Does flexibility of biofuel mandates have the ability to mitigate price spikes? Modelling potential biofuel production reductions in the context of the recent invasion of Ukraine

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Abstract

This paper looks at how reducing biofuel production by introducing flexibility to mandates can have a potentially mitigating effect on price spikes. In particular we look at the recent price spike caused by the invasion of Ukraine and the consequent impact on global agricultural impacts. We model scenarios of reduced biofuel use in a global agricultural market model to see the impact on prices of the major cereals and oilseeds. A modest reduction of 10% of the use of cereals in biofuels can have a significant impact on the magnitude of the price spike for cereals and in particular maize. The modelled price spike in maize is 37% smaller after a 10% reduction in biofuel production in G7 countries. Results for wheat and vegetable oils are smaller but still significant at 11% and 27% respectively. This modelling demonstrates the importance of biofuel mandates in global agricultural markets and consequently their impact on global food security.

Keywords: Biofuels, Agricultural prices, International markets, Food security

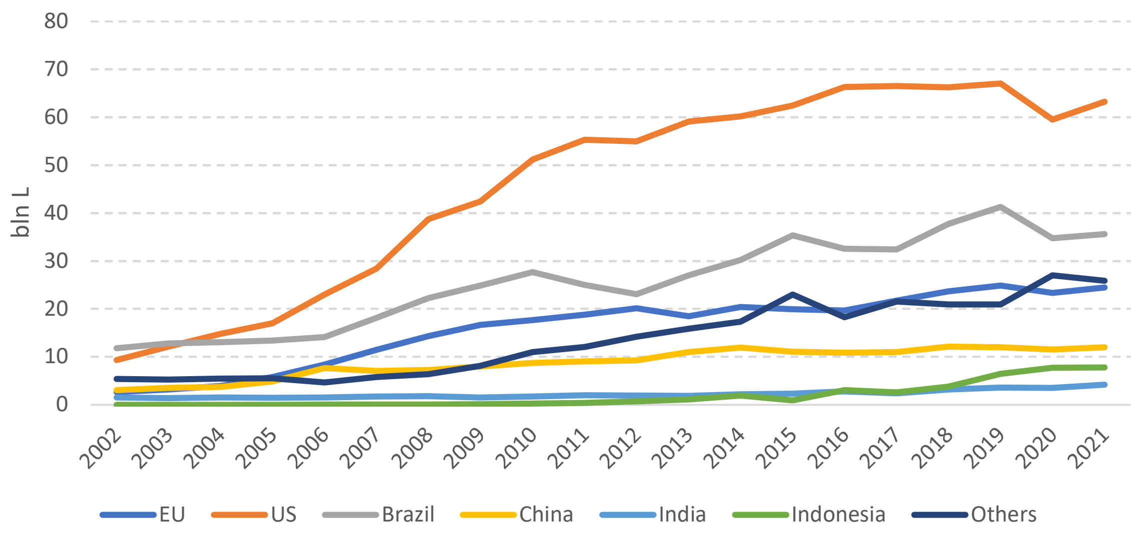
JEL Code: Q110 Agriculture: Aggregate Supply and Demand Analysis; Prices; Q160 Agricultural R&D; Agricultural Technology; Biofuels; Agricultural Extension Services

Background

Biofuel's usage has increased significantly over the last two decades in particular following the creation of the Renewable Fuel Standard in the US, starting in 2005. This has meant an increasing share of crop production is being used for fuel rather than food and feed. As a new source of competing demand this increases the price of grains and oilseeds with implications for food security particularly during food price spikes.

Figure 1:Biofuel consumption in major countries

Source: OECD-FAO Agicultural Outlook 2021



Of the major grains most important for food security globally, maize is the most important for its use in biofuels. Other grains such as wheat, barley and rye are also used but in much lower proportions than maize. Vegetable oils have had increasing usage in biofuels, particularly in Asian countries, and are now in line with maize as a proportion going into biofuels. The other major crop used for biofuels is sugar and particularly sugar cane.

Table 1: Crop use in biofuels and their importance to global calorie consumption

	Proportion of global production of crop that is used in biofuel	Proportion of global calories
Maize	16%	5%
Other coarse grain	2%	3%
Wheat	1%	18%
Vegetable oils*	17%	10%
Sugarcane*	24%	7%
Sugarbeet*	4%	

Source: OECD-FAO Agricultural Outlook database and FAO Food Balance Sheet, *For vegetable oils and sugar the proportion is a sum of only countries included in the database.

