which option has been chosen for each interface is further discussed below.

3.2.1 Downward algorithm GE→PE

The downward algorithm (i.e. the inclusion into the PE of the data sent over the link from the GE model) is straightforward, since the data from the GE is used as exogenous parameters in the PE. Concerning the *baseline calibration*, the divergent approach is opted for in the case of the linked prices, because the prices that come from the GE are price indices, whereas the prices of the PE are nominal. The divergent approach is thus implemented for the prices,

[5] By "drivers" we mean the exogenous factors which cause the model solutions to change from the base year (e.g. 2003 in the case of CAPRI) to the target year (2025).

implying that in the baseline calibration of the PE, the prices of the GE are ignored. Instead, the link ratio is computed for all prices in the downward interface and saved for later use in simulations.

In contrast to the linked prices, the consumer income is likely to be better computed in the GE, and is thus taken over in the baseline calibration of the PE. The human consumption of REST is adjusted so that it fits in the budget at the baseline price index of REST.

The algorithm for implementing the downward link in *simulation* is now: Replace the linked PE items (see table 3.3) by the value sent in the interface multiplied by the link ratio.

3.2.2 Upward algorithm PE→GE

When linking the models, one would, vaguely expressed, like to substitute the PE supply model for the AG column of the SAM, and the PE demand model for the AG row of the SAM, and then solve both models simultaneously. In most instances, this is technically not feasible, and in general also is not easily implemented due to differences in definitions and resolution. Instead, an iterative solution is required, with the objective to iteratively adjust the AG-equations of the GE in such a way that they ultimately make a perfect approximation to the aggregate behaviour of the PE in a small area around the equilibrium solution. Put differently: The iterative solution implies shifting the functions in the GE so that they run through the point which would result if the PE could have been fully included in the GE.

Before the upward algorithm is developed, the *baseline calibration* of the GE requires some attention. Since one point of the linking is to utilize the strengths of the PE within the GE, the PE baseline forecast for the AG sector should be taken into account when generating the GE baseline, in such a way that the GE baseline with respect to agriculture comes "as close as possible" to the PE results. Due to the requirement that the economy be in general equilibrium, the AG positions can only be modified at the expense of changes in other positions of the SAM. There are infinite possibilities of making such adjustments. The problem is a SAM balancing problem, treated in the literature (e.g. Golan, Judge and Robinson 1994).

One way of undertaking the SAM balancing problem is to apply a Bayesian approach (Jansson 2007). The Bayesian estimator employed is consisting of (i) a likelihood function represented by the SAM balance equations, which give a likelihood of “1” for SAMs that satisfy the balance equations and “0” else, (2) prior normal distributions of the elements of the SAM represented by normal distribution defined by assumed standard deviations 1/WEIGHT and means from the unbalanced SAM. We choose the SAM that maximizes the posterior, which is then equivalent to minimizing the weighted sum of squared deviations from the unbalanced SAM subject to balancing equations (see model BALSAM in appendix 1). The estimator does not match the PE data exactly, since this would discard too much of the given GE information, which certainly also has a value. The harmonization is thus partial, and the remaining differences are handled by the divergent approach (computation of link ratios).

In the present application, the output of the PE supply part as well as that of the PE market part is used in the GE. A straightforward solution, perhaps the one that first comes to mind, for integrating the PE results, is to treat them as exogenous in the GE. That would be equivalent to replacing the supply and demand functions for agriculture by constants. Despite its appeal such a solution has at least two drawbacks. One drawback is that it is not always possible to fix the variables of the GE. Take as an example the demand for agricultural products coming from the PE. In the GE, some of the demand takes place in the sector REST by a Leontief technology. Fixing that demand component would either fix the entire sector

REST, or require another technology. Another drawback is that the solution will be rigid. The iterative solution may converge slowly or even diverge.

If, instead of treating supply and demand for AG as constants, the functions are shifted to run through the point supplied by the PE, and if those functions behave qualitatively similar to the PE (i.e. same sign of main derivatives, e.g. increasing production if price rises etc.), the GE will be more flexible and to some extent anticipate the next PE solution.

Shifting the GE *supply functions* for AG implies adjusting the *AG column* of the SAM and the related behavioural equations. The following steps are proposed:

Step 1: *Input use*. Re-compute the input element *i* in the AG column of the SAM, by using the new AG output of the PE multiplied by the link ratio *R*, the GE Leontief coefficient *A*, and the price *P* of that input in the previous iteration. Or, $SAM_{i,'AG'} = (R_{AG\_TOOU}PE_{AG\_TOOU}/R_{AG\_PRIC}PE_{AG\_PRIC})A_{i,'AG'}P_{i,t-1}$.

Step 2: *Factor use*. Shift the use of all factors except labour in proportion to the change in total agricultural output. For labour, take the PE labour use in agriculture multiplied by link ratio directly.

Step 3: *Rents*. The previous steps is likely to result in an AG column in the SAM in which the total expenditure is not the sum of the previous rows. The main reason for this is that the PE does not make full accounting of costs. For example, capital is not in the PE, and land is only accounted for via dual values. All such differences are levelled out by re-calculating the input coefficient for REST so that the AG output of the PE is recovered precisely. This introduces new inconsistencies, since the price index of the subset of REST used in the PE will not equal the price of REST in the GE.

Step 4: Re-compute behavioural parameters so that the AG production implied by the PE would have been produced in the GE (c.p.) at the new PE AG price and the input prices of the GE in the previous iteration (they were the ones that were sent to the PE and resulted in the returned AG output).

Shifting the GE *demand functions* for AG implies adjusting the *AG row* of the SAM and the related behavioural equations.

Step 1: Shift the demand columns in the AG row except for internal demand of the AG sector itself (which was handled in the column wise shift above), so that the new AG total demand is recovered. Shift all columns by the same factor.

Step 2: Explain the change in demand for AG in other sectors as a change of the Leontief input coefficient.

Step 3: Re-compute behavioural demand parameters of final demand for AG so that c.p. the demand in the PE solution would have been recovered at the prices in the PE and the price of REST and total income of the last iteration.

4 Mapping CAPRI and GTAP to each other

A key step in linking models is to determine which variables or parameters refer to the same object in both models. Given the way in which the linking will proceed we need to establish the following concordances:

- Between CAPRI and GTAP regions.
- Between CAPRI and GTAP outputs or sectors.
- Between CAPRI intermediate inputs and GTAP outputs.
- Between CAPRI macro-economic drivers and GTAP variables.

4.1 Establishing a map between CAPRI and GTAP regions

4.1.1 Concordance of regions

The concordance between CAPRI and GTAP is created through a list of 226 countries. The full concordance by country is described in Appendix 2. Here we focus on the extent to which the regions used in the two models correspond with each other. The tables are based on the GTAP Version 7 database of November 2008 which has 113 regions and describes the world economy in 2004.

There are 47 countries that are distinguished in both models (see table 4.1), 15 regions distinguished in CAPRI which do not exist as such in GTAP although a same name may be used (see table 4.2) and 49 regions distinguished in GTAP which are not distinguished as such in CAPRI. Given the focus of SEAMLESS the main interest is in the 27 EU member states that are individual countries in both GTAP and CAPRI, and in the main competitors of the EU in agricultural markets (like Australia and New Zealand, Brazil, Canada and US). The parts of the aggregations that do correspond thus coincide with the third-country analysis in SEAMLESS focusing on the competitiveness of EU agriculture in relation to its main competitors in the agricultural markets.

A second part of the third-country analysis is the impact of EU agricultural policy on developing countries. To this purpose there is a Mali case study in SEAMLESS. Mali is a small country in terms of its economy and will therefore not affect international markets. In terms of the linking of models this implies that we do not need to consider feedback effects from the developing country models to GTAP and onwards to CAPRI. To serve the purposes of SEAMLESS it suffices to transmit changes in the global agricultural markets from GTAP to the developing country models.

Table 4.1: Matching regions in CAPRI and GTAP

CAPRI		*GTAP*	
Code	*Description*	*Code*	*Description*
DE000000	Germany	DEU	Germany
SE000000	Sweden	SWE	Sweden
FR000000	France	FRA	France
IR000000	Ireland	IRL	Ireland
DK000000	Denmark	DNK	Denmark
ES000000	Spain	ESP	Spain
EL000000	Greece	GRC	Greece

AT000000	Austria	AUT	Austria
FI000000	Finland	FIN	Finland
IT000000	Italy	ITA	Italy
UK000000	United Kingdom	GBR	United Kingdom
BL000000	Belgium	BEL	Belgium
		LUX	Luxembourg
NL000000	Netherlands	NLD	Netherlands
PT000000	Portugal	PRT	Portugal
CY000000	Cyprus	CYP	Cyprus
CZ000000	Czech Republic	CZE	Czech Republic
EE000000	Estonia	EST	Estonia
HU000000	Hungary	HUN	Hungary
LT000000	Lithuania	LTU	Lithuania
LV000000	Latvia	LVA	Latvia
MT000000	Malta	MLT	Malta
PL000000	Poland	POL	Poland
SI000000	Slovenia	SVN	Slovenia
SK000000	Slovak Republic	SVK	Slovakia
BG000000	Bulgaria	BGR	Bulgaria
RO000000	Romania	ROM	Romania
AL000000	Albania	ALB	Albania
HR000000	Croatia	HRV	Croatia
NO000000	Norway	NOR	Norway
USA	USA	USA	United States of America
CAN	Canada	CAN	Canada
MEX	Mexico	MEX	Mexico
VEN	Venezuela	VEN	Venezuela
ARG	Argentina	ARG	Argentina
BRA	Brazil	BRA	Brazil
CHL	Chile	CHL	Chile
URU	Uruguay	URY	Uruguay
PAR	Paraguay	PRY	Paraguay
BOL	Bolivia	BOL	Bolivia
IND	India	IND	India
JAP	Japan	JPN	Japan
ANZ	Australia and New Zealand	AUS	Australia
		NZL	New Zealand
MOR	Morocco	MAR	Morocco
TUN	Tunesia	TUN	Tunisia
EGY	Egypt	EGY	Egypt
TUR	Turkey	TUR	Turkey
RBU	Russia, Belarus and Ukraine	RUS	Russia
		BLR	Belarus
		UKR	Ukraine

Table 4.2: Regions in CAPRI that not fully match with GTAP regions

Code	*Description*	*Presence in GTAP*
MK000000	Macedonia	Part of rest of Europe (XER)
CS000000	Serbia	Part of rest of Europe (XER)
MO000000	Montenegro	Part of rest of Europe (XER)
BA000000	Bosnia and Herzegovina	Part of rest of Europe (XER)
KO000000	Kosovo	Not in GTAP mapping
CHN	China	China and Hong Kong are regions in GTAP, Macua is part of Rest of East Asia (XEA)
REU	Rest of Europe	Region with same name exists in GTAP but has different definition
ALG	Algeria	Part of rest of North Affrica (XNF)
ISR	Israel	Part of rest of Middle East (XME)
LDC	LDC	
ACP	ACP non LDC	
ROW	Rest of world	
RSA	Rest of South America	

4.1.2 Aggregation of regions in the linked model system

Generally the number of regions in a GTAP model needs to be restricted to about 25 for technical reasons. The choice of regions modelled in detail and those combined in an aggregate is driven by the focus of the study. The choice of regions (and sectors) is facilitated by a complete separation of model and data in GTAP and the provision of a program that aggregates the GTAP database to the model specifications. Changing the model aggregation is therefore a standard and quick procedure in GTAP.

Aggregating regions is not so straightforward in CAPRI. It is therefore preferable to maintain all CAPRI regions in the GTAP model. This would result in a rather large number of regions (the 45 CAPRI regions in table 4.1 plus the ten aggregated CAPRI regions in table 4.2 for which we created a proxy in GTAP). Having 55 regions in the GTAP model used for SEAMLESS appears feasible given that CAPRI will be used to model the agricultural sector and all agricultural sectors in GTAP will be combined. This implies that a rather standard GTAP model may be used without any complexities in the agricultural sector. Since the focus of SEAMLESS is on the agricultural sector there is also no need to have a very detailed representation of the non-agricultural sector. The dimensions of the model in terms of sector detail would therefore be limited allowing room for a larger number of regions than usual in GTAP models.

The regional aggregation used in GTAP would then comprise the 45 regions in table 4.1 (combining Australia plus New Zealand and Belgium and Luxembourg in a single GTAP region to match the specification in CAPRI) plus the ten aggregated regions in table 4.2. To complete the regional mapping in GTAP we need to map 49 remaining GTAP regions to those of CAPRI in table 4.2 This mapping is done on the basis of creating the best possible match in countries comprised in the aggregate using the mapping of individual countries to GTAP and CAPRI in Appendix 1. The resulting mapping from GTAP to CAPRI is presented in table 4.3.

Table 4.3: Mapping GTAP regions to aggregated CAPRI regions

CAPRI		*GTAP*		*Comment*
Code	*Name*	*Code*	*Name*	
NO000000	Norway	XEF	Rest of EFTA	Best available proxy in GTAP
MK000000	Macedonia			Not included in GTAP, use results from REU in CAPRI
CS000000	Serbia			Not included in GTAP, use results from REU in CAPRI
MO000000	Montenegro			Not included in GTAP, use results from REU in CAPRI
BA000000	Bosnia and Herzegovina			Not included in GTAP, use results from REU in CAPRI
KO000000	Kosovo			Not included in GTAP, use results from REU in CAPRI
CHN	China	CHN	China	
		HKG	Hong Kong	
REU	Rest of Europe	CHE	Switzerland	
		XER	Rest of Europe	
		XEF	Rest of EFTA	
RBU	Russia, Belarus and Ukraine	RUS	Russian Federation	
		XSU	Rest of Former Soviet Union	Contains Belarus and Ukraine
ALG	Algeria	XNF	Rest of North Africa	Best available proxy in GTAP
ISR	Israel	XME	Rest of Middle East	Best available proxy in GTAP
LDC	LDC	BGD	Bangladesh	
		XSA	Rest of South Asia	Countries map to CAPRI regions as 2 LDC, 2 ROW
		MWI	Malawi	
		MOZ	Mozambique	
		TZA	Tanzania	
		ZMB	Zambia	
		XSD	Rest of Southern African Devel	Countries map to CAPRI regions as 1 LDC, 1 ACP, 1 ROW
		MDG	Madagascar	
		UGA	Uganda	
		XSS	Rest of Sub-Saharan Africa	Countries map to CAPRI regions as 25 LDC, 5 ACP, 3 ROW
ACP	ACP non LDC	XOC	Rest of Oceania	Countries map to CAPRI regions as 9 ACP, 8 ROW, 5 LDC
		XFA	Rest of Free Trade Area of Ame	Countries map to CAPRI regions as 7 ROW, 6 ACP, 1 LDC
		BWA	Botswana	
		ZAF	South Africa	
		XSC	Rest of South African Customs	Countries map to CAPRI regions as 2 ACP, 1 LDC
		MUS	Mauritius	
		ZWE	Zimbabwe	
		NGA	Nigeria	
		SEN	Senegal	
ROW	Rest of world	KOR	Korea	
		TWN	Taiwan	
		XEA	Rest of East Asia	Countries map to CAPRI regions as 2 ROW, 1 CHN

		KHM	Cambodia	
		IDN	Indonesia	
		MYS	Malaysia	
		PHL	Philippines	
		SGP	Singapore	
		THA	Thailand	
		VNM	Viet Nam	
		XSE	Rest of Southeast Asia	Countries map to CAPRI regions as 4 ROW
		PAK	Pakistan	
		LKA	Sri Lanka	
		XNA	Rest of North America	Countries map to CAPRI regions as 3 ROW
		XSM	Rest of South America	Countries map to CAPRI regions as 2 ROW, 2 ACP
		XCB	Rest of the Caribbean	Countries map to CAPRI regions as 10 ROW, 1 ACP
		IRN	Iran, Islamic Republic of	
RSA	Rest of South America	COL	Colombia	
		ECU	Ecuador	
		PER	Peru	
		XCA	Central America	Countries map to CAPRI regions as 4 RSA, 2 ROW, 1 ACP

Note: in addition to these aggregated regions all CAPRI countries listed in table 4.1 will be included in the model

Neither GTAP nor CAPRI distinguishes Mali (a case study county in SEAMLESS) as an individual country. Even a recent GTAP database providing more detail on African countries does not have data on Mali. Lacking any data on Mali we need to rely on the results for the LDC aggregate as a proxy of the effects of global changes on Mali. Given the limited size of the Malian economy no feedback of changes in Mali on the global economy are expected . In case a national CGE model for Mali is used to capture the effects on the Mali economy we only need information on changes in global prices to assess in more detail their impact in Mali which makes the absence of Mali from the global model less restrictive than it appears at first sight.

4.2 Establishing a map between CAPRI and GTAP sectors

The proposed methodology for linking CAPRI and GTAP will rely on CAPRI to model international agricultural markets, while GTAP deals with the (international) feedback between the agricultural and non-agricultural sectors. In terms of establishing a concordance between CAPRI and GTAP sectors different issues are at stake, depending on which part of the linking we focus on.

In case of agricultural sectors CAPRI will model the agricultural markets in detail whereas in GTAP there will be an aggregate representation of agriculture through a single agricultural sector. The input-output structure of this agricultural sector will be obtained from CAPRI. In the case of the agricultural sector we thus need to check to what extent GTAP's agricultural sectors are covered by CAPRI's agricultural sectors (section 4.2).

In case of intermediate (i.e. non-agricultural) inputs in CAPRI's agricultural production we aim at deriving price changes from GTAP's economy-wide modeling. In this case we need to establish which GTAP sectors best capture the price changes of intermediate inputs in

CAPRI. Here the focus is on establishing to what extent CAPRI's sector are covered by GTAP (section 4.3).

4.2.1 Coverage of GTAP agricultural sectors by CAPRI

In order to establish the extent to which GTAP agricultural sectors are covered by CAPRI we created a concordance between CAPRI and GTAP through 6-digit HS 1996 concordance available for both models. The details of this concordance are presented in Appendix 3. Here we focus on the implications for linking.

GTAP distinguishes 20 agricultural sectors (12 primary and 8 processed). The linking is based on aggregating these 20 sectors to one agricultural sector in GTAP, while CAPRI models agriculture in detail. We thus need to assess to what extent the 20 agricultural GTAP sectors are covered by CAPRI. Of these 20 sectors, Raw milk has no HS codes associated with it because of lack of international tradability of unprocessed milk.

Next to the coverage of GTAP agricultural sectors, the mapping also indicated that five HS codes that are part of agriculture in CAPRI are classified in non-agricultural sectors in GTAP. The CAPRI sector other oil has the HS code 151800 associated with it (Animal or vegetable fats and oils and their fractions). In GTAP this HS code is mapped to Chemical, rubber, plastic products (crp), together with 986 other HS codes. Similarly, there are three HS codes linked to the Flower sector in CAPRI which in GTAP are mapped to the Forestry sector (frs): Foliage, branches and other parts of plants (060499), Mosses and lichens for bouquets or for ornamental purposes (060410) and Fresh foliage, branches and other parts of plants (060491). Since five codes are considered part of agricultural production in CAPRI but non-agricultural in GTAP, replacing agricultural production in GTAP by CAPRI will result in double-counting of these five HS codes. Given their limited size compared to the rest of the economy this will not affect the results.

We then turn our attention to the coverage of agricultural HS codes in GTAP by CAPRI. The first thing to note is that there is no easy concordance between CAPRI and GTAP sectors. There is only one sector (paddy rice) where both models use the same sector definition in terms of HS codes. In all other cases CAPRI sectors appear with several GTAP sectors. This provides the rationale for using an aggregate representation of agriculture in GTAP, which avoids the need to map (part) of CAPRI sectors to GTAP sectors.

To assess the extent to which an aggregate representation in GTAP would be covered by CAPRI figure 4.1 presents the share of HS codes in GTAP covered by CAPRI sectors. Of the 19 GTAP sectors five are completely covered by the CAPRI sectors: paddy rice, wheat, cereals, vegetables, fruits & nuts, processed rice. On the opposite extreme there are two GTAP sectors that are not covered by the CAPRI sectors: plant-based fibers, wool and silk-worm cocoons.

In the context of SEAMLESS it appears useful to keep the plant-based fibers as a separate sector since it includes cotton. This is a main area of contention in the WTO negotiations (related to US support of its cotton producers) and cotton is an important crop in Mali (the developing country case study country within SEAMLESS).

The other 12 GTAP sectors are partially covered with less than half of the sectors covered by CAPRI in five cases (percent of HS lines covered in brackets): sugar cane and beet (50 percent), crops nec (41 percent), animal products nec (21 percent), food products (34 percent), beverages and tobacco (6 percent).

The discussion so far has focused on the number of HS codes in each of the model classifications. It may however be that HS codes not included in CAPRI are of little economic significance. In this case replacing the data on agriculture from GTAP with CAPRI

results would not be a problem even if only part of the HS codes would be covered. We can only assess the significance of sectors in terms of trade volumes since production data are not available at such a level of detail. We therefore analyzed the amount of trade covered by the HS codes included in CAPRI and compare these with those in GTAP.

We used the BACI dataset which records bilateral trade at 6 digit level and country (which is based on COMTRADE trade data, see for more information www.cepii.org). We used the data for 2001 and summed all trade over all reporters, i.e. we looked at global trade in order to gauge the differences between CAPRI and GTAP. Figure 4.2 presents the coverage of HS lines in each GTAP sector by CAPRI next to CAPRI's coverage in terms of trade (both in percentage terms to allow a direct comparison).

At the right-hand side of figure 4.2 we find that 53 percent of HS lines and 55 percent of trade covered by the agricultural sectors in GTAP is covered by CAPRI as well. This average however obscures big differences across sectors.

4.2.2 Mapping agricultural sectors from CAPRI to GTAP

Table 4.4 groups the GTAP sectors in terms of their coverage by CAPRI and summarizes the implications for modelling. In terms of the envisaged linking with a single agricultural sector in GTAP there appears no problem for the first 12 sectors in table 4.4 where at least 84 percent of trade (and in many cases much more) is covered by CAPRI's sectors. In the case of sugar cane, raw milk and wool there is (almost) no trade indicating that these can be included in the aggregate sector without affecting the results. In the case of other crops and food products there is a bias in the sense that GTAP includes fish products here which are not part of CAPRI. Of the other HS lines CAPRI does include similar lines or there is a good concordance in terms of related primary products (like the grains). These sectors could therefore also be included in the aggregate sector. Similar argumentation can be applied to the animal products sector, where there is a bias in terms of hides and furskins (production of which is related to other livestock production with a good concordance) or there are lines which are not modelled well by GTAP.

In the case of beverages and tobacco CAPRI covers only malt and none of the other lines. This is a relatively large sector in terms of trade (10%) and it is therefore proposed to keep this sector outside of the agricultural aggregate.

