Global Price Volatility and Agriculture in the United Kingdom

Technical Report No. 2023-1

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Any opinion, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the funding organisations.

The 2022 Baseline projections used in this report are generated as part of the FAPRI-UK project. The FAPRI-UK Baseline projections are generated annually and provide a medium-term outlook for the UK agricultural sector. The stochastic baseline used in this report was generated from the UK deterministic baseline using data available up until October 2022.

The 2022 Baseline uses global prices from the FAPRI-MU global system of models. The UK level data is taken from the Department for Environment, Food and Rural Affairs. Other data for England, Wales, Scotland and Northern Ireland has been taken from the relevant government websites.

Summary

Policy challenge

Agriculture as a sector is unique in that biophysical, as well as socio-economic, conditions increase market volatility. An important source of market shocks to agriculture in the United Kingdom (UK) is increased volatility in the world price of inputs and outputs. Brexit has been followed by a series of new negotiated trade agreements, which lead towards greater liberalisation in international trade of agricultural commodities. Human and zoonotic disease outbreaks have caused demand-side and supply-side structural change. The outbreak of violent conflict has disrupted global grain markets. Overlaying all these issues, changing climatic conditions have been linked to weather-related supply disruptions. Each of these examples contribute to the overall uncertainty experienced in agricultural markets. These myriad sources of uncertainty in recent history make a strong case for analysis that illustrates the impacts of world price volatility on the UK agriculture.

Research question

This analysis investigates how different levels of world price volatility are likely to impact agriculture in the UK. Hypothetical volatility is introduced to world prices that exceeds the long-term historical pattern. The standard FAPRI-UK stochastic model incorporates medium-term projections for UK agriculture that account for some sources of uncertainty (such as extreme weather) based on historical variation. The projections assuming *status quo* levels of volatility provide a point of comparison, so that the level and effects of more extreme world price volatility can be investigated. Specifically, the impact that relatively greater global price volatility has on the frequency of extreme prices and expected income from agriculture is analysed.

Findings

In the case that assumed volatility is relatively more extreme, the chances of experiencing extreme prices for UK commodities in the projection period also increases, as expected. Price thresholds are defined, based on the 10% highest, and 10% lowest, prices for each commodity and projection year under *status quo* assumptions around volatility.

As additional volatility is introduced to the world prices, it becomes more and more likely that both the upper and lower threshold price will be breached. This means, that the range of prices expected in most cases (for example, the range including 80 percent of prices projected for a given year) broadens. This reflects the greater uncertainty around UK prices, in the context of more variable world prices. There is a slight asymmetry in impact, such that extreme low prices are marginally (2%) more likely than extreme high prices on average.

The magnitude of year-on-year UK price differences increases with higher world price volatility. The largest increase is in oilseeds and cereals, due to the relative exposure to global markets, compared to livestock commodities.

The greater frequency of more extreme UK prices impacts the expected value of outputs and cost of inputs. An *aggregate income indicator* is established, defined as revenue (using producer prices and output volume) less key input costs (using fertiliser and feed cost estimates). The range of the most likely income levels projected (in this case, the range bounding 80% of income projections) remains above observed short and long-term historic averages for most of the projection period, even when world price volatility has been assumed to be higher in the projection period than historically.

Although the likelihood of extreme high or low income increases with greater world price volatility, there is little difference in the average income, because the high and low years tend to balance each other out.

The largest driver of income change is the change in revenue. The largest driver of the difference in revenue between *status quo* and *high* volatility scenarios tends to be price, followed by area and then yield (illustrated for the case of UK wheat).

The higher level of world price volatility also increases the likelihood that current prices will be different from expected prices (based on historic averages). There is a greater likelihood an increase in the output price of UK commodities is not associated with a positive production response (using crop area or breeding stock as the relevant supply indicator), compared to when *status quo* volatility assumptions apply.

In general, it was found that increasing world price volatility has little impact on UK domestic use.

Final remarks

The analysis facilitates discussion on several topics:

- Volatility in world prices generates both ‘wins’ and ‘losses’ for UK agriculture depending on the pattern of impact.
- The average impact on prices and incomes does not tend to change because the added likelihood of extreme highs is balanced by the added likelihood of extreme lows.
- The year-on-year sensitivity of UK prices increase when world price volatility is high.

Contents

1 Introduction

Uncertain political economic and biophysical conditions increase market volatility and demonstrate the usefulness of analysis that illustrates these impacts on agricultural production, international trade, and margins. The FAPRI-UK Project generates medium-term projections for UK agriculture accounting for some sources of uncertainty (such as extreme weather) based on observed historical variation. However, the methods used do not incorporate all possible sources of volatility in a market. For example, in recent years in the UK high price volatility has sometimes been a result of things that are included in the generation of the stochastic projections, such as weather impacts on yields, but other times the variation has been associated with factors outside the scope of the model, such as the impact of COVID on eating habits or slaughter facility operations.

To investigate the potential impacts of unanticipated or more pronounced events in the projection period modelled, hypothetical volatility is introduced to world prices beyond the long-term historical pattern - implemented *via* more extreme random variation. This intervention provides a point of comparison, such that alternative stochastic projections are generated. A baseline stochastic projection is generated by assuming world price volatility follows the *status quo* degree of random variation based on historic patterns. Scenario projections are also generated, assuming world prices follow a greater magnitude of random variation in the future, than in the past. The impact of greater global price volatility on the frequency of extreme prices, and expected level of income, within the UK agricultural sector is analysed. No specific causes for higher volatility are assumed. In this sense, it is generalised and hypothetical. In recent history, world events, many of which are exogenous to the model, led to unprecedented volatility in many sectors. The way uncertainty is captured in the model means such extreme "2022-type" years are not often, if ever, generated in the projection period. The projection pathways in the stochastic framework are good at providing a range of the most likely outcomes, assuming there are no regulatory, policy, geopolitical, or other external acute shocks that would generate structural constraints on markets.

The remainder of this section describes the stochastic approach applied, and how world price volatility is increased to provide a point of comparison. Section 2 outlines the findings on the most likely range of expected UK prices given *status quo* world price volatility, how the likelihood of relatively extreme high or low UK prices changes when world price volatility increases, as well as impacts on the magnitude of year-on-year price swings.

1.1 Stochastic projections

The 2022 Stochastic Baseline projections presented here are generated as part of the FAPRI-UK project. The FAPRI-UK Baseline projections are generated annually and provide a medium-term outlook for the UK agricultural sector. Agriculture in 2022 experienced a year of uncertainty. COVID-19 continued to have an impact, while the conflict between Russia and Ukraine impacted agricultural commodity markets, particularly grain supply across the world.

The 2022 Baseline uses global prices from the November simulation of the FAPRI-MU global system of models. The global models include policies in place at that time and assumptions regarding the impact of COVID-19 that are analogous with those assumed for the FAPRI-UK Baseline. The EU model does not include any estimate of the impact of new CAP policy in the form of Member State strategic plans as they were not available when these projections were estimated. It is not clear how the changes to EU policy will impact agricultural markets, but they will have an impact and this, and other unknowns, illustrate why it is important not to treat the Baseline projection as a forecast, but as a useful point of comparison.

The model variables with incorporated uncertainty are macroeconomic variables, UK and EU crop yields, and world agricultural commodity prices and fertiliser prices. The RStudio programme (integrated development environment) is used to generate the uncertainty for crop yields, and macroeconomic and world price variables are generated using Simetar which is a Microsoft Excel Add-In. The approach generates 500 alternative values for each of these variables for each projection year (from 2023 to 2032).

Each of the 500 alternative values for the yield, macroeconomic and price variables are placed into the UK and EU models and solved repeatedly to produce a stochastic output. As draws are generated randomly and independently in each year there is no correlation across years for the draws. Since the model is dynamic, for example cow numbers are connected across years, then impacts of the variations persist across time periods. Also, as the parameters of the distributions are based on historical variation, future variation is a function of that observed in the past, and in the baseline there is no attempt to incorporate any changes that might occur in the uncertainty associated with the variables – as a result of climate change for example.

1.2 World price volatility

Baseline stochastic projections are compared to two counter-factual scenarios. In each alternative set of projections, the random component of world prices is increased proportionally to simulate additional *moderate world price volatility* or additional *high world price volatility*[1]. Table 1-1 provides the coefficient of variation (CoV), defined as the standard deviation divided by the mean. The CoV for the historic periods reflect the average variation of the one observed annual price for each year (the sum of the CoV for each year divided by the number of years in the period). The CoV reported for the stochastic projections is based on an average CoV for each year (using the 500 prices for each year) averaged over the number of years in the projection period (10 years).

Information on historic and projected volatility is also provided graphically in the appendix (see Figure A - 1 to Figure A - 11). The figures chart a rolling three-year CoV for each year in the historic period, and for two randomly selected individual stochastic draws. The average rolling three-year CoV for each year in the stochastic projections are also graphed. The average three year rolling CoV in the case of wheat, barley, maize and rapemeal price in the *moderate volatility* scenario is close to the peak in the historic period, and the average in the *high volatility* exceeds the historic peak in several projection years. For the remaining prices, the increased volatility scenarios bring the CoV above the historic average, but not above historic peaks. However, individual draws may still surpass historically observed volatility for certain time periods within the projection.

[1] The *moderate* scenario increases the random component used to make world prices stochastic by 20%, and the *high* scenario does so by 35%.

Table 1-1. The historic and projected coefficient of variation (source: FAPRI-MU and own calculations)

	Historic period		Stochastic projections 2023-2032		
	2009-2015	2015-2021	Baseline	Moderate volatility	High volatility
HRW wheat, U.S. Gulf	17%	23%	21%	25%	28%
Barley, U.S. Portland	20%	25%	24%	28%	31%
Maize, U.S. Gulf	25%	26%	25%	29%	32%
Rapeseed, Hamburg	18%	29%	17%	20%	23%
Rape meal, Hamburg	15%	20%	26%	28%	31%
Steers, Nebraska	20%	9%	8%	10%	11%
Hogs, U.S. 51-52% lean	18%	15%	12%	14%	16%
Broilers, U.S. 12-city	11%	10%	8%	9%	10%
Cheese, FOB N. Europe	14%	11%	13%	16%	17%
Butter, FOB N. Europe	18%	23%	14%	17%	19%
SMP, FOB N. Europe	21%	19%	14%	16%	18%

1.3 Macroeconomic context

The macroeconomic point projections and historic series are externally sourced from S & P October Global Outlook Projections (October 2022). These are used to generate a stochastic set of macroeconomic variables. The projections of exchange rates show the UK Sterling (GBP) more likely to strengthen against the US Dollar (Figure 1-1) and Euro (Figure 1-2) in the projection period, rather than maintain the relatively weak position in recent years. This has an impact on the UK price projections, because they are closely linked to international and EU prices. Therefore, the downward trajectory of UK (nominal) prices in the projections is in part a result of the assumptions around the relative value of the GBP, and in part due to the market response to the record high prices experienced in recent years.

Since for the macroeconomic variables the mean of the stochastic draws is close to the forecast from S & P, the bands show a downward trend over time. When interpreting the stochastic projections, it is important to understand that the analysis is not suggesting the future will be less volatile than the current market conditions, but that if no further market disruptions are introduced, prices and incomes can be expected to trend back to more typical levels, while experiencing year on year volatility that varies from commodity to commodity.

Figure 1-1. GB Pounds per US Dollar

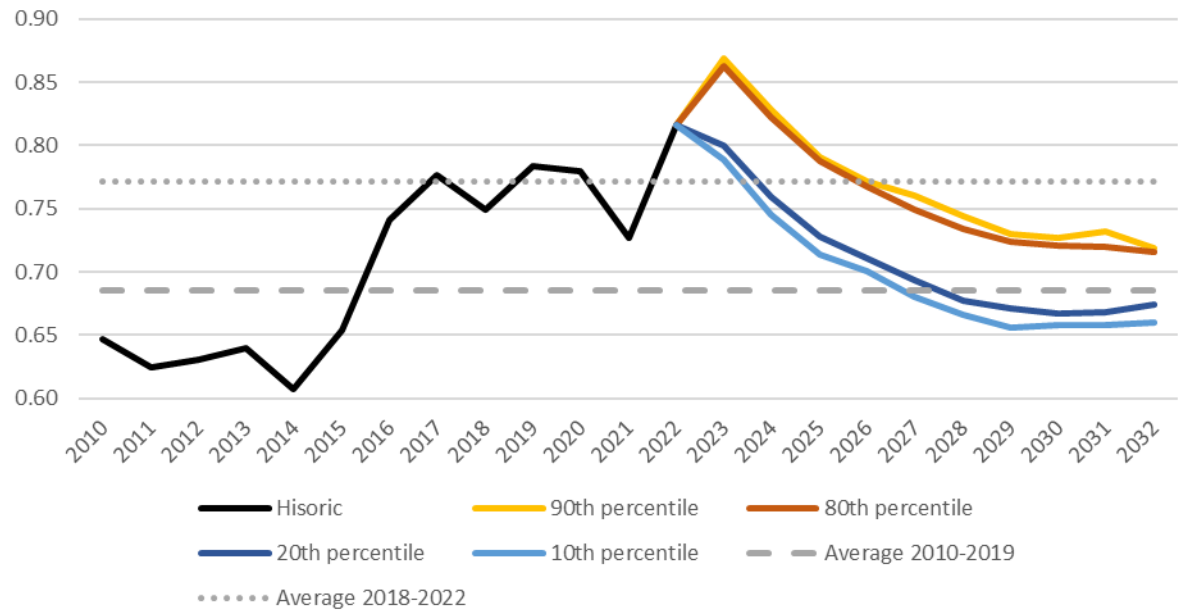
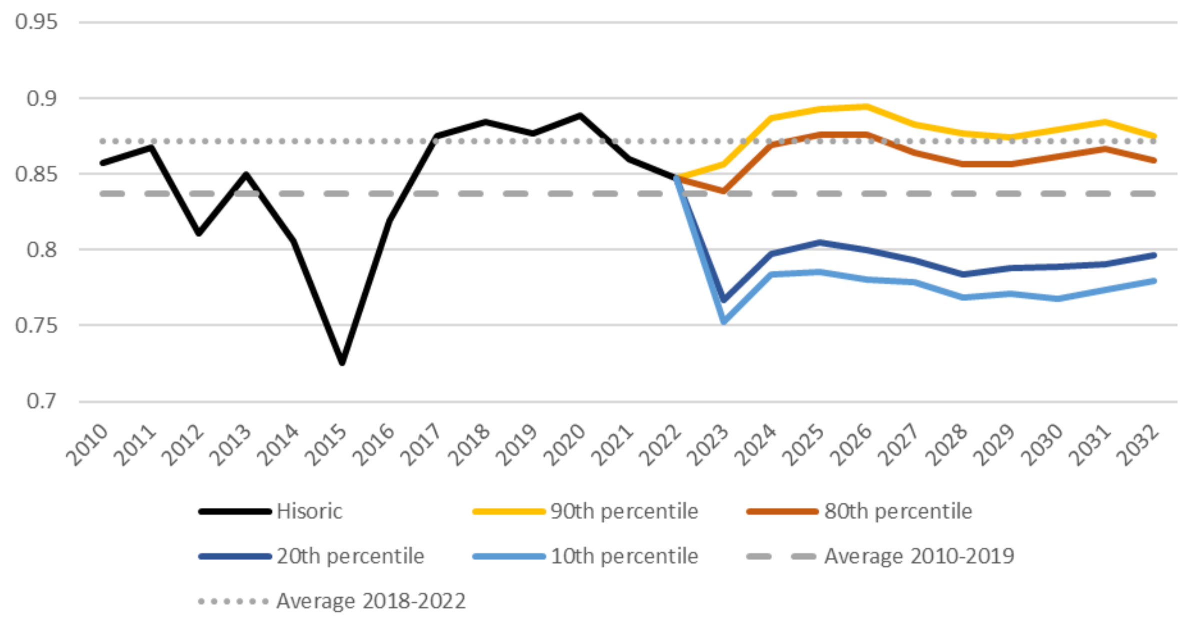


Figure 1-2. GB Pounds per Euro



2 Price impacts

In order to measure volatility, a metric is derived from the output data to quantify the impact of greater world price volatility on UK prices. It is computed by selecting threshold prices and calculating how many additional times the projected price is above or below the threshold when volatility of world prices is increased, compared to the baseline. Here, the 90th percentile in the baseline is used to set the upper threshold price for each year, and the 10th percentile is used to set the lower threshold price. The baseline is comprised of 500 projections each with a different stochastic component for selected variables that is 'drawn' from a probability function. For any price projected in the baseline, the 10th percentile price is the point at which 10 percent of the 500 projections are below that price. The 90th percentile is the point at which 10 percent of stochastic projections are above that price. Threshold prices serve simply to delineate a zone inside which markets are understood to operate in most circumstances, but by the same token, create a boundary that defines what is considered an 'extreme price' so that the impact of volatility can be investigated using the most pronounced examples (within the modelling framework).

