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Agricultural markets in Ukraine: current situation and market outlook until 2030

Update of the Ukraine country model in AGMEMOD

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Executive summary

This report presents the current situation and an outlook for the major Ukrainian agricultural commodity markets until 2030 along with the update of the Ukraine country model in AGMEMOD. AGMEMOD is a system of partial equilibrium, medium-term, dynamic, multi-market and multi-country econometric models that is applied for generating projections for agricultural commodity markets of the EU and neighbour countries. In the current work, the database of the Ukraine country model in AGMEMOD has been updated to 2019-2020, the behavioural functions representing market agents re-estimated, and the beekeeping and bioethanol sectors included.

The outlook rests upon a set of information and assumptions that were available and considered most plausible at the time when the analysis was conducted. For the projections, the continuation of current agricultural and trade policies in Ukraine is assumed, as well as coherent external projections that assume steady growth of the economy, declining population, increasing crude oil prices, improvement of crops and livestock production technologies, and moderate positive development of the world market prices for agricultural commodities. The cumulative impact of these macroeconomic developments is captured in the projections of agricultural markets in Ukraine.

The outlook results for 2030 show that while the quantity of wheat produced will increase only marginally, maize is expected to become the dominant cereal in Ukrainian agriculture. Adaptation to climate change is the main driving force behind this trend. Domestic soya beans, rapeseed and sunflower seeds production will continue growing, along with the quantities of oilseed oils and meals. Although the further developing domestic poultry sector will drive feed demand, Ukraine will continue to be a net exporter of cereals, oilseed oils and meals.

Cattle and swine farming will continue its ongoing structural change that shows the replacement of self-subsistent producers (rural households) by specialised farms. However, the specialised larger producers will not compensate the loss in animal numbers from the rural households and, therefore, production quantities of beef and pork are likely to slow down in the next decade. Conversely, poultry meat and eggs production are projected to grow. Concentrated in large enterprises, the production of poultry meat is projected to increase by more than 30%, and of eggs by more than 50%, followed by growth in exports.

Compared to the latest OECD-FAO agricultural outlook, the AGMEMOD outlook might be considered rather conservative for several Ukrainian sectors. Main reasons behind the differences of the two outlooks are discrepancies in the underlying databases, exogenous variables, and the weight given to the trends of the last decade. In this respect the two outlooks together may provide a span for the possible future developments of the Ukrainian agricultural sector by 2030.

As the COVID-19 pandemic has been ongoing since early 2020, this report also analyses its impacts on the Ukrainian agriculture. The analysis demonstrates medium to long term resilience of the Ukrainian agricultural commodities production and export to this crisis. Overall, the current report shows that AGMEMOD provides relevant results and enables a structured discussion about key development trends, changes and causes of changes in production and trade of agri-food commodities. However, to guarantee solid and reliable simulation outcomes also in the future, careful calibrations of model parameters and assumptions, as well as validation of the model's outcomes are required. Therefore, not only the Ukraine country model of AGMEMOD has to be further developed, but also the network of local modelling teams and market experts should be continued to be strengthened.

1 Introduction

Ukraine is the second largest country in Europe after the Russian Federation, with about 42.2 million hectares of agricultural land comprising 70% of the country's total area. The agricultural sector plays a major role in the Ukrainian economy, and Ukraine has become an important player on several agricultural markets, aided by its huge agricultural potential and a favourable geographical position, with access to the Black Sea and direct access to key markets in the EU, Commonwealth of Independent States (CIS), the Middle East and North Africa. Ukraine has remained among the top ten exporters of wheat, maize and sunflower oil in the world for nearly a decade. Since several years it has as well been gaining shares in the global exports of soya beans, honey, apples and berries (FAOSTAT, 2021). One of the main trading partners of Ukraine is the EU. Ukraine's exports to the EU in 2014-2018 increased from nearly 14 thousand tonnes to 106 thousand tonnes for meat products, by 74.6% for cereals, 61.0% for animal and vegetable fats and oils and by 27.7% for oilseeds (Eurostat, 2021). The rapid development and the current positions in trade create strong interest to analyse future perspectives of the Ukrainian agricultural sector.

The current study aims at providing an overview of the current situation of the agri-food sector in Ukraine and a market outlook until 2030, shedding light on possible future trends of the Ukrainian agri-food markets and the driving forces behind these trends. For the outlook, the Ukraine country model in AGMEMOD has been updated, further developed and applied. AGMEMOD is a complex system of partial equilibrium, medium-term, multi-product and multi-country econometric models. It includes all EU Member States, some EU neighbouring (e.g., Ukraine, Russian Federation, Balkan countries, and the United Kingdom), some African (e.g., Ethiopia, Ghana, Kenya and Rwanda) and other countries, and accounts for the respective domestic agricultural, trade and environmental policies (van Leeuwen et al., 2012).

In previous years, two agricultural market outlooks for Ukraine have been developed based on AGMEMOD (Bogonos and Stepaniuk, 2017; van Leeuwen et al., 2012). Building upon the previous model developments, the current work provides results based on more recent data and an extended methodological framework. In particular, the following updates and improvements have been done for this study: (i) the database of the Ukraine country model in AGMEMOD was updated to 2019 and, where possible, to 2020, (ii) the behavioural functions representing market agents have been re-estimated to account for the most recent trends in the agri-food markets of Ukraine and the world, and (iii) the markets for honey and bioethanol have been introduced. Furthermore, to improve the reliability of the estimates, along with the standard approach of estimating the behavioural functions from time series, panel data representing administrative regions of Ukraine have been used as well. Due to these updates and improvements, the Ukraine country model in AGMEMOD allows now a more elaborated outlook and scenario analysis.

The report consists of six sections. Sections 2 and 3 review the main features of crop and livestock production, use and trade in Ukraine, as well as the country's macroeconomic conditions, agricultural and trade policies. The characteristics of the Ukraine country model of AGMEMOD and the process of validation of the modelling results are described in section 4. The projections for the Ukrainian agricultural markets until 2030 and their comparison with the OECD-FAO Agricultural Outlook (2021) are presented in section 5. Section 6 concludes the report.

2 Overview of the agricultural sector of Ukraine

Agriculture is an important sector for the Ukrainian economy. In 2019 it contributed almost 10% to the country's GDP, following only trade with 15.3% and industry with 22.6%. Around 18% of Ukraine's employment and 44% of its export value (3.3 billion USD) are attributed to agriculture as well. Abundance of chornozem soils (27.8 million hectares) and landscape characteristics that allow for higher yields and larger fields, play one of the key roles in the development of agricultural production, in particular of crops. Currently, around 80% of the total utilised agricultural area (UAA) in Ukraine are used for cultivation of cereals, oilseeds, vegetables and other annual crops (WBD, 2021; SSSU, 2020a).

Five main types of agricultural producers can be distinguished in Ukraine: rural households, family farms, private and public agricultural enterprises and, the so-called, agricultural holdings (further, agroholdings). Rural households are engaged in agricultural production mainly for self-subsistence purposes, and cultivate land parcels of around 1.3 hectares. In 2019 their input to the total value (in current prices) of crop commodities was 30.1%, and of livestock commodities 48.7%. Family farms, public and private enterprises differ from each other by the type of ownership. Family farms are privately owned and run mainly by the family members (LoU, 2003). The average size of a family farm is around 134 hectares. Private agricultural enterprises are defined as enterprises whose main economic activity is agricultural production. Average acreage of land cultivated by such enterprises is around 1.2 thousand hectares. Public enterprises are owned by the state. Along with rural households, private enterprises are the main contributors to gross agricultural output in Ukraine (Bogonos and Stepaniuk, 2017; SSSU, 2020b).

Agroholdings belong to a rather unique type of agricultural enterprises. They are organized around parent companies which control and manage dozens of subsidiary agricultural enterprises. Because such parent companies do not always own the subsidiary enterprises or their majority stocks, the term "holding" may be somewhat misleading (Hermans et al., 2017). Agricultural land area cultivated by one such agroholding may range from around ten to more than 600 thousand hectares (Horovetska et al., 2017). Currently, the Ukrainian legislation does not provide a definition for an agroholding. Therefore, in most of the cases, national statistical databases of Ukraine refer to the subsidiary enterprises instead of the company itself. This poses certain challenges when attempting to include this type of agricultural production actor into the research study.

Although agricultural production in Ukraine has been growing over the past two decades, agricultural land markets have been introduced only recently. With the collapse of the Soviet Union and the declaration of independence in 1991, Ukraine began the agricultural land reform. The latter followed a complex history of adaptation of the legislation on agricultural land relations from being based on centralised planning and public ownership to market-based and private ownership. From the end of the 1990s until now there exist three types of property rights on agricultural land in Ukraine: public (8.7 million hectares), communal (1.7 million hectares), and private (31.0 million hectares). Due to a moratorium imposed on land-sale transactions, until July 2021 none of this property could be sold or purchased under the general circumstances. Therefore, the most common agricultural land transactions included inheritance and emphyteusis (around 18% of the transactions), long- and short-term leasing (around 76% of the transactions) (Nizalov et al., 2018). According to the statistical records, in 2018 the average rental price for a hectare of agricultural land in Ukraine was around 50.2 EUR per year (USSGCC, 2019; in current prices1). In July 2021, following the regulation adopted in 2020 (LoU, 2020a), the moratorium on market transactions of agricultural land was lifted. Some limitations, however, remain: exempted from the market are agricultural land of public property, foreign legal entities and individuals, as well as until July 2023, domestic legal entities. As of 2021, agricultural land may only be purchased by the citizens of Ukraine and up to the total acreage of 100 hectares, but from 2024 onwards, the possibility of land purchase will extend to 10 thousand hectares for legal entities (as long as the beneficiaries are Ukrainians that have no business abroad or offshore companies). A number of studies analyse the impacts of the absence and the introduction of agricultural land markets (Koshovnyk and Nivievskyi, 2019; Dankevych et al., 2017; Otsuka, 2007; Lerman et al., 2004). Since these impacts are not only the result of the reform itself, but the institutional and legal frameworks accompanying it (Kvartiuk and Herzfeld, 2019; Nivevskiy and Kandul, 2011; Smith, 1990), the changes the land market will bring to the Ukrainian agricultural sector are yet to be seen.

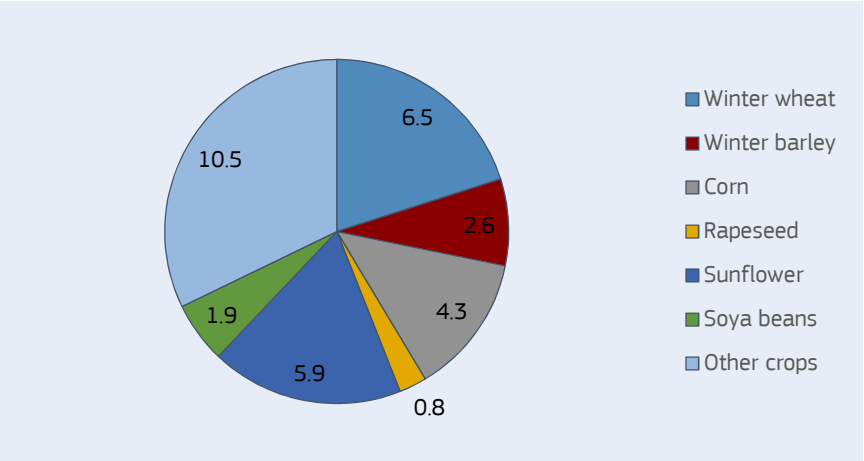
2.1 Production and trade of crop commodities

In the last decade crops production has dominated Ukrainian agriculture and showed a rather steady increase, as, for example, in 2000-2019 production of cereals increased from 23.8 to 74.1 million tonnes and of oilseeds

([1]) NBU (2021): Official exchange rate of Hryvnia versus foreign currencies. National Bank of Ukraine, Financial markets, Official Hryvnya exchange rates.

from 3.7 to 22.2 million tonnes. In 2019 crop production accounted for around 79% of the gross agricultural output. The main crops are maize, winter wheat, winter barley, sunflower, soya beans and rapeseed (SSSU, 2020b). In 2015-2019 these crops were harvested on nearly 70% of the total area of arable land, with winter wheat, sunflower and maize occupying the largest shares of this area (Figure 1).

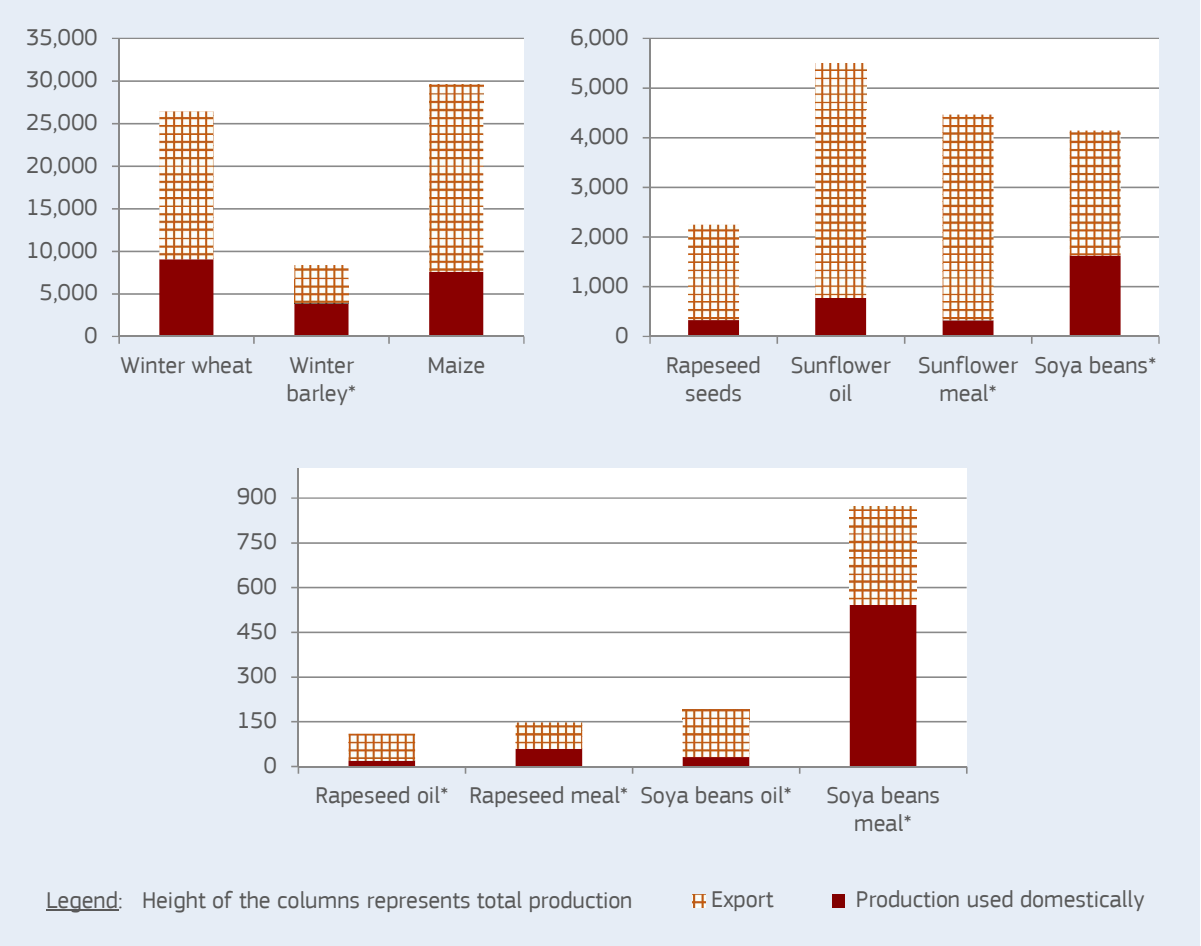
Figure 1. Average 2015-2019 crop areas, million hectares



Source: Own elaboration based on SSSU (2020b)

Cereals production in Ukraine has shown a relatively high degree of variability during the last two decades (Araujo-Enciso and Fellmann, 2020), and some studies show that yields of the main crops in Ukraine for various economic and environmental reasons have not reached their maximum potential (Deppermann et al., 2018; Graubner and Ostapchuk, 2018). In 2015-2019, for example, average yield of winter wheat in Ukraine was around 4.06 tonnes per hectare, whereas in Germany it was around 7.5 and in France 7.9 tonnes per hectare. Furthermore, yield of maize in Ukraine was around 7 tonnes per hectare, whereas in Spain around 11.3, France 8.9 and in Germany 9.3 tonnes per hectare (AGMEMOD, 2020). Among else, this situation may be attributed to adverse weather conditions with extreme weather events, likely linked to climate change. Increased fluctuations of average daily temperature and precipitation levels, as well as increased frequency of hail, squalls, snowless winters and draughts, that have been observed in the last decades, heighten the risk of yield loss and may restrain intensification of crops production (Araujo-Enciso and Fellmann, 2020; Müller et al., 2016). The relatively high vulnerability of Ukraine's crop yields to adverse weather conditions and the relatively low yields compared to EU levels are also related to limited access to credit and finance, and uncertainties in the regulatory framework of the agricultural sector, which create a barrier for input use (fertiliser and plant protection) and general investments (Keyzer et al., 2017; Schroeder and Meyers, 2017; Sedik, 2017). Furthermore, a serious threat to the Ukrainian agriculture is posed by soil erosion. According to Fileccia et al. (2014), around 500 million tonnes of soil is eroded annually in Ukraine. This corresponds to 3-30 tonnes of soil per hectare depending on the region. Although the study does not provide estimates of the corresponding yield and production losses, evidence from other countries suggests (Panagos et al., 2020; Panagos et al., 2015; Bakler et al., 2007; van der Knijff, 2000) that soil erosion causes significant losses in potential crops yields and, consequently, in production quantities. Nevertheless, due to the large areas harvested, volumes of crops production in Ukraine are far beyond the respective domestic demand which allows for large quantities exported. For example, around 66% of winter wheat, 54% of barley and 74% of maize were exported in 2015-2019. Furthermore, exports of oilseed oils, sunflower and rapeseed meals exceeded 70% of their production (FAOSTAT, 2021; SSSU, 2020b) (Figure 2).