Biofuel demand and in particular unexpected increases in biofuel demand due to volatility have been noted as a potential key contributor to past price spikes (FAO et al, 2011). However, this paper looks at how reduction in biofuel use can contribute to mitigating price spikes and not necessarily whether biofuels on their own are an important contributor to volatility. In this context biofuels can be thought of as an additional reserve of stocks which can be released to the market in times of need. Agricultural commodity markets are particularly sensitive to stock levels as seasonal and lagged supply means that in the short-term supply is very inelastic. On the other side of the market demand, especially for food, is also very inelastic. This means that in the short-term adjustment in the market has to come from large changes in price as quantity is not able to adjust. Stocks are helpful in mitigating some of this price rise but when stocks are low this can not happen and so tight stocks tends to be closely associated with price spikes in agriculture. Allowing biofuel demand to reduce in times of price spikes would allow effective stocks to be larger without the necessity of the greater costs associated with actual greater physical stock holdings.

There is a significant literature looking at how biofuel policies might have increased prices or contributed to price spikes but much less looking at how biofuel mandate flexibility could be used as a tool to mitigate price spikes. Defra has previously looked at the impact that removing biofuel mandates in the face of a purely hypothetical food price spike (Davies, 2012). It was found that a reduction in EU biofuel use by 80% would result in wheat prices around 7% lower and vegetable oil prices around 12% lower in the decade following removal, while a phase out of US biofuel support would see a 90% reduction in ethanol production and world coarse grain prices 12-14% lower after a decade. This paper contributes by using the recent example of the price spike caused by the invasion of Ukraine by Russia and how reductions in biofuel usage could have helped to mitigate a significant portion of that price rise.

The invasion of Russia has been a significant shock to agricultural markets. In recent years Russia has been the top wheat exporter with around 19% of globally traded wheat according to the USDA PSD as an average of the three seasons from 2018/19 to 2020/21. For wheat Ukraine is also important as it exports 9% of the global trade. Ukraine is also important for maize as the fourth biggest exporter at 16% of global trade. Both countries are the top exporters of sunflower oil with Ukraine at half of global trade and Russia 27%. Barley and rapeseed are also crops in which both countries combined have a significant share of the global market.

The invasion of Ukraine impacted their ability to produce due to ongoing fighting preventing access to land as well as higher costs for inputs. More importantly in the short term it cut off the access to the Black Sea ports through which the vast majority of grains from Ukraine were exported. The majority of the previous harvest had already been exported by February 2022 but a very significant portion still remained producing a shortfall on global markets and a comparative trickle of exports via more expensive land routes.

Modelling Approach

We have used the OECD-FAO Aglink-Cosimo model of international agricultural markets to assess the potential mitigation effects of changes in biofuel policy on global grain prices. Aglink-Cosimo is a dynamic partial-equilibrium of global agriculture which has been used to analyse the effects of biofuels on international agriculture, as well as recently by OECD and FAO in their modelling analysis of the impact of the Russia-Ukraine crisis on global agricultural markets.

Our modelling approach involves two stages:

a. **First stage:** we simulate a supply shock in international grain and vegetable oil markets stemming from the Russian invasion of Ukraine. This is modelled as a reduction in grain and oilseed exports from these countries, higher energy/fertilizer prices and unchanged biofuel policies. The supply shock in Scenario 1 is not intended as a precise forecast but generates projected international price changes which are broadly commensurate with both the work from other international organisations in this type of model and the actual price increases experienced in futures markets to date.

b. **Second stage**: the same supply shock is simulated in Aglink-Cosimo but with biofuel use of grains (scenario 2) and grains and oilseeds (scenario 3) in G7 countries[1] temporarily reduced in the year of the supply shock.

