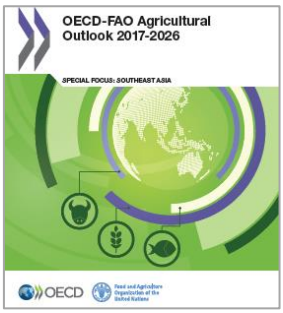


Stochastic analysis of the OECD-FAO Agricultural Outlook 2017-2026

The *Agricultural Outlook* projects future outcomes based on a specific set of assumptions about policies, the responsiveness of market participants and the future values of exogenous market drivers such as weather conditions or the macroeconomic environment. As a complement to the baseline, this note presents an uncertainty analysis based on *partial stochastic analysis*. This gives an indication of the range of possible outcomes around the baseline, given the variability observed in previous years for key agricultural and macroeconomic drivers.

Stochastic analysis involves performing multiple simulations with different values of selected exogenous variables and studying their impact on selected endogenous variables like prices, production or trade. The analysis is only *partial* in that it does not capture all the sources of variability that can affect agricultural markets. For example, uncertainty related to animal diseases is not captured. The goal is to identify key risks and uncertainties most likely to affect the projections. This allows policy makers to quantify the likely range of market variation that derives from these identifiable sources of uncertainty.

Sources of uncertainty analysed

The major sources of uncertainty in agricultural markets included in the stochastic analysis are:

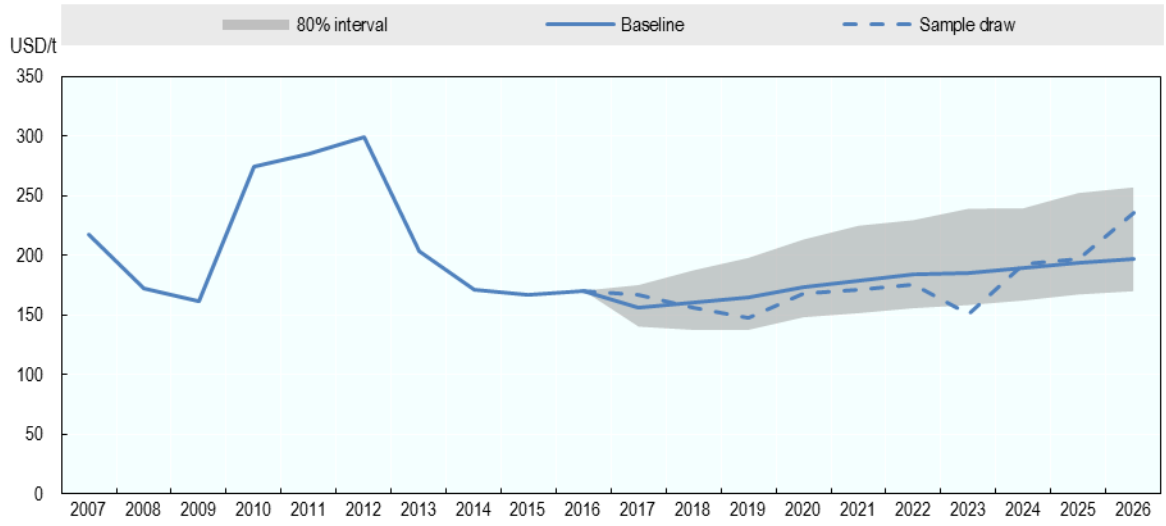
- *Global macroeconomic drivers:* Values of 32 variables: real Gross Domestic Product (GDP), the Consumer Price Index (CPI) and the GDP Deflator in the United States, the European Union, the People's Republic of China, Japan, Brazil, India, the Russian Federation and Canada; national currency-US dollar exchange rates for these regions; and the world crude oil price are assumed uncertain.

- *Agricultural yields*: Uncertainty affecting the yields of 17 crops in 20 major producing countries is also analysed, giving a total of 78 product-country-specific uncertain yields (see *Methodology* for further explanation).

The indicator used to represent and compare the impact of uncertainty on projected outcomes is the *coefficient of variation* in the last projection year, 2026. The coefficient of variation (CV) is defined as the standard deviation divided by the mean, and can therefore be interpreted as a percentage deviation from the "central" projection in the *Agricultural Outlook*.

Figure 1 illustrates for the nominal world maize price possible future values based on the combined macroeconomic and yield uncertainty. For 80% of the simulations in the stochastic analysis, the resulting nominal maize price falls inside the grey range. In addition, Figure 1 contains a "sample draw", showing a randomly selected simulation result among the 1 000 simulations performed for the stochastic analysis.