Figure 4.1: Coverage of agricultural HS codes in GTAP by CAPRI (number of HS lines by GTAP sector covered by CAPRI)

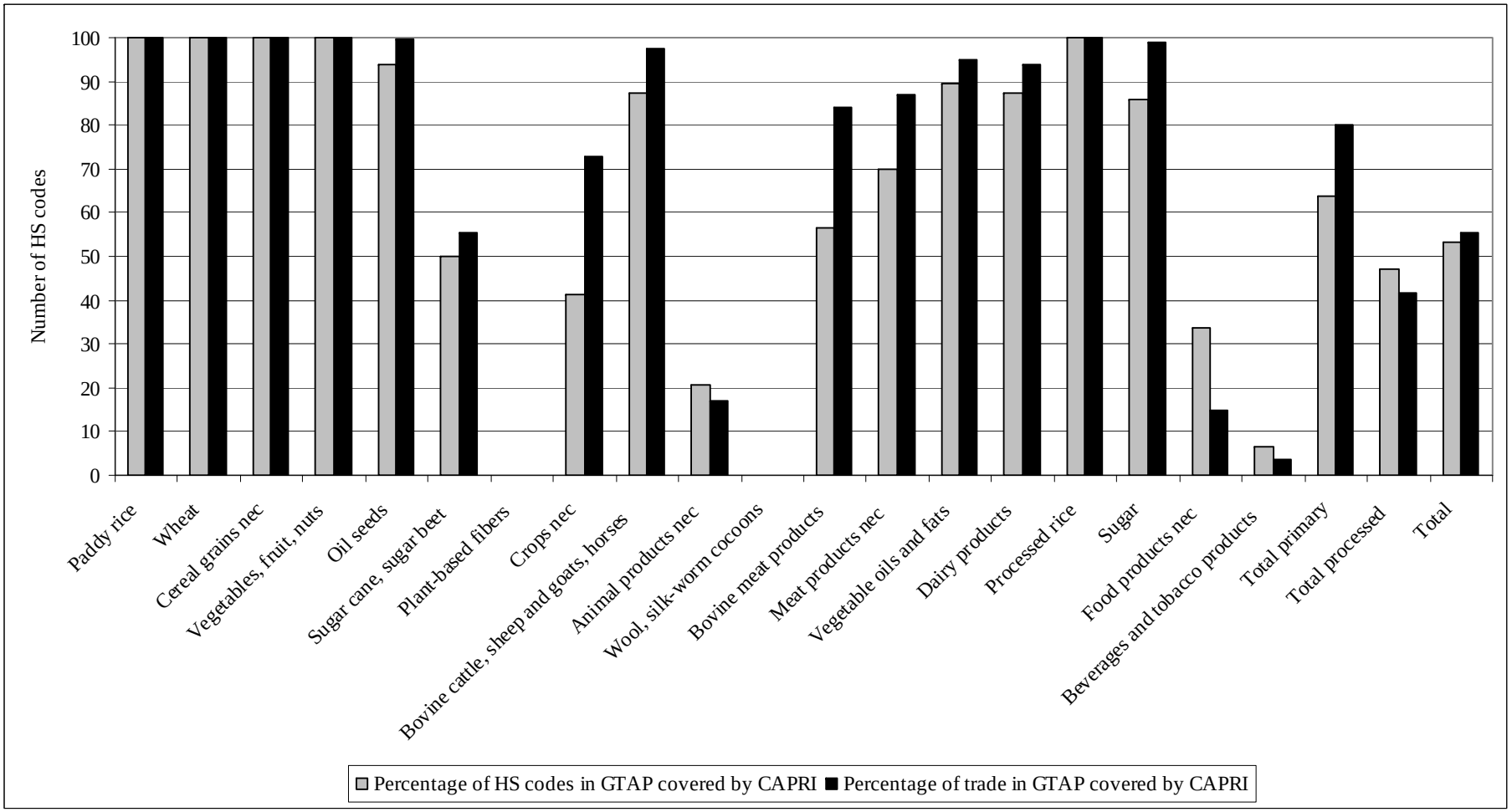


Figure 4.2: Coverage of agricultural HS codes in GTAP by CAPRI (% of HS lines and % of trade by GTAP sector covered by CAPRI sectors)

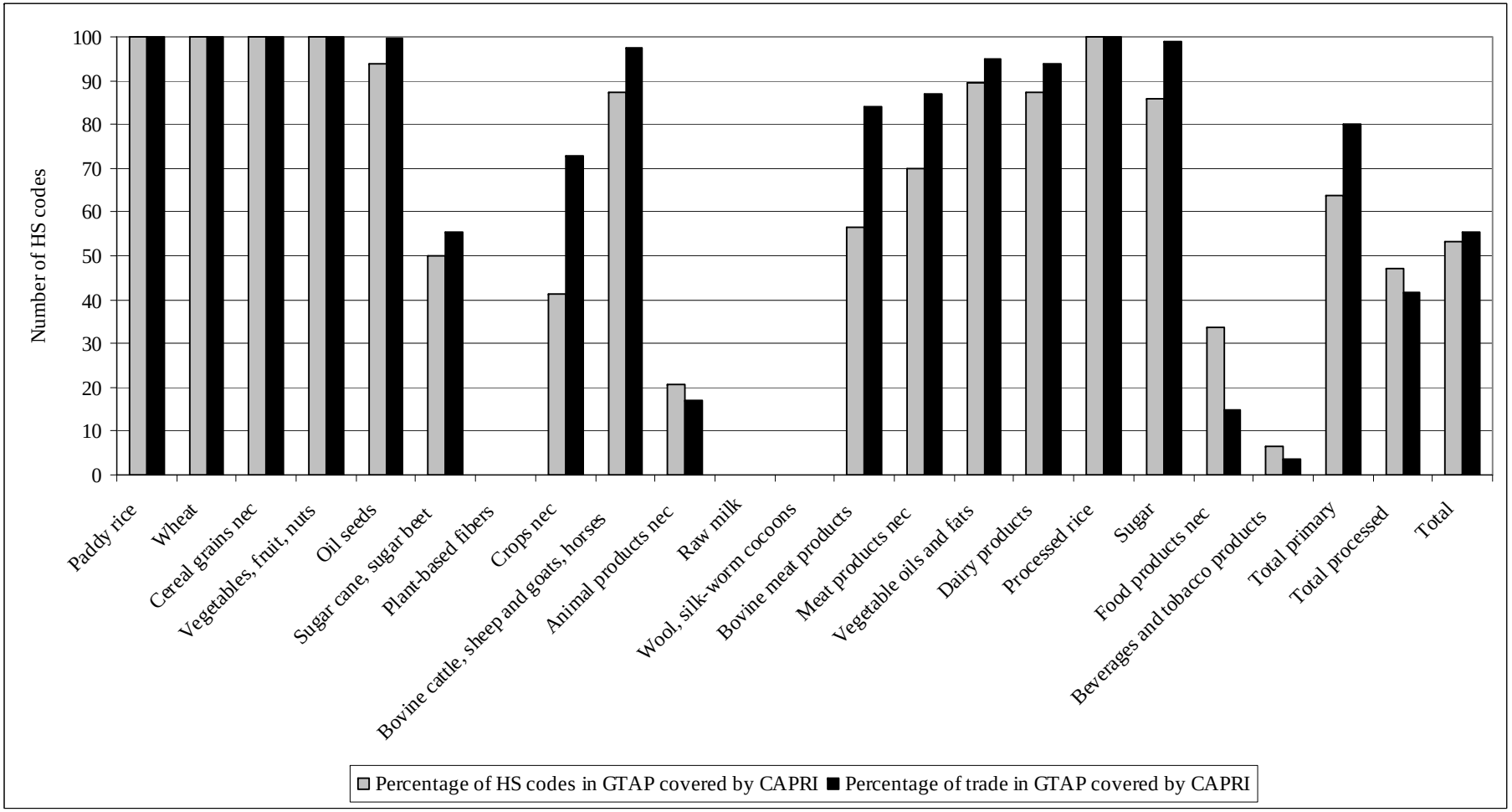


Table 4.4: Concordance of agriculture between CAPRI and GTAP

Coverage	*GTAP sectors*	*Implications for linking*
> 98 % of trade	Paddy rice	-
	Wheat	-
	Cereals	-
	Vegetables, fruits and nuts	-
	Oil Seeds	-
	Bovine cattle, sheep & goats, horses	-
	Processed rice	-
	Sugar	-
84 - 95% of trade	Bovine meat products	-
	Meat products nec	-
	Vegetable oils and fats	-
	Dairy products	-
56 – 73% of trade	Sugar cane and sugar beet	CAPRI models sugar beet and not sugar cane. There is however no international trade in cane or beets and there is a good concordance between the models in terms of sugar.
	Crops nec	GTAP includes processed fish products here as well, apart from a number of processed agricultural products not covered by CAPRI.
4 - 17% of trade	Animal products nec	Limited coverage by CAPRI of furskins and hides and 'unusual' products like frog legs etc.. More common products (live poultry, swines and eggs) are covered.
	Food products nec	Apart from a wide variety of preparations of foods, CAPRI does not cover a whole range of preparations of fish. This is one of few cases where coverage in terms of trade is significantly lower than coverage in terms of HS codes. Large trading category (30 % of agricultural trade).
	Beverages and tobacco products	CAPRI only covers malt and none of the beverages included in this sector by GTAP (10% of agricultural trade).
0% of trade	Plant-based fibres	Keep separate because of importance of cotton for WTO and Mali case
	Raw milk	No international trade in raw milk and probably captured by CAPRI's dairy sector.
	Wool, silk-worm cocoons	Not a major trading category (<0.57% of global trade) and can be ignored

Finally, plant-based fibres composes only a small part of international trade (1.86 percent), but cotton forms an important part of the Doha round and is an important crop for Mali (the case study country in SEAMLESS). Therefore it is proposed to keep plant-based fibres also outside the aggregate to allow an assessment of the impact of an WTO agreement on cotton on Mali.

The result in terms of concordance would then be that all CAPRI's agricultural sectors map into a single agricultural GTAP sector. Next to this agricultural sector the GTAP model would include beverages and tobacco and plant-based fibres as separate sectors. These sectors have no direct concordance with CAPRI, but may be linked through the use of inputs from or supply of outputs to the agricultural sector.

4.2.3 Sector aggregation used in GTAP

The discussion on sectors so far has focussed on agriculture. Besides agriculture the GTAP database also contains 37 manufacturing and services sectors. Given our intent to include a large number of regions to facilitate the mapping to CAPRI the number of sectors in the GTAP models needs to be restricted as much as possible. There are very limited possibilities for linking non-agricultural intermediate inputs from CAPRI to GTAP sectors due to incompatibilities of definitions (see secton 4.2.4 for more detail). We therefore have no reason for keeping specific non-agricultural sectors separate. We propose the following grouping in four non-agricultural sectors: natural resource extraction, labour intensive manufacturing, capital intensive manufacturing, and services. This rather coarse grouping does capture key characteristics (reliance on natural resources, factor intensity and tradability) important for the supply response.

To summarize the discussion on sector aggregation in GTAP table 5.2 presents the sector aggregation that will be used in the GTAP model.

Table 4.5: Sector aggregation in the GTAP model

No.	*Code*	*Description*	*Old sectors*
1	Agri	Primary & processed agriculture	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Crops nec; Cattle,sheep,goats,horses; Animal products nec; Raw milk; Wool, silk-worm cocoons; Meat: cattle,sheep,goats,horse; Meat products nec; Vegetable oils and fats; Dairy products; Processed rice; Sugar.
2	PFood	Processed food and beverages	Food products nec; Beverages and tobacco products.
3	Fibers	Cotton and other fibre crops	Plant-based fibers.
4	Extract	Natural resource extraction	Forestry; Fishing; Coal; Oil; Gas; Minerals nec.
5	LabMan	Labor intensive manufacturing	Textiles; Wearing apparel; Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec.
6	CapMan	Capital intensive manufacturing	Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and equipment nec; Manufactures nec.
7	Svces	Services and activities NES	Electricity; Gas manufacture, distribution; Water; Construction; Trade; Transport nec; Sea transport; Air transport; Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings.

4.3 Other links between CAPRI and GTAP

The discussion above detailed the concordance between the regions and sectors of CAPRI and GTAP providing the main basis for linking the two models. In addition we need to establish possible links between the models through non-agricultural intermediate inputs in agricultural production and exogenous drivers present in both models.

Having established a mapping of GTAP agricultural sectors to CAPRI we now turn to establishing a mapping of CAPRI's intermediate inputs to GTAP sectors. The focus here is on non-agricultural inputs with exogenous prices due to the agricultural focus of CAPRI. Table 4.6 lists these inputs and related GTAP sectors. Appendix 3 provides a detailed description of GTAP's non-agricultural sectors to assess to what extent the link to CAPRI sectors can actually be made. This description forms the basis for the provisional mapping in table 4.6.

In order to create a more generic interface for shocking inputs in CAPRI, the inputs are linked in two steps. First, an intermediate set of only six inputs is created. Those are shown in the middle column of the table. Then a concordance is established between inputs of each model and those six generic inputs. Those lists are shown in the left and right columns.

Table 4.6: Intermediate inputs with exogenous prices in CAPRI

CAPRI	Long name	Link	GTAP	Long name
FGRA	Gras	gpagr	agri	Agriculture
FMAI	Fodder maize			
FOFA	Fodder other on arable land			
FROO	Fodder root crops			
FCOM	Milk for feeding			
FSGM	Sheep and Goat Mikl for feeding			
FSTR	Straw			
FCER	Feed cereals			
FPRO	Feed rich protein			
FENE	Feed rich energy			
FMIL	Feed from milk product			
FOTH	Feed other			
ICAM	Male calves			
ICAF	Female calves			
IHEI	Young heifers			
ICOW	Young cows			
IPIG	Piglets			
IBUL	Young bulls			
ILAM	Lambs			
ICHI	Chicken			
NITF	Nitrate fertilizer	gpnser	PFood	Processed food
PHOF	Phosphate fertilizer		Fibers	Fibres
POTF	Potassium fertilizer		Extract	Extraction
SEED	Seed		LabMan	Labour intensive manufacturing
PLAP	Plant protection		CapMan	Capital intensive manufacturing
ELEC	Energy as electricity			
EGAS	Energy as gas			
EFUL	Energy as fuels			
ELUB	Energy as lubricants			
INPO	Other inputs			
IPHA	Pharmaceutical inputs			
REPM	Repairs of machinery	gpser	Svces	Services
REPB	Repairs of buildings			
SkLab	Skilled labour	SkLab	SkLab	Skilled labour
UnSkLab	Unskilled labour	UnSkLab	UnSkLab	Unskilled labour
Capital	Capital	Capital	Capital	Capital

Mapping of the CAPRI intermediate inputs to GTAP sectors is not straightforward due to a rather different focus. The non-agricultural inputs in CAPRI are more detailed and clearly linked to agriculture, whereas the non-agricultural sectors in GTAP cover much more ground since they aim at covering all non-agricultural production in the economy. The mapping in Table 4.6 attempts aims at finding the best possible corresponding GTAP sector for each CAPRI intermediate input.

Correspondence is rather limited in most cases. For example, of the HS codes referring to fertilizers that are included in the Chemical sector (CRP) of GTAP only comprise 2 percent of the HS codes in this sector.

Given the rather incompatible definitions of sectors we propose to not link CAPRI intermediate inputs to a specific GTAP sector but to construct a price-index covering several sectors. To be more specific we aggregate the non-agricultural sectors in GTAP into only four sectors (extraction, labour intensive manufacturing, capital intensive manufacturing and services) which will yield four possible sources of price changes of CAPRI's intermediate inputs. When creating the link between GTAP and CAPRI for each intermediate input the price changes in the four non-agricultural GTAP sectors need to be combined in a single price index. This could be a simple average, a price weighed with the size of the sectors or a weighing that varying by intermediate inputs based on an estimation of the relative importance of each of the non-agricultural sectors by input.

The final component of the linking is to establish the link between macro-economic variables in CAPRI and variables in GTAP. These can partly be endogenous variables in GTAP, in which case there is an additional aspect of the economy-wide interactions affecting CAPRI simulations. In other cases these macro-economic drivers are exogenous in both models, in which case we need to assure that these drivers are made consistent to the extent possible in both models when developing a baseline.

There are two main macro-economic drivers of demand in CAPRI that can be obtained from GTAP:

- GDP: GDP (INCE in CAPRI) can be obtained from the standard GTAP results
- Prices of non-agricultural goods: based on the GTAP results a price-index for non-agricultural goods can be constructed and used in CAPRI

The reader may have noticed that capital and labour do not occur at all among the inputs listed for CAPRI. This is because there is no explicit modeling of capital and labour. It is assumed that the influence of capital and labour is captured by the behavioural function in the supply model. The behavioural function is a quadratic term that is added in the objective of the representative regional farm, and that is intended to capture all effects that are not explicitly in the model, thus making its supply response resemble observed behaviour.

Both models share a number of drivers that are exogenous in both (population and endowments of land). Porjected changes in these endowments need to be made consistent in case of developing (baseline) scenarios.

5 Technical implementation of the full-scale linking

Chapters 2 and 3 addressed in general terms the linking of partial and general equilibrium models, followed by the first step of a full scale link by mapping regions and sectors of CAPRI and GTAP. In this chapter we combine these two parts into describing the technical implementation of the linking of CAPRI and GTAP, and the necessary changes that were made to either model.

5.1 Information flow in the linked system

Linking the models unfortunately requires as much (or perhaps more) software development as economic theory. Albeit the focus here be on content, not on form, some words have to be spent on the technical realization.

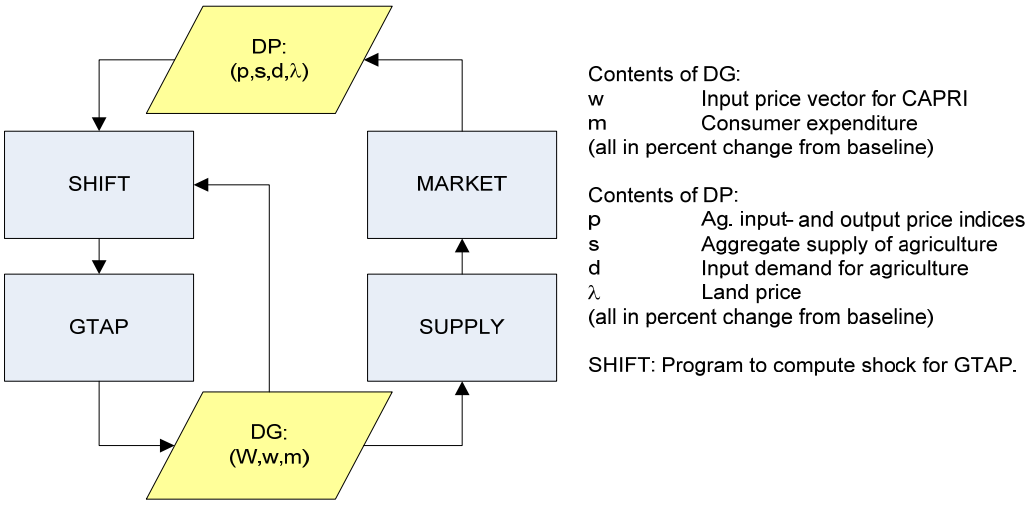
In the FP6 integrated framework project "SENSOR", CAPRI was iteratively linked with the model NEMESIS. Two important lessons, of relevance for the current model link, can be learnt from the implementation in that project:

1. In SENSOR, the entire CAPRI model was "encapsulated" in the link. Thus, NEMESIS had to wait for a complete solution of CAPRI before the next iteration could be commenced. In practice, this caused each simulation to require several hours of computation, which was detrimental for simulation experiment as well as for the model development process.
2. The way the link was implemented required many modifications of the CAPRI model code, which made maintenance difficult.

Within the current project, we opt for an approach which assumes that both models (CAPRI and GTAP) run on the same physical machine, which diminishes the technical overhead significantly, and allows for a simpler integration of the models. At the same time, an approach is opted for which restricts necessary code changes of each model to well defined domains in order to reduce maintenance costs.

In practice, the solution chosen utilizes the internal structure of CAPRI. CAPRI is, as is mentioned above, solved by iteration between a supply and a market part. This structure is utilized in the link with GTAP, by inclusion of GTAP as a new module to solve in the iterations, with the specific task of endogenizing input prices, consumer budget and the consumer price index. The algorithm is illustrated in figure 5.1.

Figure 5.1: Information and control flow in the linked model system.



In the figure, we follow the notation usually used in GTAP, denoting the absolute value of a variable by an upper case letter and letting the lower case version of the same letter denote percent change. Thus, if W is the vector of input prices computed in GTAP, then w is the vector of percentage change of those prices.

The solution process starts in the SUPPLY module, which computes the supply of primary agricultural goods on regional level within the EU. The supply is aggregated to member state level, and the supply functions of the MARKET module are recalibrated to replicate the solution of the supply model. Then the MARKET module is solved for market clearing prices, using linear approximations to the last outcome of the SUPPLY model.

The process so far is standard CAPRI procedure. However, after the MARKET module has been solved, the results are aggregated (across products) to the level in GTAP. This implies computing a price index P a volume index S, input use D, and land rent λ, and the percent change in those indices relative to the (CAPRI) baseline. Note that the use of percent change implies the "differential approach" to calibration, i.e. any differences between *absolute* levels of variables are ignored.

Consistent indices are computed in three steps, based on a reference-run-weighted Laspeyres price index and the requirement that price index times volume index yields a nominal value index of outputs:

$$P = \frac{\sum_i P_{i,sim} S_{i,ref}}{\sum_i P_{i,ref} S_{i,ref}}$$

$$\text{Value } V = PS = \frac{\sum_i p_{i,sim} s_{i,sim}}{\sum_i p_{i,ref} s_{i,ref}}$$

$$S = \frac{V}{P} = \frac{\sum_i p_{i,sim} s_{i,sim}}{\sum_i p_{i,sim} s_{i,ref}}$$

$$p = 100(P - 1)$$

$$s = 100(S - 1)$$

The second line, defining value *V* as *PQ* and also as the ratio on the right hand side is key in deriving the quantity index *S* in a consistent way. The input demand index *D* is derived in a way similar to *S*. The computation of percentage change is straightforward since all baseline values of the indices are "1".

The values are written to a HAR[6] file, called DP in the figure, and then CAPRI calls a batch command file that executes SHIFT and GTAP. SHIFT uses DP and the previous iteration's outcome of GTAP to compute the shock to technical coefficients of GTAP that are such that "at the prices of intermediate inputs and endowments stored in DG, a partial closure of GTAP containing only the agricultural production sector would have produced the outcome of DP".

When GTAP finishes by replacing the contents of DG[7]. CAPRI resumes execution and reads DG. In order to be able to compute the percentage change of the price of the aggregated inputs that are used as an intermediate stage in the mapping, also the absolute levels of the input prices *W* are required. CAPRI uses the percentage change in consumer expenditure *m* and input prices *w* to make the required shifts of exogenous variables, and then starts a new iteration by solving the SUPPLY model, the MARKET model as described above.

In each iteration, the standard CAPRI convergence check is executed, consisting of a computation of the maximum change in the absolute value of the percentage change of all prices in the MARKET model. If the maximum change between two consecutive iterations is less than 10 euro cents OR 15 iterations have been carried out, the process terminates.

5.2 Modifications to CAPRI for linking

Two kinds of CAPRI were needed in order to implement the shifting.

Firstly, no "task manager" is shown in figure 2.3. It is because the implementation is such that the whole solution process takes place inside CAPRI, where GTAP is called as a sub module. This requires that CAPRI gets three new subroutines, each represented in GAMS by an "include file". The tasks of the three include files are to

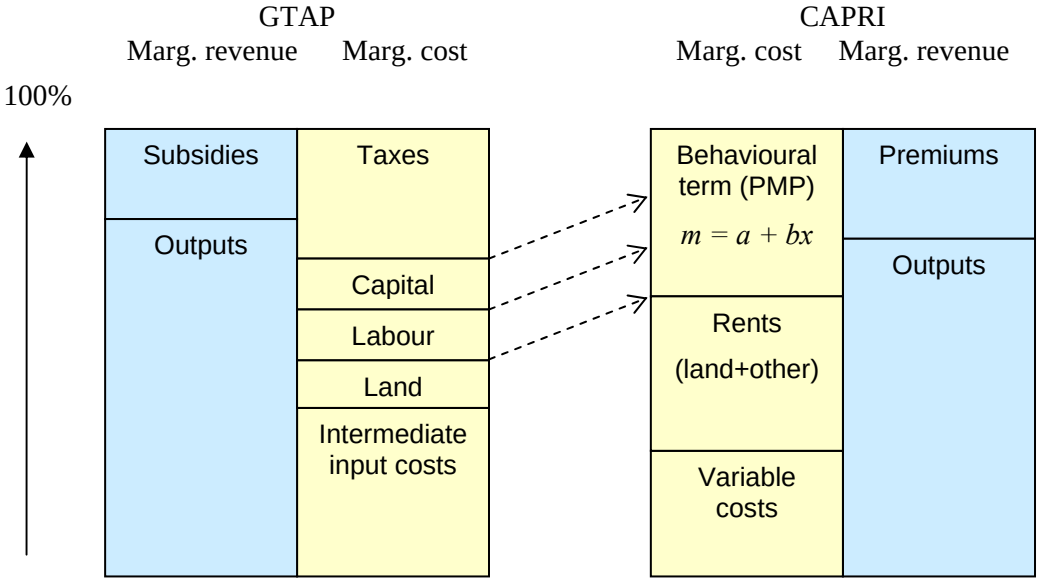
1. Declare sets and parameters used in the link, and compute labour and capital use per activity in CAPRI in the baseline (see also below)
2. Read DG, aggregate to the proper level, and shift exogenous parameters in CAPRI
3. Compute price and quantity indices for DP and execute the SHIFT-GTAP batch command file.