Figure 2. Average 2015-2019 crops and crop products produced and exported, thousand tonnes

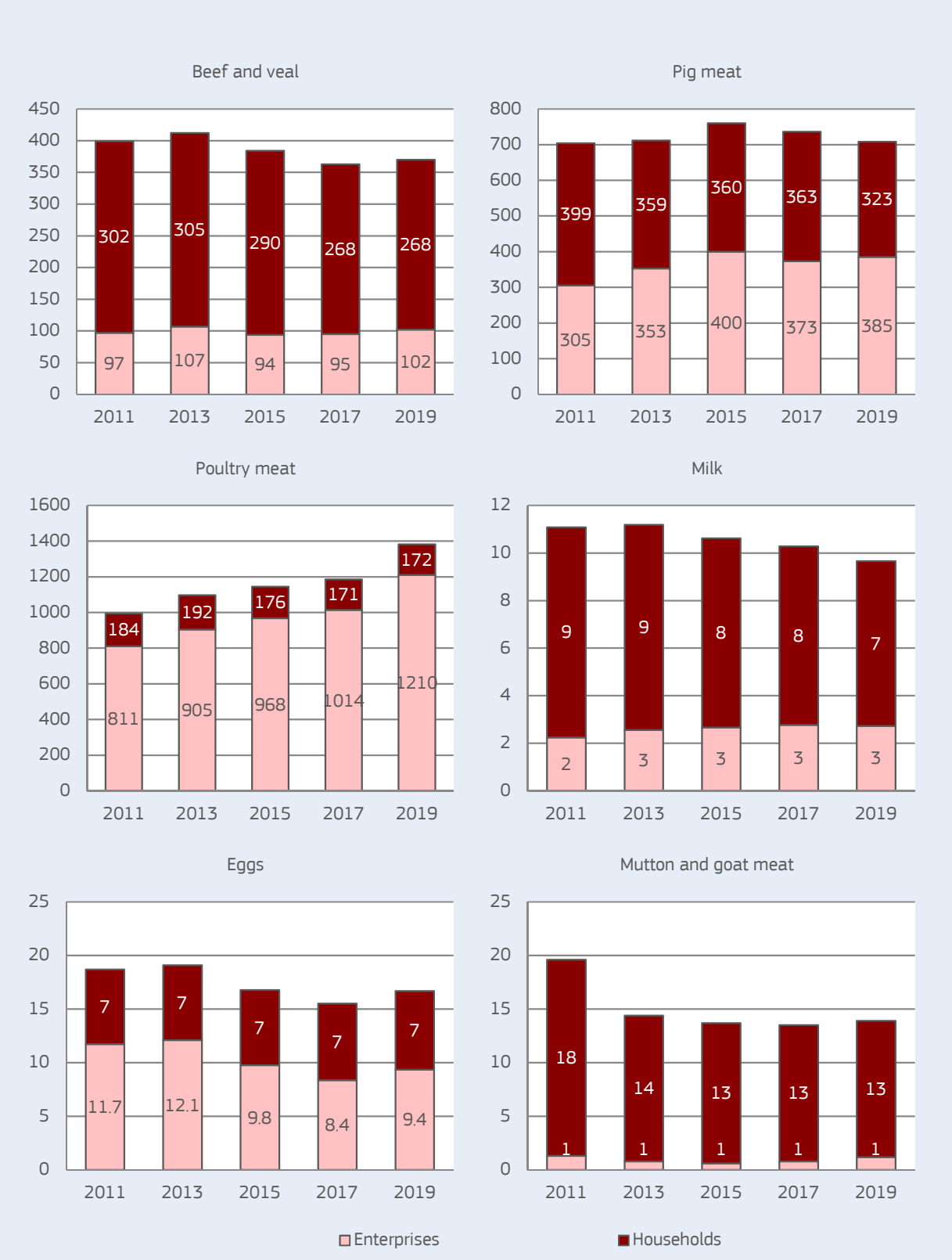


* refers to average 2015-2018
Source: Own elaboration based on SSSU (2020b) and FAOSTAT (2021)

2.2 Production and trade of livestock commodities

In contrast to crops production, production of livestock commodities grew rather marginally over the last decade. In 2019 nearly 86% of sheep and goat meat, 72.3% of beef and veal, 71.8 % of milk, 45.7% of pork, 43.9% of eggs, and 12.4% of poultry meat were produced by rural households (see Figure 3). Compared to 2010, the gross output in livestock products dropped by nearly 15%. Although livestock rearing at agricultural enterprises has been gaining pace, this did not compensate for the respective production decrease in rural households, with the exception of poultry meat production (SSSU, 2020b; SSSU, 2020c).

Figure 3. Production of the main livestock commodities by rural households and agricultural enterprises in 2010-2019, (thousand tonnes)



Source: Own elaboration based on SSSU (2020c)

Despite the general trend, the different livestock sectors have particularities in their developments. Between 2010-2018, the total cattle herd decreased from 4.8 to 3.1 million heads, i.e., by 30.6%. Most of the herd decline took place at the rural households. As throughout this period cattle slaughter weight at the agricultural

enterprises increased from 203 to 229 kilograms, whereas it reached only 159 kilograms at the rural households, the impact of herd decline on total beef and veal production was lower than the actual production decline (SSSU, 2020b; SSSU, 2020c; SSSU, 2011). Nonetheless, total beef and veal production declined by 13.6% (i.e., from around 428 to 359 thousand tonnes in live weight).

Similarly, the impact of a 31.3% decrease in the number of dairy cows on milk production was offset by increases in milk yields. In particular, between 2010-2018 the improvement of milk yield from 4.1 to 6.1 thousand kilograms per cow and year at the agricultural enterprises and from 3.9 to 4.6 thousand kilograms at the rural households led to a lesser drop in milk production compared to the decrease in animal numbers by 9.8% (from 11.2 to 10.1 million tonnes). The dominant milk type produced in Ukraine is cow milk, accounting for 98.8% of the total quantity of milk collected in 2019 ([2]) (SSSU, 2020c; SSSU, 2011). Usually, milk produced by rural households meets lower quality standards than milk produced by agricultural enterprises, which is one of the reasons why the former receive lower prices. In 2019, for example, rural households received 6.8 UAH per kilogram of cow milk and agricultural enterprises 8.2 UAH (SSSU, 2018; in current prices).

The swine sector in Ukraine is represented by two large groups of producers: rural households and agricultural enterprises. In 2019, the respective shares of swine reared by these producer groups were 43.5% and 56.5%. Between 2010-2018 the swine herd at the rural households decreased by 13.5%, whereas it increased at the agricultural enterprises by 8.8%. As a result, although marginal increases in swine slaughter weight have been observed, total pig meat production declined (SSSU, 2020b; SSSU, 2020c; SSSU, 2011). Presence of African swine fever (ASF) in the country threatens production decisions and is one of the obstacles for Ukraine's swine production. In 2019, for example, Ukraine had 42 registered outbreaks of ASF among domestic swine, and in 2017, 124 (ADIS, 2019).

Between 2010-2019, poultry meat production in Ukraine increased by 44.9%, with a 56.7% increase at the agricultural enterprises and a 5.4% decline at rural households. Eggs production fluctuated, accounting for 17.1 billion eggs in 2010, 19.6 billion eggs in 2013, 16.8 billion eggs in 2015 and 16.7 billion eggs in 2019. In 2019, nearly 89% of poultry meat and 56.1% of eggs were produced by agricultural enterprises. The remaining 11% and 44%, respectively, were produced by rural households (SSSU, 2020c; Tarasevych, 2020; SSSU, 2020d). Numbers of sheep and goats as well as their total output (i.e., wool and milk) were declining steadily in the last decades, with herd numbers and yields at the agricultural enterprises remaining relatively stable, whereas the herds at the rural households decreased (SSSU, 2020b; SSSU, 2020c; SSSU, 2011).

Quantities of livestock commodities exported from and imported to Ukraine vary. 42.7 thousand tonnes of cattle meat ([3]) was exported from, and 1.4 thousand tonnes imported to Ukraine in 2018. The changes in 2018 as compared to 2010 were, respectively, 221.1% and -43.13%. Quantities of pig meat ([4]) exported and imported in 2018 were, respectively, 2.2 and 30 thousand tonnes. The growth rates from 2010 were, respectively, 584.7% and -67.7%. Furthermore, export of butter in 2018 was 28.7% of its total production, and import less than 1%, whereas export of cheese was 6.6% of its total production, and import 10.9%. Net trade of chicken meat and eggs grew rather considerably between 2010-2018. For chicken meat it turned from -96.8 to 213.4 thousand tonnes, and for eggs from 15.7 to 111.9 thousand tonnes (FAOSTAT, 2021; SSSU, 2020b; SSSU, 2020c; SSSU, 2011).

2.3 Consumption trends

In 2019 average daily per capita kcal intake in Ukraine was 2,691, with 70.3% being attributed to plant, and 29.7% to livestock products (which is an increase in the share of 2.7 percentage points for the latter compared to 2010). Throughout 2009-2019, annual per capita consumption of beef and veal decreased from 9.6 to 7.7 kilograms, whereas it increased for pork from 16.1 to 19.0 kilograms, and for poultry (mostly chicken) meat from 23.0 to 26.0 kilograms. As a result, per capita total meat consumption increased from 49.7 to 53.6 kilograms ([5]). Conversely, in 2019 per capita consumption of eggs decreased by 2.8% and of milk and dairy commodities by 5.6% compared to 2010 (SSSU 2020a; SSSU 2020d).

([2]) When compared to some of the EU countries, cow milk yield in Ukraine has potential for further growth. For example, cow milk yields in Germany in 2018 were around 8.06 thousand kilograms (Schoof, N., R. Luick, K. Jürgens, G. Jones (2020): Dairies in Germany: Key Factors for Grassland Conservation? Sustainability 2020, 12, 4139).

([3]) Commodities considered according to FAOSTAT classification: 0875 "Meat, beef, preparations", 0867 "Meat, cattle", 0870 "Meat, cattle, boneless (beef & veal)".

([4]) Commodities considered according to FAOSTAT classification: 1035 "Meat, pig", 1041 "Meat, pig sausages", 1042 "Meat, pig, preparations", 1038 "Meat, pork".

([5]) Other types of meat, e.g., sheep and goat meat, are excluded from this calculation.

Cereals consumption in Ukraine is largely dominated by wheat. In 2019, for example, 85% of the total quantity of cereals used in the food industry was wheat, whereas only 5.3% and 2.9% were, respectively, rye and maize. In the last decade, however, annual per capita cereals consumption decreased by 12.2%. Furthermore, while per capita consumption of sugar decreased by 22.3% ([6]) and of vegetable oil by 18.9%, fruits and vegetables consumption increased by 16.7% (SSSU, 2020d). Together with the significant increase in organic food consumption (retail sales of organic food in Ukraine increased from 2 to 33 million Euros in 2010-2018) (FIBL, 2020), these changes may indicate an increase in health awareness and a shift of consumer preferences away from the more traditional diet.

([6]) From 37.1 in 2010 to 28.8 kg/per capita in 2019.

3 Agricultural and trade policies in Ukraine

The development of Ukraine's agricultural sector and of the country's economy in general are mutually dependent. By the end of 2015, almost two years after the beginning of the military conflict in Eastern Ukraine, which has led to the loss of various production facilities and infrastructure in the parts of the Donbas region and the Autonomous Republic of Crimea, as well as the so called "trade war" with the Russian Federation (Decree, 2015), the GDP of Ukraine, measured in current USD, dropped by 50.3% compared to the pre-crisis 2013. Gross agricultural domestic product, however, dropped less, i.e., by 31.7%. Respectively, its share in the GDP rose from 8.8 to 12.1%. With the local currency depreciated from 7.99 UAH/USD in 2013 to 21.85 UAH/USD in 2015 (WBD, 2021; SSSU, 2020e), the agricultural sector was able to partially offset the effects of the economic downturn by profiting from exports. Economic crisis of 2014-2015 have as well resulted in a decrease of investments in agriculture by 40.7% (measured in current USD) in 2015 compared to 2013 ([7]). By 2019 the economy partially recovered. The difference in the GDP values of 2013 and 2019 increased to -16.1%, in the gross agricultural product to -14.3% (in current USD), and investments in agriculture nearly reached the level of 2013 (SSSU, 2020f).

Support to agricultural producers in Ukraine, measured by the producer support estimate (PSE), is generally low compared to other countries (OECD 2020). Nonetheless, there are several programs that are worth mentioning. To enhance the development of the agricultural sector, financial support programs have been implemented. In 2019, 24 different programs existed, and included, among others, the partial refunding of interest paid for agricultural loans, partial compensation of expenses on advisory services, seeds, seedlings and agricultural machinery and equipment produced in Ukraine, direct payments per hectare of cultivated land to newly established farms, as well as production support to livestock, aquaculture, horticulture, hops and other sectors with smaller shares in gross agricultural product (Agro, 2019). The budget for such programs is formed annually and must comply with the general framework of Ukraine's state budget, which is as well formed annually (LoU, 2021a). In 2019, for example, the support programs to agriculture valued 230.8 million USD ([8]), of which 58.7% were directed to support the development of livestock production, 13.4% to partial compensation of expenses on agricultural machinery and equipment produced in Ukraine and 14.9% to financial support of development of family farms (Agro, 2019). Because the agricultural policy budget is adjusted each year, its size, as well as the size of the support programs vary. For example, in 2018 the total budget was 157.5 million USD and the main programs included: 56.1% for support of the development of livestock production, 22.4% to partial compensation of expenses on agricultural machinery and equipment produced in Ukraine and 4.9% to financial support of development of family farms (Agro, 2018).

Another relevant aspect in supporting agricultural producers in Ukraine is the specific taxation policy. Although this policy has undergone changes throughout the years, it has remained an important support and regulatory instrument. For example, in 1997-2010 agricultural commodities were generally exempted from VAT (LoU, 1997). Currently only the exported products are exempted from this tax, whereas products marketed domestically are levied with the reduced rate, i.e., 14% as opposed to the usual 20% (LoU, 2021b; LoU, 2018a; LoU, 2020b).

Export duties have long been used to motivate production and trade of processed agricultural commodities. For example, export of sunflower seeds was levied with 23% duty in 1999, and 17% in 2001. This stimulated decrease of sunflower seeds export, and growth of sunflower seeds oil production and export (EBRD-FAO, 2005; TRADE MAP, 2020a). Currently export duties are imposed on the export of cattle other than purebred (introduced in 1996), flax, sunflower and ryegrass seeds (introduced in 1999) (SCSU, 2019).