Figure 1. Uncertainty around the nominal world maize price

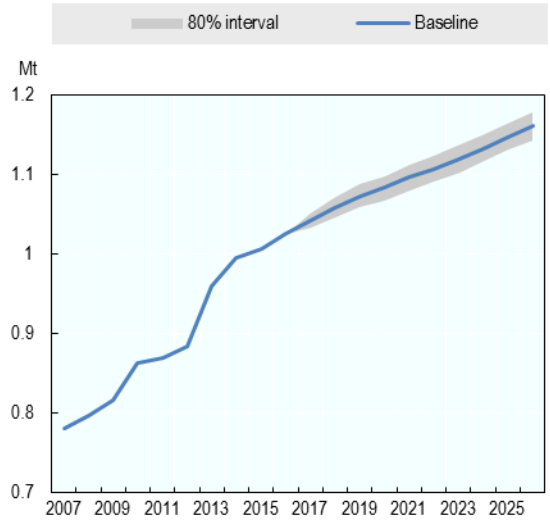


Consumption and production more stable as trade and prices act as buffer

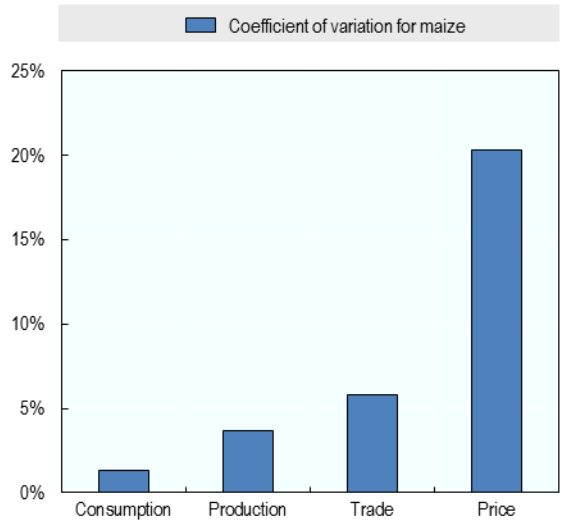
A common finding when comparing the results of the uncertainty analysis is that consumption and production volumes are typically more stable than trade volumes, which in turn are typically more stable than prices. The left-hand panel of Figure 2 illustrates the relatively narrow range around global maize consumption forecasts. Compared to the wide range around the baseline price projection in Figure 1, the variability around the consumption forecast is minor. This is also illustrated in the right-hand panel, which compares the coefficients of variation of global consumption, production, trade and (nominal) prices of maize. Whereas the coefficient of variation for global consumption is around 1%, variability of production is larger at almost 4%. For trade, the coefficient of variation is almost 6%. For prices, however, variability is much larger at 20%.

Figure 2. Maize: Variability in consumption, production, trade and prices

(a) Projected global consumption of maize



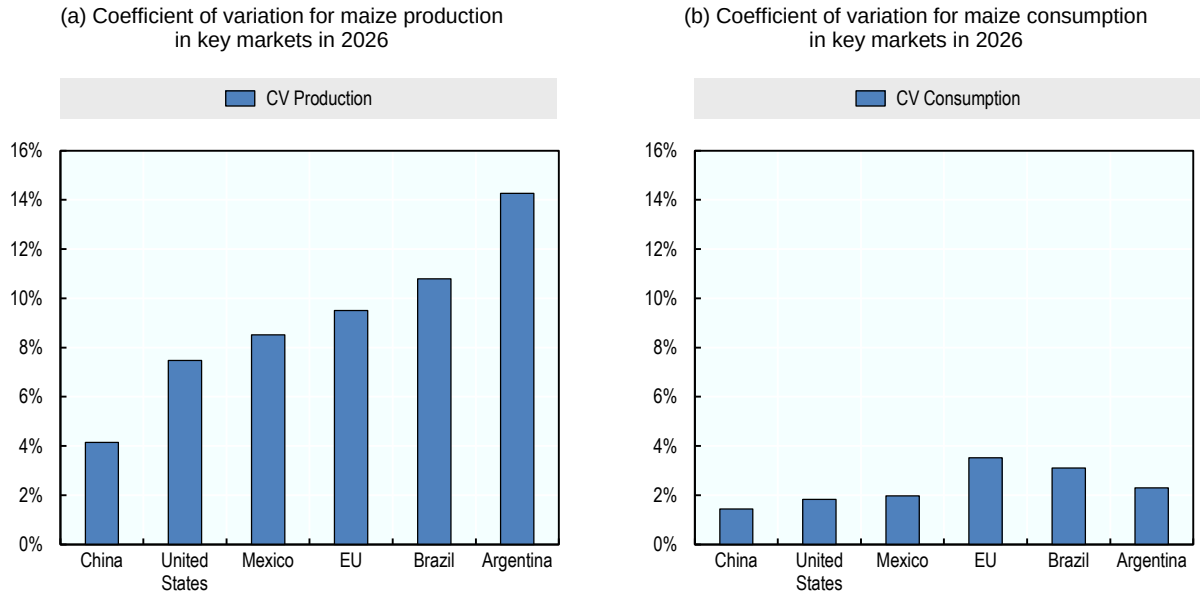
(b) Coefficient of variation for consumption, production, trade and prices in 2026



This finding is not unexpected. The demand and supply of many agricultural commodities, maize included, are relatively insensitive to prices. Shocks to demand or supply are therefore likely to lead to relatively large adjustments in prices. Stocks can be used to smooth consumption in the face of fluctuations in production. Likewise, trade is more sensitive to shocks as it is used as a buffer against shocks. International trade allows countries to increase imports in order to keep consumption more stable in years where production is low. Trade can be seen as a 'residual', adjusting to shocks in production or consumption and therefore more variable.

