Food Balance Sheets (FBS)

Methodological principles for the compilation of country-level FBS

Food and Agriculture Organization of the United Nations

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Outline

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The basic identity and approach

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1. The basic identities

Basic premise of FBS :

- within a given country in a given year, the sum of all aspects in the supply of a given product = the sum of utilizations for that product

- This concept is expressed in two basic identities of FBS:
  1) Domestic supply (P+I-E-Δstocks) = Domestic utilization
  2) Total supply (P+I - Δstocks) = Total utilization (incl. exp.)

1. The basic identities

a) Domestic supply = Domestic utilization

Production + (Imports-Exports) + Opening Stocks = Food + Feed + Seed + Tourist Food + Industrial Use + Loss + Residual Use + Closing Stocks

b) Total supply = Total utilization

Production + Imports + Opening Stocks = Exports + Food + Feed + Seed + Tourist Food + Industrial Use + Loss + Residual Use + Closing Stocks

→ Food processing **should be included where necessary in the utilization part of the equation - but this variable 'disappears' in the final stage of FBS compilation of most commodity groups. The Food Processng variable is the link to successive processed product SUAs.**

1. The basic identities

As many countries do not collect – or share - data on stock levels for the majority of products, absolute opening and closing stock levels are replaced by **estimate of the change in stock levels** during the reference period.

Total supply = Total utilization

Production + Imports – Δstocks* = Exports + Food + Feed + Seed + Tourist Food + Industrial Use + Loss + Residual Use

(*) stock variation = amounts sent to (utilization), or withdrawn from (supply), stocks (without necessarily identifying actual balances)

1. The basic identities

The basic identity can also be specified with an additional utilization variable: food processing.

Production + Imports – ΔStocks = Exports + Food + Food Processing + Feed + Seed + Tourist Food + Industrial Use + Loss + Residual Use

Food processing is included as a utilization variable in the individual commodity balances (SUA). In fact, it is the link between the different level SUAs.

However, it is not always included at the FBS level because this variable is dropped in the final stages of FBS compilation in order to avoid double-counting. BUT appears when a derived product of that primary commodity has its own FBS (e.g. Barley->Beer; Grapes-> Wine).

2. The SUA/FBS variables

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2.1. Supply and use variables

The basic supply and utilization variables as we saw earlier cover all of the aspects of the basic identity

Supply variables	Use variables
a) Production b) Imports c) Stock variation	d) Exports e) Food f) Food Processing g) Feed h) Seed i) Tourist food j) Industrial use k) Loss l) Residual and other uses

2.2. Additional variables

In order to compile the complete FBS (including estimates of per capita nutrient availability) several additional variables are required:

- **Population (UNPD)**

  - UNPD definition : "*de facto* population in a country, area or region as of 1 July of the year indicated".

    The term *de facto* indicates that not only citizens, but **all residents** should be counted in the population (including refugees or resident migrant workers).

  - Estimates of population are needed to convert aggregate national nutrient supplies into per capita nutrient supplies

2.2. Additional variables

Nutrient Conversion factors

- Nutrient conversion factors allow to derive **estimates of the amount of calories, fat, and protein available** for consumption by a country's population.

These estimates are **derived from the final "food" quantities** in the balance sheet for each product **by the nutrient conversion factors** to those quantities.

Nutrient-related variables derived:

- Food: total calorie equivalent
- Calories per capita per day
- Food: total protein equivalent
- Proteins per capita per day
- Food: total fat equivalent
- Fats per capita per day

Nutrient conversion table:
http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Food_security/Excel_sheets/Nutritive_Factors.xls

2.2. Additional variables

Extraction rates

- They are parameters that reflect the loss in weight in the **conversion (or processing) of one product into another**.

