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Compilation of Social Accounting Matrices with a Detailed Representation of the Agricultural Sector (AgroSAM)

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Abstract

Social accounting matrices (SAM) are a convenient way to represent the monetary flows between productive sectors and institutions and may serve as database for a large variety of quantitative tools used for economic analysis. The aim of this study is to construct consistent and complete SAMs for the EU27 Member States with a highly disaggregated agricultural sector, which should serve as a consistent database for quantitative policy analysis within and beyond the agricultural sector. The main challenge here was the integration of information from different data sources in several steps: (1) compilation of supply and use-tables as well as data about monetary flows between institutions into a SAM format, (2) disaggregation of the agricultural and food-sector by using input data from the agricultural sector model CAPRI, and (3) sequential cross-entropy estimations of the final SAMs in order to map different databases and missing information. The estimation steps were designed in a way that the final representation of the agricultural sector agrees with the corresponding macro-total while maintaining the core information provided by the CAPRI database.

This resulting database is meant as a contribution to existing tools for quantitative policy analysis built on SAMs, like for example computable general equilibrium models. For this reason, we have chosen a sectoral classification that is mostly compatible with the format of the GTAP database in order to facilitate its potential use also in a GTAP framework. Moreover, the tool is also flexible to match different product aggregations and feed partial equilibrium models (e.g. agricultural, forestry or energy models).

Keywords: compilation of social accounting matrices, data recovery, agricultural sector models, cross entropy estimation

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1 Background

The CAP reform of 2003 has provoked a significant change of policies affecting agricultural markets in the EU Member States (MS). This is of particular relevance for the new MS, in which the agricultural sector has a comparatively high share in the generation of national income. Moreover, rural development policies have increased their weight in the policy agenda. Therefore, the linkages between agriculture and other economic sectors, such as renewable energy and food processing industry, as well as the impacts of policy changes on factor markets (labour and land) and farm income, have received special attention by policy analysts.

Social accounting matrices (SAM) are a convenient way to represent the monetary flows between productive sectors and institutions and may serve as database for a large variety of quantitative tools used for economic analysis. However, most of the statistical departments often provide supply and use tables (SUT) and input-output tables (IOT) with a highly aggregated representation of the agricultural sector, which makes it very difficult to analyse the economic impact of specific policies on the agricultural sub-sectors and related industries. Particularly the change from agricultural subsidies linked to production to a single farm payment scheme requires databases that contain the flows between and within institutions like private and public budgets and productive sectors like agriculture and food processing industries.

The main aim of this project was therefore to construct SAMs for the EU27 Member States which would allow analysing the economic effects of the CAP reform within and beyond agriculture. The main challenge here was the integration of information from different sources, which are neither necessarily consistent nor complete, even when coming from the same data owner (e.g. structural deviations between CPA (Commodity Produced by Activity) and EAA (Economic Accounts for Agriculture) classifications used by Eurostat). A further goal of this project is to contribute to existing tools for quantitative policy analysis that are built on SAMs, like computable general equilibrium models (CGE). Therefore the provision of updated SAMs for EU MS with a high resolution of agriculture would be beneficial for both, users and modellers.

With these objectives in mind, the following aspects are highlighted:

– The construction of social accounting matrices for the EU27 with a high resolution of the agricultural sector (AgroSAMs) should allow for a proper analysis of agricultural policies.

– The number of agricultural sub-sectors should allow for (a) a detailed representation of the main agricultural policies, (b) the incorporation of datasets from already existing economic models (e.g. CAPRI), (c) aggregation algorithms allowing the reusability by other modelling systems (e.g. GTAP, GLOBE), and (d) the utilisation of readily available datasets from statistical departments (e.g. Eurostat, FAOSTAT)

– A transparent and automatised routine should allow the extraction, transformation and incorporation of new datasets, so that the update costs of the AgroSAMs is kept at a low level.

2 Target Structure of the AgroSAMs

The structure of the AgroSAMs is largely determined by the available data and the desired compatibility with the classifications used in the GTAP and CAPRI models. The upper limit for a disaggregated representation of the agricultural sector should be the "Complete and

Consistent Database" (CoCo) shared by the sector models CAPRI and CAPSIM. The lower limit is the representation in GTAP in order to allow a straightforward many-to-one mapping between the classifications. As these requirements are not fulfilled by none of the existing classifications, the formulation of a new one, called **"Modified Agro-industrial Classification" (MAC)** is pursued, which follows in general the commodity classification of the "Combined Nomenclature" (CN) and the "Commodities Produced by Activities" (CPA) used by Eurostat, but lies within the bounds given by CoCo and GTAP[1].

For commodities and activities, the structure of the target classification MAC is largely determined by the ESA (European System of National Accounts) classifications, particularly the NACE (Nomenclature of Economic Activities) and CPA (Commodities Produced by Activities) classifications at 3-digit level, in which the supply and use tables are provided. Agriculture and food-industry are here represented by one row and one column respectively. A more detailed representation of these two sectors can be achieved by using the one provided by the CoCo database. A further desirable property of the target classification is a correspondence of the activities with the most refined NACE classification level (5 digits). Regarding primary factors, the available use tables distinguish between compensation of employees, net operating surplus and consumption of fixed capital. Information about different types of labour is not provided here and CoCo does not allow for further distinction. The taxes and institutions included in the target classification follow those featured by ESA at the 3-digit level. This is a rather coarse representation as import tariffs and domestic taxes on commodities are summarized here as “indirect taxes on commodities” [2].

3 Datasets

The data sets used for the AgroSAM project are described in this section. The main focus lies on the structure and availability of these data sources

3.1 Multi-Sectoral Data

Supply and use tables (SUT) are the most useful database in the context of SAM construction as they represent the full flow of goods and services within an economy and provide also information on trade margins and certain types of taxes/subsidies. Eurostat provides SUT in two different file-formats:

- NAIO: available as bulk download in 'tab-separated' files (.tsv files)
- SUIOT: available as country-wise downloadable MS-Excel files (.xls files).

Symmetric input-output tables in basic prices (IOT) are also provided by the same sources as the SUT and in the same formats and coverage. Although IOT are often used as input for the compilation of SAMs, they do not provide the same amount of information as SUT, particularly since the transformation of basic prices into purchaser prices (e.g. trade margins as differential) is missing. In general, SUT are preferable for SAM construction. The macro aggregates provided by Eurostat (NAMA) have a full coverage of the EU27 Member States and include main indicators like total intermediate demand, compensation of employees,

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[1] The target classification and the correspondence with other models are not documented here but are available from the authors upon request

[2] Land rents would be desirable to include in the list of primary factors, but we decided not to include them at this stage of the project. For this version of the AgroSAM project, we restrain ourselves to the rather coarse representation of the primary factors as "operating surplus, gross", and "compensation of employees". Moreover, the disaggregation of import and domestic taxes on commodities will have priority in the next stages of the AgroSAM project.

gross value added and net taxes on production, but only for 31 sectors and not the 59 which are featured in the SUT framework. The national accounts by institutional sectors (NASA) represent the monetary flows between the productive sectors and the institutions as well as the flows within the institutions. Particularly direct taxes paid by non-governmental institutions (households, enterprises) and direct transfers received, as well as the distribution of factor incomes (wages, operating surplus) across the institutions are relevant to assess the full picture of a national economy in a SAM framework.

3.2 Agricultural Data

The agricultural sector models CAPRI[3] and CAPSIM[4] are both based on a common database (CoCo) which was developed at the University of Bonn and is the successor of the formerly used SPEL database. Both models and the database are currently available at JRC-IPTS (AGRILIFE[5] Unit) and provide a comprehensive picture of the agricultural sector for the EU27 Member States plus the Balkans. The main data sources for the construction of CoCo are presented in the following table.

