



**The GTAP 10A Data Base with Agricultural Production Targeting
Based on the Food and Agricultural Organization (FAO) Data**

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Abstract

This document describes a new source of inputs, based on FAO data, that allows us to estimate agricultural output targets on 133 regions of the GTAP 10A Data Base. This approach allows to overcome several limitations present under the current agricultural production targeting (APT) processing. First, a significant expansion in the regional coverage is achieved, as the number of regions undergoing APT more than doubles. Second, the detailed commodity classification of the FAO dataset allows for a more accurate mapping to the GTAP Data Base sectors. Third, a better commodity coverage in the FAO data prevents the issue of mapping a processed commodities to the corresponding primary sector. Finally, reliance on the FAO agricultural output data provides a better opportunity for further incorporation of the nutritional accounts to the GTAP Data Base, by lowering inconsistencies between GTAP and FAO agricultural accounting. Comparisons between OECD-based agricultural output (currently used in the GTAP Data Base) and FAO-derived estimates are provided in the document. FAO-based agricultural production targets are incorporated to the GTAP 10A Data Base build stream to produce a special release of the GTAP Data Base.

JEL classification: C68, D57, D58, Q10, Q11.

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1. Introduction

One of the key features of the Global Trade Analysis Project (GTAP) Data Base (Hertel, 1997) is the detailed representation of the agricultural sector. Since GTAP version 5, there are 12 agricultural and 8 food processing sectors included in the GTAP sector classification (Aguiar et al., 2019). Naturally, not all contributed input-output (IO) tables, which are used to develop the GTAP Data Base, have this level of agricultural and food sector representation. Under the current set up, this issue is addressed in two ways.

First, a special agricultural and food IO table is developed (Peterson, 2016). It is based on the set of IO tables from representative countries as well as Food and Agricultural Organization (FAO) data and is used to split up agricultural sector and related activities in the countries, which require disaggregation. Second, an agricultural production targeting (APT) is applied to selected countries (Chepeliev and Corong, 2019). The purpose of this procedure is to adjust the IO tables to match the agricultural production targets mainly in the Organisation for Economic Co-operation and Development (OECD) countries and some large agricultural producers (53 countries in total). Key data are sourced from the OECD producer and consumer support estimates (PCSE) database (OECD, 2020) and provided by the Joint Research Center (JRC) for EU countries in line with the OECD dataset (Boulanger et al., 2019).

While providing a valuable contribution to the GTAP Data Base development framework, current approach to the APT has some limitations and potential for further improvements:

- First, following the OECD agricultural commodity classification, input data includes high share of unclassified/undistributed² commodities (in some cases this category represents over 40%, like for China in 2011 or Chile in 2014), which should later be distributed among agricultural sectors, based on additional assumptions (OECD, 2020).
- Second, while covering 53 regions, production values represent around 84% of global agricultural output in 2014, but still miss most of the developing countries.
- Finally, currently used OECD data do not cover some agricultural commodities and as a result, processed food commodities' output is used to complement the dataset in those cases. For instance, sugar output is used to derive targets for sugar cane.

In an attempt to overcome these limitations, an approach to APT values estimation based on the FAO data (FAO, 2020a) and some additional data sources has been developed. Apart from addressing the aforementioned limitations in the production targeting, this approach provides a better opportunity for developing the GTAP-consistent nutritional accounts, utilizing the available FAO data.

The rest of the document is organized as follows. Section 2 provides an overview of the approach to agricultural production targeting used in the GTAP 10A Data Base. Section 3 discusses the developed approach to the FAO data processing. Section 4 provides estimates of the developed production targets and their comparison with the standard GTAP 10A Data Base

² Non-market price support (non-MPS) commodities under the OECD notation (OECD, 2009).

inputs. Section 5 provides an overview of the constructed GTAP 10A Data Base with FAO-based agricultural production targeting. Finally, Section 6 concludes.

2. Current approach

Under the current approach to APT, agricultural production data for non-EU countries are sourced from the OECD PCSE database (OECD, 2020), while data for EU countries are provided by the JRC team (Boulanger et al., 2019).³ Both data sources are also used to estimate the level of agricultural domestic support by countries and commodities in the GTAP Data Base. Thus, one of the benefits of the current approach to APT estimates is its consistency with the domestic support data. The rest of this section focuses on the producer support estimates (PSE) data processing.

The main focus of the PCSE database is to provide agricultural support estimates by countries and commodities, while values of the agricultural output are derived as accompanying estimates. In particular, PSE distinguishes country-specific market price support (MPS) commodities and reports values of agricultural production for each type of such commodity. All other commodities are treated as non-MPS and are allocated to the one aggregate group and their output is estimated as a difference between total agricultural output and sum of the outputs for MPS commodities. Appendix A provides estimates of the MPS and non-MPS commodity shares for 25 regions (excluding EU) represented in the PSE data. An average share of the non-MPS commodities is 19% in 2014. In some countries, the share of non-MPS commodities is over 35%, these include Korea, Mexico, Switzerland, Indonesia and Chile (Appendix A).

There are 72 commodities in PSE, which are further mapped to 12 GTAP agricultural sectors, see Appendix B. Currently used mapping is intended to allocate all OECD-reported agricultural commodities to the 12 GTAP agricultural sectors following mapping of the domestic support categories to these sectors. At the same time, some domestic support estimates (and correspondingly commodity outputs) are provided for food products and other sectors (e.g. forestry), which are not in the set of 12 GTAP agricultural sectors. In this way, current mapping is designed to gap-fill the values of production for agricultural commodities, by using output values of some processed food products.

In general, this is an acceptable approach to gap-fill some output values, but it could be also a potential source for double counting (like in the case of grapes and wine). Another concern with such approach is that processed food sectors introduce additional value to the raw commodities (processed meat instead of live animals, oil production instead of oil seeds, sugar cane and beet instead of refined sugar, etc), thus increasing the value of primary commodity output. It could also be the case that the large volume of raw commodity is imported for food processing (e.g. sugar cane is imported to produce refined sugar). In all these cases, in general, primary agricultural commodity output would be overestimated based on the corresponding processed commodity output.⁴ In most cases, differences in mapping are related to cattle (ctl) sector and

³ In the case of EU countries, OECD reports aggregate data on the website (OECD, 2020). Boulanger et al. (2019) are using extended OECD dataset, which reports country-by-country data for all EU member states.

⁴ The opposite could also be the case, for instance if country does not produce any sugar, but exports sugar cane or beet, then the estimate of the primary commodity production value (i.e. sugar cane or beet) based on the processed commodity production value (i.e. sugar) would be larger than the actual value.

other animal products (oap), which are remapped to cattle meat (cmt) and other meat (omt) correspondingly. Full list of the GTAP 10A Data Base sectors can be found in Appendix C.

Another issue, which is faced under the current APT data processing approach includes redistribution of the non-MPS commodities. As the output for this category is estimated as a residual in the PSE data (OECD, 2009), corresponding documentation (OECD, 2020) does not provide any information on the commodity composition of this set. In the GTAP 9 Data Base country-specific commodity shares were used to redistribute this category among GTAP agricultural sectors. Appendix D provides listing of the sectors used for non-MPS commodities redistribution (reallocation is performed proportionally to sectoral output values sourced from the OECD PCSE database). In this version of GTAP, such redistribution is performed proportionally to sectoral output values based on the FAO data (as described in the Section 3 below).

3. Estimates of the agricultural production targets using FAO data

In this section, we discuss an approach to the FAO data processing that allows us to address some of the limitations discussed above, as well as helps to expand the regional coverage. The second point is particularly important for the case of developing countries with outdated IO tables (this is the case for most African and some South American countries). Figure 1 provides an overview of the approach used to estimate agricultural production targets using FAO data.

In the **first step**, we source the values of agricultural production from FAOSTAT database (FAO, 2020a) and map them to the extended country list. We include 3 countries, which are represented in the FAOSTAT database and add them to the standard 244 GTAP countries. Added countries include Serbia and Montenegro (is disaggregated into two countries in GTAP's master list of countries⁵, but reported aggregately in FAOSTAT for 2004), South Sudan (which is considered part of Sudan in GTAP's master country list) and China (ISO3 code CPR).⁶

In the **second step**, we source agricultural production quantities for crops, processed crops, processed livestock and primary livestock. As in the case of agricultural output values, sourced on the first step, production quantities are also available for all 4 reference years: 2004, 2007, 2011 and 2014.

⁵ This is a country listing that includes 244 countries; GTAP's 121 countries are those for which we have an IO table, meaning that the remaining 20 composite regions aggregate 123 countries.

⁶ FAOSTAT reports data both for China, mainland (ISO3 code CHN) and China (ISO3 code CPR). We use China, mainland (CHN) for accessing Chinese data. China (CPR) in FAOSTAT is used additionally to CHN and only for reporting output quantities.

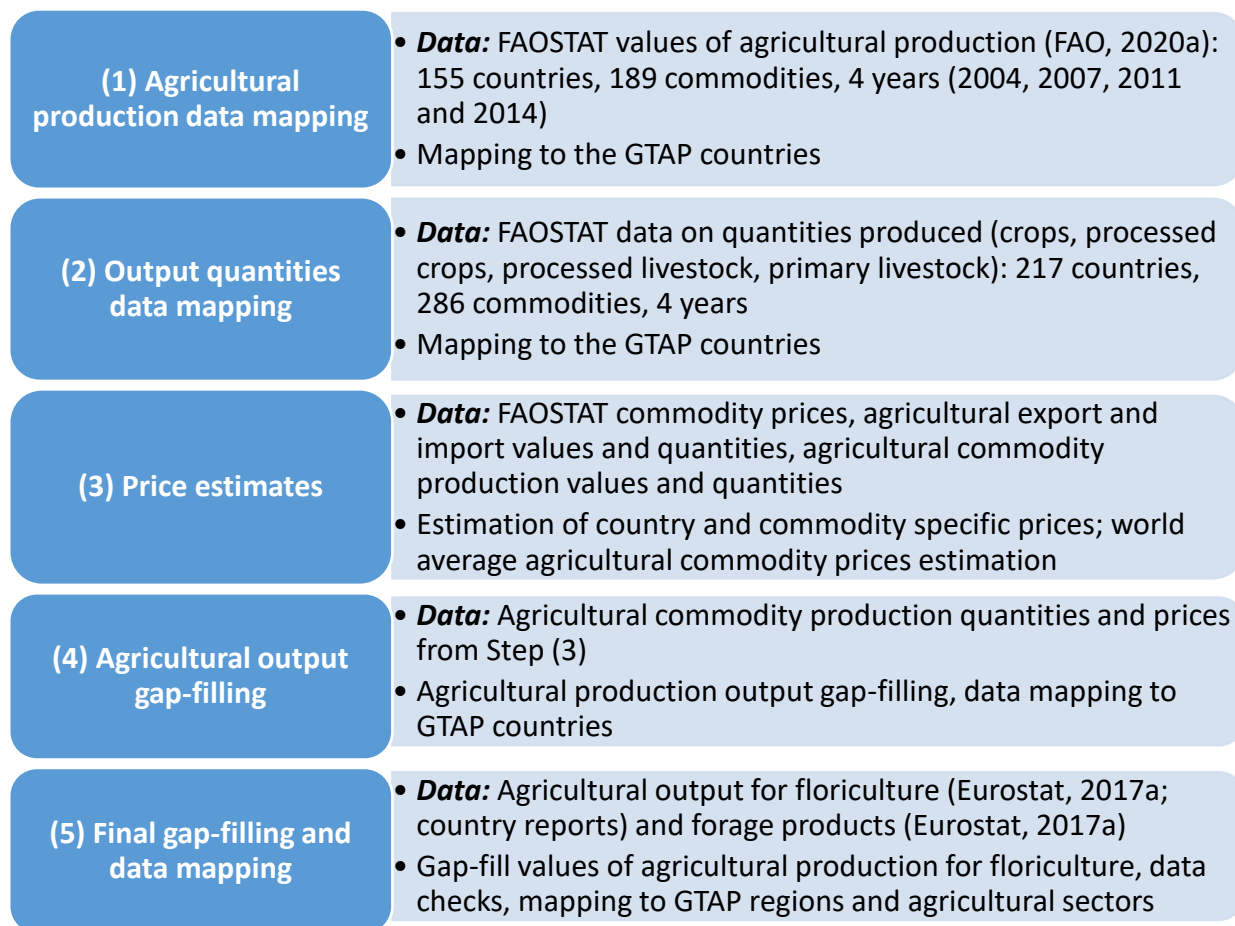


Figure 1. Steps to estimate agricultural production targets for GTAP 10A Data Base based on the FAO data

Source: author.