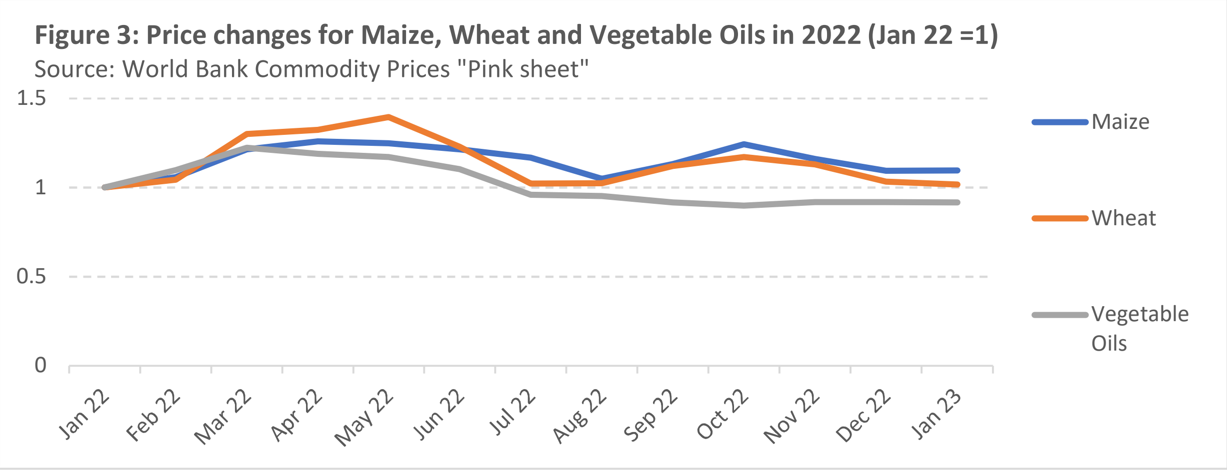
The difference in the projected international prices between these scenarios represents the mitigation potential of reduced biofuel usage in the model.

Figure 2. Scenarios modelled in Aglink-Cosimo

Factors	Scenario 1: Supply Shock	Scenario 2: Supply Shock + 10% cut in bioethanol use of cereals in G7 countries	Scenario 3: Supply Shock + 10% cut in bioethanol use of cereals in G7 countries + 10% cut in biodiesel use of vegetable oils in G7 countries
Trade disruption	50% reduction in RUS-UKR exports of wheat, maize and other coarse grains in 2022	50% reduction in RUS-UKR exports of wheat, maize and other coarse grains in 2022	50% reduction in RUS-UKR exports of wheat, maize and other coarse grains in 2022
Energy/Fertilizer Prices	Doubling of oil and fertilizer prices relative to baseline in 2022, forward curve thereafter	Doubling of oil and fertilizer prices relative to baseline in 2022, forward curve thereafter	Doubling of oil and fertilizer prices relative to baseline in 2022, forward curve thereafter
Biofuel Policy	Unchanged	10% reduction in wheat, maize and other coarse grains used for biofuels in the G7 countries.	10% reduction in wheat, & maize, other coarse grains and all vegetable oils used for biofuels in the G7 countries.

Baseline

A baseline was created to simulate the price spike that was experienced in the Spring of 2022. Prices for all commodities rose immediately following the invasion and this was particularly true of wheat and maize due to the fact the Ukraine and Russia are an important share of the market for these grains. Another contributory factor was the increase in oil prices which pushed commodity prices higher across the board.



[1] In Aglink-Cosimo, these are modelled as reductions in UK, USA, Canada, Japan and the EU. The EU is treated as a single country in Aglink-Cosimo.

In Aglink-Cosimo we have modelled this as a reduction in grain and oilseed exports from Russia and Ukraine, higher energy/fertilizer prices and unchanged biofuel policies. We have implemented a 50% reduction of maize, wheat and other coarse grains exports from both Russia and Ukraine. The prices of oil and fertiliser has been doubled compared to the baseline in 2022 and prices for subsequent years used the forward curve as of May 2022.

The baseline chosen reflects assumptions around large disruption to Russian and Ukrainian exports and reflects prices similar to those during the peak in the Spring of 2022. The assumptions and results of our baseline are similar to other published modelling around the time of the invasion such as the FAO's (2022) use of the same model.

As the model is an annual model an assumption is made that the peak in prices is maintained throughout the year (at least as an average). It should be noted that in reality prices receded from these highs and have fallen notably since the Spring. This is due to a confluence of factors, including, but not limited to, the black sea grain deal allowing increased exports from Ukraine, sanctions on Russia not limiting food exports significantly, a strong US dollar decreasing prices in dollar terms, and the stalemate in fighting meaning less agricultural land in Ukraine is directly affected. The price in Spring will partially have represented temporary shortages but also included a large uncertainty premium as it was not guaranteed that all of these factors (as well as the risk of any unexpected supply shock) would have helped reduce prices and so this risk was part of the high price. As this modelling exercise is particularly interested in price spikes and is using an annual model it is assuming that the price experienced in spring was maintained throughout most of the year and so could be thought of as a hypothetical of other mitigating factors not materialising.