In the baseline projection, 50 of the 500 projected prices are greater than the 90th percentile price (by definition). This means that should historic levels of volatility continue (and these are already included within the FAPRI modelling framework), there is about a 1 in 10 likelihood that prices will exceed the 90th percentile price. Changing the assumption around volatility, such that future volatility is assumed to be greater than historic experience, means there will be a greater than 1 out of 10 likelihood that prices will exceed the **baseline's** 90th percentile price. One way to gauge the extent additional world price volatility impacts UK price volatility is by calculating how much more likely it is for prices to exceed this threshold. So we can understand that a price-range expected to have a 1 in 10 likelihood of occurring under the *status quo* assumptions about volatility, may have a 2 in 10 likelihood, or be twice as likely to occur, when volatility increases. Counting how many times the price exceeds the upper threshold (the 90th percentile in the baseline) in a scenario with increased volatility and subtracting the expected number from the baseline (50) provides an indication of the impact on UK prices. This can be converted to a percentage, facilitating comparison across years and commodities. For example, if the upper threshold price is exceeded 55 times in the scenario, we can expect the higher price level 10% more often than in the baseline (because 5 is 10% of 50).

In the same way, prices are lower than the 10th percentile threshold price 50 times in the baseline projection (by definition). Counting how many times prices fall below this lower threshold in the scenarios, provides information on the likelihood of relatively low prices in the case of additional volatility. If, for example, the price is below the lower threshold 60 times in the scenario, then this occurs 20% more often than in the baseline (because 10 is 20% of 50).

In general, when there is a moderate increase in the level of world price volatility, the maximum increase in the likelihood of a UK price below the lower threshold ranges from 34% to 62%, and above the upper threshold from 32% to 54% (across all years and commodities). In the case when the level of world price volatility is *high*, the increased likelihood of prices below the lower threshold ranges between 48% and 90%, and above the upper threshold between 52% and 82% (across all years and commodities). The maximum increase in the likelihood of crossing a threshold price (across projections and years) for each main commodity is provided in Table 2-1. Detailed results for each commodity and year follow.

Table 2-1. Maximum increase in likelihood of a projected price below or above a threshold

	Lower threshold		Upper threshold	
Commodity	Moderate Scenario	High Scenario	Moderate Scenario	High Scenario
Wheat	50%	70%	46%	72%
Barley	36%	50%	40%	62%
Oats	36%	50%	40%	62%
Rapeseed	62%	90%	50%	82%
Milk	34%	54%	38%	62%
Cheese	36%	48%	40%	60%
Butter	40%	50%	32%	52%
Beef	42%	68%	38%	62%
Sheepmeat	56%	78%	44%	68%
Pigmeat	44%	76%	54%	74%
Poultry	44%	78%	52%	80%

2.1 Cereals and oilseeds

The upper and lower threshold prices for each year in the projection for wheat are shown in Figure 2-1 (the 90th and 10th percentiles). Taking the first projected year as an example, 2023, the lower threshold price is £196 per tonne. This is based on the 10th percentile, meaning 50 out of 500 times, in the year 2023, wheat price is below £196. For the same year, prices are above £265 per tonne 50 out of 500 times, the 90th percentile. Therefore, the lower price threshold used for comparison to the scenarios for that year is £196 per tonne and the upper price threshold is £265 per tonne[2]. In 2032, the average baseline projection for wheat price is £160 per tonne. The lower threshold in this year is £129 per tonne and the upper threshold is £194. Using the stochastic projection, there is a 1 out of 10 likelihood (or 50 out of 500) of the wheat price going below the lower threshold in 2032, and a 1 out of 10 likelihood (or 50 out of 500) of the wheat price going above than the upper threshold in 2032.

Figure 2-2 shows the number and percent increase in projections of UK wheat price exceeding a threshold for the *moderate* volatility and *high* volatility scenarios. In the *moderate* volatility scenario, the price is below the threshold for the year 2023 (£196 per tonne) 75 out of 500 times, or 25 additional occurrences (an additional 50%) than in the same year in the baseline. For the same projection year (2023) in the *high* volatility scenario, the price falls below the threshold 84 out of 500 times, or an additional 34 occurrences (an additional 68%). The upper threshold price for the year 2023 (£265 per tonne) is surpassed 64 out of 500 times (an additional 14 occurrences, or 28%) and 75 out of 500 times (an additional 25 occurrences, or 50%) in the *moderate* and *high* scenarios respectively. The lower threshold price for UK wheat (or the 10th percentile in the baseline) ranges between £129 (at the end of the projection period) and £196 per tonne (at the start of the projection period). The UK wheat price falls below the lower price threshold between 11 and 25, or 20 and 35, additional times compared to the baseline in the *moderate* and *high* scenarios respectively. The UK wheat price is above the upper price threshold (between £201 and £275 per tonne across the projection period) between 11 and 23 more times in the *moderate* scenario compared to the baseline, and between 21 and 36 more times in the *high* scenario.

[2] London wheat nearby prices are reported at £208 per tonne as of 28 March 2023 (source: AHDB) https://ahdb.org.uk/cereals-oilseeds/futures-prices.

Figure 2-1. Stochastic baseline projection of UK wheat price

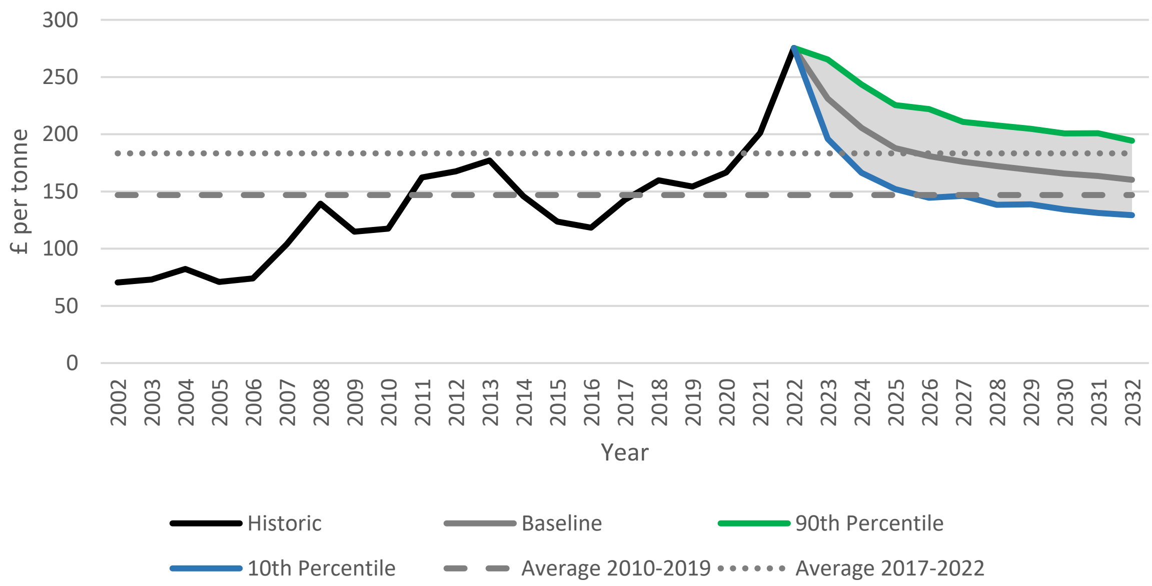


Figure 2-2. Number and percent increase in projections of UK wheat price exceeding a threshold

The stochastic baseline projection for barley is shown in Figure 2-3, along with the upper and lower threshold prices (the 90th and 10th percentiles) for each year in the projection. Barley price is showing a downwards trend over the projection period while a gradual increase in barley yield and production is expected over the same timeframe. In the case of barley, the UK price falls below the lower price threshold (ranging between £119 – £173 per tonne depending on the year projected) up to 18 additional times (36% more) in the *moderate* scenario, and up to 25 additional times (50% more) in the case of *high* volatility. The upper price threshold (ranging between £174 – £234 per tonne depending on the year projected) is exceeded up to 20, or 31 times (respectively for *moderate* and *high* volatility) more than in the baseline. The results for each year are provided in Figure 2-4.

The stochastic baseline projection of UK oats price is provided in Figure 2-5 along with the upper and lower threshold prices. A decline in oats price is projected over the 10 year period, with a sharper decline in the initial years. Oats yield is projected to remain relatively static throughout the projection period, with a very gradual increase in production attributable to an increase in the crop area. The UK oats price drops below the lower price threshold (£123 – £176 per tonne) up to 18 (36%), or 25 (50%) times more than the baseline in the scenario projections. The upper price threshold (£177 – £238 per tonne) is surpassed up to 20 (40%), or 31 (62%) additional times for each scenario projection. Details are shown in Figure 2-5.

The stochastic baseline projection of UK rapeseed price and the upper and lower thresholds is provided in Figure 2-7. Oilseed price is projected to decline over the initial years of the projection period. Oilseed crop yield is projected to remain relatively static during this time, while crop area and production increase. UK oilseed price falls lower than the benchmark lower price threshold (£309 – £407 per tonne) up to 31 additional times (62% more) in the *moderate* scenario, and up to 45 additional times (90%) in the *high* scenario. It reaches above the upper price threshold (£485 – £610 per tonne) up to 25 (50%) or 41 (82%) more times in the scenarios compared to the baseline[3]. Results are presented in Figure 2-8.

[3] Paris rapeseed nearby price is reported as £415 per tonne as of 28 March 2023 (source: AHDB) https://ahdb.org.uk/cereals-oilseeds/futures-prices

Figure 2-3. Stochastic baseline projection of UK barley price

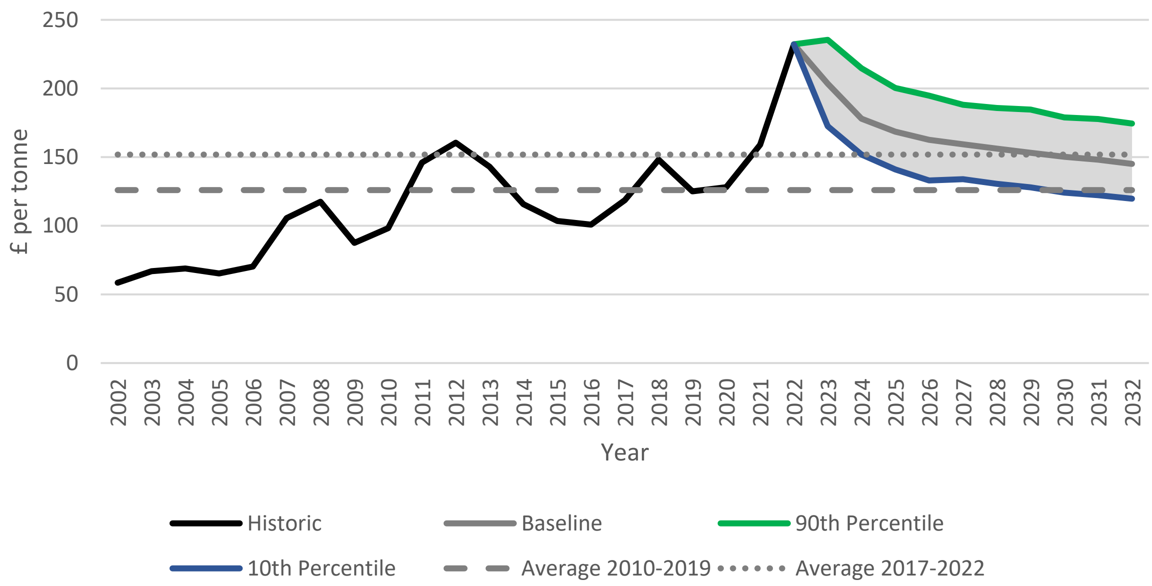


Figure 2-4. Number and percent increase in projections of UK barley price exceeding a threshold

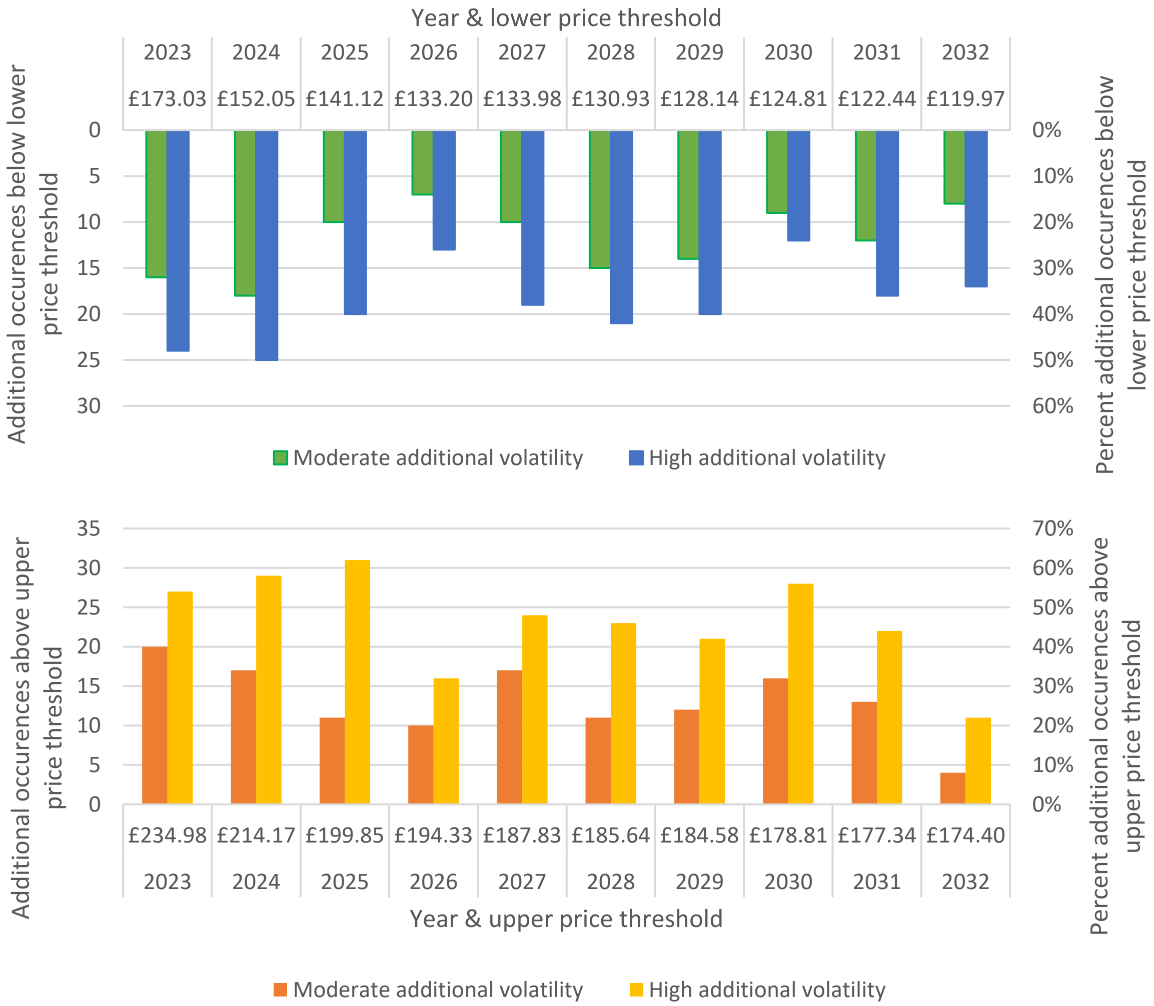


Figure 2-5. Stochastic baseline projection of UK oats price

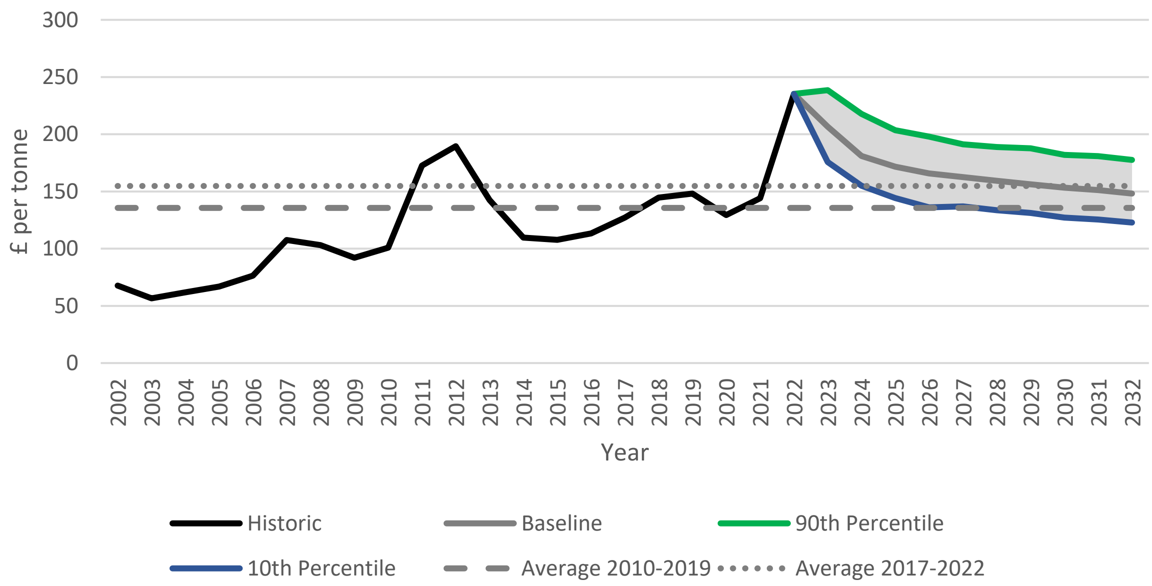


Figure 2-6. Number and percent increase in projections of UK oats price exceeding a threshold