One of the identified limitations of the FAOSTAT database is under representation of several agricultural commodities. In particular, these include “Forage products” (CPC 2.1 code 0191) and “Living plants; cut flowers and flower buds; flower seeds” (CPC 2.1 code 0196). To gap-fill the first commodity group (Forage products) we use the Eurostat data for EU countries. Following the available forage commodities production data, EU countries account for over 50% of the global forage output, which in value terms is less than 7.5 bn USD. Addition of the forage output estimates for non-EU countries should not significantly change the agricultural output estimates.

We then compare agricultural production quantities with available production values data and identify cases with available quantities and unavailable output values by countries, commodities and years. To further gap-fill these cases we use commodity prices, estimated on the next step.

Third step includes sourcing of the annual producer prices from the FAOSTAT database (FAO, 2020a) and their further gap-filling. In this particular effort we focus on the 12 agricultural sectors of the GTAP 10A Data Base (sectors No. 1-12 in the Appendix B). At the same time, FAO reports production, exports, imports and price data for a broader set of commodities, which cover

some sectors outside agricultural industry (e.g. forestry and fishing, processed food, dairy products, beverages and tobacco, meat products etc.). Therefore, we do not need to estimate prices for all commodities reported by FAO, but only for those, which are mapped to the GTAP agricultural sectors. Appendix E provides mapping between FAOSTAT commodities (with reported data on prices, quantities or production values) and GTAP sectors.

Out of 286 commodities initially sourced for APT output estimates, 203 are mapped to the 12 GTAP agricultural sectors (corresponding commodities are highlighted bold in the 2nd column of the table of Appendix E). We first map all 286 commodities to the 20 GTAP sectors (both agricultural and non-agricultural) based on the CPC and GTAP sector correspondences (GTAP, 2020; UNSD, 2020). We further exclude commodities, which may contribute to double counting in the FAO data (e.g. if FAO reports output for an aggregate commodity and then for sub aggregate). This is particularly the case for cotton. FAO reports data for “Seed cotton, unginned” (CPC code 01921.01), “Cotton lint, ginned” (CPC code 01921.02) and “Cottonseed” (CPC code 0143). As was verified for a number of countries, production quantities of seed cotton equal sum of the cotton lint and cotton seed production. Therefore, for the aim of current report we exclude “Seed cotton, unginned” (CPC code 01921.01) from the list of mapped commodities to avoid double counting.

We further exclude commodities, which do not have an associated output values. This includes live animals, as FAO reports only stock values and prices for this category, which is not sufficient information to estimate the corresponding agricultural output.

In the case of cattle (ctl) and other animal products (oap) we gap-fill the agricultural output values by using output data for primary livestock. Therefore, we remap most commodities, which are initially mapped to the cattle meat (cmt) and other meat (omt) sectors to the “ctl” and “oap” correspondingly (Appendix E). While such mapping is not based on the direct CPC and GTAP sectors correspondence, this could be considered an acceptable way of overcoming data availability issue.

To gap-fill the prices for agricultural commodities we additionally source the FAOSTAT trade data on crops and livestock products (FAO, 2020a), in particular, quantities and values of imports and exports. FAO trade data are sourced in the FAOSTAT commodity list (FCL) classification to be consistent with price data provided in the FCL classification only. We use correspondence tables between CPC 2.1 and FCL classifications (FAO, 2020b). Figure 2 provides an overview of the general approach to the commodity price estimates and gap-filling.

For each country and commodity, we estimate prices using trade quantities and values. If both exports and imports data are available for specific country and commodity case, we estimate weighted average price. In the cases when only exports or imports data are available, price estimate is based solely on the corresponding trade flow. To filter the possible unreliable price estimates we put a threshold on the trade values and quantities equal to 0.1 mn USD and 0.1 tons correspondingly. If either value or quantity is below this level, we do not use such flow for price estimates.

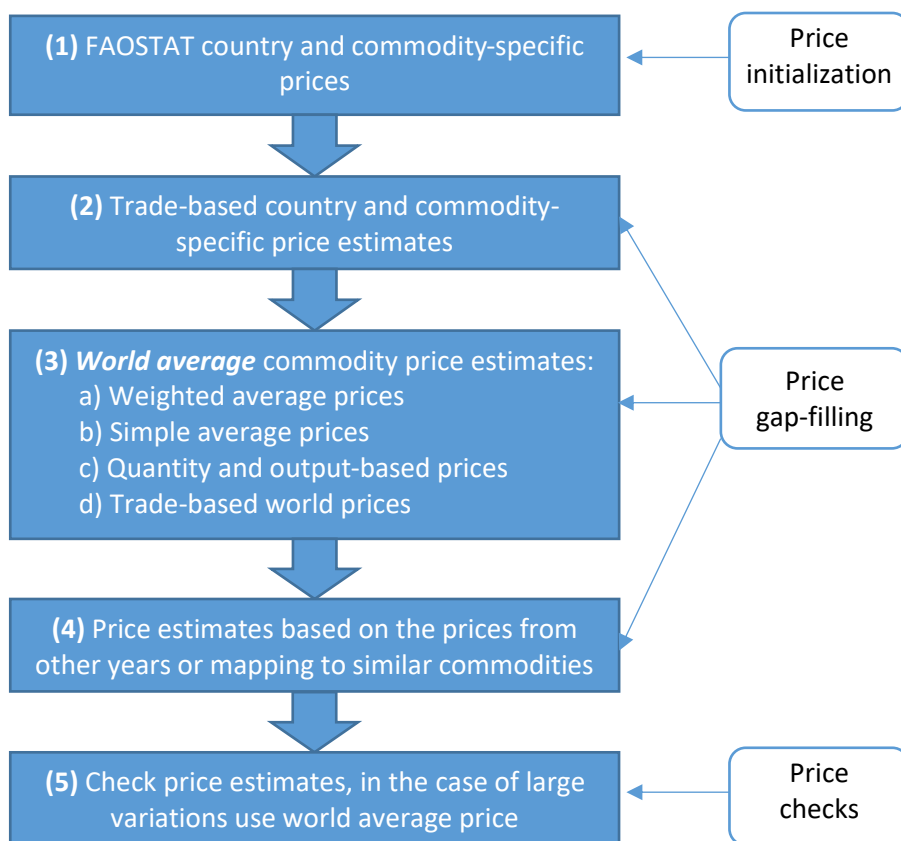


Figure 2. Steps to estimate and gap-fill agricultural commodity prices

Source: author.

We further gap-fill cases with unavailable prices using commodity-specific world average price estimates. First, we identify country and commodity cases with available prices and quantities to estimate commodity specific world average prices. If data on quantity are not available, simple average commodity-specific price is estimated. On the next step, we further gap-fill prices using commodity-specific quantities and output values. We divide world aggregate commodity output by corresponding quantity (only country-specific cases with both available value and quantity data are used). Finally, we use trade data to estimate commodity-specific world average prices and provide additional gap-filling.

Operations (a)-(d) defined on the Step 3 of Figure 2, are executed in a sequential order. Same applies to Steps (1)-(4) (Figure 2). For instance, trade-based country and commodity specific price estimates from the Step 2 are applied only to gap-fill the cases without available price data from Step 1 (Figure 2). Correspondingly, in the case of world average price estimates from the Step 3, simple average prices (operation (b)) are applied only for cases with unavailable price data after Steps 1, 2 and 3.a. Commodity-specific world average prices are assumed to be uniform across countries with unavailable data.

After steps 1-3 (Figure 2), there are some commodity cases with available production quantities, but unavailable price data. In such cases, we assume that commodities with unavailable prices can be mapped to commodities with available prices (similar commodities). If commodity prices are available at least for one benchmark year, we apply the closest available year price estimate for other years. To deflate/inflate prices between available and unavailable years we use

price indexes derived from similar commodities. Otherwise, we assume that commodities with unavailable price data have the same prices as commodities with available price data, which they are mapped to. Appendix F provides mapping for such commodity cases and indicates cases with gap-filling for the nearest available year.

Finally, we check all commodity price estimates that were derived on Steps 2-4 (Figure 2) and compare them with corresponding commodity-specific world average prices. If estimated prices are over 5 times larger or smaller than corresponding world average price, we overwrite such country-specific prices with world average. Initial FAOSTAT-derived prices (from Step 1) do not undergo this check and correction.

On the **fourth step**, we use quantities and prices to gap-fill values of agricultural production for FAO commodities associated with GTAP agricultural sectors. We also provide mapping from the extended 247 country list to the GTAP 244 countries. In particular, South Sudan from FAO data is mapped to Sudan (SUD) in GTAP country list. Aggregate data for Serbia and Montenegro from FAOSTAT for 2004 (before country's separation into the Republic of Serbia and Montenegro) is shared between the Republic of Serbia (SRB) and Montenegro (MNE) proportionally to the corresponding commodities output in 2007, 2011 and 2014 (3-year average shares are used).⁷ Due to the double counting issue, additionally reported by FAOSTAT data for China (apart from China, mainland (CHN)), are ignored.

Finally, on the **fifth step**, we provide additional agricultural output data gap-filling. In particular, as discussed at the beginning of this section, FAO does not report values and/or output quantities for floricultural commodities. To fill this gap we use several additional data sources. First, we source agricultural output data from Eurostat database (Eurostat, 2020a), in particular, data for the “Plant and flowers production”, which includes output of “Nursery plants” (Eurostat code 4210), “Ornamental plants and flowers (including Christmas trees)” (code 4220) and “Plantations” (code 4230). These data are available for 32 countries (see Appendix G) and all four benchmark years – 2004, 2007, 2011 and 2014. Following GTAP sectoral classification (GTAP, 2020) floricultural output is mapped to other crops (ocr) sector.

While on average gap-filling accounts for 15% of world total agricultural production in 2014, for some countries and commodities it represents much larger share of the domestic agricultural production. Appendix H reports value shares of the data gap-filling using price and quantity estimates by regions and sectors for 2014. Out of 141 regions represented in GTAP 10A Data Base, there are 47 region-specific cases where gap-filling accounts for over 30% of total domestic agricultural production. Furthermore, there are 21 regional cases that have a share of gap-filling over 80%, although such cases do not include large agricultural producers, but rather nonagricultural-oriented countries (Bahrein, Kuwait, Oman, etc.) or aggregated regions (Rest of Former Soviet Union, Rest of Western Asia, Central Africa, etc.).

At the sectoral level, other crops and cattle sectors are the ones with the largest gap-filling share – 52.6% and 43% respectively. In the case of other sectors, share of gap-filling on average does not exceed 14% (Appendix H).

⁷ Under the current regional aggregation of the GTAP Data Base, such data split would not have any impact, as the Republic of Serbia and Montenegro are combined into one aggregate region – “Rest of Europe” – together with 11 other countries.

While Eurostat database covers all large European floricultural producers, it does not report production data for non-European countries. According to available reports, apart from EU countries (Netherlands, France, Italy, Germany, Spain) largest world floricultural producers include USA, China and Japan (Jerugan, 2010; Hanks, 2015). For these three countries, we use a country-specific sources to estimate the floricultural output.

In the case of USA, data is sourced from US Census of agriculture and Crops outlook (Jerardo, 2005; USDA, 2014; USDA, 2015). From these documents floriculture and nursery stock output is available for the years 2007, 2009, 2012 and 2014. To estimate output in 2011 we assume constant growth rates between 2009 and 2012. In the case of 2004, only total output of the greenhouse and nursery crops is available (Jerardo, 2005), therefore we apply floriculture and nursery stock shares based on the 2007 data.

In the case of China, we use domestic floricultural sales estimates (Jia et al., 2016; ITC, 2016) and convert them to US dollars (OECD, 2020). Considering that the value of commodity sales can be much larger than production values (as the former one are measured at the farm gate, while the latter one include trade and transport margins, sales margins etc.), we use the USA data to estimate the ratio between the value of production and sales. USA floriculture sales data are sourced from Rabobank (2016) and domestic sales of domestically produced commodities are further estimated using trade data (UN, 2017). An average floriculture production/sales ratio for USA is 43% and it is applied to derive production data for China based on the sale volumes.

In the case of Japan, floricultural output values are based on the USDA Report (USDA, 2010). This source provides the value of floricultural production in Japan for 2007. We assume that the value of production between 2004 and 2007 changes proportionally to the cut flowers market size (USDA, 2010) and to project 2011 and 2014 numbers we use 2004-2007 floricultural output growth rates.

Finally, we map the agricultural output estimates to the GTAP 10A Data Base 12 agricultural sectors (Appendix E) and 141 GTAP regions.

4. Agricultural production targets estimates and comparisons

In this section, we provide estimates of the agricultural production targets for the 12 GTAP agricultural sectors and compare them with the OECD-derived data, which is currently used for agricultural production targeting in the GTAP 10A Data Base. For each non-zero output case, we provide ordinary and percentage difference between OECD-based and FAO-sourced data. We compare agricultural output for all countries reported by OECD, including individual EU countries.

