Exploring COVID-19 Food and Nutrition Security Plausible Scenario Narratives with the 'FeedUs' Model of Global Food Trade

The James Hutton Institute

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Gary Polhill, Mike Rivington and Dominic Duckett

Authors: Polhill G, Rivington M, Duckett D.
The James Hutton Institute

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Contributions and credits:

- FeedUs model and BAU scenario: Jiaqi Ge (University of Leeds); Mukta Aphale, Jennie Macdiarmid, Graham Horgan, Heather Clark, Nuala Fitton, Pete Smith (University of Aberdeen); Terry Dawson (Kings College London).
- COVID-19 Food Security Interim Scenario Narratives: Dominic Duckett, Alba Juarez Bourke, Mike Rivington (The James Hutton Institute); Richard King, Charlotte Watts (Chatham House).

Further Information: Other publications produced by the project are available here: https://www.hutton.ac.uk/research/projects/covid-19-food-and-nutrition-security

Summary

The ESRC funded project 'UK food and nutrition security during and after the COVID-19 pandemic' has assessed the global and UK impacts of COVID-19 as the pandemic unfolded. Subsequent research has developed and assessed four plausible future scenarios in respect of pandemic recovery, Brexit realignment and other global scale socio-economic and environmental drivers.

This document presents an agent-based model with the name 'FeedUs' (Ge et al. 2021), and modifications to it as part of this project. The objective was to assess the plausible scenarios in respect of impacts on the quantities of different food types imported to and exported from the UK, and which countries the UK trades with were more likely to be affected. FeedUs simulates countries as agents, who trade the food they have produced in order to meet the nutritional needs of their populations. The role of FeedUs in this project was to see how interpretations of the project's co-constructed 'Plausible Scenario Narratives' for food and nutrition in the wake of the COVID-19 pandemic (Duckett, 2021) affected the goods traded and countries traded with for the United Kingdom.

The purpose was to help inform discussion and consideration of the multiple consequences of changes in key national and international drivers affecting the UK food system. This report presents results on modelling international trade, providing information to inform discussion on how land use and management in the UK for food production may be impacted.

Key findings:

- The four plausible scenarios explored result in different impacts on food imports in terms of types and where these originate from in respect of the countries we trade with. Though not explored here, these impacts can be anticipated to have cascading consequences:
    - Changes in the balance of imports and exports will have consequences on food and nutrition security in respect of those on low incomes due to potential prices changes
    - The scales of the estimated changes will have significant consequences in terms of environmental impacts in the UK due to changes in land use to meet demand, and in exporting countries (with potentially negative impacts due to lower environmental standards).
    - Estimated changes will have consequences on the balance of trade between the UK and other countries and our trading relationships with them. Each scenario explored implies a changing dynamic with our trading partners.
- The results provide insights that will be informative in considerations of the trade-offs between increasing UK production versus changing the amount and types of foods imported, and from where, in respect of food security and environmental health.

Background to this report

This report is part of a series focussed on the UK's food and nutrition security. The overall project context is to assess the pandemic impact on food and nutrition security, assess options for alternative approaches to food production in the UK, and how this relates to international trade in food. The project further explores what lessons can be learned in respect of addressing other risks, particularly climate change, biodiversity loss, and ecosystem degradation.

Further details of the project are available on the COVID-19 Food and nutrition security project website and in the following *Nutrition Bulletin* paper:

Rivington, M., King, R., Duckett, D., Iannetta, P., Benton, T.G., Burgess, P., Hawes, C., Wellesley, L., Polhill, J.G., Aitkenhead, M., Lozada-Ellison, L.-M., Begg, G., Williams, A.G., Newton, A., Lorenzo-Arribas, A., Neilson, R., Watts, C., Harris, J., Loades, K., Stewart, D., Wardell-Johnson, D., Gandossi, G., Udugbezi, E., Hannam, J. and Keay, C. (2021) **UK food and nutrition security during and after the COVID-19 pandemic.** *Nutrition Bulletin*, 46: 88-97. https://doi.org/10.1111/nbu.12485

Other associated reports are:

UK food and nutrition security in a global COVID-19 context: an early stock take (Chatham House)

UK food and nutrition security in a global COVID-19 context: an update (Chatham House)

An overview assessment of the COVID-19 pandemic on the UK food and nutrition security (James Hutton Institute).

Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic (James Hutton Institute). Also available on Zenodo

Introduction

The COVID-19 pandemic is a public health crisis that has had a substantial impact on all aspects of life and affected everyone, including our food and nutrition security and relationships with food. This report details research using an Agent Based Model (FeedUs) applied to four expert scenario planning panel derived plausible future scenarios (to 2030). The aim was to assess possible changes in food types traded, quantities imported or exported and changes in those countries the UK trades with. The context is to contribute to a broad assessment of the UK's food and nutrition security over the next decade.

The FeedUs Model:

FeedUs was developed as part of a project called 'Delivering Food Security on Limited Land' (known to its participants and referred to henceforth as 'DEVIL'), funded by the Belmont Forum/FACCI-JPI (NERC grant number NE/M021327/1) and the Scottish Government's Environment, Agriculture and Food Strategic Research Programme 2016-2021 (Work Package 3.3). FeedUs is an agent-based model, which is a kind of dynamic computer simulation that explicitly represents a number of heterogeneous agents (in this case, countries), and their interactions (in this case, trading food).

Ge et al. (2021) provide full details of the structure and data sources for FeedUs. In the absence of those details, it can be seen as a black box that, for each year simulated, redistributes pre-defined food-production scenarios among the country agents, according to pre-defined population demand scenarios. The main data used are the annual 'Food Balance Sheets' produced by the Food and Agriculture Organization (FAO) of the United Nations, with future years' sheets based on the scenarios and developed in the DEVIL project. The model uses FAO data from 2000-2013; the FAO's methodology for collating Food Balance Sheets data having changed in 2014. It is one of the first global trade models to operate on all countries individually and all 95 food items in the FAO data. With data provided by the Rowett Institute, the output of the model can be used to calculate macro- (calories, protein, fat) and micro-nutrients (vitamins and minerals) available to each country's population.

The redistribution process is a simulation of trade that is 'relation-driven' rather than based on price in the market place (Ge et al. 2021). Countries trade with each other in rank order based on weighted criteria of GDP per capita (which acts as a proxy for price), geographic distance, historic trade relationship (both of which act as proxies for trading blocs), and emergent trading relationship (which allows the model to evolve whom countries trade with in response to the input production and demand scenarios). As Ge et al. (2018) report, the weights were calibrated on years 2001-2007, and validated against years 2008-2013 using a multi-criteria approach that assessed volumes traded and trading partners; the calibrated parameters achieving a match of volumes traded just under 65% of the time and a match of trading partners a little over 69% of the time.

FeedUs was modified as part of the "Food and Nutrition Security during and after the COVID-19 Pandemic. These modifications entailed specific adjustments in the model's code to the behaviour of the agent representing the United Kingdom, with a view to achieving some level of interpretation of the scenarios developed for the project (Duckett 2021). These scenarios, as far as FeedUs is concerned, made adjustments to the foods demanded by the UK's citizens, and the foods produced by the UK's farmers. The precise alterations and interpretations are detailed in the ensuing section.

Methods and Data

The data used were developed as part of 'Business As Usual' demand scenarios for nations' diets developed by the Rowett Institute as part of the DEVIL project, and a production scenario based on RCP2.8 climate change projections developed by the University of Aberdeen, also in the DEVIL project. Full details of these data, where not documented by Ge et al. (2021), will be in a forthcoming article on the DEVIL project.

The work done here pertains to interpreting the Duckett et al (2021) plausible scenarios by modifying the FeedUs model. These introduced five parameters that adjusted the behaviour of the agent representing the United Kingdom:

1. Adjustment to imports the UK requests from the marketplace (*i*). FeedUs is designed such

that the request made is a function of demand and production. It is worth noting that this adjustment, if negative, could then lead to there being insufficient nutrients for the population, even if the UK agent is successful in acquiring the goods it has sought from other countries. However, especially in the case of macronutrients, the problem in the UK is over, rather than under supply.

2. Adjustment to demand for beef and lamb (*d*) – assumed to be represented by the FAO food balance sheet items "Bovine Meat" and "Mutton & Goat Meat". (Perhaps debatably, offal and animal fats were not included.)
3. Adjustment to production (*p*) – encompassing production change as specified in the scenario, together with any loss of land for bioenergy production and any change to the amount of land set aside.
4. Start (y_0 = 2020) and end (y_1 = 2030) years of changes to the UK's variables in the model, implemented as a linear proportion of the values of *i*, *d* and *p*, the pre-2020 value of each being 0.

The scenarios were then interpreted as in Table 1. Each scenario was accompanied by three settings for an existing model parameter determining the proportion of possible trades that take place. If this parameter is 100%, then each time a country with something to sell can find a buyer for it, the exchange will take place. Lower percentages lead to lower priority trades not happening. At 0%, no trades happen and agents must live off the production only. The 'standard' setting for the parameter is 80%. We also simulated values of 70% (reduced global trade) and 95% (enhanced global trade). There are then 24 scenarios in total, each of which was simulated 30 times using different seeds for the pseudo-random number generator, making 720 runs of FeedUs in total. The model was run for the period 2000-2030.

Results

The main results we are interested in are the changes in foods traded and trading partners arising from scenarios in comparison with the Baseline scenario. For individual scenarios, boxplots show the mean, interquartile range, minimum and maximum volumes of goods traded across the 30 runs of the scenario. To show change between a scenario and the Baseline, a bar chart shows the difference in the median values of the runs in the two scenarios. In both cases, the *x*-axis is sorted in descending order of median volume. Though the model simulates all 95 FAO food items, the UK agent typically imported around 60 of them, and exported approximately 10.

In all results, the precise numeric magnitude is probably of less significance than a qualitative comparison of the values returned. That said, the units on the *y*-axes in all of the charts represent volume in tonnes (Mg).

Baseline

The baseline scenario graphs in Figure 1 show a wide range of countries from which the UK imports its food, dominated by North America, Argentina, neighbouring countries in the EU (especially France, Germany, Denmark, the Netherlands and Ireland), accession EU countries (e.g. Bulgaria, Romania and Czechia), as well as Turkey, Kazakhstan, Russia, Ukraine and Australia. The main imports are wheat, barley, milk, maize, wine, pork, rice and soyabeans. By contrast, four countries comprise the bulk of

Table 1. Interpretation of scenarios with respect to the three model parameters introduced (see above for i, d and p). Note that Green UK V4 and Green UK V5, though different in the project's scenario specifications, had no reasonably interpretable difference in the configuration of the modified version of FeedUs.

Scenario	Adjustment *i*	Adjustment *d*	Adjustment *p*
Baseline	0	0	+10%
Back to Basics	+10%	0	+10%
Recovery First	0	-5%	+10%
Best of British	-10%	-5%	+3%
Green UK (V1)	-10%	-5%	-12%
Green UK (V2)	-10%	-30%	-12%
Green UK (V3)	-10%	-30%	-2%
Green UK (V4 & V5)	-10%	-30%	+3%

exports: Mexico, Russia, India and Pakistan, mostly of oats and rape and mustardseed. The runs show some variability in volume, mainly for imports by country, but the ranges for the six countries with the highest imports to the UK (Canada, Argentina, France, USA, Ukraine and Germany) are consistently higher than the rest. The next group of countries (Australia, Turkey, Kazakhstan, Russia, Denmark, the Netherlands, Bulgaria, Romania, Ireland, Hungary and Belarus) have interquartile ranges that are consistently higher than the interquartile ranges of the remaining countries with lower median trade volumes.

Those with expert knowledge of the UK's food trading partners as recorded in data sources such as Defra's Food Statistics Pocketbook and the World Bank's Word Integrated Trade Solution (WITS) will observe that there are some differences in these trading partners and those reported in the results from FeedUs. For example, WITS, which for 2019, has France, Germany, The Netherlands, Ireland, Italy and Belgium as the highest trade-by-price importers. While the graphs from FeedUs show trade-by-volume rather than trade-by-price, FeedUs currently only uses proxy variables (such as geographical distance and historical trading relationship) to model trading blocs such as the European Union, which the Defra data say comprised 26% of the supply of the UK's food in 2019.

Back to Basics

In comparison with the Baseline scenario, Figure 2 shows that the Back to Basics scenario features increased import volumes from Italy, Paraguay and India especially, but reduced imports mostly from EU countries (Germany, France, Latvia, Slovenia, Poland, Czechia, Lithuania, The Netherlands and Hungary), but also from Belarus, New Zealand, Canada and Australia. Though there are small increases in imports of maize, wine, rice and soyabeans, there is an especially large reduction in the volume of milk imported (around 50% of the Baseline volume). The largest volumes of change in exports are increases to Mexico, Pakistan, China, Saudi Arabia and Viet Nam, with larger volumes of change associated with rape and mustardseed, poultry meat and oats.

UK Recovery First

The Recovery First scenario bar charts in Figure 3 show small increases in imports from Armenia, Ireland, Portugal and Thailand, with roughly 10% reductions in imports from many of the larger volumes of imports in the baseline scenario, especially Germany, the USA, New Zealand, The Netherlands, Australia, and Belarus. Larger proportional reductions are also present for countries with smaller volumes in the baseline, such as New Zealand, Latvia, Slovenia and Poland. The largest single reduction in import is for milk, which is reduced by approximately 50%. Note that while there is little trade in milk globally, there is significant trade in milk products (such as cheese) (Uberoi 2021), and the FAO's Food Balance Sheets category "Milk – Excluding butter" encompasses a wide range of milk products (including cheese, yoghurt, condensed milk and ice cream).

There are increased exports, especially to Russia and Pakistan, but China, Saudia Arabia and Viet Nam also feature notable increases. As well as the main exported products in the baseline, poultry meat is increased.

The general pattern of change is similar to Back to Basics.

Best of British

Figure 3 shows how the Best of British scenario differs from the Baseline. The pattern is broadly similar to that observed for the Back to Basics and Recovery First scenarios – the largest reductions in imports being for milk, and from countries with which the UK has generally larger volumes of import in the Baseline scenario. There are also similarities in exports with respect to countries and products. The main notable differences with Back to Basics and Recovery First are that the Netherlands, which had a reduced change in volume imported to the UK in Back to Basics and Recovery First, has an increased volume in Best of British, while Mexico, which had the largest change in export volume in Back to Basics, and a positive change in Recovery First, has almost zero change here. The magnitude of the change is also generally smaller for foods, especially for imported milk, which is about 50% smaller (about 25% reduction in comparison with the Baseline).