Table 1 Data items and their main sources in CoCo

Data items	**Source**
Activity levels	Land use statistics, herd size statistics, slaughtering statistics, statistics on import and export of live animals
Production	Farm and market balance statistics, crop production statistics, slaughtering statistics, statistics on import and export of live animals
Farm and market balance positions	Farm and market balance statistics
Sectoral revenues and costs	Economic Accounts for Agriculture (EAA)
Prices	Derived from production and EAA
Output coefficients	Derived from production and activity levels, engineering knowledge
Input coefficients	Different type of estimators, engineering functions
Activity specific income indicators	Derived from input and output coefficients and prices
Policy data	Various sources (Official Journal of the EU)

Source: Eurostat (http://epp.eurostat.cec.eu.int), several bio-physical econometric studies and European Commission (http://publications.eu.int/general/oj_en.html).

For the purposes of the AgroSAM project, CoCo is fairly detailed and includes several elements which are conceptually challenging concerning its transformation into a SAM format (e.g. data on manure production/use, fertilizer consumption, set-aside, milk quotas, activity and product premiums). This has to do with the fact that (1) CoCo does not strictly follow the "activity from/to commodity" book keeping structure of ESA (see section 5, "compilation of priors") and (2) it does not consider other sectors of the economy (e.g. processing of agricultural products like dairies are presented as end-of-pipe products, with no corresponding industrial activities to pay for). Moreover, the CoCo database includes algorithms for data consistency and completeness, which are key issues to pick up in the AgroSAM project (see Britz 2005, pp.15-30). The combination of the SUT and CoCo is in fact the major challenge of the AgroSAM project. Eventually, other estimation modules of CAPRI might be picked up in later stages of the project (e.g. estimation of labour and energy

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[3] Common Agricultural Policy Regional Impact Analysis Model, URL: http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/capri_e.htm

[4] Common Agricultural Policy Simulation Model, URL: http://www.eurocare-bonn.de/profrec/capsim/capsim_e.htm

[5] Agriculture and Life Sciences in the Economy, URL: http://agrilife.jrc.ec.europa.eu/agritrade.html

inputs, barriers to trade between the EU and the rest of the world, land prices and quota rents for sugar/milk, etc.)[6].

The Economic Accounts for Agriculture (EAA) is a rather extensive dataset for the agricultural sector of the EU27 and the main input for the CoCo database. The Agricultural Information System (AGR_IS) is only used in the analysis when no information from the EAA is available (e.g. gross trade of agricultural commodities). FAOSTAT owns the most comprehensive database on trade of agricultural commodities and inputs. This information is important to determine the import/export sub-matrices of the SAM. Since it is already used by the CAPRI Model in its market module, the product definitions are consistent with the ones found in the CoCo database (e.g. trade of wheat measured in terms of ‘raw equivalents’ found in processed products like beer or pasta). Moreover, the Agricultural Market Access Database (AMAD) has very detailed information on market policy instruments (e.g. import tariffs or tariff rate quotas), the OECD provides information on consumer/supply support equivalents (CSE/PSE) for different world aggregates and the World Bank periodically publishes population statistics. Domestic production values of the food industry and trade data are extracted from PRODCOM and COMEX databases.

4 Construction of SAMs in ESA95 Format

The first step for the construction of the AgroSAM database is the compilation of a comprehensive set of SAMs according to the ESA classification used by Eurostat. It distinguishes 59 productive sectors and commodities and, therefore, will be noted here as ESASAM. The stylized structure of the ESASAM is mainly shaped by the structure of the main input datasets, namely the SUT (either SUIOT or NAIO) and the institutional accounts (NASA). A SAM, as depicted in appendix 1, can be directly compiled based on SUT and NASA datasets. SUTs are available for 21 MS in 2000, NASA data for 23 MS. However, both datasets were only available in 18 cases.

The datasets used at this stage are in general consistent and the ESASAMs are in most cases balanced. However, small deviation between row- and column-sum of the ESASAMs could be observed. We need to ensure that the ESASAMs are balanced before entering the next stage of the compilation procedure, therefore we use a cross-entropy procedure to balance the SAMs (e.g. Robinson et al 2000). With this purpose we employ a multiplicative error term with an expected value of 1 and a range sufficiently large to accommodate possible high deviations between row- and column-sums of the ESASAMs. The error term is defined by a set of s support points and associated weights. The support points are arbitrarily defined as shown below (for the case of five support points). These weights have to add up to unity and should be as close as possible to a set of pre-defined prior weights, for which we assumed a uniform distribution.

$$b_s = \left[-3, -1.5, 0, 1.5, 3\right] \text{ with } \overline{W}_s = 0.5$$

The objective function of the balancing model is to minimize the cross-entropy between prior weights and final weights. The minimization is subject to the constraint that the weights range between 0 and 1, add up to unity and that the final ESASAM is as close as possible to the prior SAM derived from the NASA and SUT datasets, but has equal row- and column-sums.

The balancing model is summarized below[7], more details on the method can be found in section 6:

[6] The correspondence between the activity and commodity classifications in CAPRI and the modified agro-industrial classification (MAC) are omitted from this paper but are available from the authors upon request.

$$CE = \min \sum_{AC,AC'} \sum_{s} W_{AC,AC',s} \cdot \ln\left[W_{AC,AC',s} / \overline{W}_{s} \right]$$

$$s.t.$$

Eq (1) $$ESASAM_{AC,AC'} = \overline{ESASAM}_{AC,AC'} \cdot \exp\left[\sum_{AC,AC'} \sum_{s} W_{AC,AC',s} \cdot b_s \right]$$

$$\sum_{s} W_{AC,AC',s} = 1, \quad 0 \le W_{AC,AC',s} \le 1$$

$$\sum_{AC} ESASAM_{AC,AC'} = \sum_{AC'} ESASAM_{AC,AC'}$$

Where:

ESASAM:	Balanced ESASAM
$\overline{ESASAM}$:	Prior ESASAM derived from SUT and NASA datasets
W:	Weights of error support points
CE:	Cross-entropy minimand
S:	Index for support points

5 Compilation of Priors for AgroSAMs (PriorSAM)

The objective of estimating a reliable, balanced social accounting matrix with disaggregated agricultural and food industry sectors, largely depends on the reliability of the a-priori information drawn from the various sources. The compilation of the prior SAM should hence be carried out in a careful and transparent manner. Particularly the transparency of the data-massaging process of re-arranging entries in the parent datasets in order to achieve the required compatibility of formats and contents is difficult to realize[8]. In general, we followed a five step procedure: (1) derive tax rates, trade margins and input-output coefficients from ESASAM, (2) re-arrange the CoCo data into the SAM format (agricultural accounting matrix AAM), (3) merge the ESASAM and AAM into an unbalanced PriorSAM, (4) balance activity and commodity account totals, and (5) balance the PriorSAM

We could rely in most cases on the information provided by our preferred sources ESA and CoCo, but particularly the food-industry sector is not covered exhaustively in CoCo[9], such that we had to incorporate other sources of information as well.

The CoCo database builds upon the meta-database of the NewCRONOS domain manager of EUROSTAT (sub-domains: ZPA1, COSA, PRAG). Although these raw data is processed to meet the demand for completeness and consistency (Britz et al 2005), it still follows the general accounting principles of the EAA. This "data massaging" property creates serious difficulties when attempting to combine the data with data in ESA format (e.g. SUT) as the distinction between an agricultural commodity and a processed commodity is not done in the

[7] Note: Indices for time (t) and state (r) have been omitted for reasons of readability

[8] The implemented GAMS code was developed ad-hoc as new challenges occurred while including more countries, years or datasets. However, we will describe the process in a manner that allows following the most relevant steps, but it has to be noted that it will not be possible to replicate the procedure without consulting the corresponding GAMS code

[9] This might change in the near future, since the CAPRI Model is currently improving processing functions for dairies, oilseeds and biofuels it its market module, information which will most likely be fed into the base year database and used in the construction of a future PriorSAM.

same way. For instance, wine is considered as an agricultural commodity in EAA but as a processed output of the "beverage industry" in the ESA framework (Eurostat 1997). Furthermore, it is unclear how "feed cereals" should be mapped into the AgroSAM format: either as non-marketed on-farm consumption or as demand of the agricultural sector for products of the "animal feed" industry, which in turn would demand cereals as intermediate input. The mapping of farm and market balances is also not straightforward. For instance, seed use, internal use and losses on farm are not considered in the ESA framework.