Secondly, the SUPPLY model of "standard CAPRI" does not include labour and capital costs, as it is working by maximization of gross value added plus premiums and the use of capital and labour in agriculture is generally a small share of the total resource base in European countries. Nevertheless, when agriculture is connected to the rest of the economy via GTAP, then changes in factor prices may well occur, for example as a consequence of non-agricultural shocks. The endowments linked were Capital, Skilled Labour and Unskilled Labour. To facilitate discussion, we henceforth refer only to "capital and labour".

[6] CAPRI is written in GAMS. Thus, we first write a GDX file (GAMS data exchange), and then call the program GDX2HAR.EXE to convert the GDX file into HAR (Header Array file) which GTAP (being a GEMPACK program) can read.
[7] The solution of GTAP is in the form of a so-called "solution file", with extension SL4. In practice, we let the batch command file used for executing GTAP convert the SL4 file to HAR format (see previous note) using the GEMPACK utility SLTOHT.EXE. The resulting HAR file is then converted to GDX using the utility HAR2GDX.EXE.

In order to establish a link between factor price changes in GTAP and agricultural production in CAPRI, input coefficients for capital and labour were computed for CAPRI using the GTAP database. The computation of input coefficients is illustrated in figure 5.2.

Figure 5.2: Accounting for marginal revenues and costs in CAPRI and GTAP, and the computation of input coefficients for labour and capital for CAPRI using GTAP data.



On the vertical axis of the figure, the marginal revenues and costs are measured, normalized to 100%. We see that the accounting for marginal revenues from this accounting perspective is rather similar in the two models. Important differences are found on the cost side. GTAP, on the left hand side, being a general equilibrium model, is explicitly accounting for all cost items, also the rents. CAPRI, on the right hand side explicitly accounts only for the traded variable inputs. Restrictions relating to feeding, fertilization, land use or set-aside are only showing up as dual values in the optimization problem.

The most crucial difference is that the producer problem of CAPRI contains a behavioural term, henceforth referred to as the "PMP-term", the derivative of which (and thus the cost of which) is a linear function, in the figure denoted by "$m = a + bx$". That term is intended to capture the joint effect of all other (non-explicit) influences on the farmers' decisions, most notably the effect of fixed factors as labour and capital, but also of crop-rotation etc.

Input coefficients for labour and capital for each agricultural activity are now defined by multiplying the share of capital and labour in total marginal cost of GTAP by the total marginal cost of CAPRI, for production activities mapped as close as possible to GTAP activities (see mapping in appendix). The resulting numbers are thought of as quantities consumed at the price "1". They are pushed into the cost structure of CAPRI by adjusting the constant term a of the PMP term. Thus, if in any simulation, the labour price of GTAP changes by p%, then the same percentage change is applied to the input coefficient in CAPRI, to obtain a change in Euro, and a is shifted by that same amount.

For the purpose of computing the input coefficients, a particular aggregation of the GTAP database in the baseline was used. In that aggregation, agriculture was disaggregated to the greatest possible degree, and all other sectors were aggregated to a single sector "non-agriculture". The disaggregated agricultural sectors of GTAP were mapped to CAPRI production activities using the mapping shown in table A 3.19.

5.3 Modifications to GTAP for linking

With CAPRI modelling agriculture we use the standard GTAP model (Version 6.2a available from the GTAP website). The key concept of our approach to linking the two models is to shift the functions describing the behaviour of the aggregate agricultural sector in GTAP such that it mimics the (aggregated) results of CAPRI. Production in GTAP is described through CES functions. Our aim is to recalibrate these functions such that they reflect the results from CAPRI.

The shifting of functions within GTAP is less straightforward than it seems at first sight. GTAP is written in linearized form and not in levels (like for example CAPRI). The advantage of using a linearized form is that model results are derived in percentage changes which are generally of more interest than results in levels. A more profound advantage is that the linearized version of the CES function used for modelling production decisions directly shows the relative impacts of the substitution effect (first term at the right-hand-side) and the expansion effect (second term at the right-hand-side):

$$q_i = \sigma (p_o - p_i) + q_o,$$

where q_i is the percentage change in demand for input i and p_i the percentage change in the price of input i, q_o and p_o are the percentage changes in quantity and price of output o, σ is the elasticity of substitution.

The linearized representation in GTAP of CES-functions has one major drawback for our current purposes. It does not contain the (constant) distribution parameters that we want to change in order to replicate the behaviour of CAPRI in terms of agricultural production:

$$Q_o = \alpha [\Sigma \delta_i Q_i^{-\rho}]^{-1/\rho} \qquad \text{with } \sigma = 1/(1 + \rho),$$

where Q_o is the output level, Q_i the input level, α the efficiency parameter and δ_i the distribution parameters. We can however interpret the changes in parameters as changes in technology and then use the standard technological shift parameters available in GTAP. For example, for shifting the distribution parameters on production factors we need to calibrate the afe_i technical shifters:

$$q_i = -afe_i + \sigma(p_o - p_i - afe_i) + q_o,$$

The shifting of functions in GTAP could in theory be implemented through a closure swap of the full model whereby the technical shifters are endogenous and all other variables are exogenous. In practice this turned out to be rather complex to implement and making it hard to trace problems and results. We therefore introduce an intermediate step (see figure 5.1) in which we calibrate the technical shifters in a separate program and then use the computed shifters in the GTAP model.

5.3.1 The SHIFTER program for calibrating GTAP to CAPRI results

The SHIFTER program calibrates the shifter parameters of the GTAP model to mimic the results of CAPRI for the agricultural sector. In essence the SHIFTER program is build by copying the relevant equations from GTAP and swapping exogenous and endogenous variables. Figure 5.3 sketches the production function in GTAP and the associated shifters.

SHIFTER determines the primary factor augmenting technical change (*afe*) governing the composition of the value-added nest, the composite intermediate input augmenting technical change (*af*) governing the composition of intermediate inputs nest and value-added augmenting technical change (*ava*) governing the contributions of value-added and

intermediate inputs to total production (which allows us to adjust the cost-shares of value-added and primary inputs in GTAP to the coefficients in CAPRI).

Figure 5.3: Production structure and equations of the SHIFTER program to determine the shifters for GTAP (variables in bold are coming from CAPRI, in italic are exogenous in SHIFTER and GTAP)

```
    Production structure
    --------------------
                             qo(j,r)  [ao(j,r)]
                           (Production)
                             /\
                            /  \  <----- CES (ESUBT = 0, thus LEONTIEF)
                           /    \
                          /      \
                         /        \
      [ava(j,r)]  qva(j,r)        qf(i,j,r)  [af(i,j,r)]
              {value-added)   (Intermediate inputs)
                  /|\
 CES ----->      / | \
(ESUBV)         /  |  \
               /   |   \
              /    |    \
          Land   Labor  Capital
               qfe(i,j,r)
             [afe(i,j,r)]

!< ------------------------------------------------------------------------
    EQUATIONS
   ------------------------------------------------------------------------  >!

! (1) Determine ava(j,r) to replicate share of value-added and intermediates !
Equation ZEROPROFITS
# industry zero pure profits condition (HT 6) #
(all,j,AGRI_COMM)(all,r,REG)
    ps(j,r) + ao(j,r)
        = sum(i,ENDW_COMM, STC(i,j,r) * [pfe(i,j,r) - afe(i,j,r) - ava(j,r)])
        + sum(i,TRAD_COMM, STC(i,j,r) * [pf(i,j,r)  - af(i,j,r)])
        + profitslack(j,r);


! (2) Determine pva !
Equation VAPRICE
# effective price of primary factor composite in each sector/region (HT 33) #
(all,j,AGRI_COMM)(all,r,REG)
    pva(j,r) = sum(k,ENDW_COMM, SVA(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]);


! (3) Determine qva !
Equation VADEMAND
# sector demands for primary factor composite #
(all,j,AGRI_COMM)(all,r,REG)
    qva(j,r)
        = -ava(j,r) + qo(j,r) - ao(j,r)
        - ESUBT(j) * [pva(j,r) - ava(j,r) - ps(j,r) - ao(j,r)];


! (4) Determine shift in afe(i,j,r) to replicate use of primary factors!
Equation ENDWDEMAND
# demands for endowment commodities (HT 34) #
(all,i,ENDW_COMM)(all,j,AGRI_COMM)(all,r,REG)
    qfe(i,j,r)
        = - afe(i,j,r) + qva(j,r)
        - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)];
```

```
! (5) Determine shift in af(i,j,r) to replicate use of intermediate inputs!
Equation INTDEMAND
# industry demands for intermediate inputs, including cgds #
(all,i,TRAD_COMM)(all,j,AGRI_COMM)(all,r,REG)
    qf(i,j,r)
        = - af(i,j,r) + qo(j,r) - ao(j,r)
        - ESUBT(j) * [pf(i,j,r) - af(i,j,r) - ps(j,r) - ao(j,r)];
```

A linear-dependency exists between the equations determining the various shifters, e.g. we can increase share of value-added (*ava*) by raising the output from all primary factors (*afe*). We therefore need to exogenize one shifter. We base our choice on the data availability on CAPRI. CAPRI has data on the shares of value-added and intermediate inputs (*ava*) and on the use of intermediate inputs (*af*). However of the production factor CAPRI only explicitly models land use while labour and capital re modelled implicitly. Since work is done on including labour in CAPRI we fix the shifter for capital to zero.

With this choice made we have a system of equations (bottom part of figure 5.3) which calibrates the technical shifters for GTAP based on percentage changes in prices and quantities of agricultural production, land, labour, and intermediate inputs. With the percentage change data coming from CAPRI and the resulting shifters adjust the behaviour of the agricultural sector in GTAP to the behaviour observed in CAPRI.

The calibration of the shifters in a separate program makes the system less flexible than originally aimed for by calibration through a closure swap of the full GTAP model. There are only a very limited number of equations included in SHIFTER, however, which makes checking the behaviour of the program easier as well as adjustments to the equations in case these are changed in GTAP.

As is obvious from the SHIFTER program we focus on only a rather limited link between the two models in terms of agricultural production. Possible future extensions of the link could include shifting imports and exports of the agricultural sector in line with changes observed in CAPRI and linking the two models through changes in the consumption of regional households.

6 Results of linked system of models

At this stage of development we are interested not primarily in simulation results *per se*, but most of all in the way the results are influenced by the presence of a link between the models. In order to investigate the interaction of the models a baseline and a non-agricultural trade liberalization (NAMA) scenario were developed. The liberalization scenario, described below, was designed in such a way that only variables present in GTAP were shocked whereas CAPRI was affected only by the interaction with GTAP.

GTAP was first solved without CAPRI, to obtain a benchmark for the system prior to linking. The corresponding benchmark for CAPRI is the baseline, since NAMA contained no direct shock for CAPRI. Then the linked system was solved, and the results compared with the benchmark results. The outcomes are reported below.

6.1 Scenario

The scenario used for testing the system consists of a change in non-agricultural tariffs based on the ongoing World Trade Organization's (WTO) negotiations. Limiting the shock to non-agriculture allows us to trace how a shock to GTAP transmits to CAPRI without being confounded by a simultaneous shock in CAPRI, as would be the case when shocking agricultural tariffs.

6.1.1 Default approach to reducing non-agricultural tariffs

The scenario is based on the modalities of non-agricultural market access (NAMA) as of December 6th, 2008. These modalities describe in detail the reductions in tariffs for different groups of countries. The non-agricultural or NAMA market access negotiations are based on a "Swiss formula" for reducing tariffs (to be applied to bound tariffs[8]):

$$t_f = [M \cdot t_i] / [M + t_i]$$

where t_f, t_i are the final and initial bound rate of duty; M is the coefficient determining the maximum tariff after applying the formula. In order to apply the Swiss formula the coefficient M needs to be determined. In the December 2008 package ranges for final numbers are presented as described in table 6.1. For developing countries there are three options of which two imply a stronger default cut but with room for reducing cuts on specific products. Since these exceptions are hard to implement without the choices of each developing country known we implement the coefficient of 25 without further flexibilities for developing countries. Least developed countries are exempted from making tariff reductions, their obligations are limited to increasing the number of bound tariffs in ad valorem terms. This does not affect applied tariffs and therefore does not affect the scenario definition. Least developed countries shall have duty free and quota free access to developed countries for at least 97% of products from LDCs. The current text however is not clear on which products will be included and what the rules of origin are that will apply and we therefore implemented it for all non-agricultural products.

[8] WTO negotiations are on so-called bound tariffs which are the maximum tariffs WTO members can levy on imports of other WTO members. In practice tariffs applied to imports are often substantially lower than the bound tariffs, especially in the case of developing countries. As a result impressive looking cuts in bound tariffs could have limited to no effect on applied tariffs.

Table 6.1: Parameters of the Swiss formula for non-agricultural market access

Countries	July 2008 text	Additional flexibilities	Scenario	Phasing
Developed	8	-	8	5 years (6 equal rate reductions)
Developing	20	(i) less than formula cuts for up to 14 percent of non-agricultural national tariff lines provided that the cuts are no less than half the formula cuts and that these tariff lines do not exceed 16 percent of the total value of a Member's non-agricultural imports; or (ii) keeping, as an exception, tariff lines unbound, or not applying formula cuts for up to 6.5 percent of non-agricultural national tariff lines provided they do not exceed 7.5 percent of the total value of a Member's non-agricultural imports.	-	-
	22	(i) less than formula cuts for up to 10 percent of non-agricultural national tariff lines provided that the cuts are no less than half the formula cuts and that these tariff lines do not exceed 10 percent of the total value of a Member's non-agricultural imports; or (ii) keeping, as an exception, tariff lines unbound, or not applying formula cuts for up to 5 percent of non-agricultural national tariff lines provided they do not exceed 5 percent of the total value of a Member's non-agricultural imports.	-	-
	25	No flexibilities	25	10 years (11 equal rate reductions)
Least developed	-	-	-	-

Note: Reductions to be applied to bound tariffs, in case of unbound tariffs the 2001 applied MFN rate + 25 percent points shall be used; non-ad valorem duties shall be converted to ad valorem equivalents based on method in document TN/MA/20 using 1999-2001 import data; implementation of reductions shall start January 1st of the year following the entry into force of the DDA (NAMA text, p3).

6.1.2 Exceptions to default cuts defined in the modalities

Several exceptions to the default cuts in non-agricultural tariffs are included in the draft modalities.

Exceptions for members with low binding coverage. Developing countries with less than 35% of their NAMA tariffs bound do not have to make reductions but are required to bind 75% of their tariffs in case less than 15% of tariff lines has bindings or else bind 80% of their NAMA tariffs. The average bound tariff shall not exceed 30%.

Exceptions for small and vulnerable economies. Small and vulnerable economies are defined as those with less than 0.1% of world 1999-2001 NAMA trade. These economies can opt for

an alternative reduction schemes with a value of *M* between 18 and 30 depending on the average level of their bound tariffs. Lacking information on these levels we implement an average coefficient of 27 for small and vulnerable economies.

*Exceptions for recently acceded members (RAMs).*Two groups of recently acceded members can be distinguished. One group does not have to reduce tariffs beyond the reductions that remain to be implemented following their accession to the WTO: Albania, Armenia, Former Yugoslav Republic of Macedonia, Kyrgyz Republic, Moldova, Saudi Arabia, Tonga, Viet Nam and Ukraine. Of the remaining RAMs China, Taiwan, Oman and Croatia have an extended implementation period of 3 to 4 years. The other RAMs (Ecuador, Georgia, Jordan, Kyrgyz republic, Mongolia and Panama) qualify as small and vulnerable economies and can apply those flexibilities. Since we do not include timing of reductions in our scenario, i.e. we consider the impact of a full implementation of the NAMA reductions, the latter extended implementation period is not accounted for.

Preference erosion. To counter the impact of preference erosion tariff reductions are delayed for a number of products defined in Annex 2 for the EU and Annex 3 for the US to the NAMA text. This delay may affect developing countries that do not benefit from the preferences. For products defined in Annex 3 the reductions are therefore immediately implemented on products originating in developing countries that do not currently benefit from preferential access. Again, not accounting for phasing in of reductions our scenario does not include these delays in implementation.

Next to these key exceptions there are more flexibilities and exceptions included in the NAMA modalities for specific groups of developing countries that we could not include due to lack of conclusiveness of the modalities and/or because countries have various options and we cannot determine which choice will be made.

6.1.3 Construction of the NAMA scenario

The NAMA scenario is constructed using a datatset detailing bilateral trade at 6-digit product and country level, the MAcMap dataset Version 2.1 with data for 2004 (Bouët et al., 2004). This dataset is related to the trade database used in exploring the mapping between GTAP and CAPRI sectors in chapter 4. The scenario is implemented at this detailed level and the resulting changes in tariffs are then aggregated to GTAP sectors and regions to be implemented in the model. The scenario is constructed in the following steps:

- Bind currently unbound tariffs (only applied to 6-digit codes with no bounds):
  - Compute bound rates as MFN applied rate + 25 percent points.
- Identify small and vulnerable countries:
  - Definition: having less than 0.1% of world 1999-2001 NAMA trade.
- Reduce bound tariffs:
  - Non-WTO members: no reductions;
  - Least developed countries: no reductions;
  - Countries with less than 35% of NAMA tariffs bound: no reductions;
  - Bolivia: no reductions;
  - RAMs: no reductions for Albania, Armenia, Former Yugoslav Republic of Macedonia, Kyrgyz Republic, Moldova, Saudi Arabia, Tonga, Viet Nam and Ukraine;
  - Fiji: apply Swiss formula with coefficient of 30 to bound tariffs only;
  - All other small and vulnerable countries: apply Swiss formula with coefficient of 27;

- Remaining developing countries: apply Swiss formula with coefficient of 25;
- Developed countries and South Korea (not developing for NAMA reductions): apply Swiss formula with coefficient of 8.
- Remove all tariffs on imports from LDCs.

o Determined new applied tariffs:
- If an importer is not a member of the WTO all applied tariffs on all its imports remain as they are;
- If for a bilateral pair the exporter is not a member of the WTO all the applied tariff on this flow remains as it is initially;
- In all other cases the minimum of the reduced bound and the applied tariff becomes the new applied tariff.

o Aggregate to model level:
- Aggregate all new applied tariffs to the model aggregation using bilateral trade flows as weight[9].

6.1.4 Scenario implemented in GTAP

Although we have a much more aggregated scenario for GTAP it is still rather detailed for presentation purposes, consisting shocks on bilateral tariffs between 55 regions for seven sectors. We therefore limit its presentation to an even more aggregate representation highlighting major changes in tariffs.

Figure 6.1 presents the reduction in levied tariffs, i.e. tariffs on imports from other regions, for all countries in the GTAP model and for each of the seven GTAP sectors. Figure 6.2 presents the change in tariffs faced countries, i.e. the tariffs faced when exporting to other regions.

The first thing to note is the variation in tariff reductions for EU-member states which seems puzzling at first sight given the common trade policy of the EU. These variations are caused not by differences in tariffs between EU countries, but by differences in the size of trade flows with partner countries. Since tariffs are aggregated using trade flows as weight these differences result in different aggregate tariffs and tariff reductions.

The second striking feature of the scenario is the presence of reductions in tariffs in all sectors despite implementing only the NAMA modalities. This is due to the fact that we implement the reductions at detailed 6-digit level and then aggregate to GTAP sectors. Due to their highly aggregated nature all GTAP sectors include some products that are part of the non-agricultural modalities and therefore tariff reductions are found in all GTAP sectors.

[9] The aggregation is done with the TASTE program developed by Mark Horridge and David Laborde available at http://www.monash.edu.au/policy/taste.htm.

Figure 6.1: Tariff reductions levied by countries (simple average over partner regions, %)

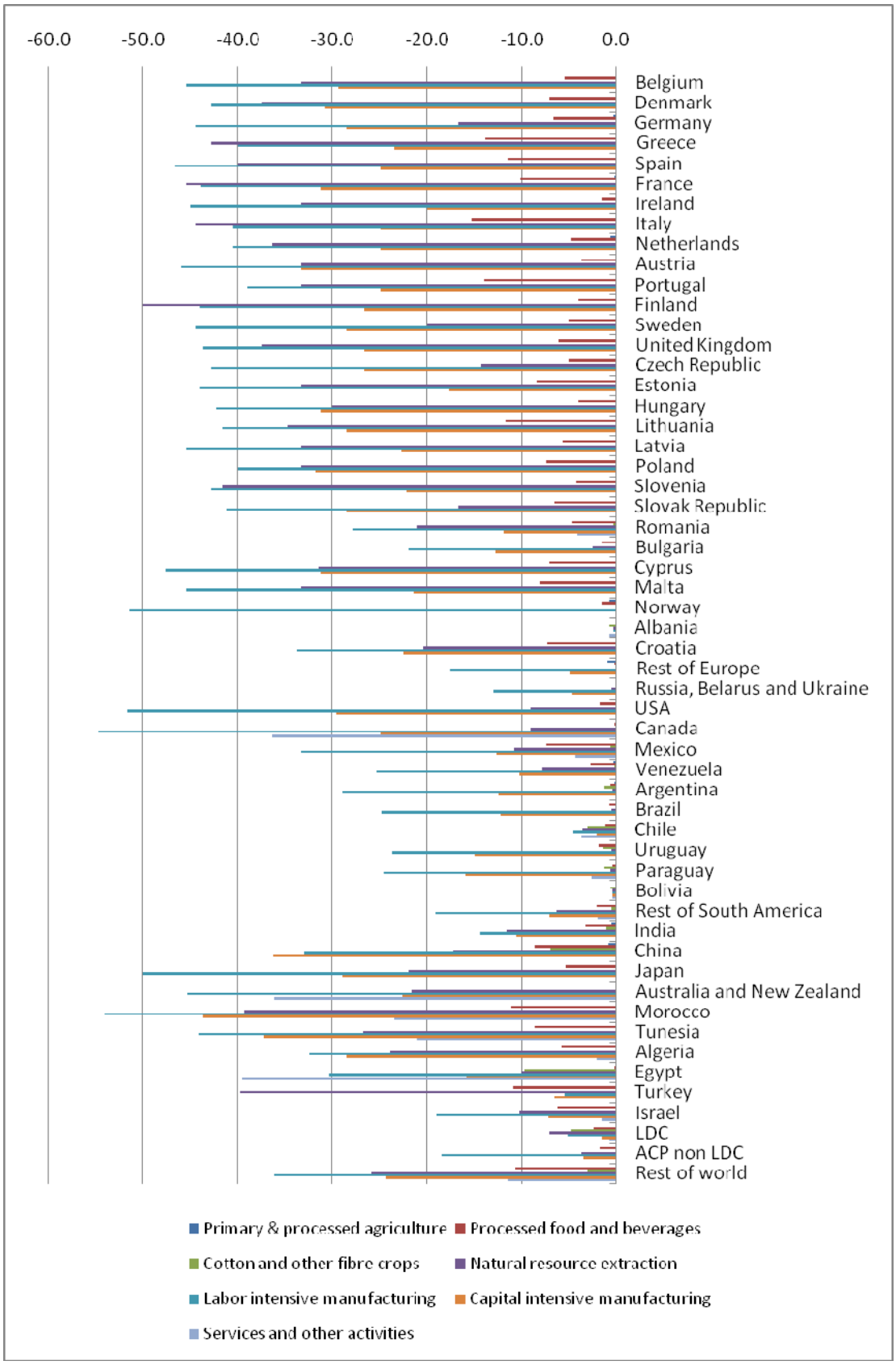
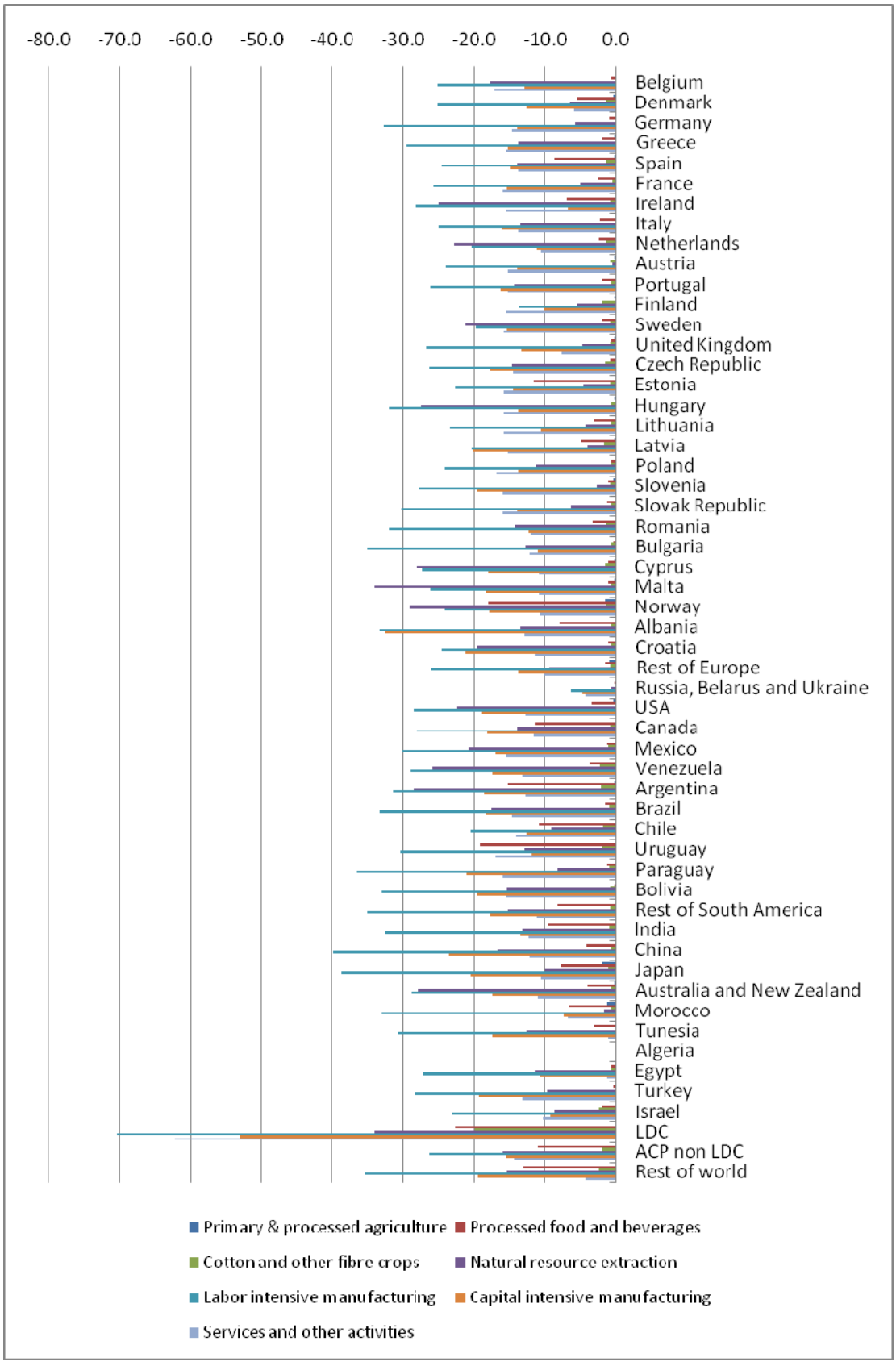


Figure 6.2: Tariff reductions faced by countries (simple average over levying regions, %)



The preferential treatment of the least developed countries is clear when combining figure 6.1 and 6.2. The group of LDC countries has to reduce its own tariffs by a maximum of 7 percent (which indicates that some non-LDC countries are included in the GTAP aggregate since LDCs are fully except from tariff reductions in the WTO negotiations). At the same time the tariffs levied by other regions on products originating in LDCs are reduced by 20 to 70 percent.