Figure 3 shows for six large markets the coefficient of variation of maize production and consumption. The six markets differ in terms of the variability of production, with relatively low variability in China and greater variability in Brazil and Argentina. Remarkably, however, this variation in production does not translate into consumption. As shown in the right-hand side of Figure 3, the CV for consumption for all markets is lower than 5% and is considerably below the CV of production, indicating that "smoothing" takes place through stocks and international trade.

Figure 3. Maize: variability in production versus consumption for key markets



Despite flat price projections, risk of price peaks remains

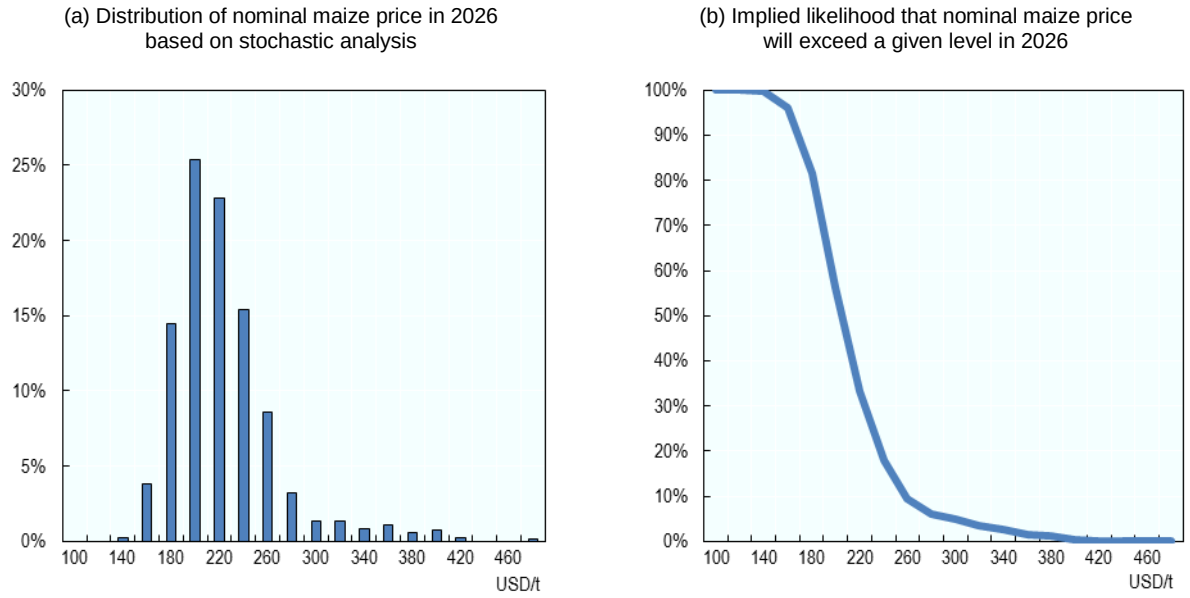
The *Agricultural Outlook* projects relatively flat nominal and real price evolutions for maize (as well as for most other commodities). Our stochastic analysis adds a range around this estimate based on the effects of macroeconomic and yield shocks, as explained earlier. To facilitate the exposition, the range shown in Figure 1 only indicated the values between the 10th and 90th percentile – i.e. after excluding the 20% most extreme values. However, more extreme price swings (whether positive or negative) are likely to occur over the coming decade.

To see this, note that under the assumptions of the stochastic analysis, the likelihood that prices will remain within the "range" is 80% *in any given year*. The likelihood that prices remain in this range throughout the decade is therefore $(0.80)^{10}$ or around 11%. In other words, the likelihood that prices will fall outside the range (either above or below) *at some point* in the next decade is 89%. When we restrict ourselves to high prices, the likelihood that prices will be higher than the range at some point in the next decade is 65%. The central projection is that prices are broadly flat, but as this analysis shows, price peaks – or troughs – remain a possibility.

The left-hand side of Figure 4 shows the uncertainty around nominal maize prices in 2026 by plotting the estimated likelihood of different prices (under the limited set of shocks introduced in the stochastic analysis). The distribution of maize prices shows that most estimates cluster around a median estimate of around USD 200/t, consistent with the central projection shown in Figure 1. There is variation on both sides, but the distribution is not symmetric – there is a longer "tail" to the right. While there is a roughly equal chance of prices being above or below the central projection, the longer tail indicates that there is a higher risk of a large positive price shock (e.g. USD 100 above the central projection) than a large negative one (e.g. USD 100 below the central projection).