In the last decade, there have been significant changes in the Ukrainian trade policy. Starting from late 2013, trade relations between Ukraine and the Russian Federation have significantly deteriorated. On the one hand, Russia imposed restrictions on goods imported from the Ukrainian borders and suspended CIS FTA (The Commonwealth of Independent States Free Trade Agreement) with Ukraine in 2015. On the other hand, Ukraine banned imports of certain commodities and imposed import duties on goods originating from Russia. After signing the Association Agreement with the EU, which entered into force on January 1, 2016 (FTA, 2014), Ukraine has increased considerably its exports of agricultural commodities to the EU. While in 2013 the export value of goods exported to the EU was 4.6 billion USD, it reached 6.8 billion USD in 2019. Trade liberalisation, improved investment opportunities and alignment of sanitary, phytosanitary and technical requirements of agri-

([7]) Although lending interest rate for agricultural producers have remained around 15% since 2013.
([8]) In current prices.

food commodities to the EU standards ([9]) have contributed to this increase. By contrast, the value of agricultural imports from the EU have decreased from 3.2 to 2.6 billion USD ([10]).

Trade agreements are an important tool to enhance trade between countries. Currently, Ukraine has 17 free trade agreements (FTAs) covering 47 countries. Following the agreement with the EU, the FTA with Canada was signed (came into force in 2017). Furthermore, in 2018, Ukraine acceded to the Regional Convention on Pan-Euro-Mediterranean Preferential Rules of Origin (Pan-Euro-Mediterranean Convention), and in 2021 FTAs with Israel and the United Kingdom came into force. An FTA is currently negotiated with Turkey. Some earlier FTAs include Montenegro, North Macedonia, CIS countries except the Russian Federation, EFTA States, Azerbaijan, Georgia and Turkmenistan. Moreover, since 2008, when Ukraine joined the WTO, it became a member of a number of WTO multilateral agreements (see Annex 1 for details).

In the past, Ukraine repeatedly implemented temporary export restrictions in years of grave harvest failures in the crop sector (Götz et al. 2016; Fellmann et al. 2014), which created some uncertainty and disincentives for investments in the related domestic sectors (Keyzer et al., 2017; Sedik, 2017; Götz et al., 2013). In recent years, the Ukrainian government and main associations signed annually a Memorandum of Understanding (MoU) on grain exports. The MoUs cover issues like interaction of grain market participants, information exchange on export prospects and monitoring of the functioning of grain markets. The MoU typically also include an annex on recommended volumes of grain exports, but these have rather the character of non-binding agreements and in the past the actual exports have often exceeded the agreed volumes (OECD, 2021).

Overall, export promotion is currently among the priorities of the Ukrainian government. At the end of 2017, the Cabinet of Ministers of Ukraine (CMU) approved the Export Strategy of Ukraine for 2017-2021. In 2019, the revised version of the strategy was adopted, i.e., Strategy for the Export Development of Agricultural, Food and Processing goods in Ukraine until 2026 (CMU, 2017; OECD, 2021). The strategy is an action plan that identifies key aspects of development of exports, including improvement of the respective institutions. Its objectives include increasing the competitiveness of products, expanding the range of export products, market diversification, stimulating the promotion of Ukrainian food brands, and providing information and analytical support for the exports of agricultural products, food and processed goods. Furthermore, the Export Promotion Office, established in 2018, provides consultation and advise for Ukrainian exporters to access new markets.

([9]) Currently, agricultural producers in Ukraine may either standardise their production processes and commodities according to ISO requirements, test their commodities for adherence to the safety standards in specialised accredited laboratories or using specialised surveillance systems to declare adherence to the proclaimed standards (ISO/IEC (2004): Standardisation and related activities – General vocabulary. Guide 2:2004, ISO, IEC, Switzerland, 2004; Агромегаполіс (2018): Ensuring safety and quality of agricultural and food products in accordance with the requirements of the Association Agreement (basic analytical material for seminars in the regions), International Renaissance Foundation, Civic Synergy, EU UA CSP, ГО Агромегаполіс, Kyiv, 2018 (*translated from Ukrainian*: Забезпечення безпечності і якості аграрної та харчової продукції відповідно до вимог Угоди про асоціацію. Базовий аналітичний матеріал до семінарів у регіонах. Міжнародний фонд Відродження, Громадська Синергія, Українська сторона Платформи Громадянського Суспільства Україна.ЄС).

([10]) In constant prices (2015 base), USDA International Macroeconomic Dataset, Historical Data Files; SSSU (2020): Cooperation between Ukraine and EU countries in 2019, Statistical yearbook, State statistical service of Ukraine; SSSU (2014): Cooperation between Ukraine and EU countries in 2013, Statistical yearbook, State statistical service of Ukraine.

4 The Ukraine country model in AGMEMOD

This chapter first provides a brief general overview on the AGMEMOD model and the development of the Ukraine country model in AGMEMOD. Furthermore, for the Ukrainian agricultural market outlook the database and behavioural functions have been updated and the projections had to go through a validation process, which is also briefly described in the subsequent sections.

4.1 The AGMEMOD model

AGMEMOD is an econometric, dynamic, partial-equilibrium, multi-country, multi-market model. It covers all EU Members States, some non-EU countries (e.g., Balkan countries, Ukraine, Kazakhstan, Russian Federation, some African countries) and a stylised version of the rest of the world (RoW). The model provides annual projections (currently) until the year 2030 for markets of the main agricultural commodities at national and aggregated EU levels. AGMEMOD is based on a set of commodity-specific model templates and country-specific models. The template approach facilitates aggregation of the simulation results, analytical consistency across countries and comparison of policy impacts. The model does not only provide baseline projections, but as well allows analysing impacts of countries' agricultural policies (e.g., CAP) and macroeconomic changes on the agricultural markets (Salamon et al., 2019).

The commodity markets in AGMEMOD are represented by equations for supply and demand, stocks, international trade and market prices. They represent behavioural responses of economic agents to changes in prices and exogenous variables such as agricultural policy instruments, GDP, currency exchange rate, tariff rate quotas etc. The equations' parameters are usually estimated as time series regressions from the AGMEMOD database. The latter contains annual observations on the endogenous and exogenous variables. Depending on the country, these data range from 1973 until the latest available year. Most of the data is obtained from national statistics, Eurostat, Short-term Outlook and Commodity price dashboard of the European Commission (Salamon et al., 2017; Chantreuil et al., 2012).

Following the partial equilibrium approach, commodity prices adjust to clear each commodity market considered in AGMEMOD. Lagged endogenous variables introduce (recursive) dynamic behaviour when entered as determinants in the next period's equilibrium supply and/or demand. Closing of global commodity balances in AGMEMOD is achieved by forming world market prices in the RoW model. Commodity markets in a country are linked to each other by substitution or complementary parameters on the supply or demand side. Interactions between the crops and livestock sub-models are captured via the derived demand for feed. The various meat types, dairy products and crops are partly substitutes in demand, while cattle, pig, sheep and goat, and poultry compete for feed (Salamon et al., 2017; Chantreuil et al., 2012).

Each country model comprises markets for its main agricultural commodities. These commodities usually include six types of cereals, three types of oilseeds and their processed products (oil and meal), sugar beet and sugar, protein crops, potatoes, live animals such as cattle, sheep and goats, pigs and poultry and their products such as meat, milk, dairy and eggs. The projections for the crops sector cover area harvested, yield per hectare, total production as a product of area harvested and yield, domestic use, quantities imported and exported, stocks and domestic market price. Crops area is defined following the top-down approach. In particular, the total country land area is divided into woods, usable agricultural area (UAA) and other areas. UAA is split into permanent grassland, kitchen gardens, arable land, land under permanent crops, fodder from arable land and vegetable area.

The livestock sector in AGMEMOD comprises a complex system of total animal numbers, numbers of dairy and suckler cows, sows and ewes, livestock reproduction rates, total number of slaughtered animals, slaughter weight, death loss, numbers imported and exported. Meat production is determined by the number of slaughtered animals and their slaughter weight. Markets of milk and dairy products include milk delivered to dairies, consumed at the farm level and for human consumption, and milk fat and protein coefficients which are used in the equations of production of butter, cream, cheese, whole and skimmed milk powder (Salamon et al., 2017; Chantreuil et al., 2012).

As equations in AGMEMOD are estimated econometrically, the model does not require calibration. However, when it is used for producing the Agricultural Outlook for the EU countries, its EU country models are calibrated to projections of the EU Agricultural Outlook. In particular, the projected by AGMEMOD values of production, use and trade at the EU-14 and EU-N13 aggregate levels must, to the extent possible, reproduce the values of the EU Outlook. Therefore, parameters of equations for the EU country models are accordingly modified (Salamon et al., 2017). This is not the case for the non-EU country models which generate projections based on the original, estimated and adjusted by the market experts, modelling parameters.

4.2 Development of the Ukraine country model in AGMEMOD

Although AGMEMOD has been developed for the EU countries, its general applicability to analysing various research questions in agricultural economics, policy and trade led to its extension towards countries and regions outside the EU. In 2012, as part of the study "The agri-food sector in Ukraine: current situation and market outlook until 2025", Ukraine was integrated into the overall AGMEMOD modelling framework (van Leeuwen et al., 2012). The complete database and behavioural equations representing the main crop and livestock markets, as well as policy and macroeconomic data have been introduced in this first project. In 2014-2016, within the AGRICISTRADE project (https://cordis.europa.eu/project/id/612755), the Ukraine country model was transformed from the general country modelling approach to simulating production and market prices at the regional level. In particular, crop and livestock production activities were first modelled at the level of six geographic regions, i.e., East, West, South, North, Center and Crimean peninsula, and then aggregated into the country level output, whereas behavioural equations of market prices at the regional and country levels included cross-dependencies.

In 2016-2017, the partners from The Institute for Economic Research and Policy Consulting (Kyiv) and the project German Ukrainian Agricultural Policy Dialogue (Kyiv) further extended the Ukraine country model. In particular, crops production was split into five regions according to agri-climatic and socio-economic classification of the country's territory and five producer groups. Based on this extension and following multiple workshops with market experts (APD, 2021) that aimed at verifying the projections, the Agricultural Outlook Ukraine 2017-2030 (Bogonos and Stepaniuk, 2017) was developed. The model was as well used for analysing several policy scenarios such as, for example, on the impacts of more effective regulation in the agricultural sector (Bogonos and Pylaieva, 2017).

4.3 Database update

The database of the Ukraine country-model starts from 1992. For the current study it has been updated until 2019 and, where possible, 2020. The series include observations on production (e.g., crops yields and area harvested, livestock number and crop, slaughter weight, production of oilseed oils and meals), domestic use (e.g., use for feed, human consumption and processing, losses), prices, change in stocks, import and export. Observations on most of the domestic market prices and supply components were obtained from the State Statistics Service of Ukraine. For quantities exported and imported, components of domestic use and domestic prices for oilseed oils and meals, FAOSTAT and statistics of the International Trade Centre were used.

The projections of the agricultural commodity balances in AGMEMOD are based on the number of factors, including agricultural and trade policies, production costs, world market prices of the agricultural commodities, and macroeconomic indicators such as, for example, national GDP, GDP deflator, currency exchange rate and population. These are exogenous variables, i.e. variables that are not computed or projected by the model. Their observed and projected values are collected from various external sources and implemented into the model as a separate component representing modelling assumptions. For example, the series on annual values of the exchange rate of Ukrainian Hryvnya (UAH) to United States Dollar (USD) ([11]) were collected from the National Bank of Ukraine statistics, whereas its projected changes as well as data and projections on GDP, GDP deflator and population in Ukraine were collected from the National Agricultural Statistics Service of the United States Department of Agriculture (USDA, 2020). The agricultural trade policy of 2017 and beyond is represented in the database with FTA agreements, e.g., with the EU and Canada (FTA, 2017; FTA, 2014), and the law of Ukraine on customs duties (LoU, 2020d). Other factors such as, for example, values of foreign investments in agriculture and socio-political conditions are not directly represented in the model. Instead, their impacts are partially captured by the estimates of time series regressions, representing the behaviour of economic agents in agriculture.

Agricultural policy support in Ukraine until 2021 consisted of two major instruments: (i) payments, which were targeted either on specific farming/entrepreneurial activities (e.g., the partial refunding of interest paid for agricultural loans) or on specific sectors or types of agricultural producers (e.g., payments to newly established farms and support of livestock production) (see section 3), and (ii) zero VAT on exported goods. While the latter instrument, although not explicitly defined in the behavioural functions of the Ukraine country model, is inherent in the estimations due to its continuity and applicability to the commodities modelled, we assume that the direct payments have had only marginal effects on Ukraine's agricultural production. Because the targets of these payments have changed rather often (LoU, 2020c; LoU, 2019; LoU, 2018b; LoU, 2017), medium- and long-term effectiveness of such support may be limited, and conducting of the respective impact analysis merely possible. Furthermore, as some of the payments refer to rather specific farming activities and the respective data are

([11]) The exchange rate of UAH to EUR is calculated based on the EUR/USD exchange rate used in the EU Agricultural Outlook 2019.

not available at the commodity level, their quantification for the use in the model may be prone to considerable errors. Finally, according to OECD (2020), the producer support estimate (PSE) in Ukraine in 2011-2020 ranged from -3.86% to 2.96% of gross farm receipts. This is low compared to other countries, especially when compared to the PSE of the same period in the EU, which ranged from a minimum of 17.27% to a maximum of 19.66%, and in 'the OECD total', which ranged between 16.36% to 18.72%. Therefore, considering the before mentioned, direct monetary support to the Ukrainian producers has not been included in the modelling assumptions for 2021-2030, neither has been explicitly accounted for when estimating the equations.

Although the model allows for running simulations for the values of the world market prices, the current study is conducted within the general frameworks of the OECD-FAO and the EU Agricultural Outlooks. Accordingly, the historical and projected values of the world market prices for the commodities analysed correspond to those of the EU Agricultural Outlook 2019-2030 (EC, 2019).

Another group of assumptions is related to production costs (SSSU, 2019-2008). In particular, real costs for producing crop and livestock commodities are included in the behavioural equations, which represent the supply side of the agricultural markets. These costs comprise payments for rented land and property, labour, fodder, seeds, fertilizers, fuel, depreciation, as well as expenses on additional materials such as disinfectants, services and veterinary treatment. Their real values are assumed to remain at the level of 2019 throughout the entire projection period.

4.4 Update of behavioural functions

As it has already been mentioned in the previous chapters, the AGMEMOD model produces market projections based on the functions representing behaviour of the market agents and equalities. The latter are computations which represent production or market balances in equilibrium. For example, quantity of total milk produced equals the number of dairy cows times their productivity. This type of functions often includes outputs of behavioural equations and do not require updates unless certain structural changes in the sector or the model have taken place. The behavioural equations, on the contrary, are estimated econometrically and refer to such variables as, for example, market prices, consumption per capita, quantities exported and imported, crop yields and areas, processing coefficients, number of livestock slaughtered and discarded, number of young animals and production of eggs and poultry meat. Their periodic update is necessary in order to capture recent developments of the sector. Therefore, in the current study the behavioural functions in the Ukraine country model were re-estimated in order to account for the most recent data available, i.e., until 2019 and, where possible, 2020.

To estimate the equations that represent production, panel data were used. These data included observations for the period of 2008-2019 (2020) for 24 administrative regions of Ukraine. Because the sample size was around 264 observations, inclusion of additional variables such as production costs was possible, and statistical significance of the estimates improved compared to using the time series data (number of observations of which covered the period 1990-2019 (2020) and, thus, did not exceed 30). The equations were estimated as linear regressions.

Data processing preceded the estimation. It included detection of inconsistencies and outliers. The inconsistencies referred mostly to the mismatches in the balances at regional and country levels. For example, the product of animal slaughter weight and number of animals slaughtered did not equal the total weight of animals slaughtered in the region or country. Such inconsistencies were dealt with by adjusting the primary values, i.e., slaughter weight and/or number of animals slaughtered, to the respective values of the neighbouring regions or average values at the country level. Many of the outliers detected referred to specialisation of the region. Therefore, they were only removed from the sample if they had considerably worsened the overall fit of the regression.