- Extraction rates are **expressed as a percentage**, and are calculated as the amount (by weight) of derived product that is produced using a given amount of input product:

$$Extraction\ rate = \frac{Quantity\ of\ output}{Quantity\ of\ input}$$

e.g. to produce 80 MT of maize flour, 100 MT of maize are needed:

$$Extraction\ rate = \frac{80\ MT\ maize\ flour}{100\ MT\ maize} = 0.8 = 80\%$$

2.2. Additional variables

Extraction rates are key components of the FBS, both when calculating the production of processed products from primary ones, and when converting derived product quantities (particularly trade data) back up to primary product equivalent.

N.B.: In cases where several output products are produced from a single transformation process of one input good → check that the cumulative extraction rate is not more than 100%.

Carrying forward the example of maize flour, the same transformation process that produces flour also produces both maize bran and maize germ.

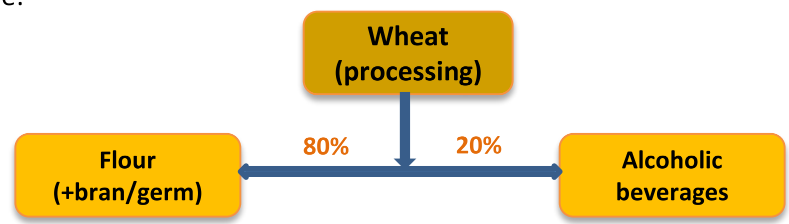
The only exception is in cases where water, vinegar, or other products have been added during the transformation process resulting in an extraction rate higher than 100% (e.g. canned mushrooms)

2.2. Additional variables

- **Processing shares**

  - Percentages of the amount of a given commodity sent to different processing paths.

    example:



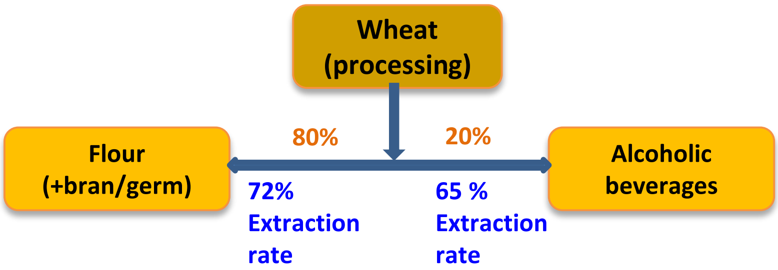
  - Necessary for FBS because: goods can be processed into an array of derived products, and the input used for the production of these derived goods is seldom known with certainty

NOTE THAT:

1. for co-products, their processing shares will be identical.
2. the processing shares must sum to 100 (given that all of the higher-level good sent to processing is transformed into some other good)

2.2. Additional variables

Shares can be applied to the amount of a good sent to processing to calculate the amount of input into a given transformation process, and then an extraction rate can be applied to those inputted quantities to derive a production estimate.



3. Supply Utilization Accounts (SUAs) and link with FBS through Standardization & Aggregation using commodity trees

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3.1. Supply Utilization Accounts (SUAs) and FBS

SUA

- Are the accounting balances for all individual products
- Supply and utilization occurring for each product, both primary and derived

FBS

- Primary commodity equivalent aggregate level (in order to facilitate interpretation)
- Doesn't provide a holistic picture on how the commodity is being consumed, traded, or otherwise used after being processed into various derived products

3.1. Supply Utilization Accounts (SUAs) and FBS

Example of blank SUA table for soybeans (w/ **co-products)**:

Product	Production	Imports	Exports	Stock change	Food	Food processing	Feed	Seed	Net Tourist Cons.	Industrial Use	Loss
Soybeans	1	-	-	-	-	-	-	-	-	-	-
Oil of soybeans	2a	-	-	-	-	-	-	-	-	-	-
Cake of soybeans	2a	-	-	-	-	-	-	-	-	-	-
Soy sauce	2b	-	-	-	-	-	-	-	-	-	-
Margarine & shortening	3a	-	-	-	-	-	-	-	-	-	-
Hydrogenated oils and fats	3b	-	-	-	-	-	-	-	-	-	-

For each primary commodity family, compilers should elaborate SUAs for both the primary commodity in question and all of its derived sub-products, which can include several different levels of processing.