The first step in utilizing the CoCo dataset was to transform it into an agricultural accounting matrix (AAM) to facilitate the mapping of CoCo and MAC accounts at a later stage. The AAM distinguishes strictly between activity and commodity accounts and agricultural, processing, and other industrial activities. As a consequence, it was necessary to introduce activity accounts not included in the CoCo database. The commodity 'beef' for instance is produced by the cattle sectors, which is not consistent with the concept of the ESA accounts. In there, the transformation of live cattle into beef ready for human consumption or further processing is an activity within the food and beverage industry complex (ESA code da15) rather than belonging to agriculture. The same applies for pork, poultry meat, and wine.

An important feature in this context is that basically two agricultural accounting matrices were created: One in value terms (AAMV) and one in quantity terms (AAMQ). AAMQ is basically a balance sheet for CoCo commodities, arranged in SAM format, but with empty accounts for activity expenditures and consequently only with balanced commodity accounts. AAMV is the corresponding matrix with filled activity accounts and quantities on the commodity markets measured at basic prices obtained from CoCo (Unit Value at Basic Prices, UVAB). This treatment of the available data allows controlling the estimates for prices and quantities at a later stage and prevents the creation of un-plausible values, which can occur when using only value-data for the SAM estimation. Appendix 2 illustrates the structure of the target SAM, the acronyms used for the respective entries, and provides a legend for the operations described in the following section. An outline of the operations to obtain the AAM from the CoCo dataset is also displayed in appendix 3.

5.1 Activity Accounts of the Agricultural Sector

For the agricultural sector, the procedure of re-arranging the CoCo data is in general straightforward. We use the CoCo notation whenever possible to allow the comparison of the computations with the CAPRI documentation (Britz et al. 2005). Starting with the activity accounts, the first step is the derivation of an aggregate output value of each agricultural activity:

Eq (2) $$AAMV_{'Total',A} = ALV_A = TOOU_A \cdot LEVL_A \quad \forall A \in Agriculture$$

Where:

AAMV:	Agricultural accounting matrix in value terms based on CoCo data
ALV:	Total value of activity level
TOOU:	Total output value per activity level **(CoCo)**
LEVL:	Activity level **(CoCo)**
A:	Index for activities (here only agriculture)

Taxes paid (or received as negative taxes i.e. subsidies) by each activity equal the CAP premiums per activity as indicated by CoCo times the activity level:

Eq (3) $AAMV_{'T\_PRME',A} = TXA_A = -PRME_A \cdot LEVL_A \quad \forall A \in Agriculture$

Where:

TXA: Value of tax or subsidy received or paid by activity
PRME: CAP premium effectively paid **(CoCo)**

The rate for activity-related taxes is here computed as the share of taxes paid (or subsidies received) in the total output value of the activities:

Eq (4) $ta_A = \dfrac{TXA_A}{ALV_A} \quad \forall A \in Agriculture$

Value added at basic prices can also be taken directly from CoCo:

Eq (5) $\sum_F AAMV_{F,A} = VAD_A = GVAB_A \cdot LEVL_A \quad \forall A \in Agriculture$

Where:

VAD: Value-added per activity
GVAB: Gross value-added at basic prices per activity level **(CoCo)**
F: Fixed factors (here: labour and capital)

A wage indicator is also provided in the CoCo database, but the exact unit in which they are measured is not explained in the documentation (Britz et al. 2005). Furthermore, we are not sure whether this information was processed by the consistency algorithm of CoCo. However, in the absence of other data, we used WAGE as an instrument for the distribution of the corresponding entry in the ESA SAM.

Eq (6) $AAMV_{'F\_LAB',A} = LAB_A = \dfrac{WAGE_A \cdot LEVL_A}{\sum_A WAGE_A \cdot LEVL_A} \cdot LAB^{ESA}_{Agriculture} \quad \forall A \in Agriculture$

Aggregate input demand from agricultural activities is expressed as input demand per unit of activity level times the activity level.

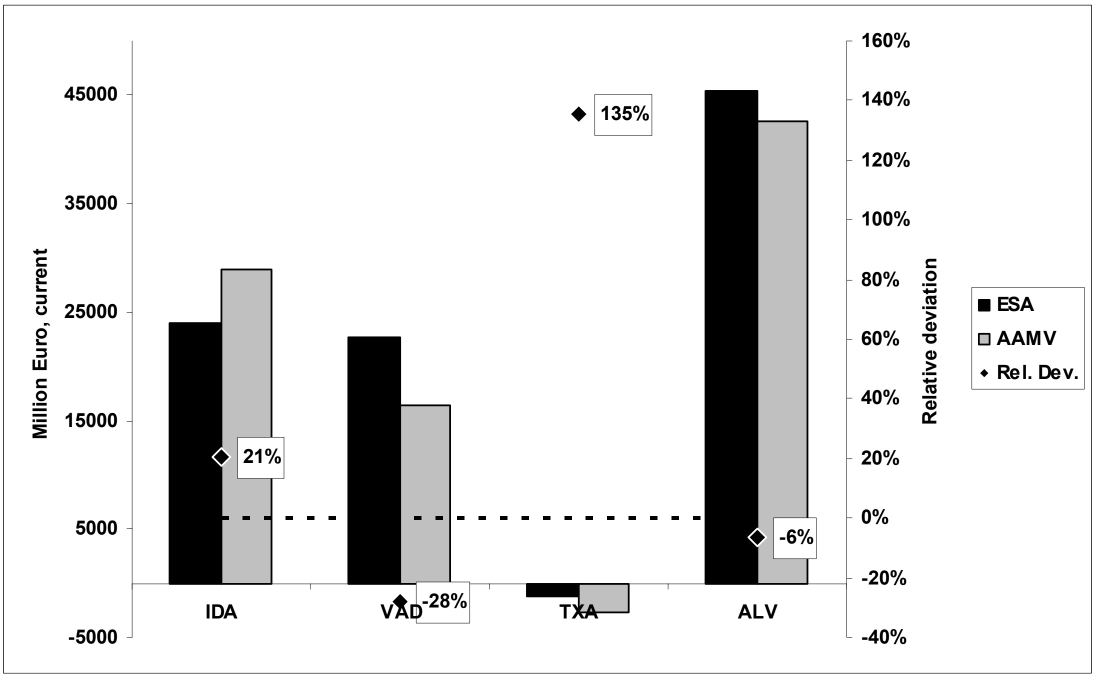
Eq (7) $\sum_C AAMV_{C,A} = IDA_A = TOIN_A \cdot LEVL_A \quad \forall A \in Agriculture$

Where: IDA Vector of aggregate input demand per activity (in million Euros)

TOIN Total intermediate input **(CoCo)**

The results for the agricultural sector are displayed against the corresponding ESA totals in figure 1. It appears that intermediate demand of the agricultural sector as obtained from the CoCo database is 21% larger than the corresponding figure from the ESA accounts. The reason behind this could be that CoCo provides values also for non-marketed inputs like pastures and manure. The higher total output value indicated by ESA may originate in the fact that agricultural output encompasses a wider range of products as are considered by CoCo. Taxes on activities ("Other net taxes on production", d29_m_d39, in ESA notation) indicated by ESA are considerably lower (in absolute terms) than the aggregate CAP Premiums from CoCo. Again, the reason for this observation is not clear, since details on the composition of the figures in question are not provided by either source. It seems anyway that some components of the CAP premiums are booked as direct subsidies to agricultural holdings in the ESA framework rather than as activity-related payments in the CoCo database.

Figure 1 Comparison between ESA and AAMV totals, Agricultural Sector, Germany year 2000, in Million Euro (current prices)



Source: Eurostat, CoCo, own calculations

Although the two databases present substantial differences in the definition and coverage of featured items, without clear information on the exact nature of those deviations, a multitude of components of the CoCo database can be considered as reliable information (e.g. produced and trade quantities of agricultural and some processed commodities, activity levels, output- and input-coefficients, and basic prices). Both databases can be harmonized by incorporating the qualitative information about the potential sources of the deviations in the finally chosen estimation method.