The regressions fitting followed four steps. First, the hypotheses on the potential relationship between the dependent and explanatory variables were formed based on microeconomic theory, sector characteristics and information provided by the market experts and producers via personal communication. Next, these relationships were analysed graphically. At the third stage, the variables were tested for autocorrelation. Fourth, the estimation results were analysed for general fit of the model, statistical significance and compliance with the economic theory. Based on this analysis, the equations with greater statistical reliability and which better described the current and expected trends of the dependent variables were introduced into the AGMEMOD model.

In some cases, the regressions had to be estimated from time series instead of panel data. For example, data analysis demonstrated that in 2016-2019 around 73% of chicken eggs and 52% of chicken meat production

were concentrated in 3 and 5, respectively, administrative regions of Ukraine. When using panel data, this led to low statistical significance of the explanatory variables and the regressions themselves. Therefore, time series data at the country level were used.

In AGMEMOD, crop production is defined as a product of yield and area harvested of this crop. The allocation of agricultural land among various crops and grassland is based on a group-wise substitution approach and expressed as proportions. For example, change in total oilseeds area determines the areas of cereals, fruits and vegetables, industrial crops and grassland, all expressed as proportions of total UAA. Crops which belong to one group, e.g., rapeseed, sunflower and soya beans, compete with each other for the land area within this group, i.e., oilseeds area. Areas of oilseeds and cereals are substitutes. Their behavioural equations, as well as the equations representing area shares of specific crops within these groups, were updated in the Ukraine country model. They include gross market returns ([12]), variables that serve as proxy of crops profitability, and thus play a significant role in defining the substitution rates. Gross market returns are included in crop yields functions as well. They represent the incentive to intensify the production, i.e., the greater the gross market returns are, the greater is the incentive to increase the yield. Because in some cases the estimation of relationship between yield or area harvested and gross market returns did not provide with feasible results, the latter was replaced with market prices.

In the livestock sector, behavioural functions estimated from panel data include livestock reproduction rates, number of slaughtered animals, average slaughter weight and average annual milk yield per dairy cow. Gross market returns are included in these regressions as well. If the relationship was found insignificant, domestic market prices and some of the production costs were used as explanatory variables instead.

Behavioural functions for acreage of oilseed and cereal crops, as well as for animal numbers estimated from panel data are introduced into the AGMEMOD model together with a multiplication factor. This factor represents the number of administrative regions, and allows the correction of the average values per region produced by the panel data regressions to the level of the entire country, as required by the model.

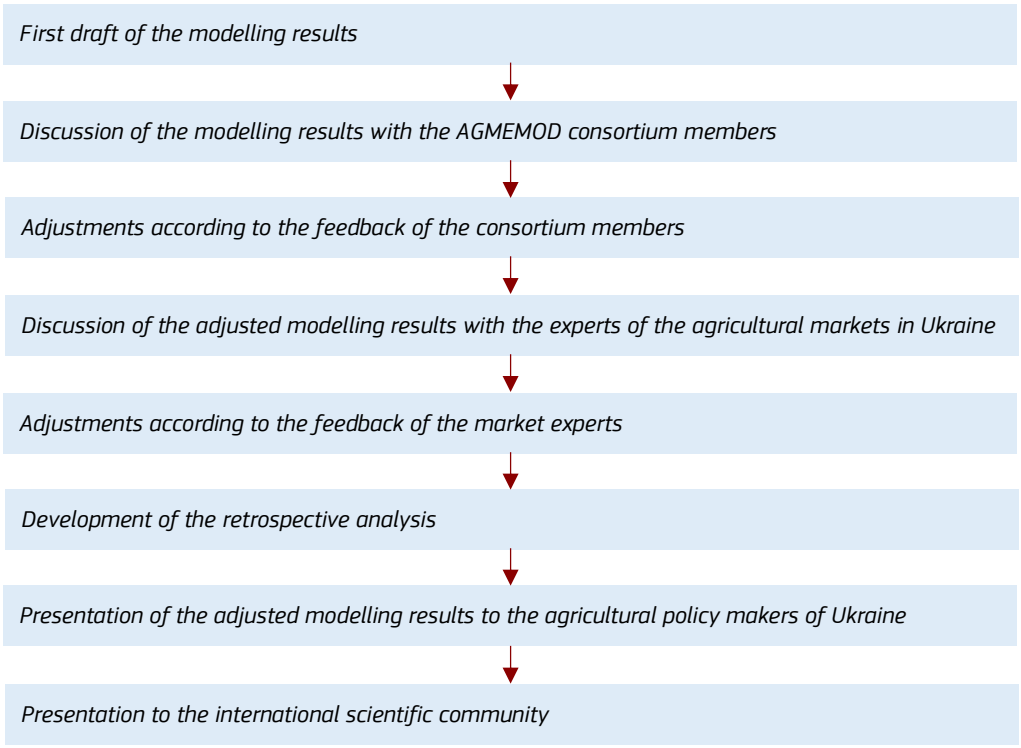
Per capita consumption, feed use, losses, processing use, other factory use, processing coefficients, domestic market prices, quantities exported, imported and changes in stocks were estimated from time series data with ordinary least squares (OLS). The respective functions include various independent variables which explain the behaviour of the regressands with regard to the economic theory and statistical significance. For example, the regressions fit for the domestic market prices include the respective world market prices, self-sufficiency rate and exchange rate of national currency to USD or EUR; the regressions fit for per capita consumption include real values of the domestic market prices and of GDP per capita. Logarithmic trend and dummy variables are used in the behavioural equations estimated from time series, as well as panel data. They allow accounting for technological changes and unusual events affecting the sector (e.g., Ukraine's 2014 Revolution of Dignity).

4.5 Validation of the projections

Validation is an integral part of the development of the AGMEMOD projections. It aims at assuring, to the degree possible, the plausibility of the projections. Validation of the current projections followed in principle a similar approach as the standard AGMEMOD Outlook validation process (Salamon et al., 2019; Salamon et al., 2008). In particular, after the first projections had been produced, they were presented to the panel of AGMEMOD Consortium members. This internal validation aimed at discussing methodological and data issues, and the possible pitfalls which can normally occur when the projections are not produced frequently (as the last AGMEMOD Outlook for Ukraine was produced in 2016 (Bogonos and Stepaniuk, 2017). Next, the baseline was adjusted according to the comments of the internal reviewers, and then discussed at the round table with agricultural market experts of Ukraine. After introducing the market expert knowledge into the projections, the outlook was then presented to a group of agricultural policy makers of Ukraine. This presentation did not only include the market projections, but also the retrospective analysis. In particular, the model was run for projecting production, trade and prices in 2014-2019, and the outcome was compared to the respective values observed. Such examination has provided with a background of model performance and demonstrated its fit for the current purpose. Finally, the adjusted and verified projections were presented to an international community of agricultural researchers and analysists which provided additional feedback, interpretations and perspectives in the context of the agricultural sector trends in the world. A schematic representation of the validation process is depicted in Figure 4.

([12]) Defined as sum of market prices, public support and negative of production costs. Production costs, domestic market prices, public support and, consequently, gross market returns introduced into the regressions represent real values. In particular, they are deflated with the GDP deflator with 2000 as the base year.

Figure 4. Validation process of the agricultural and food markets projections for Ukraine until 2030



Source: Own elaboration

5 Market outlook for Ukraine

The current section presents the outlook for the major agricultural commodity markets in Ukraine until 2030. The cereal markets include wheat, maize, barley, rye and oats, and the oilseed markets refer to the seeds, oils and meals of sunflower, rapeseed and soya. Livestock commodities analysed are beef, pork, cow milk, poultry meat and eggs. The outlook rests upon a set of assumptions described in section 4.

Box 1. Impacts of the COVID-19 pandemic

The implications of the COVID-19 pandemic were analysed by comparing the projections based on the "pre-COVID", to the projections based on the "COVID" future values of the exogenous variables. The "pre-COVID" development of the exogenous variables were generated in 2019. The "COVID" future values of the national macroeconomic indicators and the world market prices for agricultural commodities and crude oil included the changes occurred in 2020. The values were assumed to recover gradually and depending on the magnitude of the shock.

The examination of impacts of the pandemic on the Ukrainian agriculture has demonstrated the resilience of the agricultural commodities production and export in the longer term. Thus, although production, trade and domestic use were affected in the short-term, mainly due to changes in the commodity prices and GDP, the impacts in the mid- and longer terms, i.e., 2025 and 2030, respectively, were marginal.

The resilience of the export-oriented growing industries (e.g., cereals and oilseeds) may be attributed to favourable gross margins before and during the pandemic. The absence of major shifts in the sectors which have already been declining, i.e., cattle and swine, may possibly be explained by the fact that the existing unfavourable circumstances were neither shattered nor enforced by the COVID-19 crisis to the extent noticeable at the country level.

Figure: Areas of oilseeds and cereals under "COVID" and "pre-COVID" scenarios (1000 hectares)

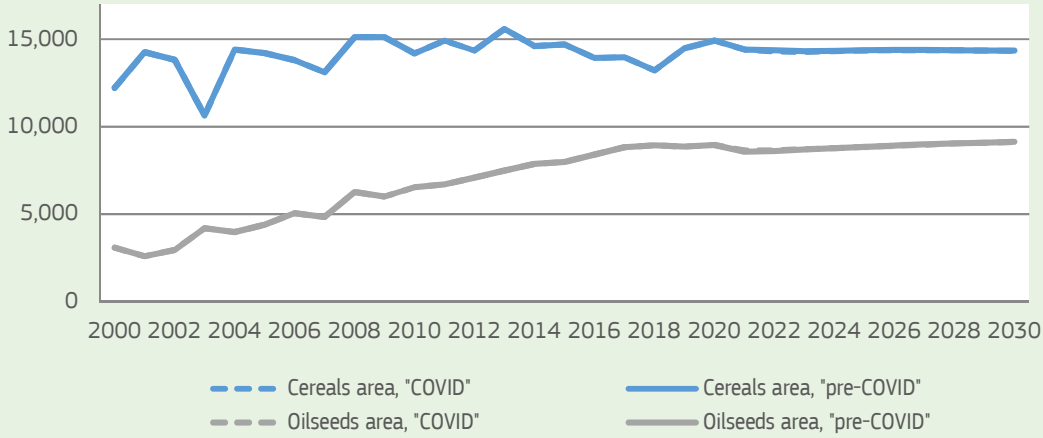
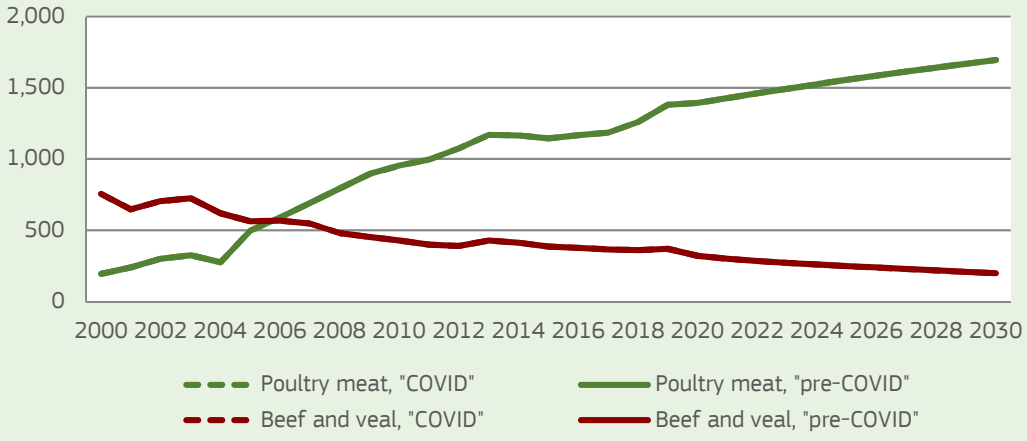


Figure: Production of beef and veal and poultry meat under "COVID" and "pre-COVID" scenarios (1000 tonnes)

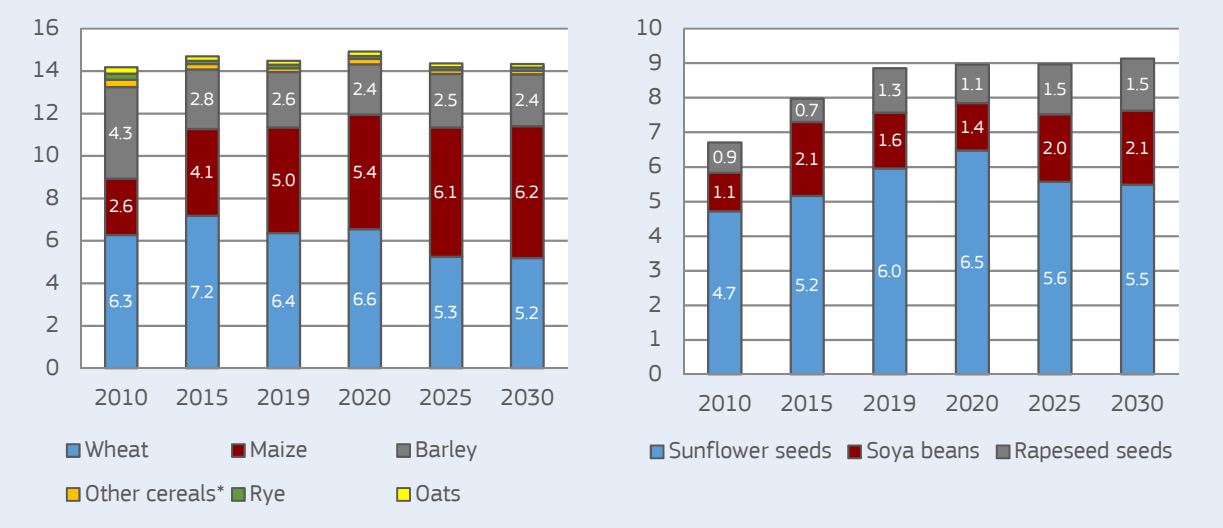


5.1 Arable crops

By 2030 total cereals area harvested is projected to remain nearly unchanged compared to the last decade: 14.3 million hectares. Total oilseeds area, however, is expected to grow. The latter may reach 9.1 million hectares, which is 4.3% more compared to the respective average in 2016-2019. The increase will mainly be driven by growth of soya beans and rapeseed areas: respectively, to 2.1 and 1.5 million hectares (+19.2% and +69.8% compared to the respective average values of 2016-2019). Although sunflower will partially be substituted by rapeseed and soya beans, it will continue to be produced on the largest share of the total oilseeds area: around 5.5 million hectares in 2030. Growth of demand for feed and relative changes in the market prices significantly contribute to these trends (see Annex 2 for market prices in Ukraine).

Despite relative stability of the total cereals area, the areas of specific cereals will change. The most significant change is projected for the area harvested of maize: from 5.0 in 2019 to 6.2 million hectares in 2030. Maize will substitute wheat and barley, where the areas are projected to decline by 18.5% (to 5.2 million hectares) and 6.2% (to 2.5 million hectares), respectively, compared to the 2016-2019 average. The increase in maize area follows, among other reasons, climate change adaptation. With the expansion of on average warmer weather to the north, maize can now be successfully integrated into the crop rotation and cultivated in more regions compared to two decades ago (Tarariko et al., 2017). Figure 5 presents the observed and projected changes in the areas harvested of the main arable crops in Ukraine.