Each of these subsequent processing levels is linked back to the previous level through an extraction rate and the “processing” variable.

3.1. Supply Utilization Accounts (SUAs) and FBS

SUAs can include several different levels of processing
(extraction rates & processing shares are applied)

- Soybean (1) is processed into soybean oil and cake (2a), and/or processed into soy sauce (2b)
- Soybean oil (2a) is processed into margarine/shortening (3a) and/or hydrogenated oils and fats (3b)

The derived product quantities of each of these subsequent processing levels is related to the extraction rate (and can be linked back to the previous level through the inverse extraction rate).

*Production quantity (output) = Quantity of input * Extraction rate*

Example: Quantity of soybean oil = 100 MT soybean * 0.18 = 18 MT

3.1. Supply Utilization Accounts (SUAs) and FBS

The backward link using the inverse extraction rate:

$$\textit{Quantity of input (``for processing'')} = \frac{\textit{Quantity of output}}{\textit{Extraction rate}}$$

REMEMBER THAT:

- It is incorrect to simply add the quantities of primary and derived products together.
- Derived products must first be converted back to their "primary commodity equivalent" and then all of the primary commodity equivalents can be added together to arrive at one overall aggregate and balance.

3.1. Supply Utilization Accounts (SUAs) and FBS

Likewise, in the standardization process:

$$\textit{Primary commodity equivalent} = \frac{\textit{Quantity of derived product}}{\textit{Extraction rate}}$$

This linking of primary to derived commodities using extraction rates is fundamental to the FBS compilation process.

REMEMBER THAT: most food manufacturing commodities produce multiple outputs, and it is even possible for those outputs to undergo further transformation into second-level derived goods.

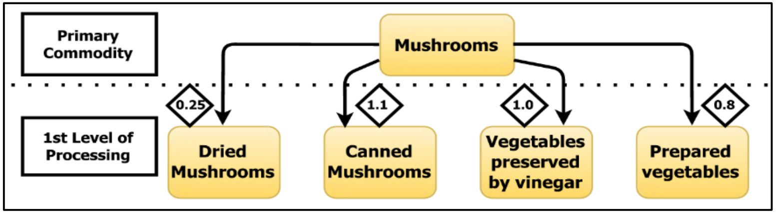
In order to better conceptualize these primary/derived product relationships, commodities and their derived products are organized into "commodity trees"

3.2. Commodity Trees

Commodity trees "stem" from **one primary product** and then branch out into one or more successive levels of **processed products**, with each level **linked by extraction rates**.

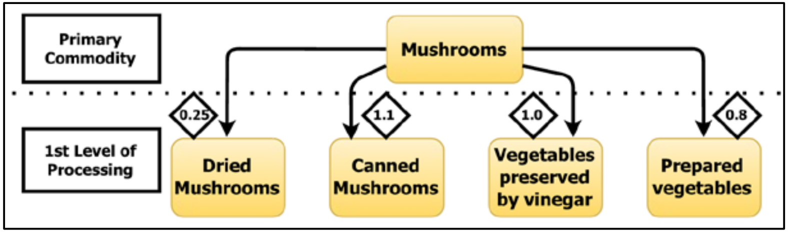
- They are designed to be exhaustive.

Example 1: Mushroom Commodity Tree



- the primary commodity "mushrooms" can be processed into 4 different derived products
- the extraction rate for each of these conversion processes is noted in the diamond above each derived product.

3.2. Commodity Trees



Dried mushrooms: extraction rate = 0.25 → for every 100 MT of mushrooms that enter the process to become dried mushrooms, 25 MT of dried mushrooms will be produced.