Having derived IDA, VAD, TXA, and ALV (see also appendix 2), we have obtained the minimum necessary set of items in the activity accounts to connect it to the corresponding commodity accounts.

5.2 Commodity Accounts

The CoCo database provides information on quantities of produced and trade commodities as well as the related prices. This information is deemed to be of significant use for the final estimation of the monetary flows within the target AgroSAMs, since the usage of quantities and plausible bounds on price estimates can be used to curb the possible variation of the final estimate and hence avoid severely distorted results.

We will start with the transformation of the quantity-related data of the CoCo database into SAM format, which will be called AAMQ (Agricultural Accounting Matrix in quantity terms) in the following. Again, we use the CoCo notation whenever possible to allow the comparison of the computations with the CAPRI documentation (Britz et al. 2005).

Domestic marketed production quantities QX are computed by:

Eq (8) $\sum_{A} AAMQ_{A,C} = QX_{C} = \begin{cases} NETF_{C} & \forall C \in Agriculture \\ MAPR_{C} & \forall C \in FoodIndustry \end{cases}$

Where:

AAMQ	Agricultural accounting matrix in quantity terms based on CoCo data
QX	Domestic marketed production (quantities)
NETF	Net trade on farm **(CoCo)**
MAPR	Marketed production **(CoCo)**
C:	Index for commodities

Imports and exports are derived in a similar way:

Eq (9) $$\begin{aligned} &AAMQ_{C,'ROW'} = QE_{C} = EXPT_{C} \;\; \forall C \in Agriculture, FoodIndustry \\ &AAMQ_{'ROW',C} = QM_{C} = IMPT_{C} \;\; \forall C \in Agriculture, FoodIndustry \end{aligned}$$

Where:

QE	Exports of commodities (quantities)
QM	Imports of commodities (quantities)
EXPT	Exports total **(CoCo)**
IMPT	Imports total **(CoCo)**

Total domestic supply QDS is composed of domestic production QX plus imports QM minus exports QE. On the demand side, the items IDC (domestic intermediate demand for commodities; note the difference to IDA which is the intermediate demand for commodities by activities), GVT (governmental consumption), H (final consumption by households), STC (stock changes), FCF (fixed capital formation), and LOS (losses on markets) can only partially be derived from the CoCo. So is investment demand for agricultural commodities treated as "on-farm usage" of investment commodities like young animals and live plants (e.g. trees for orchards), but not as consumption on markets. Domestic demand in the AAMQ as derived from CoCo data is consequently represented by the following entries:

Eq (10) $$\begin{aligned} &QDD_{C} = QX_{C} + QM_{C} - QE_{C} = QIDC_{C} + QH_{C} + QSTC_{C} + QLOS_{C} \\ &\forall C \in Agriculture, Foodindustry \end{aligned}$$

With the following correspondence to CoCo data regarding intermediate consumption, household consumption, stock changes and losses:

Eq (11) $$\sum_{A} AAMQ_{C,A} = QIDC_{C} = INDM_{C} + PRCM_{C} + FEDM_{C} + SEDM_{C}$$

Eq (12) $$AAMQ_{C,'I\_HHLD'} = QH_{C} = HCOM_{C}$$

Eq (13) $$AAMQ_{C,'I\_STCH'} = QSTC_{C} = STCM_{C}$$

Eq (14) $$AAMQ_{C,'T\_TRD'} = QLOS_{C} = LOSM_{C} + SADM_{C}$$

Where:

QDD	Domestic absorption

QIDC	Intermediate demand per commodity
QH	Household final consumption per commodity
QSTC	Stock changes
QLOS	Losses on markets
INDM	Industrial use market **(CoCo)**
PRCM	Processing to derived products market **(CoCo)**
FEDM	Feed use on market **(CoCo)**
SEDM	Seed use on market **(CoCo)**
HCOM	Human consumption market **(CoCo)**
STCM	Stock changes on market **(CoCo)**
LOSM	Losses on market **(CoCo)**
SADM	Statistical adjustment on market **(CoCo)**

Losses on markets are here booked in the account for transaction costs and will serve at a later stage as proxy for the estimation of commodity-specific trade margins in the AgroSAM.

5.3 Intermediate Input and Output Matrices

Accounts for activities and commodities are linked via two sub-matrices, the input table **I** and the output table **D** in appendix 1. CoCo provides information about the intermediate demand of the agricultural sector in value terms (e.g. pharmaceutical inputs or energy in constant 1995 Euro/ha) and in quantity terms (fertilizer in kg/ha), while outputs (or yields) of each agricultural activity are recorded as quantities (kg/ha).

The sub-matrix for domestic output can be therefore fully derived by multiplying the output coefficient with the activity levels:

Eq (15) $$AAMQ_{A,C} = QD_{A,C} = OUTP_{C,A} \cdot LEVL_A$$

Where:

QD	Domestic production quantity by activity
OUTP	Output coefficient **(CoCo)**

The input matrix I on the other hand has two representations:

$$AAMQ_{C,A} = QI_{C,A} = INPT_{C,A} \cdot LEVL_A \;\; \forall INPT_{C,A} \textit{ measured in quantities}$$

Eq (16) $$AAMV_{C,A} = VI_{C,A} = INPT_{C,A} \cdot LEVL_A \;\; \forall INPT_{C,A} \textit{ measured in values}$$

Where:

QI	Domestic intermediate demand quantity by activity
VI	Domestic intermediate demand value by activity
INPT	Input coefficient

5.4 Splitting Agriculture and Food Industry

One of the main challenges when attempting to harmonize the CoCo database with the supply and use tables in ESA format is the fundamental difference in the treatment of processed agricultural commodities. These are part of the agricultural sector in the EAA (and consequently CoCo) framework, but belong to the food processing industries in the ESA framework.

For this reason, a new set of auxiliary activities was introduced in the SAM while processing the CoCo data. These correspond with the agricultural outputs in CoCo considered as processed commodities in the AgroSAM framework, particularly beef, pork, sheep and goat meat, and wine. The domestically produced quantities are here mapped to the corresponding industrial activities:

Eq (17) $$AAMQ_{A,C} = QD_{A,C} = QX_C \cdot PRCOUT_{A,C} \quad \forall A,C \in FoodIndustry$$

Where:

PRCOUT Binary aggregator matrix (1 if activity A produces commodity C, else 0)

Since these products are not anymore considered as outputs of the agricultural sector, the corresponding entries under agricultural activities have to be set to 0:

Eq (18) $$AAMQ_{A,C} = QD_{A,C} = 0 \quad \forall A \in Agriculture, C \in FoodIndustry$$

A similar approach is chosen for the input demand. The new activity "beef meat" (A_BEEF) demands slaughtered animals from the agricultural sector, the activity "Rice milled" demands paddy rice, and so on:

Eq (19) $$AAMQ_{C,A} = QI_{C,A} = QX_C \cdot PRCINP_{C,A} \quad \forall A \in FoodIndustry, C \in Agriculture$$

Where:

PRCINP Binary aggregator matrix (1 if activity A demands commodity C, else 0)

Together with the cost-share coefficient ζ(.) obtained from the ESASAM, we can now derive the prior information of the cost structure of the processing industries. The total output value of the new activities at basic prices is computed by:

Eq (20) $$AAMV_{'Total',A} = ALV_A = \sum_C QX_C \cdot PB_C \cdot PRCOUT_{A,C} \quad \forall A \in FoodIndustry$$

Expenditures for labour, capital, and intermediate inputs are derived by multiplying the ESA cost shares with the activity output, as following:

Eq (21) $$AAMV_{'LAB',A \in A\_ESA} = LAB_{A \in A\_ESA} = \zeta LAB\_ESA_{A\_ESA} \cdot ALV_{A \in A\_ESA}$$
$$\forall A \in FoodIndustry$$