Another observation from the two figures is that the tariffs on labour-intensive manufactured goods are reduced more than those on capital intensive products, indicating that initial tariffs on labor intensive manufacturing are higher. The percentage change in tariffs depicted in figure 6.1 and 6.2 provide an insight in the pattern of change but do not indicate the change in the levels of protection – huge changes in already very low tariffs does not yield much additional market access.

Table 6.2 and 6.3 therefore display the changes in tariffs in a different manner. For the sake of readability we aggregated the regions (again by simple averaging over the constituent regions) and present the initial bound and applied tariffs (left-hand-side of the table) and the reduction in percent points after full implementation of the NAMA agreement (right-hand-side of the table).

For the EU27 and rest of Europe we find that although tariffs levied on labour-intensive manufacturing are higher than those on capital-intensive manufacturing the actual levels are already low (1.7 and 0.7 percent). The increase in effective market access is therefore also limited. We find much higher reductions in bound tariffs for especially South America (15.2 and 13.0 percent points) and North Africa (21.2 and 16.4 percent points) but these regions have significant ‘water in their tariffs’ (i.e. a large difference between bound an applied rates). The effective reduction in applied tariffs is therefore limited to 2.3 percent for labour- and 0.7 percent for capital-intensive manufactured goods imported by South America, and 5.9 and 2.8 percent for North Africa. These differences illustrate the importance of accounting for the difference between bound and applied rates.

Overall we can thus conclude that the NAMA agreement has a limited impact on tariffs (as indicated by the bottom-right panes in table 6.2 and 6.3). These aggregate representation however hid peaks in specific bilateral trade flows and subsequent reductions in these. For example, for the EU27 we find a maximum decrease in tariffs levied by the EU of 15.9 percent points and a maximum decrease in tariffs faced by the EU27 of 30.8 percent points. We can thus expect some action in the model runs despite the overall limited size of the shock. Impacts on the agricultural tariffs are not completely zero due to the aggregated nature of the GTAP sectors but so limited that we can ignore them in CAPRI when shocking the linked model system.

Table 6.2: Bound and applied tariffs levied by regions, before and after NAMA agreement (%)

		Tariffs before NAMA agreement							Percentage point reduction in tariffs after NAMA agreement						
	Regions levying tariffs	*Primary & processed agriculture*	*Processed food and beverages*	*Cotton and other fibre crops*	*Natural resource extraction*	*Labor intensive manufactu*	*Capital intensive manufactu*	*Services and other activities*	*Primary & processed agriculture*	*Processed food and beverages*	*Cotton and other fibre crops*	*Natural resource extraction*	*Labor intensive manufactu*	*Capital intensive manufactu*	*Services and other activities*
Bound tariffs	EU27	39.5	23.0	2.0	3.4	7.1	4.1	1.6	0.0	1.6	0.7	1.7	3.7	1.8	0.8
	Rest of Europe	60.7	33.2	2.8	6.1	9.1	5.2	2.3	0.8	1.2	0.5	1.3	3.3	1.5	0.5
	Russia, Belarus and Ukraine	37.1	45.0	28.3	31.9	38.0	34.1	29.5	0.0	3.2	6.0	11.7	19.2	16.0	13.1
	NAFTA	35.8	21.2	13.8	13.2	15.7	12.9	19.2	0.2	0.9	3.9	6.4	9.2	7.2	12.2
	South America	36.2	34.2	36.2	32.2	32.5	29.4	34.3	0.2	2.0	8.5	12.1	15.2	13.0	16.6
	Asia	52.8	49.9	33.6	16.1	17.1	14.2	15.6	0.3	2.0	3.0	7.7	8.6	7.5	7.9
	Australia and New Zealand	4.4	7.9	0.2	1.3	18.4	7.5	13.2	0.0	0.2	0.0	0.5	13.3	4.6	8.9
	North Africa	57.7	68.0	25.5	31.4	35.0	29.3	28.9	0.1	4.6	6.8	14.7	21.2	16.4	15.3
	LDC	74.1	78.9	108.5	43.3	40.9	39.3	54.1	0.0	0.6	0.8	1.9	1.4	0.5	0.7
	ACP non LDC	71.9	80.4	43.3	21.9	32.7	25.6	25.5	0.1	2.1	0.1	3.1	10.6	3.7	11.4
	Rest of World	53.6	58.8	30.2	21.7	29.5	18.8	27.1	0.1	4.7	2.4	11.1	16.9	10.4	14.0
Applied tariffs	EU27	13.2	7.0	0.4	0.4	1.7	0.7	0.1	0.0	0.4	0.0	0.1	0.6	0.1	0.0
	Rest of Europe	30.7	14.1	1.3	2.2	4.2	2.2	1.3	0.2	0.2	0.0	0.0	0.5	0.1	0.0
	Russia, Belarus and Ukraine	11.7	20.4	3.3	6.8	12.7	8.9	4.3	0.0	0.0	0.0	0.0	1.7	0.4	0.0
	NAFTA	18.8	9.5	3.3	1.9	7.1	2.6	1.9	0.0	0.4	0.0	0.2	3.0	0.4	0.1
	South America	9.0	12.1	6.6	5.0	10.9	7.1	2.2	0.0	0.1	0.1	0.1	2.3	0.7	0.0
	Asia	25.3	26.3	5.4	5.4	8.4	6.5	0.1	0.1	1.1	0.1	0.7	2.1	1.2	0.0
	Australia and New Zealand	2.3	3.8	0.0	0.4	7.7	2.3	1.5	0.0	0.0	0.0	0.1	3.5	0.5	0.5
	North Africa	28.7	35.9	2.4	9.7	14.6	9.3	6.8	0.0	2.0	0.1	2.8	5.9	2.8	1.6
	LDC	15.8	19.9	5.2	11.7	15.5	11.2	4.6	0.0	0.5	0.3	0.8	0.8	0.2	0.0
	ACP non LDC	15.3	24.2	4.7	4.4	15.2	8.8	0.5	0.0	0.4	0.0	0.2	2.8	0.3	0.0
	Rest of World	18.3	24.3	2.9	4.6	10.3	5.4	2.2	0.0	2.6	0.1	1.2	3.7	1.3	0.3

Table 6.3: Bound and applied tariffs faced by regions, before and after NAMA agreement (%)

		Tariffs before NAMA agreement							Percentage point reduction in tariffs after NAMA agreement						
	Regions levying tariffs	*Primary & processed agriculture*	*Processed food and beverages*	*Cotton and other fibre crops*	*Natural resource extraction*	*Labor intensive manufactu*	*Capital intensive manufactu*	*Services and other activities*	*Primary & processed agriculture*	*Processed food and beverages*	*Cotton and other fibre crops*	*Natural resource extraction*	*Labor intensive manufactu*	*Capital intensive manufactu*	*Services and other activities*
Bound tariffs	EU27	48.6	36.6	15.2	14.4	17.3	13.7	13.9	0.1	1.2	3.1	6.0	9.1	6.4	6.9
	Rest of Europe	43.8	32.6	15.3	15.5	16.2	14.6	13.9	0.8	3.1	3.6	5.8	8.0	6.9	6.8
	Russia, Belarus and Ukraine	41.8	33.2	17.1	12.6	14.6	13.3	13.9	0.0	0.3	0.0	0.6	1.7	2.3	2.4
	NAFTA	39.1	36.7	15.6	12.1	15.5	12.1	13.4	0.1	1.6	2.2	5.7	7.9	5.7	6.6
	South America	43.1	34.2	15.6	13.4	16.5	13.5	13.4	0.1	3.2	3.0	5.2	8.4	6.1	6.7
	Asia	37.4	31.5	16.6	13.2	19.3	13.3	13.6	0.4	3.2	3.1	4.2	10.1	6.2	6.8
	Australia and New Zealand	51.7	37.7	19.3	12.1	15.5	12.9	13.5	0.1	1.5	3.2	5.8	7.1	6.1	6.7
	North Africa	37.0	32.1	15.8	13.8	19.1	14.0	13.3	0.1	1.5	2.1	5.2	8.2	5.3	5.2
	LDC	33.5	25.9	17.4	14.1	18.7	13.7	13.6	0.0	6.2	2.7	8.4	14.4	9.1	10.6
	ACP non LDC	42.9	33.3	18.9	12.6	16.6	13.5	13.7	0.1	4.7	1.4	6.1	8.0	6.3	6.2
	Rest of World	44.3	31.4	17.1	13.9	18.3	13.0	14.1	0.0	4.4	1.3	3.5	9.2	5.9	2.3
Applied tariffs	EU27	12.7	11.9	2.4	3.1	5.7	3.5	1.2	0.0	0.3	0.0	0.5	1.5	0.5	0.2
	Rest of Europe	18.3	13.7	2.5	4.4	6.0	4.6	1.9	0.1	0.8	0.0	0.8	1.7	1.0	0.2
	Russia, Belarus and Ukraine	23.3	19.3	2.4	2.6	6.4	4.2	2.1	0.0	0.1	0.0	0.0	0.4	0.2	0.1
	NAFTA	15.3	16.5	2.0	2.5	5.7	3.4	1.7	0.0	0.9	0.0	0.5	1.7	0.6	0.2
	South America	24.1	16.4	1.9	3.1	5.8	3.7	1.6	0.0	1.1	0.0	0.5	1.9	0.6	0.2
	Asia	24.2	16.8	2.6	3.6	11.0	4.8	2.0	0.1	1.2	0.0	0.5	4.1	0.9	0.2
	Australia and New Zealand	24.9	24.1	2.5	3.0	7.4	4.7	2.3	0.0	1.0	0.0	0.8	2.1	0.8	0.3
	North Africa	16.9	12.9	2.4	2.8	7.2	3.8	1.6	0.0	0.2	0.0	0.2	1.7	0.4	0.1
	LDC	10.9	8.1	2.4	2.9	5.9	3.6	2.0	0.0	1.8	0.5	1.0	4.2	1.9	1.3
	ACP non LDC	19.2	15.9	2.5	2.4	5.7	3.8	1.9	0.0	1.8	0.1	0.4	1.5	0.6	0.3
	Rest of World	23.2	15.8	2.2	2.9	9.5	4.5	2.1	0.0	2.1	0.1	0.5	3.4	0.9	0.1

6.2 Results

This section presents results of GTAP "standalone" and for the linked system. The focus is on prices and quantities of commodities for EU countries. In order to improve clarity of the exposition, we choose the font *Arial italic* when we refer to sectors and products in the models.

6.2.1 Results of GTAP standalone

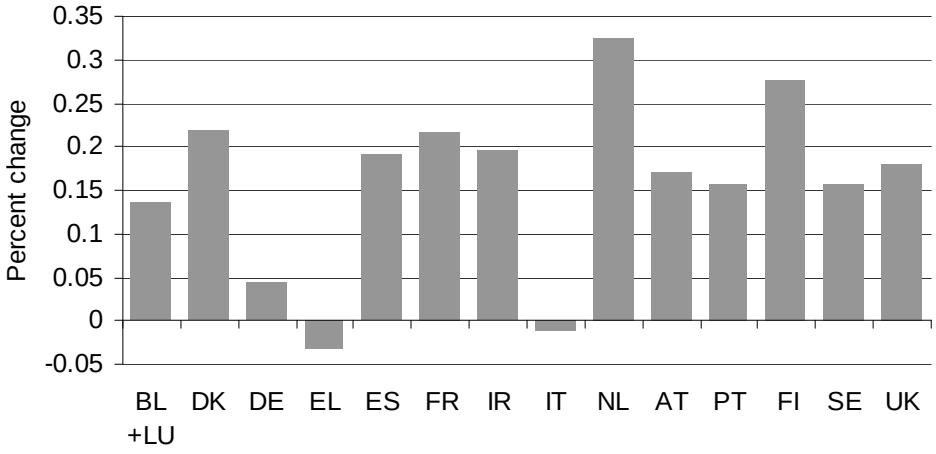
First, GTAP was solved (Euler 16 steps) without CAPRI in order to generate a benchmark against which to evaluate the results of the linked system. The result of the standalone solution of GTAP for the NAMA scenario compared with the baseline are shown in table 6.4. Columns for natural resources and fibres have been omitted because they generally constitute a very small share of agricultural (*Agri*) firms' costs.

Table 6.4: Price changes of agriculture's purchases in NAMA with GTAP standalone, for selected EU member states

	Agri	*PFood*	*Extract*	*LabMan*	*CapMan*	*Svces*	*Land*	*UnSkLab*	*SkLab*	*Capital*
BE+LU	-0.13	-0.18	-0.05	-0.52	-0.30	-0.11	0.26	-0.10	-0.06	-0.06
DK	-0.12	-0.26	-0.31	-0.33	-0.20	-0.10	0.47	-0.09	-0.06	-0.06
DE	-0.13	-0.17	-0.03	-0.38	-0.21	-0.14	-0.01	-0.13	-0.12	-0.12
EL	-0.11	-0.13	-0.05	-0.33	-0.19	-0.11	-0.16	-0.09	-0.08	-0.08
ES	-0.20	-0.25	-0.11	-0.41	-0.26	-0.24	0.25	-0.23	-0.22	-0.22
FR	-0.20	-0.23	-0.10	-0.39	-0.25	-0.23	0.32	-0.23	-0.22	-0.22
IE	-0.19	-0.21	-0.08	-0.46	-0.22	-0.16	0.28	-0.18	-0.16	-0.25
IT	-0.11	-0.16	-0.04	-0.28	-0.20	-0.11	-0.13	-0.10	-0.10	-0.10
NL	-0.16	-0.22	0.11	-0.41	-0.25	-0.22	0.58	-0.24	-0.21	-0.21
AT	-0.18	-0.21	-0.16	-0.37	-0.22	-0.20	0.21	-0.23	-0.19	-0.22
PT	-0.27	-0.32	-0.10	-0.39	-0.28	-0.32	0.06	-0.34	-0.32	-0.33
FI0	-0.37	-0.38	-0.32	-0.48	-0.32	-0.39	0.24	-0.43	-0.39	-0.43
SE	-0.23	-0.28	-0.18	-0.39	-0.27	-0.25	0.13	-0.25	-0.22	-0.26
UK	-0.21	-0.26	-0.08	-0.43	-0.29	-0.25	0.19	-0.26	-0.23	-0.23

The general picture that emerges from the table is that input prices of *Agri* are reduced, except for the endowment *Land*. *Land* prices are influenced by on the one hand substitution with other inputs (downward pressure) and on the other hand by the changes in total output of agriculture, shown in figure 6.3. *Land* is imperfectly mobile between sectors of the economy, and is predominantly used by *Agri*. When input prices of agriculture decrease, profits increase and also production. Increased production leads to increased demand for *Land*, which tends to increase its price. In order to clear output markets, the output price of *Agri* also drops, and in the equilibrium, agricultural production actually decreases in two member states (IT and EL, not shown). The slight decrease in output of *Agri* leads to net decreases of prices for *Land* in those member states.

Figure 6.3: Change (%) in output quantity of Agri in NAMA with GTAP standalone, for selected EU member states



6.2.2 Results of GTAP standalone versus linked with CAPRI

In this section we compare the results from GTAP of the NAMA scenario with and without CAPRI linked, in order to investigate to what extent the linking of CAPRI matters. Focus is again on selected EU member states.

Table 6.5: Effect of link on input prices in GTAP, for selected EU member states, % difference

	Agri	*PFood*	*Extract*	*LabMan*	*CapMan*	*Svces*	*Land*	*UnSkLab*	*SkLab*	*Capital*
BL +LU	116.65	16.19	-11.09	0.15	0.03	2.71	-97.08	-12.19	-11.89	34.65
DK	166.23	15.54	-2.21	-0.84	-0.84	-2.87	-136.27	-34.36	-37.46	44.06
DE	112.46	17.40	-21.02	0.16	0.00	1.93	1899.18	-6.99	-5.15	11.38
EL	62.75	18.72	-11.32	1.32	1.03	5.24	158.90	0.34	-2.00	12.89
ES	108.59	21.86	-5.44	0.32	0.27	1.57	-33.01	-12.02	-6.05	12.42
FR	93.83	15.89	-6.01	0.31	0.28	1.13	69.27	-6.35	-3.93	9.22
IR	68.79	13.64	-9.17	0.17	0.63	0.74	94.99	-7.76	-7.75	6.27
IT	85.22	18.24	-15.32	0.54	0.05	0.74	198.15	-5.10	-4.79	3.34
NL	98.72	17.60	-5.50	-0.07	-0.36	0.05	-46.52	-8.84	-5.38	8.39
AT	98.53	16.13	-3.29	0.38	0.22	0.98	35.44	-5.73	-4.22	7.48
PT	103.90	22.06	-5.44	4.40	4.30	9.13	-403.15	-4.31	1.41	36.12
FI	91.96	15.62	-0.76	1.00	0.62	1.95	66.60	-7.44	-4.43	10.08
SE	160.43	16.13	-2.38	0.20	-0.07	0.40	-227.83	-7.70	-6.88	9.92
UK	91.03	7.55	-7.53	0.02	-0.03	0.89	305.85	-4.09	-3.42	6.71

Table 6.5 shows the relative difference (%) of input prices with the linked system relative to the standalone simulation with GTAP. The numbers have been computed as

$$\text{Sign}(p_2 - p_1)*\text{abs}(100*(p_2/p_1 - 1)) \qquad (2)$$

where p_1 is the price change in NAMA when solved "standalone" and p_2 is the price change in NAMA when the linked system is solved. Thus, note that we talk about *the percentage change of the percentage change* in simulation. As would be expected, the effect is large on items directly linked to CAPRI, i.e. the prices of *Agri* and *Land*, whereas the input price reaction of other items is smaller the less their relation to agriculture. The most remarkable change of results is that of *Land* price in Germany. The price change with the link is about 20

times larger. However, table 6.5 reveals that the price change with GTAP standalone was only 0.01% in Germany, and thus an increase by a factor 20 is not longer very remarkable.

Of the sectors not directly influenced by CAPRI, the largest effect is seen in processed foods *PFood*. This is only natural because *Agri* is an important input into *PFood*. Also on the sector Extract there is a clear change of some results, most of all for BL+LU, DE, EL and IT. Those instances, however, arise due to the fact that the effect in "Standalone" is almost zero (see table 6.5) so that also an absolutely small effect of the link seems large (in equation 2, p_1 is small).

The change of prices of *Capital* and Labour (*SkLab* and *UnSkLab*) are typically affected by a few percent, and the general pattern is that the price change with the linked system is smaller than with GTAP standalone.

6.2.3 Results of CAPRI for the linked system

As an aggregate, output of agriculture increases in response to lower prices for inputs, but certain reallocations also take place within the agricultural sector.

Prices of endowments as well as variable inputs fall, as shown in section 6.2.2. Initially, this induces producers to use more intensive technologies, e.g. higher cereals yields using more variable inputs, labour and capital. Increased production increases demand for and the opportunity cost (shadow price) of land. Activities with less capital use, labour use or variable costs — prominently fodder activities — benefit less from the lower input prices but suffer from higher opportunity costs for land, and are consequently reduced. This impacts on animal husbandry via higher feed prices, not offset by lower capital, labour or variable input costs.

Figure 6.4: Production results for CAPRI for EU27 and selected sectors in the NAMA simulation compared with the baseline.

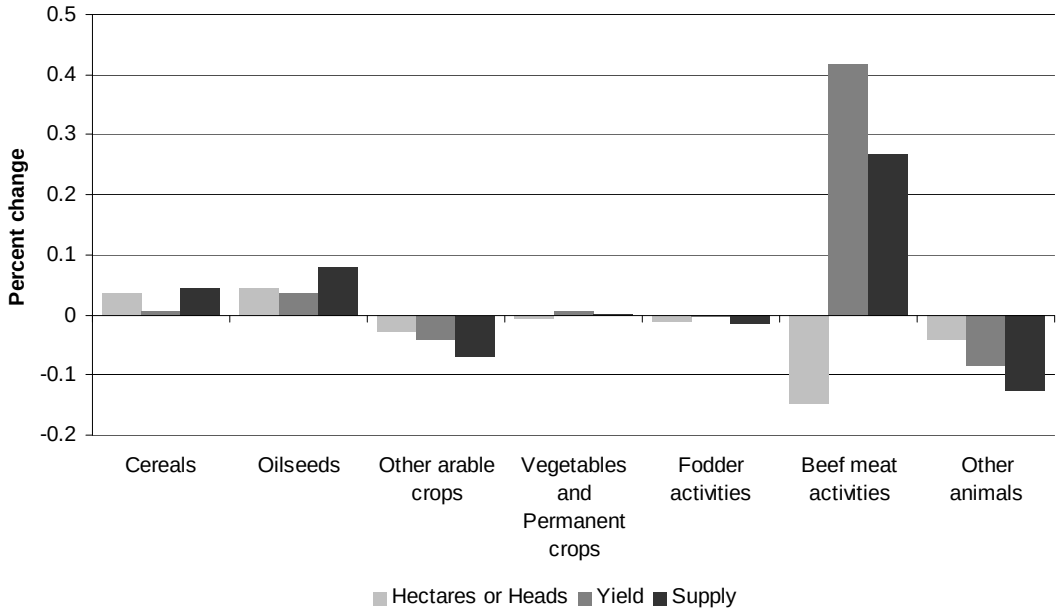


Figure 6.4 shows results of the NAMA simulation in CAPRI, percentage change of production of selected product aggregates for EU27. In general, the impact of the NAMA scenario on agriculture is small. For the important product group cereals, the impact is less than a tenth of a percent , and foe all sectors the effect is below half a percent.