Green UK V1

In Figure 5, there is a general pattern of increased imports, especially from the countries with larger volumes of imports to the UK in the Baseline scenario. In a notable contrast with the Back to Basics, Recovery First and Best of British Scenarios, there is a large increase in the volume of milk imported (a little under 50%); further, the four products with the largest increase in imports in Back to Basics (maize, rice, wine and soyabeans) are the four with the largest decrease in this scenario. Another significant contrast with the non-green scenarios is that all exports have decreased in volume, especially to Mexico, India, Russia and Ireland, and for the three products showing the largest increase in the non-green scenarios (rape, oats and poultry meat).

Green UK V2

As Figure 6 shows, the main highlights for the Green UK V2 scenario are broadly similar to those for the Green UK V1 scenario. The main difference is associated with the greater reduction in demand for beef and lamb Green UK V2 entails in comparison with Green UK V1, which leads to increases in exports of the associated products, to various countries including Canada, China, Germany, Italy and The Netherlands.

Green UK V3

The Green UK V3 scenario in Figure 7 features qualitative differences from Green UK V1 and Green UK V2. Volumes of imports are generally down as opposed to up in comparison with the Baseline. The largest decreases are for maize, wine, pork, rice, soyabeans and wheat. While there are small increases in imports from Armenia, Thailand and France, there are larger decreases in imports from Argentina, Slovakia and Pakistan especially. On the export side, another notable change is that there are more countries with changed exports than the other scenarios, and much smaller reductions in those exports featuring reduced exports in Green UK V2.

Green UK V4 & V5

Figure 8 shows that the Green UK V4 (and V5) scenario differs again. Just as for many of the non-green scenarios, imports of milk decrease the most in comparison with the Baseline (though the magnitude of decrease is slightly smaller). This leads to a similar set of countries associated with a decrease in imports, though France is a notable exception, as it is one of the countries with a larger increase in imports. Besides the decrease, rather than small increase in milk, the set of products featuring decreased imports is broadly the same as Green UK V3. Another similarity with Green UK V3 is the larger number of countries showing a change in export. The main contrast with Green UK V3 (and the other Green UK scenarios) is that exports of all products has increased (rather than decreased), especially mutton and goat meat. Green UK V4/5 also features the same increases in exports shown by the non-green scenarios (rape and mustardseed, poultry and oats).

Increased global trade

Increasing the proportion of possible global trades enabled by the model leads mainly to increased imports of barley and wheat, with higher volumes of import especially from Canada, Ukraine and Russia (Figure 9). Perhaps unexpectedly, it also leads to slightly reduced exports of beef. This may be explained by countries that would have prioritized the UK more during trading rounds (presumably Tanzania) having greater opportunity to fulfil their demand for beef from other countries (e.g. with lower GDP). There are small increases in exports to Slovakia, Belgium and Germany.

Decreased global trade

Decreasing the opportunities for global trade leads to reductions in imports of wheat especially, with smaller reductions in imports of barley (Figure 10). The UK buys less from many of the countries from which it buys more in Figure 9: Ukraine, Russia and Canada especially. Exports are also reduced, with oats featuring in the reductions as well as beef reductions observed when opportunities for trade are increased.

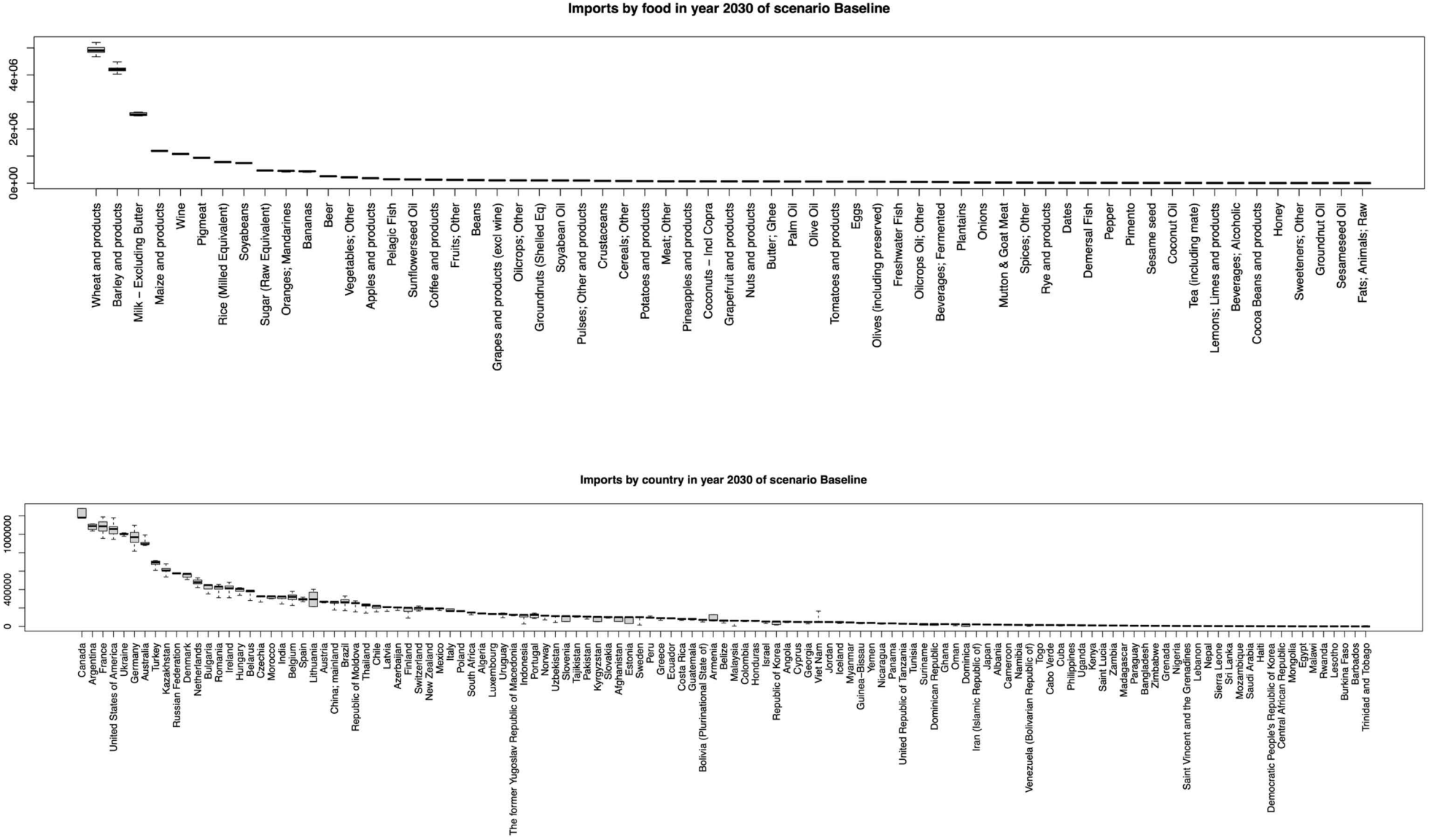
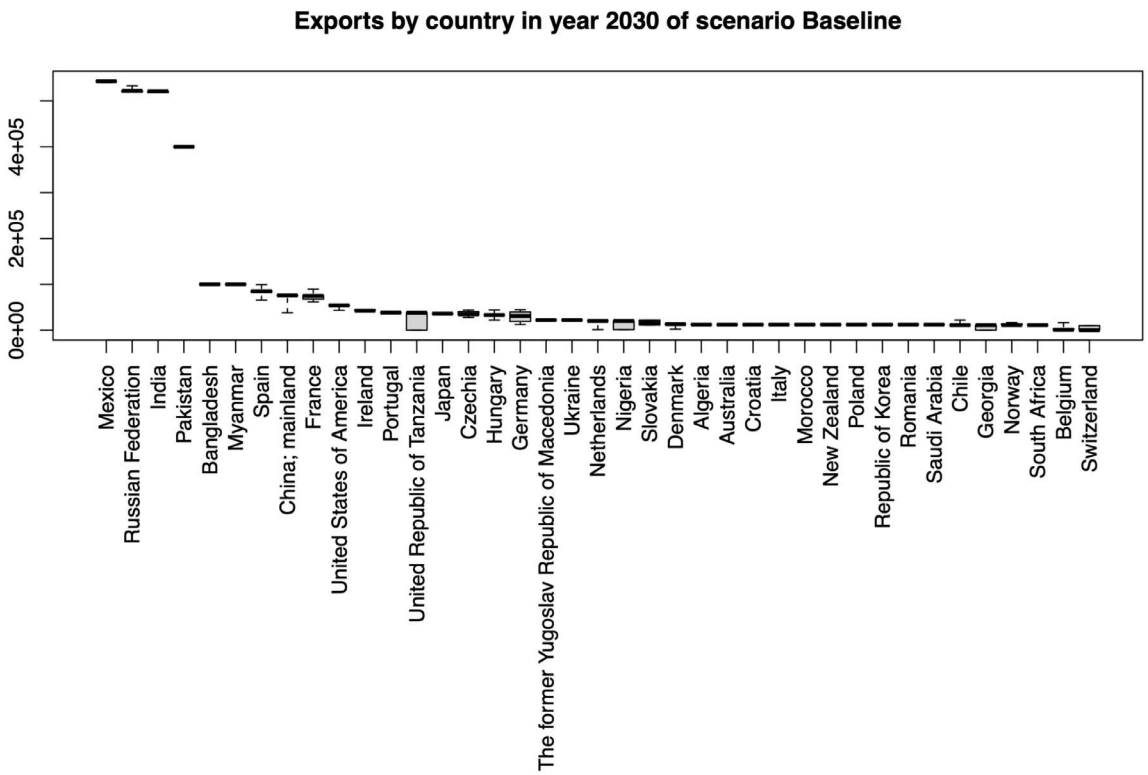


Figure 1. Boxplots showing baseline imports and exports, sorted on the x-axis (which shows country traded with or food traded) in descending order of volume (y-axis)



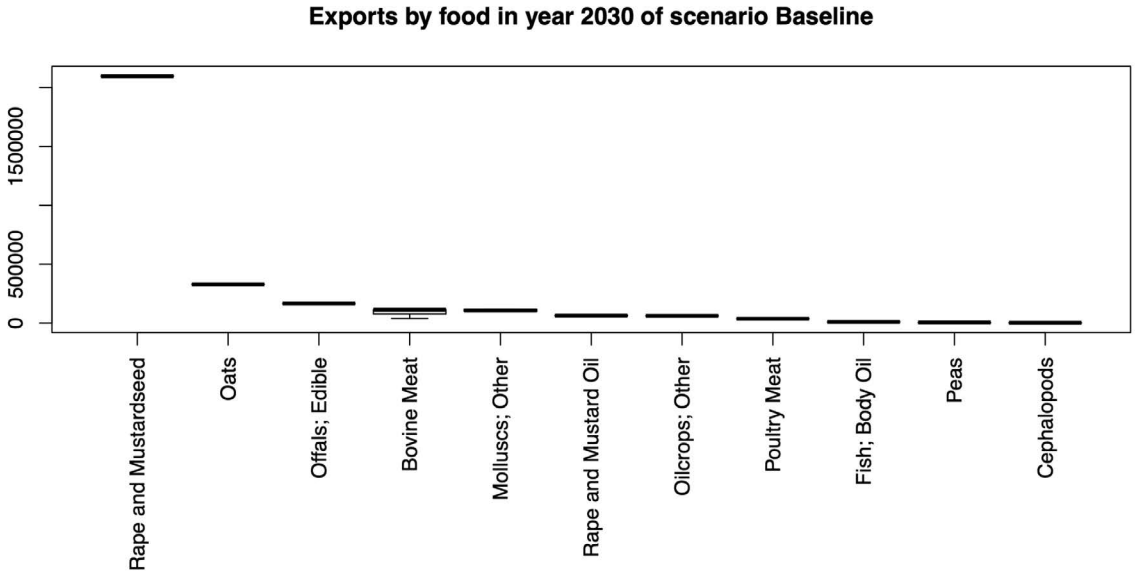


Figure 1 (cont). Boxplots showing baseline imports and exports, sorted on the x-axis (which shows country traded with or food traded) in descending order of volume (y-axis)