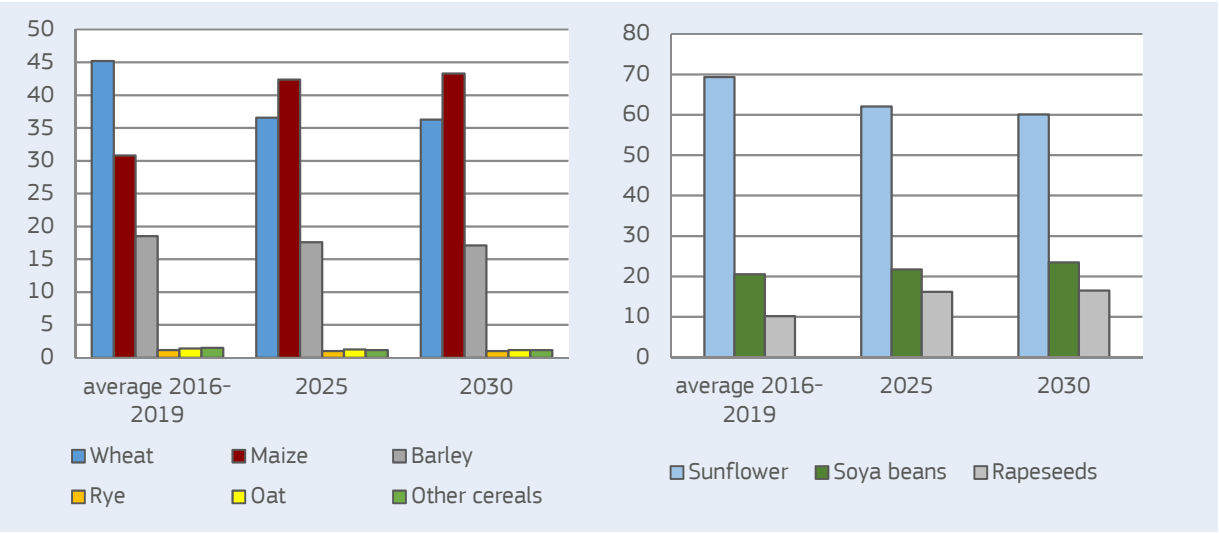
Figure 5. Observed and projected areas harvested of cereals and oilseeds, million hectares



* – other cereals include rice, buckwheat and millet

As presented in Figure 6, the share of wheat in the total cereals area will decline from 45.2% in 2016-2019 to 36.3% in 2030 and of barley from 18.5% to 17.1%, allowing maize to increase from 30.8% to 43.3% and become the major cereal in the country. By 2030, the share of sunflower in the total oilseeds area is expected to decline from 69.3% in 2016-2019 to 60.0%. Conversely, the shares of rapeseed and soya beans areas are projected to increase from 10.2% to 16.5% and from 20.5% to 23.4%, respectively.

Figure 6. Shares of crops in the total cereals and oilseeds areas, %



5.1.1 Cereals

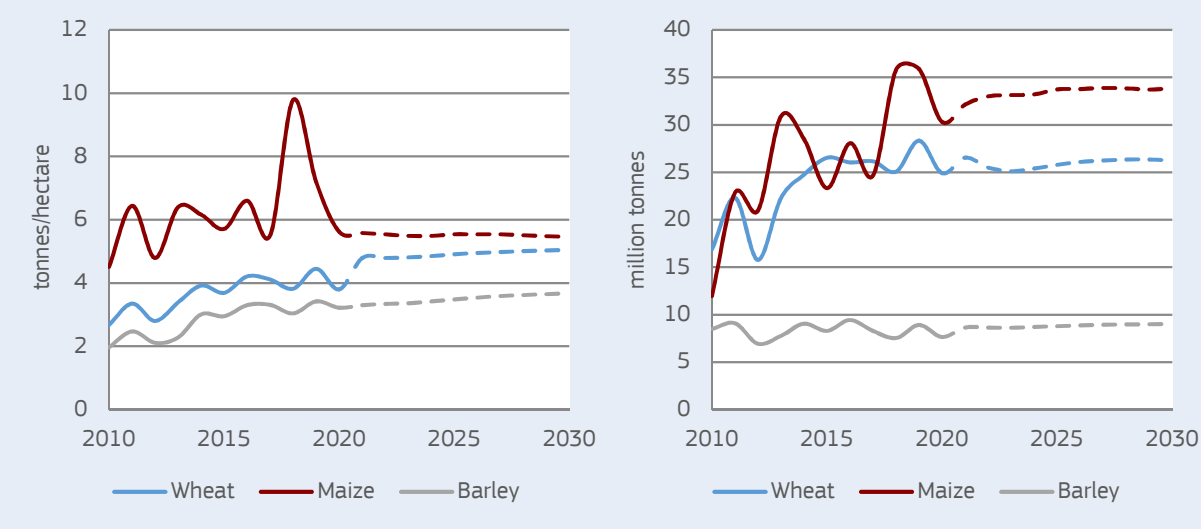
By 2030, total cereals production in Ukraine is projected to increase by 4.4% (to 70.5 million tonnes) compared to the 2016-2019 average. This increase is attributed mainly to the growth of maize production (from 31.1 million tonnes in 2016-2019 to 33.9 million tonnes in 2030) which especially results from a significant expansion of the area harvested. Maize yield, on the contrary, is expected to remain at around its 2010-2017 ([13]) average level. Significant annual weather fluctuations which increase yield uncertainty on the one hand, and a possibility to compensate lower yields with greater areas on the other hand, result in refraining from yield intensification beyond the general trend of technology improvement, e.g., availability of better quality seeding materials (Melnyk et al., 2017). Along with maize, production of barley, rye and oats is expected to increase as well. In particular, barley production will grow to 9.0 million tonnes (+5.5% compared with the average of 2016-2019), rye production to 482.2 thousand tonnes (+4.9% compared with the average of 2016-2019) and oats production to 469.1 thousand tonnes (+2.0% compared with the average of 2016-2019). Such growth will result from improvement of the yields.

Compared to the change in area harvested of wheat (-18.5%), the change in production of wheat will be moderate, decreasing from 28.3 in 2016-2019 to 26.2 million tonnes in 2030 (-0.6%) due the growth in yield. With climate change narrowing the area where wheat can be cultivated successfully, intensification of wheat production is expected to take place (improvement of seeding materials, farming and cultivation practices and an ongoing farm structural change (Nivievskyi et al., 2015; USAID, 2020; Balmann et al., 2013). Thus, by 2030 the yield is expected to increase to 5.1 tonnes per hectare, i.e., by 21.8% as compared to the average of 2016-2019.

Figure 7 demonstrates observed and projected changes in yield and production of the main cereals in 2010-2030 in Ukraine.

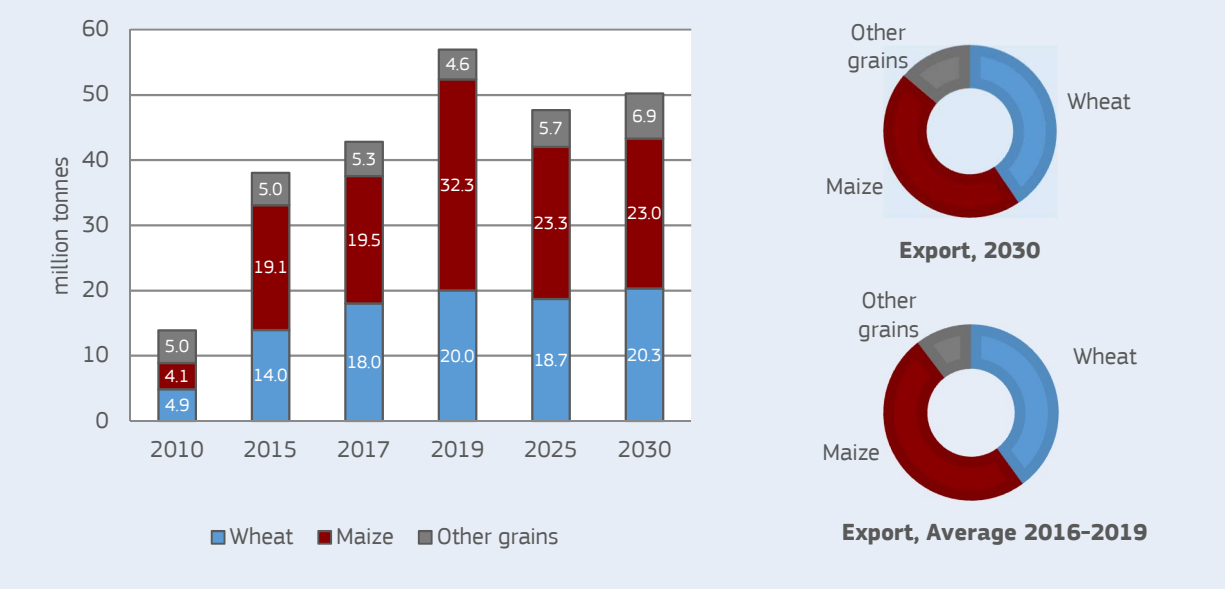
([13]) 2018 and 2019 were the years with exceptionally high maize yields.

Figure 7. Yield and production of the main cereals



Export of cereals will follow the expanding production and grow from 45.6 million tonnes in 2016-2019 to 50.2 million tonnes in 2030. In particular, exports of the main cereals, i.e., wheat, maize and barley, are expected to increase, respectively, by 11.5%, 1.2% and from 4.5 to 6.7 million tonnes. The share of maize in the total export quantity is projected to decline by 4%, whereas for wheat and other cereals it is expected to grow by 0.5% and 3.4%, respectively. Import quantities of wheat, maize, oats and barley are expected to remain less than 0.3% of the respective export quantities. Figure 8 shows the changes in export quantities and export structure of grains.

Figure 8. Changes in quantities exported and export structure



The rather moderate growth in maize exports compared to the growth in production can be attributed to growing domestic demand. In particular, the expected positive development of the poultry sector (see the section on outlook for livestock) and the resulting increase in demand for poultry feed will lead to a higher rate of maize use at the domestic market and, therefore, lower growth of maize export. The increase in export of wheat follows changes in the domestic demand as well, as domestic demand decreases due to a decline in domestic use of wheat for feed and food. In particular, lower feed use will be mainly an outcome of a decreasing dairy

cows herd (see the section on outlook for livestock), and lower food use of declining total population (see section 4.1) and per capita wheat consumption ([14]).

Overall, total domestic use of cereals is expected to drop by 6.7% in 2030 compared to the average of 2016-2019. This is related to a decline in demand of wheat, barley and rye for feed use which, in turn, follows negative trends in the development of the cattle sector, and for food use which results from a declining total population and per capita consumption of wheat, maize and rye.

Box 2. Bioethanol market in Ukraine

Background

Ukraine produces all major types of fossil fuels, but in quantities it is insufficient to meet the domestic demand. Between 2014-2018, 21.6-36.9% of coal, an average of 42.5% of natural gas, 75.6-100% of gasoline and 83.5-100% of diesel supplied to the domestic market were imported (SSSU, 2020). Aiming to improve fuel self-sufficiency and following the commitments undertaken with the accession to the Energy Community ([15]), the Government of Ukraine adopted the "National Renewable Energy Action Plan for the period up to 2020" (LoU, 2020). The plan established mandatory national indicative targets for the use of renewable energy sources. In 2017, the Government approved the Energy Strategy of Ukraine until 2035 (i.e., "Security, energy efficiency, competitiveness") (CMU, 2017). It is set to achieving at least 25% share of energy from renewable sources in the total energy and fuel consumption in the country. In 2014-2019, the share of renewable energy sources in the total energy consumption changed from 2.6% to 4.6%, and the energy share from biofuels and waste from 1.8% to 3.4% (SSSU, 2020).

Analytical framework

We applied the AGMEMOD model to specifically analyse the future prospects of the biofuels market in Ukraine. As biodiesel production and use quantities in Ukraine have remained less than one thousand tonnes per year since 2013 (UABP 2021; SSSU, 2020), only the bioethanol market was considered. The database and behavioral functions representing production, use, prices and trade were included in the Ukraine country model of AGMEMOD. The data were collected from the publications of State Statistics Service of Ukraine, personal communication with the largest bioethanol producer in Ukraine, SOE "UKRSPYRT" (UKRSPYRT, 2021), and with the Ukrainian Association of Bioethanol Producers, "Ukrbioethanol" (UABP, 2021).

Bioethanol production, use, market price and trade were projected until 2030 considering the policy, social, and economic framework in Ukraine in 2020. The assumptions on the changes in the world market prices of agricultural commodities, biofuels and crude oil, population, exchange rate, GDP and GDP deflator follow those described in section 4 of this report. Future changes in the additional exogenous variable, i.e., price for gasoline in Ukraine, which plays an important role in the definition of the bioethanol price at the domestic market, were assumed to follow the annual changes of the world market price of crude oil.

Future prospects

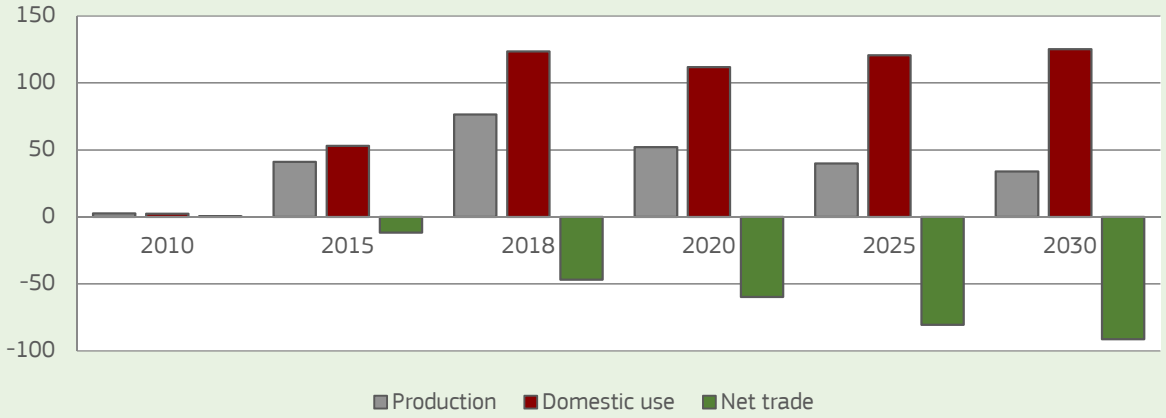
The projections show that by 2030 Ukraine will produce 33.8 thousand tonnes of bioethanol. This is considerably less than in the peak 2018-2019 and 2013 years, but nearly 19% more than in 2014-2017. These past fluctuations resulted from changes in bioethanol production from maize and sugar beet, which are, by far, the major bioethanol feedstock in Ukraine. In 2010-2016, for example, nearly 90% of bioethanol was produced from sugar beet. Because the latter is as well the major raw material for sugar production, its uses compete. Thus, when production of bioethanol increased in 2013 and 2015, production of sugar dropped. In 2018-2019, however, more than tripled quantity of maize was used for bioethanol production compared to 2014-2017. This led to an almost 178% increase in total bioethanol production. Considering the volumes of maize produced in Ukraine, further increase in its processing into bioethanol may positively affect the future development of bioethanol production.

Following the political interest in "greener" economy (DoP, 2019; ECPR, 2020; EU4E, 2021) and favorable market prices, bioethanol use is expected to grow. By 2030, it will increase to 125.3 thousand tonnes, i.e., by 30% compared to 2016-2019. The gap between the demand and production will be closed by imports, leaving Ukraine as a net importer of bioethanol.

([14]) Declining per capita consumption of wheat has been observed since 2000 and is likely to represent changes in consumer preferences (see section 2).

([15]) The Energy Community is an international organisation that brings together the EU and neighbouring countries with the aim of creating an integrated pan-European energy market.

Figure: Observed and projected values of bioethanol production, use and net trade in Ukraine, thousand tonnes



Takeaways

Future prospects for development of bioethanol production and use in Ukraine are promising. The agricultural sector in Ukraine with its vast areas of arable land, large quantities of crops produced and technological advances may relatively quickly place more focus on the production of feedstock for bioethanol. It must, however, be supported by favorable market and institutional conditions, such as, for example, the adoption of the legislation allowing (bio-)ethanol production by private companies (Dibrova et al., 2020; LoU, 1995). Furthermore, international commitments of Ukraine regarding the mitigation of greenhouse gas emissions and clean energy (e.g., RED II signed by Ukraine within the DCFTA 2014 (FTA, 2014), fuels diversification strategy (LoU, 2020) and growing domestic and global demands for renewable fuels will as well drive the development of bioethanol production.

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5.1.2 Oilseed seeds

Oilseeds production in Ukraine is projected to increase from 20.3 in 2016-2019 to 25.1 million tonnes in 2030. Production of all three major oilseed crops are projected to grow: sunflower seeds to 15.8, soya beans to 5.4 and rapeseed seeds to 3.9 million tonnes (i.e., by +14.1%, +31.7% and +65.4%, respectively, compared to the average of 2016-2019). While the growth of sunflower seeds production can be attributed to the improvement in yields, and the increase in rapeseed seeds to the growth in area harvested, soya beans production reflects the increase in both, yield and area harvested.