Before moving to the overview of the comparison results, two points should be discussed. First, in the case of non-EU countries, agricultural production data includes an unclassified commodity category (non-MPS commodities discussed in Section 2), which can be over 35% of total agricultural production for some countries (Appendix A). For the purposes of current comparison, we do follow a non-MPS redistribution approach discussed in Section 2.

Second, as discussed in Chepeliev and Corong (2019), agricultural production targets are explicitly imposed within the GTAP Data Base build stream through the agricultural production targeting step. Nevertheless, this does not ensure that the targets are exactly preserved throughout the build stream and agricultural output values observed in the final output files of the GTAP Data

Base might be different from targeted output values (see Chepeliev and Corong (2019) for further discussion).

The remainder of this section provides comparisons between FAO-based and OECD-based agricultural production targets. A more detailed comparison by commodities and regions for the 2011 reference year can be found in Chepeliev and Aguiar (2018). The latter report concludes that in general FAO-based agricultural production targets are more consistent the statistics reported by the national statistical agencies and international organizations than the OECD data.

Total FAO-sourced agricultural production values for 51 countries under comparison differs by only 2.4% from the OECD-based statistics (Table 1). Though there are some countries with differences over 30%, including Greece and Vietnam, in most cases the discrepancy is below 15%.

The largest absolute difference is observed for China, where OECD reports agricultural output to be 164 bn USD higher than the FAO-based estimates or by around 12%. China Statistical Yearbook (NBSC, 2018) suggests that the gross output value of agriculture and animal husbandry in 2014 was around 1248 billion USD – between FAO and OECD estimates, but closer to the FAO data.

For EU on average, OECD is reporting around 6% lower agricultural output compared to FAO, with lager discrepancies for Greece (-48%), France (-13%), Italy (-21%), Portugal (-15%) (Table 1). As discussed in Chepeliev and Aguiar (2018), these differences are largely coming from underreporting of grapes and olives production in the OECD database (OECD, 2020).

Table 1. Comparison of the agricultural production for selected countries in 2014, mn USD

No.	Country	OECD	FAO	Absolute difference	Difference, %
1	Austria	7765	9182	-1417	-18.2
2	Belgium	10564	11652	-1088	-10.3
3	Bulgaria	4951	5164	-213	-4.3
4	Cyprus	798	711	87	10.9
5	Czech Republic	6232	7158	-926	-14.9
6	Germany	72874	72155	719	1.0
7	Denmark	13619	12127	1492	11.0
8	Estonia	1067	1079	-12	-1.1
9	Greece	11477	16965	-5488	-47.8
10	Spain	50513	53465	-2952	-5.8
11	Finland	4844	4261	583	12.0
12	France	75541	85492	-9951	-13.2
13	Croatia	2216	2428	-212	-9.6
14	Hungary	9584	8709	875	9.1
15	Ireland	9242	9459	-217	-2.3
16	Italy	49528	59823	-10295	-20.8
17	Lithuania	3075	3307	-232	-7.5

No.	Country	OECD	FAO	Absolute difference	Difference, %
18	Luxembourg	529	505	24	4.5
19	Latvia	1486	1523	-37	-2.5
20	Malta	157	173	-16	-10.2
21	Netherlands	31535	30392	1143	3.6
22	Poland	29337	30444	-1107	-3.8
23	Portugal	7359	8501	-1142	-15.5
24	Romania	19585	22213	-2628	-13.4
25	Sweden	7307	6622	685	9.4
26	Slovenia	1458	1423	35	2.4
27	Slovakia	2836	2477	359	12.7
28	Great Britain	38223	36770	1453	3.8
29	Australia	49080	41116	7964	16.2
30	Canada	50516	44871	5645	11.2
31	Japan	79018	77137	1881	2.4
32	Korea	42653	38458	4195	9.8
33	Mexico	58135	54682	3453	5.9
34	New Zealand	18235	23259	-5024	-27.6
35	Norway	4515	5318	-803	-17.8
36	Switzerland	9163	10376	-1213	-13.2
37	Turkey	63991	76436	-12445	-19.4
38	USA	406355	390650	15705	3.9
39	Israel	8388	7517	871	10.4
40	Brazil	186865	221756	-34891	-18.7
41	China	1359198	1194861	164337	12.1
42	Indonesia	128464	144259	-15795	-12.3
43	Kazakhstan	14107	13539	568	4.0
44	Russia	90899	96771	-5872	-6.5
45	Ukraine	33626	35888	-2262	-6.7
46	South Africa	19038	22426	-3388	-17.8
47	Chile	13132	11823	1309	10.0
48	Colombia	27698	26391	1307	4.7
49	Vietnam	37731	51463	-13732	-36.4
50	Costa Rica	4916	5769	-853	-17.4
51	Philippines	32270	35443	-3173	-9.8
Total		3211695	3134389	77306	2.4

Source: estimated by author based on FAO (2020) and OECD (2020).

These points can be also verified from the sectoral output comparisons in the EU countries, where the largest absolute discrepancies between FAO and OECD data are observed for

vegetables fruit and nuts (-35.6 bn USD) and oil seeds (-11.7 bn USD) (Table). For the non-EU countries observed differences are much lower reaching 18% for the sugar cane and beet, 11% for plant-based fibers and less than 10% for all other agricultural sectors (Table 2).

Table 2. Comparison of the agricultural production by sectors in 2014, mn USD

No.	Sector	OECD	FAO	Absolute difference	Difference, %
EU countries					
1	Paddy rice	1036	1871	-835	-80.6
2	Wheat	34579	35875	-1296	-3.7
3	Cereal grains	33506	34604	-1098	-3.3
4	Vegetables, fruit, nuts	82131	117722	-35591	-43.3
5	Oil seeds	17310	29034	-11724	-67.7
6	Sugar cane, sugar beet	5990	6351	-361	-6.0
7	Plant-based fibers	774	636	138	17.8
8	Other crops	71396	62410	8986	12.6
9	Cattle	50216	41445	8771	17.5
10	Other animal products	96028	89815	6213	6.5
11	Raw milk	80532	84131	-3599	-4.5
12	Wool	206	288	-82	-39.8
Non-EU countries					
13	Paddy rice	202431	211532	-9101	-4.5
14	Wheat	103474	99442	4032	3.9
15	Cereal grains	230360	217211	13149	5.7
16	Vegetables, fruit, nuts	816088	787997	28091	3.4
17	Oil seeds	207076	199299	7777	3.8
18	Sugar cane, sugar beet	99994	81786	18208	18.2
19	Plant-based fibers	34864	30977	3887	11.1
20	Other crops	81219	82828	-1609	-2.0
21	Cattle	278537	253220	25317	9.1
22	Other animal products	512932	490704	22228	4.3
23	Raw milk	161738	166050	-4312	-2.7
24	Wool	9572	9175	397	4.1

Source: estimated by author based on FAO (2020) and OECD (2020).

It should be noted that reported comparisons are subject to several uncertainties. In particular, in both FAO-based and OECD-based data treatment, in cases of cattle (ctl) and other animal products (oap) agricultural output values are gap-filled using output data for primary livestock.

Although FAO data has much higher regional and commodity coverage than OECD datasets, it does not always report values of agricultural production for all country/commodity cases. For instances, when commodity output value is not reported, but production quantity data

is available, we derive prices and estimate output values by multiplying prices and quantities (see Section 3 for more details). While such approach is aimed at the more consistent agricultural output representation, in some cases it may introduce additional uncertainty as price data is not always readily available and should be derived using different assumptions (Figure 2).

In the case of forage products, OECD does not report output of these commodities. Under the current APT set up, no specific treatment is applied to estimate the values of forage commodities production. As a result, this may lead to under representation of the other crops output in some countries. Although, in general, this should not have significant impact on the agricultural output totals and consistency of the comparison results.

5. GTAP 10A Data Base with FAO-based APT

The FAO database reports non-zero agricultural output values for all but one of the GTAP 10A Data Base regions (i.e., Rest of the World). Yet for 7 composite regions⁸ not all countries within the region are covered. Therefore, we do not consider targets for these composite regions to be reliable enough and thus do not include them into targeting. For the case of 28 EU countries, we have relied on the agricultural output values contributed by Boulanger et al. (2019), to be consistent with domestic support estimates for these countries. The estimated agricultural production targets based on the FAO-data were used for the 2014 GTAP 10A Data Base in 93 countries and 12 composite regions.

In this section, we first provide an overview of the adjustments in production targets through the build stream, in line with the discussion in Chepeliev and Corong (2019). After this, we compare the standard GTAP 10A Data Base and GTAP 10A Data Base with FAO-based agricultural production targets developed in this document.

In some cases, the export and agricultural production targets are simply incompatible. We encounter both hard inconsistencies, where the export target exceeds the production target, and soft inconsistencies, where the export target is lower than the production target, but still leaves very little domestic product available for the domestic market. Since the trade data are central to the whole data reconciliation process, in these cases, it is the production targets not the export targets that must adjust. Accordingly, in such cases, we adjust the production targets before applying them to the IO data.

Table 3 reports some of the notable adjustments for export-production inconsistencies. Here and in subsequent tables, we select the items for which changes or differences are more significant than others, where the criterion for “most significant” takes account both of the absolute magnitude of the item and the relative magnitude of the change or difference.

Adjustments are more prevalent for wool (wol), other crops (ocr) and plant-based fibers (pfb) sectors. For the 2014 base year, 416 targets are adjusted which is about 33 percent of the total. Although so many of the targets are adjusted, targets for many of the largest sectors undergo no adjustment. In fact, the total target, summed over sectors and countries, is increased by only 2.6%. For comparison, in the standard GTAP 10A Data Base build and 2014 base year,

⁸ These include Rest of Oceania (XOC), Rest of North America (XNA), Rest of South America (XSM), Rest of Caribbean (XCB), Rest of Europe (XER), Rest of Western Africa (XWF) and Rest of Eastern Africa (XEC).

corresponding increase is 7.4%, though over different regional coverage (Chepeliev and Corong, 2019).

Table 3. Production target adjustments for 2014: selected cases (mn USD)

GTAP Region	Sector	Domestic Absorption	Exports	Initial Production Target	Adjusted Production Target
chn	wol	83042	3883	6076	24644
kor	wht	7753	1	7	1939
nga	ocr	10388	548	303	3145
kor	pfb	2302	1	0	577
kor	wol	2281	118	0	688
bra	wol	5843	71	46	1531
ind	ocr	48965	2881	7821	15122
xws	pfb	4742	256	112	1441
can	ocr	2584	834	125	1480
isr	ocr	14	238	0	241
per	ocr	7532	1094	952	2977
irn	pfb	3554	72	102	960
col	ocr	5193	3591	2350	4890
xws	wol	2405	51	36	652
ken	osd	3563	34	106	925
pak	pfb	17292	188	2259	4511
xsu	wol	4095	32	197	1056
gha	ocr	348	2090	800	2177
mar	pfb	994	30	2	278
kor	gro	3284	1	134	822

Source: developed by author.

Table 4 shows the effects of the production adjustments. We compare the production level after GDP scaling (third column) to the adjusted production targets (fifth column). We also report the production levels obtained without the export and production subsidy adjustments been applied (fourth column).

We find that the largest adjustments are concentrated in a few countries, in China, Russia, Brazil and United States. Large adjustments are especially common for vegetables, fruit and nuts (v_f), other crops (ocr) and cattle (ctl). Although there are some upward adjustments, most adjustments are downward. Overall, in the countries subject to targeting, agricultural production falls by 13%. For comparison, in the standard GTAP 10A Data Base build stream corresponding downward adjustment for the 2014 base year was 30%, though over different regional coverage (Chepeliev and Corong, 2019).

Table 4. Production adjustments for 2014: selected cases (mn USD)

GTAP Region	Sector	Scaled	Without Production Adjustments	With Production Adjustments
chn	v_f	217075	57341	57341
chn	osd	187793	80362	80362
chn	ocr	2675	33340	33340
chn	ctl	83057	6076	24644
chn	wol	68331	18686	18686
chn	pfb	322697	458850	458850
rus	v_f	130030	63385	63385
usa	ctl	7051	34744	34744
bra	v_f	50365	7821	15122
rus	rmk	26450	66848	66848
ind	v_f	47078	15781	15781
bra	ocr	31840	6327	7976
tur	v_f	45212	11927	16088
idn	v_f	91219	50170	50170
ind	osd	26752	6164	8049
jpn	v_f	53854	24988	24988
rus	gro	25615	54344	54344
aus	oap	20008	44862	44862
rus	ctl	17958	3538	4554
usa	ocr	17016	2455	4263

Source: developed by author.

The production adjustment is performed before the main data construction program. The adjusted targets are attained quite accurately within the adjustment program itself, but nothing in the main program guarantees that they will be maintained through the regular IO processing. In Table 5 we examine the largest deviations between the production targets and the final data.