The right-hand side of Figure 4 uses this information to calculate the probability that nominal maize prices in 2026 will exceed a given level. Thus, the stochastic analysis suggests that there is an 80% likelihood that nominal maize prices will exceed USD 180/t, but only a 10% likelihood that they will exceed USD 260/t. Importantly, the estimates in Figure 4 only include the uncertainty from the shocks included in the stochastic analysis. Including other sources of uncertainty would increase the likelihood of more extreme values (whether more negative or positive).

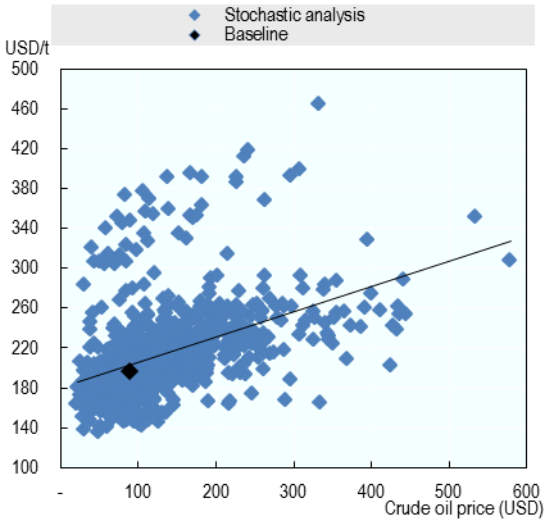
Figure 4. Likelihood distribution of 2026 maize price



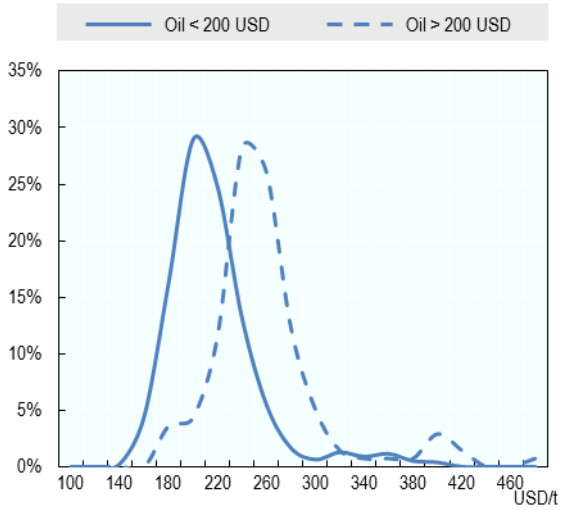
The relatively stable central projections in the *Agricultural Outlook* are therefore consistent with the likelihood of large price swings. Price increases are particularly likely if oil prices are high, as shown in Figure 5. The left-hand panel of Figure 5 shows nominal maize prices and the nominal crude oil price in 2026 across all simulations of the stochastic analysis, as well as in our baseline. A linear trend line summarizes the impact of higher oil prices on maize prices across our stochastic analyses: an increase in the oil price by USD 100 would increase the nominal maize price by around USD 25 on average. Even with oil prices below USD 100, other shocks (such as negative weather conditions leading to low yields) may drive the maize price above USD 300/t; but higher maize prices are considerably more likely in an environment of high oil prices. This is confirmed by the right-hand panel of Figure 5, which shows the distribution of nominal maize prices across stochastic analyses for oil prices above and below USD 200. Higher oil prices clearly shift the entire distribution of possible maize prices to the right, and increase the likelihood of exceptionally high maize prices (e.g. above USD 380/t), which can be triggered in case of a perfect storm of high demand and low yields in a high oil price environment.