The biggest negative impact is for the group "other animals", which contains mainly pigs and poultry. For those sectors, the net impact is negative despite capital, labour and most variable inputs becoming cheaper. The explanation is twofold. Firstly, the sectors depend strongly on cereals and other crop products for feeding, and those products get more expensive. Secondly, CAPRI does not allow technology to change within pigs and poultry. This is in contrast with (most) ruminant sectors in CAPRI, where the producer chooses among technologies along a simple (generally two points) frontier. Thus, whereas the relative price changes lead to reduced animal stock but higher total production for the bovine sectors, similar mechanisms lead to a decline in total production of pigs and poultry meat. The extent to which this would also occur in reality is an empirical question.

6.2.4 Inconsistencies and missing links

The (brief) results presentation above hides some unpleasant problems, that we dig up and examine in the current section. When comparing results for the same variable from both models, and the results deviate widely, then either some link between the models is missing and/or the underlying data and equations are widely inconsistent. Here we examine results for the price of *Land* (as input into *Agri*), the output price index of *Agri*, and the total output of *Agri*. Those three variables are all computed by CAPRI and used by SHIFTER to shock the production technology in GTAP. If the link were complete and the models similar, we would expect that after convergence, GTAP would come up with a solution that is very similar to the values give by CAPRI (and SHIFTER). As we show below, this is unfortunately not the case.

Table 6.6: Output quantities of GTAP standalone, CAPRI (linked) and GTAP linked

	GTAP Standalone	CAPRI	GTAP Linked
BL+LU	0.135	0.002	-0.065
DK	0.219	0.049	-0.212
DE	0.044	0.024	-0.072
EL	-0.031	-0.006	0.002
ES	0.190	0.034	-0.055
FR	0.218	0.006	0.027
IR	0.197	0.007	0.165
IT	-0.012	0.007	-0.010
NL	0.324	0.020	0.081
AT	0.172	0.039	-0.041
PT	0.158	0.012	-0.126
FI	0.277	0.046	-0.075
SE	0.158	-0.006	-0.315
UK	0.179	0.012	-0.010
Mean	0.159	0.017	-0.050
StdDev	0.100	0.018	0.117
Covariance*	-	0.001	0.000
Correlation*	-	0.440	-0.120

** Covariance and correlation are computed for the current column with respect to the previous*

Table 6.6 shows output quantity (qo) as computed in GTAP standalone, in CAPR and in GTAP after convergence of the linked system. The first column corresponds to the results shown in figure 6.3. The second column is an output index computed in CAPRI (see section on linkages), and the last column shows the final result from GTAP. The last four lines of the table show some descriptive statistics. Correlation is perhaps the most interesting. In the last row of the second column is the correlation of quantities computed in CAPRI with those computed in GTAP standalone, 44%. This is broadly what we would expect: CAPRI reacts different from GTAP, but generally in the same direction.

The final row of the final column shows the correlation of the final GTAP results with the CAPRI results, -12%. This indicates that albeit shifter shocks GTAP so that the *Agri* sector if solved partially with the same input prices facing CAPRI would give identical results to CAPRI, the presence of the remaining equations (the general equilibrium) in GTAP is such that the result of GTAP is not even positively correlated with the CAPRI results. The reason for this behaviour is to be sought in the equations of GTAP that are most directly interacting with agricultural outputs: Human consumption and input use by other sectors (notably *PFood*). The CAPRI solution implies a change in product mix, input use of *Agri* in other sectors and consumption that is not communicated upstream to GTAP via the link.

Table 6.7: Output prices of GTAP standalone, CAPRI (linked) and GTAP linked

	GTAP Standalone	CAPRI	GTAP Linked
BL+LU	-0.149	0.064	0.018
DK	-0.123	0.119	0.094
DE	-0.146	0.031	0.013
EL	-0.111	-0.025	-0.048
ES	-0.218	0.038	0.017
FR	-0.218	-0.011	-0.022
IR	-0.192	-0.052	-0.069
IT	-0.119	-0.003	-0.034
NL	-0.197	0.004	-0.022
AT	-0.204	0.003	-0.013
PT	-0.301	0.039	0.005
FI	-0.382	0.025	-0.035
SE	-0.253	0.192	0.153
UK	-0.245	-0.024	-0.034
Mean	-0.204	0.029	0.002
StdDev	0.076	0.063	0.059
Covariance*		0.000	0.003
Covariance*		-0.075	0.907

** Covariance and correlation are computed for the current column with respect to the previous*

Table 6.7 shows the output prices of GTAP standalone, CAPRI (linked) and GTAP linked, and the same descriptive statistics as table 6.8. The results for prices appear to be far less problematic than the results for quantities. Or rather, the problems are different. On the one hand, the correlation between CAPRI results is -7.5%, indicating that the market in CAPRI reacts rather different from that in GTAP. This should come as no surprise, since at this stage of progress (January 2009), only the European countries were linked, whereas the NAMA shock applies to the whole world. For all third countries, thus, the shocks were not communicated downstream to CAPRI, which should lead to different world market prices. On the other hand, the correlation between the final linked GTAP results are now by and large consistent with the results of CAPRI, with a correlation of 91%. This probably reflects the fact that agricultural taxes were not shocked in neither model, and that one very important market for agricultural goods, namely the use of *Agri* in *Agri*, was included in the link (by the computation in CAPRI of a price index for pf(*Agri*,*Agri*)). The high degree of correlation is in fact surprising given that in CAPRI, the sector's own use of *Agri* (fodder and young animals) is of very different composition from the *average* output, but that this is not reflected in any way in GTAP.

One can also compute the correlation between "standalone" and "linked" results for GTAP, to see the extent to which the behaviour of agriculture in GTAP is influenced by the presence of the link. The result, based on the tables above, is a correlation of only 1.18% for prices and 5.4% for commodities, thus showing that changes barely go in "the same direction".

Table 6.8: Land prices of GTAP standalone, CAPRI (linked) and GTAP linked

	Standalone	Shifter	Linked
BL+LU	0.257	0.156	0.008
DK	0.470	0.476	-0.171
DE	-0.012	0.460	0.220
EL	-0.161	0.110	0.095
ES	0.255	0.392	0.171
FR	0.316	0.480	0.535
IR	0.280	0.160	0.545
IT	-0.130	0.169	0.127
NL	0.576	0.159	0.308
AT	0.212	0.473	0.287
PT	0.060	0.154	-0.183
FI	0.243	0.702	0.406
SE	0.133	0.578	-0.170
UK	0.192	0.854	0.777
Mean	0.192	0.380	0.211
StdDev	0.206	0.235	0.291
Covariance*		0.007	0.025
Correlation*		0.154	0.363

Table 6.8 shows the change in land prices in respective model. We see that SHIFTER (and thus also CAPRI) generally returns changes in the same direction as GTAP standalone (positive correlation of 0.154), and that the reaction of GTAP in the linked system also is qualitatively consistent with the results of SHIFTER (and thus CAPRI). Nevertheless, the correlation is not very high (0.363), and thus one may expect that with an improved link, the fit would improve too.

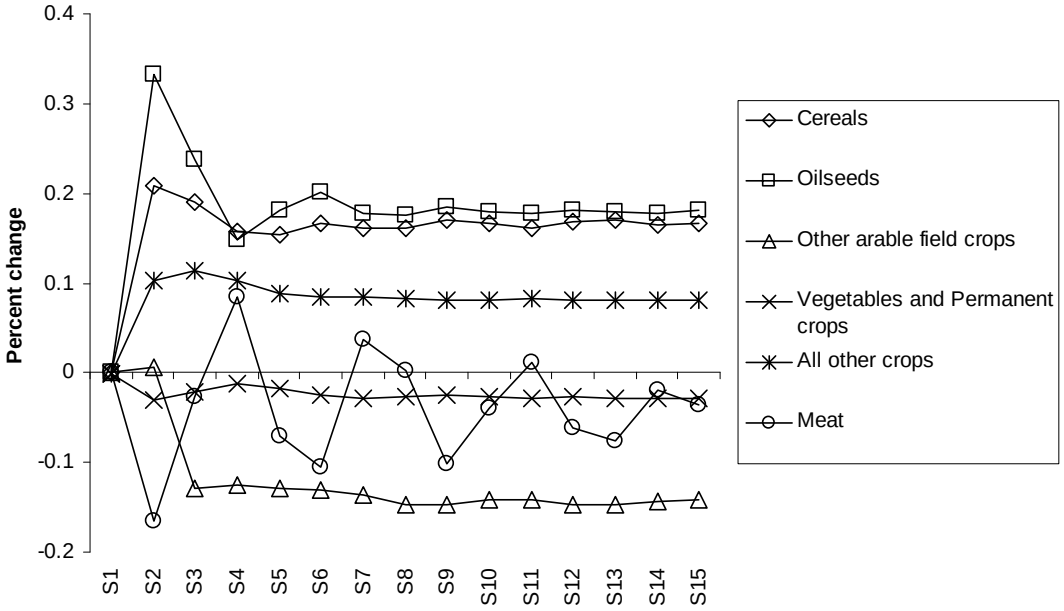
6.3 Convergence

As described in section 5.1, GTAP is included within the solution algorithm of CAPRI, and is thus subject to the same convergence analysis, implying that only the relative change of market prices within CAPRI between consecutive iterations are analysed, and that iteration terminates if no price changes by more than 0.1% or if an upper limit (typically 15) of iterations is reached. Note that this measure of convergence relates to the same model variable in consecutive iteration steps, and not as was discussed in the previous section, the convergence of the value of a variable of GTAP to the corresponding variable in CAPRI.

Figure 6.5 shows the development of the prices of some product aggregates in CAPRI (the MARKET model). Iteration S2 includes results from GTAP for the first time. One may see that after the initial shock, most prices are fairly stable after about 10 iterations, and only beef prices keep fluctuating, with apparently decreasing amplitude, to any significant extent after that. Considering the scale of the changes in the last few iterations, being less than 0.1%, the final outcome should be judged as fairly stable.

It is conceivable that faster convergence could be obtained if some dampening mechanism were implemented that would prevent the wave-like behaviour of beef prices, possibly in combination with a forward-looking expectation of the next iteration's outcome of GTAP based on previous iterations' results. Such mechanisms are already present between the SUPPLY and MARKET modules within CAPRI.

Figure 6.5: Market prices in iterations within CAPRI. GTAP first included between S1 and S2.



7 Conclusions

This deliverable reports on the development of linking of CAPRI and GTAP in a flexible and generic manner (in the sense of not being focussed on a one-off application). The linking aims at combining the strength of CAPRI in detailed modelling of the EU agricultural sector with the economy-wide modelling of GTAP. The combination of the two models allows us to assess in detail the impacts of changes in the overall economy on the agricultural sector in the EU as well as the impact of changes in this sector on the overall economy.

Aiming at a generic link between the two models we started by a formal treatment of establishing a link between a partial equilibrium model like CAPRI and a general equilibrium model like GTAP. We showed that by approximating the partial equilibrium model in the general equilibrium model through (partial) adjustments of the supply curve a fast converging and stable system can be developed. We then further investigated the practical scope for such a linked system by developing a didactic example. Apart from further exploring the foreseen method for linking the example also allowed is start developing the link in practical (software) terms.

We then turned from the didactic models to linking CAPRI and GTAP which required a careful mapping of sectors and regions between the two models. The result was a GTAP model configured for use with CAPRI in terms of having the best possible match in terms of countries/regions (55 in total). The large number of regions required a more aggregate treatment of sectors in order to keep a fast solving system. All agricultural sectors were aggregated except for processed food and fibre crops which have limited to no coverage in CAPRI. The non-agricultural sectors were further aggregated in four large groups (natural resource extraction, labour intensive manufacturing, capital intensive manufacturing and services), leading to a total of seven sectors in the GTAP model.

The originally foreseen linking methodology was adjusted in the course of the work on the actual linking of CAPRI and GTAP in response to particular features of the two models (described in sections 2 and 5 respectively). The actual method of linking however remained true to the objective of developing a generic link. The adjustments to CAPRI and GTAP require minimal to no adjustments to the models themselves making the adjustments transferable to other versions of the models. In the case of GTAP there are no adjustments to GTAP itself, the linking only requires an additional program calibrating standard GTAP parameters to CAPRI results. The use of a separate calibration program makes the impacts of the link with CAPRI transparent and proved invaluable when debugging the linked system.

In the case of CAPRI the adjustments consist of a limited set of three include files and an extension of the set of possible inputs by labour and capital. The core CAPRI model can be updated or replaced with little effort.

We tested the linked system with a realistic scenario of a tariff reduction for non-agricultural products based on the latest modalities of the WTO multilateral negotiations. Focussing on non-agricultural tariffs implies that the initial shock is limited to GTAP only, allowing us to better trace the impact of the link to CAPRI (no additional shocks are needed for CAPRI that confound the analysis). From a CAPRI perspective the scenario assess the changes in agriculture in response to a change in non-agricultural policy beyond the scope of the CAPRI model.

The linked system turned out to converge quickly as expected based on the formal development of the link earlier on in this deliverable. The results at first sight are also promising although the size of the impact is limited. This is of course in large part due to the limited size of the initial shock. Effects on GTAP results (compared with the stand-alone version of GTAP) are largest for the agricultural sector and land, as expected since these are

now directly linked to CAPRI. In fact, the behaviour of agriculture in GTAP is strongly influenced by the presence of the link, with a correlation between "standalone" and "linked" results being 1.18% for prices and 5.4% for commodities, thus showing that changes barely go in "the same direction".

Albeit each individual variable appears to converge over iterations, there turned out to be quite a low correlation between the equilibrium values of overlapping variables of the two models, e.g. between agricultural production or price in CAPRI and agricultural production in GTAP. This was especially the case for quantities. The reason seems to be that the SHIFTER program until now only adjusts "a column of the SAM", i.e. the production behaviour of agriculture, whereas the market balance, "the row of the SAM", is left inconsistent. Thus, if CAPRI computes an increase of agricultural production in some region where GTAP "standalone" would compute a decrease, the shift of technology produced by SHIFTER is not sufficient to force the consumers (and other sectors) of GTAP to consume the greater quantities from CAPRI (especially since demand is inelastic). Clearly, also the final and intermediate consumption of agricultural goods would have to be shifted in GTAP.

In retrospect the development of the linked system was most challenging from a technical point of view. CAPRI and GTAP are written in different types of software which increases the chance of errors, for example because of a different order in set names. It also posed a technical challenge in the sense of requiring 'bi-lingual' researchers capable of programming and especially debugging in both GAMS (for CAPRI) and GEMPACK (for GTAP). Valuable experience was gained while trying ways of implementing the link between the two models which will make future developments of the link easier to achieve.

Having a achieved a system that converges despite a clear limitation in the extent of the current link (as illustrated by the diverging behaviour of quantity changes in GTAP and CAPRI) indicates that the linking method is robust. This offers scopes for future developments the link between the two models. Having a running system implies that future efforts can focus on improving the conceptual side of the linking as opposed to fixing technical problems.

The current results also indicate a clear direction for future work on a link between the two models. The lack of convergence of quantity changes suggests that link needs to be expanded from the current focus on agricultural the production to linking changes at the demand for agricultural products (i.e. linking changes in consumer demand and trade flows).

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Glossary

Applied tariff	Import tariff (generally expressed in ad valorem terms, i.e. as a percent of the price of the product) levied at the border on imports from other countries.
Bound tariff	Maximum tariff that a WTO member can levy on imports from another WTO member. These tariffs are the ones negotiated on in WTO negotiations but may be considerably higher than actually applied tariffs.
General equilibrium model (GE)	Economic model of the full economy, describing all flows of products and money in an economy (for example, GTAP).
Partial equilibrium model (PE)	Economic model of part of an economy, for example only of the agricultural sector like CAPRI.
WTO	World Trade Organization, a multilateral platform where member states negotiate on global reductions in barriers to trade (like tariffs and domestic support).

Appendix 1: Equations of the didactic example

Here we reprint the equations of the simple CGE model and the simple PE model in GAMS format. The complete set of files for running the didactic model in GAMS is provided electronically.

```
*-------------------------------------------------------------------------------
*           Definition of GE model
*-------------------------------------------------------------------------------

positive variable VP(i)      'Price';
positive variable VID(i,j)   'Industrial commodity demand';
positive variable VCD(i)     'Consumer commodity demand';
positive variable VS(i)      'Supply quantity';
positive variable VSAM(i,j)  'Any SAM entry';

variable o          'An objective variable';

equation EID(i,j)   'Industrial commodity demand (Leontief)';
equation ELD(j)     'First order condition for profit maximisation w.r.t. L';
equation EKD(j)     'First order condition for profit maximisation w.r.t. K';
equation ECD(i)     'Consumer demand';
equation ES(i)      'Production function (Cobb-Douglas)';
equation EMB(i)     'Market balance';
equation EFB(i)     'Factor balance';

equation EREV(i)    'Definition of revenues';
equation EEXP(i)    'Definition of expenditures';
equation ESAM(i)    'SAM balance constraint';
equation ECRT       'Criterion function in SAM balancing';


* Partial model: Production and input demand

EID(com,sec) .. VID(com,sec) =e= VS(sec)*A(com,sec);

ELD(sec) .. (VP(sec) - sum(com, A(com,sec)*VP(com)))
              *BETA(sec)*ALPHA(sec)*VID('L',sec)**(BETA(sec)-1)*VID('K',sec)**(1-
BETA(sec))
           - VP('L') =e= 0;

EKD(sec) .. (VP(sec) - sum(com, A(com,sec)*VP(com)))
              *(1-BETA(sec))*ALPHA(sec)*VID('L',sec)**BETA(sec)*VID('K',sec)**(-
BETA(sec))
           - VP('K') =e= 0;

ES(sec) .. VS(sec) =e= ALPHA(sec)*VID('L',sec)**BETA(sec)*VID('K',sec)**(1-BETA(sec));


* Partial model: Consumer behaviour

ECD(com) .. VCD(com)*VP(com) =e= THETA(com)*sum(fac, ENDOWMENT(fac)*VP(fac));


* Commodity and factor balances

EMB(com) $ (VP.lo(com) lt VP.up(com)) .. VS(com) =e= sum(sec, VID(com,sec)) +
VCD(com);

EFB(fac) $ (VP.lo(fac) lt VP.up(fac)) .. sum(sec, VID(fac,sec)) =e= ENDOWMENT(fac);


* SAM balancing equations

EREV(i)     ..  VSAM(i,'REVENUES')       =e=
                    sum(j $ (not (sameas(j,'REVENUES') or sameas(j,'EXPENDITURES'))),
VSAM(i,j));
```

```
EEXP(j) $ (not sameas(j,'REVENUES')) ..
                VSAM('EXPENDITURES',j)   =e=
                    sum(i $ (not (sameas(i,'REVENUES') or sameas(i,'EXPENDITURES'))),
VSAM(i,j));

ESAM(i) $ (not (sameas(i,'REVENUES') or sameas(i,'EXPENDITURES')))   ..
                VSAM(i,'REVENUES') =e= VSAM('EXPENDITURES',i);

ECRT        .. o =e= sum((i,j) $ WEIGHT(i,j), WEIGHT(i,j) * sqr(SAM(i,j) -
VSAM(i,j)));

model GE 'General equilibrium model' /EID,ELD,EKD,ES,ECD,EMB,EFB/;
model BALSAM 'SAM balancing model' /EREV,EEXP,ESAM,ECRT/;


*-------------------------------------------------------------------------------
*   Variables and equations of PE model
*-------------------------------------------------------------------------------

positive variable VX(act)   'Level of production (Land allocation)';
         variable VS(io)    'Net production';
         variable VM(act)   'Gross margin in production activity';
         variable VL        'Dual value of land';
positive variable VP(io)    'Endogenous price';
positive variable VD(io)    'Consumer demand';

equation EM(act)            'Gross margin definition';
equation EFOCP(act)         'Producer first order condition';
equation ES(io)             'Net production';
equation EL                 'Dual value of land';
equation EFOCD(io)          'Consumer first order condition';
equation EMB(io)            'Market balance';

EM(act)     ..  VM(act) =e= sum(pen $ A(pen,act), A(pen,act) * VP(pen))
                        +   sum(pex $ A(pex,act), A(pex,act) * PRICE(pex))
                        +   SUBSIDY(act);

EFOCP(act)  ..  VM(act) - C(act) - sum(act1, B(act,act1)*VX(act1)) - VL =e= 0;

ES(prd)     ..  VS(prd) =e= sum(act, A(prd,act)*VX(act));

EL          ..  VL =e= [sum(act, 1/B(act,act) * (VM(act)-C(act))) - ENDOWMENT('LAND')]
/ sum(act, 1/B(act,act));

EFOCD(con)  ..  VD(con) * (sum(pen $ sameas(pen,con), VP(pen)) + sum(pex $
sameas(pex,con), PRICE(pex))) =e= THETA(con) * ENDOWMENT('INCOME');

EMB(pen)    ..  VD(pen) - VS(pen) =e= 0;

model PE 'Partial equilibrium agricultural model' /EM,EFOCP,ES,EL,EFOCD,EMB/;
```

Appendix 2: CAPRI-GTAP country concordance

Countries			*CAPRI*		*GTAP*	
Codes		*Name*	*Code*	*Description*	*Code*	*Description*
ZMB	894	Zambia	LDC	LDC	ZMB	Zambia
SCG	891	Serbia and Montenegro	REU	Rest of Europe	SCG	Rest of Europe
YEM	887	Yemen	ROW	Rest of world	YEM	Rest of Middle East
VEN	862	Venezuela	VEN	Venezuela	VEN	Venezuela
UZB	860	Uzbekistan	ROW	Rest of world	UZB	Rest of Former Soviet Union
URY	858	Uruguay	URU	Uruguay	URY	Uruguay
BFA	854	Burkina faso	LDC	LDC	BFA	Rest of Sub-Saharan Africa
USA	842	United states of america	USA	USA	USA	United States of America
TZA	834	United Republic of Tanzania	LDC	LDC	TZA	Tanzania
GBR	826	United kingdom	UK000000	United Kingdom	GBR	United Kingdom
EGY	818	Egypt	EGY	Egypt	EGY	Egypt
MKD	807	Macedonia, TFYR	REU	Rest of Europe	MKD	Rest of Europe
UKR	804	Ukraine	RBU	Russia, Belarus and Ukraine	UKR	Rest of Former Soviet Union
UGA	800	Uganda	LDC	LDC	UGA	Uganda
TKM	795	Turkmenistan	ROW	Rest of world	TKM	Rest of Former Soviet Union
TUR	792	Turkey	TUR	Turkey	TUR	Turkey
TUN	788	Tunisia	TUN	Tunesia	TUN	Tunisia
ARE	784	United arab emirates	ROW	Rest of world	ARE	Rest of Middle East
TTO	780	Trinidad and tobago	ACP	ACP non LDC	TTO	Rest of Free Trade Area of the Americas
TGO	768	Togo	LDC	LDC	TGO	Rest of Sub-Saharan Africa
THA	764	Thailand	ROW	Rest of world	THA	Thailand
TJK	762	Tajikistan	ROW	Rest of world	TJK	Rest of Former Soviet Union
SYR	760	Syrian arab republic	ROW	Rest of world	SYR	Rest of Middle East
CHE	757	Switzerland	REU	Rest of Europe	CHE	Switzerland
SWE	752	Sweden	SE000000	Sweden	SWE	Sweden
SWZ	748	Swaziland	ACP	ACP non LDC	SWZ	Rest of South African Customs Union
SUR	740	Suriname	ACP	ACP non LDC	SUR	Rest of South America
SDN	736	Sudan	LDC	LDC	SDN	Rest of Sub-Saharan Africa