Overall, deviations from target are not extreme and take place mainly in the composite regions. Bearing in mind that the differences presented are those considered most serious, we may say that the targets are well preserved. There is a slight general downward bias in the errors: overall, agricultural production for the targeted countries are below target by only 3.2%.

Table 5. Deviations from production targets for 2014: selected cases (mn USD)

GTAP Region	Sector	Target	Final
v_f	xnf	15720	4453
v_f	xea	3769	312
oap	arg	4385	10510
pdr	idn	54344	39588
rmk	xse	1360	40
ctl	xnf	5922	2318
pdr	xea	500	1
c_b	xse	1352	4119
oap	xse	6156	2641
gro	xea	703	10
v_f	chn	458850	423043
osd	xac	1131	85
rmk	xws	2845	6107
oap	xcf	224	1508
rmk	xac	207	1438
osd	xse	2548	830
c_b	xsc	520	14
oap	xea	1143	180
gro	xsu	249	1256
c_b	xcf	532	1832

Source: developed by author.

We next compare the agricultural production output from the standard GTAP 10A Data Base (GTAP 10A standard) and this version with FAO-based targets (GTAP 10A FAO).

Aggregate global agricultural output in the GTAP 10A FAO is around 10% higher than in the GTAP 10A standard. At the sectoral level, largest differences in global agricultural output are observed for the vegetables, fruit and nuts (v_f) and sugar cane and beet (c_b) sectors – both with significantly lower output in the standard GTAP 10A Data Base. In the case of vegetables, fruit and nuts production, almost 80% of this difference is coming from the vegetables, fruit and nuts production in China, where GTAP 10A standard reports much lower output value to the specific treatment of the non-MPS commodities redistribution.

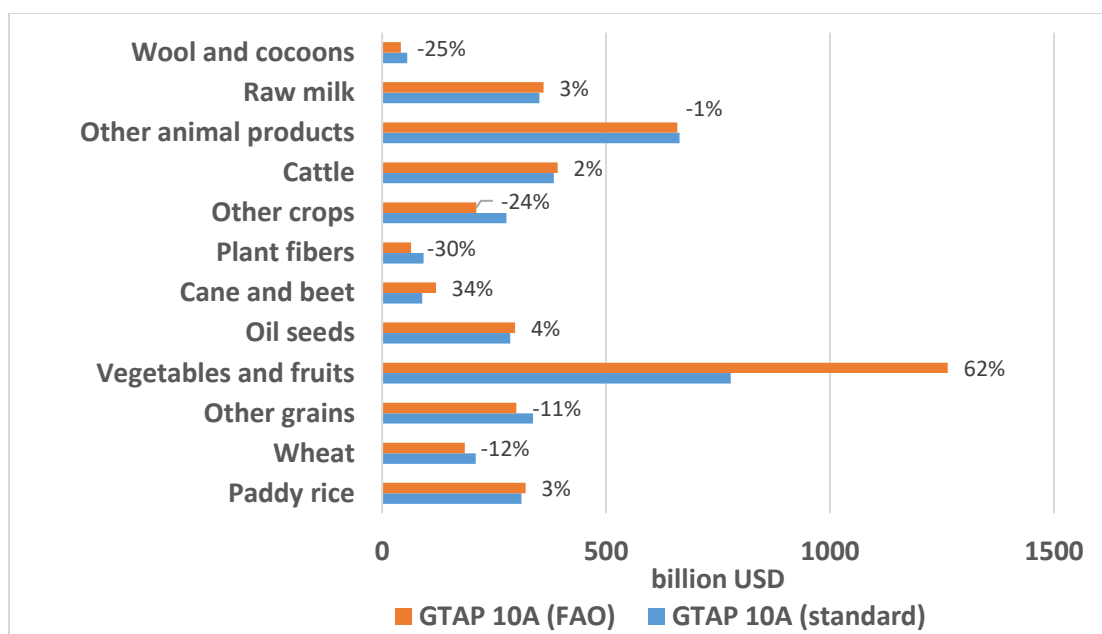


Figure 3. Global agricultural output comparison by sectors for 2014

Source: author.

At the regional level, large discrepancies are observed for the regions that are not going through the APT procedure in the standard GTAP 10A Data Base, namely those in Africa and Asia. In general, countries in these regions are experiencing mostly upward target adjustments, in some cases over 100% (e.g. Malawi, Guinea, Rest of Central Africa, Brunei Darussalam, Rest of Southeast Asia, Oman). For the most OECD countries differences are below 20%.

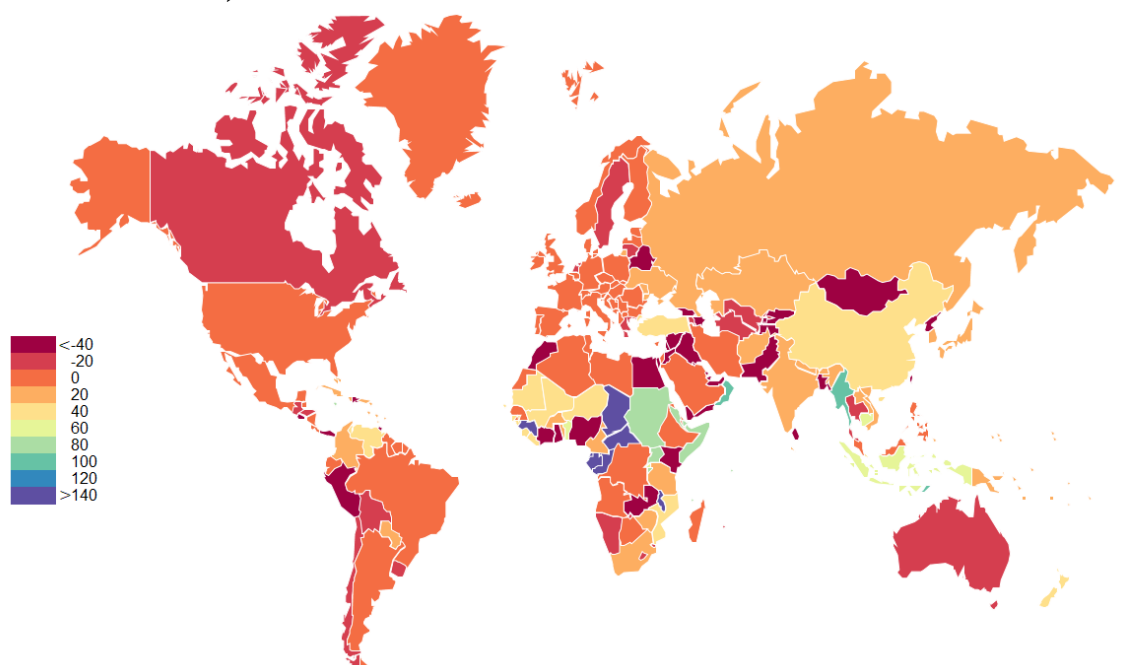


Figure 4. Agricultural output comparison by countries GTAP 10A (FAO) vs GTAP 10A (standard) for 2014, %

Source: author.

6. Implied prices of the agricultural commodities

Unlike the inclusion of energy data in GTAP (McDougall and Chepeliev, 2020), where implied energy prices are preserved because both energy values and volumes are targeted, in the case of APT only values are targeted. Yet in many applications, volume-based agricultural and food data might need to be incorporated into the GTAP Data Base. These can include volumes of the agricultural output, nutritional information, agriculture-derived energy flows (e.g. biogas from agricultural residue, biofuels from energy crops, etc.). Large variations in implied prices of agricultural commodities could significantly complicate the incorporation of such volume accounts, as well as impact the follow up policy simulations. In this section, we estimate the implied prices of primary agricultural commodities in the GTAP 10A (FAO) and GTAP 10A (standard) Data Bases, as well as compare these estimates with the prices directly reported by the FAO. To estimate prices, corresponding values of agricultural output are divided by FAO-derived volumes of output. Table 6 reports price comparisons for the sectors and regions with output above 10000 tons. Several key points can be summarized.

First, for most agricultural sectors both GTAP (standard) and GTAP (FAO)-reported global average implied prices are relatively close to the FAO estimates, especially for a more homogeneous sectors, such as ‘pdr’, ‘wht’ and ‘gro’. At the same time, while in the case of GTAP (standard) the number of sectors with price deviations from FAO not exceeding 15% is 7, FAO-based targeting increases this number to 10. The two sectors that have large price deviations even under FAO targeting procedure are ‘pfb’ and ‘wol’ – in both cases a large share of commodities covered by these sectors goes to the non-food use (textiles, industry, etc.) and is not entirely captured by the FAO, which explains the difference in implied prices. For instance, in the case of ‘wol’ FAO reports 25 GTAP regions with non-zero output volumes, while GTAP Data Base, based on the contributed input-output tables, reports 102 regions with non-zero value of ‘wol’ output.

Second, FAO-based agricultural targeting significantly reduced price variation, in particular, standard deviation (SD). For 11 out of 12 agricultural sectors SDs are lower in the GTAP (FAO) than in the GTAP (standard); the only exception is the ‘rmk’ sector. For most sectors, though, FAO reports much lower SDs than both GTAP (standard) and GTAP (FAO).

Third, FAO-based APT results in the implied prices to be much closer to the FAO-reported prices compared to the GTAP (standard). Deviation from FAO prices falls for 11 out of 12 agricultural sectors following FAO-based APT implementation.

Finally, much larger SDs and deviations from FAO are observed if cases with output below 10000 tons are included. Without such filtering SDs increase substantially – in most sectoral cases by 10-20 times and more. In case of small agricultural producers relatively minor adjustment of output in absolute terms (e.g. from 1 mn USD to 10 mn USD) could imply a large relative change and as a result implied prices could deviate much more than in the case of large agricultural producers that undergo less substantial adjustments in relative terms.

Table 6. Comparisons between agricultural commodity prices implied by GTAP (FAO), GTAP (standard) and directly reported by FAO for 2014 (USD/ton)

Sector	Mean			Standard deviation			Deviation from the FAO	
	FAO	GTAP (std)	GTAP (FAO)	FAO	GTAP (std)	GTAP (FAO)	GTAP (std)	GTAP (FAO)
pdr	465	417	431	36	112	75	112	69
wht	271	286	253	12	886	863	885	862
gro	241	250	223	17	57	41	52	33
v_f	498	278	451	33	169	59	160	45
osd	366	319	331	50	895	874	892	871
c_b	58	41	55	35	40	27	52	27
pfb	1195	810	575	62	713	184	702	161
ocr	3422	5063	3817	4400	4263	4255	1156	891
ctl	5090	4548	4654	175	548	357	541	339
oap	2269	2166	2149	78	274	208	273	190
rmk	508	448	460	22	101	134	97	133
wol	12181	56435	44116	2470	22454	11785	36552	13815

Source: developed by author.

Notes: “Mean” is estimated as the global average prices. “Deviations from FAO” is estimated using the formula for the standard deviation, where FAO commodity and region-specific prices are used instead of the mean.

While in some regional cases deviations between FAO and GTAP-implied prices can be relatively high, for the largest agricultural producers much lower deviations are observed (Table 7). This is especially the case for the GTAP (FAO), with on average 2.5 times lower price deviations for the top 10 producers, compared to the GTAP (standard). Largest price deviations are observed for the ‘pfb’ and ‘wol’ sectors, due to the high shares of non-food related content, significantly underrepresented in the FAO database. At the same time, for 9 out of 12 sectors average deviation in GTAP (FAO) prices from the FAO-derived prices are below 15% for the top 10 agricultural producers.

To sum up, as price comparisons show, the GTAP (FAO) 10A Data Base provides a much better representation of the implied prices compared to the GTAP (standard), as prices have lower SDs and are much closer to the FAO-reported estimates. At the same time, considering that within the APT procedure only values are adjusted, while value-quantity linkage is not preserved (quantities are not tracked), we should not expect implied prices to closely align with the FAO data in all cases, especially for the small agricultural producers. For the large agricultural producers implied prices in the GTAP (FAO) Data Base show close alignment with FAO data, with an exception of ‘pfb’ and ‘wol’ sectors that have a large share of commodities that go to industrial use.

Table 7. Simple average of the absolute deviation in prices from FAO for top 10 agricultural producers by GTAP sectors and regions for 2014, %

Sector	Deviation from the FAO prices, %		Share of the top 10 in global production, %
	GTAP (std)	GTAP (FAO)	FAO
pdr	34.4	6.0	85.3
wht	18.5	11.8	69.7
gro	17.1	13.6	69.8
v_f	55.8	6.2	63.6
osd	21.3	6.8	77.4
c_b	60.9	9.5	74.8
pfb	87.5	51.2	87.8
ocr	108.7	41.1	73.6
ctl	26.2	6.6	59.6
oap	16.7	10.6	67.0
rmk	21.9	10.3	61.8
wol	1454.1	703.8	99.9

Source: developed by author.

Notes: “Share in global production, %” is based on the volumes of output reported by FAO.