Implementation of biofuel flexibility

Several countries in Aglink-Cosimo have biofuel policies which are explicitly modelled. However, in this modelling exercise we have chosen to exogenously reduce biofuel use by a fixed percentage. This reflects that mandate designs differ substantially in their details across countries and therefore that a greater degree of flexibility could take many policy forms. It also reflects that there is a great degree of uncertainty in the policy parameters which drive biofuel production in both the model and real life as large-scale biofuel production has not been observed in the absence of biofuel policies and mandates.

It could be argued that greater flexibility of mandates would not actually reduce biofuel production by the amounts stated in this modelling exercise. That is, if biofuel production is driven by market forces in which fuel derived from agricultural commodities is competitive with conventional fuel then we would not expect a reduction in biofuel use unless the government was to make policies to deliberately reduce it.

Biofuels are typically more expensive than conventional fuel on an energy basis (as conventional fuel is more energy dense) though it has been argued that ethanol is valued for its octane properties (Irwin and Good, 2016). There is a broad consensus that in the US soybeans as a feedstock for biodiesel are almost certainly a direct result of the mandate but there is more scepticism that maize being used as a feedstock for ethanol is, at least in the short term, possibly not driven by the mandate at the margin. This is due to the blend wall (ethanol demand is effectively approximately 10% of overall gasoline due to the ubiquity of E10), its octane properties and the fact that ethanol is cheaper on a per litre basis even if not on an energy basis.

It should be noted, it can be true that biofuel demand may not reduce in the short term even if, as it is reasonable to believe, the vast majority of biofuel production is a result of mandates and other biofuel support policies. This is due to the fact that there is significant fixed costs and economies of scale in biofuel production such that variable costs will not reflect total costs and additionally stickiness on the demand side due to limited consumer information.

By reducing biofuel use by a fixed amount this modelling is indicative of the direction and broad magnitude that introducing greater flexibility would have on biofuel markets. It also reflects that governments could make decision to cap the use of crops being used in biofuels to achieve these outcomes.

Results

The simulation results for wheat and maize, two of the three most consumed cereal globally, are shown in Figure 4. Reduced utilisation of grains in ethanol use leads to increased exports and lower imports of wheat and maize amongst the major bioethanol producers, relative to Scenario 1. These two factors act to increase availability on the global markets for wheat and maize. As a consequence, the projected rise in global prices of wheat and maize, due to the RUS-UKR supply shock, is lower in Scenario 2 relative to Scenario 1. Comparing the projected international price effects in these scenarios allows us to infer the mitigation potential of the reduction the biofuel use of grain.

Figure 4: Projected effects of a temporary 10% cut in grain ethanol amongst G7 countries

world price change relative to baseline	Scenario 1: RUS-UKR Supply shock	Scenario 2: RUS-UKR Supply shock + 10% cut in grain ethanol	mitigation effect* from cut in biofuel use
wheat	35%	31%	**11%**
maize	30%	19%	**37%**

*The mitigation effect is the % of the original price spike which is mitigated by the change in grain ethanol use.

In Scenario 1, the supply shock leads to modelled increases in global wheat and maize prices of 35% and 29% respectively. In Scenario 2, these projected price increases are lower at 31% and 18% respectively. In other words, the 10% temporary cut in bioethanol use amongst the G7 mitigates 11% of the price spike in wheat and 37% of the price spike in maize. These numbers are presented as mitigations of the price spikes rather than absolute values as the reduction in price from biofuel flexibility is partially endogenous to the size of the price spike and also both the mitigation effect and the price spike itself share similar uncertainties around the response of the global market to a given volume of grain which is either removed or additional.