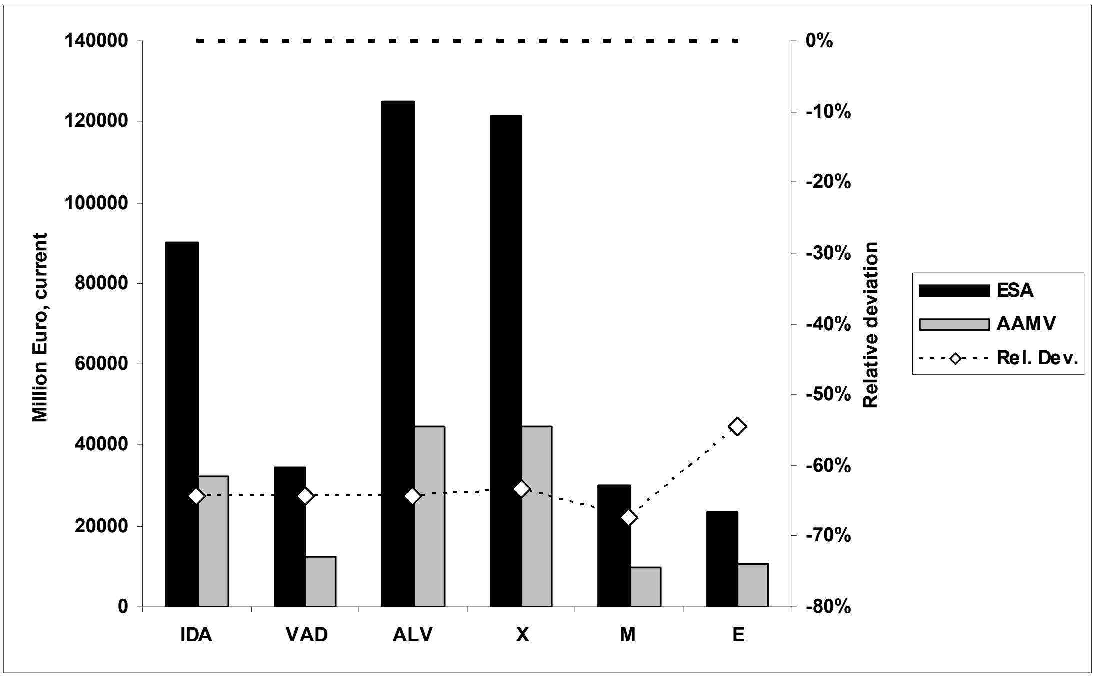
Eq (22) $$AAMV_{'CAP',A \in A\_ESA} = CAP_{A \in A\_ESA} = \zeta CAP\_ESA_{A\_ESA} \cdot ALV_{A \in A\_ESA}$$
$$\forall A \in FoodIndustry$$

Eq (23) $$AAMV_{'IDA',A\in A\_ESA}=IDA_{A\in A\_ESA}=\zeta IDA\_ESA_{A\_ESA}\cdot ALV_{A\in A\_ESA}$$

$$\forall A\in FoodIndustry$$

The thus derived values are compared with the ESA totals in figure 2. It appears that, in contrast to the agricultural sector, the food industry sector is only represented to a limited extent in the CoCo database and consequently in the agricultural accounting matrix.

Figure 2 Comparison between ESA and AAMV totals, Food Industry Sector, Germany year 2000, in Million Euro (current prices)



Source: Eurostat, CoCo, own calculations

Because of the substantial deviation between ESA and AAM values in the food processing sector, we have to include additional information from PRODCOM and COMEXT datasets. The accounts for exports, imports, and domestic production were adjusted as shown below:

Eq (24) $$VX_C=\begin{cases} VX_C \ \forall C=\{Beef, Pork, Poultry, Dairy\} \\ PRODCOM_C \ \forall C=\{AnimalFeed, Beverages\} \\ VX^{ESA}-\sum_{C\notin Otherfood} VX_C \ \forall C=\{Otherfood\} \end{cases}$$

Eq (25) $$VM_C=\begin{cases} VM_C \ \forall C=\{Beef, Pork, Poultry, Dairy\} \\ COMEXT_C \ \forall C=\{AnimalFeed, Beverages\} \\ VM^{ESA}-\sum_{C\notin Otherfood} VM_C \ \forall C=\{Otherfood\} \end{cases}$$

Where:

VX	Exports by commodity
VM	Imports by commodity

5.5 Prices and Values

The ESA supply and use tables distinguish between basic prices and purchaser's prices. We will introduce export and import prices in addition to account for deviating weighted average prices when aggregating groups of CoCo commodities at a later stage. This can happen when merging comparatively heterogeneous types of products, e.g. cheese, milk-powder, and cream, into a dairy aggregate, with a different composition of the individual commodities in each group.

However, as a starting point we used unit values at basic prices (UVAB) to determine starting values for domestic, import, and export prices. In case they were not available from CoCo for certain processed commodities (e.g. oilcakes or molasses), we had to rely on other sources, among which FAOSTAT appeared to be the most appropriate for the commodity groups distinguished in CoCo. It should be emphasized at this stage that the prices entering the following computations are best first guesses, which will be altered in the subsequent balancing steps. The starting values for basic prices are:

Eq (26) $$PB_C = \begin{cases} UVAB_C \ \forall C \in Agriculture, FoodIndustry \\ FAOPRIC_C \ if \ not \ UVAB_C \end{cases}$$

Where:

PB	Starting values for basic commodity prices
UVAB	Unit value at basic prices (CoCo)
FAOPRIC	Prices for processed commodities from FAOSTAT

With this price vector at hand, we can now connect the two agricultural accounting matrices:

Eq (27) $$AAM_{AC,AC'} = \begin{cases} AAMV_{AC,AC'} \ if \ AAMV_{AC,AC'} \\ AAMQ_{AC,AC'} \cdot PB_{AC} \ if \ not \ AAMV_{AC,AC'} \end{cases}$$

Where:

AAM	Agricultural accounting matrix in basic prices

6 Balancing the AgroSAMs

The balancing procedure proposed here to consolidate CoCo and ESA data is split into two steps. First, we balance only the sub-vectors of the target-SAM (grey entries in appendix 2), before we include the matrices of domestic production by activity and intermediate demand. There are two reasons for this. First, we reasoned that the explicit incorporation of price and quantity data (instead of using only values when directly working on a SAM) allows for a better incorporation of qualitative knowledge about the reliability of the underlying information. We may have, for instance, high trust in the balance-sheet data for dairy products but a lower trust in the corresponding prices. The chosen approach allows expressing this trust in terms of lower and upper bounds on the deviations between prior and balanced data. Second, we experienced rather long computation time when solving the balancing problem in one step. It turned out that we could balance also the rather large sub-matrices (intermediate demand, domestic output) when first deriving their row- and column-sums by balancing the market items and then using the thus obtained, pre-balanced values as starting points for the second step. In general, the problem at hand may be summarized as the need to find a set of quantities and prices (and values) that are as close as possible to the prior data but satisfy a number of accounting constraints. The chosen approach has to allow the incorporation of qualitative information, like the degree of assumed reliability of the prior data, and whether an entry is positive or negative. We decided to express the relation between prior and balanced data via a correction coefficient kappa (κ):

Eq (28) $$Y = \bar{Y} \cdot \kappa \text{, with the properties } \begin{array}{l} E[\kappa] = 1 \\ 0 < \kappa \leq \infty \end{array}$$

Where:

Y	Balanced value for quantities (Q), prices (P), and values (V)
$\bar{Y}$	Prior value for quantities (Q), prices (P), and values (V)
κ	Correction coefficient

The expected value should be 1 (in which case the balanced value equals the prior), and it should not assume negative values in order to avoid the change of the sign of any prior entry. Furthermore, it should not be equal to zero as we assume that once there is a prior entry, there should also be a non-zero entry in the balanced dataset. The assumed reliability of the prior data should also influence the possible outcomes for kappa. These desired properties made us choose a cross-entropy approach similar to the one applied for the balancing of the ESASAMs, but with some modifications.