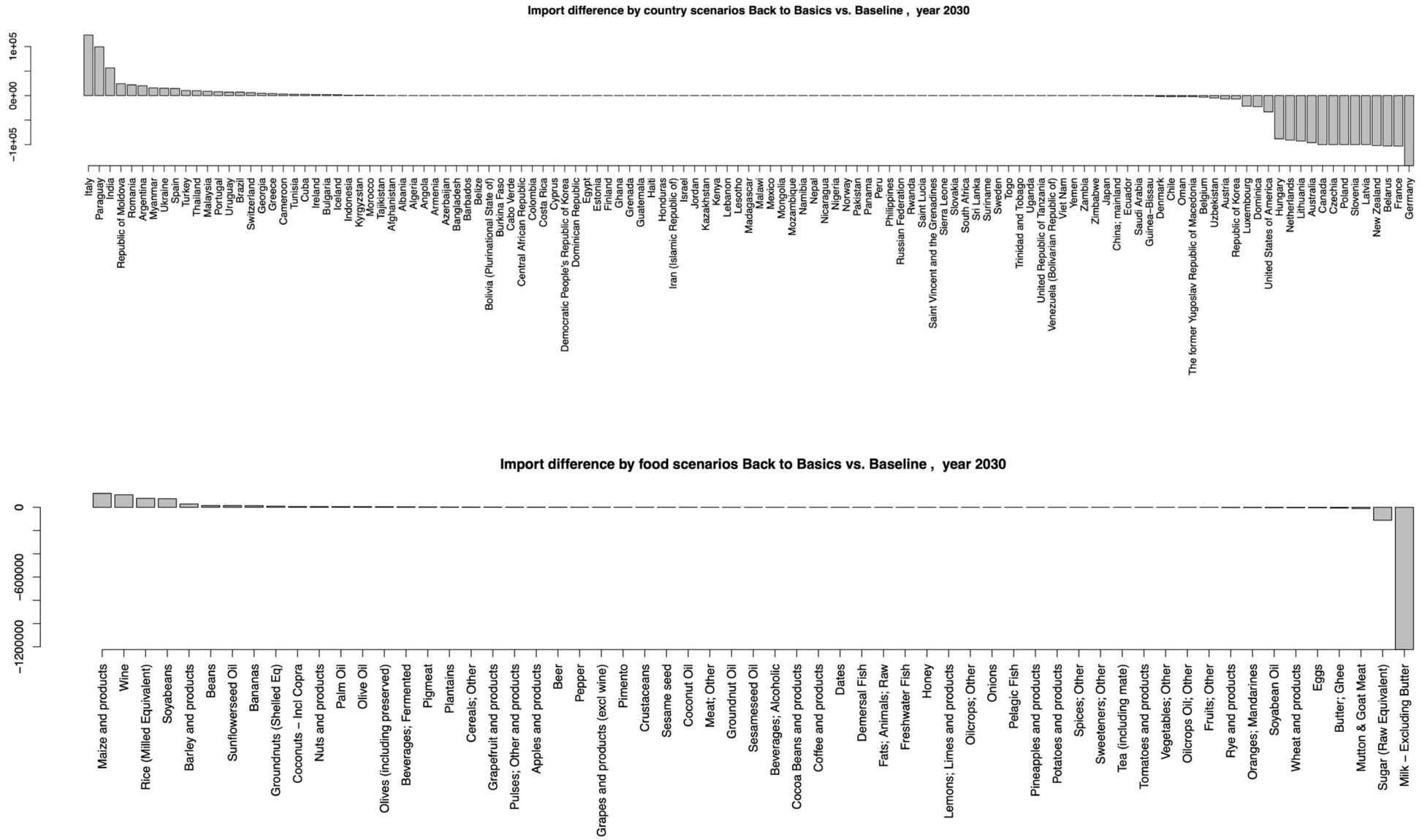
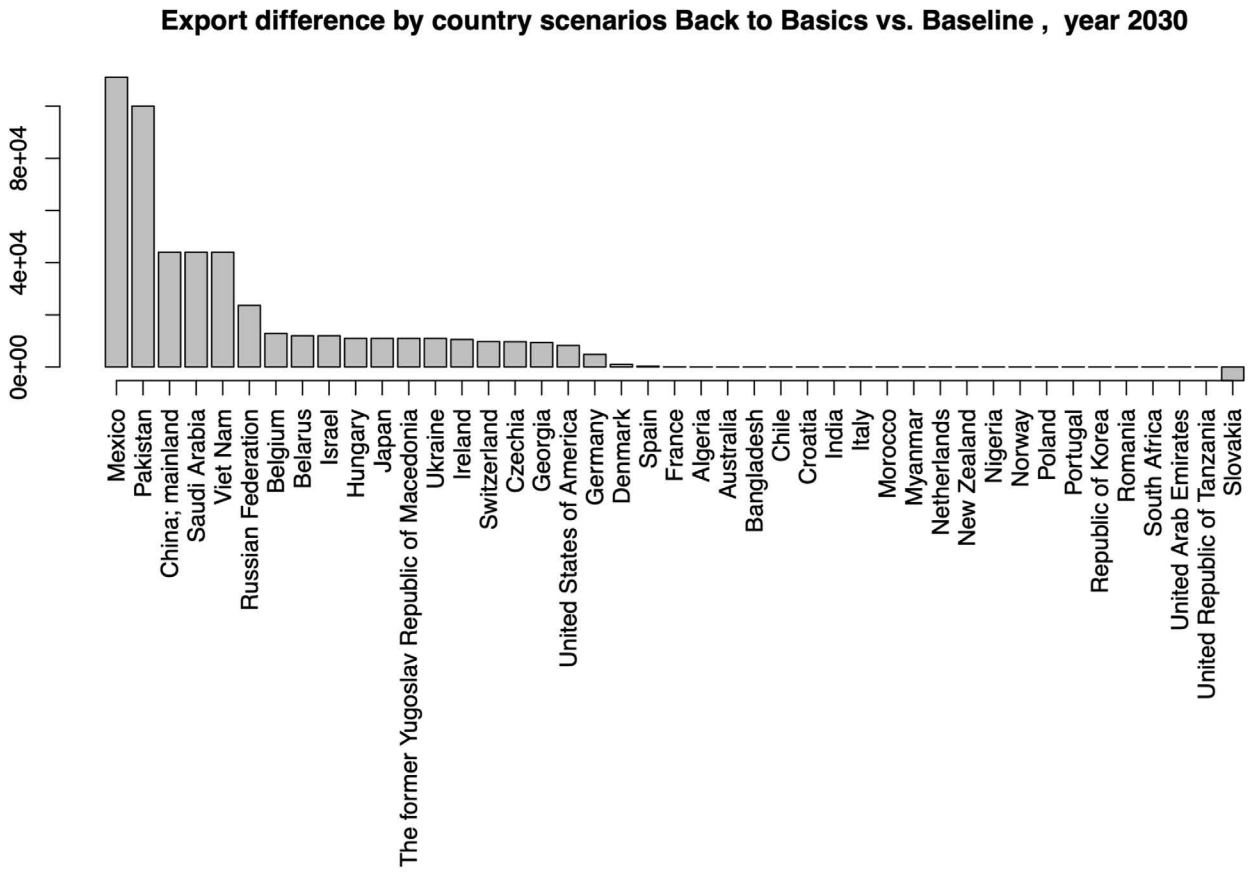


Figure 2. Bar charts for the Back to Basics scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



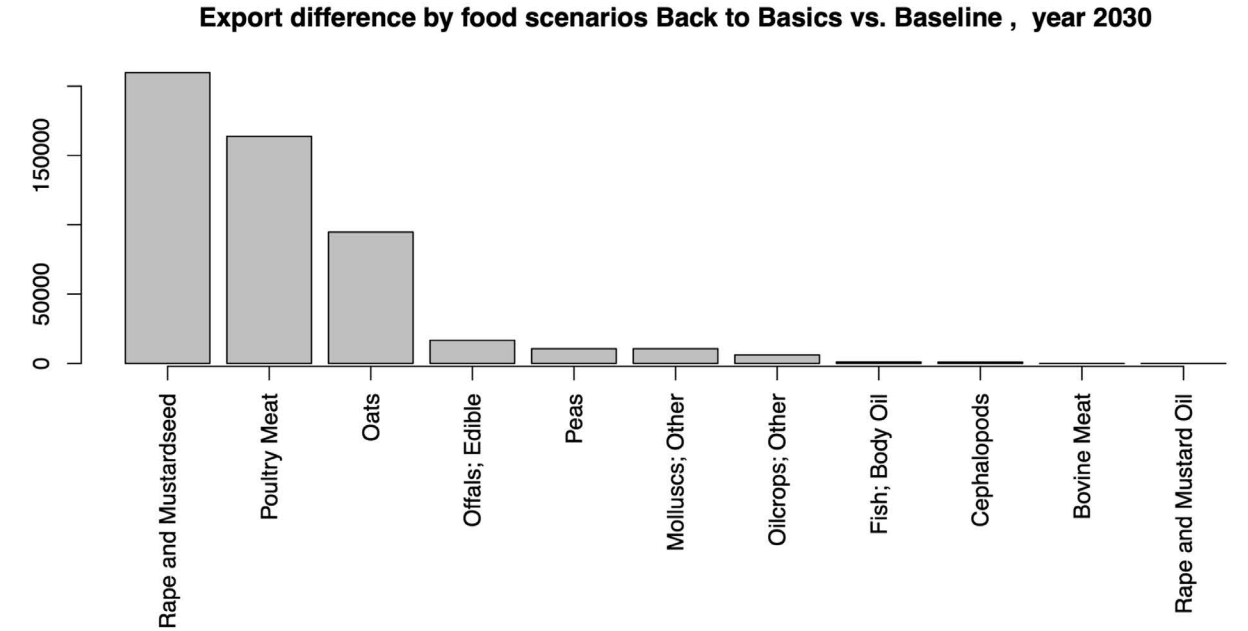


Figure 2 (cont). Bar charts for the Back to Basics scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

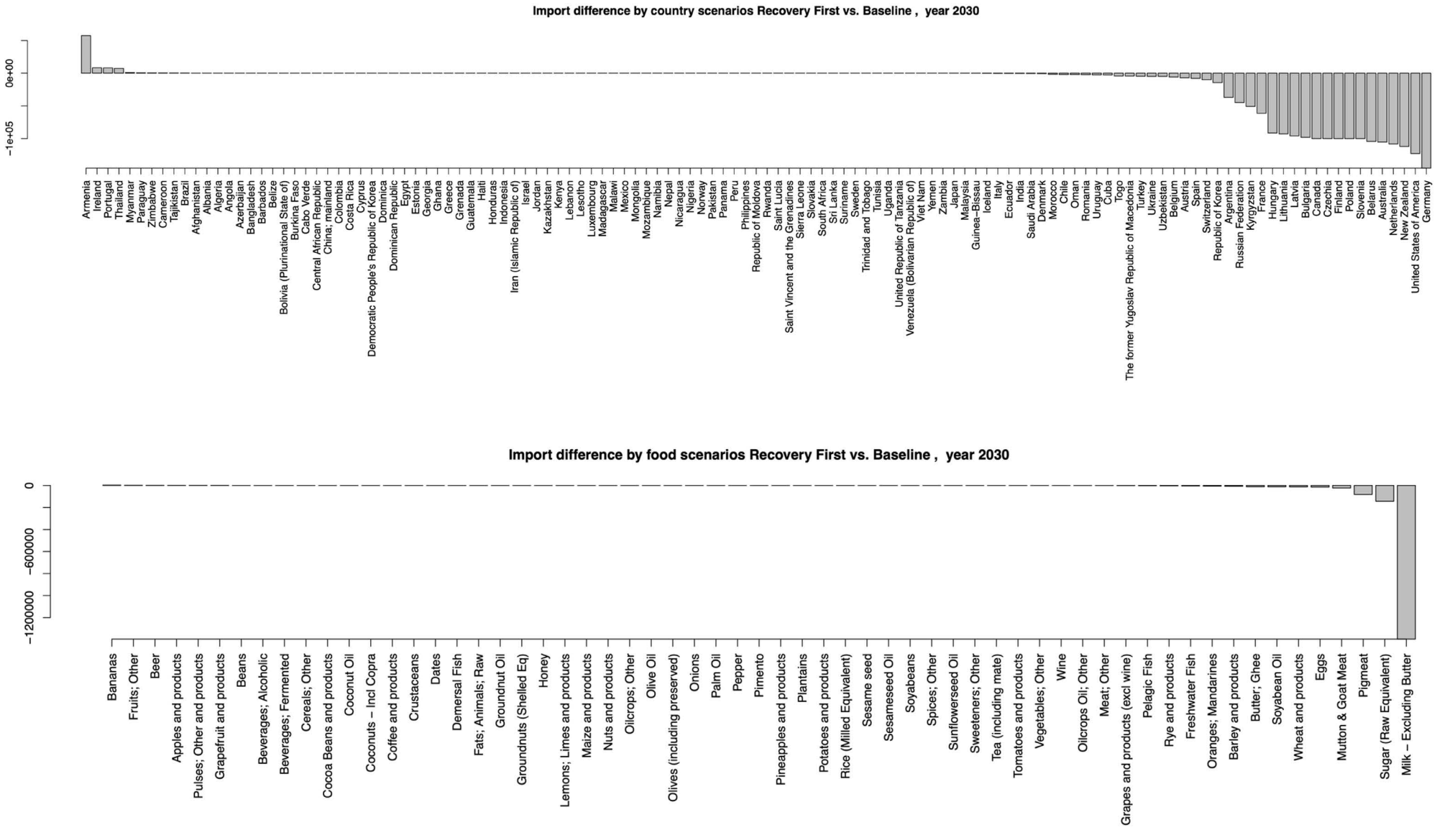
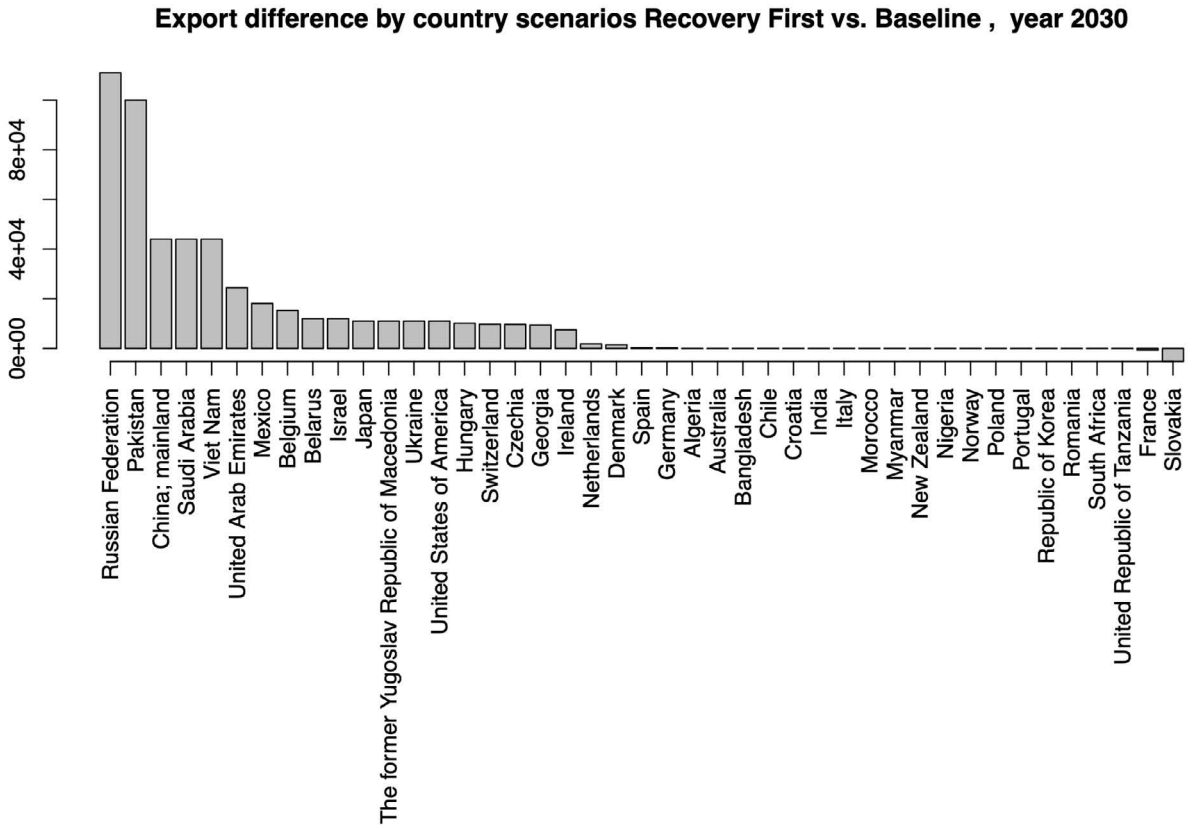


Figure 3. Bar charts for the Recovery First scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



