Implications of an EU Import Stop on Food: A Dark Cloud with a Silver Lining?

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0. Abstract

Disruptions of international trade chains are omnipresent: The COVID-19 pandemic, the recent US-Chinese "trade war" and the congestion of the Suez Canal. What are the effects and underlying mechanisms of a comprehensive trade stop?

To answer these questions, I used the partial equilibrium model CAPRI and simulated an almost complete stop for all food imports into the EU.

In the import stop scenario, EU prices increased for all products, but to different extent. This led to an increase in agricultural production, which caused an increase in GHG emissions. The EU's trading partners experienced a decrease in income from exports. As also the EU's exports decreased, the trading partners substituted these through an increase in domestic production. This increase was largest in animal production which is associated with a high value-added and thus income opportunities to the concerned regions. These results clearly show that an EU import stop in food has a substantial negative impact in monetary and environmental terms in- and outside of the EU. However, the results suggest that a reduction of EU exports can foster the economic development in other regions.

I could show that the effects of a comprehensive, far-reaching import stop are higher than the sum of the effects of the single product import stops. This finding indicates that the implication of imposing or lifting a trade restriction for a specific product can differ depending on which trade restrictions are in place for other products.

1. Introduction

The Suez Canal is among the world's most relevant trade routes. Its obstruction in 2021 lead to costs of an estimated USD 9.6 billion (Russon, 2021) in prevented trade. This event together with the recent US-Chinese "trade war" (BBC, 2020) and supply chain disruptions due to the COVID-19 pandemic (FAO, 2020) have called into question one of the central dogmas of economics i.e., that the benefits of international trade necessarily outweigh its costs. This raises the question: Under certain circumstances, is it possible for self-sufficiency to become a more desirable alternative to dependency on imports and politically unreliable trading partners?

Despite the occasional advantages of isolationist policies, in many cases this strategy does not reduce the risk of market disruption. To encounter outbreaks of swine fever and bird flu, import bans have been measures taken temporarily by the EU for specific regions (USDA, GAIN, 2020). Implementing import bans permanently, however, would increase the risk of market disruption by an overreliance on domestic production as the sole source of a commodity. A domestic outbreak of animal disease will have a larger impact on a country's supply if there are no trade relations in place that can substitute for the shortage in domestic production. The same applies for extreme weather events.

Isolationist policies do not only have implications for the risks, but also for the equilibrium state of the markets. A deliberate reduction of trade has monetary effects on consumers and producers in the country imposing these restrictions, as well as in countries that are trading partners. Trade disruptions can also shift production to places where it is less (or more) GHG-efficient and can therefore also have environmental implications.

The body of literature provides many studies on different scenarios which usually focus on specific scenarios in trade that are likely to become reality in the foreseeable future, such as Brexit, free trade agreements like TTIP or sanctions against Russia. However, simulations of more extensive trade disruptions help understand how market mechanisms function and how the trade stops of the individual products interact with each other. Therefore, these simulations are relevant, even if they do not have immediate cases for application. Analyses of comprehensive trade stops have been conducted for the global and complete economy (sources, Wang….), but to my knowledge there are no studies conducting a detailed analysis of trade disruptions for the agricultural sector. As the provider of food, agriculture is a vital and strategically important sector. It is also the main user of the production factor land, shaping land use and the environment in all parts of the world.

To close this gap in literature, I simulate an import stop on food by the EU with the partial equilibrium model CAPRI. We find that in the import stop scenario, exports from the EU decreased substantially, but less than imports. Prices in the EU increased, while prices decreased for most products in the rest of the world. Combined with the change in the trade balance, these price changes meant an increase in the income the EU generates from its net exports, while it meant a decrease in the trade-related income for the EU's trading partners. In the EU, the import stop scenario lead to an intensification of production and an increase of land used in agriculture. This caused an increase of agriculture associated GHG emissions in the EU and on the global level.

2. Methods

2.1. The Partial Equilibrium Model on Agriculture

All simulations were conducted using the partial equilibrium model CAPRI (Common Agricultural Policy Regionalised Impact modelling system) (Britz, Witzke, 2014). First, the CAPRI market module, which models the global production, trade and use of agriculture and food, was solved. The resulting producer price vector was used to solve the supply module which models the agricultural production in detail (soft-linkage top-down approach).

The market module consists of a spatial, non-stochastic, global multi-commodity model encompassing 56 agricultural products, both primary and processed. The model has global coverage extending to approximately 80 countries and country blocks (i.e., free trade areas or small and closely related countries).