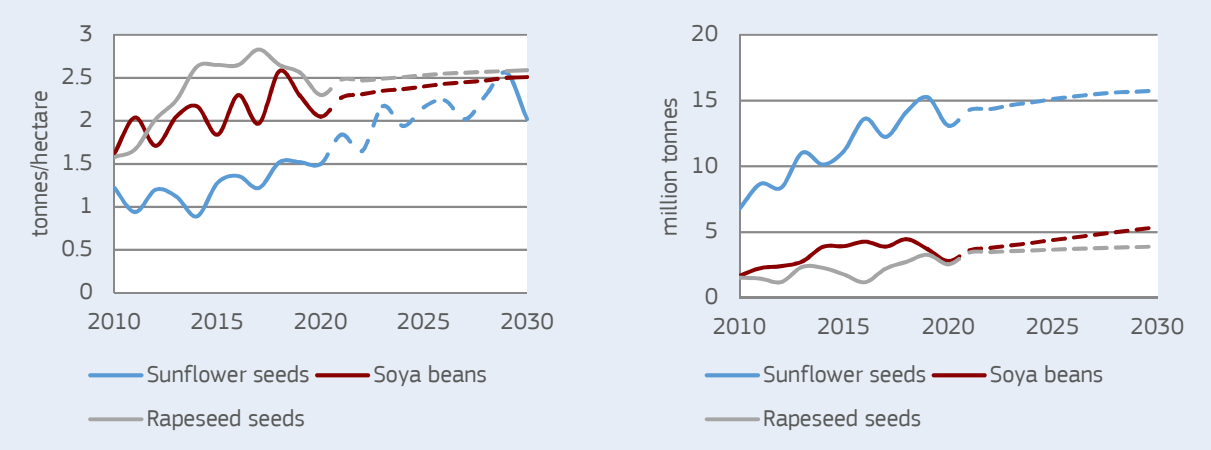
Because domestic and export demand for sunflower oil are expected to remain high, intensification of sunflower seeds production ([16]), which has already been observed in the last two decades, is projected to continue. Thus, despite the decline in area harvested, the improvement in yield which is projected to reach 2.9 tonnes per hectare by 2030 (+26.3% compared to the average of 2016-2019), will result in greater production volumes.

Along with the area, the yield of rapeseed seeds ([17]) will grow. By 2030 it is projected to reach 2.6 tonnes per hectare, and thus, support the increase in production.

With growing demand for soya beans meal from the domestic poultry sector and favourable market prices, soya beans area harvested and yield are expected to grow considerably. In particular, in 2030 increase in yield is expected to reach 9.8% (2.5 tonnes per hectare) and in area harvested 19.2% compared to the respective average values of 2016-2019.

Figure 9 shows observed and projected changes in yield and production of the main oilseed crops in Ukraine in 2010-2030.

Figure 9. Yield and production of the main oilseed crops



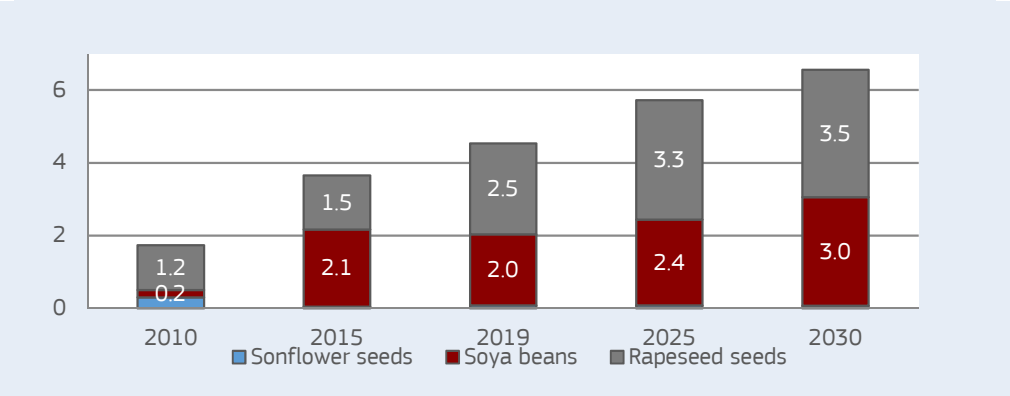
Sunflower oil is expected to continue being the major oilseeds commodity exported from Ukraine, with the share of sunflower seeds export in the total production volume remaining around 0.5% (i.e., 74 thousand tonnes). Imports of sunflower seeds to Ukraine will remain rather low as well, i.e., 45.9 thousand tonnes. Conversely, export quantities of rapeseed seeds and soya beans are projected to grow (Figure 10). Following the increase in production, export of rapeseed seeds is expected to grow to 3.5 million tonnes and of soya beans to almost

([16]) Enhanced by application of improved cultivation practices and high-yielding varieties (Melnyk et al., 2017).

([17]) Yield of rapeseed seeds in Ukraine experienced considerable annual fluctuations between 2014-2019. The lowest value was registered for 2019, i.e., 2.56 tonnes per hectare, and the highest in 2017, i.e., 2.83 tonnes per hectare. The expected until 2030 increase in the yield does not consider such fluctuations and, thus, provides with a smoothed growth rate.

3 million tonnes (i.e., an increase by 71.9% and 23.5%, respectively, compared to the average values of 2016-2019). Despite higher quantities exported, the shares of exports in the total production volumes will drop by 2030 compared to the average values of 2016-2019: from around 90% to 76.2% for rapeseed seeds and from 57.6% to 52.7% for soya beans. This is mainly due to increased demand for poultry feed at the domestic market. Imports of these commodities are expected to constitute less than 0.2% of their exports.

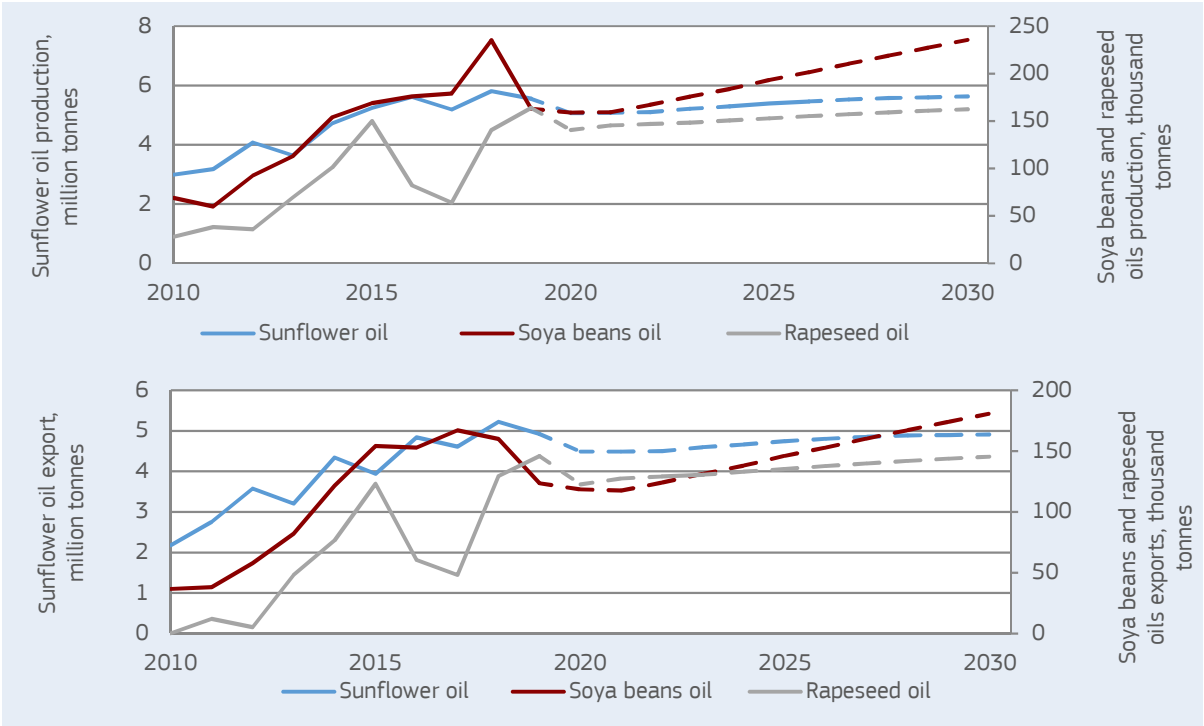
Figure 10. Export quantities of rapeseed seeds and soya beans, million tonnes



5.1.3 Oilseed oils and meals

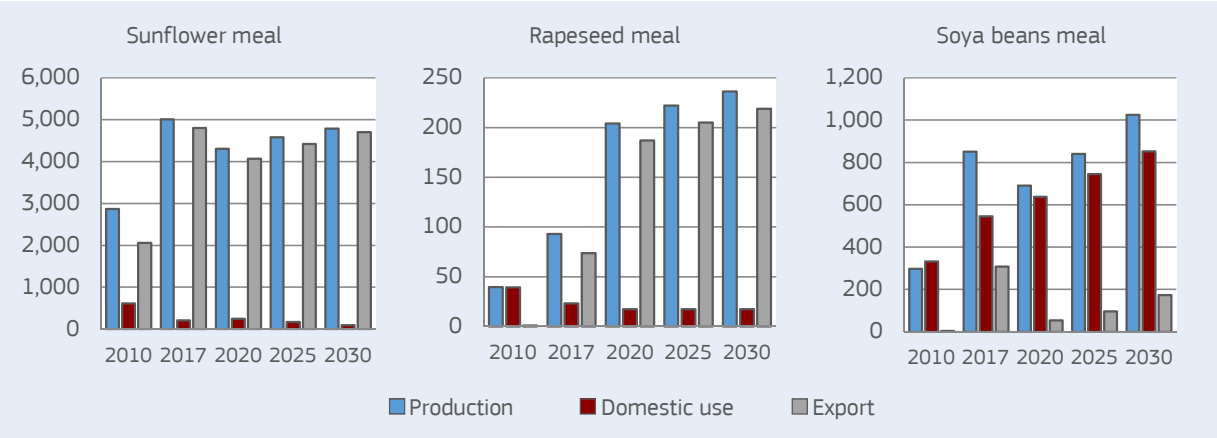
Production and exports of oilseed oils and meals are projected to continue growing until 2030 (Figure 11), following the production trends of the respective feedstocks. In particular, by 2030 production of oils from sunflower seeds, rapeseed seeds and soya beans show growth rates of 1.7%, 44.3% and 25.2%, respectively, compared to 2016-2019. Thus, sunflower oil production is projected to be 5.6, rapeseed oil 162.5, and soya bean oil 235.7 thousand tonnes. The exports will follow the production increase. In 2030, exports of sunflower, rapeseed seeds and soya beans oils will increase by, respectively, 0.3% (to 4.9 million tonnes), 51.5% (to 145.5 thousand tonnes) and 19.9% (to 180.9 thousand tonnes) compared to the average values of 2016-2019. Shares of quantities exported in the total production volumes will remain beyond 75%. Import quantities of oilseed oils are not expected to exceed one thousand tonnes each.

Figure 11. Production and export of oilseed oils



Reflecting the growth in oils production, production of oilseed meals will grow as well. In particular, in 2030 sunflower seeds meal production is projected to increase by 1.1% (to 4.8 million tonnes), rapeseed seeds meal by 47.7% (to 236.1 thousand tonnes) and soya beans meal by 20.1% (to 1.0 million tonnes) compared to the respective average values in 2016-2019. Exports of meals will increase as well, with export quantities of sunflower and rapeseed seeds meals projected to increase to, respectively, 4.7 million tonnes (+7.2% compared the average value in 2016-2019) and 219.0 thousand tonnes (+145.1% ([18]) compared the average value in 2016-2019). Export quantity of soya beans meal will be limited by the domestic demand, which is expected to nearly double until 2030 due to the development of the poultry sector (see the section on the outlook for livestock). Accordingly, soya beans meal exports decrease from 285.6 thousand tonnes in 2016-2019 to 173.7 thousand tonnes in 2030. Quantities imported of the meals of sunflower seeds, rapeseed seeds and soya beans are expected to remain less than 1% of the quantities exported. Figure 12 shows the changes in the market balances of oilseed meals in 2010-2030.

Figure 12. Production, domestic use and export of oilseed meals, thousand tonnes



5.2 Livestock

The projections show that production of cow milk, beef and pork will continue declining, whereas production of poultry meat and eggs are further growing. The former mainly reflects structural changes, and the latter benefits from economies of scale.

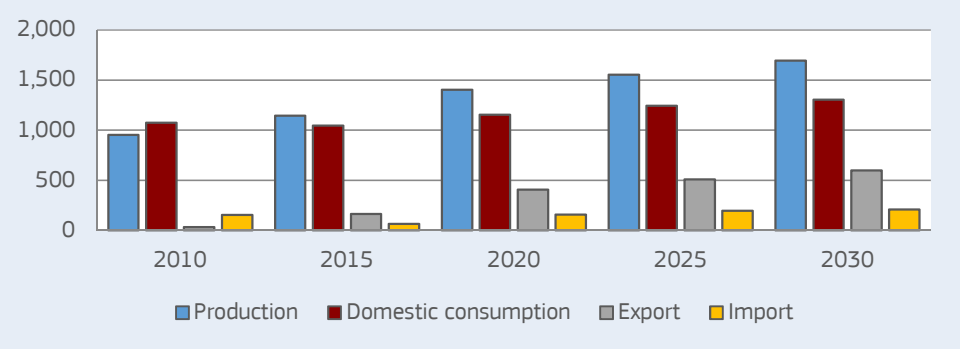
5.2.1 Poultry meat and eggs

After the stagnation period of 2013-2016 (see section 2), the trend of increasing poultry (mostly chicken) meat production has resumed. The projections until 2030 show a growth to 1.7 million tonnes, i.e., an increase by 35.8% compared to the average value of 2016-2019. The main factor contributing to this increase are positive gross margins. Poultry meat producers in Ukraine are usually large enterprises which as well produce poultry feed. This allows them to benefit from economies of scale and lower production costs (USCS, 2016). As the development of the Ukrainian economy is assumed to be positive ([19]), per capita consumption of poultry meat will continue growing and is projected to reach 32.9 kg per year by 2030 (an increase of 32.2% compared to the average value of 2016-2019). Total poultry consumption will, however, increase at a lower rate, i.e., +23.5%, because the population in Ukraine is expected to decrease.

Until 2030 Ukraine will remain a net exporter of poultry meat. Exports are expected to grow from 25.2% of total production in 2016-2019 to 35.3% in 2030, and will reach 598.5 thousand tonnes (which is a considerable increase compared to the 315.0 thousand tonnes in 2016-2019). Poultry meat imports play an important role in Ukraine's export expansion. While the internal market is supplied with cheaper poultry meat offal imported and produced domestically, more of poultry carcasses and premium cuts are exported ([20]) (Tarasevych and Gray, 2020). Figure 13 shows the market balances of poultry meat in 2010-2030.

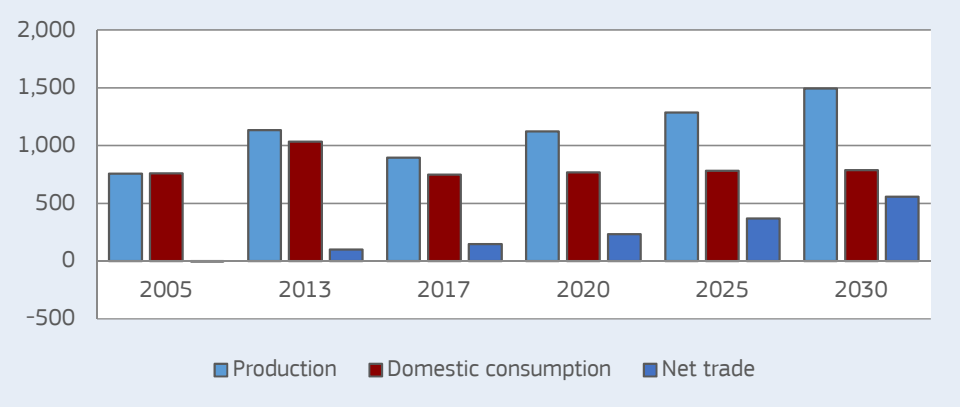
([18]) Export quantity of rapeseed seeds meal in 2016-2019 fluctuated between 73.7 (2017) and 271.2 (2019) thousand tonnes.
([19]) Steadily increasing real GDP per capita is assumed. This economic indicator is used in the model as a proxy for consumer income.
([20]) The share in imports of chicken meat of the commodity subgroup "Frozen cuts and edible offal of fowls of the species Gallus domesticus" in 2019 was 90.3% (ITC Trade Map, https://bit.ly/33oaqQY).