Kappa is here expressed as an exponential function of s support points (b_s) and their associated weights (W_s).These weights have to add up to unity and should be as close as possible to a set of pre-defined prior weights.

Eq (29) $$\kappa = \exp\left[\sum_s W_s \cdot b_s\right]$$

The support points are arbitrarily defined according to the 3-sigma rule (in the case of five support points). SIG is a variance parameter and prior weights are computed according to Robinson (2007), thus assuming a non-uniform, symmetric distribution symmetric around 0.

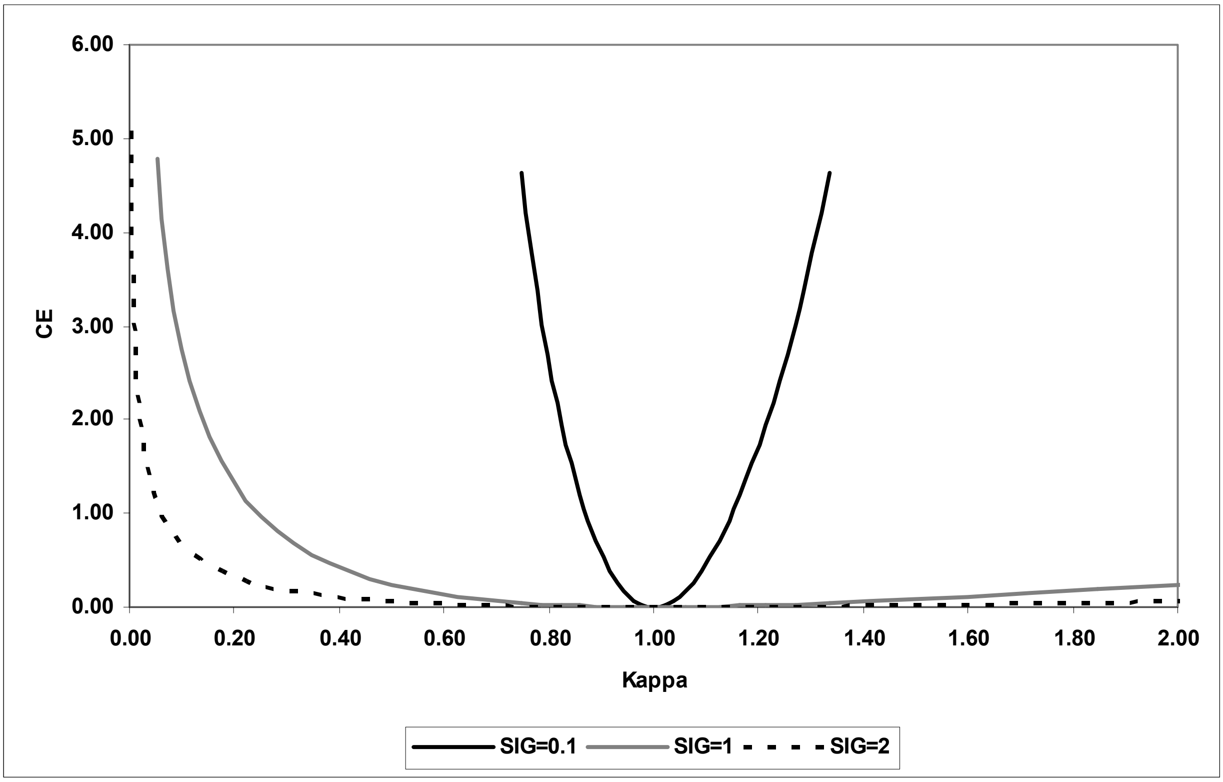
Eq (30) $$\begin{aligned} b_s &= [-3, -1.5, 0, 1.5, 3] \cdot SIG \\ \bar{W}_s &= \left[\tfrac{1}{162}, \tfrac{16}{81}, \tfrac{48}{81}, \tfrac{16}{81}, \tfrac{1}{162}\right] \end{aligned}$$

The cross-entropy minimization model can be summarized as follows:

Eq (31) $$\begin{aligned} & CE = \min \sum_s W_s \cdot \ln\left[W_s / \bar{W}_s\right] \\ & s.t. \\ & \kappa = \exp\left[\sum_s W_s \cdot b_s\right] \\ & \sum_s W_s = 1 \\ & Y = \bar{Y} \cdot \kappa \\ & \textit{accounting identities for } Y \end{aligned}$$

When solving the problem above for different values for kappa and SIG, we obtain (by neglecting the accounting identities for Y) a plot of the objective function as shown in figure 3:

Figure 3 Cross-Entropy Function of Kappa



Source: Own calculation

In fact, the values for SIG (0.1, 1, and 2) as used in figure 3 were chosen to express the trust we had in the different prior data. It has to be noted here that the decision, which value to choose for SIG is a qualitative judgement and not supported by a systematic quantitative assessment of potential variances of the prior data[10]. Instead of deriving any other quantitative indicator like variance over time, or EU27 member states, we reasoned that domestic production and trade of cereals, oilseeds, and dairy products are comparatively well monitored, whereas "fodder crops", "other crops", or other "animals" where derived as residuals or according to assumptions about input coefficients in the raw dataset that had entered the CoCo procedure in the first place.

6.1 Balancing the Account Totals

The balancing model for the account totals is summarized in table 6. It was implemented in GAMS and put to work as a non-linear optimization problem, solved with the numerical solver CONOPT3. The model in table 2 deviates in some respects from the general structure outlined above. We allow for instance for a change of sign in the cases of tax rates on activities and commodities (Eq 5 and 6 in table 2), mainly because the fact that we had only the average tax rates as priors, which may change from a tax to a subsidy depending on the commodity in question. Equations 13 and 14 in table 2 represent the commodity balance

[10] We assume that knowledge about the variances obtained in the original CoCo estimation procedure would improve the quality of the decision made here, but have not been used for this study.

equations, either in value-terms or in quantities. The important difference is that losses on markets (LOS) are part of the quantity balance, but not of the value-balance. Thus, the differences have to be compensated during the balancing process by adjusting trade margins and tax rates accordingly[11].

Table 2 Equations of the first balancing model

No.	Equation	Description
1	$\min_{W} I\left(W\right)=\sum_{itm}\left[\sum_{ac}\sum_{s}W_{ac,s}^{itm}\cdot\ln\left(W_{ac,s}^{itm}/\overline{W}_{s}\right)\right]$	Cross-Entropy minimand
2	$Q_{c}^{citm}=\overline{Q}_{c}^{citm}\cdot\kappa_{c}^{citm}$	Definition of final commodity quantities
3	$P_{c}^{pitm}=\overline{P}_{c}^{pitm}\cdot\kappa_{c}^{pitm}$	Definition of final commodity prices
4	$V_{a}^{aitm}=\overline{V}_{a}^{aitm}\cdot\kappa_{a}^{aitm}$	Definition of final activity values
5	$ta_{a}=\overline{ta}_{a}+\sum_{s}W_{a,s}^{ta}\cdot\overline{b}_{a,s}^{ta}$	Definition of final activity tax rates
6	$tc_{c}=\overline{tc}_{c}+\sum_{s}W_{c,s}^{tc}\cdot\overline{b}_{c,s}^{tc}$	Definition of final commodity tax rates
7	$hm_{c}=\overline{hm}_{c}\cdot\exp\left[\sum_{s}W_{c,s}^{tc}\cdot\overline{b}_{c,s}^{tc}\right]$	Definition of final trade margins
8	$\kappa_{c}^{citm}=\exp\left[\sum_{s}W_{c,s}^{citm}\cdot\overline{b}_{s}^{citm}\right]$	Definition of the correction term for commodity quantities
9	$\kappa_{c}^{pitm}=\exp\left[\sum_{s}W_{c,s}^{pitm}\cdot\overline{b}_{s}^{pitm}\right]$	Definition of the correction term for prices
10	$\kappa_{A}^{Aitm}=\exp\left[\sum_{s}W_{A,s}^{Aitm}\cdot\overline{b}_{s}^{Aitm}\right]$	Definition of the correction term for activity values
13	$Q_{C}^{X}+Q_{C}^{M}=Q_{C}^{IDC}+Q_{C}^{GVT}+Q_{C}^{H}+Q_{C}^{STC}+Q_{C}^{FCF}+Q_{C}^{E}+Q_{C}^{LOS}$	Balance for commodity quantities
14	$\left[P_{C}^{X}Q_{C}^{X}+P_{C}^{M}Q_{C}^{M}\right]\cdot\left[1+hm_{C}+tc_{C}\right]$ $=$ $P_{C}^{DD}Q_{C}^{IDC}+P_{C}^{DD}Q_{C}^{GVT}+P_{C}^{DD}Q_{C}^{H}+P_{C}^{DD}Q_{C}^{STC}+P_{C}^{DD}Q_{C}^{FCF}+P_{C}^{E}Q_{C}^{E}$	Balance for commodity values
15	$V_{A}^{ALV}\cdot\left[1-ta_{A}\right]=V_{A}^{IDA}+V_{A}^{VAD}$	Activity value balance
16	$V_{A}^{VAD}=V_{A}^{LAB}+V_{A}^{CAP}$	Definition of Value Added
11	$\sum_{s}W_{A,s}^{(.)}=1 \quad \text{with } 0<W_{A,s}^{(.)}<1$	Sum of weights