It is a system of behavioral equations depicting supply, human consumption, animal feed, and processing, as well as energy and nutrient requirements in animal feed and agricultural land use.

Trade is modelled as multilateral relations among countries or country blocks. CAPRI uses the Armington assumption for import demand in international trade (Armington, 1969). According to Armington, consumers are assumed to differentiate products by their origin and to prefer domestic products. Trade policy instruments, such as tariffs or quotas are included in the model through exogenous parameters.

The supply module models all agricultural production, including agricultural inputs and outputs of each of the 280 administrative regions (NUTS-2) in the EU, Norway, Western Balkans and Turkey. The objective variable in the mathematical programming models is farm income. Restrictions concerning land availability, nutrient balances, nutrient requirements of animals, and political legislation such as quotas and set-aside obligations apply.

The following five are used as decision variables: crop acreages, total land use, herd sizes, fertilizer application rates and feed mixes.

The supply module contains a feed module which models the relationship between crop and animal production, driven by the respective prices and taking the nutrient requirements of animals into account.

The parameters for the Hessian matrix of the normalized quadratic function for profit, feed cost and for processing were set to half their default value for freshwater fish and rapeseed. This ensures a higher responsiveness of these equations to exogenously induced shocks and a model solution in which all equations are feasible.

2.2. Scenario Implementation

The baseline scenario serves as comparison to the counterfactual scenarios. The baseline scenario depicts the year 2030 as it is reasonable to assume that any policy finalized to date will have been implemented within ten years and markets will have adjusted accordingly. The baseline scenario accounts for the most probable developments in agriculture, including any policies that are implemented already or are planned for the time until 2030. It also includes current projections for population growth, inflation, GDP growth and technological progress.

The scenario ALL_FOOD corresponds to all aspects of the baseline scenario, but in addition simulates extensive import reductions for all products in the model, that are consumed as foods or are used as animal fodder, i.e., 49 out of 56 traded goods. Conversely, imports are not disrupted for commodities that cannot be produced in the EU (coffee, tea, cocoa) or agricultural non-food products (textiles, tobacco, biodiesel, bioethanol).

Due to the model formulation, a complete elimination of imports is not possible for all products. This is because of the specification of import demand according with the Armington assumption which prevents absolute quantities imported from reaching zero if they exceed zero in the baseline scenario. Despite this limitation, the import reductions in the ALL_FOOD scenario allow conclusions to be drawn regarding the implications of a scenario with severely reduced imports or a complete import stop.

Cereal	
Wheat	*-98%*
Rye & meslin	*-97%*
Barley	*-98%*
Oats	*-97%*
Maize	*-95%*
Other cereal	*-99%*
Oilseeds	
Rapeseed	*-99%*
Sunflower	*-99%*
Soybean	*-99%*
Other arable field crops	
Pulses	*-98%*
Potatoes	*-98%*
Vegetables and permanent crops	

Dairy products	
Butter	*-100%*
Skimmed milk powder	*-87%*
Cheese	*-89%*
Fresh milk products	*-92%*
Cream	*-100%*
Concentrated milk	*-99%*
Whole milk powder	*-100%*
Casein	*-99%*
Whey powder	*-99%*
Oils	
Rapeseed oil	*-99%*
Sunflower seed oil	*-100%*
Soya oil	*-98%*
Olive oil	*-97%*

Tomatoes	*-92%*
Other vegetables	*-90%*
Apples, pears and peaches	*-98%*
Table grapes	*-41%*
Citrus fruit	*-100%*
Other fruits	*-90%*
Table olives	*-91%*
Table wine	*-94%*
Meat	
Beef	*-100%*
Pork	*-95%*
Sheep & goat meat	*-100%*
Poultry	*-96%*
Other animal products	
Eggs	*-98%*
Palm oil	*-93%*
Oil cakes	
Rapeseed cake	*-100%*
Sunflower cake	*-98%*
Soya cake	*-97%*
Secondary products	
Rice, milled	*-77%*
Sugar	*-100%*
DDGS	*-87%*
Protein rich by products	*-99%*
Energy rich by products	*-95%*

Table 1: Import reductions per product in the scenario ALL_FOOD

The import reductions were simulated in the ALL_FOOD scenario by increasing the import tariffs for a given product by a factor of its import price, thereby causing import of the product to be prohibitively expensive. For each product, we used the minimum value of this factor causing the desired import reduction.