Figure 13. Market balances of poultry meat, thousand tonnes



The development of large-scale entrepreneurship in the poultry (i.e., chicken) sector has as well motivated the growth of poultry eggs production. The latter was observed in 2005-2013. In 2014-2016 the sector stagnated due to the socio-economic crisis in the country, but starting from 2017, the positive development resumed. The projections until 2030 indicate growth of eggs production to 1.5 million tonnes, which is an increase by 63.2% compared to the average value of 2016-2019. Per capita eggs consumption will grow to 320 eggs per year, and total consumption by 4% compared to the average value of 2016-2019. The substantial increase in eggs production will also lead to an increase in exports. The export share in the total production quantity is projected to grow from 17.8% in 2016-2019 to 37.6% in 2030. This will enhance the status of Ukraine as net eggs exporter. Quantities imported will remain below 1% of quantities exported. Figure 14 displays the market balances of poultry eggs in 2010-2030.

Figure 14. Market balances of poultry eggs, thousand tonnes



Box 3. Prospects for the natural honey market in Ukraine

Background

The beekeeping industry in Ukraine plays a relevant role for the country's exports and with respect to support of rural communities. Since 2000, Ukraine annually produced around 3% of the global honey quantity, and starting from 2014 more than half of its production has been exported. For example, in 2019, 69.9 thousand tonnes of honey were produced, and 78.4% of it exported. The main importers of Ukrainian honey are the European Union and United States of America. Within the EU-Ukraine DCFTA, Ukraine was granted a tariff-free import quota for honey. In 2014-2019 the quota ranged from 5 to 8.1 thousand tonnes and the above-quota tariff was 17.3%. In 2019, honey exports to the EU reached 44.2 thousand tonnes which was 70.5% higher than in 2014 and 5.5 times above the tariff-free quota (FTA, 2014; SSSU, 2020; FAOSTAT, 2020; ITC, 2019; Regulation (EU), 2017).

More than 90% of honey in Ukraine is produced by rural households. These households are non-specialised honey producers, who market their produce directly to the consumers and to honey collecting enterprises. Public monetary support of this sector is not regular. In 2020, beekeepers who kept more than 10 apiaries were subject to direct payments of 200 UAH (around 7.02 EUR (NBU, 2021) per apiary with a maximum of 60 thousand UAH per beekeeper. In 2019, however, no such support was granted (SSSU, 2020; CMU, 2020).

Analytical framework and data

To analyse the potential of the future development of beekeeping and honey production in Ukraine, the mid-term projections for the number of bee colonies, honey production, use and trade were produced. These projections were estimated with the AGMEMOD model. In particular, the current version of the Ukraine country model of AGMEMOD was extended to include the beekeeping sector.

Honey production, use, trade, market price and the number of bee colonies were projected until 2030 under the assumption that the general policy, social and economic frameworks in Ukraine will remain as in 2020. Major data sources included the State Statistics Service of Ukraine and FAOSTAT. Observed and future values of population, exchange rate, GDP and GDP deflator were collected from the statistical database of USDA (see section 4 of this report). Historical values of the additional exogenous variable, i.e., the export price of honey, which plays an important role in the definition of the respective domestic market price (due to the high share of honey exported in the total production quantity), were calculated as weighted average of honey market prices in 17 countries: 15 EU member states and the USA as the major importers of Ukrainian honey and China as the country with the leading positions in both the global honey production and exports. The changes until 2030 of this export price were assumed to follow the logarithmic trend. Using the available data, behavioural equations representing the Ukrainian honey sector were estimated.

Future prospects

Following the projections, by 2030 the production of natural honey in Ukraine will increase to 75.8 thousand tonnes. This growth will mostly be driven by a positive development in the productivity of the honey bee colonies (see Figure below). In particular, the productivity is expected to grow by 6.2% compared to the average value of 2016-2019. It will follow the already observed trend of technology improvement, e.g., improvements in bee feeding materials and bee and beehive management practices. Limited availability of forage sources for honey bees, e.g., forests, agricultural fields with bee-pollinated crops and with reduced pesticides application, will likely be among the key factors hindering positive future changes in the number of honey bee colonies. Therefore, after the peak in 2020, which was driven by the direct subsidy, the number of bee colonies is projected to slowly decline. Because by the time of conducting this analysis the continuation of subsidies for honey production was still under discussion, the public support was not included in the modelling assumptions for 2021-2030.

Figure. Observed and expected values of average productivity of a honey bee colony and total number of honey bee colonies in Ukraine

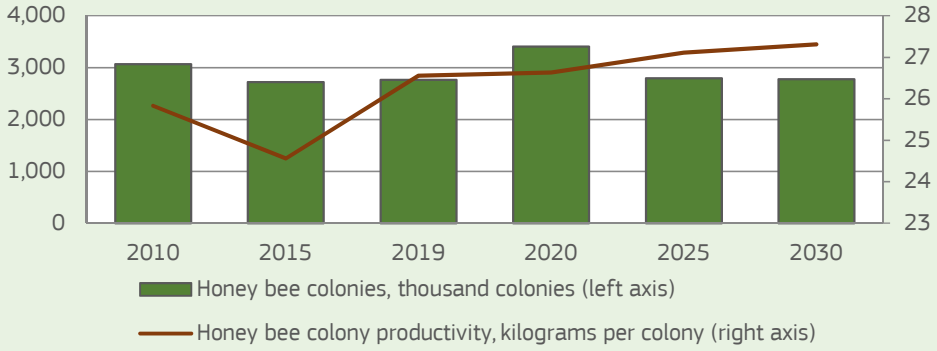
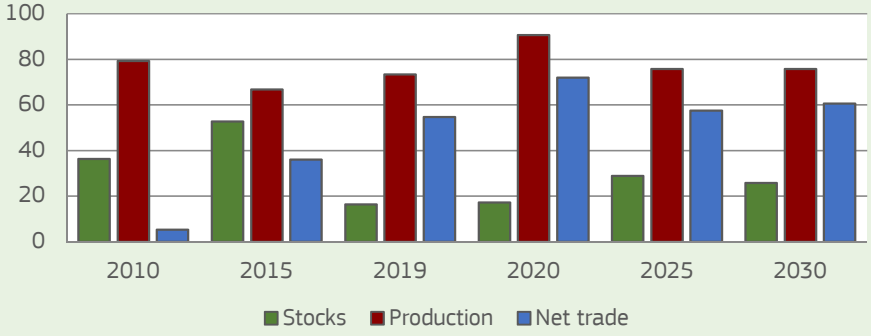


Figure. Observed and expected values of natural honey production, stocks and net trade, thousand tonnes



As production will grow and domestic use will decrease due to the decline in population and stable per capita honey consumption, exports of natural honey will increase (see Figure above). By 2030, exports are projected to grow by 6.0% compared to the average value in 2016-2019. Disregarding the 2020 spike in export quantity (as a result of subsidised production) and due to the rather low import quantity projected, the future development of the net trade volume of natural honey in Ukraine will follow a steadily increasing trend.

Caveats

Because two statistical databases, i.e., State Statistics Service of Ukraine (SSSU) and FAOSTAT, were used to construct the database, market balancing required additional efforts. Firstly, the original time series on the number of honey bee colonies were increased by 5%. This percentage was the data collection error recognised by the data source, i.e., SSSU. It was assumed to represent underestimation in the population size. In this way the fit of the supply side of the database to the assumption of market equilibrium was improved. Since most of the honey in Ukraine is produced by rural households, which are rather challenging to collect the data from, this assumption holds a certain level of viability. Secondly, quantities of honey in stocks were calculated in order to achieve equilibrium on the honey market for each of the observed years. Although the discrepancies in the time series have been dealt with maximum accuracy, the analysis may still reflect the imprecisions of the database.

Takeaways

The projection results together with the past trends in the development of the Ukrainian beekeeping industry suggest that natural honey production and exports will gradually grow. Considering the absence of evidence for a positive development of honey consumption in Ukraine, the share of exports in the total production quantity will remain rather high, i.e., around 80%.

Financial support has demonstrated to have considerable potential in providing further impetus to the development of the beekeeping industry. Its long-term positive impact, however, may be hindered by the general unfavourable factors for the sector, such as, for example, reduction of forage sources, intensive use of pesticides on the crop fields and climate change. Therefore, improving the general conditions for beekeeping may have significant positive effects on honey production in Ukraine and could further enhance the projected increase in production and exports, whereas their degradation may turn the development trend downwards.

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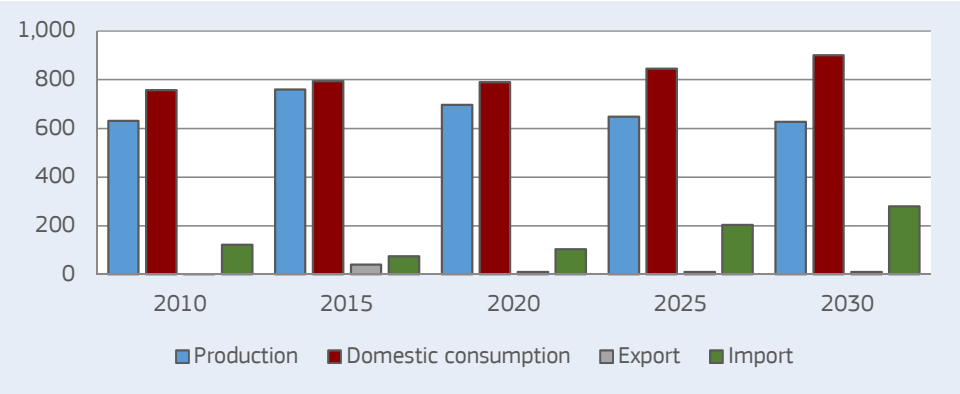
5.2.2 Pig meat

According to the projections, pig meat production in Ukraine will decrease from an average of 722.3 thousand tonnes in 2016-2019 to 630.0 thousand tonnes in 2030 (-12.8%). The reasons for this decline are negative developments in average slaughter weight and swine herd. In particular, the number of pigs is expected to drop to 4.3 million heads (-33.7% compared to the average 2016-2019) and slaughter weight to 85.6 kg (-1.6%

compared to the average 2016-2019). A decreasing number of swine producers as a result of rural households exiting the sector and challenging gross margins are among the key reasons for these negative trends.

Since 2003, pork consumption in Ukraine has outpaced the domestic production. This trend is expected to continue. With improving consumer income ([21]) (SSSU, 2020b), per capita pork consumption is projected to increase from 19.3 kg per year in 2016-2019 to 22.7 kg per year in 2030. This implies an increase in total domestic pork consumption by 10.5%. The widening gap between domestic production and consumption will result in quantities imported growing from 102.0 thousand tonnes in 2016-2019 to 280.3 thousand tonnes in 2030. With rather low exports (i.e., below 4% of quantities imported), Ukraine is expected to remain a net importer of pig meat. Figure 15 shows the market balances of pig meat in 2010-2030.

Figure 15. Market balances of pig meat, thousand tonnes



5.2.3 Beef and cow milk production

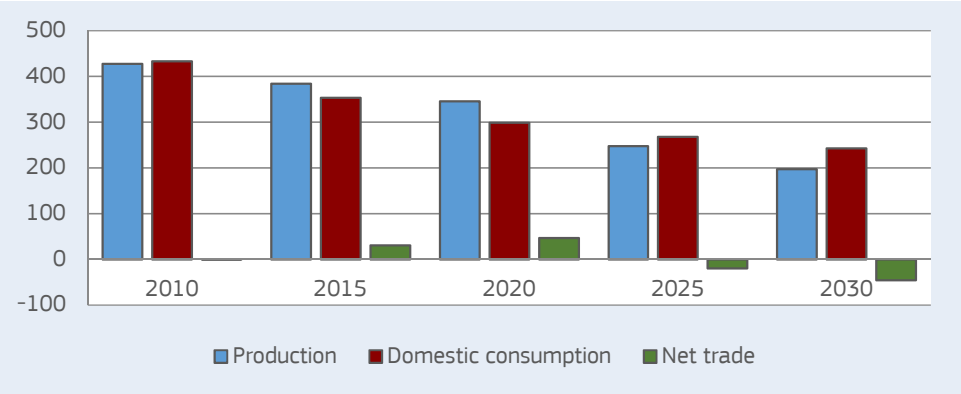
Currently, cow milk and beef (and veal) production in Ukraine are strongly linked. The latter is, to a large extent, a by-product of the former, especially at the rural households, which in 2019 produced 72.3% of beef and 71.8 % of cow milk (SSSU, 2020c; SSSU, 2020b). Therefore, the developments of both industries can be explained by the same underlying reasons.

Following the records of market prices and production costs of the State Statistical Service of Ukraine, gross margins of cattle rearing have since long ago been following a negative trend (SSSU, 2020b). Together with the assumed status quo in agricultural and trade policies, and increasing inflation of the national currency, the gross margins are not expected to improve over the projection period (see Annex 2 for market prices). Consequently, the cattle sector in Ukraine is not expected to expand.

The projections show that the total cattle herd (including dairy cows) and number of cattle slaughtered will continue declining, by 50.5% and 45.8%, respectively, by 2030 compared to the 2016-2019 average. As cattle slaughter weight will remain nearly unchanged, total quantity of beef production is expected to drop from 367.3 thousand tonnes in 2016-2019 to 197.4 thousand tonnes in 2030. Because the quantity of beef consumed is expected to exceed the quantity produced, Ukraine will become a net importer of beef. Net trade of cattle meat is projected to change from net exports of 39.3 thousand tonnes in 2016-2019 to net imports of 45.6 thousand tonnes in 2030 (Figure 16).

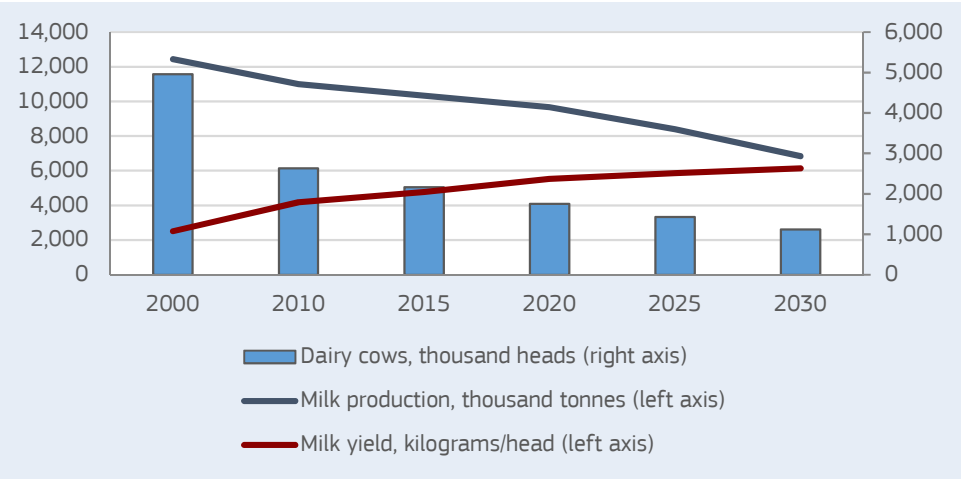
([21]) Income of consumers is represented by GDP per capita.

Figure 16. Market balances of beef and veal, thousand tonnes



Although milk yield per cow and year is expected to grow from 5.1 to 6.1 thousand kilograms, milk production is projected to decline from 10.0 million tonnes in 2016-2019 to 6.8 million tonnes in 2030. This is because the yield increase will not compensate for the further decline in the number of dairy cows by 43.4% in 2030 compared to the average of 2016-2019 (Figure 17).

Figure 17. Changes in the number of dairy cows, cow milk yield and production



The positive development in milk yields reflects the trend of an increasing number of specialised enterprises, as they apply relatively more efficient production technologies and rear more productive breeds of dairy cows than households. Although a similar trend exists in the beef production sector (ULF, 2021; MHP, 2021), the respective effects may not yet be visible at the country level. With further growth of such highly specialised dairy and beef producers, the future development of the respective sectors in Ukraine may take a positive turn with respect to production growths.