[11] It would be preferable to associate only the trade margins (when interpreted as transaction costs on markets) with the losses, but we found no way to isolate the effect of trade margins in the domestic transmission of basic into purchaser's prices for each commodity. Detailed data on tax rates would mitigate this problem, but that would require the incorporation of additional datasets, which were not available yet.

No.	Equation	Description
12	$\sum_{s} W_{C,s}^{(.)} = 1 \quad \text{with } 0 < W_{C,s}^{(.)} < 1$	Sum of weights
17	$V_{A^{ESA}}^{ESA,(.)} = \sum_{A} M_{A,A^{ESA}} \cdot V_{A}^{(.)}$	Activity values add up to ESA totals
18	$V_{C^{ESA}}^{ESA,(.)} = \sum_{C} M_{C,C^{ESA}} \cdot Q_{C}^{(.)} \cdot P_{C}^{(.)}$	Commodity values add up to ESA totals

6.2 Balancing the Sub-Matrices

In a second step, we use the obtained balanced vectors as starting values for the estimation of intermediate demand and output matrices. The priors for tau and iota were computed from the prior data for VD and VI as described in chapter 5.3 (see Eq. (16)):

Eq (32) $\overline{\tau}_{A,C} = \dfrac{VD_{A,C}}{ALV_A}$ and $\overline{\iota}_{A,C} = \dfrac{VI_{A,C}}{IDA_A}$

The model is solved again with equation 1b replacing 1a and four additional constraints 19 to 22 (see table 3).

Table 3 Equations of the second balancing model

No.	Equation	Description
1b	$\min_{W,\tau,\iota} I(W,\tau,\iota) = \sum_{itm}\left[\sum_{ac}\sum_{s} W_{ac,s}^{itm} \cdot \ln\left(W_{ac,s}^{itm} / \overline{W}_{s}\right)\right] + \sum_{a}\sum_{c} \tau_{A,C} \cdot \ln\left(\tau_{A,C} / \overline{\tau}_{A,C}\right) + \sum_{a}\sum_{c} \iota_{C,A} \cdot \ln\left(\iota_{C,A} / \overline{\iota}_{C,A}\right)$	New Cross Entropy Minimand
19	$\sum_{A} V_{A}^{IDA} \cdot \iota_{C,A} = Q_{C}^{IDC} \cdot P_{C}^{DD}$	Intermediate demand by activity an for commodities
20	$\sum_{A} V_{A}^{ALV} \cdot \tau_{A,C} = Q_{C}^{X} \cdot P_{C}^{X}$	Link between activity values and commodity prices times quantities
21	$\sum_{C} \iota_{C,A} = 1 \quad \text{with } 0 < \iota_{C,A} < 1$	Adding-up condition for ι
22	$\sum_{C} \tau_{A,C} = 1 \quad \text{with } 0 < \tau_{A,C} < 1$	Adding-up condition for τ

7 Some Conclusions

The task to combine the database of an agricultural sector model with supply-and use tables from Eurostat (CoCo and ESA) confronted us with a huge number of methodological and data-handling challenges. We tried to use the information from both databases as exhaustively as possible, but we had at some stages (e.g. in the case of food industry) to rely on additional sources. It was possible to compile a prior dataset which we considered as sufficiently reliable to apply a cross-entropy balancing method. This was implemented as a two-step procedure, which first produced a balanced set of sub-vectors of the target SAM and then a fully balanced matrix. Using this procedure, we were able to compile AgroSAMs for three Member States: Czech Republic, Germany and Spain. These are currently under internal validation.

Nevertheless, there is still a huge potential for improvement. Our original intention was to create a database which can be mapped (many-to-one) into the format required by GTAP. This task could not be fulfilled totally. Although it was possible to represent the agricultural and food-industry sectors in a way that is compatible with GTAP, we could not obtain data for a required split of the oil and gas sector, the ferrous and non-ferrous metal sector, and a few others. All attempts to acquire at least information about domestic production were not successful. A last resort would have been to use the GTAP database itself. However, we decided to leave the decision, which dataset to use for the split of the respective sectors to the user, in case he intends to run GTAP on our database. An additional shortcoming of the procedure described in this report is the lack of detailed information on policy measures like taxes on commodities, for which we only had the average rate from the supply and use tables. Here there is certainly room for significant improvements.

The current state of our approach allows a fully flexible incorporation of additional data, for which we will continue to search. The procedure described in the previous chapters represents a first step, and further improvements will be made according to the comments of the interested readers and users of the AgroSAMs.

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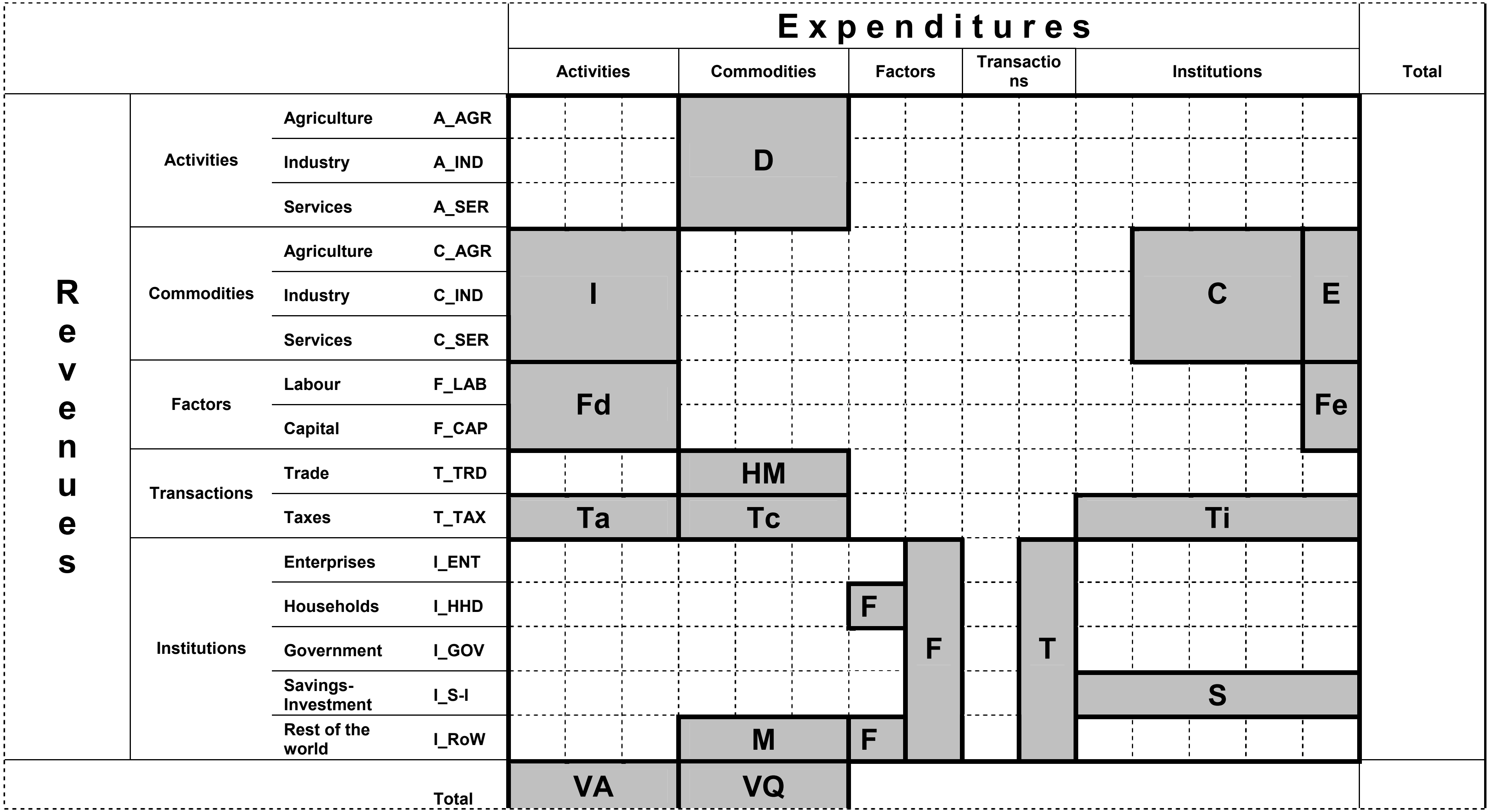
9 Appendices