ESP	724	Spain	ES000000	Spain	ESP	Spain
ZWE	716	Zimbabwe	ACP	ACP non LDC	ZWE	Zimbabwe
ZAF	710	South africa	ACP	ACP non LDC	ZAF	South Africa
SVN	705	Slovenia	SI000000	Slovenia	SVN	Slovenia
VNM	704	Viet nam	ROW	Rest of world	VNM	Viet Nam
SVK	703	Slovakia	SK000000	Slovak Republic	SVK	Slovakia
SGP	702	Singapore	ROW	Rest of world	SGP	Singapore
IND	699	India	IND	India	IND	India
SYC	690	Seychelles	ACP	ACP non LDC	SYC	Rest of Southern African Development Community
SEN	686	Senegal	ACP	ACP non LDC	SEN	Senegal
SAU	682	Saudi arabia	ROW	Rest of world	SAU	Rest of Middle East
VCT	670	Saint Vincent and the Grenadines	ROW	Rest of world	VCT	Rest of Free Trade Area of the Americas
LCA	662	Saint lucia	ROW	Rest of world	LCA	Rest of Free Trade Area of the Americas
KNA	659	Saint kitts and nevis	ROW	Rest of world	KNA	Rest of Free Trade Area of the Americas
RWA	646	Rwanda	LDC	LDC	RWA	Rest of Sub-Saharan Africa
RUS	643	Russian federation	RBU	Russia, Belarus and Ukraine	RUS	Russian Federation
ROM	642	Romania	RO000000	Romania	ROM	Romania
QAT	634	Qatar	ROW	Rest of world	QAT	Rest of Middle East
GNB	624	Guinea-bissau	LDC	LDC	GNB	Rest of Sub-Saharan Africa
PRT	620	Portugal	PT000000	Portugal	PRT	Portugal
POL	616	Poland	PL000000	Poland	POL	Poland
PHL	608	Philippines	ROW	Rest of world	PHL	Philippines
PER	604	Peru	RSA	Rest of South America	PER	Peru
PRY	600	Paraguay	PAR	Paraguay	PRY	Paraguay
PNG	598	Papua new guinea	ACP	ACP non LDC	PNG	Rest of Oceania
PAN	591	Panama	RSA	Rest of South America	PAN	Central America
PAK	586	Pakistan	ROW	Rest of world	PAK	Pakistan
NOR	579	Norway	NO000000	Norway	NOR	Rest of EFTA
NGA	566	Nigeria	ACP	ACP non LDC	NGA	Nigeria
NER	562	Niger	LDC	LDC	NER	Rest of Sub-Saharan Africa
NIC	558	Nicaragua	ROW	Rest of world	NIC	Central America
NZL	554	New zealand	ANZ	Australia and New Zealand	NZL	New Zealand
VUT	548	Vanuatu	LDC	LDC	VUT	Rest of Oceania

NLD	528	Netherlands	NL000000	Netherlands	NLD	Netherlands
NPL	524	Nepal	ROW	Rest of world	NPL	Rest of South Asia
NAM	516	Namibia	ACP	ACP non LDC	NAM	Rest of South African Customs Union
OMN	512	Oman	ROW	Rest of world	OMN	Rest of Middle East
MOZ	508	Mozambique	LDC	LDC	MOZ	Mozambique
MAR	504	Morocco	MOR	Morocco	MAR	Morocco
MDA	498	Moldova, Republic of	REU	Rest of Europe	MDA	Rest of Former Soviet Union
TWN	490	China, Taiwan Province of	ROW	Rest of world	TWN	Taiwan
MEX	484	Mexico	MEX	Mexico	MEX	Mexico
MUS	480	Mauritius	ACP	ACP non LDC	MUS	Mauritius
MRT	478	Mauritania	LDC	LDC	MRT	Rest of Sub-Saharan Africa
MLT	470	Malta	MT000000	Malta	MLT	Malta
MLI	466	Mali	LDC	LDC	MLI	Rest of Sub-Saharan Africa
MDV	462	Maldives	ROW	Rest of world	MDV	Rest of South Asia
MYS	458	Malaysia	ROW	Rest of world	MYS	Malaysia
MWI	454	Malawi	LDC	LDC	MWI	Malawi
MDG	450	Madagascar	LDC	LDC	MDG	Madagascar
LUX	442	Luxembourg	BL000000	Belgium	LUX	Luxembourg
LTU	440	Lithuania	LT000000	Lithuania	LTU	Lithuania
LBY	434	Libyan arab jamahiriya	ROW	Rest of world	LBY	Rest of North Africa
LVA	428	Latvia	LV000000	Latvia	LVA	Latvia
LSO	426	Lesotho	LDC	LDC	LSO	Rest of South African Customs Union
LBN	422	Lebanon	ROW	Rest of world	LBN	Rest of Middle East
LAO	418	Lao People's Democratic Republic	ROW	Rest of world	LAO	Rest of Southeast Asia
KGZ	417	Kyrgyzstan	ROW	Rest of world	KGZ	Rest of Former Soviet Union
KWT	414	Kuwait	ROW	Rest of world	KWT	Rest of Middle East
KOR	410	Korea, Republic of	ROW	Rest of world	KOR	Korea
KEN	404	Kenya	ACP	ACP non LDC	KEN	Rest of Sub-Saharan Africa
JOR	400	Jordan	ROW	Rest of world	JOR	Rest of Middle East
KAZ	398	Kazakhstan	ROW	Rest of world	KAZ	Rest of Former Soviet Union
JPN	392	Japan	JAP	Japan	JPN	Japan
JAM	388	Jamaica	ROW	Rest of world	JAM	Rest of Free Trade Area of the Americas
CIV	384	Côte d'ivoire	ACP	ACP non LDC	CIV	Rest of Sub-Saharan Africa

ITA	381	Italy	IT000000	Italy	ITA	Italy
ISR	376	Israel	ISR	Israel	ISR	Rest of Middle East
IRL	372	Ireland	IR000000	Ireland	IRL	Ireland
IRN	364	Iran, Islamic Republic of	ROW	Rest of world	IRN	Iran, Islamic Republic of
IDN	360	Indonesia	ROW	Rest of world	IDN	Indonesia
ISL	352	Iceland	ROW	Rest of world	ISL	Rest of EFTA
HUN	348	Hungary	HU000000	Hungary	HUN	Hungary
HKG	344	China, Hong Kong SAR	CHN	China	HKG	Hong Kong
HND	340	Honduras	RSA	Rest of South America	HND	Central America
GUY	328	Guyana	ACP	ACP non LDC	GUY	Rest of South America
GTM	320	Guatemala	RSA	Rest of South America	GTM	Central America
GRD	308	Grenada	ROW	Rest of world	GRD	Rest of Free Trade Area of the Americas
GRC	300	Greece	EL000000	Greece	GRC	Greece
GHA	288	Ghana	ACP	ACP non LDC	GHA	Rest of Sub-Saharan Africa
DEU	276	Germany	DE000000	Germany	DEU	Germany
GEO	268	Georgia	ROW	Rest of world	GEO	Rest of Former Soviet Union
GAB	266	Gabon	ACP	ACP non LDC	GAB	Rest of Sub-Saharan Africa
FRA	251	France	FR000000	France	FRA	France
FIN	246	Finland	FI000000	Finland	FIN	Finland
EST	233	Estonia	*******	Germany	EST	Estonia
ERI	232	Eritrea	LDC	LDC	ERI	Rest of Sub-Saharan Africa
ETH	231	Ethiopia	LDC	LDC	ETH	Rest of Sub-Saharan Africa
GNQ	226	Equatorial guinea	LDC	LDC	GNQ	Rest of Sub-Saharan Africa
SLV	222	El salvador	ROW	Rest of world	SLV	Central America
ECU	218	Ecuador	RSA	Rest of South America	ECU	Ecuador
DOM	214	Dominican republic	ACP	ACP non LDC	DOM	Rest of Free Trade Area of the Americas
DMA	212	Dominica	ACP	ACP non LDC	DMA	Rest of Free Trade Area of the Americas
DNK	208	Denmark	DK000000	Denmark	DNK	Denmark
BEN	204	Benin	LDC	LDC	BEN	Rest of Sub-Saharan Africa
CZE	203	Czech republic	CZ000000	Czech Republic	CZE	Czech Republic
CYP	196	Cyprus	CY000000	Cyprus	CYP	Cyprus

CUB	192	Cuba	ACP	ACP non LDC	CUB	Rest of the Caribbean
HRV	191	Croatia	HR000000	Croatia	HRV	Croatia
CRI	188	Costa rica	RSA	Rest of South America	CRI	Central America
COG	178	Congo	LDC	LDC	COG	Rest of Sub-Saharan Africa
COL	170	Colombia	RSA	Rest of South America	COL	Colombia
CHN	156	China	CHN	China	CHN	China
CHL	152	Chile	CHL	Chile	CHL	Chile
TCD	148	Chad	LDC	LDC	TCD	Rest of Sub-Saharan Africa
LKA	144	Sri lanka	ROW	Rest of world	LKA	Sri Lanka
CAF	140	Central african republic	LDC	LDC	CAF	Rest of Sub-Saharan Africa
CAN	124	Canada	CAN	Canada	CAN	Canada
CMR	120	Cameroon	ACP	ACP non LDC	CMR	Rest of Sub-Saharan Africa
KHM	116	Cambodia	ROW	Rest of world	KHM	Cambodia
BLR	112	Belarus	RBU	Russia, Belarus and Ukraine	BLR	Rest of Former Soviet Union
MMR	104	Myanmar	ROW	Rest of world	MMR	Rest of Southeast Asia
BGR	100	Bulgaria	BG000000	Bulgaria	BGR	Bulgaria
BRN	096	Brunei darussalam	ROW	Rest of world	BRN	Rest of Southeast Asia
SLB	090	Solomon islands	LDC	LDC	SLB	Rest of Oceania
BLZ	084	Belize	ACP	ACP non LDC	BLZ	Central America
BRA	076	Brazil	BRA	Brazil	BRA	Brazil
BWA	072	Botswana	ACP	ACP non LDC	BWA	Botswana
BIH	070	Bosnia and herzegovina	REU	Rest of Europe	BIH	Rest of Europe
BOL	068	Bolivia	BOL	Bolivia	BOL	Bolivia
BTN	064	Bhutan	LDC	LDC	BTN	Rest of South Asia
BMU	060	Bermuda	ROW	Rest of world	BMU	Rest of North America
BEL	056	Belgium	BL000000	Belgium	BEL	Belgium
BRB	052	Barbados	ACP	ACP non LDC	BRB	Rest of Free Trade Area of the Americas
ARM	051	Armenia	ROW	Rest of world	ARM	Rest of Former Soviet Union
BGD	050	Bangladesh	LDC	LDC	BGD	Bangladesh
BHR	048	Bahrain	ROW	Rest of world	BHR	Rest of Middle East
BHS	044	Bahamas	ACP	ACP non LDC	BHS	Rest of Free Trade Area of the Americas
AUT	040	Austria	AT000000	Austria	AUT	Austria
AUS	036	Australia	ANZ	Australia and New Zealand	AUS	Australia

ARG	032	Argentina	ARG	Argentina	ARG	Argentina
AZE	031	Azerbaijan	ROW	Rest of world	AZE	Rest of Former Soviet Union
ATG	028	Antigua and barbuda	ACP	ACP non LDC	ATG	Rest of Free Trade Area of the Americas
DZA	012	Algeria	ALG	Algeria	DZA	Rest of North Africa
ALB	008	Albania	AL000000	Albania	ALB	Albania

Appendix 3: CAPRI-GTAP sector concordance for agriculture

The mapping is limited to GTAP sectors where there is at least one shared HS code with a CAPRI sector. This implies that no tables are included for:

- Coal (coa)
- Electronic equipment (ele)
- Metal products (fmp)
- Fishing (fsh)
- Gas (gas)
- Gas manufacture, distribution (gdt)
- Ferrous metals (i_s)
- Leather products (lea)
- Wood products (lum)
- Motor vehicles and parts (mvh)
- Motor vehicles and parts (nfm)
- Mineral products nec (nmm)
- Oil (oil)
- Machinery and equipment nec (ome)
- Manufactures nec (omf)
- Minerals nec (omn)
- Transport equipment nec (otn)
- Petroleum, coal products (p_c)
- Plant-based fibers (pfb)
- Paper products, publishing (ppp)
- Textiles (tex)
- Wearing apparel (wap)
- Wool, silk-worm cocoons (wol)

In case of chemical, rubber or plastic products (crp) there is one shared HS codes with CAPRI, HS 151800 (Animal or vegetable fats and oils and their fractions), linked to the CAPRI sector other oil (OTHO). Since this is only one out of 987 HS codes that are mapped to this GTAP sector there is no table is included.

Table A3.1: Mapping for Paddy rice (pdr)

Code	*CAPRI*	*HS6*	*HS description*
PARI	Paddy rice	100610	Rice in the husk, 'paddy' or rough
PARI	Paddy rice	100620	Husked or brown rice

Table A3.2: Mapping for Wheat (wht)

Code	*CAPRI*	*HS6*	*HS description*
SWHE	Soft wheat	100190	Wheat and meslin (excl. durum wheat)
DWHE	Durum wheat	100110	Durum wheat

Table A3.3: Mapping for Cereal grains nec (gro)

Code	*CAPRI*	*HS6*	*HS description*
RYEM	Rye and meslin	100200	Rye
OCER	Other cereals	100810	Buckwheat
OCER	Other cereals	100700	Grain sorghum
OCER	Other cereals	100890	Cereals (excl. wheat and meslin, rye, barley, oats, maize, rice, buckwheat,
OCER	Other cereals	100830	Canary seed
OCER	Other cereals	100820	Millet (excl. grain sorghum)
OATS	Oats	100400	Oats
MAIZ	Grain maize	100590	Maize (excl. seed)
MAIZ	Grain maize	100510	Maize seed
BARL	Barley	100300	Barley

Table A3.4: Mapping for Vegetables, fruit, nuts (v_f)

Code	*CAPRI*	*HS6*	*HS description*
TOMA	Tomatoes	070200	Tomatoes, fresh or chilled
TAGR	Table grapes	080620	Dried grapes
TAGR	Table grapes	080610	Fresh grapes
PULS	Pulses	071331	Dried, shelled beans of species 'vigna mungo (l.) hepper or vigna radiata (
PULS	Pulses	071339	Dried, shelled beans 'vigna and phaseolus', whether or not skinned or split
PULS	Pulses	070890	Fresh or chilled leguminous vegetables, shelled or unshelled (excl. peas 'p
PULS	Pulses	070820	Fresh or chilled beans 'vigna spp., phaseolus spp.', shelled or unshelled
PULS	Pulses	070810	Fresh or chilled peas 'pisum sativum', shelled or unshelled
PULS	Pulses	071340	Dried, shelled lentils, whether or not skinned or split
PULS	Pulses	071310	Dried, shelled peas 'pisum sativum', whether or not skinned or split
PULS	Pulses	071350	Dried, shelled broad beans and horse beans, whether or not skinned or split
PULS	Pulses	071332	Dried, shelled adzuki beans 'phaseolus or vigna angularis', whether or not
PULS	Pulses	121210	Locust beans, incl. locust bean seeds, fresh or dried, whether or not groun
PULS	Pulses	071320	Dried, shelled chickpeas, whether or not skinned or split
PULS	Pulses	071333	Dried, shelled kidney beans 'phaseolus vulgaris', whether or not skinned or
PULS	Pulses	071390	Dried, shelled leguminous vegetables, whether or not skinned or split (excl
POTA	Potatoes	070190	Fresh or chilled potatoes (excl. seed)
POTA	Potatoes	070110	Seed potatoes
PEAR		080820	Fresh pears and quinces
PEAR		081340	Dried peaches, pears, pawpaws, tamarinds and other edible fruit n.e.s.

PEAC		080930	Fresh peaches, incl. nectarines
OVEG	Other vegetables	071420	Sweet potatoes, fresh or dried, whether or not sliced or in the form of pel
OVEG	Other vegetables	071490	Arrowroot, salep, jerusalem artichokes and similar roots and tubers with hi
OVEG	Other vegetables	080711	Fresh watermelons
OVEG	Other vegetables	070990	Fresh or chilled vegetables n.e.s.
OVEG	Other vegetables	080719	Fresh melons (excl. watermelons)
OVEG	Other vegetables	070490	Fresh or chilled cabbages, kohlrabi, kale and similar edible brassicas (exc
OVEG	Other vegetables	070310	Fresh or chilled onions and shallots
OVEG	Other vegetables	070320	Garlic, fresh or chilled
OVEG	Other vegetables	070390	Leeks and other alliaceous vegetables, fresh or chilled (excl. onions, shal
OVEG	Other vegetables	070410	Fresh or chilled cauliflowers and headed broccoli
OVEG	Other vegetables	070700	Cucumbers and gherkins, fresh or chilled
OVEG	Other vegetables	070420	Brussels sprouts, fresh or chilled
OVEG	Other vegetables	070970	Fresh or chilled spinach, new zealand spinach and orache spinach
OVEG	Other vegetables	070511	Fresh or chilled cabbage lettuce
OVEG	Other vegetables	070519	Fresh or chilled lettuce (excl. cabbage lettuce)
OVEG	Other vegetables	070521	Fresh or chilled witloof chicory
OVEG	Other vegetables	070951	Fresh or chilled mushrooms
OVEG	Other vegetables	070930	Fresh or chilled aubergines
OVEG	Other vegetables	070910	Fresh or chilled globe artichokes
OVEG	Other vegetables	070940	Fresh or chilled celery (excl. celeriac)
OVEG	Other vegetables	070952	Fresh or chilled truffles
OVEG	Other vegetables	070960	Fresh or chilled fruits of the genus capsicum or pimenta
OVEG	Other vegetables	070690	Fresh or chilled salad beetroot, salsify, celeriac, radishes and similar ed
OVEG	Other vegetables	070610	Fresh or chilled carrots and turnips
OVEG	Other vegetables	070529	Fresh or chilled chicory (excl. witloof chicory)
OVEG	Other vegetables	070920	Fresh or chilled asparagus
OFRU	Other fruits	080720	Fresh pawpaws 'papayas'
OFRU	Other fruits	080300	Bananas, incl. plantains, fresh or dried
OFRU	Other fruits	080450	Fresh or dried guavas, mangoes and mangosteens
OFRU	Other fruits	080440	Fresh or dried avocados
OFRU	Other fruits	080430	Fresh or dried pineapples
OFRU	Other fruits	080420	Fresh or dried figs
OFRU	Other fruits	080410	Fresh or dried dates
OFRU	Other fruits	080910	Fresh apricots
OFRU	Other fruits	081040	Fresh cranberries, bilberries and other fruits of the genus vaccinium
OFRU	Other fruits	080940	Fresh plums and sloes
OFRU	Other fruits	081010	Fresh strawberries
OFRU	Other fruits	081020	Fresh raspberries, blackberries, mulberries and loganberries
OFRU	Other fruits	081030	Fresh black, white or red currants and gooseberries
OFRU	Other fruits	081050	Fresh kiwifruit
OFRU	Other fruits	081090	Kiwifruit, tamarinds, cashew apples, jackfruit, lychees, sapodillo plums an
OFRU	Other fruits	081310	Dried apricots
OFRU	Other fruits	081320	Dried prunes
OFRU	Other fruits	080920	Fresh cherries
NUTS		081350	Mixtures of nuts or dried fruits
NUTS		080132	Fresh or dried cashew nuts, shelled
NUTS		080121	Fresh or dried brazil nuts, in shell
NUTS		080212	Fresh or dried almonds, shelled and peeled
NUTS		080111	Desiccated coconuts
NUTS		080119	Fresh coconuts, whether or not shelled or peeled
NUTS		080122	Fresh or dried brazil nuts, shelled
NUTS		080131	Fresh or dried cashew nuts, in shell
NUTS		080211	Fresh or dried almonds in shell
NUTS		080221	Fresh or dried hazelnuts in shell

NUTS		080222	Fresh or dried hazelnuts, shelled and peeled
NUTS		080231	Fresh or dried walnuts in shell
NUTS		080240	Fresh or dried chestnuts, whether or not shelled or peeled
NUTS		080250	Fresh or dried pistachios, whether or not shelled or peeled
NUTS		080290	Nuts, fresh or dried, whether or not shelled or peeled (excl. coconuts, bra
NUTS		080232	Fresh or dried walnuts, shelled and peeled
CITR	Citrus fruits	080590	Fresh or dried citrus fruit (excl. oranges, lemons, grapefruit, mandarins,
CITR	Citrus fruits	080540	Fresh or dried grapefruit
CITR	Citrus fruits	080530	Fresh or dried lemons and limes
CITR	Citrus fruits	080510	Fresh or dried oranges
CITR	Citrus fruits	080520	Fresh or dried mandarins incl. tangerines and satsumas, clementines, wilkin
APPS		080810	Fresh apples
APPS		081330	Dried apples
AMAN		071410	Fresh or dried manioc 'cassava', whether or not sliced or in the form of pe

Table A3.5: Mapping for Oil seeds (osd)

Code	*CAPRI*	*HS6*	*HS description*
SUNF	Sunflower seed	120600	Sunflower seeds, whether or not broken
SOYA	Soya seed	120100	Soya beans, whether or not broken
RAPE	Rape seed	120500	Rape or colza seeds, whether or not broken
OOIL	Other oil	120760	Safflower seeds, whether or not broken
OOIL	Other oil	120730	Castor oil seeds, whether or not broken
OOIL	Other oil	120799	Oil seeds and oleaginous fruits, whether or not broken (excl. edible nuts,
OOIL	Other oil	120791	Poppy seeds, whether or not broken
OOIL	Other oil	120750	Mustard seeds, whether or not broken
OOIL	Other oil	120740	Sesamum seeds, whether or not broken
OOIL	Other oil	120710	Palm nuts and kernels, whether or not broken
OOIL	Other oil	120400	Linseed, whether or not broken
OOIL	Other oil	120792	Shea nuts 'karite nuts', whether or not broken
OOIL	Other oil	120220	Shelled ground-nuts, whether or not broken (excl. roasted or otherwise cook
OOIL	Other oil	120720	Cotton seeds, whether or not broken
NUTS		120210	Ground-nuts in shell, not roasted or otherwise cooked
		120300	Copra

Table A3.6: Mapping for Sugar cane and beet (c_b)

Code	*CAPRI*	*HS6*	*HS description*
SUGB	Sugar beet	121291	Sugar beet, fresh or dried, whether or not ground
		121292	Sugar cane, fresh or dried, whether or not ground

Table A3.7: Mapping for Crops nec (ocr)

Code	*CAPRI*	*HS6*	*HS description*
TOBA	Tobacco	240120	Tobacco, partly or wholly stemmed or stripped, otherwise unmanufactured
TOBA	Tobacco	240110	Tobacco, not stemmed or stripped
TOBA	Tobacco	240130	Tobacco refuse
TEA		090300	Mate
TEA		090240	Black fermented tea and partly fermented tea in immediate packings of > 3 k
TEA		090240	Black fermented tea and partly fermented tea in immediate packings of > 3 k
TEA		090220	Green tea in immediate packings of > 3 kg
NURS	Nurseries	060110	Bulbs, tubers, tuberous roots, corms, crowns and rhizomes, dormant (excl. t
NURS	Nurseries	060290	Live plants, incl. their roots, and mushroom spawn (excl. bulbs, tubers, tu
NURS	Nurseries	060240	Roses, whether or not grafted
NURS	Nurseries	060230	Rhododendrons and azaleas, whether or not grafted
NURS	Nurseries	060220	Edible fruit or nut trees, shrubs and bushes, whether or not grafted
NURS	Nurseries	060120	Bulbs, tubers, tuberous roots, corms, crowns and rhizomes, in growth or in
NURS	Nurseries	060210	Unrooted cuttings and slips
HOPS		121020	Hop cones, ground, powdered or in the form of pellets; lupulin
HOPS		121010	Hop cones, fresh or dried (excl. ground, powdered or pellets)
FPEG		120921	Alfalfa seed for sowing
FPEG		120926	Timothy grass seed for sowing
FPEG		120925	Rye grass seed for sowing
FPEG		120924	Kentucky blue grass seed for sowing
FPEG		120923	Fescue seed for sowing
FPEG		120922	Clover 'trifolium spp.' seed for sowing
FPEG		120929	Seeds of forage plants for sowing (excl. cereals and sugar beet, alfalfa, c
FLOW	Flowers	060310	Fresh cut flowers and flower buds, for bouquets or for ornamental purposes
FLOW	Flowers	060390	Dried, dyed, bleached, impregnated or otherwise prepared cut flowers and bu
COFF		090111	Coffee (excl. roasted and decaffeinated)
		121300	Cereal straw and husks, unprepared, wheher or not chopped, ground, pressed
		090412	Pepper of the genus piper, crushed or ground
		120930	Seeds of herbaceous plants cultivated mainly for flowers, for sowing
		120991	Vegetable seeds, for sowing
		120999	Seeds, fruits and spores, for sowing (excl. leguminous vegetables and sweet
		090411	Pepper of the genus piper, neither crushed nor ground
		121110	Liquorice roots, fresh or dried, whether or not cut, crushed or powdered
		121120	Ginseng roots, fresh or dried, whether or not cut, crushed or powdered
		090420	Fruits of the genus capsicum or of the genus pimenta, dried or crushed or g
		121299	Fruit stones and kernels and other vegetable products, incl. unroasted chic
		121410	Alfalfa meal and pellets
		121490	Swedes, mangolds, fodder roots, hay, alfalfa, clover, sainfoin, forage kale
		090820	Mace
		180100	Cocoa beans, whole or broken, raw or roasted
		230810	Acorns and horse-chestnuts for animal feeding, whether or not in the form o
		230890	Maize stalks, maize leaves, marc and other vegetable materials, waste, resi
		121190	Plants, parts of plants, seeds and fruit used in perfumery, medicaments or
		090920	Coriander seeds
		140310	Broomcorn
		090500	Vanilla
		090910	Seeds of anise or badian
		090930	Cumin seeds
		090940	Caraway seeds
		090950	Seeds of fennel or juniper
		090950	Seeds of fennel or juniper
		091010	Ginger