Figure 5. Impact of higher oil prices

(a) Relationship between maize prices and oil prices in the stochastic analysis



(b) Distribution of nominal maize prices in 2026 under low and high oil prices

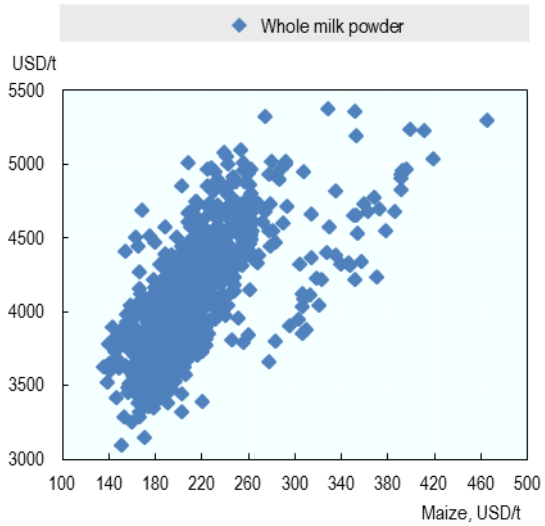


Impact on different commodities

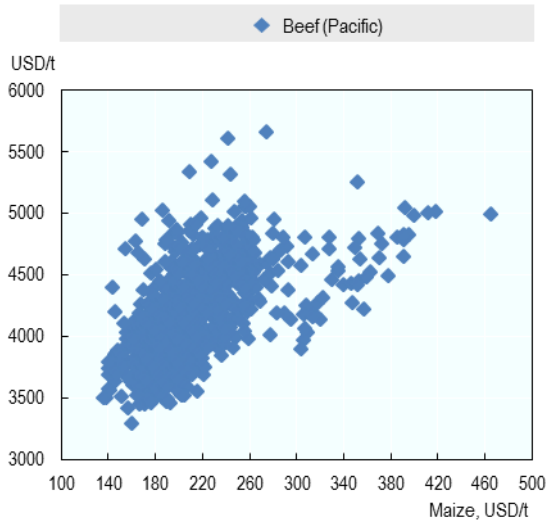
The above charts focus on maize, as maize is a key agricultural commodity which is widely traded and is used as animal feed and as biofuel feedstock. As a result, maize prices are strongly correlated with many other agricultural prices. There is a strong relationship between maize and other cereals, as there is typically a high degree of substitutability on both the production and the consumption side. Moreover, there is a strong relationship with ethanol prices, as maize serves as an important feedstock. As shown in Figure 6, in our stochastic analysis there is also a strong correlation with dairy prices (as measured by the price of whole milk powder) and meat prices (as measured here by the price of beef on the Pacific market). Due to the interrelations between agricultural markets, maize prices can therefore be used as a convenient proxy when discussing uncertainty in the projections of the *Agricultural Outlook*. The results of the stochastic analysis of nominal prices for selected commodities can be found in Figure 7.

Figure 6. Maize prices are highly correlated with other commodities in the stochastic analysis

(a) Relationship between maize prices and prices of whole milk powder



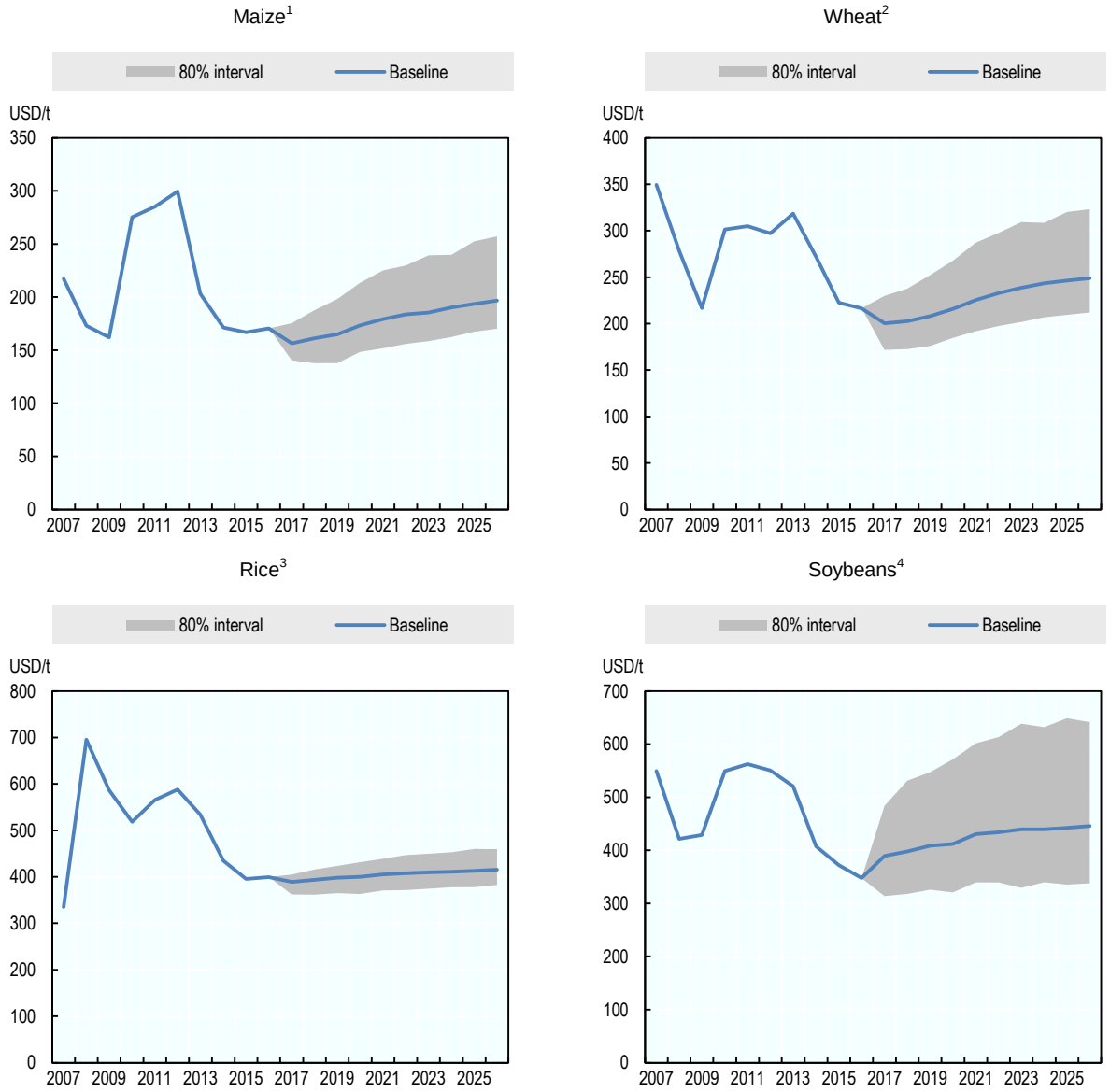
(b) Relationship between maize prices and prices of beef and veal (Pacific)