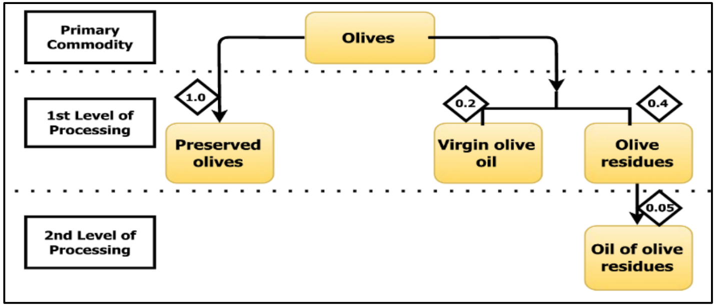
Extraction rates for most processes are less than 1.

Exceptions: water or brine are added in the processing.

Example - canned mushroom: extraction rate = 1.1 → for every 100 MT of mushrooms entering the canning process, 110 MT of canned mushrooms results (due to the fact that brine is added in the process of canning).

3.2. Commodity Trees

Example 2: Olive Commodity Tree



The transformation process has two outputs:

- virgin olive oil
- olive residues

Virgin olive oil: extraction rate = 0.2
→ for every 100 MT of olives milled, 20 MT of olive oil are produced.
But **this same process** also creates 40 MT of olive residues.

Multiple products that are produced **from a single transformation process** are called **co-products.**

NOTE THAT: only one commodity from each transformation process is standardized and aggregated - in order to avoid double-counting.

- o the product that is standardized will typically be the one that makes the largest contribution to food.

3.2. Commodity Trees

Countries are encouraged to :

1) review the commodity trees, and

2) update them, using country-specific extraction rates

NIGERIA			
CROPS AND DERIVED PRODUCTS			
	Seeding rates	Extraction rates	Waste of supply
	KG/HA	%	%
CEREALS			
Wheat	50		2
Flour of Wheat		72	2
Bran of Wheat		25	
Rice, Paddy	50		7.3
Rice, Husked		70	3

→ In the absence of extraction rate estimates from the country, extraction rates of neighboring countries can certainly be adopted as a next-best option (particularly if the neighboring country utilizes similar technologies)

Technical Conversion Factors for Agricultural Commodities:
http://www.fao.org/fileadmin/templates/ess/documents/methodology/tcf.pdf

4. The Balancing Mechanism

4.1. The Balancing Mechanism

The objective is to balance supply & utilization in quantity terms with these main steps:

- Balance each SUA level
- Standardise & Aggregate (by FBS group)
- Balance at the primary equivalent FBS level

4.1. The Balancing Mechanism

FBSs are derived from the SUAs

SUA
- SUA : Supply Utilization Account
- The balance is compiled for every food item consumed within a country

Validation & Balancing

stand.
- Commodities are converted in their primary commodity equivalent and aggregated

Validation & Balancing

FBS
- Primary commodity equivalent balances are combined in to one FBS

4.1. The Balancing Mechanism

Reasons for balancing

- Supply-side variables are often measured data (e.g. production and import quantities), while most utilization-side variables are imputed or estimated (e.g. loss, feed) resulting most often in an unbalanced equation

- In the rare cases where all supply and demand variables are measured independently, it is not likely that the point estimates alone would lead to a precisely-balanced supply and utilization equation.
- This can be due to discrepancies in:
  - data sources
  - data collection and compilation methods
  - reference periods and measurement errors occurring at any if these stages

4.1. The Balancing Mechanism

Previous SUA approach: one element of the equation as the balancing item.

- Variables used for balancing vary but food or feed are commonly used.
- Most appropriate method when all of the variables are measured *except* for the balancing item.

- Drawbacks:

  (i) in most countries, few of the utilization variables are measured, such that the supply = utilization equation will actually have more than one unknown;

  (ii) estimates for the balancing item could fluctuate wildly from year to year;

  (iii) if the errors are biased, those annual errors accumulate, and it may become difficult to distinguish from the error itself;

  (iv) the choice of variable to use as the balancer can be problematic

4.2. The Balancing Mechanism : SUA level

New Approach: 3 step approach:

1. SUA are checked for consistency and variables created or changed (if necessary).

When some **utilization** variable of a derived commodity has a missing value or has one that makes the supply = utilization equation unbalanced, values are created/increased/decreased according to a **"rank"** based on the time-series mean of the particular variable compared to the value of the other utilizations.