	090830	Cardamoms
	091020	Saffron
	090620	Crushed or ground cinnamon and cinnamon-tree flowers
	090610	Cinnamon and cinnamon-tree flowers (excl. crushed and ground)
	091030	Turmeric 'curcuma'
	090700	Cloves, whole fruit, cloves and stems
	090810	Nutmeg
	120919	Beet seed for sowing (excl. sugar beet)
	091099	Spices n.e.s. (excl. mixtures of different types of spices)
	091091	Mixtures of different types of spices
	120911	Sugar beet seed, for sowing
	091040	Thyme and bay leaves
	091050	Curry

Table A3.8: Mapping for Bovine cattle, sheep and goats, horses (ctl)

Code	*CAPRI*	*HS6*	*HS description*
SGMT	Sheep and goat meat	010410	Live sheep
SGMT	Sheep and goat meat	010420	Live goats
OANI	Other animals output	010120	Live asses, mules and hinnies
OANI	Other animals output	010119	Live horses (excl. pure-bred for breeding)
OANI	Other animals output	010111	Pure-bred breeding horses
BEEF	Beef	010210	Pure-bred breeding bovines
BEEF	Beef	010290	Live bovine animals (excl. pure-bred for breeding)
		051110	Bovine semen

Table A3.9: Mapping for Animal products nec (oap)

Code	*CAPRI*	*HS6*	*HS description*
POUM	Poultry meat	010599	Live domestic ducks, geese, turkeys and guinea fowls weighing > 185 g
POUM	Poultry meat	010593	Live fowls of the species gallus domesticus, weighing > 2 kg
POUM	Poultry meat	010592	Live fowls of the species gallus domesticus, weighing > 185 g but <= 2 kg
POUM	Poultry meat	010511	Live fowls of species gallus domesticus, weighing =< 185 g (excl. turkeys a
POUM	Poultry meat	010519	Live domestic ducks, geese, turkeys and guinea fowls, weighing =< 185 g
POUM	Poultry meat	010512	Live domestic turkeys, weighing <= 185 g
PORK	Pork meat	010391	Live pure-bred swine, weighing < 50 kg (excl. pure-bred for breeding)
PORK	Pork meat	010310	Pure-bred breeding swine
PORK	Pork meat	010392	Live pure-bred swine, weighing >= 50 kg (excl. pure-bred for breeding)
EGGS	Laying hens	040700	Birds' eggs, in shell, fresh, preserved or cooked
		430130	Raw furskins of the following types of lamb: astrakhan, caracul, persian, b
		410129	Raw hides and skins of bovine animals, weighing > 14 kg, fresh or wet-salte
		410130	Raw hides and skins of bovine animals, dry-salted, limed, pickled or otherw
		410140	Raw hides and skins of equine animals, fresh or salted, dried, limed, pickl
		410210	Raw hides and skins of sheep or lambs, with wool on, fresh or salted, dried
		410221	Raw hides and skins of sheep and lambs, without wool on, pickled, whether o
		410229	Raw hides and skins of sheep and lambs, without wool on, fresh or salted, d
		410310	Raw hides and skins of goats or kids, fresh or salted, dried, limed, pickle
		410320	Raw hides and skins of reptiles, fresh or salted, dried, limed, pickled or
		410390	Other raw hides and skins, fresh or salted, dried, limed, pickled or otherw
		430120	Raw furskins of rabbit or hare, whether or not without heads, tails or feet
		430140	Raw furskins of beaver, whether or not without heads, tails or feet
		430150	Raw furskins of muskrat, whether or not without heads, tails or feet
		410122	Raw butts and bends of bovine animals, fresh or wet-salted, whether or not
		430160	Raw furskins of fox, whether or not without heads, tails or feet
		430170	Raw furskins of true and eared seals, whole, whether or not without heads,
		430180	Raw furskins, whole, whether or not without heads, tails or feet (excl. tho
		430190	Heads, tails, feet and other pieces or cuttings of furskins suitable for us
		430110	Raw furskins of mink, whole, whether or not without heads, tails or feet
		050290	Badger and other brush making hair and waste thereof
		041000	Turtles' eggs, birds' nests and other edible products of animal origin n.e.
		410121	Whole raw bovine hides and skins, weighing > 14 kg, fresh or wet-salted, wh
		010600	Live animals (excl. horses, asses, mules, hinnies, bovine animals, swine, s
		020820	Fresh, chilled or frozen frogs' legs
		030760	Snails, live, fresh, chilled, frozen, salted, dried or in brine, with or wi
		050210	Pigs', hogs' or boars' bristles and waste of such bristles
		050400	Guts, bladders and stomachs of animals other than fish, whole and pieces th
		050510	Feathers used for stuffing and down, not further worked than cleaned, disin
		051199	Products of animal origin n.e.s., dead animals, unfit for human consumption
		410110	Whole raw bovine hides and skins, weighing =< 8 kg when dried, =< 10 kg whe
		040900	Natural honey
		152190	Beeswax, other insect waxes and spermaceti, whether or not refined or colou
		050590	Skins and other parts of birds, with their feathers or down, feathers and p
		051000	Ambergris, castoreum, civet and musk; cantharides; bile, whether or not dri
		050790	Tortoise-shell, whalebone and whalebone hair, horns, antlers, hooves, nails
		050710	Ivory, unworked or simply prepared, its powder and waste (excl. cut to shap
		050690	Bones and horn-cores and their powder and waste, unworked, defatted, degela
		050610	Ossein and bones treated with acid

Table A3.10: Mapping for Bovine meat products (cmt)

Code	*CAPRI*	*HS6*	*HS description*
SGMT	Sheep and goat meat	020450	Fresh, chilled or frozen meat of goats
SGMT	Sheep and goat meat	020430	Frozen lamb carcases and 1/2 carcases
SGMT	Sheep and goat meat	020422	Fresh or chilled cuts of sheep, unboned (excl. carcases and 1/2 carcases)
SGMT	Sheep and goat meat	020443	Frozen boned cuts of sheep
SGMT	Sheep and goat meat	020442	Frozen cuts of sheep, unboned (excl. carcases and 1/2 carcases)
SGMT	Sheep and goat meat	020441	Frozen sheep carcases and 1/2 carcases (excl. lambs)
SGMT	Sheep and goat meat	020410	Fresh or chilled lamb carcases and 1/2 carcases
SGMT	Sheep and goat meat	020421	Fresh or chilled sheep carcases and 1/2 carcases (excl. lambs)
SGMT	Sheep and goat meat	020423	Fresh or chilled boneless cuts of sheep
PORK	Pork meat	020900	Pig fat, free of lean meat and poultry fat not rendered, fresh, chilled, fr
OANI	Other animals output	020500	Meat of horses, asses, mules or hinnies, fresh, chilled or frozen
BEEF	Beef	020220	Frozen bovine cuts, unboned (excl. carcases and 1/2 carcases)
BEEF	Beef	020210	Frozen bovine carcases and 1/2 carcases
BEEF	Beef	020130	Fresh or chilled bovine meat, boneless
BEEF	Beef	020110	Fresh or chilled bovine carcases and half-carcases
BEEF	Beef	020230	Boneless, frozen meat of bovine animals
BEEF	Beef	020120	Fresh or chilled bovine cuts, unboned (excl. carcases and 1/2 carcases)
		020641	Frozen edible livers of swine
		150590	Wool grease and fatty substances derived therefrom incl. lanolin (excl. cru
		150510	Crude wool grease
		150200	Fats of bovine animals, sheep or goats, raw or rendered, whether or not pre
		150100	Lard; other pig fat and poultry fat, rendered, whether or not pressed or so
		020690	Frozen edible offal of sheep, goats, horses, asses, mules and hinnies
		020649	Edible offal of swine, frozen (excl. livers)
		020630	Fresh or chilled edible offal of swine
		020629	Frozen edible bovine offal (excl. tongues and livers)
		020622	Frozen edible bovine livers
		020621	Frozen edible bovine tongues
		020610	Edible offal of bovine animals, fresh or chilled
		020680	Fresh or chilled edible offal of sheep, goats, horses, asses, mules and hin

Table A3.11: Mapping for Meat products nec (omt)

Code	*CAPRI*	*HS6*	*HS description*
POUM	Poultry meat	020725	Frozen turkeys of the species domesticus, not cut into pieces
POUM	Poultry meat	160231	Prepared or preserved meat or offal of turkeys (excl. sausages and similar
POUM	Poultry meat	020726	Fresh or chilled cuts and edible offal of turkeys of the species domesticus
POUM	Poultry meat	020727	Frozen cuts and edible offal of turkeys of the species domesticus
POUM	Poultry meat	020732	Fresh or chilled ducks, geese and guinea fowls of the species domesticus, n
POUM	Poultry meat	020733	Frozen ducks, geese and guinea fowls of the species domesticus, not cut int
POUM	Poultry meat	020734	Fresh or chilled edible fatty livers of ducks or geese of the species domes
POUM	Poultry meat	020736	Frozen cuts and edible offal of ducks, geese or guinea fowls of the species
POUM	Poultry meat	020724	Fresh or chilled turkeys of the species domesticus, not cut into pieces
POUM	Poultry meat	020735	Fresh or chilled cuts and edible offal of ducks, geese or guinea fowls of t
POUM	Poultry meat	020714	Frozen cuts and edible offal of fowls of the species gallus domesticus
POUM	Poultry meat	020713	Fresh or chilled cuts and edible offal of fowls of the species
POUM	Poultry meat	020712	Frozen fowls of the species gallus domesticus, not cut into pieces
POUM	Poultry meat	020711	Fresh or chilled fowls of the species gallus domesticus, not cut into piece
POUM	Poultry meat	160232	Prepared or preserved meat or meat offal of fowls of the species gallus dom
POUM	Poultry meat	160239	Prepared or preserved meat or offal of chickens, ducks, geese and guinea fo
PORK	Pork meat	160249	Prepared or preserved meat and offal of swine, incl. mixtures (excl. hams,
PORK	Pork meat	160242	Prepared or preserved shoulders and cuts thereof, of swine
PORK	Pork meat	160241	Hams and cuts thereof, prepared or preserved
PORK	Pork meat	021012	Bellies and cuts thereof of swine, salted, in brine, dried or smoked
PORK	Pork meat	020321	Frozen carcases and 1/2 carcases of swine
PORK	Pork meat	021019	Meat of swine, salted, in brine, dried or smoked (excl. unboned hams, shoul
PORK	Pork meat	020322	Frozen hams, shoulders and cuts thereof, unboned
PORK	Pork meat	020319	Fresh or chilled meat of swine (excl. carcases and 1/2 carcases, and hams,
PORK	Pork meat	020312	Fresh or chilled hams, shoulders and cuts thereof of swine, unboned
PORK	Pork meat	020311	Fresh or chilled carcases and 1/2 carcases of swine
PORK	Pork meat	021011	Unboned hams, shoulders and cuts thereof of swine, salted, in brine, dried
PORK	Pork meat	020329	Frozen meat of swine (excl. carcases and 1/2 carcases, and hams, shoulders
BEEF	Beef	021020	Meat of bovine animals, salted, in brine, dried or smoked
BEEF	Beef	160250	Prepared or preserved meat or offal of bovine animals (excl. sausages and s
		230110	Flours, meals and pellets, of meat or offal, unfit for human consumption; g
		160300	Extracts and juices of meat, fish or crustaceans, molluscs and other aquati
		160290	Prepared or preserved meat, offal or blood (excl. meat or offal of poultry,
		020810	Fresh, chilled or frozen meat and edible offal of rabbits or hares
		020890	Fresh, chilled or frozen meat and edible offal of pigeons, whales, seals an
		160220	Preparations of liver of any animal (excl. sausages and similar products an
		021090	Meat and edible offal, salted, in brine, dried or smoked, and edible flours
		150300	Lard stearin, lard oil, oleostearin, oleo-oil and tallow oil (excl. emulsif
		150410	Fish-liver oils and their fractions, whether or not refined (excl. chemical
		150420	Fats and oils of fish and their fractions, whether or not refined (excl. li
		150430	Fats and oils and their fractions of marine mammals, whether or not refined
		150600	Other animal fats and oils and their fractions, whether or not refined, but
		160100	Sausages and similar products, of meat, offal or blood; food preparations b

Table A3.12: Mapping for Vegetable oils and fats (vol)

Code	*CAPRI*	*HS6*	*HS description*
SUNO	Sunflower seed oil	151211	Crude sunflower-seed or safflower oil
SUNO	Sunflower seed oil	151219	Sunflower-seed or safflower oil and their fractions, whether or not refined
SUNO	Sunflower seed oil	151221	Crude cotton-seed oil
SUNO	Sunflower seed oil	151229	Cotton-seed oil and its fractions, whether or not refined, but not chemical
SUNC	Sunflowe seed cake	230630	Oil-cake and other solid residues, whether or not ground or in the form of
SOYO	Soya oil	150710	Crude soya-bean oil, whether or not de-gummed
SOYO	Soya oil	150790	Soya-bean oil and its fractions, whether or not refined (excl. chemically m
SOYC	Soya cake	230400	Oil-cake and other solid residues, whether or not ground or in the form of
SOYA	Soya seed	120810	Soya bean flour and meal
RAPO	Rape seed oil	151490	Rape, colza or mustard oil and fractions thereof, whether or not refined, b
RAPO	Rape seed oil	151410	Crude rape, colza or mustard oil
RAPC	Rape seed cake	230640	Oil-cake and other solid residues, whether or not ground or in the form of
OTHO	Other oil	151521	Crude maize oil
OTHO	Other oil	151790	Edible mixtures or preparations of animal or vegetable fats or oils and edi
OTHO	Other oil	151710	Margarine (excl. liquid)
OTHO	Other oil	151590	Fixed vegetable fats and oils and their fractions, whether or not refined,
OTHO	Other oil	151560	Jojoba oil and its fractions, whether or not refined, but not chemically mo
OTHO	Other oil	151550	Sesame oil and its fractions, whether or not refined, but not chemically mo
OTHO	Other oil	151540	Tung oil and its fractions, whether or not refined, but not chemically modi
OTHO	Other oil	150810	Crude ground-nut oil
OTHO	Other oil	151529	Maize oil and fractions thereof, whether or not refined, but not chemically
OTHO	Other oil	151519	Linseed oil and fractions thereof, whether or not refined, but not chemical
OTHO	Other oil	151311	Crude coconut oil
OTHO	Other oil	150890	Ground-nut oil and its fractions, whether or not refined (excl. chemically
OTHO	Other oil	151190	Palm oil and its fractions, whether or not refined (excl. chemically modifi
OTHO	Other oil	151329	Palm kernel and babassu oil and their fractions, whether or not refined, bu
OTHO	Other oil	151321	Crude palm kernel and babassu oil
OTHO	Other oil	151319	Coconut oil and its fractions, whether or not refined, but not chemically m
OTHO	Other oil	151511	Crude linseed oil
OTHO	Other oil	151530	Castor oil and fractions thereof, whether or not refined, but not chemicall
OTHO	Other oil	151110	Crude palm oil
OTHO	Other oil	151000	Other oils and their fractions, obtained solely from olives, whether or not
OTHC	Other cake	230610	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230620	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230670	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230650	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230660	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230690	Oil-cake and other solid residues, whether or not ground or in the form of
OTHC	Other cake	230500	Oil-cake and other solid residues, whether or not ground or in the form of
OOIL	Other oil	120890	Flours and meal of oil seeds or oleaginous fruit (excl. soya and mustard)
OLIO	Olive oil	150910	Virgin olive oil and its fractions
OLIO	Olive oil	150990	Olive oil and fractions (excl. virgin and chemically modified)
		152200	Degras; residues resulting from the treatment of fatty substances or animal
		152110	Vegetable waxes, whether or not refined or coloured (excl. triglycerides)
		140420	Cotton linters
		151620	Vegetable fats and oils and their fractions, partly or wholly hydrogenated,
		151610	Animal fats and oils and their fractions, partly or wholly hydrogenated, in

Table A3.13: Mapping for Dairy products (mil)

Code	*CAPRI*	*HS6*	*HS description*
WMIP	Whole milk powder	040229	Milk and cream in solid forms, of a fat content by weight of > 1.5 %, sweet
WMIP	Whole milk powder	040221	Milk and cream in solid forms, of a fat content by weight of > 1.5 %, unswe
SMIP	Skimmed milk powder	040210	Milk and cream in solid forms, of a fat content by weight of =< 1.5 %
FRMI	Fresh milk products	040390	Buttermilk, curdled milk and cream, kephir and other fermented or acidified
FRMI	Fresh milk products	040410	Whey and modified whey, whether or not concentrated or containing added sug
FRMI	Fresh milk products	040110	Milk and cream of a fat content by weight of =< 1 %, not concentrated nor c
FRMI	Fresh milk products	040310	Yogurt, whether or not flavoured or containing added sugar or other sweeten
FRMI	Fresh milk products	040490	Products consisting of natural milk constituents, whether or not sweetened,
FRMI	Fresh milk products	040120	Milk and cream of a fat content by weight of > 1 % but =< 6 %, not concentr
CREM	Cream	040130	Milk and cream of a fat content by weight of > 6 %, not concentrated nor co
COCM	Concentrated milk	040291	Milk and cream, concentrated but unsweetened (excl. in solid forms)
COCM	Concentrated milk	040299	Milk and cream, concentrated and sweetened (excl. in solid forms)
CHES	Cheese	040610	Fresh cheese, i.e. unripened or uncured cheese, including whey cheese, and
CHES	Cheese	040610	Fresh cheese, i.e. unripened or uncured cheese, including whey cheese, and
CHES	Cheese	040620	Grated or powdered cheese
CHES	Cheese	040630	Processed cheese, not grated or powdered
CHES	Cheese	040640	Blue-veined cheese
CHES	Cheese	040690	Cheese (excl. fresh cheese, incl. whey cheese, not fermented, curd, process
BUTT	Butter	040510	Butter (excl. dehydrated butter and ghee)
BUTT	Butter	040520	Dairy spreads of a fat content, by weight, of >= 39% but < 80%
BUTT	Butter	040590	Fats and oils derived from milk, and dehydrated butter and ghee (excl. natu
		170219	Lactose in solid form and lactose syrup, not containing added flavouring or
		210500	Ice cream and other edible ice, whether or not containing cocoa
		170211	Lactose in solid form and lactose syrup, not containing added flavouring or
		350110	Casein

Table A3.14: Mapping for Processed rice (pcr)

Code	*CAPRI*	*HS6*	*HS description*
RICE	Rice milled	100630	Semi-milled or wholly milled rice
RICE	Rice milled	100640	Broken rice

Table A3.15: Mapping for Sugar (sgr)

Code	*CAPRI*	*HS6*	*HS description*
SUGA	Processed sugar	170111	Raw cane sugar (excl. added flavouring or colouring)
SUGA	Processed sugar	170112	Raw beet sugar (excl. added flavouring or colouring)
SUGA	Processed sugar	170191	Refined cane or beet sugar, containing added flavouring or colouring, in so
SUGA	Processed sugar	170199	Cane or beet sugar and chemically pure sucrose, in solid form (excl. cane a
MOLA	Molasse	170310	Cane molasses resulting from the extraction or refining of sugar
MOLA	Molasse	170390	Beet molasses resulting from the extraction or refining of sugar
		170220	Maple sugar, in solid form, and maple syrup (excl. flavoured or coloured)

Table A3.16: Mapping for Food products nec (ofd)

Code	*CAPRI*	*HS6*	*HS description*
TOMA	Tomatoes	200210	Tomatoes, whole or in pieces, prepared or preserved otherwise than by vineg
TOMA	Tomatoes	200290	Tomatoes, prepared or preserved otherwise than by vinegar or acetic acid (e
TEA		090210	Green tea in immediate packings of =< 3 kg
TEA		090230	Black fermented tea and partly fermented tea in immediate packings of =< 3
TEA		090230	Black fermented tea and partly fermented tea in immediate packings of =< 3
TABO	Table olives	071120	Olives, provisionally preserved but unsuitable in that state for immediate
SWHE	Soft wheat	110900	Wheat gluten, whether or not dried
SWHE	Soft wheat	110811	Wheat starch
SWHE	Soft wheat	110100	Wheat or meslin flour
SWHE	Soft wheat	110321	Wheat pellets
SWHE	Soft wheat	110311	Groats and meal of wheat
STAR	Starch	110813	Potato starch
RYEM	Rye and meslin	110210	Rye flour
RICE	Rice milled	110819	Starch (excl. wheat, maize, potato and manioc)
RICE	Rice milled	110314	Rice groats and meal
RICE	Rice milled	110230	Rice flour
PULS	Pulses	071022	Shelled or unshelled beans, uncooked or cooked by steaming or by boiling in
PULS	Pulses	071029	Leguminous vegetables, shelled or unshelled, uncooked or cooked by steaming
PULS	Pulses	200559	Unshelled beans 'vigna spp., phaseolus spp.', prepared or preserved otherwi
PULS	Pulses	200551	Shelled beans 'vigna spp., phaseolus spp.', prepared or preserved otherwise
PULS	Pulses	200540	Peas 'pisum sativum', prepared or preserved otherwise than by vinegar or ac
PULS	Pulses	110610	Flour and meal of peas, beans, lentils and other dried leguminous vegetable
PULS	Pulses	071021	Shelled or unshelled peas, uncooked or cooked by steaming or by boiling in
POTA	Potatoes	200520	Potatoes, prepared or preserved otherwise than by vinegar or acetic acid (e
POTA	Potatoes	200410	Potatoes, prepared or preserved otherwise than by vinegar or acetic acid, f
POTA	Potatoes	110510	Potato flour and meal
POTA	Potatoes	071010	Potatoes, uncooked or cooked by steaming or by boiling in water, frozen
POTA	Potatoes	110520	Flakes, granules and pellets of potatoes
OVEG	Other vegetables	200560	Asparagus, prepared or preserved otherwise than by vinegar or acetic acid (
OVEG	Other vegetables	071290	Dried vegetables and mixtures of vegetables, whole, cut, sliced, broken or
OVEG	Other vegetables	071110	Onions provisionally preserved, but unsuitable in that state for immediate
OVEG	Other vegetables	071220	Dried onions, whole, cut, sliced, broken or in powder, but not further prep
OVEG	Other vegetables	071190	Vegetables and mixtures of vegetables provisionally preserved, but unsuitab
OVEG	Other vegetables	071140	Cucumbers and gherkins provisionally preserved, but unsuitable in that stat
OVEG	Other vegetables	200590	Vegetables and mixtures of vegetables, prepared or preserved otherwise than
OVEG	Other vegetables	071230	Dried mushrooms and truffles, whole, cut, sliced, broken or in powder, but
OVEG	Other vegetables	200580	Sweetcorn 'zea mays var. saccharata', prepared or preserved otherwise than
OVEG	Other vegetables	200510	Homogenized vegetables, put up for retail sale as infant food or for dietet
OVEG	Other vegetables	200490	Vegetables and mixtures of vegetables, prepared or preserved otherwise than
OVEG	Other vegetables	071040	Sweetcorn, uncooked or cooked by steaming or by boiling in water, frozen
OVEG	Other vegetables	071090	Mixtures of vegetables, uncooked or cooked by steaming or by boiling in wat
OVEG	Other vegetables	071080	Vegetables, uncooked or cooked by steaming or by boiling in water, frozen (
OVEG	Other vegetables	200320	Truffles, prepared or preserved otherwise than by vinegar or acetic acid
OVEG	Other vegetables	071030	Spinach, new zealand spinach and orache spinach, uncooked or cooked by stea
OVEG	Other vegetables	071130	Capers provisionally preserved but unsuitable in that state for immediate c
OVEG	Other vegetables	200110	Cucumbers and gherkins, prepared or preserved by vinegar or acetic acid
OVEG	Other vegetables	200120	Onions, prepared or preserved by vinegar or acetic acid
OVEG	Other vegetables	200190	Vegetables, fruit, nuts and other edible parts of plants, prepared or prese
OVEG	Other vegetables	200310	Mushrooms prepared or preserved otherwise than by vinegar or acetic acid
OLIV	Olive oil	200570	Olives, prepared or preserved otherwise than by vinegar or acetic acid (exc
OFRU	Other fruits	081400	Peel of citrus fruit or melons, incl. watermelons, fresh, frozen, dried or
OFRU	Other fruits	081220	Strawberries, provisionally preserved, but unsuitable in that state for imm
OFRU	Other fruits	081210	Cherries, provisionally preserved, but unsuitable in that state for immedia