Conclusion

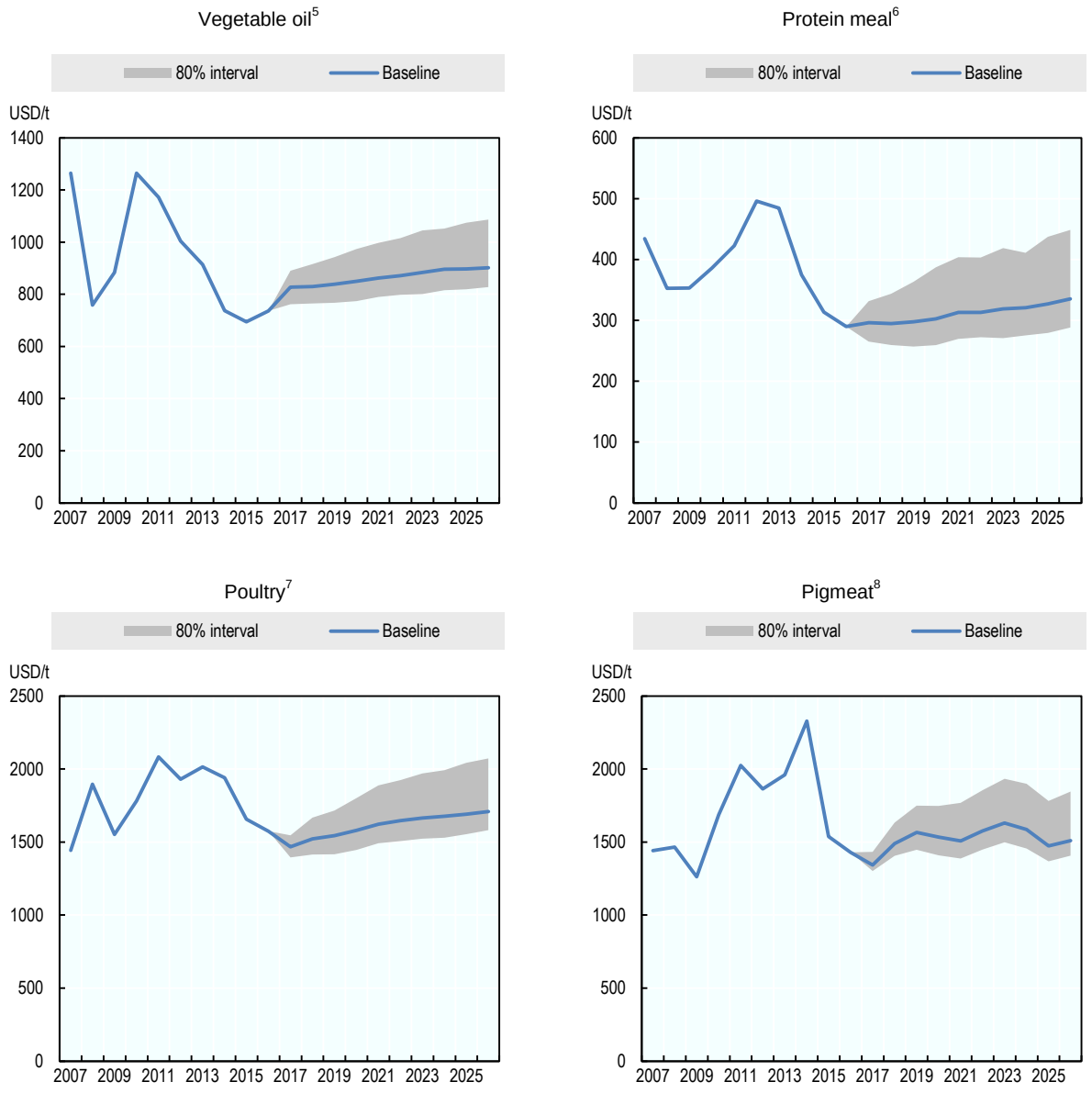
This analysis shows how partial stochastic analysis can be used to supplement the information provided by the deterministic baseline, by identifying which baseline variables are more affected by the uncertainty associated with a given set of exogenous variables. The results are based on the past pattern of variability in yields and macroeconomic drivers. However, it should be borne in mind that past trends may not continue in the future. For example, climate change could bring more yield variability, or economic growth patterns observed in recent past might change. The analysis does not capture these possible developments.