7. Discussion and conclusions

The comparisons between OECD-based agricultural output and FAO-derived estimates show overall consistency between the two data sets, though some moderate deviations are observed at the country/commodity level. Further data verification provides more support to the FAO-sourced estimates based on the comparison with national statistics and reports by international organizations.

The estimated agricultural production targets based on the FAO-data were incorporated to the GTAP 10A Data Base build stream for the 2014 reference year. In general, imposed agricultural output targets are well preserved throughout the build stream, with somewhat larger adjustments for the composite regions compared to the individual countries.

This new approach allows to overcome several limitations present in the current APT process. First, a significant expansion in the regional coverage is achieved, as the number of regions undergoing APT more than doubles. Second, a detailed commodity classification of the FAO dataset allows for a more accurate mapping to the GTAP 10A Data Base sectors, compared to the OECD dataset and avoids the issue of the unclassified commodity group redistribution. Third, a better commodity coverage in the FAO data allows to avoid the issue of the processed commodities output mapping to the corresponding primary sector (e.g. sugar output is used to derive targets for sugar cane and beet). Finally, reliance on the FAO agricultural output data provides a better opportunity for further incorporation of the nutritional accounts to the GTAP Data Base, by lowering inconsistencies between GTAP and FAO agricultural accounting. GTAP 10A (FAO) Data Base implied agricultural prices have lower variation and are closer to the FAO-reported prices compared to the GTAP 10A (standard) Data Base.

There are several further improvements and modifications that should be considered in the context of agricultural production targeting procedures. First, for a more consistent treatment of

the FAO data, additional step might include further gap-filling of the forage commodities output for non-EU countries, although in general this should not significantly impact sectoral output values. Second, in terms of the currently used OECD-based APT data, more attention should be paid to the cases of under reported commodities in the OECD database (e.g. olives, grapes, etc.). While data for EU countries is provided together with producer and consumer support estimates, some country and sector specific cases experience large under reporting, which may also introduce inconsistencies for the agricultural support levels interpretation. Such country and commodity cases require additional verification. Third, considering large variations in agricultural production from year to year due to the impact of weather conditions, variations in yield, etc., a multi-year averaging approach might be considered in the future. Further steps toward APT procedure improvements may include implementation of the FAO-sourced targets to the standard GTAP Data Base build for non-EU countries, providing a better representation of agricultural sector, especially in many developing countries.

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Appendix A. Share of MPS and non-MPS commodities output for the selected non-EU countries and regions in the PCSE OECD database (2014)

No.	Region	MPS commodities share, %	non-MPS commodities share, %	Total value of agricultural production, bn USD	World share, % ⁹
1	Australia	77.1	22.9	49.1	1.3
2	Canada	85.9	14.1	50.5	1.3
3	Rest of European Free Trade Association	79.9	20.1	0.3	0.0
4	Japan	66.2	33.8	79.0	2.1
5	Korea	64.3	35.7	42.7	1.1
6	Mexico	60.7	39.3	58.1	1.5
7	New Zealand	74.7	25.3	18.2	0.5
8	Norway	76.9	23.1	4.5	0.1
9	Switzerland	63.7	36.3	9.2	0.2
10	Turkey	72.9	27.1	64.0	1.7
11	United States	77.3	22.7	406.4	10.6
12	Israel	78.3	21.7	8.4	0.2
13	Brazil	81.8	18.2	186.9	4.9
14	China	87.3	12.7	1359.2	35.4
15	Indonesia	64.5	35.5	128.5	3.3
16	Kazakhstan	68.6	31.4	14.1	0.4
17	Russia	81.2	18.8	90.9	2.4
18	Ukraine	83.0	17.0	33.6	0.9
19	South Africa	75.9	24.1	19.0	0.5
20	Chile	59.1	40.9	13.1	0.3
21	Colombia	79.8	20.2	27.7	0.7
22	Viet Nam	82.8	17.2	37.7	1.0
23	Costa Rica	85.7	14.3	4.9	0.1
24	Philippines	89.1	10.9	32.3	0.8
25	Total/average	81.4	18.6	2738.3	71.4

Source: author's estimates based on OECD (2020) and GTAP 10A Data Base (Aguilar et al., 2019).

⁹ World shares are estimated by dividing OECD-sourced total value of agricultural production by world aggregate output value for 12 agricultural sectors reported in the GTAP 10A Data Base (pdr, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk and wol).

Appendix B. Mapping between PCSE OECD database commodities and GTAP 10A Data Base sectors

No.	Code	OECD Commodity	Code	GTAP Sector	Alternative mapping
1	AF	Alfalfa	OCR	Crops nec	
2	AP	Apples	V_F	Vegetables, fruit, nuts	
3	AV	Avocado	V_F	Vegetables, fruit, nuts	
4	BA	Barley	GRO	Cereal grains nec	
5	BF	Beef and veal	CTL	Bovine cattle, sheep and goats, horses	cmt
6	BL	Blueberries	V_F	Vegetables, fruit, nuts	
7	BN	Beans	V_F	Vegetables, fruit, nuts	
8	BS	Bananas	V_F	Vegetables, fruit, nuts	
9	CC	Chinese cabbage	V_F	Vegetables, fruit, nuts	
10	CF	Coffee	OCR	Crops nec	
11	CH	Cherries	V_F	Vegetables, fruit, nuts	
12	CN	Coconut	V_F	Vegetables, fruit, nuts	
13	CO	Cocoa beans	OCR	Crops nec	
14	CP	Chick pea	V_F	Vegetables, fruit, nuts	
15	CS	Cashew nuts	V_F	Vegetables, fruit, nuts	
16	CT	Cotton	PFB	Plant-based fibers	
17	CU	Cucumber	V_F	Vegetables, fruit, nuts	
18	CV	Cassava	V_F	Vegetables, fruit, nuts	
19	CW	Common wheat	WHT	Wheat	
20	DW	Durum wheat	WHT	Wheat	
21	EG	Eggs	OAP	Animal products nec	
22	FL	Plants and flowers	OCR	Crops nec	
23	FV	Fruits and vegetables	V_F	Vegetables, fruit, nuts	
24	FX	Flaxseed	OSD	Oil seeds	
25	GA	Garlic	V_F	Vegetables, fruit, nuts	
26	GN	Groundnuts	OSD	Oil seeds	
27	GP	Grapefruit	V_F	Vegetables, fruit, nuts	
28	GR	Grapes	V_F	Vegetables, fruit, nuts	
29	IF	Fruit and vegetables imported	V_F	Vegetables, fruit, nuts	
30	LN	Lentils	V_F	Vegetables, fruit, nuts	
31	MA	Maize	GRO	Cereal grains nec	
32	MG	Mango	V_F	Vegetables, fruit, nuts	
33	MK	Milk	RMK	Raw milk	
34	MN	Mandarin	V_F	Vegetables, fruit, nuts	
35	OA	Oats	GRO	Cereal grains nec	

No.	OECD		GTAP		Alternative mapping
	Code	Commodity	Code	Sector	
36	OG	Other grains	GRO	Cereal grains nec	
37	ON	Onion	V_F	Vegetables, fruit, nuts	
38	OP	Other pulses	V_F	Vegetables, fruit, nuts	
39	OR	Orange	V_F	Vegetables, fruit, nuts	
40	PA	Pineapple	V_F	Vegetables, fruit, nuts	
41	PB	Pepper	V_F	Vegetables, fruit, nuts	
42	PC	Peaches	V_F	Vegetables, fruit, nuts	
43	PE	Dry peas	V_F	Vegetables, fruit, nuts	
44	PI	Plantain	V_F	Vegetables, fruit, nuts	
45	PK	Pig meat	OAP	Animal products nec	omt
46	PL	Palm Oil	OSD	Oil seeds	vol
47	PO	Potatoes	V_F	Vegetables, fruit, nuts	
48	PP	Red pepper	V_F	Vegetables, fruit, nuts	ocr
49	PR	Pears	V_F	Vegetables, fruit, nuts	
50	PT	Poultry meat	OAP	Animal products nec	omt
51	RB	Rubber	OCR	Crops nec	frs
52	RI	Rice	PDR	Paddy rice	
53	RP	Rapeseed	OSD	Oil seeds	
54	RS	Refined sugar	C_B	Sugar cane, sugar beet	sgr
55	RY	Rye	GRO	Cereal grains nec	
56	SB	Soybeans	OSD	Oil seeds	
57	SF	Sunflower	OSD	Oil seeds	
58	SH	Sheep meat	CTL	Bovine cattle, sheep and goats, horses	cmt
59	SO	Sorghum	GRO	Cereal grains nec	
60	SP	Spinaches	V_F	Vegetables, fruit, nuts	
61	SW	Strawberries	V_F	Vegetables, fruit, nuts	
62	TB	Tobacco	OCR	Crops nec	b_t
63	TE	Tea	OCR	Crops nec	
64	TM	Tomatoes	V_F	Vegetables, fruit, nuts	
65	WI	Wine	V_F	Vegetables, fruit, nuts	b_t
66	WL	Wool	WOL	Wool, silk-worm cocoons	
67	WM	Water melon	V_F	Vegetables, fruit, nuts	
68	WO	Welsh Onion	V_F	Vegetables, fruit, nuts	
69	WT	Wheat	WHT	Wheat	
70	XE	Non MPS commodities	OT	-	-
71	XEFV	XEFV	V_F	Vegetables, fruit, nuts	
72	XF	Fruit and vegetables exported	V_F	Vegetables, fruit, nuts	

Notes: Alternative mapping is based on the correspondence between CPC codes and GTAP sectoral classifications.

Source: developed by author based on GTAP (2020).

Appendix C. GTAP 10A Data Base sectoral breakdown

No.	Code	Description
1	pdr	Rice: seed, paddy (not husked)
2	wht	Wheat: seed, other
3	gro	Other Grains: maize (corn), sorghum, barley, rye, oats, millets, other cereals
4	v_f	Veg & Fruit: vegetables, fruit and nuts, edible roots and tubers, pulses
5	osd	Oil Seeds: oil seeds and oleaginous fruit
6	c_b	Cane & Beet: sugar crops
7	pfb	Fibres crops
8	ocr	Other Crops: stimulant; spice and aromatic crops; forage products; plants and parts of plants used primarily in perfumery, pharmacy, or for insecticidal, fungicidal or similar purposes; beet seeds (excluding sugar beet seeds) and seeds of forage plants; natural rubber in primary forms or in plates, sheets or strip, living plants; cut flowers and flower buds; flower seeds, unmanufactured tobacco; other raw vegetable materials nec
9	ctl	Cattle: bovine animals, live, other ruminants, horses and other equines, bovine semen
10	oap	Other Animal Products: swine; poultry; other live animals; eggs of hens or other birds in shell, fresh; reproductive materials of animals; natural honey; snails, fresh, chilled, frozen, dried, salted or in brine, except sea snails; edible products of animal origin n.e.c.; hides, skins and furskins, raw; insect waxes and spermaceti, whether or not refined or coloured
11	rmk	Raw milk
12	wol	Wool: wool, silk, and other raw animal materials used in textile
13	frs	Forestry: forestry, logging and related service activities
14	fsh	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing
15	coa	Coal: mining and agglomeration of hard coal, lignite and peat
16	oil	Oil: extraction of crude petroleum, service activities incidental to oil and gas extraction excluding surveying (part)
17	gas	Gas: extraction of natural gas, service activities incidental to oil and gas extraction excluding surveying (part)
18	oxt	Other Mining Extraction (formerly omn): mining of metal ores; other mining and quarrying
19	cmt	Cattle Meat: fresh or chilled; meat of buffalo, fresh or chilled; meat of sheep, fresh or chilled; meat of goat, fresh or chilled; meat of camels and camelids, fresh or chilled; meat of horses and other equines, fresh or chilled; other meat of mammals, fresh or chilled; meat of mammals, frozen; edible offal of mammals, fresh, chilled or frozen
20	omt	Other Meat: meat of pigs, fresh or chilled; meat of rabbits and hares, fresh or chilled; meat of poultry, fresh or chilled; meat of poultry, frozen; edible offal of poultry, fresh, chilled or frozen; other meat and edible offal, fresh, chilled or frozen; preserves and preparations of meat, meat offal or blood; flours, meals and pellets of meat or meat offal, inedible; greaves
21	vol	Vegetable Oils: margarine and similar preparations; cotton linters; oil-cake and other residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degreas; residues resulting from the treatment of fatty substances or animal or vegetable waxes; animal fats
22	mil	Milk: dairy products
23	pcr	Processed Rice: semi- or wholly milled, or husked
24	sgr	Sugar and molasses
25	ofd	Other Food: prepared and preserved fish, crustaceans, molluscs and other aquatic invertebrates; prepared and preserved vegetables, pulses and potatoes; prepared and preserved fruits and nuts; wheat and meslin flour; other cereal flours; groats, meal and pellets of wheat and other cereals; other cereal grain products (including corn flakes); other vegetable flours and meals; mixes and doughs for the preparation of bakers' wares; starches and starch products; sugars and sugar syrups n.e.c.; preparations used in animal feeding; lucerne (alfalfa) meal and pellets; bakery products; cocoa, chocolate and sugar confectionery; macaroni, noodles, couscous and similar farinaceous products; food products n.e.c.