Figure 2-7. Stochastic baseline projection of UK rapeseed price

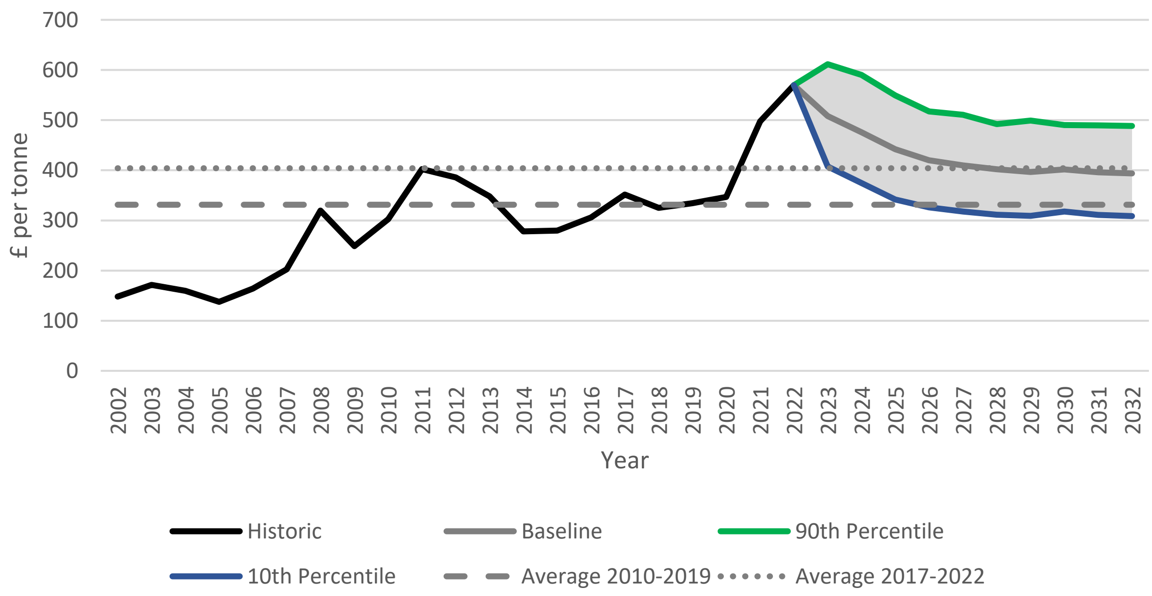


Figure 2-8. Number and percent increase in projections of UK rapeseed price exceeding a threshold

2.2 Dairy

The stochastic baseline projection for UK farmgate milk price along with the upper and lower price threshold is shown in Figure 2-9. A sharp decline (from an observed historic high) is expected in the initial year of the projection, with a gradual declining trend in the longer term[4]. Nevertheless, milk production is expected to increase during this time. Taking the first projected year as an example, 2023, the lower threshold price is 34 pence per litre. This is based on the 10th percentile, meaning 50 out of 500 times, in the year 2023, milk price is below 34 pence per litre, and so this serves as the lower threshold used for comparison. For the same year, prices are above 39 pence per litre 50 out of 500 times in the stochastic baseline, the 90th percentile, so this price provides the upper threshold used for comparison. Using the stochastic projection, there is a 1 out of 10 likelihood (or 50 out of 500) of a milk price below the lower threshold in 2032, and a 1 out of 10 likelihood (or 50 out of 500) of a milk price above the upper threshold in 2032.

The number of times UK farmgate milk prices fall below or above a threshold in a scenario, compared to the baseline, for each year in the projection period, is provided in Figure 2-10. In the *moderate* volatility scenario, the price is lower than the threshold for the year 2023 67 out of 500 times, or 17 additional occurrences (34% more) than in the same year in the baseline. For the same projection year (2023) in the *high* volatility scenario, the price falls below the threshold 75 out of 500 times, or an additional 25 occurrences (50% more). The upper threshold price for the year 2023 is surpassed 62 out of 500 times (an additional 12 occurrences) and 70 out of 500 times (an additional 20 occurrences) in the *moderate* and *high* scenarios respectively. The lower threshold price (or the 10th percentile in the baseline) ranges between 29 pence per litre (at the end of the projection period) and 34 pence per litre (at the start of the projection period). Price falls below the lower threshold between 7 and 17 additional times (between 14% and 34%) compared to the baseline in the *moderate* scenario, and between 15 and 27 additional times (between 30% and 54%) in the *high* scenario. The upper price threshold ranges between 33 pence per litre and 39 pence per litre across the projection period. The milk price is above this threshold between 9 and 19, or 13 and 31 additional times in the *moderate* and *high* scenarios respectively.

The baseline stochastic projection for UK cheese price is provided in Figure 2-11. In line with other dairy commodities, a sharp decline is expected in cheese price in the initial year of the projection with an ongoing, more moderate, declining trend in the longer term also observed. Production and domestic use are also expected to increase during this period. UK cheese price falls below the lower price threshold (£285 – £330 per 100 kilos) up to 18 (36%) and 24 (48%) more times in the scenarios. It exceeds the upper price threshold (£316 – 378 per 100 kilos) up to 20 (40%) and 30 (60%) more times in the scenarios. Results are shown in Figure 2-12.

The stochastic baseline projection of UK butter price, along with the upper and lower thresholds is provided in Figure 2-13. The baseline projects a sharp decline in price in 2023, with an overall declining trend in the longer term. Butter production is projected to increase during this time because additional milk is produced, while butter net exports remain low. The UK butter price is below the lower price threshold (£346 - £414 per 100 kilos) up to 17 (34%) and 25 (50%) more times in the scenarios. The upper price threshold (£391 – £477 per 100 kilos) is broken an additional 16 (32%) to 26 (52%) times in the scenarios. Results are provided in Figure 2-14.

[4] Farmgate milk price for January 2023 reported as 49 pence per litre as of 28 March 2023 (source: AHDB) with additional price cuts announced suggesting a further reduction to about 42 pence per litre from 1 April. Reduced demand due to cost of living pressures, and entering seasonal supply increases, indicate prices are likely to reduce further before the end of the year.

Figure 2-9. Stochastic baseline projection of UK farmgate milk price.

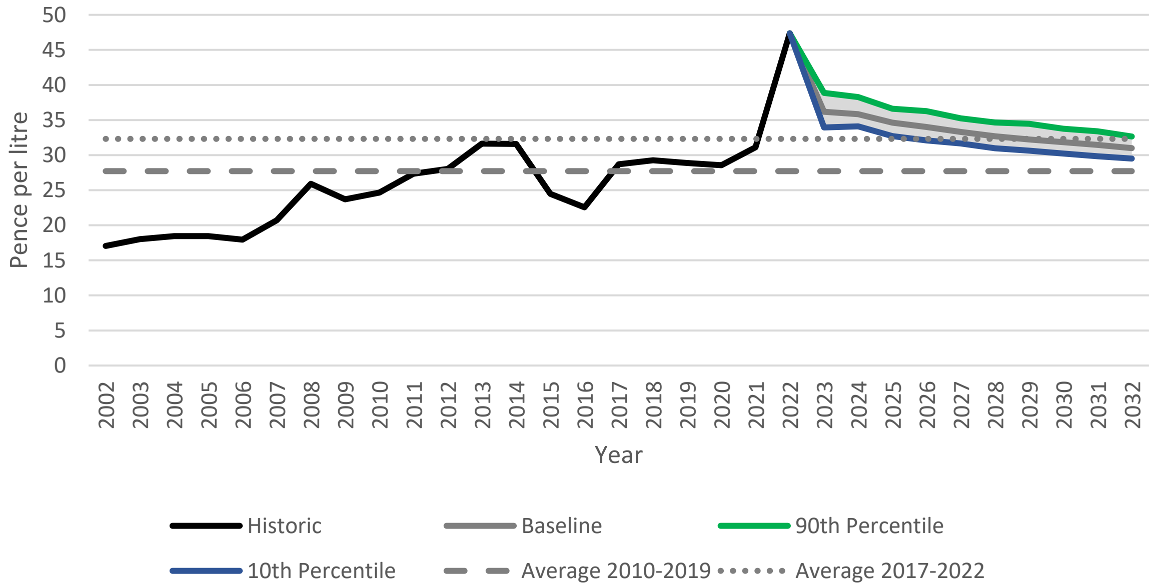


Figure 2-10. Number and percent increase in projections of UK milk price exceeding a threshold

Figure 2-11. Stochastic baseline projection UK cheese price

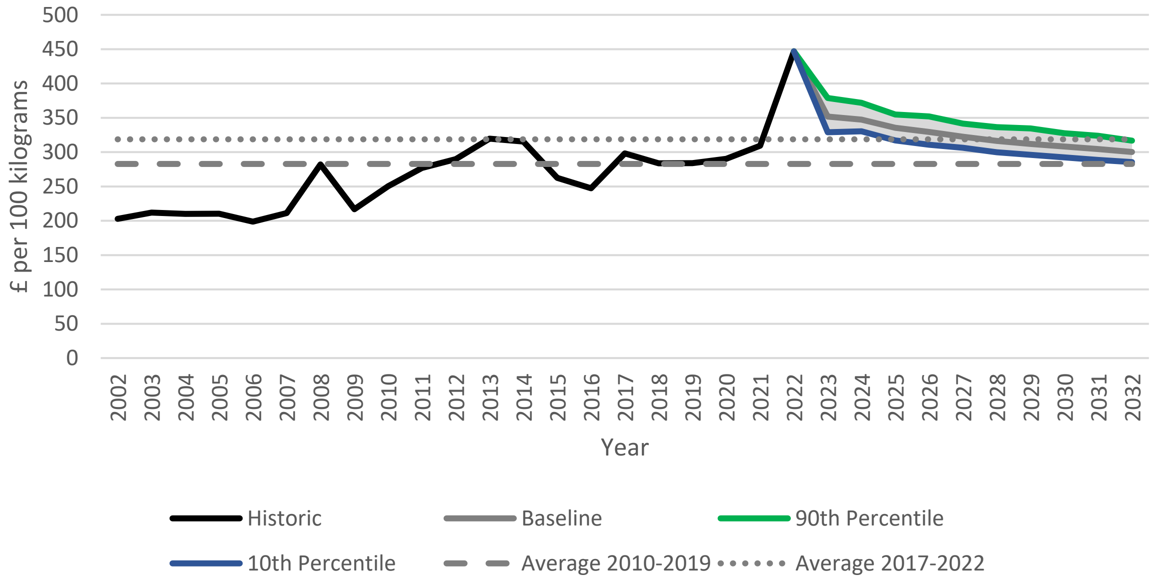


Figure 2-12. Number and percent increase in projections of UK cheese price exceeding a threshold

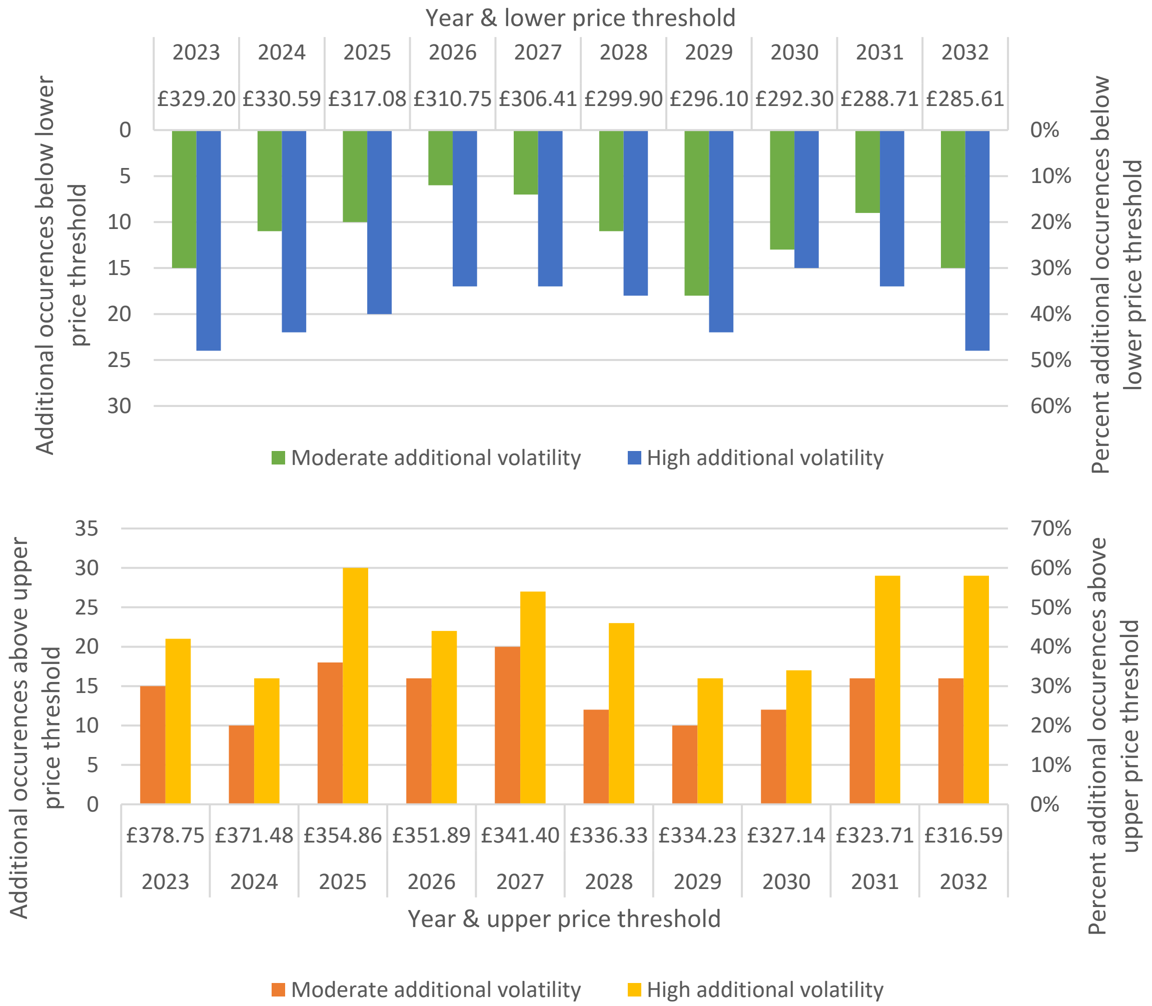


Figure 2-13. Stochastic baseline projection of UK butter price

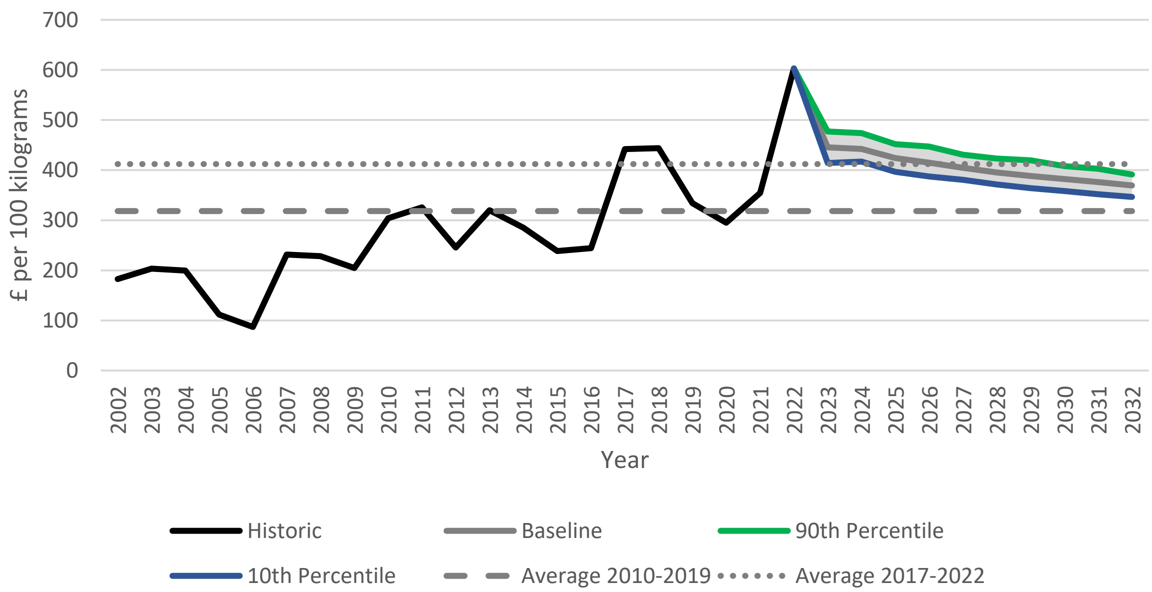


Figure 2-14. Number and percent increase in projections of UK butter price exceeding a threshold

2.3 Meat

The stochastic baseline projection of UK beef price is provided in Figure 2-15, along with the upper and lower threshold prices (the 90th and 10th percentiles) for each year in the projection period. The baseline beef price fluctuates in the initial years of the projection period with a downward trend projected in the longer term[5]. Beef production is expected to remain relatively static during the projection, while suckler cow numbers gradually decline. Taking the first projected year as an example, 2023, the lower threshold price is £413 per tonne. This is based on the 10th percentile, meaning 50 out of 500 times, in the year 2023, beef price is below £413. For the same year, prices are above £468 per tonne 50 out of 500 times in the stochastic baseline, the 90th percentile so this provides the upper price threshold used for comparison. In 2032, the lower threshold is £333 per tonne and the upper threshold is £385 per tonne. This means there is a 1 out of 10 likelihood (or 50 out of 500) of beef price going below the lower threshold, and a 1 out of 10 likelihood (or 50 out of 500) of beef price going above the upper threshold.