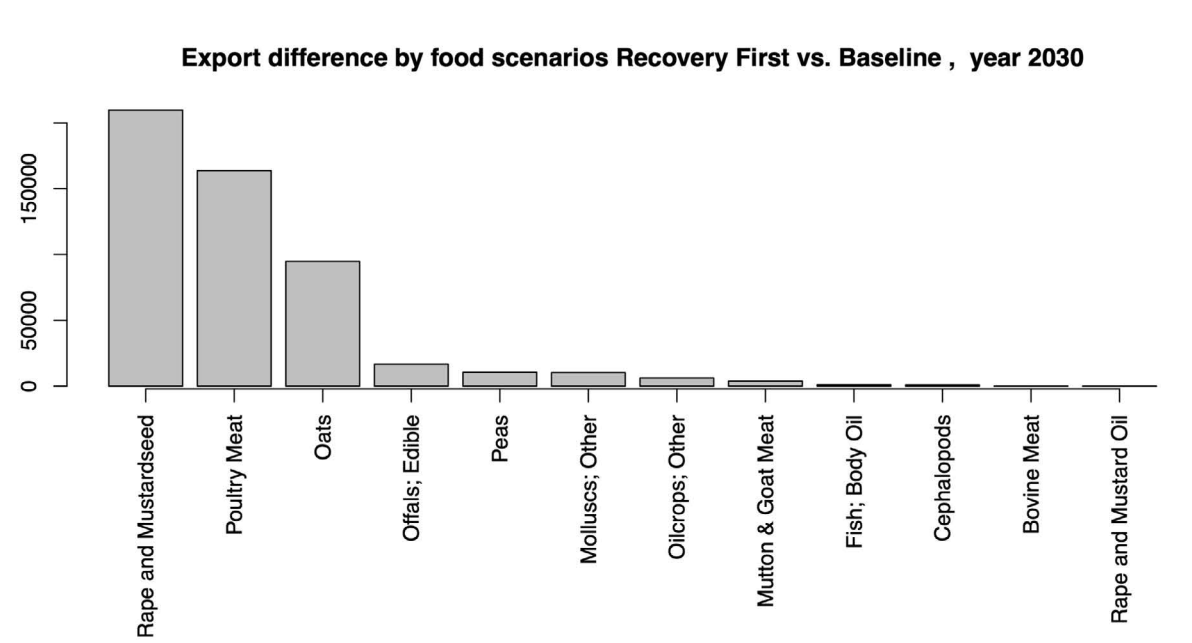


Figure 3 (cont). Bar charts for the Recovery First scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

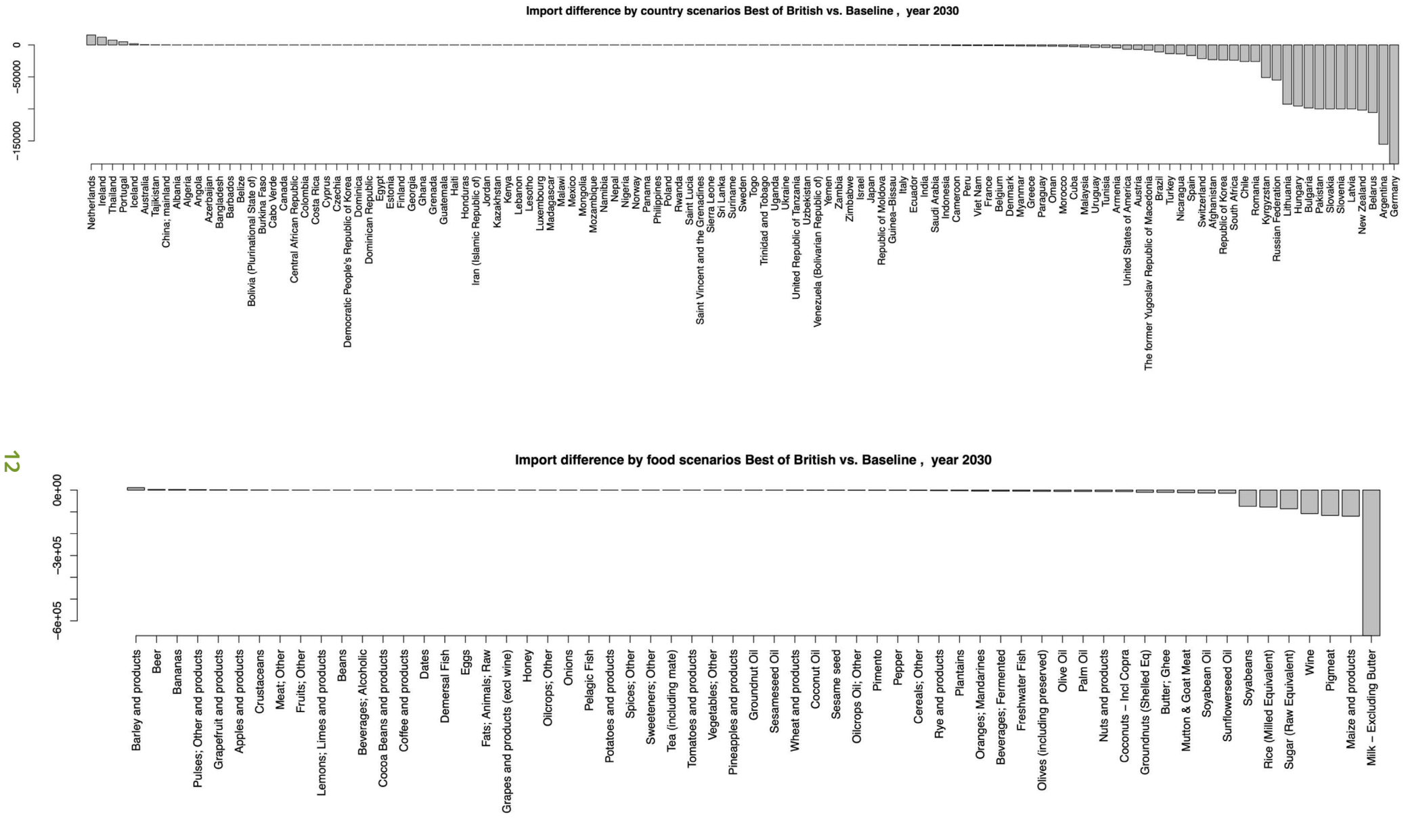
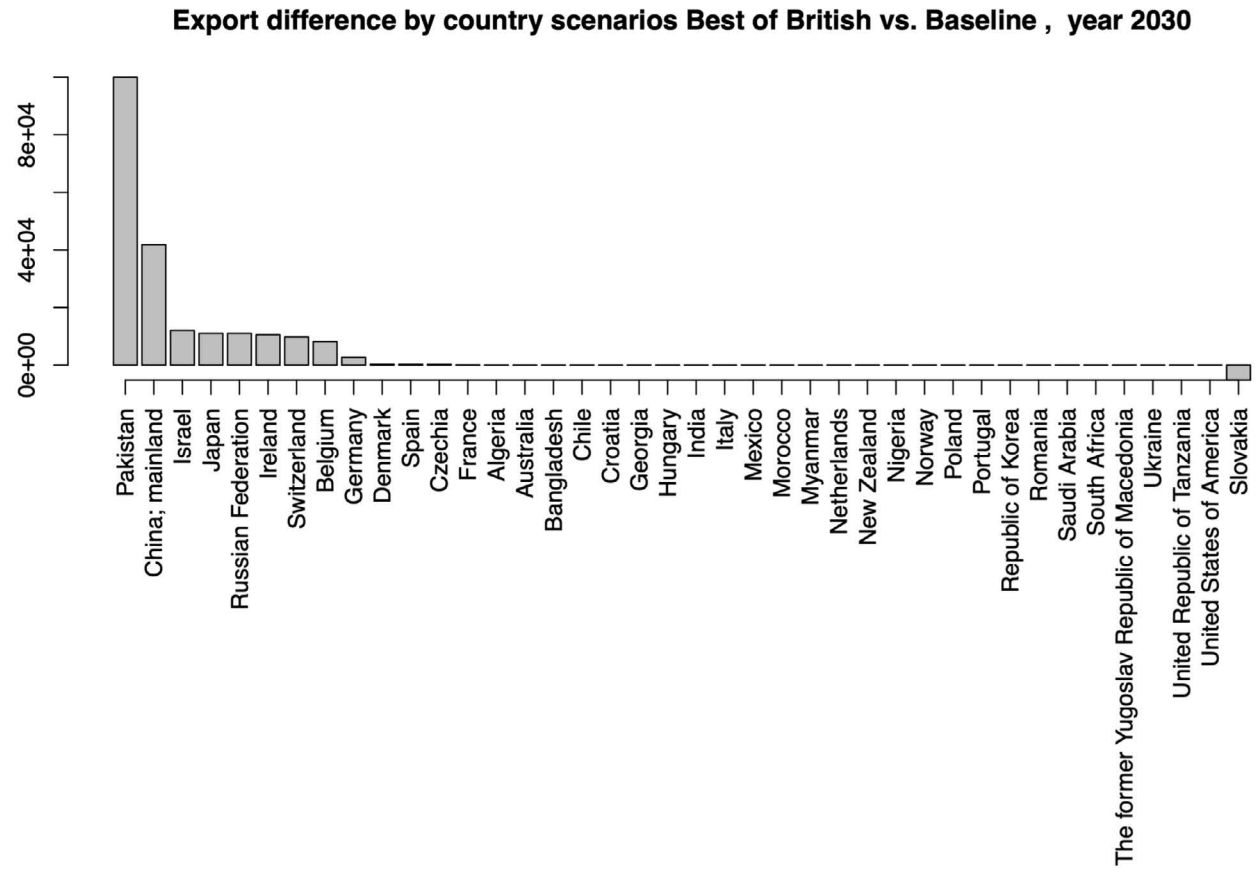


Figure 4. Bar charts for the Best of British scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



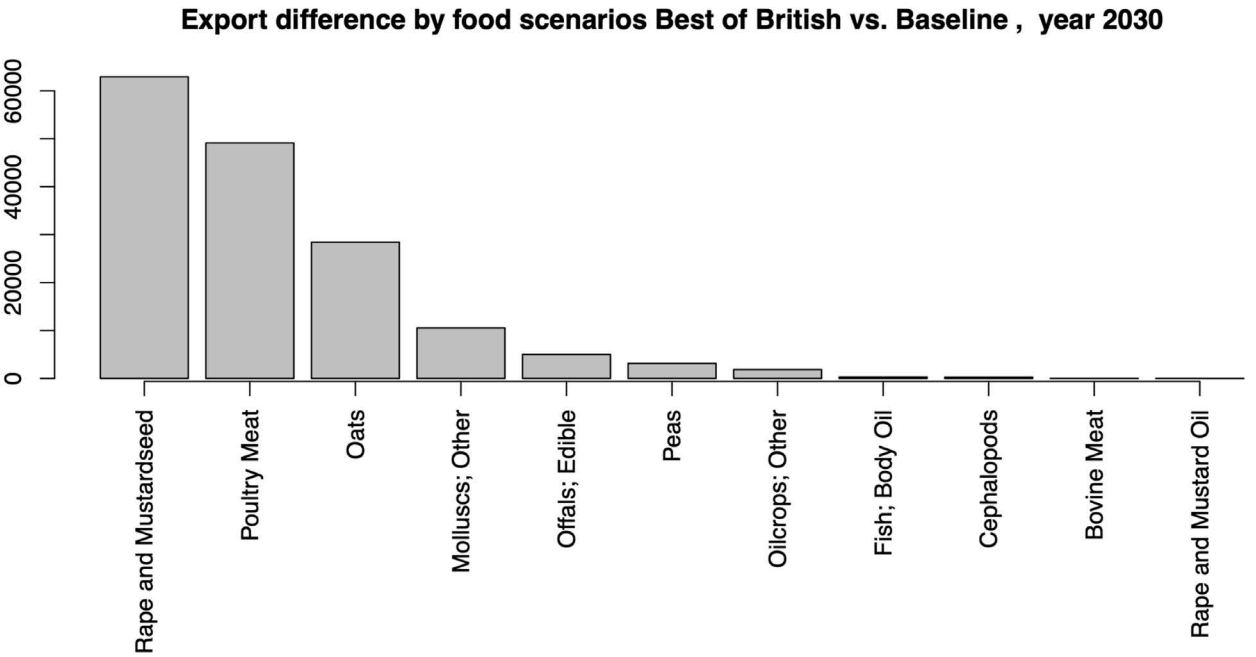
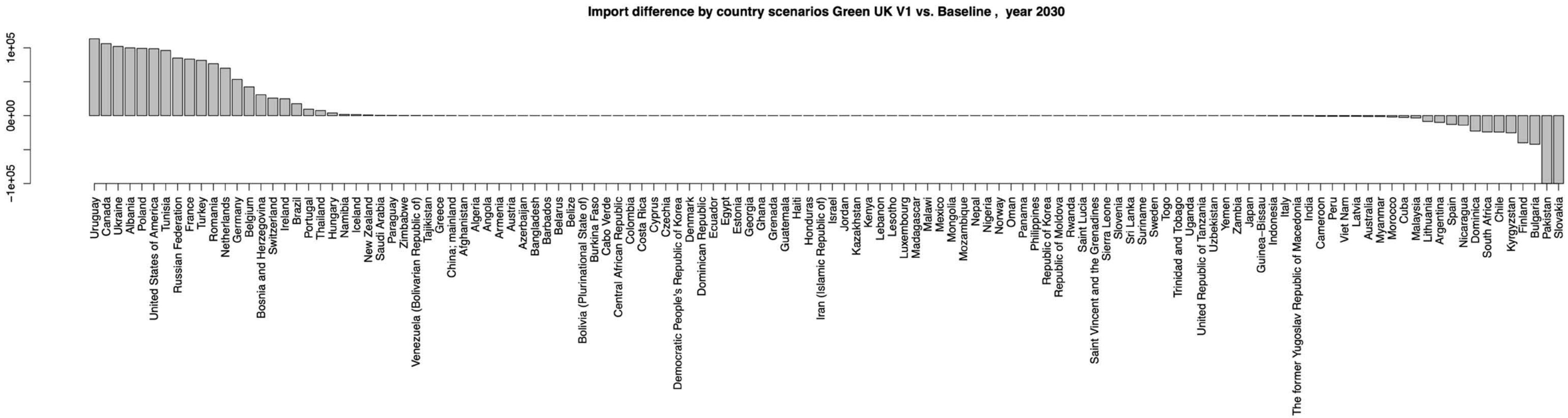


Figure 4 (cont). Bar charts for the Best of British scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