OFRU	Other fruits	081190	Frozen fruit and nuts, uncooked or cooked by steaming or boiling in water,
OFRU	Other fruits	081120	Frozen raspberries, blackberries, mulberries, loganberries, black-, white-
OFRU	Other fruits	081110	Frozen strawberries, uncooked or cooked by steaming or boiling in water, wh
OFRU	Other fruits	081290	Fruit and nuts, provisionally preserved, but unsuitable in that state for i
OCER	Other cereals	110319	Groats and meal of cereals (excl. wheat, oats, maize and rice)
OCER	Other cereals	110290	Cereal flours (excl. wheat, meslin, rye, maize and rice)
OCER	Other cereals	110329	Cereal pellets (excl. wheat)
OCER	Other cereals	110419	Rolled or flaked grains of cereals (excl. barley and oats)
OCER	Other cereals	110429	Grains of cereals, hulled, pearled, sliced, kibbled or otherwise worked (ex
OCER	Other cereals	110430	Germ of cereals, whole, rolled, flaked or ground
OATS	Oats	110412	Rolled or flaked grains of oats
OATS	Oats	110422	Hulled, pearled, sliced, kibbled or otherwise worked oat grains (excl. oat
OATS	Oats	110312	Groats and meal of oats
MAIZ	Grain maize	110313	Groats and meal of maize 'corn'
MAIZ	Grain maize	110220	Maize 'corn' flour
MAIZ	Grain maize	110812	Maize starch
MAIZ	Grain maize	110423	Hulled, pearled, sliced, kibbled or otherwise worked maize grains (excl. ma
EGGS	Laying hens	350211	Egg albumin, dried 'e.g. in sheets, scales, flakes, powder'
EGGS	Laying hens	040899	Birds' eggs, not in shell, fresh, cooked by steaming or boiling in water, m
EGGS	Laying hens	040891	Dried birds' eggs, not in shell, whether or not sweetened (excl. egg yolks)
EGGS	Laying hens	040819	Egg yolks, fresh, cooked by steaming or boiling in water, moulded, frozen o
EGGS	Laying hens	040811	Dried egg yolks, whether or not sweetened
EGGS	Laying hens	350219	Egg albumin (excl. dried [e.g. in sheets, scales, flakes, powder])
COFF		090121	Roasted coffee (excl. decaffeinated)
COFF		090122	Roasted, decaffeinated coffee
COFF		090112	Decaffeinated coffee (excl. roasted)
COFF		090190	Coffee husks and skins; coffee substitutes containing coffee in any proport
BARL	Barley	110421	Hulled, pearled, sliced, kibbled or otherwise worked grains of barley (excl
BARL	Barley	110411	Rolled or flaked grains of barley
AMAN		110620	Flour and meal of sago or of manioc, arrowroot, salep, jerusalem artichokes
AMAN		110814	Manioc starch
		030549	Smoked fish, incl. fillets (excl. pacific salmon, atlantic salmon, danube s
		110820	Inulin
		030542	Herrings 'clupea harengus, clupea pallasii', smoked, incl. fillets
		030270	Fresh or chilled fish livers and roes
		030310	Frozen pacific salmon 'oncorhynchus spp.'
		030321	Frozen trout 'salmo trutta, salmo gairdneri, salmo clarki, salmo aguabonita
		030329	Frozen salmonidae (excl. pacific salmon, atlantic salmon, danube salmon and
		110630	Flour, meal and powder of products of Chapter 8 'all types of edible fruit'
		030322	Frozen atlantic salmon 'salmo salar' and danube salmon 'hucho hucho'
		030530	Fish fillets, dried, salted or in brine, not smoked
		030520	Fish livers and roes, dried, smoked, salted or in brine
		130213	Hop extract or sap
		030331	Frozen lesser or greenland halibut, atlantic halibut and pacific halibut
		030541	Pacific salmon 'oncorhynchus spp.', atlantic salmon 'salmo salar' and danub
		130239	Mucilages and thickeners derived from vegetable products, whether or not mo
		160419	Prepared or preserved fish, whole or in pieces (excl. minced and salmon, he
		160416	Prepared or preserved anchovies, whole or in pieces (excl. minced)
		160415	Prepared or preserved mackerel, whole or in pieces (excl. minced)
		160414	Prepared or preserved tunas, skipjack and atlantic bonito, whole or in piec
		160413	Prepared or preserved sardines, sardinella and brisling or sprats, whole or
		160412	Prepared or preserved herrings, whole or in pieces (excl. minced)
		160411	Prepared or preserved salmon, whole or in pieces (excl. minced)
		130211	Opium
		160420	Prepared or preserved fish (excl. whole or in pieces)

170410	Chewing gum, whether or not sugar coated
130232	Mucilages and thickeners, derived from locust beans, locust bean seeds or g
130231	Agar-agar, whether or not modified
130220	Pectic substances, pectinates and pectates
130219	Vegetable saps and extracts (excl. liquorice, hops, pryrethrum, roots of pl
130214	Sap and extract of pryrethrum or of roots of plants containing rotenone
030563	Anchovies 'engraulis spp.', salted or in brine only (excl. fillets)
130212	Liquorice sap and extract (excl. with a sucrose content by weight of > 10%
121230	Apricot, peach or plum stones and kernels
160210	Homogenized prepared meat, offal or blood, put up for retail sale as infant
030749	Cuttle fish 'sepia officinalis, rossia macrosoma, sepiola spp.' and squid '
030729	Scallops, incl. queen scallops, of the genera pecten, chlamys or placopecte
030510	Fish meal fit for human consumption
030372	Frozen haddock
030373	Frozen coalfish
030374	Frozen mackerel 'scomber scombrus, scomber australasicus, scomber japonicus
030375	Frozen dogfish and other sharks
030376	Frozen eels 'anguilla spp.'
030333	Frozen sole 'solea spp.'
030739	Mussels 'mytilus spp., perna spp.', frozen, dried, salted or in brine, with
030350	Frozen herrings 'clupea harengus, clupea pallasii'
030759	Octopus 'octopus spp.', frozen, dried, salted or in brine, with or without
030799	Aquatic invertebrates, with or without shell, n.e.s., sea urchins, sea cucu
030490	Frozen fish meat, whether or not minced (excl. fillets)
030420	Frozen fish fillets
030410	Fresh or chilled fillets and other fish meat, whether or not minced
030380	Frozen fish livers and roes
030379	Frozen freshwater and saltwater fish (excl. salmonidae, flat fish, tunas, s
030377	Frozen sea bass 'dicentrarchus labrax, dicentrarchus punctatus'
030341	Frozen albacore or longfinned tunas
030559	Dried fish, salted, not smoked (excl. cod and other fillets)
030561	Herrings 'clupea harengus, clupea pallasii', salted or in brine only (excl.
030332	Frozen plaice
030371	Frozen sardines 'sardina pilchardus, sardinops spp.', sardinella and brisli
030562	Cod 'gadus morhua, gadus ogac, gadus macrocephalus', salted or in brine onl
030378	Frozen hake 'merluccius spp., urophycis spp.'
030339	Frozen flat fish (excl. halibut, plaice and sole)
051191	Products of fish or crustaceans, molluscs or other aquatic invertebrates; d
030611	Frozen rock lobster and other sea crawfish, whether in shell or not, incl.
030360	Frozen cod 'gadus morhua, gadus ogac and gadus macrocephalus'
030342	Frozen yellowfin tunas
030343	Frozen skipjack or stripe-bellied bonito
030349	Frozen tunas (excl. albacore or longfinned and yellowfin)
030612	Frozen lobsters, whether in shell or not, incl. lobsters in shell, cooked b
030613	Frozen shrimps and prawns, whether in shell or not, incl. shrimps and prawn
030614	Frozen crabs, whether in shell or not, incl. crabs in shell, cooked by stea
030619	Frozen crustaceans, fit for human consumption, whether in shell or not, inc
030551	Dried cod 'gadus morhua, gadus ogac, gadus macrocephalus', whether or not s
030569	Fish, salted or in brine only (excl. herrings, cod, anchovies and fillets i
200919	Orange juice, whether or not containing added sugar or other sweetening mat
200830	Citrus fruit, prepared or preserved, whether or not containing added sugar
210112	Preparations with a basis of extracts, essences or concentrates of coffee o
210111	Extracts, essences and concentrates of coffee
200990	Mixtures of fruit juices, incl. grape must, and vegetable juices, whether o
200980	Juice of fruit or vegetables, whether or not containing added sugar or othe

200970	Apple juice, whether or not containing added sugar or other sweetening matt
200960	Grape juice, incl. grape must, whether or not containing added sugar or oth
200950	Tomato juice, whether or not containing added sugar or other sweetening mat
200940	Pineapple juice, whether or not containing added sugar or other sweetening
210130	Roasted chicory and other roasted coffee substitutes, and extracts, essence
200920	Grapefruit juice, whether or not containing added sugar or other sweetening
210210	Active yeasts
200911	Frozen orange juice, whether or not containing added sugar or other sweeten
200899	Fruit, nuts and other edible parts of plants, prepared or preserved, whethe
200892	Mixtures of fruits, nuts and other edible parts of plants, prepared or pres
200891	Palm hearts, prepared or preserved, whether or not containing added sugar o
200880	Strawberries, prepared or preserved, whether or not containing added sugar
200870	Peaches, prepared or preserved, whether or not containing added sugar or ot
200860	Cherries, prepared or preserved, whether or not containing added sugar or o
200850	Apricots, prepared or preserved, whether or not containing added sugar or o
200840	Pears, prepared or preserved, whether or not containing added sugar or othe
200930	Juice of citrus fruit, whether or not containing added sugar or other sweet
230120	Flours, meals and pellets of fish or crustaceans, molluscs or other aquatic
160430	Caviar and caviar substitutes prepared from fish eggs
350510	Dextrins and other modified starches, e.g. pregelatinised or esterified sta
230990	Preparations of a kind used in animal feeding (excl. dog or cat food put up
230910	Dog or cat food, put up for retail sale
230320	Beet-pulp, bagasse and other waste of sugar manufacture
230310	Residues of starch manufacture and similar residues
230250	Bran, sharps and other residues of leguminous plants, whether or not in the
230240	Bran, sharps and other residues of cereals, whether or not in the form of p
230230	Bran, sharps and other residues of wheat, whether or not in the form of pel
210120	Extracts, essences and concentrates of tea or mate, and preparations with a
230210	Bran, sharps and other residues of maize 'corn', whether or not in the form
210320	Tomato ketchup and other tomato sauces
220900	Vinegar and substitutes for vinegar obtained from acetic acid
210690	Food preparations n.e.s.
210610	Protein concentrates and textured protein substances
210420	Food preparations consisting of finely homogenized mixtures of two or more
210410	Soups and broths and preparations therefor
210330	Mustard flour and meal, whether or not prepared, and mustard
210310	Soya sauce
210230	Prepared baking powders
210220	Inactive yeasts; other dead single-cell micro-organisms (excl. packaged as
230220	Bran, sharps and other residues of rice, whether or not in the form of pell
170250	Chemically pure fructose in solid form
180690	Chocolate and other preparations containing cocoa, in containers or immedia
180632	Chocolate and other preparations containing cocoa, in blocks, slabs or bars
180631	Chocolate and other preparations containing cocoa, in blocks, slabs or bars
180620	Chocolate and other food preparations containing cocoa, in blocks, slabs or
180610	Cocoa powder, sweetened
180500	Cocoa powder, not containing added sugar or other sweetening matter
180400	Cocoa butter, fat and oil
180320	Cocoa paste, wholly or partly defatted
180310	Cocoa paste (excl. defatted)
190110	Preparations for infant use, retail sale, of flour, meal, starch or malt ex
170260	Fructose in solid form and fructose syrup not containing added flavouring o
170490	Sugar confectionery not containing cocoa, incl. white chocolate (excl. chew
170240	Glucose in solid form and glucose syrup not containing added flavouring or
170230	Glucose in solid form and glucose syrup, not containing added flavouring or

160590	Molluscs and aquatic invertebrates, prepared or preserved
160540	Crustaceans, prepared or preserved (excl. crabs, shrimps, prawns and lobste
160530	Lobster, prepared or preserved
160520	Shrimps and prawns, prepared or preserved
160510	Crab, prepared or preserved
200820	Pineapples, prepared or preserved, whether or not containing added sugar or
210390	Preparations for sauces and prepared sauces; mixed condiments and seasoning
180200	Cocoa shells, husks, skins and other cocoa waste
200799	Jams, jellies, marmalades, purees or pastes of fruit, obtained by cooking,
200819	Nuts and other seeds, incl. mixtures, prepared or preserved (excl. peanut b
170290	Sugars in solid form, incl. artificial, and sugar syrups, not flavoured or
200811	Ground-nuts, prepared or preserved n.e.s.
190120	Mixes and doughs, of flour, meal, starch or malt extract, not containing co
200791	Citrus fruit jams, jellies, marmalades, purees or pastes, obtained by cooki
200710	Homogenized preparations of jams, jellies, marmalades, fruit or nut purees
200600	Fruit, nuts, fruit-peel and other parts of plants, preserved by sugar, drai
190590	Bread, pastry, cakes, biscuits and other bakers' wares, whether or not cont
190540	Rusks, toasted bread and similar toasted products
190530	Sweet biscuits, waffles and wafers, whether or not containing cocoa (excl.
190520	Gingerbread and the like, whether or not containing cocoa
190510	Crispbread
190219	Uncooked pasta, not stuffed or otherwise prepared, not containing eggs
190490	Cereals in grain form, pre-cooked or otherwise prepared (excl. by swelling
190190	Preparations of flour, meal, starch or malt extract, not containing cocoa p
190420	Prepared foods obtained from unroasted cereal flakes or from mixtures of un
190410	Prepared foods obtained by swelling or roasting cereals or cereal products,
190300	Tapioca and substitutes therefor prepared from starch, in the form of flake
190240	Couscous, whether or not prepared
190230	Pasta, cooked or otherwise prepared (excl. stuffed)
190211	Uncooked pasta, not stuffed or otherwise prepared, containing eggs
190220	Pasta, stuffed with meat or other substances, whether or not cooked or othe

Table A3.17: Mapping for Beverages and tobacco (b_t)

Code	*CAPRI*	*HS6*	*HS description*
BARL	Barley	110720	Roasted malt
BARL	Barley	110710	Malt (excl. roasted)
		240220	Cigarettes containing tobacco
		220830	Whiskies
		220840	Rum and taffia
		220850	Gin and geneva
		220860	Vodka
		220890	Ethyl alcohol of an alcoholic strength by volume of < 80 %; spirits, liqueur
		220820	Spirits obtained by distilling grape wine or grape marc
		240210	Cigars, cheroots and cigarillos containing tobacco
		220870	Liqueurs and cordials
		240290	Cigars, cheroots, cigarillos and cigarettes consisting wholly of tobacco su
		240310	Smoking tobacco with or without a proportion of tobacco substitutes
		240391	Tobacco, 'homogenized' or 'reconstituted' from finely-chopped tobacco leave
		240399	Chewing tobacco, snuff and other manufactured tobacco and manufactured toba
		230700	Wine lees; argol
		220210	Waters, incl. mineral and aerated, with added sugar, sweetener or flavour
		220110	Mineral waters and aerated waters, not containing added sugar, other sweete
		230330	Brewing or distilling dregs and waste
		220190	Ordinary natural water, not containing added sugar, other sweetening matter
		220720	Denatured ethyl alcohol and other spirits of any strength
		220290	Non-alcoholic beverages (excl. water, fruit or vegetable juices and milk)
		220300	Beer made from malt
		220410	Sparkling wine of fresh grapes
		220421	Wine of fresh grapes, incl. fortified wines, and grape must whose fermentat
		220710	Undenatured ethyl alcohol, of actual alcoholic strength of >= 80 %
		220429	Wine of fresh grapes, incl. fortified wines, and grape must whose fermentat
		220600	Cider, perry, mead and other fermented beverages and mixtures of fermented
		220590	Vermouth and other wine of fresh grapes, flavoured with plants or aromatic
		220510	Vermouth and other wine of fresh grapes, flavoured with plants or aromatic
		220430	Grape must, partly fermented, of an actual alcoholic strength of > 0.5 % vo

Table A3.18: Mapping for Forestry (frs)

Code	*CAPRI*	*HS6*	*HS description*
FLOW	Flowers	060499	Foliage, branches and other parts of plants, without flowers or flower buds
FLOW	Flowers	060410	Mosses and lichens for bouquets or for ornamental purposes, fresh, dried, d
FLOW	Flowers	060491	Foliage, branches and other parts of plants, without flowers or flower buds
		450110	Natural cork, raw or merely surface-worked or otherwise cleaned
		440420	Hoopwood; split poles; piles, pickets and stakes of wood, pointed but not s
		440410	Hoopwood; split poles; poles and pickets, pointed but not sawn lengthwise;
		440399	Wood in the rough, whether or not stripped of bark or sapwood, or roughly s
		440392	Beech 'fagus spp.' in the rough, whether or not stripped of bark or sapwood
		440391	Oak 'quercus spp.' in the rough, whether or not stripped of bark or sapwood
		440110	Firewood, in the form of logs, billets, twigs, faggots or similar
		440349	Tropical wood specified in the subheading note 1 to this Chapter in the rou
		140190	Reeds, rushes, osier, raffia, cleaned, bleached or dyed cereal straw, lime
		440341	Dark red meranti, light red meranti and meranti bakau wood in the rough, wh
		440320	Coniferous wood in the rough, whether or not stripped of bark or sapwood, o
		130110	Natural lac
		140490	Vegetable products n.e.s
		140410	Raw vegetable materials primarily for dyeing or tanning n.e.s.
		140390	Piassava, brush-grass, istle and other vegetable materials primarily for br
		140210	Kapok, whether or not put up as a layer, with or without supporting materia
		140120	Rattans
		140110	Bamboos
		130190	Natural gums, resins, gum-resins and balsams (excl. gum arabic)
		130120	Natural gum arabic
		140290	Vegetable hair, eel-grass and other vegetable materials of a kind used prim
		400130	Balata, gutta-percha, guayule, chicle and similar natural gums, in primary

Table A3.19: Disaggregated mapping of CAPRI products to GTAP sectors (codes as above)

CAPRI activity or commodity	GTAP tradable commodity
pari	pdr
swhe,dwhe	wht
ryem,barl,oats,maiz,ocer	gro
toma,oveg,appl,ofru,citr,tagr,tabo,twin,owin	v_f
rape,sunf,soya,oliv,ooil	osd
sugb	c_b
text	(not mapped)
puls,pota,toba,oind,nurs,flow,ocro,maif,roof,ofar	ocr
ycow,ybul,yhei,ycam,ycaf	ctl
ypig,ylam,ychi	oap
comi	rmk
beef,sgmt	cmt
pork,poum,eggs	omt
rapo,suno,soyo,olio,ooil	vol
butt,smip,ches,frmi,crem,cocm,wmip	mil
rice	pcr
suga	sgr

Appendix 4: Detailed description of composition non-agricultural sectors in GTAP

Table A4.1: Products covered in GTAP's non-agricultural sectors

GTAP	*Sectors from the International Standard Industry Classification*
Fishing (fsh)	Hunting, trapping and game propagation including related service activities; Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
Coal (coa)	Mining and agglomeration of hard coal; Mining and agglomeration of lignite
Oil (oil)	Extraction of crude petroleum and natural gas (part); Service activities incidental to oil and gas extraction excluding surveying (part); Mining and agglomeration of peat
Gas (gas)	Extraction of crude petroleum and natural gas (part); Service activities incidental to oil and gas extraction excluding surveying (part)
Minerals (nec)	Mining of uranium and thorium ores; Mining of metal ores; Other mining and quarrying
Textiles (tex)	Manufacture of textiles; Manufacture of man-made fibres
Wearing apparel (wap)	Manufacture of wearing apparel; dressing and dyeing of fur
Leather products (lea)	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
Wood products (lum)	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Paper products, publishing (ppp)	Manufacture of paper and paper products; Publishing of books, brochures, musical books and other publications; Publishing of newspapers, journals and periodicals; Publishing of recorded media; Other publishing (photos, engravings, postcards, timetables, forms, posters, art reproductions, etc.); Printing and service activities related to printing; Reproduction of recorded media
Petroleum, coal products (p_c)	Manufacture of coke oven products; Manufacture of refined petroleum products; Processing of nuclear fuel
Chemical,rubber,plastic prods (crp)	Manufacture of basic chemicals; Manufacture of other chemical products; Manufacture of rubber and plastic products
Mineral products nec (nmm)	Manufacture of other non-metallic mineral products
Ferrous metals (i_s)	Manufacture of basic iron and steel; Casting of iron and steel
Metals nec (nfm)	Manufacture of basic precious and non-ferrous metals; Casting of non-ferrous metals
Metal products (fmp)	Manufacture of fabricated metal products, except machinery and equipment;
Motor vehicles and parts (mvh)	Manufacture of motor vehicles, trailers and semi-trailers
Transport equipment	Manufacture of other transport equipment

nec (otn)	
Electronic equipment (ele)	Manufacture of office, accounting and computing machinery; Manufacture of radio, television and communication equipment and apparatus
Machinery and equipment nec (ome)	Manufacture of machinery and equipment n.e.c.; Manufacture of electrical machinery and apparatus n.e.c.; Manufacture of medical, precision and optical instruments, watches and clocks
Manufactures nec (omf)	Manufacturing n.e.c.; Recycling
Electricity (ely)	Production, collection and distribution of electricity
Gas manufacture, distribution (gdt)	Manufacture of gas; distribution of gaseous fuels through mains; Steam and hot water supply
Water (wtr)	Collection, purification and distribution of water
Construction (cns)	Construction
Trade (trd)	Sales, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel; Wholesale trade and commission trade, except of motor vehicles and motorcycles; Non-specialized retail trade in stores; Retail sale of food, beverages and tobacco in specialized stores; Other retail trade of new goods in specialized stores; Retail sale of second-hand goods in stores; Retail trade not in stores; Repair of personal and household goods; Hotels and restaurants
Transport nec (otp)	Land transport; transport via pipelines; Supporting and auxiliary transport activities; activities of travel agencies
Sea transport (wtp)	Water transport
Air transport (atp)	Air transport
Communication (cmn)	Post and telecommunications
Financial services nec (ofi)	Financial intermediation, except insurance and pension funding; Activities auxiliary to financial intermediation
Insurance (isr)	Insurance and pension funding, except compulsory social security
Business services nec (obs)	Real estate activities; Renting of transport equipment; Renting of other machinery and equipment; Renting of personal and household goods n.e.c.; Computer and related activities; Research and development; Other business activities
Recreation and other services (ros)	Recreational, cultural and sporting activities; Other service activities; Private households with employed persons
PubAdmin/Defence/ Health/Educat (osg)	Public administration and defense; compulsory social security; Education; Health and social work; Sewage and refuse disposal, sanitation and similar activities; Activities of membership organizations n.e.c.; Extra-territorial organizations and bodies
Dwellings (dwe)	Not available in ISIC