5.3 Comparison of the AGMEMOD and the OECD-FAO Agricultural Outlook (2021) projections for Ukraine

Compared to projections of the latest OECD-FAO Agricultural Outlook (OECD-FAO, 2021), the projections presented by AGMEMOD seem rather conservative and generally less optimistic. For example, production of wheat is not likely to exceed 26.5 million tonnes by 2030 according to the AGMEMOD projections, whereas OECD-FAO (2021) projects 35.9 million tonnes. The AGMEMOD projections for maize production is nearly 30% lower and for sunflower and rapeseed seeds almost 15% below the respective OECD-FAO projections. As regards production of livestock commodities, our outlook is also more pessimistic than the outlook of the OECD-FAO (2021) ([22]):

([22]) Projections by 2030 compared to the respective average values of 2016-2019.

- beef and veal projected by AGMEMOD -46.2%, by OECD-FAO (2021) -13.3%,
- pig meat projected by AGMEMOD -12.8%, by OECD-FAO (2021) +13.3%,
- poultry meat projected by AGMEMOD 35.8%, by OECD-FAO (2021) 45.2%,
- milk projected by AGMEMOD -31.4%, by OECD-FAO (2021) -13.2%,
- eggs projected by AGMEMOD 63.2%, by OECD-FAO (2021) 7.1%.

The reasons behind such differences are both model- and assumptions-specific. Difference in historical records, i.e., the databases, belongs to the model-specific group of reasons. For example, the average in the historical 2016-2019 acreage of cereals, oilseeds, protein and industrial crops is 4.5% lower in AGMEMOD than in the OECD-FAO (2021) outlook. While this might seem like a still moderate difference in relative terms it is considerable in absolute terms, as such a difference in cropland represents 1.2 million hectares. Thus, and because in both databases cereals and oilseeds occupy around 93% of total cropland, greater database values result in greater values of the projections of areas harvested. As projections of area harvested and of the crop yield form the projection of the quantity produced of the respective crop, differences between the underlying databases in the area harvested result in the differences between the production projections.

Another factor impacting the projections of crops production is that the area of cropland in OECD-FAO (2021) is projected to grow by 9.4% and in AGMEMOD by 3.6%. This represents the difference in the underlying assumptions of substitutability of agricultural land uses. Namely, the current AGMEMOD outlook restricts the changes between arable land, permanent crops and grassland, whereas the OECD-FAO outlook seems to be more flexible in this regard. Consequently, in AGMEMOD, projections of crop areas rely on substitution within the specific crop groups (e.g., among cereals, oilseeds, industrial and protein crops as members of 'cropland' group, and among sunflower, rapeseed and soya as members of 'oilseeds' group), rather than on growth of total cropland area. On the contrary, in the OECD-FAO outlook, growth of cropland seems to play a more prominent role in this regard. For example, in the AGMEMOD outlook, area of wheat is expected to decline from 6.4 (2016-2019 average) to 5.2 million hectares (in 2030). This results in a change of the share of wheat in the total cereals area from 45.2% to 36.3%. At the same time, maize area is expected to grow from 4.3 (2016-2019 average) to 6.2 million hectares (in 2030), and its share in the total cereals area changes from 30.8% to 43.3%. In the OECD-FAO outlook, however, both wheat and maize areas grow: from 6.5 to 7.1 million hectares and from 4.6 to 5.6 million hectares, respectively. The corresponding shares of these crops in the total OECD-FAO outlook cereals area change less drastically, from 44.6% to 44.0% for wheat and from 31.3% to 34.2% for maize.

In addition to the abovementioned, it is clear that the differences among the trends projected by the two outlooks are also based on the expectations regarding the impacts of various exogenous factors, implicitly or explicitly included in the estimations. Factors explicitly included in the estimations usually are projections of the GDP, GDP deflator, crude oil prices, population, currency exchange rates, domestic policies, etc. As they differ between the two outlooks, the projections differ as well. Factors implicitly included in the estimations are, for example, climate change and extreme weather events. In the current AGMEMOD outlook, climate change related impacts pose challenges to wheat cultivation and do not have considerable negative effects on maize growth. Therefore, projections for area of maize cultivation are quite positive. Since in OECD-FAO (2021) area of wheat continues to grow, it is likely that negative climate change related impacts are not as strong and/or factors positively affecting the wheat area have been given greater weights for the projections. Furthermore, while total oilseeds areas projected by the two outlooks are quite close (6.2% difference in absolute value terms ([23]), the AGMEMOD outlook expects considerable growth in soya cultivation, whereas the OECD-FAO (2021) projects a decline in soya production. In the AGMEMOD outlook, Ukraine is expected to respond to the growing domestic demand for protein feed of the poultry (mostly chicken) sector and to keep up with the respective global trends by cultivating more soya. OECD-FAO (2021), on the contrary, expects Ukraine to further strengthen its positions in sunflower and rapeseed production sectors.

The discussion so far focused on crop areas as explanation for the differences in crop production. Crop yields have been omitted, because with the exception of maize yield, the respective projections are quite close. For example, the difference in the projections for yields between the current AGMEMOD outlook and the OECD-FAO outlook is 0.6% for wheat, for soya beans -5.3%, and for other oilseeds 0.4%. The yield growth rates from the average of 2016-2019 to 2030 by AGMEMOD and the OECD-FAO (2021) outlooks are, respectively, 21.8% and 23.9% for wheat, 15.9% and 9.9% for soya beans, and 11.6% and 13.0% for other oilseeds. As regards maize yield, OECD-FAO projects 7.9 and AGMEMOD 5.5 tonnes per hectare of maize harvest by 2030. While in the AGMEMOD outlook significant annual weather fluctuations (as seen in the past) and the possibility to compensate lower yields with greater areas result in refraining from yield intensification, OECD-FAO (2021)

([23]) |6.2|%, modulus.

considers exceptional soil fertility conditions and increasing integration of maize into the crop rotation as the main drivers of increasing maize yields in Ukraine.

Although the projections for production of beef and veal show similar trends, OECD-FAO expects a far less drastic decline compared to the current AGMEMOD outlook. The AGMEMOD projections are based on the assumptions that (i) the exit rate from the sector of rural households which rear cattle will remain high, (ii) entering of specialised cattle rearing farms into the sector will be hindered by high investment requirements, and (iii) a certain slowing down of the decline rate in beef and veal production is a current temporary effect of the improved cattle breeds. These assumptions result in a decline of beef and veal production projected at a rate close to the one observed in the last two decades. Conversely, the OECD-FAO (2021) outlook gives more weight to the trends of the last decade and therefore provides with less pessimistic projections. Quite similar explanations can be applied to the differences in projections for the pig meat and milk production.

The projections of AGMEMOD and OECD-FAO for the production of poultry meat in terms of both, the trend and the growth rate, are rather close. The projections for eggs production demonstrate similar trends, but vary in terms of growth rates. In 2016, eggs production in Ukraine dropped by 22.5% compared to 2014, due to the loss of production facilities in the Donbas region where the military unrest had begun. Since then, the sector has struggled to recover, not only because of the capital investments needed for the new facilities, but also due to the legal tensions of the major eggs producer in Ukraine (Agroberichten, 2021). Similar to the other sectors, the AGMEMOD outlook considers that the effects of these events will recede over the medium-term and expects the return of the sector to its former growth rates, whereas the OECD-FAO (2021) projections give more weight to the current situation.

The review focused on projections for production of primary agricultural commodities and did not analyse the differences in projections for prices, trade and consumption, as well as for markets of oilseed oils, meal and bioethanol. Although one can make conclusions on the differences in the volumes of trade and production of oils and meals based on the analysis of production of the primary commodities (e.g., wheat, maize, sunflower seeds), the differences in domestic use and prices for some of the commodities may need extensive analysis. Nevertheless, this review provides explanations that may not only hold for production but generally for demand, trade and prices as well.

6 Discussion and conclusions

After more than a decade of application for producing the outlook of agri-food markets at the aggregated and individual EU country level, AGMEMOD has proved to be providing solid mid-term projections. Econometric estimation of parameters, which allows capturing the appropriate market structures, and the network of market experts who provide feedback and validation of model outcomes present a particular value of the model. AGMEMOD also contains market balances for countries outside the EU. The outlook for Ukraine was produced by the AGMEMOD network for the first time in 2012. A decade later, after the country has become an associated member of the EU, experienced major shifts in its international, trade and domestic agricultural policies, as well as gained leading positions in some of the global agri-food markets, the analysis of the current and future trends in development of its agricultural production and primary processing industries required an update of the Ukraine country model in AGMEMOD. The latter contains complete market balances for the major agricultural commodities. For the current study, its database, external variables, trade, policy and macroeconomic assumptions have been updated, the behavioural equations re-estimated and two new markets added (bioethanol and natural honey). Accordingly, the current outlook captures the major and most recent changes in the Ukrainian agri-food industry.

According to the projections for 2030, cereals production is expected to increase due to yield improvements, whereas oilseeds production will grow mainly due to area expansion. The largest growth is expected for maize, rapeseed seeds and soya beans. Grain maize is projected to substitute some of the wheat area, which together with the nearly stable yield results in 8.9% production growth. Despite yield improvements, the area switch towards maize takes wheat off the leading position in Ukraine's cereals production. Production of barley, oats and rye will grow very moderately due to positive changes in yields. For oilseeds, considering the low starting point, production of rapeseed seeds is projected to grow most compared to soya beans and sunflower seeds, mainly by replacing some of the sunflower area. Nevertheless, production of sunflower seeds will continue dominating oilseeds production in Ukraine and is projected to reach 15.8 million tonnes. Soya beans production is expected to reach 5.4 million tonnes and rapeseed 3.9 million tonnes. Production of oilseed oils and meals will follow the production of the respective oilseeds. Despite an increase in domestic demand for feed, induced by the positive development of the poultry sector, and with steadily declining demand for cereals and oils as food, mainly due to the decreasing population, Ukraine will remain a net exporter of cereals, oilseeds and oilseed oils and meals.

Cow milk, beef and pork production are projected to decline. One of the reasons is the restructuring of the livestock sector, with rural households as smallholder producers exiting, and larger specialised milk, beef and swine farms entering the sector. However, as the specialised larger producers might not compensate the loss in animal numbers from the rural households, and despite some drop in beef and pork consumption (mainly due to declining population), Ukraine is projected to be a net importer of beef and pig meat. Net imports may reach 45.6 thousand tonnes for beef and 270.3 thousand tonnes for pork. In contrast, developments in the chicken meat and eggs sectors are rather positive. In Ukraine, producers of these commodities are usually large enterprises, which also produce chicken feed. This allows these producers to benefit from economies of scale and lower production costs (USCS, 2016). Until 2030, Ukraine's chicken meat production is projected to grow by 35.8% and chicken eggs production by 63.2%. Domestic per capita consumption of chicken meat and eggs is expected to increase as well, which will drive domestic use upwards despite the declining population. Ukraine will further improve its net exporting position for these two commodities.

The comparison between the AGMEMOD and OECD-FAO (2021) agricultural outlook (section 5.3) shows that the AGMEMOD projections might be considered rather conservative for most of the Ukrainian sectors. The reasons behind the differences of the two outlooks are both model- and assumptions-related. Major sources for the differences are discrepancies in the underlying databases (historical data), which form the core of the econometric estimations for future developments, with the AGMEMOD data often showing lower values than OECD-FAO data. Furthermore, in the crops sector, land expansion and substitutability of agricultural land uses are more limited in AGMEMOD. Differences also emerge from deviating assumptions on exogenous variables such as, for example, GDP, crude oil prices, exchange rates and population. Moreover, the OECD-FAO outlook gives more weight to the trends of the last decade than AGMEMOD. In this respect, the two outlooks together may provide a `corridor´ for the possible developments of the Ukrainian agricultural sector by 2030.

As the AGMEMOD outlook has been conducted under the assumption of 'no' public monetary support to agricultural production, the projections represent responses of market agents to the market's stimuli such as, for example, relative values of market prices for commodities, currency inflation and exchange rates, trade policy (e.g., FTAs), as well as to the exogenously defined rates of technological change. The assumption of 'no' direct payments is not expected to have considerable impacts on the modelling results, mainly due to the rather

low Producer Support Estimate (PSE) generated by these payments in Ukraine (cf. section 4.3). Thus, it may be concluded that the positive trends (i.e., production and export of cereals, oilseeds, oilseed oils and meals) will continue as long as the global markets and general socioeconomic conditions in the country are beneficial for the respective industries. Although public support has the potential to help the stagnating sectors (i.e., milk, beef and pork production), one should be cautious about the efficiency of such support. As the case of the beekeeping sector demonstrates (cf. Box 3), public support, even long-term, may not compensate for the general unfavourable conditions for the sector (e.g., reduction of safe natural forage for bees). Thus, improving the latter may have the same importance for the positive evolution of the currently declining agri-food industries as the former.

The impact analysis of the COVID-19 pandemic presented evidence of the resilience of the Ukrainian agricultural commodities production and export to the crisis in the medium to longer term. Overall, the current report confirms that AGMEMOD provides relevant results and enables discussion about key development trends, changes and causes of changes in production and trade of agri-food commodities. As, however, econometric estimates of parameters do not guarantee solid and reliable simulation outcomes, careful calibrations of model parameters and assumptions, as well as validation of the model's outcomes, are required. Therefore, not only the Ukraine country model of AGMEMOD has to be further developed, but also the network of local modelling teams and market experts should be continued to be strengthened.

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List of abbreviations and definitions

AGMEMOD	Agricultural Member State Modelling (model)
GDP	Gross Domestic Product
OLS	Ordinary Least Squares estimator
UAH	Ukrainian Hryvnya (national currency of Ukraine)
USD	United States Dollar

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Annexes

Annex 1. Selected trade agreements of Ukraine

Agreements within the WTO	General Agreement on Tariffs and Trade 1994 (GATT 1994) and 12 other multilateral agreements on trade in goods (including the WTO Trade Facilitation Agreement) WTO General Agreement on Trade in Services 1994 (GATS) and its Annexes WTO Agreement on Trade-Related Aspects of Intellectual Property Rights 1994 (TRIPS) Understanding on Rules and Procedures Governing the Settlement of Disputes (DSU) Trade Policy Review Mechanism (TPRM) Trade Facilitation Agreement (came into force on 22 February 2017)
Regional and bilateral trade agreements	Agreement on Free Trade between the Cabinet of Ministers of Ukraine and the Government of the State of Israel (Ukraine – Israel FTA), which was ratified by Ukraine on 11 July 2019. Canada-Ukraine FTA, which entered into force on 1 August 2017 (CUFTA) Deep and Comprehensive FTA between the EU and Ukraine (within the framework of the Association Agreement between the European Union and its Member States, on the one part, and Ukraine, on the other part), which entered into force on 1 September 2017 and had been provisionally applied since 1 January 2016 (DCFTA). During the Brexit transition period lasting until 31 December 2020, the UK will continue to be bound by the DCFTA. At the same time, the UK and Ukraine have started the negotiations on a new free trade deal. FTA between the Government of Montenegro and the Government of Ukraine, which entered into force on 1 January 2013 (Ukraine-Montenegro FTA) Commonwealth of Independent States FTA, which entered into force on 20 September 2012 (CIS FTA). The CIS FTA was concluded by Armenia, Belarus, Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan, Moldova, and the Russian Federation. However, as of 1 January 2016, Russian Federation and Ukraine suspended the FTA with respect to each other FTA between EFTA States and Ukraine, which entered into force on 1 June 2012 (EFTA-Ukraine FTA) Agreement on Free Trade between the Republic of Macedonia and Ukraine, which entered into force on 5 July 2001 (Ukraine-Macedonia FTA) Agreement on Free Trade between the Government of Ukraine and the Government of the Republic of Azerbaijan, which entered into force on 26 August 1996 (Ukraine-Azerbaijan FTA). Agreement on Free Trade between the Government of Ukraine and the Government of Republic of Georgia, which entered into force on 4 June 1996 (Ukraine-Georgia FTA). Agreement on Free Trade between the Government of Ukraine and the Government of Turkmenistan, which entered into force on 4 November 1995 (Ukraine-Turkmenistan FTA).

Source: Own elaboration

Annex 2. Observed and projected market prices for agricultural commodities in Ukraine

Source: 2005-2010 (2019) – based on SSSU (2020b), (2019) 2025-2030 – own elaboration

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