The number of occurrences UK beef prices fall below or above a threshold in a scenario, compared to the baseline, for each year in the projection period, is provided in Figure 2-16. In the *moderate* volatility scenario, the price is lower than the threshold for the year 2023 (£413 per tonne) 59 out of 500 times, or 9 additional occurrences (18% more) than in the same year in the baseline. For the same year (2023) in the *high volatility* scenario, the price falls below the threshold 66 out of 500 times, or an additional 16 occurrences (32% more). The upper threshold price (£468 per tonne) is surpassed 61 out of 500 times (an additional 11 occurrences) and 69 out of 500 times (an additional 19 occurrences) in the *moderate* and *high* scenarios respectively.

The lower threshold price for UK beef (or the 10th percentile in the baseline) ranges between £333.19 (at the end of the projection period) and £412.95 per tonne (at the start of the projection period). The UK beef price falls below the lower price threshold between 9 (18%) and 21 (42%) additional times compared to the baseline in the *moderate* scenario, and between 16 (32%) and 34 (68%) additional times in the *high* scenario. The upper price threshold ranges between £385.70 and £467.80 per tonne across the projection period. The UK beef price is above this threshold between 11 (22%) and 19 (38%) more times in the *moderate* scenario compared to the baseline, and between 16 (32%) and 31 (62%) more times in the *high* scenario.

The stochastic baseline projection for UK sheepmeat price is provided in Figure 2-17. Sheepmeat price is projected to decline sharply in the first two years of the projection, followed by a gradual decline. Sheepmeat production is also projected to gradually decline during the projection period which is attributable to the decline also experienced in the breeding flock. Sheepmeat price drops below the lower price threshold (£370 – £496 per 100 kilos) up to an additional 28 (56%) or 39 (78%) times in the *moderate* and *high* scenario respectively. The upper price threshold (£436 – £558 per 100 kilos) is breached up to 22 or 34 more times compared to the baseline. Results are shown in Figure 2-18.

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[5] Prices reported for the week of the 25 March 2023 are 488 pence per kilo for steers, 486 for heifers, 466 for young bulls, and 384 for cows (source: AHDB) https://ahdb.org.uk/beef/gb-deadweight-cattle-prices-by-region

Figure 2-15. Stochastic baseline projection of UK beef price

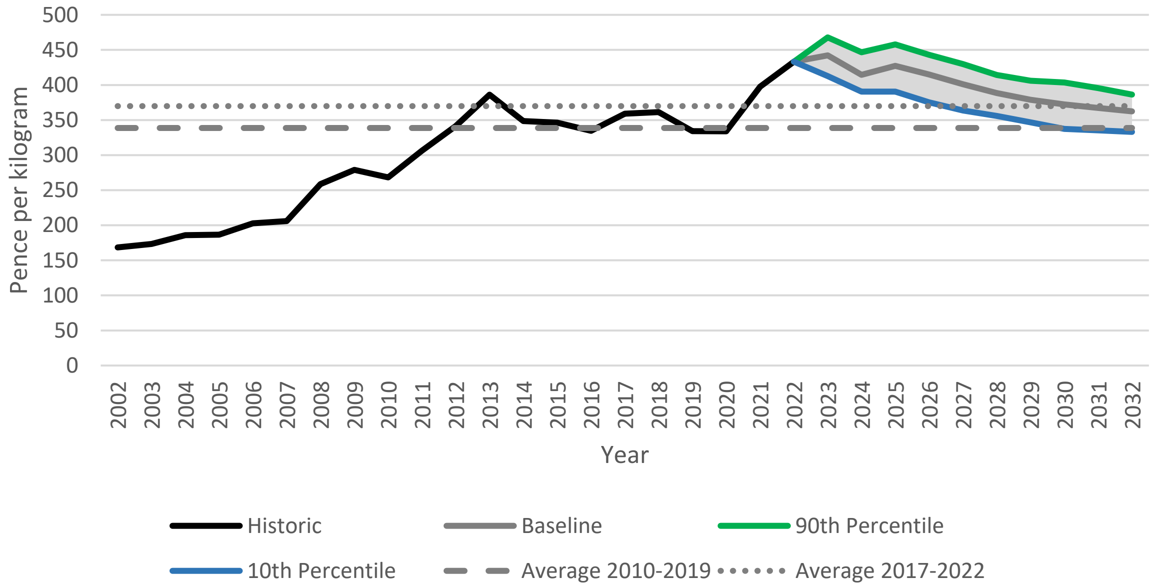


Figure 2-16. Number and percent increase in projections of UK beef price exceeding a threshold

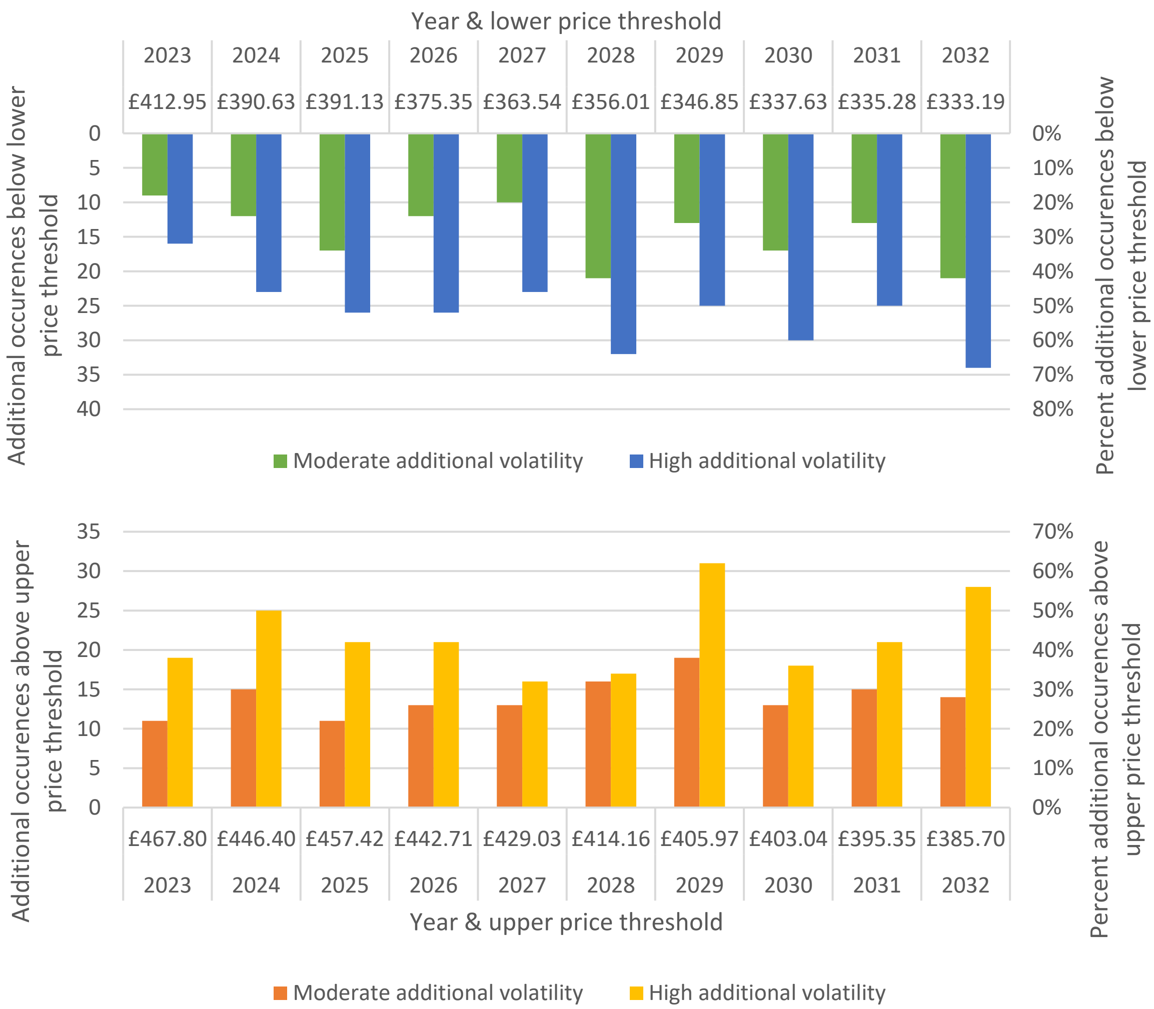


Figure 2-17. Stochastic baseline projection of UK sheepmeat price

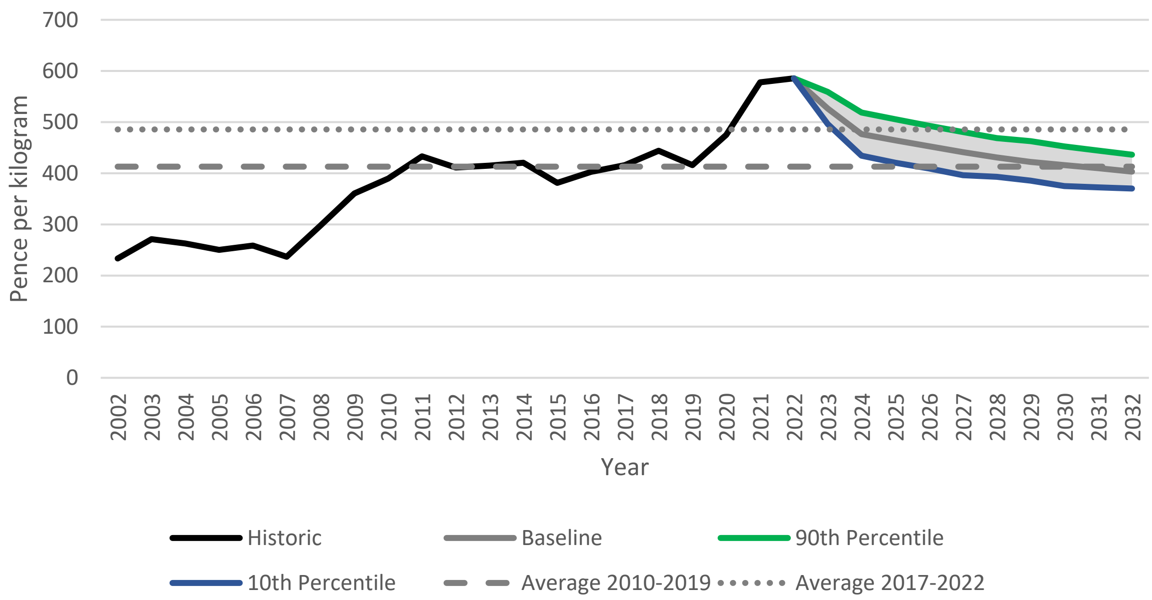
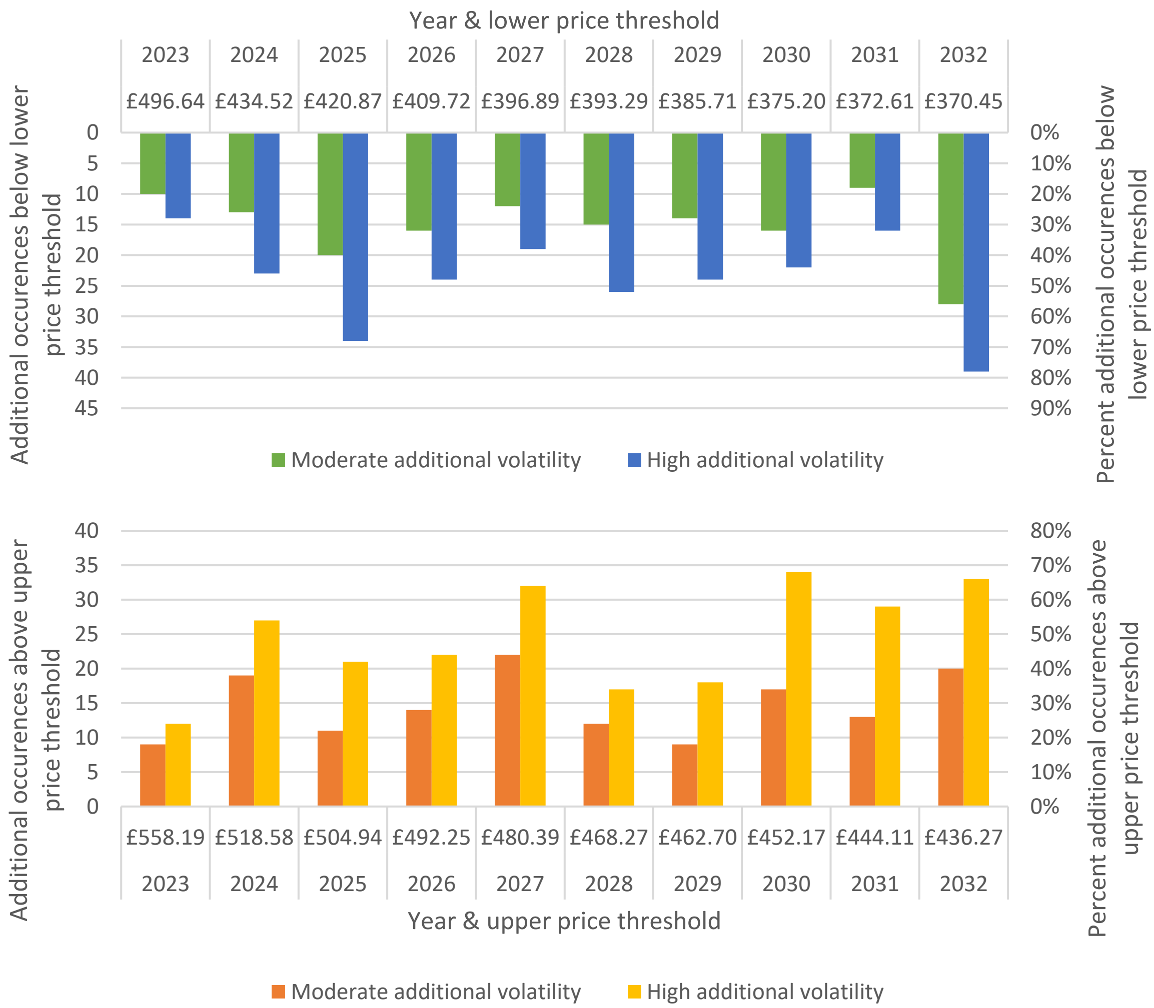


Figure 2-18. Number and percent increase in projections of UK sheepmeat price exceeding a threshold



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The stochastic baseline projection of UK pigmeat price along with the upper and lower threshold is provided in Figure 2-19. A sharp decline in pigmeat price is projected in the first 2 years of the baseline projection. Throughout the projection timeframe, pigmeat production and domestic use are to remain relatively static. The UK pigmeat price is projected below the lower price threshold (£112 – £145 per 100 kilos) up to an additional 22 (44% more) or 38 (76% more) times in the volatility scenarios. Prices go above the upper price threshold (£141-171 per 100 kilos) up to an additional 27 or 37 times (54% or 74% more time). Results are provided in Figure 2-20.

The stochastic baseline projection of UK poultry price is provided in Figure 2-21. Poultrymeat price is expected to decline over the longer term while production and domestic use are expected to increase. The poultry price fails to hit the benchmark lower price threshold (£105 – £138 per 100 kilos) up to 22 (44%) or 39 (78%) times more in the scenarios compared to the baseline. The benchmark upper price threshold (£125-£159 per 100 kilos) is exceeded up to an additional 26 or 40 times. Results are shown in Figure 2-22.