No.	Code	Description
26	b_t	Beverages and Tobacco products
27	tex	Manufacture of textiles
28	wap	Manufacture of wearing apparel
29	lea	Manufacture of leather and related products
30	lum	Lumber: manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
31	ppp	Paper & Paper Products: includes printing and reproduction of recorded media
32	p_c	Petroleum & Coke: manufacture of coke and refined petroleum products
33	chm	Manufacture of chemicals and chemical products
34	bph	Manufacture of pharmaceuticals, medicinal chemical and botanical products
35	rpp	Manufacture of rubber and plastics products
36	nmm	Manufacture of other non-metallic mineral products
37	i_s	Iron & Steel: basic production and casting
38	nfm	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver
39	fmp	Manufacture of fabricated metal products, except machinery and equipment
40	ele	Manufacture of computer, electronic and optical products
41	eeq	Manufacture of electrical equipment
42	ome	Manufacture of machinery and equipment n.e.c.
43	mvh	Manufacture of motor vehicles, trailers and semi-trailers
44	otn	Manufacture of other transport equipment
45	omf	Other Manufacturing: includes furniture
46	ely	Electricity; steam and air conditioning supply
47	gdt	Gas manufacture, distribution
48	wtr	Water supply; sewerage, waste management and remediation activities
49	cns	Construction: building houses factories offices and roads
50	trd	Wholesale and retail trade; repair of motor vehicles and motorcycles
51	afs	Accommodation, Food and service activities
52	otp	Land transport and transport via pipelines
53	wtp	Water transport
54	atp	Air transport
55	whs	Warehousing and support activities
56	cmn	Information and communication
57	ofi	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding
58	ins	Insurance (formerly isr): includes pension funding, except compulsory social security
59	rsa	Real estate activities
60	obs	Other Business Services nec
61	ros	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)
62	osg	Other Services (Government): public administration and defense; compulsory social security, activities of membership organizations n.e.c., extra-territorial organizations and bodies
63	edu	Education
64	hht	Human health and social work
65	dwe	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)

Source: based on GTAP (2020).

Appendix D. GTAP agricultural sectors used for non-MPS commodities redistribution in selected countries in GTAP 810

No.	Region	Sectors used for non-MPS commodities sectoral redistribution			
		Vegetables, fruits, nuts (v_f)	Sugar cane, sugar beet (c_b)	Plant-based fibers (pfb)	Crops nec (ocr)
1	Australia	+		+	+
2	Brazil				
3	Canada	+	+	+	
4	Switzerland	+		+	+
5	Chile				
6	China				
7	Colombia				
8	Costa Rica				
9	EU-28				
10	Indonesia				
11	Iceland	+		+	+
12	Israel				
13	Japan	+		+	+
14	Kazakhstan				
15	Korea	+		+	+
16	Mexico	+		+	+
17	Norway	+		+	+
18	New Zealand	+		+	+
19	Philippines				
20	Russia				
21	Turkey	+		+	+
22	Ukraine				
23	United States	+			+
24	Viet Nam				
25	South Africa				

Source: based on

¹⁰ Sectoral mapping is based on the GTAP 7 Data Base methodology.

Appendix E. Mapping between FAO commodities and GTAP agricultural sectors¹¹

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
1	0111	Wheat	wht	+
2	0112	Maize (corn)	gro	+
3	0113	Rice	pdr	+
4	0114	Sorghum	gro	+
5	0115	Barley	gro	+
6	0116	Rye	gro	+
7	0117	Oats	gro	+
8	0118	Millet	gro	+
9	01191	Triticale	gro	+
10	01192	Buckwheat	gro	+
11	01193	Fonio	gro	+
12	01194	Quinoa	gro	+
13	01195	Canary seed	gro	+
14	01199.02	Mixed grain	gro	+
15	01199.90	Cereals n.e.c.	gro	+
16	01211	Asparagus	v_f	+
17	01212	Cabbages	v_f	+
18	01213	Cauliflowers and broccoli	v_f	+
19	01214	Lettuce and chicory	v_f	+
20	01215	Spinach	v_f	+
21	01216	Artichokes	v_f	+
22	01219.01	Cassava leaves	v_f	+
23	01221	Watermelons	v_f	+
24	01229	Cantaloupes and other melons	v_f	+
25	01231	Chillies and peppers, green (Capsicum spp.)	v_f	+
26	01232	Cucumbers and gherkins	v_f	+
27	01233	Eggplants (aubergines)	v_f	+
28	01234	Tomatoes	v_f	+
29	01235	Pumpkins, squash and gourds	v_f	+
30	01239.01	Okra	v_f	+
31	01241.01	String beans	v_f	+
32	01241.90	Other beans, green	v_f	+
33	01242	Peas, green	v_f	+
34	01243	Broad beans and horse beans, green	v_f	+
35	01251	Carrots and turnips	v_f	+
36	01252	Green garlic	v_f	+

¹¹ Bold CPC 2.1 codes in column 2 represent commodity cases, which are mapped to GTAP agricultural sectors. In column 5: “NA” indicates cases with commodities that are not mapped to any GTAP sector (in most cases due to double counting or inappropriate data (see Section 3 for more details)); “+” indicates cases when APT sectoral mapping coincide with mapping based on CPC codes provided in column 4; sectoral codes in column 5 indicate cases with APT sectoral mapping different from CPC-based mapping.

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
37	01253.01	Onions and shallots, green	v_f	+
38	01253.02	Onions and shallots, dry (excluding	v_f	+
39	01254	Leeks and other alliaceous vegetables	v_f	+
40	01270	Mushrooms and truffles	v_f	+
41	01290.01	Green corn (maize)	v_f	+
42	01290.90	Other vegetables, fresh n.e.c.	v_f	+
43	01311	Avocados	v_f	+
44	01312	Bananas	v_f	+
45	01313	Plantains and others	v_f	+
46	01314	Dates	v_f	+
47	01315	Figs	v_f	+
48	01316	Mangoes, guavas, mangosteens	v_f	+
49	01317	Papayas	v_f	+
50	01318	Pineapples	v_f	+
51	01319	Other tropical and subtropical fruits, n.e.c.	v_f	+
52	01321	Pomelos and grapefruits	v_f	+
53	01322	Lemons and limes	v_f	+
54	01323	Oranges	v_f	+
55	01324	Tangerines, mandarins, clementines	v_f	+
56	01329	Other citrus fruit, n.e.c.	v_f	+
57	01330	Grapes	v_f	+
58	01341	Apples	v_f	+
59	01342.01	Pears	v_f	+
60	01342.02	Quinces	v_f	+
61	01343	Apricots	v_f	+
62	01344.01	Sour cherries	v_f	+
63	01344.02	Cherries	v_f	+
64	01345	Peaches and nectarines	v_f	+
65	01346	Plums and sloes	v_f	+
66	01349.10	Other pome fruits	v_f	+
67	01349.20	Other stone fruits	v_f	+
68	01351.01	Currants	v_f	+
69	01351.02	Gooseberries	v_f	+
70	01352	Kiwi fruit	v_f	+
71	01353.01	Raspberries	v_f	+
72	01354	Strawberries	v_f	+
73	01355.01	Blueberries	v_f	+
74	01355.02	Cranberries	v_f	+
75	01355.90	Other berries and fruits of the genus	v_f	+
76	01356	Locust beans (carobs)	v_f	+
77	01359.01	Persimmons	v_f	+
78	01359.02	Cashewapple	v_f	+
79	01359.90	Other fruits, n.e.c.	v_f	+
80	01371	Almonds, in shell	v_f	+
81	01372	Cashew nuts, in shell	v_f	+

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
82	01373	Chestnuts, in shell	v_f	+
83	01374	Hazelnuts, in shell	v_f	+
84	01375	Pistachios, in shell	v_f	+
85	01376	Walnuts, in shell	v_f	+
86	01377	Brazil nuts, in shell	v_f	+
87	01379.01	Areca nuts	v_f	+
88	01379.02	Kola nuts	v_f	+
89	01379.90	Other nuts (excluding wild edible nuts and	v_f	+
90	0141	Soya beans	osd	+
91	0142	Groundnuts, excluding shelled	osd	+
92	0143	Cottonseed	osd	+
93	01441	Linseed	osd	+
94	01442	Mustard seed	osd	+
95	01443	Rapeseed or colza seed	osd	+
96	01444	Sesame seed	osd	+
97	01445	Sunflower seed	osd	+
98	01446	Safflower seed	osd	+
99	01447	Castor oil seeds	osd	+
100	01448	Poppy seed	osd	+
101	01449.01	Melonseed	osd	+
102	01449.02	Hempseed	osd	+
103	01449.90	Other oil seeds, n.e.c.	osd	+
104	01450	Olives	osd	+
105	01460	Coconuts, in shell	osd	+
106	01491.01	Oil palm fruit	osd	+
107	01491.02	Palm kernels	osd	+
108	01499.01	Karite nuts (sheanuts)	osd	+
109	01499.02	Tung nuts	osd	+
110	01499.03	Jojoba seeds	osd	+
111	01499.04	Tallowtree seeds	osd	+
112	01499.05	Kapok fruit	osd	+
113	01499.06	Kapokseed in shell	osd	+
114	01510	Potatoes	v_f	+
115	01520	Cassava	v_f	+
116	01530	Sweet potatoes	v_f	+
117	01540	Yams	v_f	+
118	01550	Taro	v_f	+
119	01591	Yautia	v_f	+
120	01599.10	Edible roots and tubers with high starch or	v_f	+
121	01610	Coffee, green	ocr	+
122	01620	Tea leaves	ocr	+
123	01630	Maté leaves	ocr	+
124	01640	Cocoa beans	ocr	+
125	01651	Pepper (Piper spp.), raw	ocr	+
126	01652	Chillies and peppers, dry (Capsicum spp. and	ocr	+

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
127	01653	Nutmeg, mace, cardamoms, raw	ocr	+
128	01654	Anise, badian, coriander, cumin, caraway,	ocr	+
129	01655	Cinnamon and cinnamon-tree flowers, raw	ocr	+
130	01656	Cloves (whole stems), raw	ocr	+
131	01657	Ginger, raw	ocr	+
132	01658	Vanilla, raw	ocr	+
133	01659	Hop cones	ocr	+
134	01691	Chicory roots	ocr	+
135	01699	Other stimulant, spice and aromatic crops,	ocr	+
136	01701	Beans, dry	v_f	+
137	01702	Broad beans and horse beans, dry	v_f	+
138	01703	Chick peas, dry	v_f	+
139	01704	Lentils, dry	v_f	+
140	01705	Peas, dry	v_f	+
141	01706	Cow peas, dry	v_f	+
142	01707	Pigeon peas, dry	v_f	+
143	01708	Bambara beans, dry	v_f	+
144	01709.01	Vetches	v_f	+
145	01709.02	Lupins	v_f	+
146	01709.90	Other pulses n.e.c.	v_f	+
147	01801	Sugar beet	c_b	+
148	01802	Sugar cane	c_b	+
149	01809	Other sugar crops n.e.c.	c_b	+
150	0191	Forage products	ocr	+
151	01921.01	Seed cotton, unginned	pfb	+
152	01921.02	Cotton lint, ginned	pfb	+
153	01922.01	Jute, raw or retted	pfb	+
154	01922.02	Kenaf, and other textile bast fibres, raw or	pfb	+
155	01929.02	True hemp, raw or retted	pfb	+
156	01929.03	Kapok fibre, raw	pfb	+
157	01929.04	Ramie, raw or retted	pfb	+
158	01929.05	Sisal, raw	pfb	+
159	01929.06	Agave fibres, raw, n.e.c.	pfb	+
160	01929.07	Abaca, manila hemp, raw	pfb	+
161	01929.08	Coir, raw	pfb	+
162	01929.90	Other fibre crops, raw, n.e.c.	pfb	+
163	01930.01	Peppermint, spearmint	ocr	+
164	01930.02	Pyrethrum, dried flowers	ocr	+
165	01950.01	Natural rubber in primary forms	ocr	+
166	01970	Unmanufactured tobacco	ocr	+
167	02111	Cattle	ctl	NA
168	02112	Buffalo	ctl	NA
169	02121.01	Camels	ctl	NA
170	02121.02	Other camelids	ctl	NA
171	02122	Sheep	ctl	NA