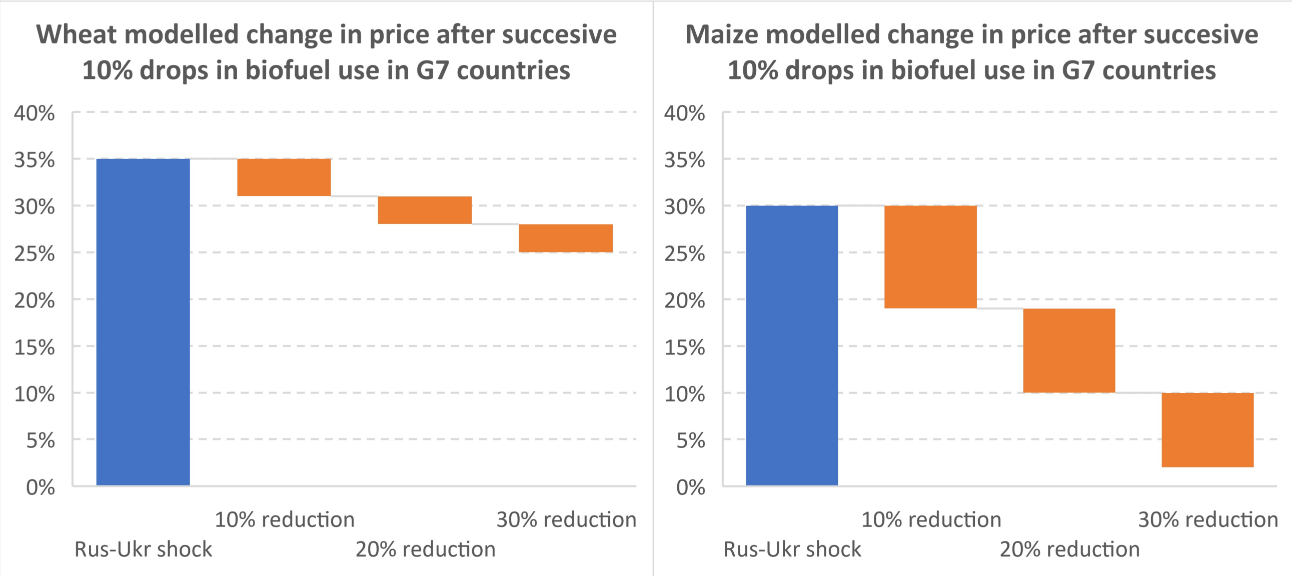
The projected effects of the cut in biofuel use are greater on the maize market than the wheat market, reflecting the relative size of biofuel use in the consumption of these commodities. Some of the reduction in the wheat price will be due to cross price effects from the reduction in maize rather than just direct impacts from more wheat being available as in some markets there is close substitutability for wheat and maize in animal feed,

Additional modelling, full results of which are included in Annex 1, of a reduction in biodiesel in addition to bioethanol suggests that a 10% cut of crop-based virgin vegetable oil use in biofuels in the G7 countries will have a significant mitigation effect on price rises. The mitigation effect of reducing biofuel use by 10% is around 27% of the price impact of the Russian invasion, across vegetable oils with the impact on the price of oilseeds being similar at 25-29%. Reductions in the price of vegetable oils will also have small marginal reductions in the price of cereals.

In addition to this main scenario, we have run additional scenarios with greater reductions of 20% and 30%. Increasing the reduction of biofuel use by 20% or 30% would continue to have significant reductions in the price of vegetable oils and grains though this result isn't entirely linear with a small degree of diminishing marginal returns.

If other major biofuel producing countries were to also introduce a temporary reduction of agricultural feedstocks going to biofuels then there would be a greater reduction in global prices. Modelling of reductions in the top 5 bioethanol producers (USA, EU, Canada, China, Brazil) would see greater mitigation impacts of 40% of maize rather than 37% for the G7 countries. These numbers are similar due to the importance particularly of the US for maize and the overlap between the countries in both scenarios but shows the advantage of more production being reduced across more countries.

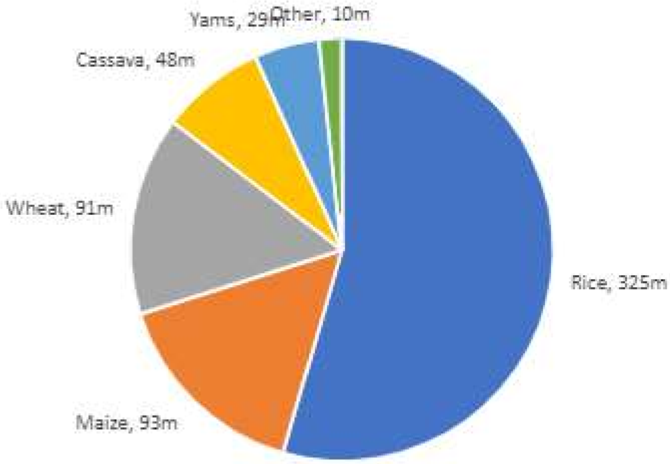
Figure 5: Mitigating impact of 10%, 20%, and 30% reduction in biofuel use in the G7 on the price rise after the Russian invasion of Ukraine