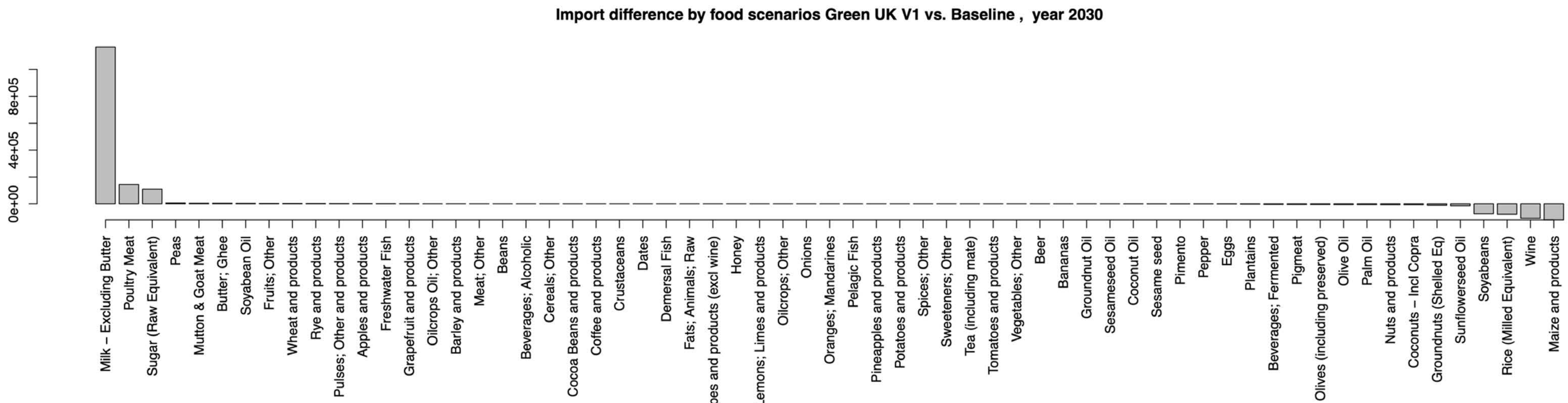
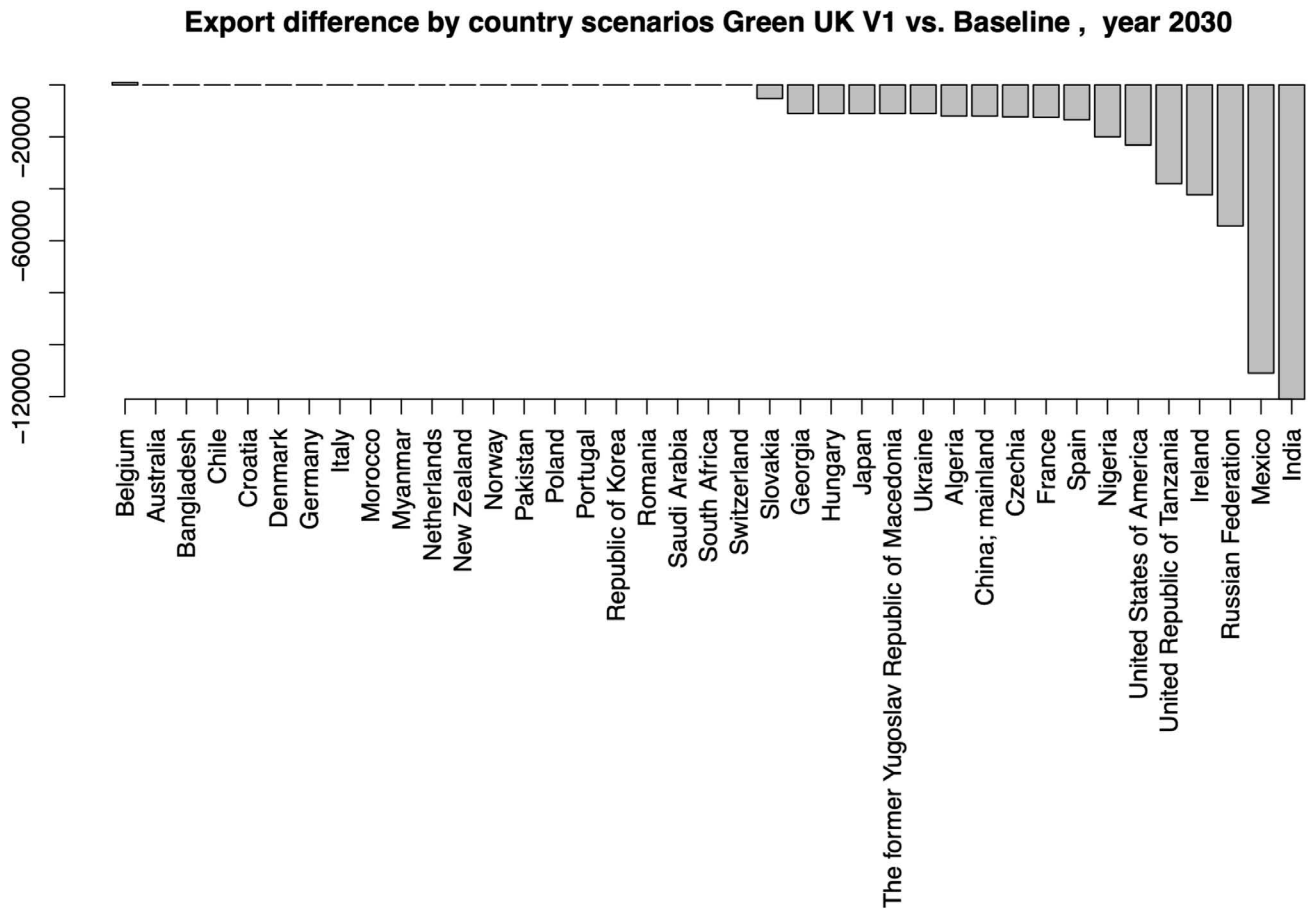


Figure 5. Bar charts for the Green UK V1 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



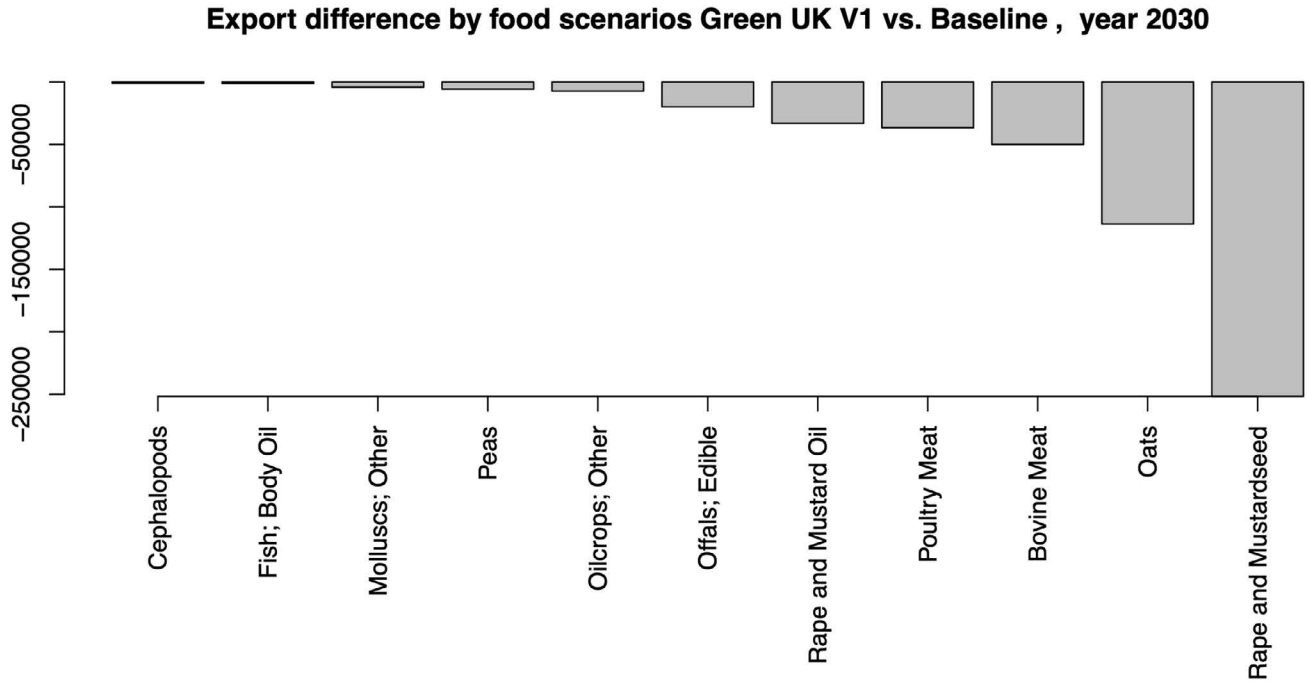


Figure 5 (cont). Bar charts for the Green UK V1 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

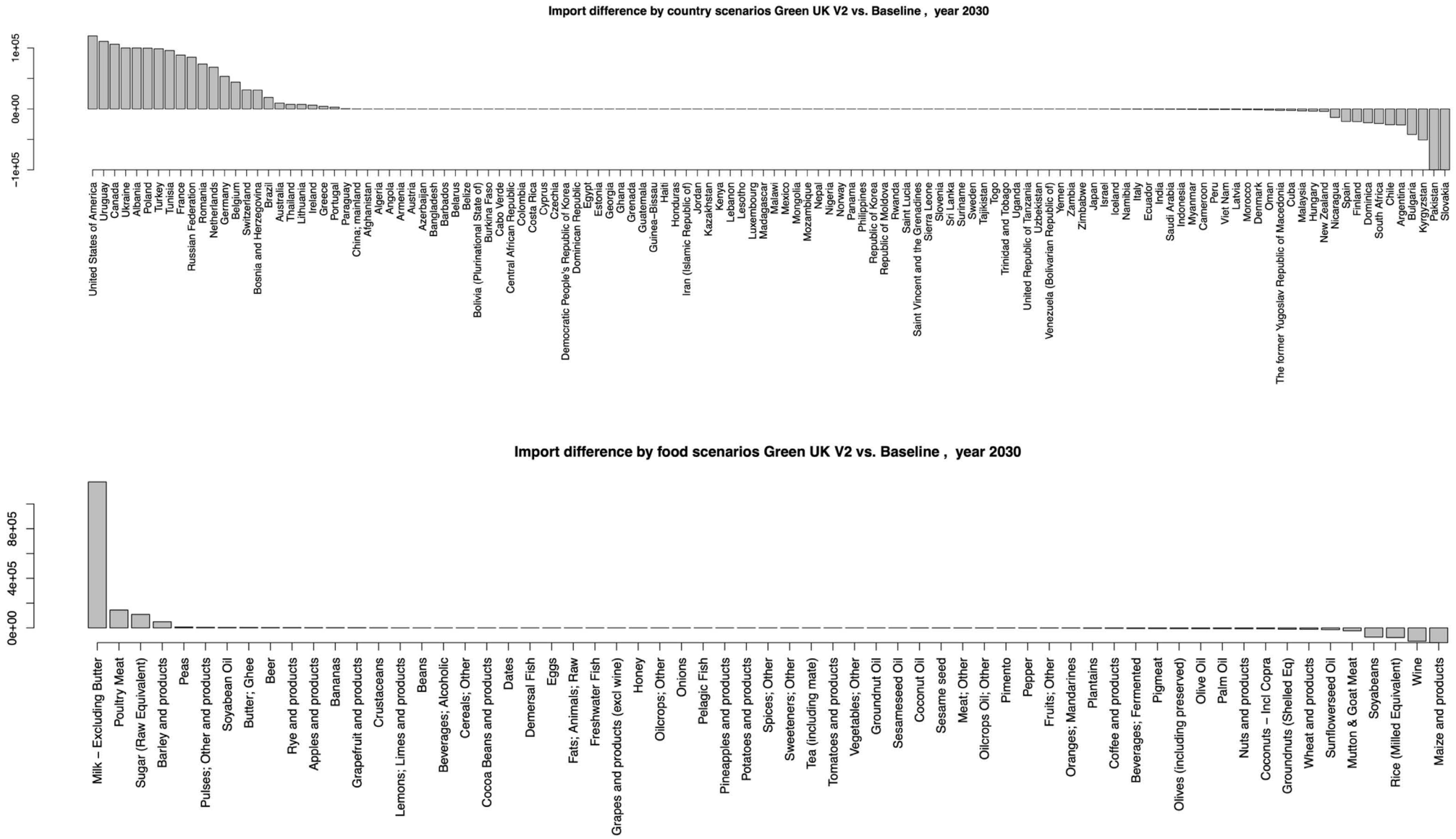


Figure 6. Bar charts for the Green UK V2 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

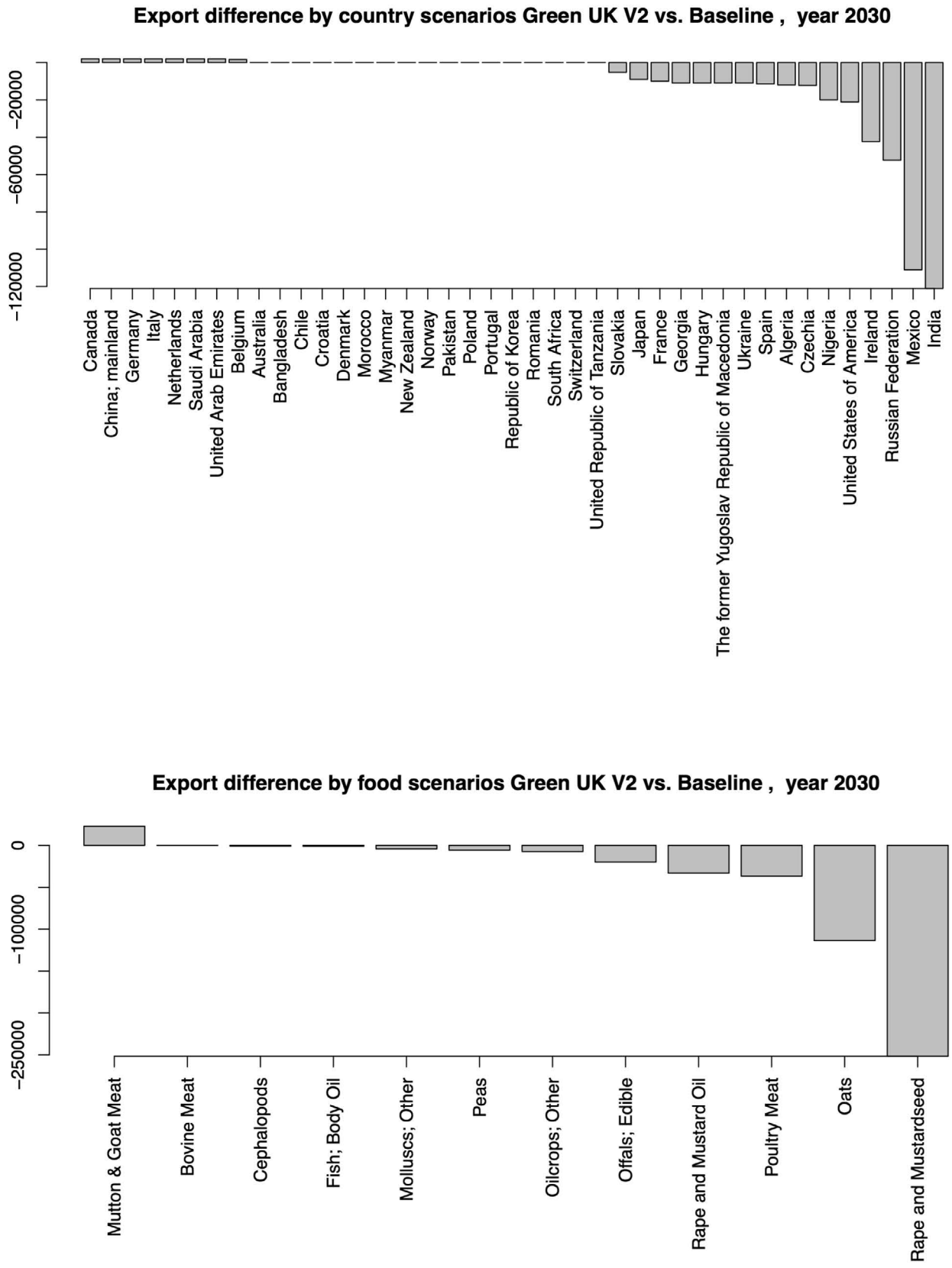


Figure 6 (cont). Bar charts for the Green UK V2 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