Figure 2-19. Stochastic baseline projection of UK pigmeat price

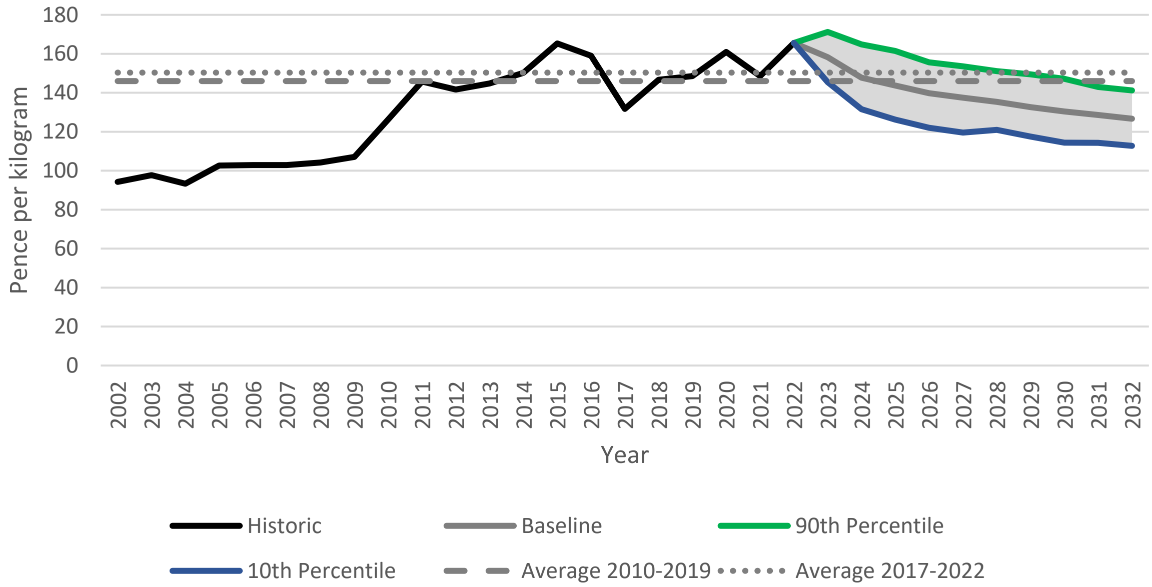


Figure 2-20. Number and percent increase in projections of UK pigmeat price exceeding a threshold

Figure 2-21. Stochastic baseline projection of UK poultry price

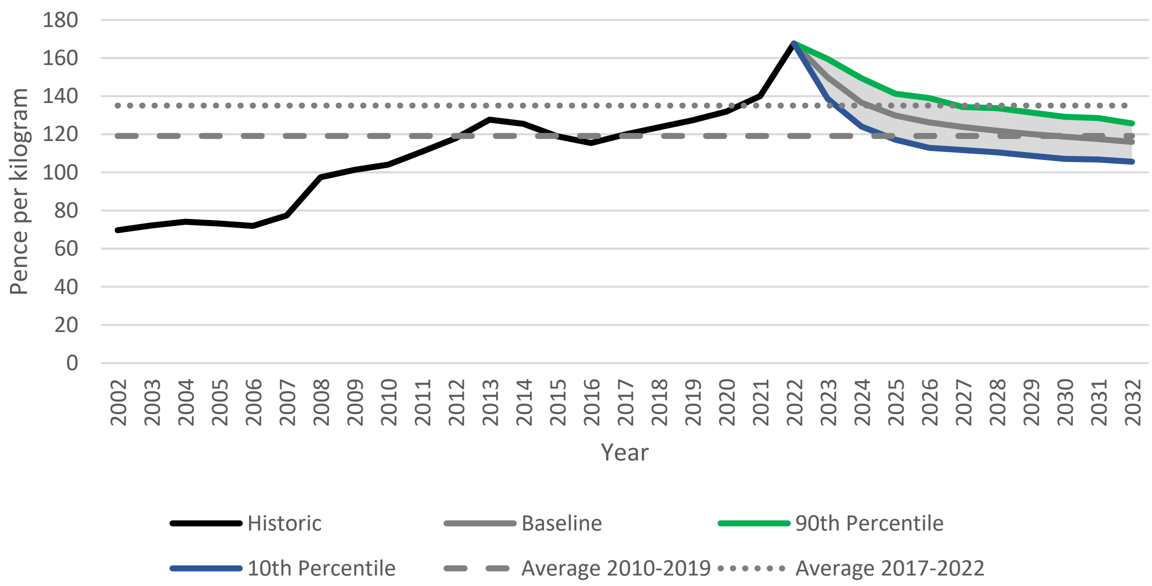
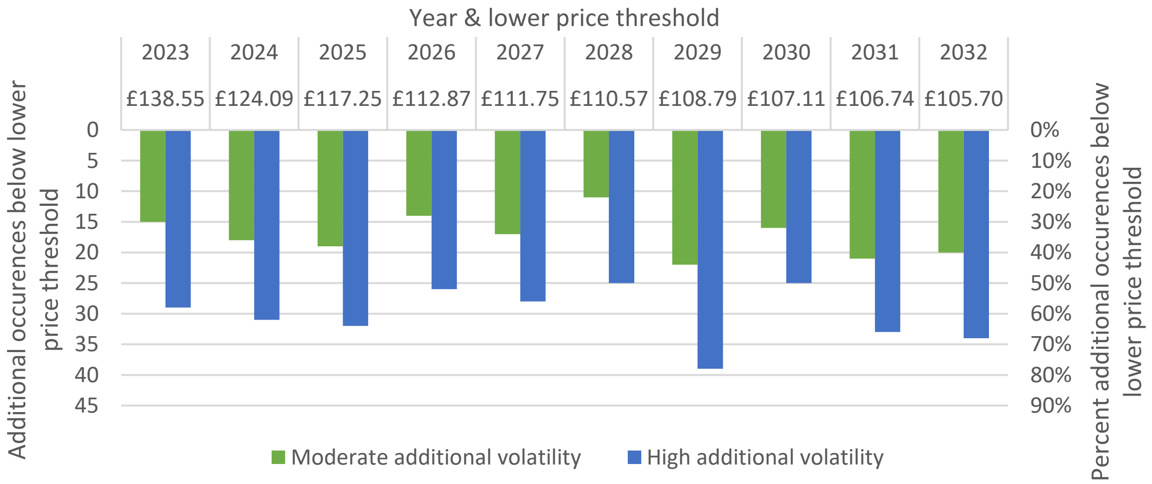
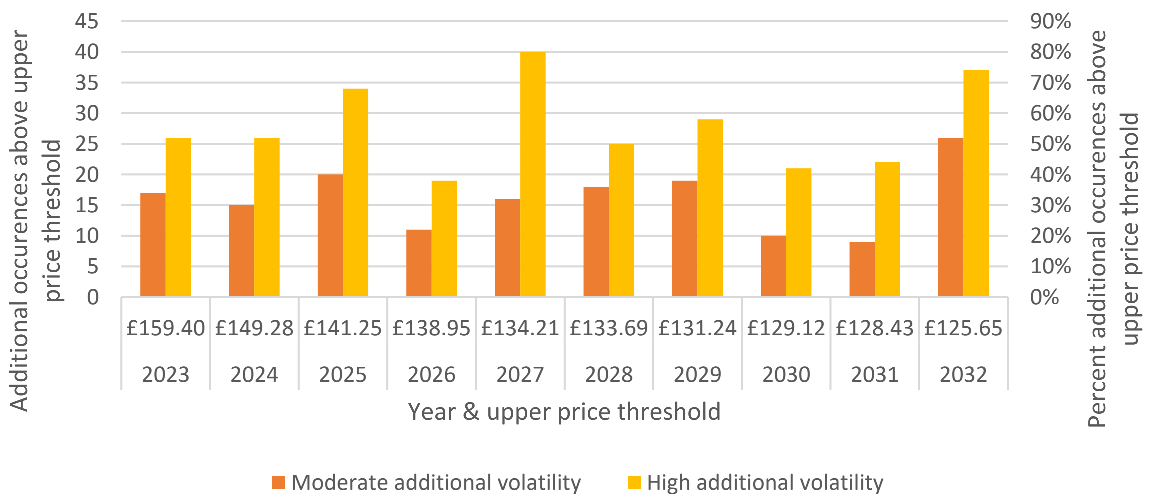


Figure 2-22. Number and percent increase in projections of UK poultrymeat price exceeding a threshold





2.4 Annual volatility of UK prices

Here, the sensitivity of extreme changes in UK prices year on year to world price volatility is analysed. The annual change in price (expressed as a percent of the price the year before) for each commodity is compared for each stochastic projection between *status quo* and *high* volatility. The number of occurrences when the difference (*high* volatility year-on-year price change less the *status quo* volatility year-on-year price change) is at least + or -5% is counted, and presented for each commodity in Table 2-2.

UK cereals and oilseed prices experience the most additional year-on-year price volatility when world price volatility is relatively *high.* For example, the change in UK wheat price from the year 2022 to the year 2023 is at least 5% (of the 2022 price) an additional 41 out of 500 times when world price volatility is *high* compared to *status quo* world price volatility. Of the crops, UK rapeseed year-on-year price change is most sensitive to *high* world price volatility. Over the 10-year projection period, UK rapeseed year-on-year change is at least 5% greater with *high* volatility than *status quo* volatility 232 times on average. This is consistent with historically observed volatile behaviour in rapeseed price. As illustrated earlier in Figure 2-8, rapeseed has the largest difference between the upper and lower price threshold. Cereals (as a group) show at least a 5% difference between 117 and 140 times.

The remaining commodities show less sensitivity to changes in world price volatility levels. This is consistent with expectations, as crop commodities are most closely aligned with global markets, and this is also reflected in the model structure. When investigating all commodities, the year with the largest number of occurrences with 5% or more difference on the year before is 2027.

Table 2-2. Number of occurrences the difference in year-on-year price change between high and status quo volatility scenarios is either + or -5%

	Year										
Commodity	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	*Average of years*
Wheat	41	128	141	147	158	152	152	142	163	166	*139.0*
Barley	40	92	107	133	150	140	127	132	140	141	*120.2*
Oats	39	91	105	129	144	135	121	129	139	135	*116.7*
OSR	150	231	243	236	258	243	257	232	244	235	*232.9*
Milk	0	4	0	0	0	0	1	0	1	1	*0.7*
Cheese	0	5	0	1	0	0	1	0	1	1	*0.9*
Butter	0	2	1	1	2	0	1	0	1	1	*0.9*
Beef	0	3	3	3	10	6	8	7	12	6	*5.8*
Sheepmeat	0	1	3	13	25	14	8	14	13	15	*10.6*
Pigmeat	4	16	29	44	51	48	30	40	44	41	*34.7*
Poultry	0	2	15	12	10	5	6	9	5	8	*7.2*
Average of commodities	*24.9*	*52.3*	*58.8*	*65.4*	*73.5*	*67.5*	*64.7*	*64.1*	*69.4*	*68.2*	

3 Income impacts

The expected impacts of a hypothetical increase in the volatility of world commodity prices on agricultural income is now considered. The income impacts are assessed by defining and projecting forward an aggregate income indicator. First, the indicator is used to determine the impact of world commodity price volatility on the likelihood of relatively extreme incomes. Second, a decomposition approach is applied to identify the different pathways world commodity price volatility impacts on revenue. Lastly, the extent to which world commodity price volatility impacts decision-making based on historic prices (and so in-year income) is explored.

3.1 An aggregate agricultural income indicator

The *aggregate income indicator* constructed for this exercise is defined as the value of production *less* intermediate fertiliser and animal feed use. The value of production (revenue) is calculated as the UK producer price multiplied by the volume of primary production for wheat, barley, oats, oilseeds, beef and veal, pigmeat, sheepmeat, poultrymeat and liquid milk. An estimate of the aggregate fertiliser bill is calculated as a reference price per unit of nitrate, phosphate, or potassium[6] multiplied by the projected UK price index for the nutrient, multiplied by the projected volume used. The feed bill is an aggregation across livestock commodities based on a reference cost of compound feed per unit of output[7] multiplied by the projected input cost index for that livestock category, multiplied by the projected output.

The net revenue calculated provides an *indication* of relative income across years and scenarios. However, it is not a complete accounting of the sector as some outputs are not included in the model, and many elements of intermediate consumption are not included (such as seeds, energy, services) as well as other costs (such as capital consumption, compensation of employees, rent and interest). The *aggregate income indicator* is calculated for each stochastic projection (500 projections x 10 years) in the baseline and for the *high additional volatility* scenario.

The approach is applied to historic years to provide a validity check that a change in income projected forward by the model, can be expected to be consistent with official accounting for the sector. The historic *aggregate income indicator* for commodities and costs included in the FAPRI-UK model is compared to the UK Aggregate Agricultural Account[8] (adjusted to only include the same outputs and costs). The calculation based on FAPRI-UK variables follows a very similar pattern. This provides confidence that if *aggregate income* is projected to increase or decrease using the model, the same directional change would be reflected by the established accounting approach.

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[6] Reference fertiliser price for AN, MOP, DAP and TSP taken from AHDB GB Fertiliser Price Series Fertiliser information | AHDB. Nutrient price conversion: AN - 34.5% N, DAP and TSP – 20% P, MOP – 50% K

[7] Costs of production reference price for beef, sheepmeat, milk and pigmeat taken from AHDB. Cost of production reference price for poultry estimated from Poultry World and Poultry Network

[8] Total income from farming in the UK - GOV.UK (www.gov.uk) Last updated: 12th May 2022

Figure 3-1. Percentage change year on year of the aggregate income indicator (indexed 2010 = 100) (sources Defra, FAPRI-UK and own calculations)

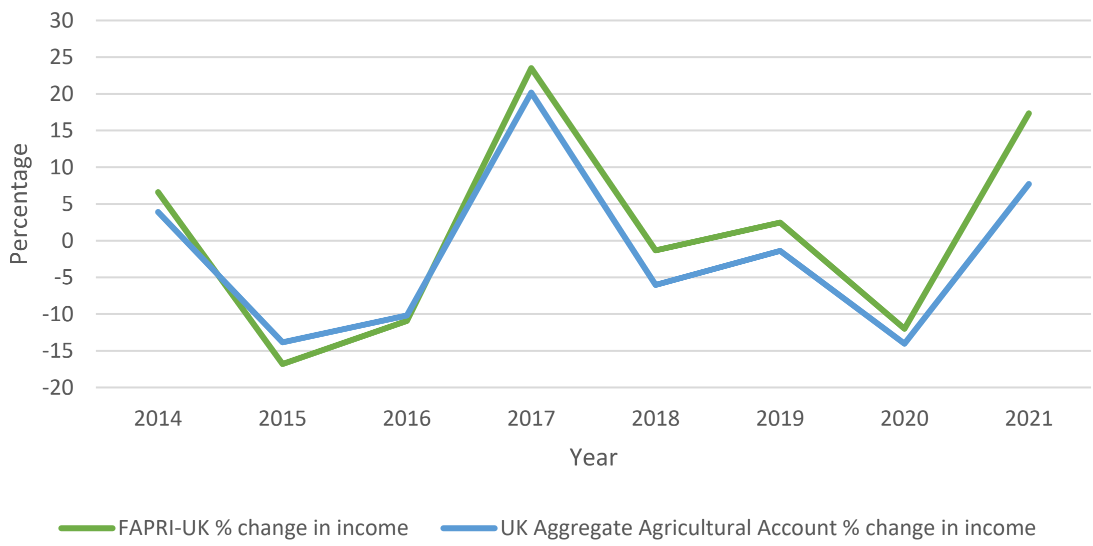


Figure 3-2The *aggregate income indicator* is generated within the stochastic baseline projections (see Figure 3-2). This results in 500 aggregate income projections for each year. There is a peak corresponding to the year 2022 - in the wake of observed record high prices. Thereafter an overall decline in the *income indicator* is found over the projection period, as prices stabilise. By way of explanation, it is important to note that assumption underpinning the projection period does not include any acute, additional shocks to macroeconomic conditions, geopolitical conflict, or, zoonotic or human epidemics as have been prevalent in recent years. This means, in general, prices gravitate back towards their long-term historic average, as supply and demand adjust in response to price signals. However, despite the market corrections shaping the general trend and range of outcomes, income is largely expected to stay above historic averages. This can be illustrated with reference to the path of the 10th percentile. Until the year 2029, the *income indicator* remains above the 2010 to 2019 historic average for 90 percent of the time. In the final three years of the projection period, the *income indicator* is very close to or above the level observed in the year 2015 for 80 percent of the time.

In the case of the *high* world price volatility scenario, the *aggregate income indicator* remains above the 2010-2019 historic average for 90 percent of the time in the projection period, and 80 percent of the time until the year 2030. The *income indicator* is below the more recent historic average (2017-2022) 80 percent of the time from the year 2031 in the scenario, compared to from 2030 in the baseline. The *income indicator* remains above the relatively high 2017-2022 average 10 percent of the time for the entire projection period.