Discussion

The largest reduction, unsurprisingly given its importance in biofuel use, is Maize. Maize is often regarded as a feed grain, and this is its primary use in many European countries, and its contribution to calories on a global level is far behind rice and wheat. However, in many countries most at risk of undernourishment it is a staple grain and so can play just as important a role as wheat in food insecurity globally. A 30% reduction of maize use in ethanol in the G7 countries alone would according to this modelling be able to completely ameliorate the price impacts from the shock in scenario 1.

Figure 6: Millions of globally under-nourished people by top source of calorie in country 2019 (source: FAO)



Vegetable oils account for around 10% of calorie consumption globally and 7% in the Least Developed Countries making them an important part of global food security but secondary to the key role that cereals such as wheat and maize play. Vegetable oils can also be an important part of household budgets in many countries and even before the Russian invasion of Ukraine were experiencing very high prices.

Across all commodities there is some diminishing returns to cutting biofuel production further. This is expected for the same reason that larger supply shocks have disproportionate impacts. The tighter that agricultural markets are, and therefore the lower stock levels are, then the more sensitive prices are the small changes in the quantity of agricultural commodities available. Therefore, as markets become successively less tight the marginal benefit of additional available grain is lower than previously. However, the fact that the diminishing returns are quite modest means that mandate flexibility which is broader based both in terms of countries and products covered would have greater benefit.

Not modelled in this paper due to the limitations of the model used is the impact that knowledge of potential future mandate flexibility could have on the markets. Stockholder's incentives would change such that expectations of future reductions in commodities going to biofuel would cause greater release of stocks into the market as expectations of the future path of prices would change.

Limitations and other considerations

Generally lower quality grains will be used for production of bioethanol. This fact has been used to argue that therefore there is little impact on food prices from biofuel demand as these grains are not destined for human consumption. In the model used for this paper all grains are entirely homogenous and there is no differentiation between grains for food or other uses. This is likely a reasonable reflection of reality when considering prices as an average over a year though there is often variation in the premium between milling and feed products for shorter time horizons. This is due to the ability to substitute at the margin within grains. For example, though wheat going into biofuels may not be able to be repurposed to directly be used in bread making it frees up wheat to go into animal feed and this in turn allows wheat that is on the higher quality end of current animal feed use to be freed up for bread manufacturing. It should also be considered that not all food requires “high quality” grains – for example biscuit manufacturing requires lower protein content and so a different specification than the high protein content desired for milling wheat.

While the milling premium is variable and can be larger during price spikes this also encourages manufacturers to be more flexible with the specifications required in their recipes providing a negative feedback loop to large changes in the milling premium. Based on these factors, though not all grains are perfectly homogenous, there are enough margins of substitution such that different qualities of grain track each other closely and impact on the lower end of the market will translate into lower food prices. Even ignoring biofuel use, variations in wheat quality are normal season to season based on weather but the market is able to adjust without prices of milling and feed wheat substantially decoupling.

By-products from biofuel production have become an important part of the feed complex for animals. A particularly important example of this is Dried Distiller’s Grains (DDGs) which are a by product of ethanol production form maize and have become very significant in the US. The model used explicitly accounts for this by including this coproduct of biofuel production as a source of animal feed. Without this accounting of DDGs the impact on prices from reducing biofuels would be greater than the results presented.

Despite the importance of DDGs and other coproducts in animal feed, it is important to note, as energy is extracted from grains in order to make biofuels the nutritional by products of feedstocks for biofuel production will always be less than if the grain itself was directly fed to animals. So, while accounting for the impacts of this by products is important, the net impact of freeing up grains from biofuel production is always more feed available. In the modelling, the effect on DDG and other feed prices is outweighed by lower feed grain prices such that alongside maize, DDG and oilseed meal prices are all lower in Scenario 2 as compared to Scenario 1

Reducing biofuel production has additional impacts beyond the scope of this paper and the model used. The primary impact is on the price of oil as it is a direct substitute for use in road fuel. However, as biofuel use is a relatively small portion of overall fuel use and oil production is far from being a perfectly competitive market the impact should be relatively modest.