- official and semi official values are never touched
- This step only applies to derived commodities
- At the end of this step NOT all the SUAs are balanced

4.2. The Balancing Mechanism : SUA level

<u>The "rank" value assignment - 1. How Ranks are calculated</u>

- Ranks are based on the mean of each utilization variable in each country over the period 2000-2013
- After ranking, inverse ranks are applied to allocate the correct order of magnitude of adjustment
- Variables that have a mean value represent the *<u>active variables</u>* for that country- commodity combination (i.e. the variables for which an imputed value is expected all years)

Malt, whether or not roasted			
Utilization Variable	**Mean Value 2000-2013**	**Rank**	**Inverse Rank**
Exports	86,934	2	4
Stock change	0	5	1
Food	10,643	4	2
Food processing	94,650	1	5
Feed	-	-	
Seed	-	-	
Net Tourist Cons.	-	-	
Industrial Use	28,576	3	3
Loss	-	-	

4.2. The Balancing Mechanism : SUA level

The "rank" value assignment - 2. how ranks are used

→ If the SUA for this commodity has a difference between utilization and supplies, this is allocated in the *active variables* according to the following rules:

- If only one *active variable* is empty, it is supposed that the difference in the equation depends on this gap, therefore that active variable is filled with the 100% of the imbalance
- If more than one *active variable* is empty, the imbalance is distributed according to the following proportion:

$$allocation\ proportion = \frac{Inverse\ Rank}{Sum\ of\ Active\ Inverse\ Ranks\ being\ filled}$$

*N.B. The utilization variables **exports** and **stocks** are never adjusted*

4.2. The Balancing Mechanism: SUA level

The "rank" value assignment - example of ranks use in 3 different scenarios

Malt, whether or not roasted					
Utilization Variable	Rank	Inverse Rank	Allocation proportion if only Food has missing value	Allocation proportion if 2 variables have missing values	Allocation proportion if 3 variables have missing values
Exports	2	4	*	*	*
Stock change	5	1	*	*	*
Food	4	2	2/2 (100%)	2/5 (40%)	2/10 (20%)
Food processing	1	5	*	*	5/10 (50%)
Feed	-	-	-	-	-
Seed	-	-	-	-	-
Net Tourist Cons.	-	-	-	-	-
Industrial Use	3	3	*	3/5 (60%)	3/10 (30%)
Loss	-	-	-	-	-

* These *active variables* are not filled because they have a value (official or semi-official) and, therefore, do not need to be filled

4.3. The Balancing Mechanism: FBS level

New Approach: 2 step approach:

2. After Standardization, equation is balanced at FBS level

Because the FBS equations may come from unbalanced SUAs, they are also unbalanced. The balancing can be accomplished with different methodologies, one of which is considered the gold standard or "**preferred approach**":

As described in the next slide, this method reallocates the imbalance according to the measurement error of each variable.

3. SUA nutritive values (kcal, proteins, fats) are consequently adjusted proportionally to the new food value

After the FBS balancing, if food figures have been changed, SUA nutrient values need to be adjusted. This happens proportionally to the new value of the food variable.

4.3. The Balancing Mechanism: FBS level

3 steps to distribute the equation's imbalance:

Step 1: calculate the imbalance from the supply = utilization identity of the FBS

$$Imb = P + I - dSt - X - Fo - Fe - Se - T - IU - Lo - ROU$$

where: *Imb* is the imbalance for a given commodity in a given country

- if the calculated imbalance is **positive** → supply > utilization → adjustments in the supply variables (production and imports) should be downward;
- if the calculated imbalance is **negative** → supply < utilization → adjustments in the utilization variables must be positive

4.3. The Balancing Mechanism: FBS level

Step 2: Distribute the imbalance to achieve supply=utilization:

- Can be complicated or computationally demanding, depending on the approach (measurement error basis, residual, etc. - explained after)

Step 3: check that all newly balanced quantities are within any set **bounded values**, and rebalance if necessary.