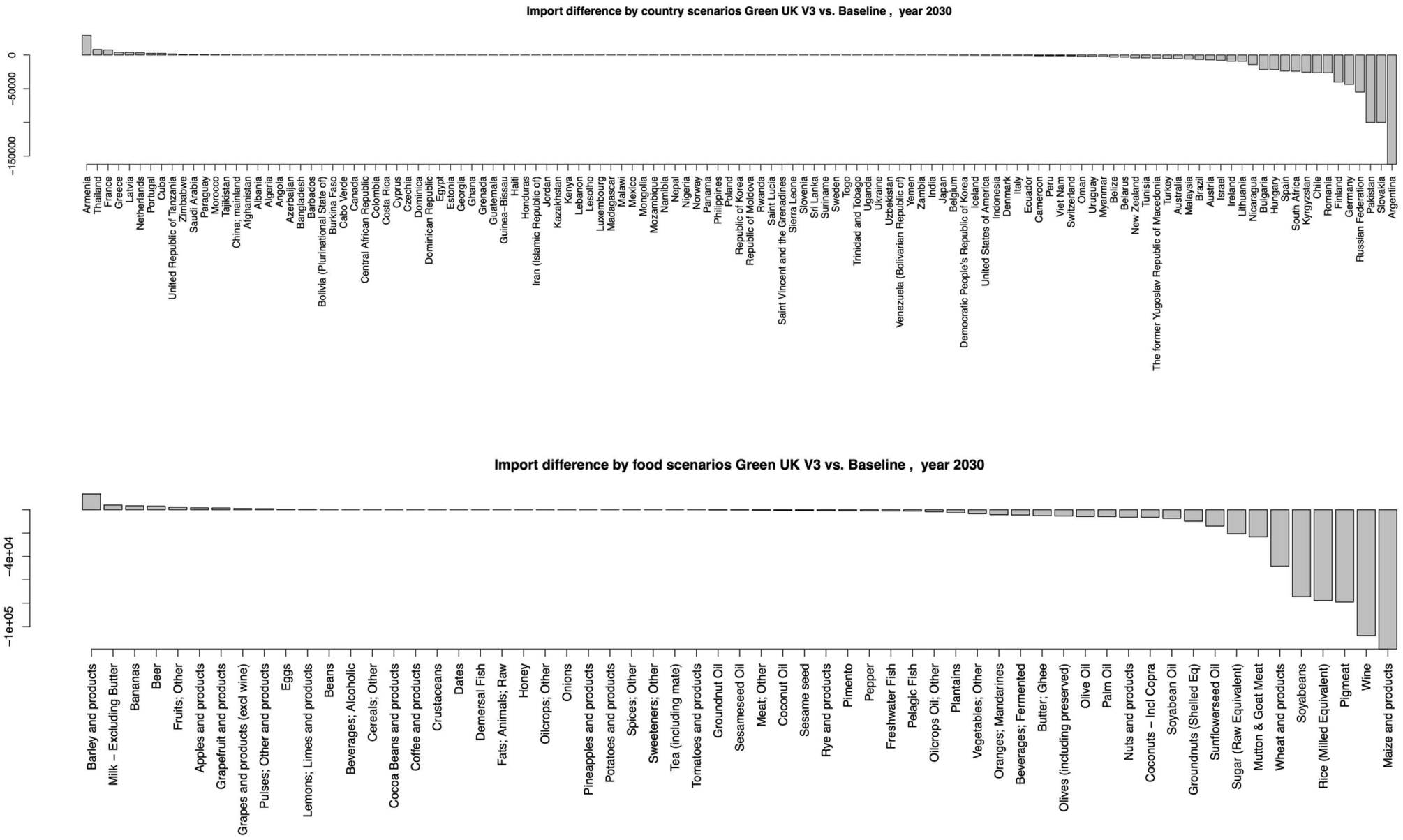


Figure 7. Bar charts for the Green UK V3 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

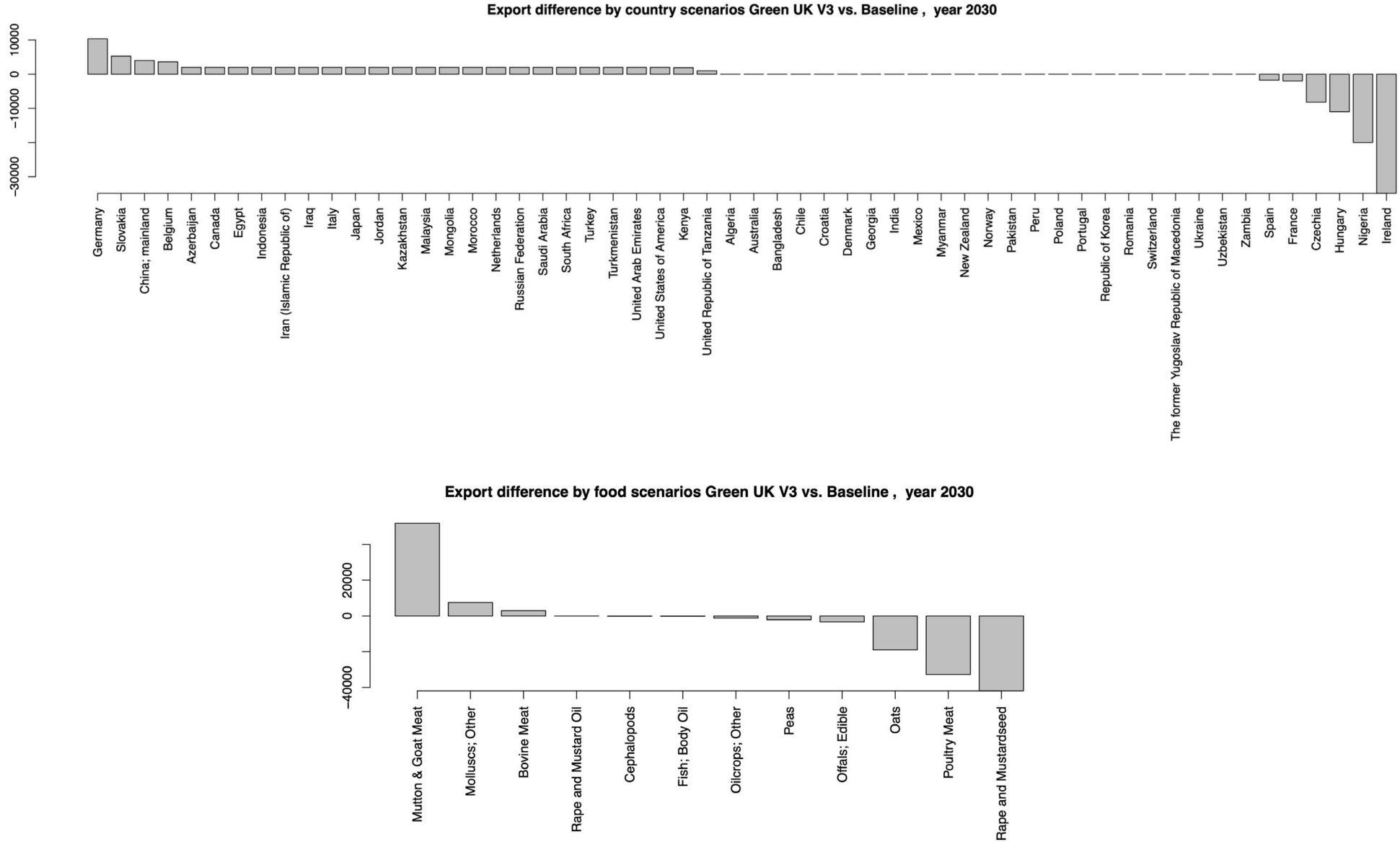
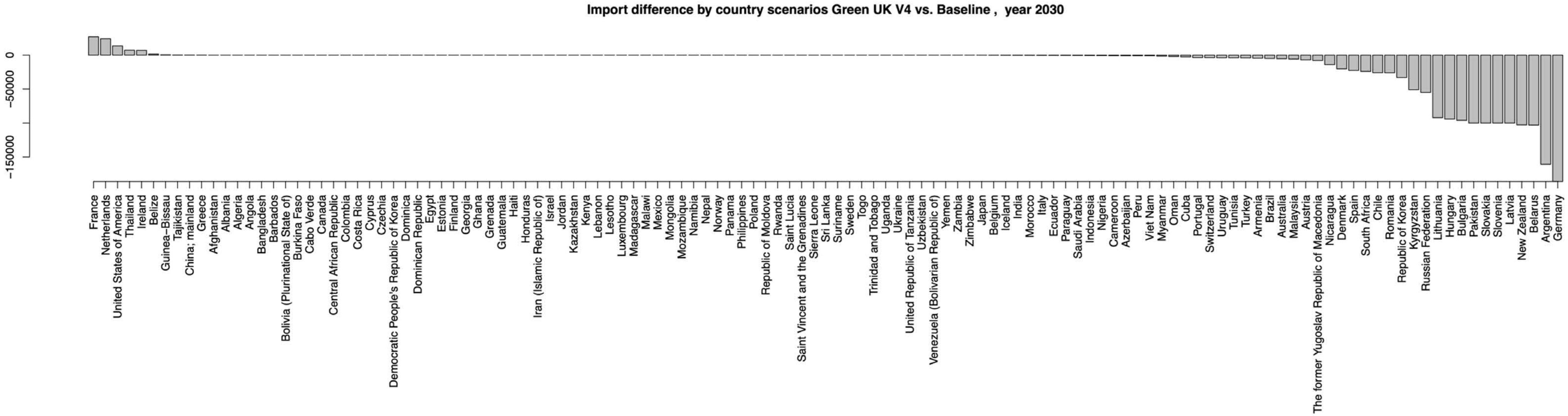


Figure 7 (cont). Bar charts for the Green UK V3 scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



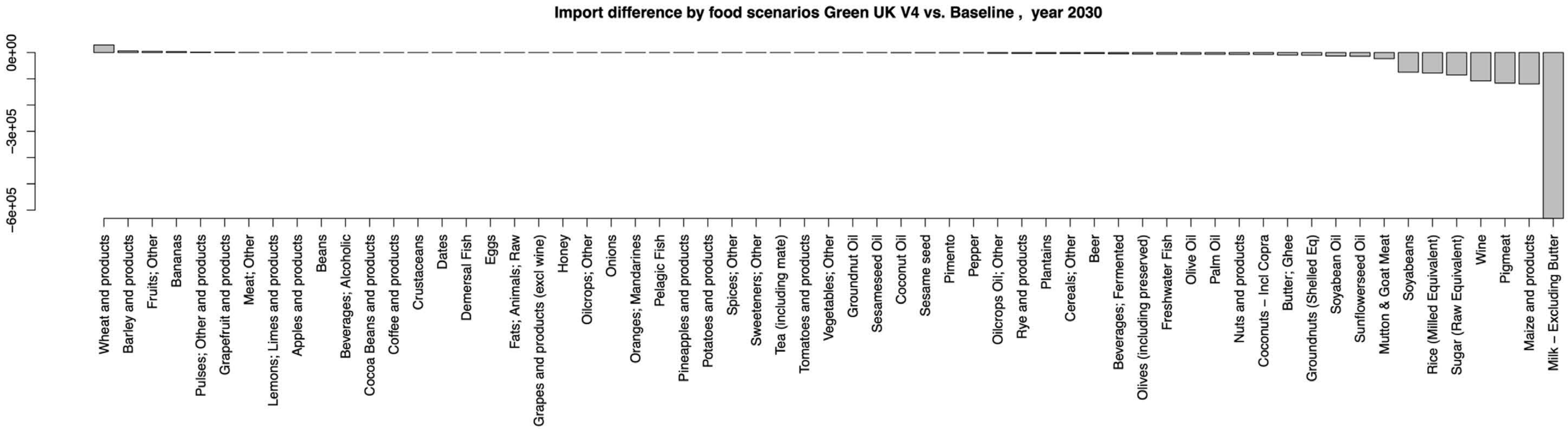


Figure 8. Bar charts for the Green UK V4 (and V5) scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.