According to the World Bank (2022), biofuels currently account for 0.5% of global energy consumption[6]. In terms of the oil market, global biofuel production is equivalent to around 1.75 mb/d in crude oil equivalent, compared to global oil consumption of around 100 mb/day, giving biofuels roughly a 1.75% share in the international market. Bioethanol accounts for around 60% of total biofuel production (Dale, 2021) and hence a 10% cut in bioethanol use would be equivalent to only around 0.1% of global oil demand. While directionally we would expect reduced biofuel use to increase the price of oil, these quantities are unlikely to have material impacts on global oil prices compared to concurrent drivers of oil price movements. The price of fuel for road users is more ambiguous as we would expect the price of ethanol to decline and this could potentially offset any increase in the price of oil.

Larger changes than a 10% cut in biofuels could have a more important impact on the price of oil. If there are significant changes in the price of oil this will have a feedback effect on food prices and food security. Increased price of oil will in turn have an increase in the price of food via both increasing the cost of agricultural production and increased costs of distributing and retailing food. There may also be an income effect from increased oil prices which can make food less affordable.

Nevertheless, is its likely welfare increasing to spread a shock so more is absorbed in the energy market than food market as food consumption rises slower with income than energy consumption.

In addition to oil there may be impacts in other markets. There are several by-products created in the process of biofuel production. Animal feed inputs has already been discussed above but there are also products which are used outside of agriculture. One example of this is carbon dioxide which can be produced during ethanol production and has several uses including in food manufacturing and is important for animal welfare as it is used during the slaughtering process.

Given we have modelled the price results of individual commodities it should be possible to use these to have a more detailed look at the impact on food security, given diets in areas most vulnerable to food insecurity. However, it also possible to do some quick back of the envelope calculations.

Biofuel policies internationally can have several policy objectives including energy security, greenhouse gas emission reduction and agricultural price support. The effectiveness of biofuels as a successful instrument to reduce greenhouse gas emissions has been questioned with results differing substantially across different feedstocks. The significant welfare costs internationally from food price spikes can mean the trade off between food prices and emission savings changes during a time of acute crisis.

Nonetheless, the impact on GHG emissions is an important factor to consider when reducing biofuel usage even temporarily and policies might consider where emission can be saved elsewhere or at a different point intime.

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Annex 1: Full Model Results

Table 1: Projected mitigation effect of cuts in G7 bioethanol use of grain							
% change in international prices (relative to baseline)	UKR shock	UKR shock + G7 bioethanol cut			**mitigation effect***		
		10 pc cut	20 pc cut	30 pc cut	**10 pc cut**	**20 pc cut**	**30 pc cut**
Wheat	35%	31%	28%	25%	**11%**	**20%**	**27%**
Maize	30%	19%	10%	2%	**37%**	**67%**	**94%**
others:							
other coarse grains	25%	21%	17%	14%	**16%**	**30%**	**42%**
Soybeans	14%	12%	10%	8%	**16%**	**30%**	**42%**
other oilseeds	25%	24%	23%	21%	**6%**	**11%**	**15%**
veg oils	25%	25%	25%	25%	**0%**	**1%**	**1%**

*% of simulated price increase in UKR shock scenario mitigated by biofuel use cut

Table 2: Projected mitigation effect of G7 bioethanol + biodiesel cuts							
% change in international prices (relative to baseline)	UKR shock	UKR shock + G7 bioethanol & biodiesel cut			**mitigation effect***		
		10 pc cut	20 pc cut	30 pc cut	**10 pc cut**	**20 pc cut**	**30 pc cut**
Wheat	35%	31%	28%	25%	**11%**	**21%**	**28%**
Maize	30%	19%	10%	1%	**37%**	**68%**	**96%**
others:							
other coarse grains	25%	20%	17%	14%	**17%**	**31%**	**43%**
Soybeans	14%	10%	6%	3%	**29%**	**55%**	**78%**
other oilseeds	25%	19%	13%	8%	**25%**	**49%**	**70%**
veg oils	25%	18%	12%	6%	**27%**	**53%**	**77%**