- If the balancing process will produce results where certain balanced quantities are estimated outside of bounded (or likely) values, this problem is resolved by:

  1) setting the value in question at the boundary level and assigning that value a zero standard deviation (so, a fixed, “balanced” value)

  2) repeating Steps 1 and 2 in order to redistribute the imbalance

4.4. The recommended approach to distribute the imbalance at FBS level

Different methods can be used to distribute the imbalances.

Recommended approach : **Distribute imbalance proportionally based on aggregated error**

Rationale: the variables with the highest measurement errors (considered the least reliable) are adjusted proportionally more than variables with a lower assigned measurement error.

Step 1: Use measurement error percentages and point estimates to quantify the error of each variable.

Step 2: Sum up the individual errors of each variable to calculate an aggregated error for the equation.

Step 3: Calculate the proportion of the aggregated error for each of the elements.

Step 4: Distribute the imbalance proportionally.

Step 5: Ensure that any constraints are met, and recalculate if necessary.

4.5. Other balancing mechanisms

a) Assigning small, positive imbalances to a “residual use” category

- This approach could be utilized in cases where a positive imbalance is below an *a priori* threshold (< 5% of total supply or total demand).
- It should not be used for imbalances greater than this level.
- In this way the error does not accumulate in any of the other variables, and it is dealt with in a transparent way.

b) Single balancer approach

- One utilization variable is calculated as the remainder after all other utilizations are accounted for.
- Note that not all variables are appropriate as balancers in the single balancer approach, and
- the degree of appropriateness may even differ from product to product.

4.6. Constraints on the balancing process

Step 3 of the recommend balancing approach alludes to the idea that the balancing process should take into account certain constraints on the values (“bounded” values)

A) ROW CONSTRAINTS

1) For each commodity supply must be equal to utilization

SUPPLY = UTILIZATION

2) As an extension of this row constraint, a country’s exports of a given commodity cannot exceed their supply of that commodity

Production + Imports – Δstock ≥ Exports

- useful way of either identifying errors in trade data or alerting country-level FBS analysts that production of a new commodity is taking place

4.6. Constraints on the balancing process

B) COLUMN CONSTRAINTS

1) Single-year column constraints

examples:

- changes in food availability and derived DES estimates: barring catastrophe, DES estimates are unlikely to vary greatly on an annual basis → aggregate changes of 100 calories per capita is the absolute upper bound.

- stocks: subtraction from stocks in a given year cannot be greater than the overall level of stocks.

2) Multiple-year column constraints

examples:

- stocks: it is considered highly unlikely that a country would either add to stocks or take away from stocks for many years in a row → impose a bound on the stocks changes in the balancing process

4.6. Constraints on the balancing process

C) *“VERTICAL STANDARDIZATION”* CONSTRAINT

In cases where production, trade, and other utilizations of derived products come from official data:

→ ensure that there is a sufficient quantity of primary product sent to processing to ensure that each of the derived product accounts do not have any negative discrepancies (“row constraint”).

D) IMBALANCE EXCEEDS AGGREGATE MEASUREMENT ERROR

- These instances can result from much larger error in one of the point estimates than is indicated by the assigned measurement error

- It does indicate that the confidence intervals are set too conserve

Conclusions

1. Food balance sheets:
   - based on an overall supply = utilization identity
   - accounts of primary and derived products are organized into commodity trees and linked by extraction rates
2. Individual supply utilization accounts of derived products are filled and balanced, then aggregated up to the primary commodity equivalent level
3. Accounts at the primary commodity equivalent level are then balanced
4. The recommended approach

References

- *Guidelines for the compilation of Food Balance Sheets* (FAO, 2017), chapter 2 (Global Strategy & FBS Team)
- *The FAO source book for the compilation of Food Balance Sheets* (FAO, 2016) (Global Strategy & FBS Team)
- *Technical Conversion Factors for Agricultural Commodities* (FAO, 1972)

THANK YOU!

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