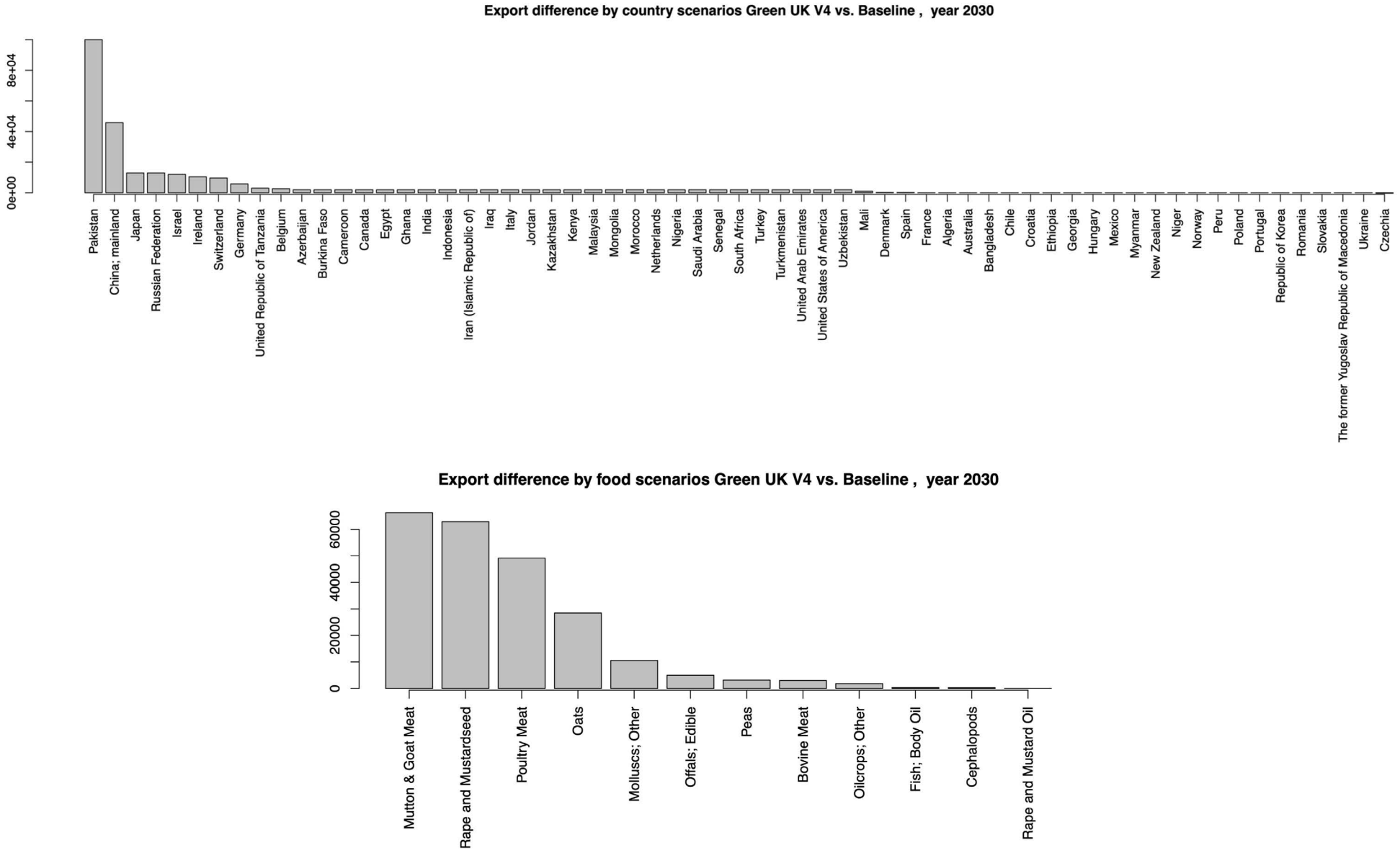
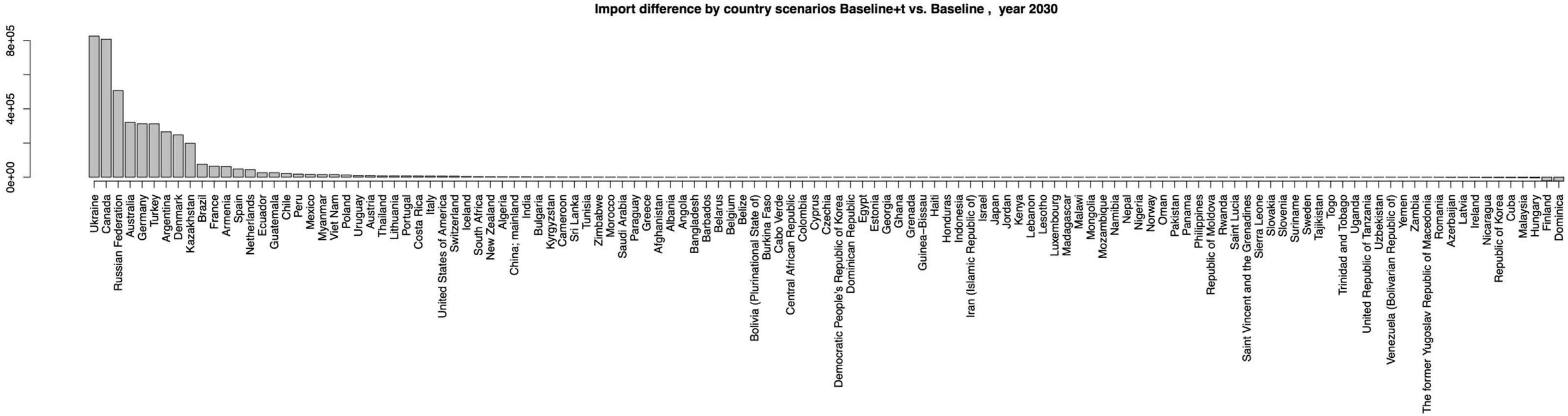


Figure 8 (cont). Bar charts for the Green UK V4 (and V5) scenario, showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food.



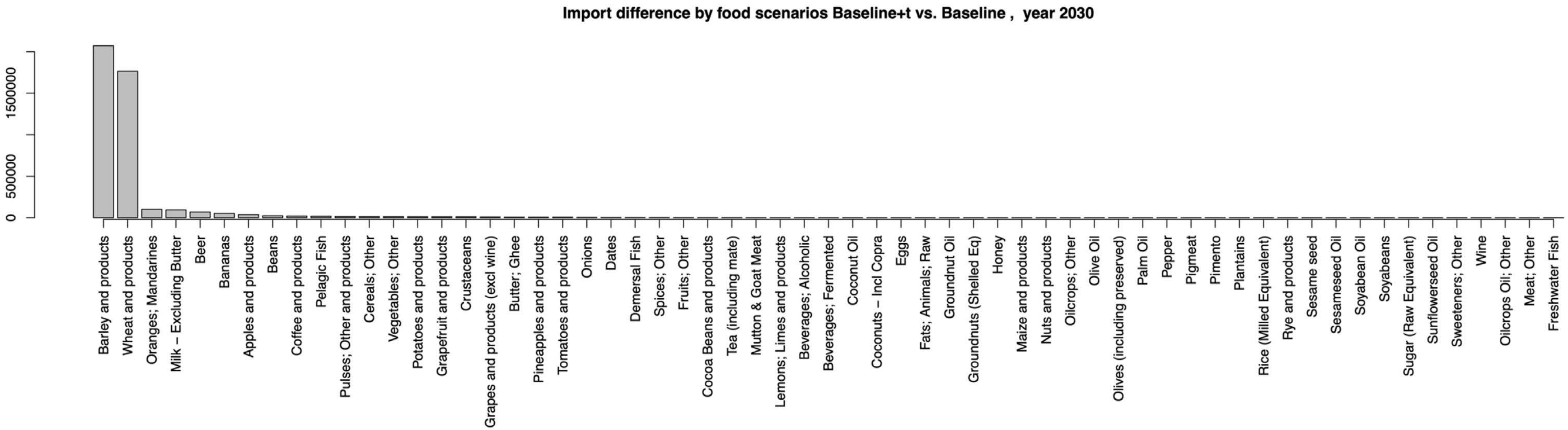
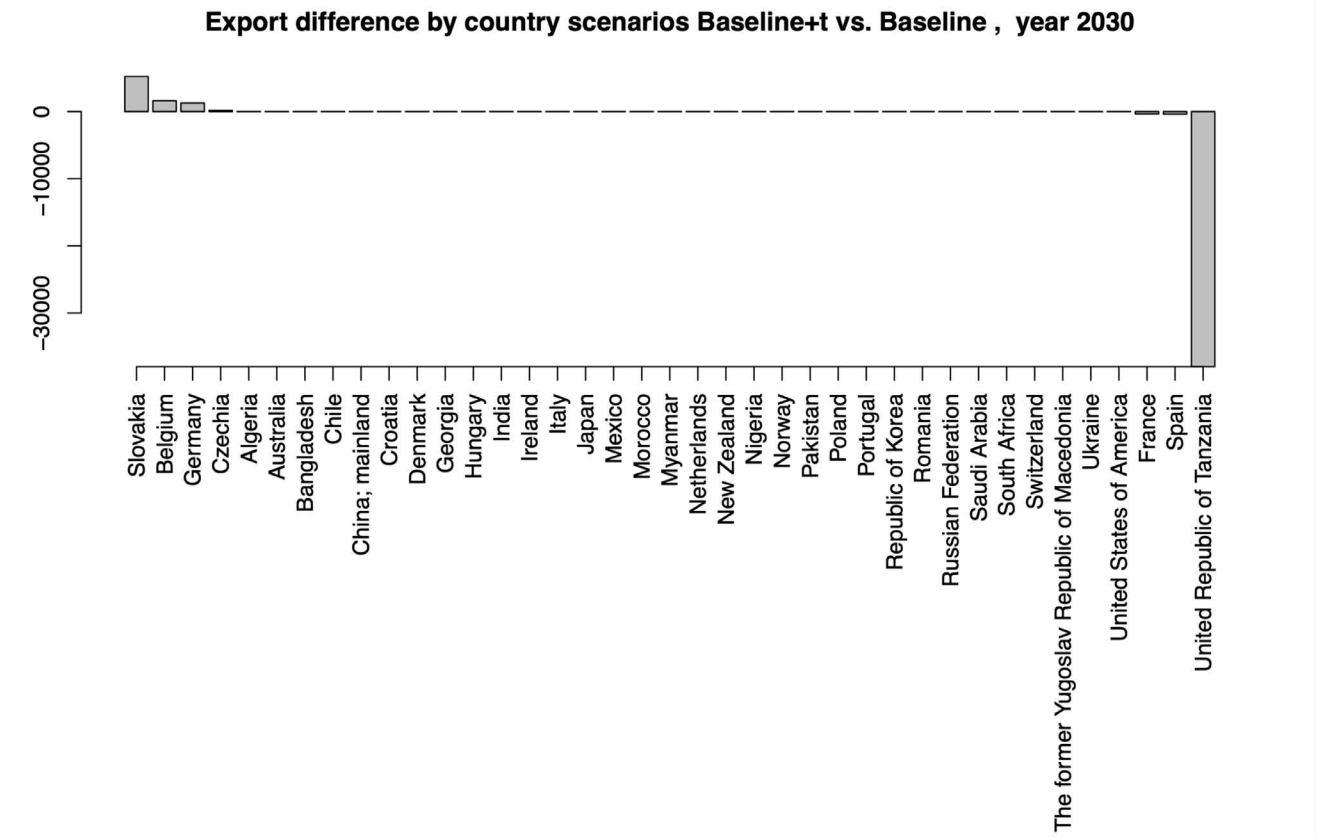


Figure 9. Bar charts showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food, when greater global change is enabled than in the Baseline.



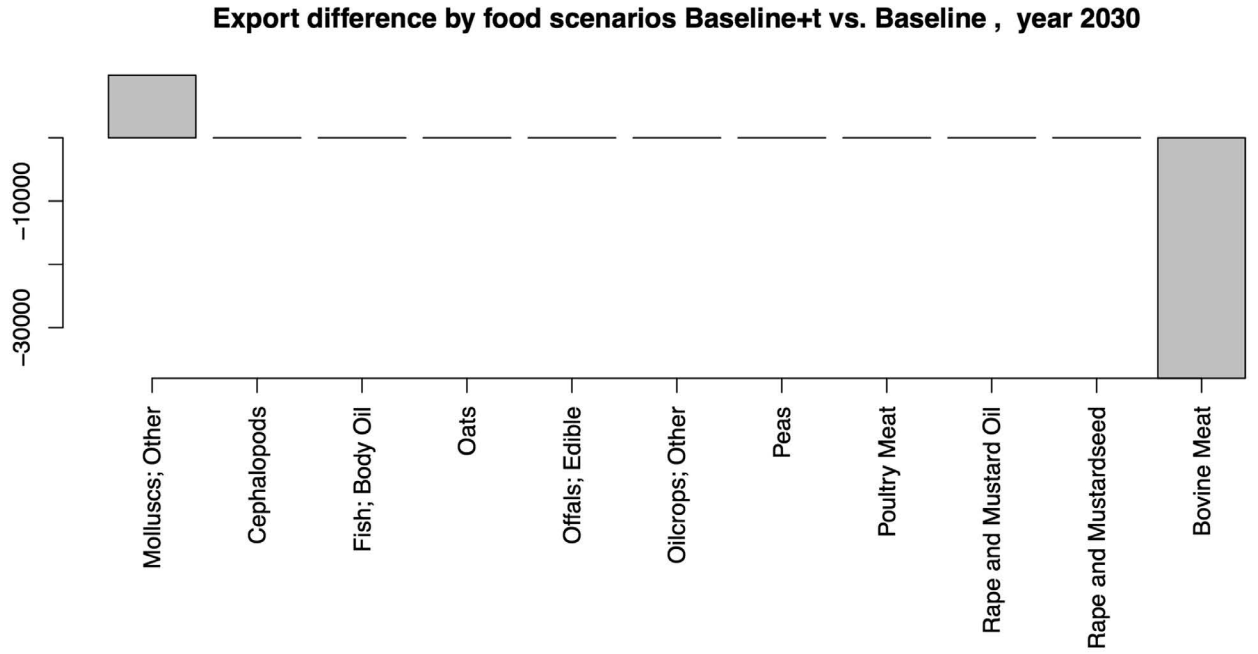


Figure 9 (cont). Bar charts showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food, when greater global change is enabled than in the Baseline.