The 10th and 90th percentiles of the projected *aggregate income indicator* are expressed as a percentage of the observed historic averages between the years 2010 and 2019 (in Figure 3-3) and the years 2017 and 2022 (in Figure 3-4). In the near-term (years 2023 and 2024) income is projected to be above 140% of the long-term (10 year) average in 10% of stochastic projections (90th percentile) for the high volatility scenario, and below 112% of the long-term average about 10% of the time (10th percentile). Using the short-term (5 year) average, this equates to just over 122% and under 98% using the same range (top and bottom deciles). In comparison, with baseline *status quo* volatility, in the near term (2023-2024) the *indicator* is projected to be above 138% of the long-term average and below 114% of the long-term average in about 10% of projections. Expressed as a percentage of the short-term average, the percentiles are above and below 120% and 100% in 10% of projections, respectively.

Figure 3-1. Percentage change year on year of the aggregate income indicator (indexed 2010 = 100) (sources Defra, FAPRI-UK and own calculations)

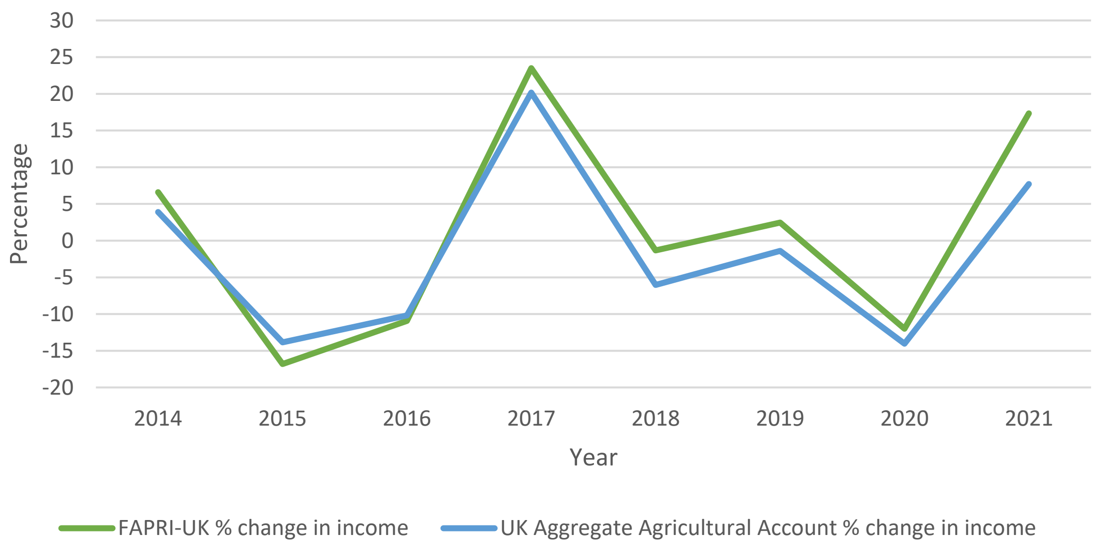


Figure 3-2. Index (2010=100): Historic and stochastic projection of the aggregate income indicator in the status quo and high volatility scenarios (source: FAPRI-UK)

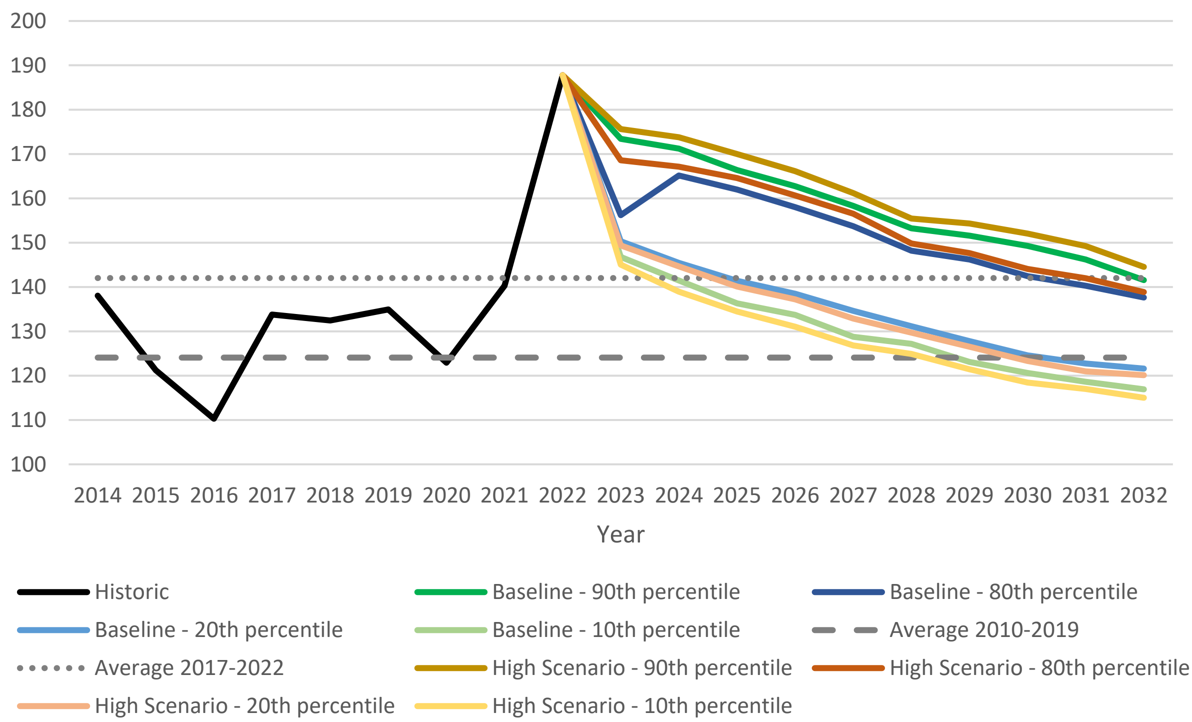


Figure 3-3. The 10th and 90th percentiles of the aggregate income indicator expressed as a percentage of the observed long-term historic average (2010 to 2019)

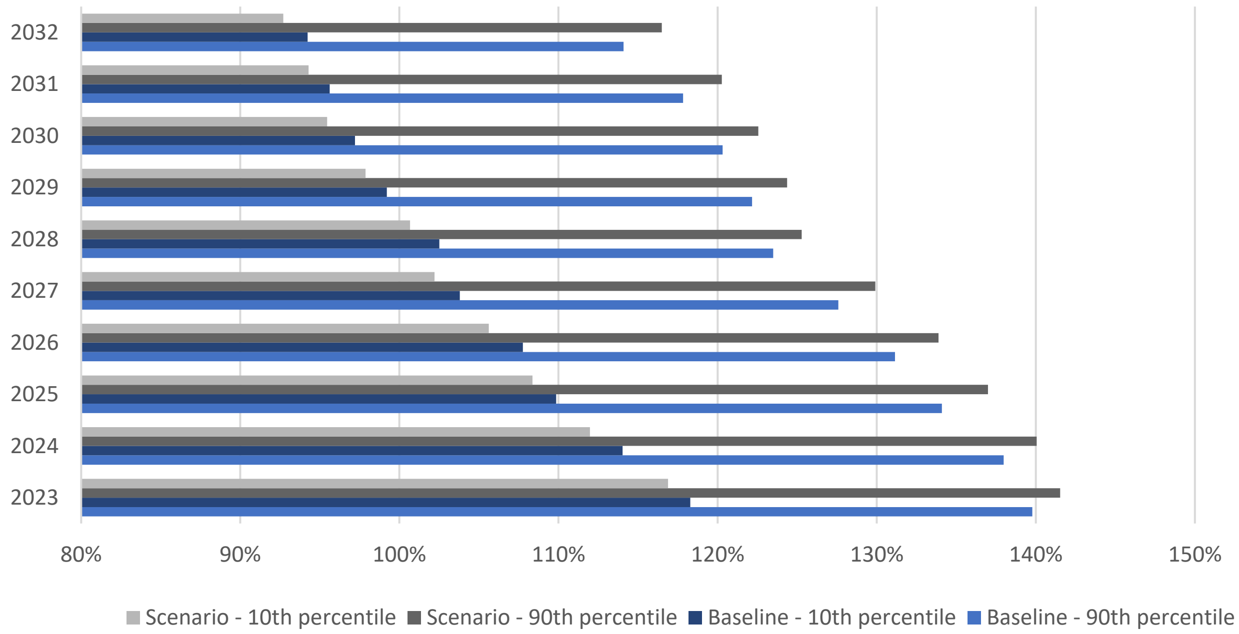
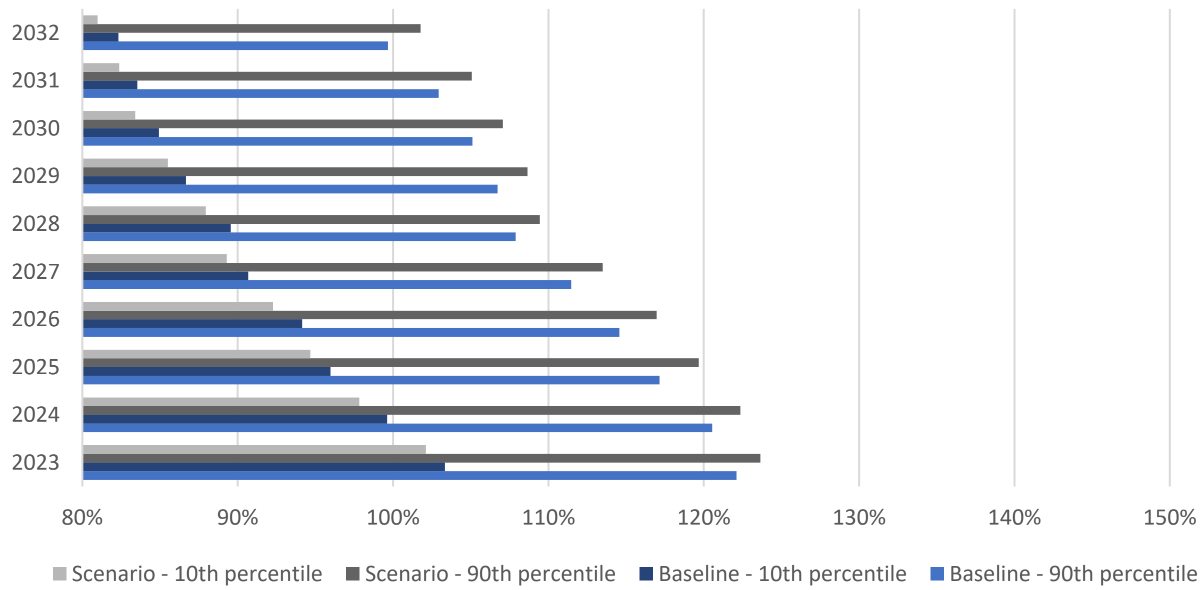


Figure 3-4. The 10th and 90th percentiles of the aggregate income indicator expressed as a percentage of the short-term observed historic average (2017 to 2022)



3.2 Decomposition of income impacts

While the frequency of more extreme values increases in a *high* volatility scenario, there is almost no difference in the average aggregate income comparing the two different levels of world commodity price volatility modelled (Figure 3-5). This suggests that the impact of high commodity price volatility on income is symmetric, in the sense that relatively higher income projections are balanced out by relatively lower income projections. Considering that, on average in all projections, changes in revenue have a much larger influence on expected income than the changes in fertiliser and feed costs, further investigation of how world commodity price volatility levels impact revenue is carried out.

Revenue is determined by price, as well as factor productivity (yield), and the amount of resource dedicated to production (land and breeding stock). The most direct way relatively high world price volatility impacts UK agriculture revenue is *via* producer prices, with potential indirect impacts on yield (due to changing prices of key inputs such as fertilisers) and how resources are used (due to changing the expected return of different alternative uses of a resource such as cropland).

As an illustrative example, the difference in wheat revenue when comparing *status quo* and *high* world price volatility can be compared and contrasted *via* the relative contribution to each of wheat price, yield, and area. To do this, the ten draws with the lowest corresponding income (averaged over the projection period) were analysed. The difference in wheat revenue is calculated by subtracting wheat revenue when world price volatility is assumed to be *status quo* from wheat revenue when world price volatility is assumed to be *high,* for the same stochastic projection. The percentage of that differential due to a change in price, yield, and area is calculated using a log transformation.[9]

Three examples are charted in Figure 3-6 to illustrate the range of results. The solid line tracks the difference in wheat revenue between the two volatility assumptions over the projection period for an individual draw. The bars show how much price, yield and area each contribute to that difference from the baseline revenue, for that specific draw, when world commodity price volatility is *high*. In the case of Projection 21, an increase in world price volatility impacts wheat revenues mainly *via* changing UK wheat price. There is only one year when the difference in area is proportionally more important than price, but on average price is dominant, followed by area, with very little impact from yield differences. In contrast, additional world price volatility impacts wheat revenue in Projection 96 largely through changes in yield, with changes in price and area relatively less important. Projection 457 is dominated by price impacts for five of the ten years in the period, with yield and area impacts playing important contributions as well in the other five years.

A table, listing the results of the ten projections with the lowest average income is provided as an appendix. On average, across all ten projections, price is the dominant way a change in world price volatility impacts wheat revenue, followed by wheat area, and then to a much lesser extent wheat yield.

[9] Revenue can be expressed as price times yield times area. The natural logarithm of revenue can be expressed as the log of price plus the log of yield plus the log of area. Subtracting the *status quo* expression from the *high* expression gives the log of the change in revenue as equal to the log of the change in price plus the log of the change in yield plus the log of the change in area. The percentage contribution of price can then be calculated as the log of the change in price divided by the log of the change in revenue.

Figure 3-5. Average revenue, fertiliser and feed costs of 500 projections under two different volatility assumptions (5000 draws each)