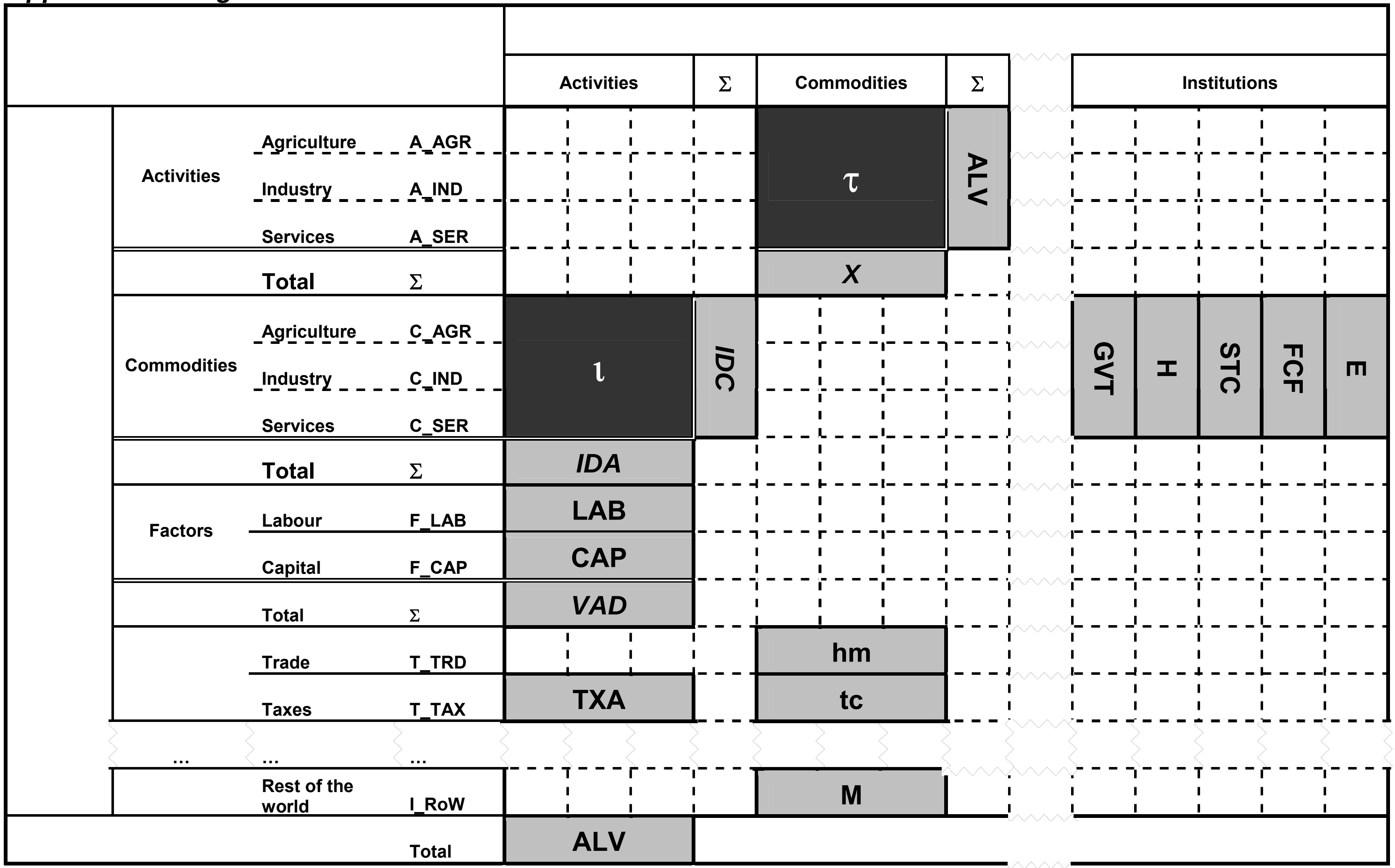
Appendix 1 Stylized SAM and Sub-Matrices



Where the following legend can be followed:

Description	*Code*	*Source*
Domestic production by sectors	**D**	Supply
Intermediate demand	**I**	Use
Domestic final consumption	**C**	Use
Exports	**E**	Use
Domestic factor payments (value added)	**Fd**	Use
Factor revenues from abroad	**Fe**	NASA
Trade margins	**H**	Supply
Taxes and subsidies on production	**Ta**	Use, NASA
Taxes and subsidies on products	**Tc**	Supply, NASA
Direct taxes paid by institutions	**Ti**	NASA
Distribution of factor income across institutions	**F**	NASA
Distribution of taxes and transfers across institutions	**T**	NASA
Imports	**M**	Supply
Savings of institutions	**S**	Residual
Total domestic production by activity	**VA**	Use/Supply
Total domestic production by commodity	**VQ**	Supply

Appendix 2 Target structure of the AAMs



Appendix 3 Summary of Operations from CoCo to AAM

			Activities		Σ	Commodities		Σ	Institutions				
			A_AGR	A_NAG					I_GVT	I_HHD	I_STC	I_FCF	I_RoW
Activities	Agriculture	A_AGR	$\sum_C[LOSF_C\text{-}SEDF_C\text{-}INTF_C] \cdot ASHR_{C,A}$			$LEVL_A \cdot IO_{A,C}$ - $LOSF_C$- $SEDF_C$- $INTF_C$		$LEVL_A$ $TOOU_A$.					
	Non-agriculture	A_NAG					$MAPR_C \cdot ASHR_{C,A}$						
	Total	Σ				$NETF_C$, MAPR							
Commodities	Agriculture	C_AGR	$LEVL_A \cdot IO_{C,A}$,	$NETF_C$ / $ASHR_{C,A}$	$INDM_C$ + $PRCM_C$ + $FEDM_C$ + $SEDM_C$					$HCOM_C$	$STCM_C$		$EXPT_C$
	Non-agriculture (including processed commodities)	C_NAG	$LEVL_A \cdot IO_{C,A}$										
	Total	Σ	$LEVL_A \cdot TOIN_A$										
Factors	Labour	F_LAB	$LEVL_A \cdot WAGE_A$										
	Capital	F_CAP											
	Total	Σ	$LEVL_A * GVAP_A$										
	Trade	T_TRD				$-LOSM_C – SADM_C$							
	Taxes	T_TAX	$LEVL_A * PRME_A$										
…	…	…											
	Rest of the	I_RoW				$IMPT_C$							
		Total	$LEVL_A * TOOU_A$										