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
172	02123	Goats	ctl	NA
173	02131	Horses	ctl	NA
174	02132	Asses	ctl	NA
175	02133	Mules and hinnies	oap	NA
176	02140	Swine / pigs	oap	NA
177	02151	Chickens	oap	NA
178	02152	Turkeys	oap	NA
179	02153	Geese	oap	NA
180	02154	Ducks	oap	NA
181	02191	Rabbits and hares	oap	NA
182	02192.01	Other rodents	oap	NA
183	02194	Other birds	oap	NA
184	02196	Bees	oap	NA
185	02199.20	Other live animals, n.e.c.	oap	NA
186	02211	Raw milk of cattle	rmk	+
187	02212	Raw milk of buffalo	rmk	+
188	02291	Raw milk of sheep	rmk	+
189	02292	Raw milk of goats	rmk	+
190	02293	Raw milk of camel	rmk	+
191	0231	Hen eggs in shell, fresh	oap	+
192	0232	Eggs from other birds in shell, fresh, n.e.c.	oap	+
193	02910	Natural honey	oap	+
194	02920	Snails, fresh, chilled, frozen, dried, salted or	oap	+
195	02941	Shorn wool, greasy, including fleece-washed	wol	+
196	02944	Silk-worm cocoons suitable for reeling	wol	+
197	02951.01	Raw hides and skins of cattle	oap	ctl
198	02951.03	Raw hides and skins of buffaloes	oap	ctl
199	02953	Raw hides and skins of sheep or lambs	oap	ctl
200	02953.01	Raw hides and skins of sheep or lambs, with	oap	NA
201	02954	Raw hides and skins of goats or kids	oap	ctl
202	02960.01	Beeswax	oap	+
203	03211	Balata, gutta-percha, guayule, chicle and	frs	+
204	21111.01	Meat of cattle with the bone, fresh or chilled	cmt	ctl
205	21111.01I	Meat of cattle with the bone, fresh or chilled	cmt	NA
206	21112	Meat of buffalo, fresh or chilled	cmt	ctl
207	21112I	Meat of buffalo, fresh or chilled (indigenous)	cmt	NA
208	21113.01	Meat of pig with the bone, fresh or chilled	omt	oap
209	21113.01I	Meat of pig with the bone, fresh or chilled	omt	NA
210	21114	Meat of rabbits and hares, fresh or chilled	omt	oap
211	21114I	Meat of rabbits and hares, fresh or chilled	omt	NA
212	21115	Meat of sheep, fresh or chilled	cmt	ctl
213	21115I	Meat of sheep, fresh or chilled (indigenous)	cmt	NA
214	21116	Meat of goat, fresh or chilled	cmt	ctl
215	21116I	Meat of goat, fresh or chilled (indigenous)	cmt	NA
216	21117.01	Meat of camels, fresh or chilled	cmt	ctl

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
217	21117.01I	Meat of camels, fresh or chilled (indigenous)	omt	NA
218	21117.02	Meat of other domestic camelids, fresh or	cmt	ctl
219	21117.02I	Meat of other domestic camelids, fresh or	omt	NA
220	21118.01	Horse meat, fresh or chilled	cmt	ctl
221	21118.01I	Horse meat, fresh or chilled (indigenous)	cmt	NA
222	21118.02	Meat of asses, fresh or chilled	cmt	ctl
223	21118.02I	Meat of asses, fresh or chilled (indigenous)	cmt	NA
224	21118.03	Meat of mules, fresh or chilled	cmt	ctl
225	21118.03I	Meat of mules, fresh or chilled (indigenous)	cmt	NA
226	21119.01	Meat of other domestic rodents, fresh or	cmt	ctl
227	21119.01I	Meat of other domestic rodents, fresh or	omt	NA
228	21121	Meat of chickens, fresh or chilled	omt	oap
229	21121A	Meat indigenous, chicken	omt	NA
230	21122	Meat of ducks, fresh or chilled	omt	oap
231	21122I	Meat of ducks, fresh or chilled (indigenous)	omt	NA
232	21123	Meat of geese, fresh or chilled	omt	oap
233	21123I	Meat of geese, fresh or chilled (indigenous)	omt	NA
234	21124	Meat of turkeys, fresh or chilled	omt	oap
235	21124I	Meat of turkeys, fresh or chilled (indigenous)	omt	NA
236	21170.01	Meat of pigeons and other birds n.e.c., fresh,	omt	oap
237	21170.01I	Meat of pigeons and other birds n.e.c., fresh,	omt	NA
238	21170.02	Game meat, fresh, chilled or frozen	omt	oap
239	21170.92	Other meat n.e.c. (excluding mammals),	omt	oap
240	21170.93	Offals n.e.c. (excluding mammals), fresh,	omt	oap
241	21521	Pig fat, rendered	vol	+
242	21523	Tallow	vol	+
243	2161	Soya bean oil	vol	+
244	2162	Groundnut oil	vol	+
245	21631.01	Sunflower-seed oil, crude	vol	+
246	21631.02	Safflower-seed oil, crude	vol	+
247	21641.01	Rapeseed or canola oil, crude	vol	+
248	2165	Palm oil	vol	+
249	2166	Coconut oil	vol	+
250	2167	Olive oil	vol	+
251	2168	Cottonseed oil	vol	+
252	21691.02	Oil of maize	vol	+
253	21691.07	Oil of sesame seed	vol	+
254	21691.12	Oil of linseed	vol	+
255	21691.14	Oil of palm kernel	vol	+
256	21700.02	Margarine and shortening	vol	+
257	22110.02	Skim milk of cows	mil	+
258	22120	Cream, fresh	mil	+
259	22130.02	Whey, dry	mil	+
260	22130.03	Whey, condensed	mil	+
261	22211	Whole milk powder	mil	+

No.	CPC 2.1 code	Commodity name	Mapping based on CPC codes	Mapping for APT targets
262	22212	Skim milk and whey powder	mil	+
263	22221.01	Whole milk, evaporated	mil	+
264	22221.02	Skim milk, evaporated	mil	+
265	22222.01	Whole milk, condensed	mil	+
266	22222.02	Skim milk, condensed	mil	+
267	22230.01	Yoghurt	mil	+
268	22230.04	Buttermilk, dry	mil	+
269	22241.01	Butter of cow milk	mil	+
270	22241.02	Ghee from cow milk	mil	+
271	22242.01	Butter of buffalo milk	mil	+
272	22242.02	Ghee from buffalo milk	mil	+
273	22249.01	Butter and ghee of sheep milk	mil	+
274	22249.02	Butter of goat milk	mil	+
275	22251.01	Cheese from whole cow milk	mil	+
276	22251.02	Cheese from skimmed cow milk	mil	+
277	22252	Cheese from milk of buffalo, fresh or	mil	+
278	22253	Cheese from milk of sheep, fresh or	mil	+
279	22254	Cheese from milk of goats, fresh or	mil	+
280	2351f	Raw cane or beet sugar (centrifugal only)	sgr	+
281	23540	Molasses (from beet, cane and maize)	sgr	+
282	24212.02	Wine	b_t	+
283	24310.01	Beer of barley, malted	b_t	+
284	26110	Raw silk (not thrown)	tex	+
285	26190.01	Flax, processed but not spun	tex	+
286	39110.01	Hair of horses	oap	+

Source: developed by author based on GTAP (2020).

Appendix F. Mapping between FAO commodities with available and unavailable prices¹²

Commodities with unavailable prices		Commodities with available prices		No of cases for gap-filling	Other year prices use
CPC 2.1 code	Commodity name	CPC 2.1 code	Commodity name		
02951.01	Raw hides and skins of cattle	21111.01	Meat of cattle with the bone, fresh or chilled	610	
02953	Raw hides and skins of sheep or lambs	21115	Meat of sheep, fresh or chilled	563	
02954	Raw hides and skins of goats or kids	21116	Meat of goat, fresh or chilled	519	
01929.90	Other fibre crops, raw, n.e.c.	01929.05	Sisal, raw	88	
02951.03	Raw hides and skins of buffaloes	21112	Meat of buffalo, fresh or chilled	81	
01929.02	True hemp, raw or retted	01929.05	Sisal, raw	71	
01449.02	Hempseed	01449.90	Other oil seeds, n.e.c.	45	
01929.08	Coir, raw	01929.05	Sisal, raw	32	
01929.06	Agave fibres, raw, n.e.c.	01929.05	Sisal, raw	24	+
01922.02	Kenaf, and other textile bast fibres, raw or retted	01922.01	Jute, raw or retted	24	+
21170.93	Offals n.e.c. (excluding mammals), fresh, chilled or frozen	21170.92	Other meat n.e.c. (excluding mammals), fresh, chilled or frozen	19	
01377	Brazil nuts, in shell	01379.90	Other nuts (excluding wild edible nuts and groundnuts), in shell, n.e.c.	17	
01359.02	Cashewapple	01359.90	Other fruits, n.e.c.	16	
01449.01	Melonseed	01449.90	Other oil seeds, n.e.c.	16	+
01929.04	Ramie, raw or retted	01929.05	Sisal, raw	15	+
02920	Snails, fresh, chilled, frozen, dried, salted or in brine, except sea snails	0232	Eggs from other birds in shell, fresh, n.e.c.	12	
01499.05	Kapok fruit	01499.01	Karite nuts (sheanuts)	8	
01499.04	Tallowtree seeds	01499.01	Karite nuts (sheanuts)	8	
21119.01	Meat of other domestic rodents, fresh or chilled	21111.01	Meat of cattle with the bone, fresh or chilled	8	
01499.02	Tung nuts	01499.01	Karite nuts (sheanuts)	7	+
01929.03	Kapok fibre, raw	01929.05	Sisal, raw	6	¹³
21117.02	Meat of other domestic camelids, fresh or chilled	21111.01	Meat of cattle with the bone, fresh or chilled	6	+
01219.01	Cassava leaves	01215	Spinach	4	
01499.03	Jojoba seeds	01499.01	Karite nuts (sheanuts)	4	+
01499.06	Kapokseed in shell	01499.01	Karite nuts (sheanuts)	4	+
39110.01	Hair of horses	02941	Shorn wool, greasy	4	

Source: developed by author.

¹² This mapping includes only commodities with available FAO-based production quantities and unavailable price data after 3 price gap-filling steps provided on Figure 2. In case of commodities with price mapping from other years, commodities with available prices are used to deflate/inflate prices between years.

¹³ While kapok prices are available for some years, they were considered unreliable after comparison with international statistics and raw sisal price is used instead.

Appendix G. Floricultural output data availability from Eurostat database¹⁴

No.	Eurostat country code (ISO 2)	Eurostat country name	GTAP country code (ISO 3)	Data availability		
				Nursery plants	Ornamental plants and flowers	Plantations
1	AT	Austria	AUT	+	+	+
2	BE	Belgium	BEL	+	+	NA
3	BG	Bulgaria	BGR	+	+	+
4	CH	Switzerland	CHE	+	+	+
5	CY	Cyprus	CYP	+	+	NA
6	CZ	Czech Republic	CZE	+	+	+
7	DE	Germany	DEU	+	+	+
8	DK	Denmark	DNK	+	+	+
9	EE	Estonia	EST	+	+	+
10	EL	Greece	GRC	+	+	+
11	ES	Spain	ESP	+	+	+
12	FI	Finland	FIN	+	+	NA
13	FR	France	FRA	+	+	+
14	HR	Croatia	HRV	+	+	+
15	HU	Hungary	HUN	+	+	+
16	IE	Ireland	IRL	+	+	NA
17	IS	Iceland	ISL	+	+	NA
18	IT	Italy	ITA	+	+	NA
19	LT	Lithuania	LTU	NA	NA	+
20	LU	Luxembourg	LUX	+	+	+
21	LV	Latvia	LVA	+	+	+
22	MK	Former Yugoslav	MKD	NA	NA	NA
23	MT	Malta	MLT	+	NA	NA
24	NL	Netherlands	NLD	+	+	+
25	NO	Norway	NOR	+	+	+
26	PL	Poland	POL	+	+	NA
27	PT	Portugal	PRT	+	+	+
28	RO	Romania	ROU	+	+	+
29	SE	Sweden	SWE	+	+	NA
30	SI	Slovenia	SVN	+	+	+
31	SK	Slovakia	SVK	NA	+	NA
32	UK	United Kingdom	GBR	+	NA	NA

Source: based on Eurostat (2020).

¹⁴ In the “Data availability” part of the table “+” indicates cases when country has non-zero floricultural commodity output at least for one of the four benchmark years; “NA” indicates cases with “0” or non-available output data for all four benchmark years.