Figure 7. Results of stochastic analysis of nominal prices for selected commodities



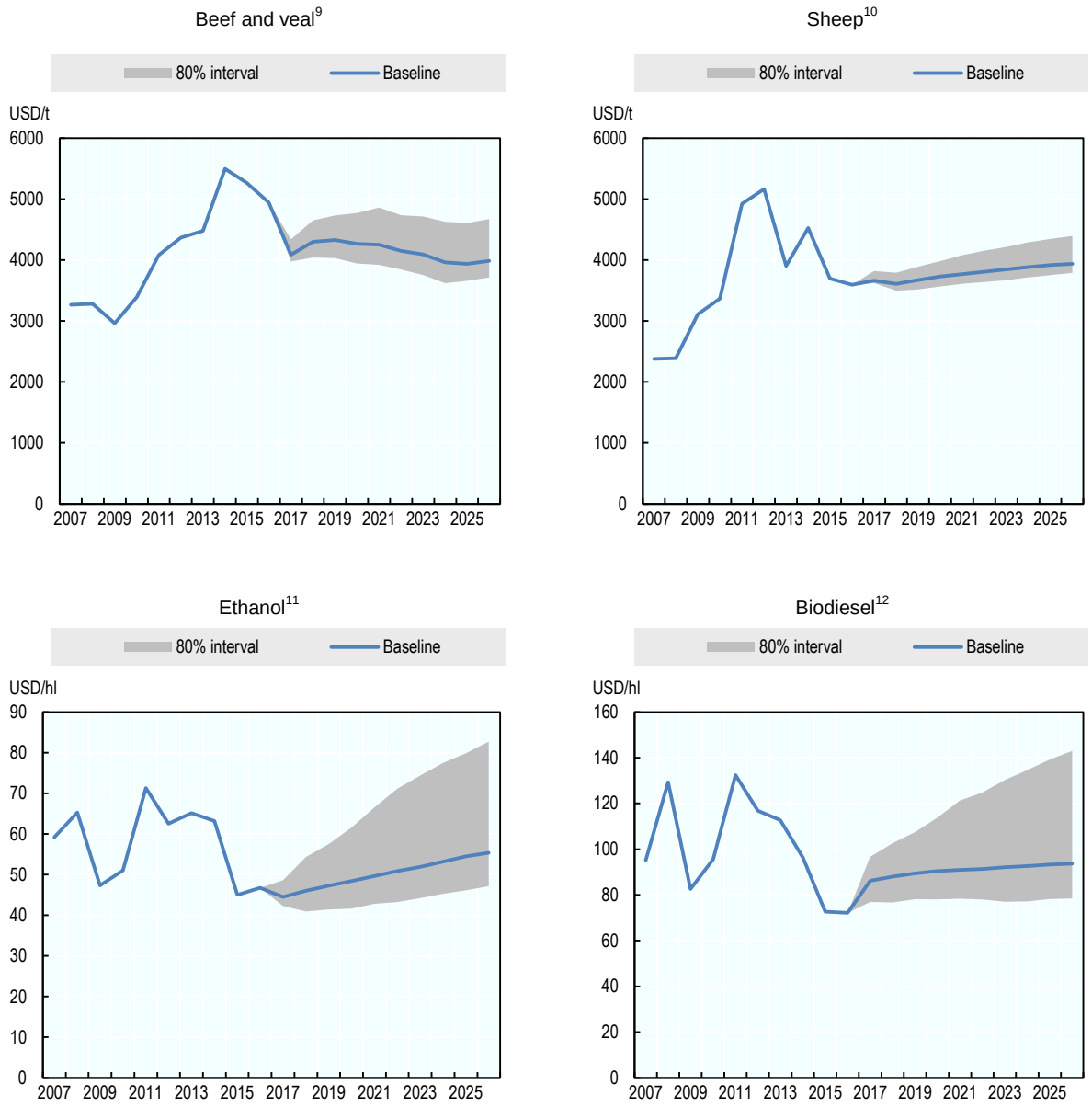
1. No.2 yellow corn, United States FOB Gulf Ports (September/August).
2. No.2 hard red winter wheat, ordinary protein, United States FOB Gulf Ports (June/May).
3. Milled 100%, grade b, nominal price quote, FOB Bangkok (January/December).
4. Soybean, U.S., CIF Rotterdam

Figure 7. Results of stochastic analysis of nominal prices for selected commodities *(cont.)*



5. Weighted average price of oilseed oils and palm oil, European port.
6. Weighted average meal price, European port.
7. Brazil: export unit value for chicken (FOB), product weight.
8. Barrows and gilts, No. 1-3, 230-250 lb lw, Iowa/South Minnesota - lw to dw conversion factor 0.74.