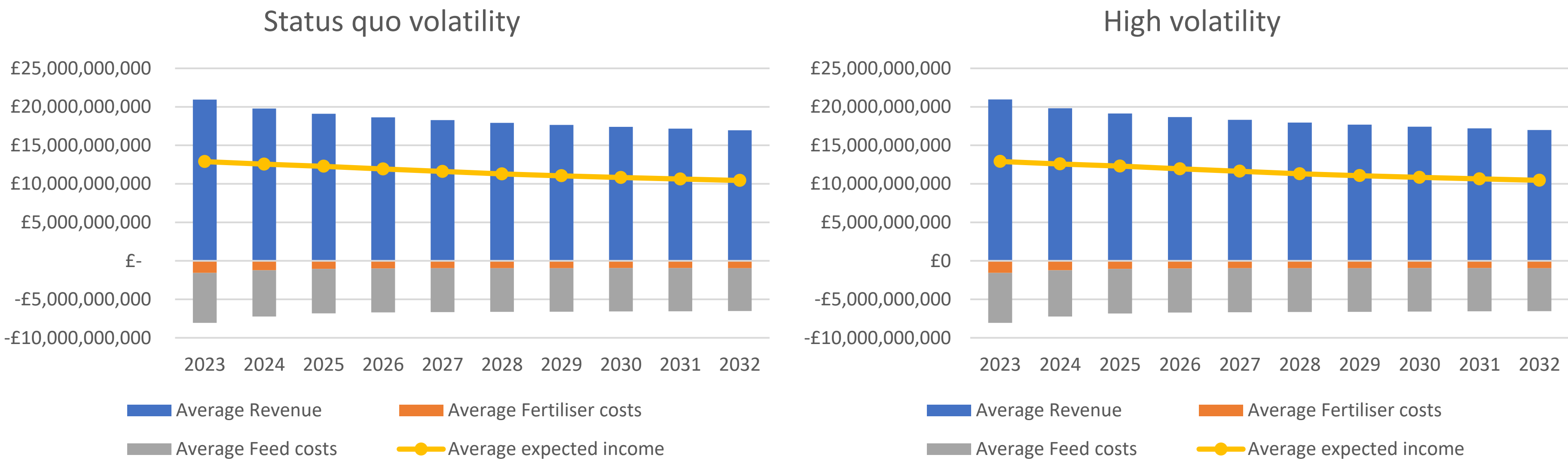
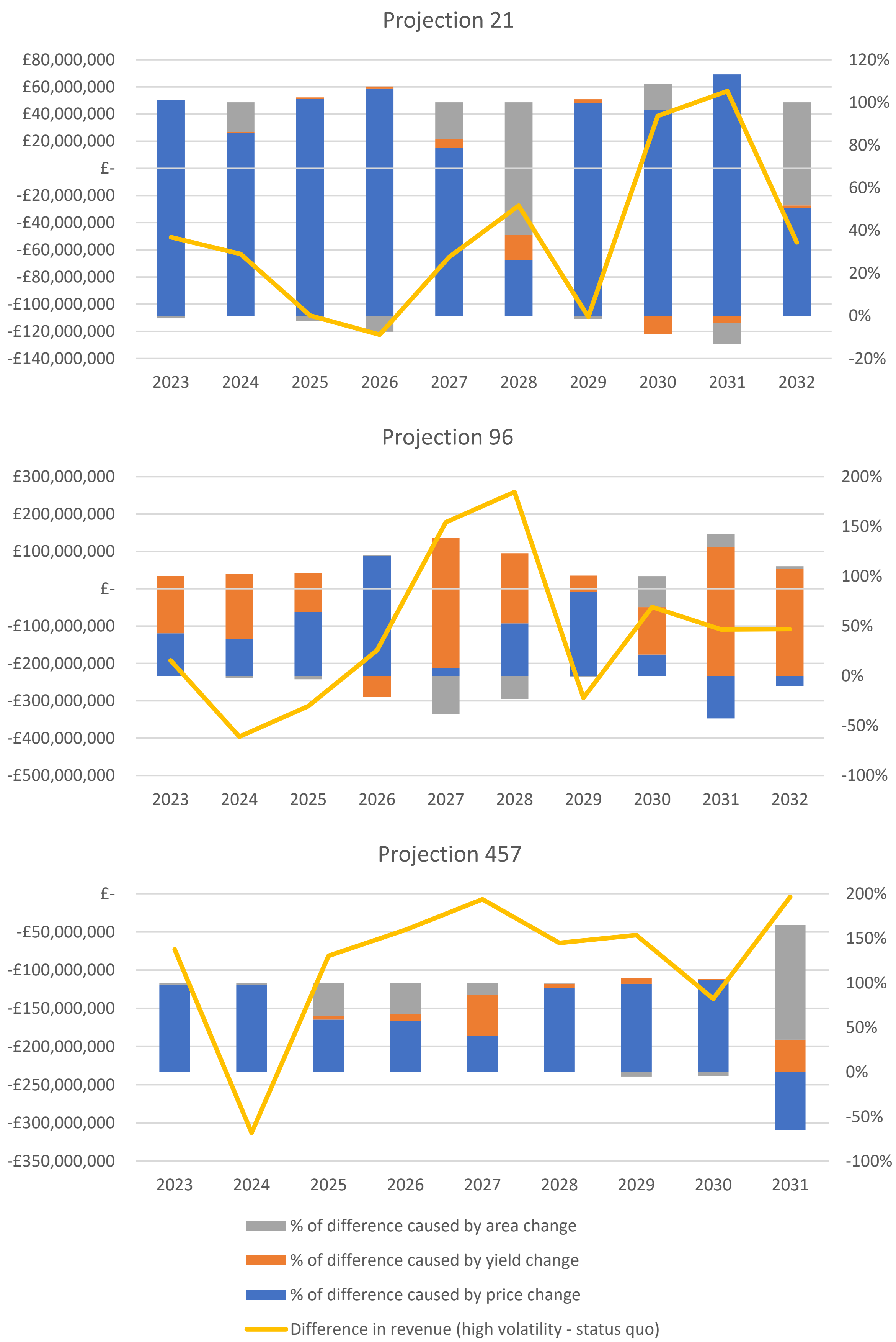


Figure 3-6. Revenue difference (high – status quo volatility) and decomposition



3.3 Complexities of price volatility and supply response

A greater degree of world commodity price volatility can be expected to reduce the accuracy of using historic average prices to form expected prices. The practical implication for aggregate income, is that as prices deviate from recent historic levels and trends, the historic average price, used in part to allocate resource to different production activities, is further away from the actual price. In the model, UK prices and the variables that determine supply are solved for simultaneously. So the price-supply response is not sequential, and in fact supply impacts price, as well as price impacting supply. This means, within the stochastic baseline, there can be projections when increasing year-on-year prices coincide with a falling year-on-year supply response. In circumstances when *high* world price volatility increases the likelihood of this pattern, this could indicate an opportunity cost to the sector, other things being equal, in the form of foregone additional revenue.

The scenario analysis indicates that when world price volatility is relatively *high*, there is a greater likelihood that a price increase does not correspond with a positive supply response. To measure the sensitivity of this pattern to world price volatility, crop area and breeding stock numbers are used as indicators of a production response to expected price changes. For beef and dairy, the number of occurrences when beef and milk prices in the projection period, are above the most recent three-year historic average, but suckler or dairy cow numbers in the projection period are less than those three years previously, are counted. The approach for wheat and oilseeds is to use those projections with a relatively higher wheat or oilseed price in the current year compared to the year before, but a lower wheat or oilseed crop area. The number of times these patterns occur in the 5000 baseline projections (500 projections x 10 years) is compared to the number in the *high* volatility scenario projections (also 5000).

The frequency with which these patterns occur are compared between the *status quo* and *high* world price volatility assumptions and results are presented in Table 3-1. Using the percent change when world price volatility is assumed to be *high* as an indicator of sensitivity, the largest proportional change is for milk (15%), but this is from a relatively low baseline level. This is followed by oilseeds (8% increase from the baseline), beef (9%) and wheat (3%). The highest proportional response is in the case of milk production, even in the scenario with *high* world price volatility, while the instances of counter-intuitive supply response is much less than in the beef sector (777 compared to 1663). In terms of the number of occurrences, beef increases by 133, and milk only by 99. This is feasible when considering that there are other means to increase milk supply in the short term other than increasing herd size (e.g. by feeding additional concentrates). Oilseeds show a larger proportional increase than wheat, but also start from a lower baseline level. Wheat is the largest crop by area in the UK, and wheat price tends to be relatively higher compared to alternatives such as barley, so even in cases when all cereal prices are expected to fall, wheat may still be a logical choice for planting. Oilseed prices move more independently from cereals, and this could help explain why area is more sensitive to price increases, as it offers an alternative to cereals generally.

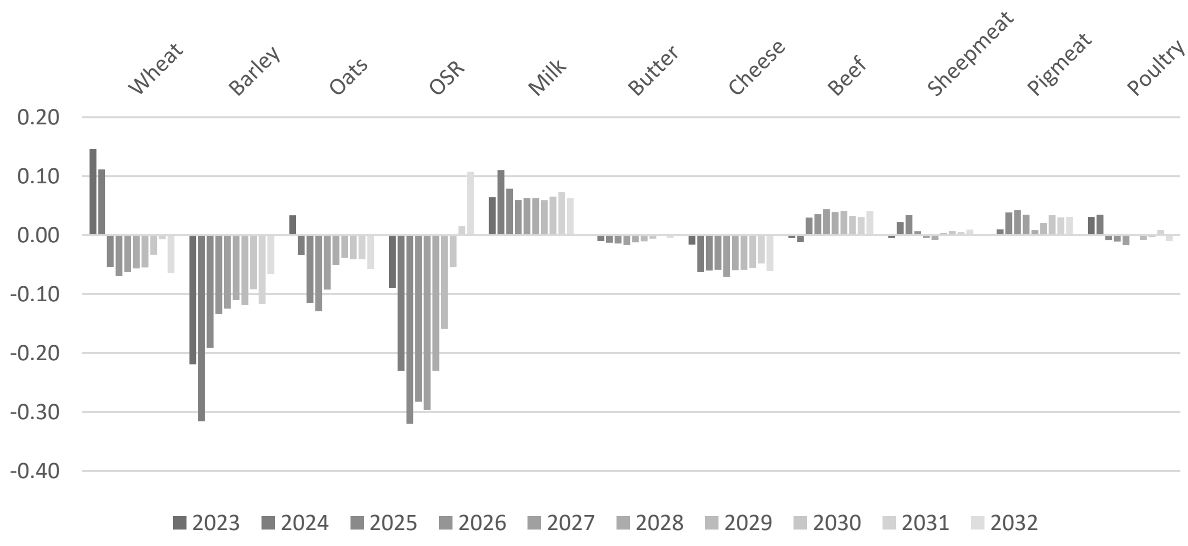
Table 3-1. Number of instances a price increase does not trigger a positive production response (out of 5000) and percent change comparing different levels of world price volatility

Production response measured	Sub-sector	Status quo volatility	High volatility	Increase with *high* volatility
Occurrences current year price is higher than three-year-historic-average, but cow herd is smaller	Beef	1530	1663	9%
	Milk	678	777	15%
Occurrences current year price is higher than the price the previous year, but area is smaller	Wheat	1413	1456	3%
	Oilseeds	1099	1191	8%

3.4 World price volatility and stability of domestic supply

Relatively *high* world price volatility compared to the *status quo* increases the likelihood of extreme low and high income years, as well as the likelihood of unexploited income opportunities due to a mismatch between expected (historic average) and outturn prices. Despite this, the stochastic scenario analysis indicates that there is very little impact on the stability of supply of the main UK commodities. Domestic use for the UK is defined as domestic production, less exports, plus imports. It includes intermediate use by UK agriculture (such as cereals used for feed by livestock) as well as national consumption outside of agriculture (all other uses). The percentage difference in UK domestic use between *high* world price volatility and *status quo* world price volatility is presented in Figure 3-7. Overall, the difference is very small, at most just over 0.3% smaller (in the case of barley and oilseed) and just over 0.1% larger (in the case of wheat, oilseed and milk).

Figure 3-7. Percent difference in domestic use between high and status quo world price volatility



4 Conclusions

Imposing volatility on world commodity prices allows us to consider the potential impact this market environment may have on UK farm-gate prices. In the context of stochastic projections, relatively greater volatility increases the likelihood of more extreme prices. Here we assess that impact by measuring how many additional times prices reach very high, or very low, values compared to the baseline. Defining 'extreme prices' as lying above the 10% highest, and below the 10% lowest in the baseline. As additional volatility is introduced to the world prices, it becomes more and more likely that both the upper and lower threshold price will be breached. This means, that the range of prices expected in most cases (for example, the range including 80 percent of prices projected for a given year) broadens. This reflects the greater uncertainty around UK prices, in the context of more variable world prices. There is a slight asymmetry in impact, such that extreme low prices are marginally (2%) more likely than extreme high prices on average.

The magnitude of year-on-year UK price differences increases with higher world price volatility. The largest increase is in oilseeds and cereals, due to the relative exposure to global markets, compared to livestock commodities.

In turn, additional UK price volatility triggered by more variation in world prices, impacts the income from agriculture *via* output prices, input prices, and production patterns. An *aggregate income indicator* is established, defined as revenue (using producer prices and output volume) less key input costs (using fertiliser and feed cost estimates). The range of the most likely income levels projected (in this case, the range bounding 80% of income projections) remains above observed short and long-term historic averages for most of the projection period, even when world price volatility has been assumed to be higher in the projection period than historically. Although the likelihood of extreme high or low income increases with greater world price volatility, there is little difference in the average income, because the high and low years tend to balance each other out.

The largest driver of income change is the change in revenue. The largest driver of the difference in revenue between *status quo* and *high* volatility scenarios tends to be price, followed by area and then yield (illustrated for the case of UK wheat). In general, it was found that increasing world price volatility has little impact on UK domestic use.

Overall, the analysis confirms that higher world price volatility increases the likelihood of UK prices reaching high, and low, extremes. The additional price uncertainty for agricultural outputs and inputs translates into more uncertainty in terms of returns to agriculture.

Appendix

Figure A - 1. Rolling three year coefficient of variation of world wheat price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

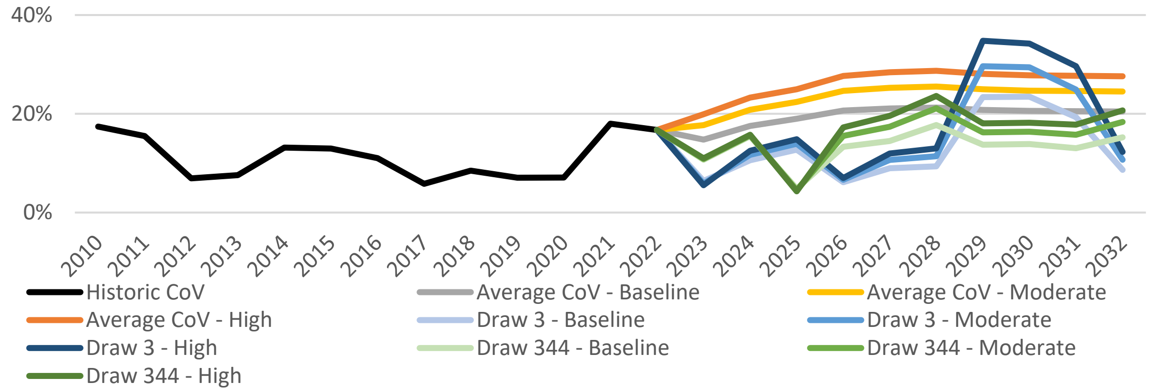


Figure A - 2. Rolling three year coefficient of variation of world barley price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

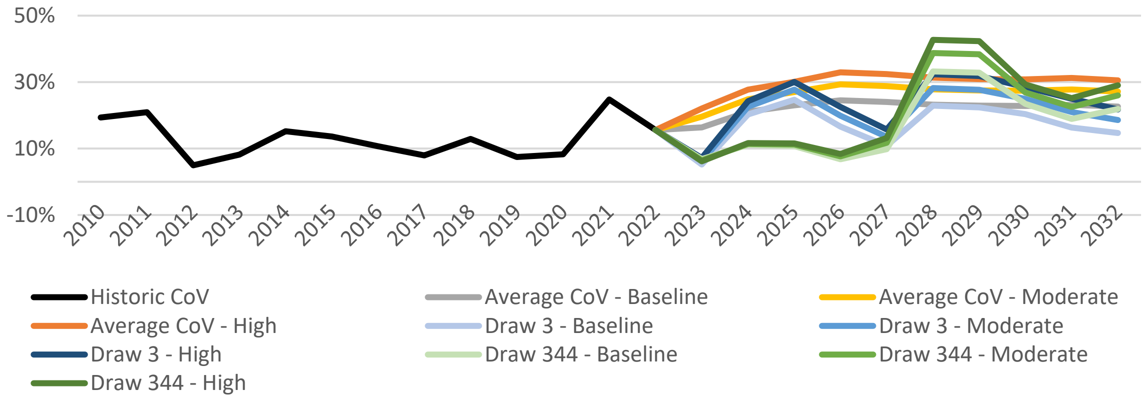


Figure A - 3. Rolling three year coefficient of variation of world maize price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

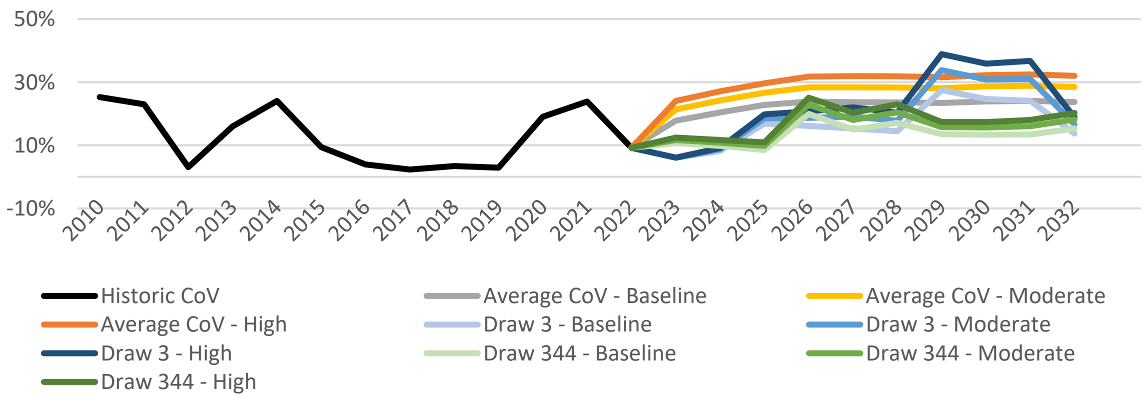


Figure A - 4. Rolling three year coefficient of variation of world rapeseed price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

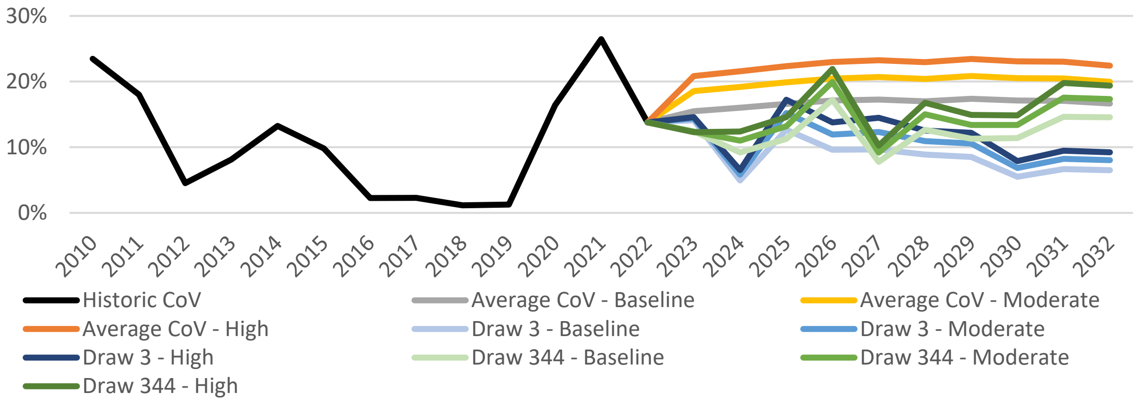


Figure A - 5 Rolling three year coefficient of variation of world rapemeal price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