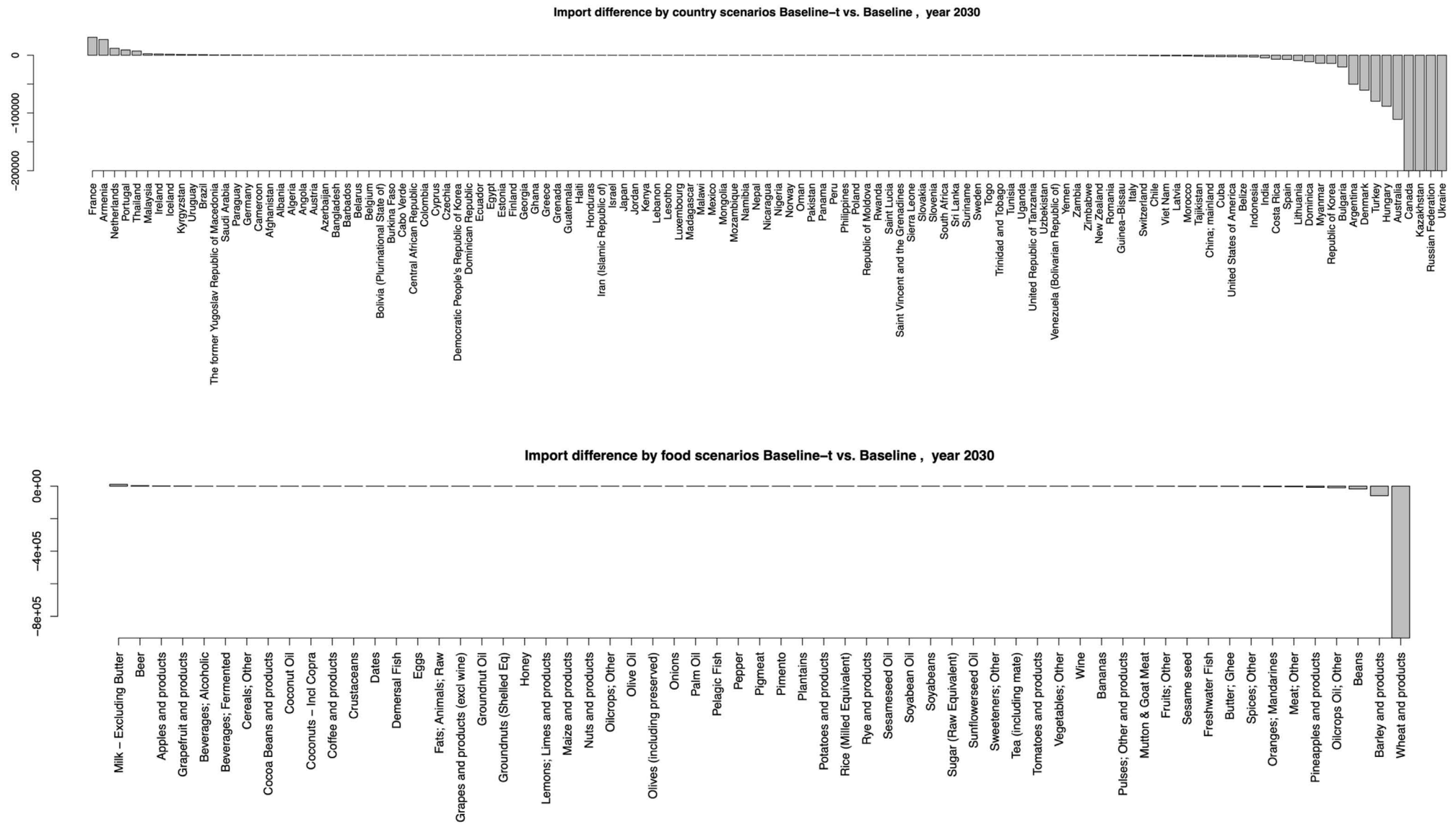
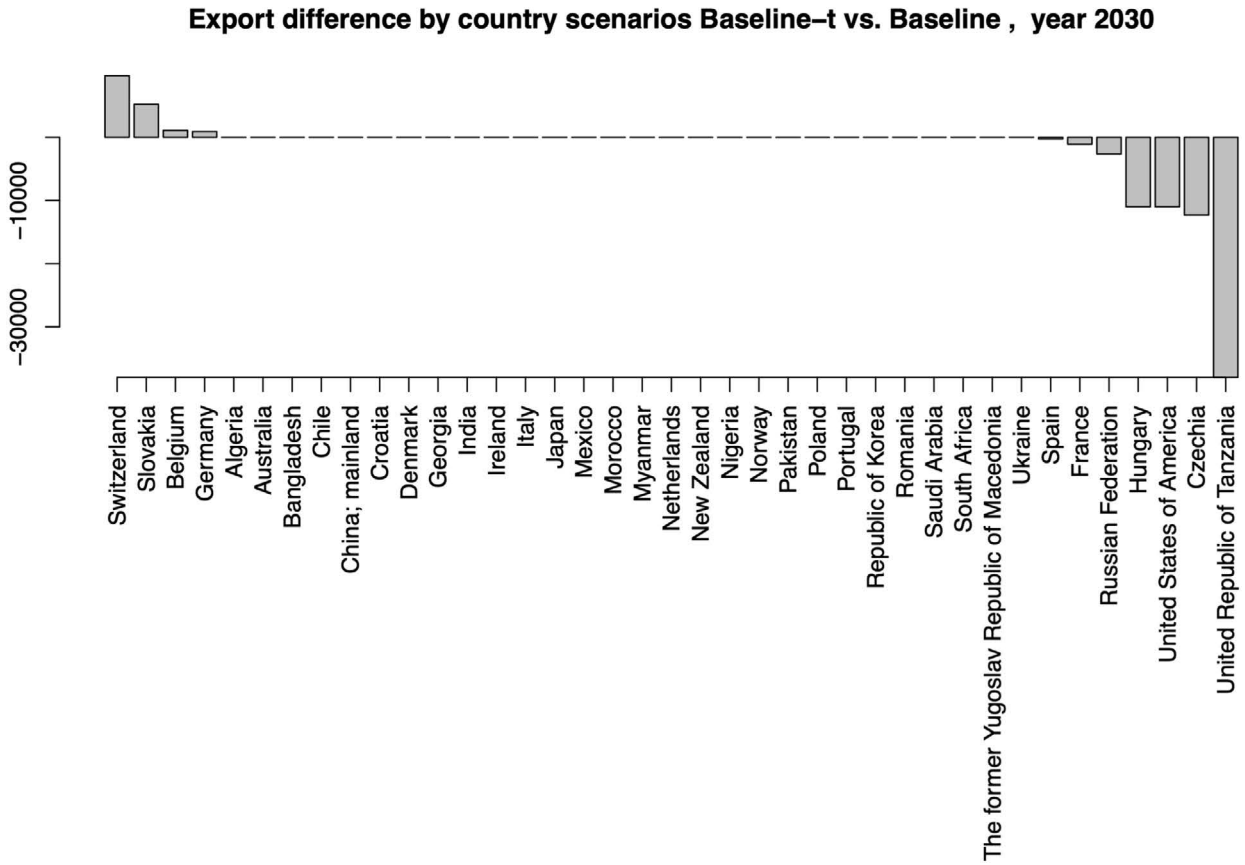


Figure 10. Bar charts showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food, when less global change is enabled than in the Baseline.



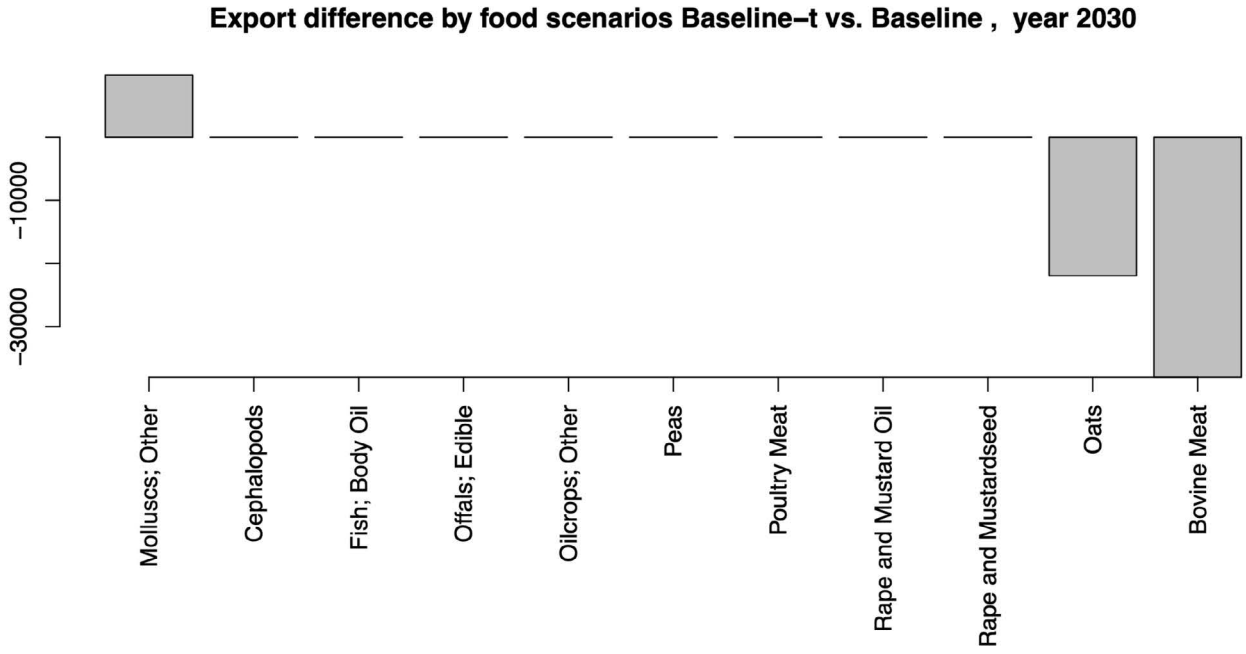


Figure 10 (cont). Bar charts showing the difference between the median volumes traded for imports and exports, sorted in descending order of volume by country and food, when less global change is enabled than in the Baseline.

Discussion

From a modelling point of view, clearly the implementations of the scenario have had an effect on the model's outcomes. Though not shown in this report, the boxplots for each scenario akin to those shown in Figure 1 for the Baseline scenario indicate similar levels of uncertainty across the applicable runs.

The results for the model should be interpreted in the light of what the model actually does: use a series of prioritization rounds based on weighting parameters to enable countries to exchange a pre-defined set of goods produced according to a pre-defined pattern of demand. Though there are weighting parameters that act as proxies for preferential and free trading blocs such as the European Union Customs Union, the African Free Trade Zone, and the United States-Mexico-Canada Agreement, these are not directly simulated, and blocs such as the Trans-Pacific Strategic Economic Partnership Agreement (Brunei, Chile, Singapore and New Zealand), while it could be handled by weighting for historical trade, would not be well-catered for by weighting by distance. It is also worth noting that the calibrated weighting parameters are optimized to fit global trade (Ge et al. 2021) rather than UK-specific data. A separate calibration exercise attempting to optimize fit to the UK only (allowing larger error for other trades in the world) would be a potentially illuminating exercise.

The results do show some consistent patterns with respect to the goods and countries most affected by each scenario. If there is a surprise, it is that the sign, rather than the magnitude, of change is more likely to differ from one scenario to another. Milk is the most extreme example of this, showing large negative differences in Back to Basics, Recovery First, Best of British and Green UK V4/5, but large positive differences in Green UK V1 and Green UK V2. Countries such as Germany also show similar behaviour though with less notable magnitude.

The results presented are on the basis of arithmetic change in volume, as opposed to proportional change. This means the biggest volumes of goods in the Baseline scenario (wheat, barley, milk, etc.) have a disproportionately larger scope to be affected by the scenarios. Arguably, proportional change is also of interest, especially for higher-value-per-unit-mass goods. While it would not have been difficult to calculate this and present it, it would have added significantly to the number of charts.

References

Duckett, D., Rivington, M., King, R., Juarez-Bourke, A., Lorenzo-Arribas, A. (2021) 'Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic' doi:10.5281/zenodo.4966627

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Appendix A: Plausible Scenarios

The complete scenarios report is available from the following URL:

https://www.hutton.ac.uk/sites/default/files/files/Scenarios%20for%20UK%20Food%20and%20Nutrition%20Secrurity%20in%20the%20wake%20of%20the%20Covid-19%20Pandemic.pdf

The future is inherently uncertain. However, we can look at both past events and the current situation to identify themes and construct patterns to promote strategic thinking. Scenario Planning utilises abductive reasoning in this way to yield plausible hypothesis. In contrast to deductive or inductive logic, there is no attempt to verify the projections. The plausibility test acts rather to harness human creativity and imagination in making plans that are robust enough and sufficiently flexible to deal with unpredictable developments.

The project has adopted an 'exploratory' scenario development approach, a method often deployed to stimulate creative thinking or to gain insight into the cascading effects of social, economic, and environmental drivers. Scenarios are crafted to form plausible accounts of what the future might look like by considering how known drivers of change will potentially operate over time.

Exploratory scenario planning typically asks a focal question containing a time horizon. We selected the year 2030, a timescale sufficiently distant to get a strategic view looking beyond current operational concerns but staying within policy cycles and avoiding the science fiction associated with distant futures. We asked our scenario planners the following question:

What will FNS look like in the UK in 2030 given changes to the food system following the emergence of the COVID 19 pandemic?

Six overarching drivers of change were determined by the research team in a semi-structured interview guide. Drivers of change are forces that will shape the future environment. The six preselected overarching drivers are: Demographics, Economy, Public Health, Institutions & Governance, Technology, Ecology & Climate. Experts were invited to articulate specific challenges and opportunities in each of the six categories forming key drivers of change for our focal question. We recruited our expert scenario planners, acknowledged Duckett et al (2021), from areas relevant to Food and Nutrition Security including health, agriculture, aquaculture, and food systems. They worked with our bespoke, structured technique to develop four scenarios considering key drivers of change and their plausible impacts on the UK's food and nutrition security. Our 'virtual' process was developed to fully comply with the COVID-19 lockdown measures in force during 2020.

No one knows how or which drivers will influence events given that the future is inherently uncertain, however, scenario planning works by exploring different assumptions about how drivers of change may operate. Contrasting sets of assumptions frame the four following scenarios.

Scenario 1 : 'UK Recovery First'

A national recovery at any cost has been achieved against the backdrop of recessionary pressures. Neither a radical green recovery nor any widespread levelling-up have occurred, resulting in higher food prices, negative Food and Nutrition Security outcomes for those on the lowest incomes and mounting societal unrest.

Scenario 2: 'Green UK First'

A domestic green recovery has achieved environmental improvements within a less globalised, more inward-looking world. Levelling-up has not been achieved and inequality alongside higher food prices has resulted in negative Food and Nutrition Security outcomes for those on low incomes.

Scenario 3: 'Best of British'

The UK has responded to greater protectionism by investing in UK agriculture putting quality at the centre but without any effective levelling-up, resulting in negative Food and Nutrition Security outcomes for those on low incomes set against higher quality produce for many others. Innovation and technology have helped the food sector to recover and prosper and there has been continuing

consolidation resulting in larger farms and food businesses. Hospitality is radically reshaped around suburban spaces.

Scenario 4: Back to Basics

Economic recovery has been achieved within this, the most prosperous of our post BREXIT scenarios, featuring a return to globalisation and buoyant international trade. The return to the pre pandemic baseline has been an uphill struggle and neither Green Recovery nor levelling-up have markedly reshaped this unsustainable and unequal future.

Scenarios - Concluding remarks

It is not possible to represent an exhaustive range of future possibilities in a complex socio-technical system such as the UK food system. Unanticipated factors or 'unknown unknowns' will shape the future beyond anyone's ability to foresee. However, what we have been able to do is to creatively use relevant expertise to think through 'what if' scenarios, or synthetic futures, considering plausible assumptions in a limited range of contrasting permutations.

Aberdeen
The James Hutton Institute
Craigiebuckler
Aberdeen AB15 8QH
Scotland
UK

Dundee
The James Hutton Institute
Invergowrie
Dundee DD2 5DA
Scotland
UK

Farms
Balruddery Research Farm
Invergowrie
Dundee DD2 5LJ

Glensaugh Research Farm
Laurencekirk
Aberdeenshire AB30 1HB