**Appendix H. Value shares of the data gap-filling using price and quantity estimates by regions and sectors
for 2014 (% unless noted otherwise)¹⁵**

No.	Region name	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Average	Total gap- fill, mn USD
1	Australia	0	0	0	2	11	0	0	0	1	3	0	0	1	570
2	New Zealand	0	0	1	12	100	0	100	0	100	66	0	0	32	7390
3	Rest of Oceania	27	100	94	96	99	29	100	98	79	73	16	0	93	4901
4	China	0	0	0	1	5	0	0	29	2	0	10	0	2	19165
5	Hong Kong	0	0	0	25	0	0	0	100	100	99	0	0	94	408
6	Japan	0	0	0	1	0	0	100	70	100	60	0	0	19	14916
7	Korea	0	100	3	1	6	0	100	2	0	73	0	0	13	4851
8	Mongolia	0	0	9	15	100	0	0	0	54	56	0	0	32	470
9	Taiwan	100	100	100	100	100	100	100	100	100	100	100	100	100	9772
10	Rest of East Asia	100	100	100	100	100	0	100	100	100	100	100	100	100	7602
11	Brunei Darussalam	0	0	0	30	0	0	0	33	8	1	24	0	5	8
12	Cambodia	0	0	0	5	3	0	100	41	25	0	100	100	3	218
13	Indonesia	0	0	0	24	16	100	99	6	10	0	41	0	10	15144
14	Lao People's	0	0	0	2	1	0	81	0	0	0	0	0	1	40
15	Malaysia	0	0	0	35	1	0	100	4	0	1	0	0	3	814
16	Philippines	0	0	0	2	1	0	0	0	0	0	0	0	1	193
17	Singapore	0	0	0	0	100	0	0	0	100	82	0	0	76	250
18	Thailand	0	100	7	54	1	0	99	1	1	1	0	100	18	8775
19	Viet Nam	0	0	0	60	2	0	100	0	0	0	100	100	19	9753
20	Rest of Southeast	99	100	94	100	100	100	100	98	99	99	100	0	99	35976
21	Bangladesh	0	0	0	54	3	66	3	62	0	0	4	0	20	5285
22	India	0	0	0	18	0	0	0	0	86	58	6	0	12	41845
23	Nepal	0	0	0	4	0	0	0	0	25	0	8	24	6	469
24	Pakistan	0	0	0	49	52	0	0	100	77	71	6	0	32	16645
25	Sri Lanka	0	0	0	2	0	0	100	0	2	0	4	0	5	221
26	Rest of South Asia	75	100	88	94	99	91	100	48	99	95	99	0	96	6979
27	Canada	0	0	1	2	0	100	100	19	100	87	0	0	31	13996

¹⁵ Countries and regions with average gap-filling over 30% are highlighted bold.

No.	Region name	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Average	Total gap- fill, mn USD
28	United States of	0	0	0	0	0	0	0	82	100	0	0	0	19	73531
29	Mexico	0	0	0	11	14	0	0	3	2	1	0	0	4	2102
30	Rest of North	0	0	0	100	0	0	0	0	100	100	100	0	100	6
31	Argentina	0	0	0	12	1	0	0	5	100	28	0	0	31	17251
32	Bolivia	0	0	0	24	1	0	0	0	10	1	15	0	7	398
33	Brazil	0	0	0	5	2	0	0	0	3	2	1	0	2	4501
34	Chile	0	0	4	9	72	0	100	0	6	8	1	0	9	1009
35	Colombia	0	0	0	28	94	0	16	7	2	1	0	0	14	3773
36	Ecuador	0	0	1	14	9	0	4	12	100	24	1	0	26	2587
37	Paraguay	0	0	0	17	1	0	0	0	0	0	0	0	2	163
38	Peru	0	0	0	15	14	0	0	20	7	1	2	0	7	1186
39	Uruguay	0	0	0	1	1	100	0	100	0	1	0	0	1	87
40	Venezuela	0	100	0	0	17	0	0	0	0	0	0	0	0	126
41	Rest of South	88	0	94	29	8	100	0	50	70	50	2	0	68	885
42	Costa Rica	0	0	0	12	99	0	100	11	100	82	0	0	24	1370
43	Guatemala	100	100	100	100	100	100	100	100	100	100	100	0	100	10601
44	Honduras	0	100	0	10	15	0	0	1	100	66	0	0	24	792
45	Nicaragua	0	0	0	50	8	100	67	0	2	1	0	0	29	885
46	Panama	0	0	0	12	57	0	0	51	100	79	0	0	53	964
47	El Salvador	100	0	100	99	67	100	57	92	1	90	100	0	95	2100
48	Rest of Central	100	0	100	100	100	100	0	100	100	100	100	0	100	359
49	Dominican Republic	0	0	0	6	29	0	66	1	0	0	0	0	4	120
50	Jamaica	0	0	0	15	0	0	100	10	100	93	95	0	21	578
51	Puerto Rico	0	0	0	0	0	0	0	9	0	0	0	0	0	4
52	Trinidad and Tobago	0	0	0	9	0	0	0	24	100	91	0	0	46	165
53	Caribbean	100	0	99	97	85	100	100	96	99	94	93	0	97	10613
54	Austria	0	0	14	2	0	0	100	100	0	0	0	0	14	1300
55	Belgium	0	0	68	2	16	0	0	88	100	30	1	0	36	4205
56	Cyprus	0	0	0	0	0	0	0	98	0	0	0	0	3	25
57	Czech Republic	0	0	1	1	1	0	100	94	0	0	0	0	11	816
58	Denmark	0	0	3	4	0	0	0	100	0	1	0	0	13	1611
59	Estonia	0	0	4	19	0	0	0	100	0	0	0	0	12	128

No.	Region name	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Average	Total gap- fill, mn USD
60	Finland	0	0	3	5	0	0	0	100	0	4	0	0	12	499
61	France	0	0	2	10	3	16	100	100	0	1	5	100	17	14708
62	Germany	0	0	0	19	1	0	0	99	0	1	0	0	18	13266
63	Greece	0	0	2	3	2	0	9	85	1	0	0	3	7	1228
64	Hungary	0	0	0	10	1	0	100	96	1	0	0	0	7	569
65	Ireland	0	0	0	42	100	0	0	100	0	6	0	0	17	1627
66	Italy	0	0	3	9	2	0	100	96	2	84	0	0	25	14730
67	Latvia	0	0	0	4	3	0	0	100	0	0	0	0	13	193
68	Lithuania	0	0	0	3	2	0	0	100	100	86	0	0	29	973
69	Luxembourg	0	0	0	1	0	0	0	100	0	0	1	0	38	192
70	Malta	0	0	0	13	0	0	0	100	0	0	5	0	11	20
71	Netherlands	0	0	0	2	10	0	100	99	100	86	0	0	57	17394
72	Poland	0	0	15	22	3	0	100	94	1	47	0	0	23	7134
73	Portugal	0	0	0	10	12	60	0	100	81	0	0	0	17	1480
74	Slovakia	0	0	0	7	0	0	0	99	3	36	0	0	12	287
75	Slovenia	0	0	2	14	9	0	0	96	1	0	1	0	27	379
76	Spain	0	0	1	2	1	0	21	98	0	3	0	3	11	6042
77	Sweden	0	0	2	17	4	0	0	100	1	29	0	0	31	2082
78	United Kingdom	0	0	0	1	0	0	0	100	0	33	0	0	12	4587
79	Switzerland	0	0	0	1	2	0	0	99	0	12	0	0	19	1984
80	Norway	0	0	0	0	0	0	0	100	0	0	0	0	21	1132
81	Rest of EFTA	0	0	0	1	0	0	0	100	0	0	8	0	37	146
82	Albania	0	0	0	2	0	0	100	53	0	0	0	0	1	27
83	Bulgaria	0	0	0	19	2	0	0	77	58	16	0	0	11	549
84	Belarus	0	0	0	15	0	0	0	0	100	81	0	0	32	3922
85	Croatia	0	0	0	1	9	0	0	96	18	75	0	0	30	733
86	Romania	0	0	2	1	1	0	100	100	6	1	0	0	11	2372
87	Russian Federation	0	0	2	0	4	0	100	84	1	0	1	0	1	855
88	Ukraine	0	0	1	14	1	0	100	96	100	76	0	0	22	7996
89	Rest of Eastern Europe	0	0	0	27	0	0	0	0	1	0	6	0	8	127
90	Rest of Europe	0	0	2	22	5	0	0	29	88	72	10	0	27	2459
91	Kazakhstan	0	0	13	28	48	0	2	11	100	56	2	0	39	5273

No.	Region name	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Average	Total gap- fill, mn USD
92	Kyrgyztan	0	0	0	29	100	0	0	61	100	43	0	0	42	1470
93	Tajikistan	0	0	0	2	77	0	6	65	0	18	13	0	5	169
94	Rest of Former Soviet	52	100	100	94	100	100	100	100	90	76	79	100	90	26772
95	Armenia	0	0	15	21	0	100	0	0	0	0	19	0	13	285
96	Azerbaijan	0	0	0	4	47	0	0	34	0	0	0	0	2	117
97	Georgia	0	0	1	17	2	0	0	95	0	1	2	0	9	132
98	Bahrain	0	0	0	100	0	0	0	0	100	100	100	0	100	178
99	Iran Islamic Republic	0	0	0	13	1	0	0	0	100	0	0	0	11	6218
100	Israel	0	0	0	3	2	0	0	100	100	88	0	0	28	2101
101	Jordan	0	0	0	8	0	0	0	0	40	0	0	0	8	218
102	Kuwait	0	100	100	100	100	0	0	100	100	100	100	0	100	875
103	Oman	0	0	5	87	0	0	0	100	100	100	100	0	92	1409
104	Qatar	0	0	1	5	0	0	0	100	5	0	0	0	4	10
105	Saudi Arabia	0	0	100	5	100	0	0	0	20	0	9	0	8	1007
106	Turkey	0	0	0	2	6	0	0	19	0	0	0	0	1	1139
107	United Arab	0	100	100	100	0	0	0	100	100	100	100	0	100	1505
108	Rest of Western Asia	0	18	11	31	74	25	95	32	48	37	64	1	36	10075
109	Egypt	0	0	1	9	0	0	0	100	0	0	3	0	3	1060
110	Morocco	0	0	1	10	0	0	93	99	6	8	9	0	9	1225
111	Tunisia	0	0	5	18	3	0	100	97	100	25	7	0	27	1367
112	Rest of North Africa	0	4	7	11	50	0	0	21	9	20	30	0	13	3773
113	Benin	0	0	0	12	100	100	12	100	100	100	100	0	23	1361
114	Burkina Faso	0	0	0	44	22	100	0	97	100	100	100	0	43	1994
115	Cameroon	0	100	3	17	46	100	0	12	100	19	38	0	24	2849
116	Cote d'Ivoire	0	0	0	10	3	0	15	4	0	1	0	0	6	614
117	Ghana	0	0	0	15	27	100	97	23	0	0	100	0	16	1080
118	Guinea	0	0	17	53	1	100	100	70	0	1	0	0	27	677
119	Nigeria	0	0	0	2	33	0	0	7	0	0	0	0	3	2213
120	Senegal	0	0	0	23	14	0	0	100	100	94	0	0	44	1130
121	Togo	0	0	0	10	46	0	39	7	42	8	100	0	13	245
122	Rest of Western Africa	13	78	1	29	27	62	42	83	47	31	44	0	28	6801
123	Central Africa	7	0	15	36	27	40	100	78	61	70	23	0	36	3795

No.	Region name	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Average	Total gap- fill, mn USD
124	South Central Africa	89	100	34	54	80	100	100	93	100	100	5	0	60	9026
125	Ethiopia	0	0	21	69	27	0	100	14	100	69	15	0	46	10441
126	Kenya	0	0	0	17	46	0	0	2	0	0	0	0	6	811
127	Madagascar	0	0	0	56	78	0	35	17	4	3	100	100	33	1547
128	Malawi	0	0	0	12	7	100	69	7	3	0	100	0	13	840
129	Mauritius	100	0	0	6	0	0	100	31	0	0	0	0	0	7
130	Mozambique	0	100	3	11	20	0	60	1	2	1	13	0	9	512
131	Rwanda	0	0	1	3	0	0	0	36	0	0	24	0	3	158
132	Tanzania	100	100	100	100	100	100	100	100	100	100	100	0	100	21900
133	Uganda	100	100	100	100	100	100	100	100	100	100	100	0	100	10972
134	Zambia	0	100	0	31	26	100	100	100	1	0	0	0	29	1405
135	Zimbabwe	100	0	2	90	31	100	100	24	100	100	0	0	62	2000
136	Rest of Eastern	59	82	85	81	99	98	98	65	99	72	97	0	93	29585
137	Botswana	0	0	5	95	41	0	100	0	100	100	17	0	91	392
138	Namibia	0	0	0	91	0	0	0	0	0	53	0	0	57	405
139	South Africa	100	0	0	4	11	0	0	30	0	1	0	0	2	441
140	Rest of South African	100	100	100	100	100	100	100	100	100	100	100	0	100	1075
141	Rest of the World	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	5.0	2.5	3.8	13.5	10.0	11.5	9.0	52.6	43.0	12.2	8.0	2.4	15.0	661244

Source: developed by author.