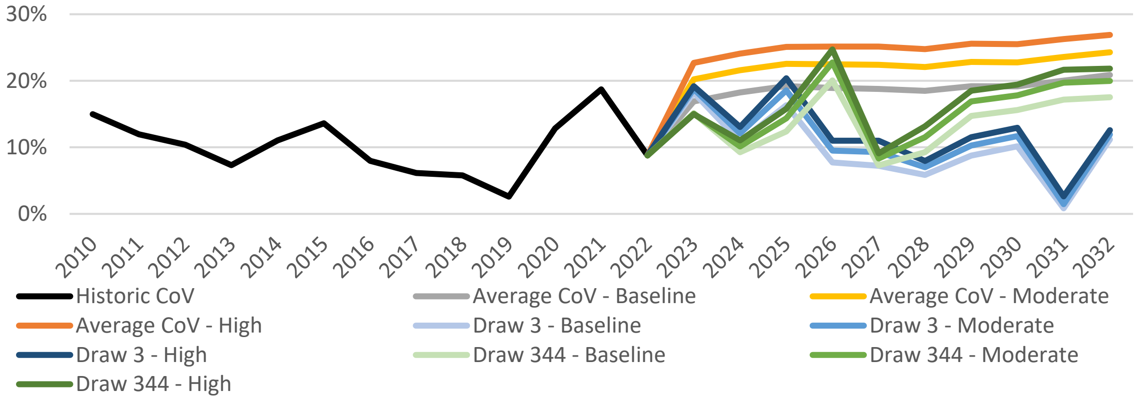


Figure A - 6. Rolling three year coefficient of variation of world steers price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

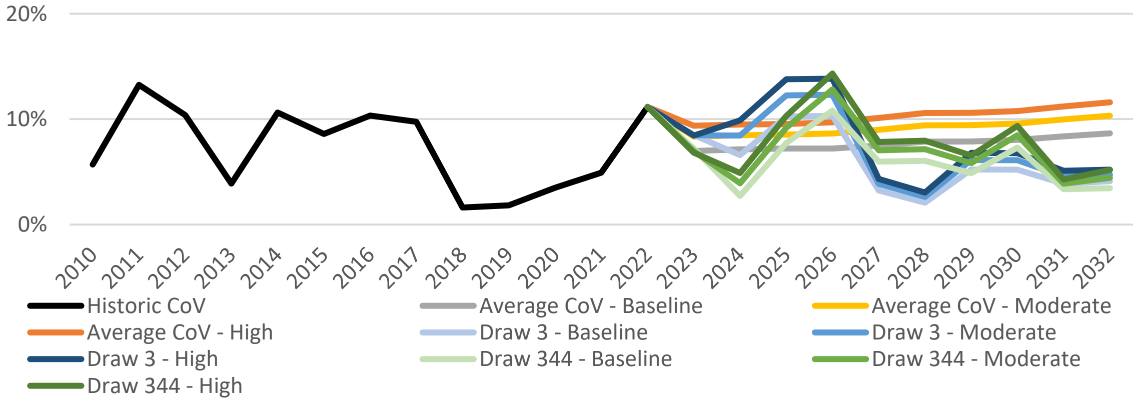


Figure A - 7. Rolling three year coefficient of variation of world steers price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

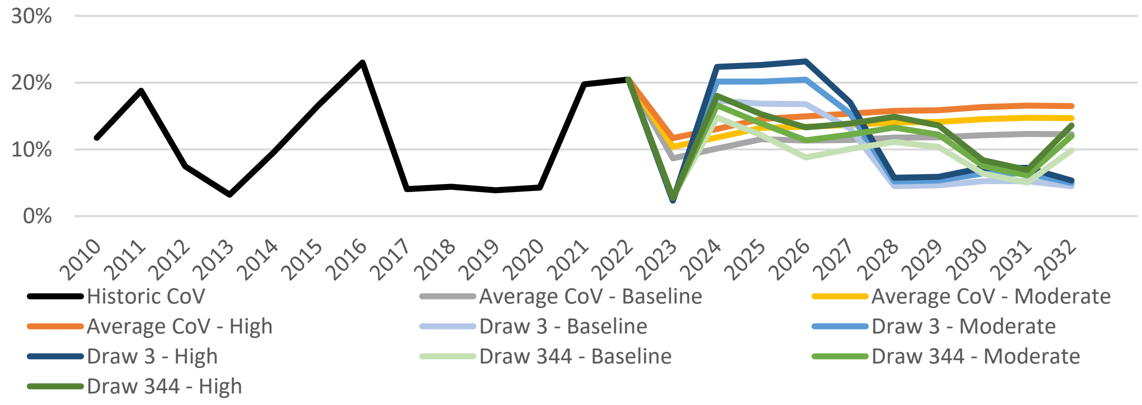


Figure A - 8. Rolling three year coefficient of variation of world broiler price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

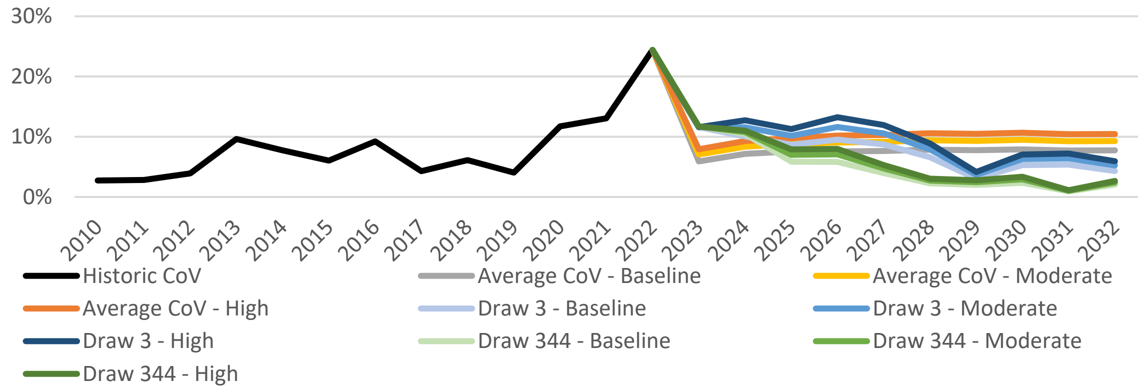


Figure A - 9. Rolling three year coefficient of variation of world cheese price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

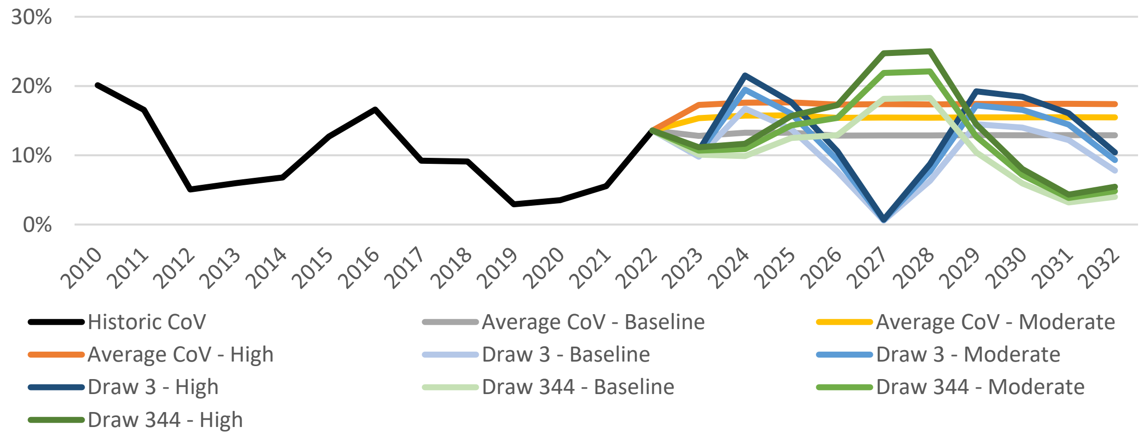


Figure A - 10. Rolling three year coefficient of variation of world cheese price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

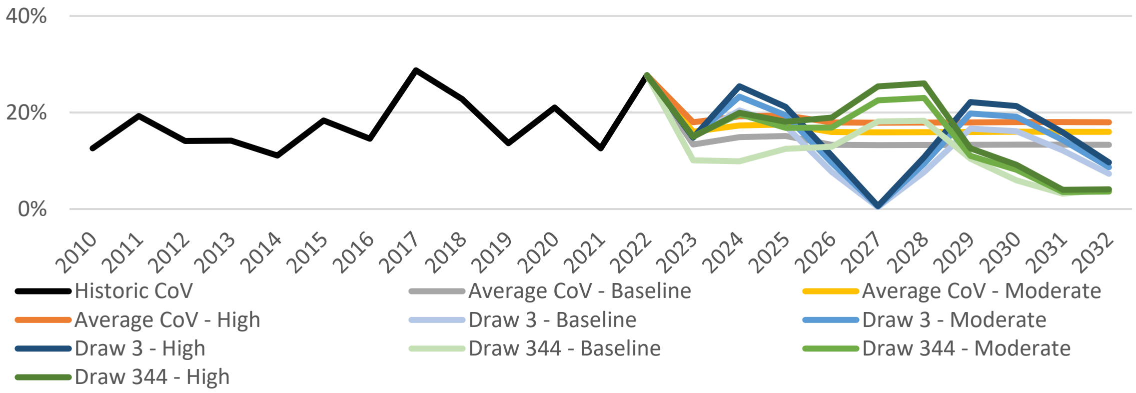


Figure A - 11. Rolling three year coefficient of variation of world skim milk powder price historically, for two randomly selected stochastic draws, and averaged for the baseline, moderate and high volatility scenarios

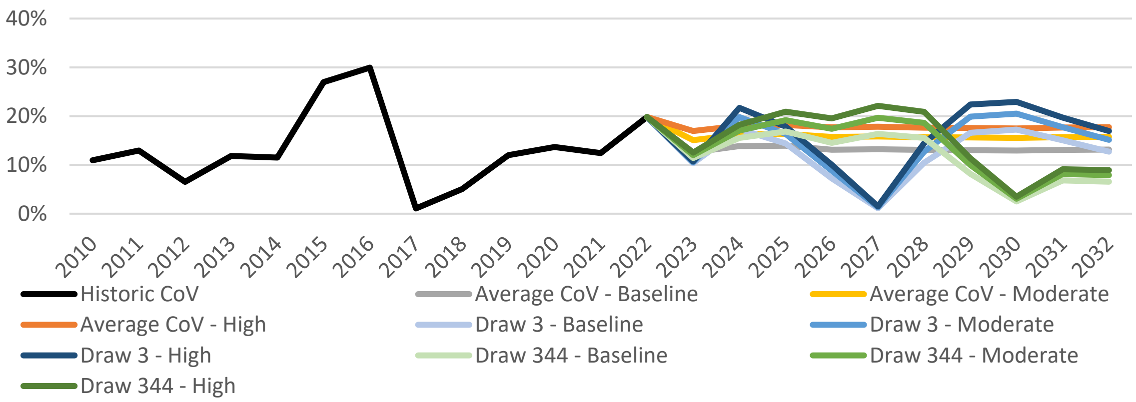


Table A - 12. Decomposition of the difference in wheat revenue by price yield and area when world price volatility is increased

Projection		Year									
		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
21	Impact *via* price	101%	86%	102%	106%	79%	26%	100%	97%	113%	50%
	Impact *via* yield	0%	1%	1%	1%	4%	12%	2%	-9%	-4%	1%
	Impact *via* area	-1%	14%	-2%	-7%	17%	62%	-1%	12%	-10%	48%
	Revenue high vol. - revenue status quo vol. (£1000)	- 50,716	- 63,069	- 108,386	- 122,481	- 65,357	- 27,495	- 109,391	38,571	56,862	- 54,500
82	Impact *via* price	96%	100%	75%	114%	99%	88%	87%	141%	136%	122%
	Impact *via* yield	0%	0%	3%	1%	1%	5%	5%	5%	13%	-7%
	Impact *via* area	5%	0%	22%	-16%	0%	8%	8%	-45%	-49%	-15%
	Revenue high vol. - revenue status quo vol. (£1000)	- 46,495	- 192,717	- 61,109	- 135,082	- 194,823	- 76,378	- 89,831	- 63,674	- 28,848	47,510
96	Impact *via* price	43%	37%	64%	120%	8%	53%	84%	21%	-43%	-10%
	Impact *via* yield	58%	65%	40%	-21%	130%	70%	16%	48%	130%	108%
	Impact *via* area	0%	-2%	-3%	1%	-38%	-23%	-1%	31%	13%	2%
	Revenue high vol. - revenue status quo vol. (£1000)	- 192,077	- 396,128	- 314,693	- 165,071	177,901	259,049	- 292,339	- 48,782	- 108,956	- 108,179
165	Impact *via* price	99%	122%	95%	-66%	50%	265%	126%	83%	223%	100%
	Impact *via* yield	0%	-2%	0%	9%	9%	30%	2%	2%	-4%	0%
	Impact *via* area	1%	-20%	5%	158%	41%	-195%	-28%	14%	-120%	0%
	Revenue high vol. - revenue status quo vol. (£1000)	- 161,050	73,450	- 207,630	- 17,935	- 21,634	- 6,358	- 29,830	- 74,580	28,980	182,585
190	Impact *via* price	100%	52%	94%	103%	106%	588%	27%	102%	91%	85%
	Impact *via* yield	0%	4%	3%	1%	15%	131%	14%	2%	16%	1%
	Impact *via* area	0%	44%	3%	-4%	-21%	-619%	59%	-5%	-7%	14%
	Revenue high vol. - revenue status quo vol. (£1000)	- 246,821	- 42,811	- 71,467	- 170,965	- 24,674	- 3,727	- 17,481	- 75,525	- 13,298	- 76,113

	Impact *via* price	98%	109%	47%	117%	101%	42%	116%	96%	19%	126%
	Impact *via* yield	0%	0%	30%	3%	1%	4%	5%	2%	-4%	3%
278	Impact *via* area	2%	-10%	23%	-20%	-2%	54%	-21%	2%	85%	-28%
	Revenue high vol. - revenue status quo vol. (£1000)	- 99,492	92,036	- 134,319	1,217	- 104,815	- 123,301	- 237,804	- 30,177	- 9,112	- 52,198
	Impact *via* price	98%	106%	109%	-1372%	103%	76%	99%	116%	428%	78%
	Impact *via* yield	0%	-1%	0%	-76%	1%	1%	0%	10%	35%	6%
279	Impact *via* area	2%	-5%	-9%	1548%	-4%	23%	0%	-26%	-364%	16%
	Revenue high vol. - revenue status quo vol. (£1000)	- 99,492	92,036	- 134,319	1,217	- 104,815	- 123,301	- 237,804	- 30,177	- 9,112	- 52,198
	Impact *via* price	-106%	90%	85%	-118%	101%	146%	84%	86%	114%	200%
	Impact *via* yield	-28%	0%	0%	8%	0%	-10%	4%	7%	2%	8%
285	Impact *via* area	234%	11%	14%	210%	-2%	-36%	12%	7%	-16%	-108%
	Revenue high vol. - revenue status quo vol. (£1000)	1,356	- 61,147	- 149,209	- 22,360	- 197,745	26,500	- 43,822	- 28,344	- 80,919	- 24,025
	Impact *via* price	93%	90%	83%	96%	817%	103%	180%	108%	197%	87%
	Impact *via* yield	-1%	0%	-1%	0%	-26%	0%	-7%	-2%	13%	0%
333	Impact *via* area	8%	10%	18%	4%	-691%	-3%	-73%	-5%	-110%	13%
	Revenue high vol. - revenue status quo vol. (£1000)	- 19,255	143,974	- 68,724	- 277,009	4,981	- 207,759	40,455	159,653	- 10,937	134,994
	Impact *via* price	98%	98%	59%	57%	41%	94%	99%	104%	-65%	101%
	Impact *via* yield	0%	0%	4%	8%	45%	5%	6%	1%	36%	0%
457	Impact *via* area	2%	2%	37%	35%	14%	1%	-5%	-4%	129%	-2%
	Revenue high vol. - revenue status quo vol. (£1000)	- 72,952	- 312,823	- 81,328	- 47,317	- 7,426	- 64,534	- 54,200	- 137,465	- 4,287	- 224,271