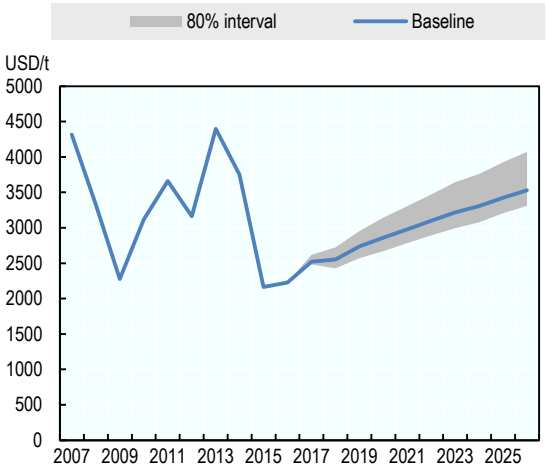
Figure 7. Results of stochastic analysis of nominal prices for selected commodities *(cont.)*



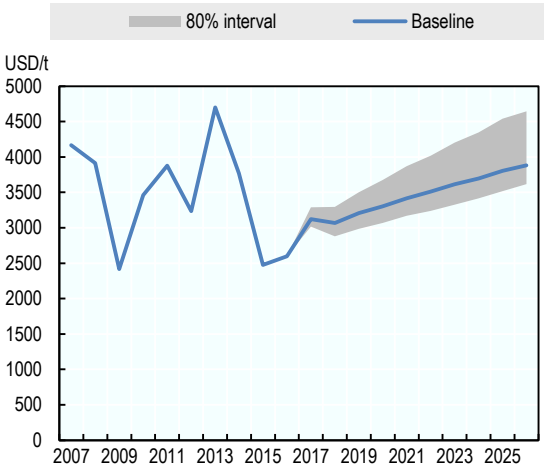
9. Choice steers, 1100-1300 lb lw, Nebraska - lw to dw conversion factor 0.63.
10. New Zealand: Lamb schedule price, all grade average.
11. Wholesale price, United States, Omaha.
12. Producer price Germany net of biodiesel tariff and energy tax.

Figure 7. Results of stochastic analysis of nominal prices for selected commodities *(cont.)*

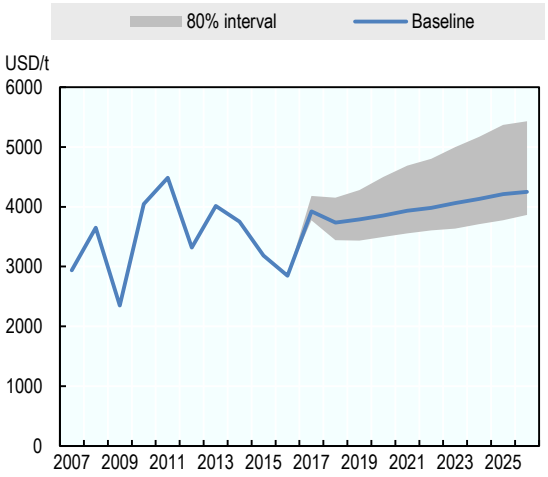
Skimmed Milk Powder (SMP)[13]



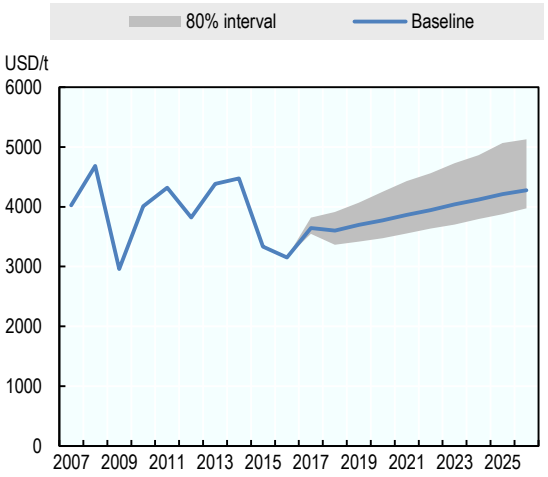
Whole Milk Powder (WMP)[14]



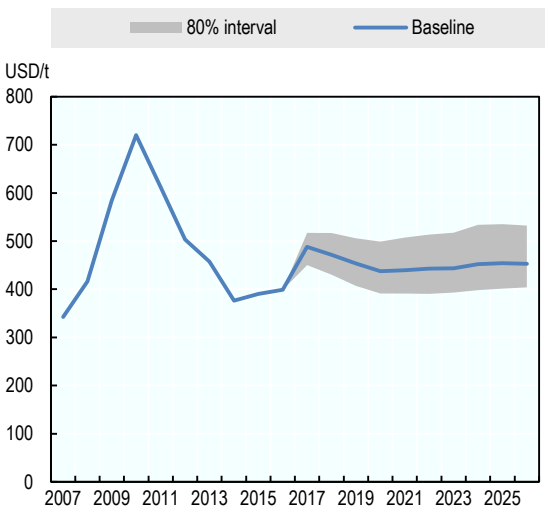
Butter[15]



Cheese[16]



White sugar[17]



Notes

13. FOB export price, non-fat dry milk, 1.25% butterfat, Oceania.
14. FOB export price, WMP 26% butterfat, Oceania.
15. FOB export price, butter, 82% butterfat, Oceania.
16. FOB export price, cheddar cheese, 39% moisture, Oceania.
17. Refined sugar price, Euronext, Liffe, Contract No. 407 London, Europe, October/September.