Cereal	
Wheat	*0.5*
Rye & meslin	*0.5*
Barley	*0.5*
Oats	*0.5*
Maize	*0.5*
Other cereal	*1.0*
Oilseeds	
Rapeseed	*1.5*
Sunflower	*1*
Soybean	*2.5*
Other arable field crops	
Pulses	*1.0*
Potatoes	*1.0*
Vegetables and permanent crops	
Tomatoes	*0.5*
Dairy products	
Butter	*1.0*
Skimmed milk powder	*0.5*
Cheese	*1.0*
Fresh milk products	*1.5*
Cream	*1.0*
Concentrated milk	*1.0*
Whole milk powder	*1.0*
Casein	*1.0*
Whey powder	*1.0*
Oils	
Rapeseed oil	*1.0*
Sunflower seed oil	*1.0*
Soya oil	*1.5*
Olive oil	*1.0*
Palm oil	*2.5*

Other vegetables	*6.0*
Apples, pears and peaches	*0.5*
Table grapes	*0.5*
Citrus fruit	*3.5*
Other fruits	*4.0*
Table olives	*0.5*
Table wine	*0.5*
Meat	
Beef	*1.0*
Pork	*0.5*
Sheep & goat meat	*1.5*
Poultry	*0.5*
Other animal products	
Eggs	*0.5*
Oil cakes	
Rapeseed cake	*1.5*
Sunflower cake	*1.5*
Soya cake	*2.0*
Secondary products	
Rice, milled	*5.0*
Sugar	*2.0*
DDGS	*0.5*
Protein rich by products	*1.0*
Energy rich by products	*0.5*

Table 2: Tariff rates as multiplication factors of the import price

In a partial equilibrium model government budget is not accounted for. Therefore, the tariff increase did not affect the simulation results by a change in government income or spending.

To determine the underlying mechanisms leading from the import stop to the observed effects, scenarios in which imports were stopped for only one product or product group were run.

3. Results

3.1. Economic and Environmental Analysis

3.1.1. Implications for the EU market

3.1.1.1. General market balance

In the import stop scenario, imports decreased for all product groups. These decreases in imports were met by different reactions in net production. Oilseed production increased substantially in percentage terms, followed by increases in other arable field crops (potatoes and pulses) and vegetables and permanent crops. The production increases for oilseeds, other arable field crops, vegetables and secondary product were in absolute terms nearly completely substitute for the lack in imported quantities or even overcompensated for them. The production effects for cereals and oils were rather modest. For meat, other animal products (eggs) and oil cakes production they even decreased. This production decrease was a direct effect of the decrease in domestically available oilseed quantities and was in absolute terms much larger than the decrease in import quantities. As substitution for the lack of imports was not possible over production increases for oilseed products and animal products, the induced shock was absorbed through a decrease in exports. Substantial export decreases in absolute terms can be observed for all product groups, except for oilseeds. For them, export reductions were large in percentage terms, but in absolute terms the export reductions only absorbed a small part of the shock. This was to be expected as exports for oilseeds are already small in the baseline.

Human consumption showed surprisingly little change in percentage terms. No product group showed a decrease that was in absolute terms a relevant absorption of the shock of decreased imports. An absorption of the shock could be observed at best indirectly in the substantial increase in the consumption of other arable field crops and vegetables, which are substitutes for product groups that were more severely affected by the import ban, such as meat and animal products.

Reductions in the processed quantities absorbed relevant amounts of the shock for cereals, other arable field crops (pulses, potatoes), vegetables, other animal products (eggs) and oils. The quantities used for biofuel processing are reduced overall and show a change in their composition: Less oils and secondary products (sugar) are utilized, whereas cereal quantities are increased. A similar pattern can be observed for animal feed. There is a substantial decrease in the use of oilseed cakes, both in percentage and in absolute terms. More cereals are fed to animals instead, but this increase only makes up for a fraction of the decrease in fed oilseed cakes in absolute terms and also in percentage terms this remains a marginal increase for the market balance of cereals.

	Source		Use				
	Imports without intra trade	Net production	Exports without intra trade	Human consump-tion plus losses	Processing	Biofuels processing	Feed use
Cereals	-22230	2702	-13136	1555	-4871	550	-3626
	-94%	1%	-33%	2%	-27%	5%	-2%
Oilseeds	-17331	14030	-2532	-143	-81	0	-546
	-90%	51%	-83%	-7%	0%	0%	-27%
Other arable field crops	-6398	8141	-2242	5822	-2251	0	413
	-98%	19%	-63%	19%	-22%	0%	10%
Vegetables and Permanent crops	-16218	13776	-7180	6336	-904	-207	-487
	-53%	11%	-32%	5%	-24%	-13%	-18%
Meat	-677	-3898	-4146	-233	-196	0	0

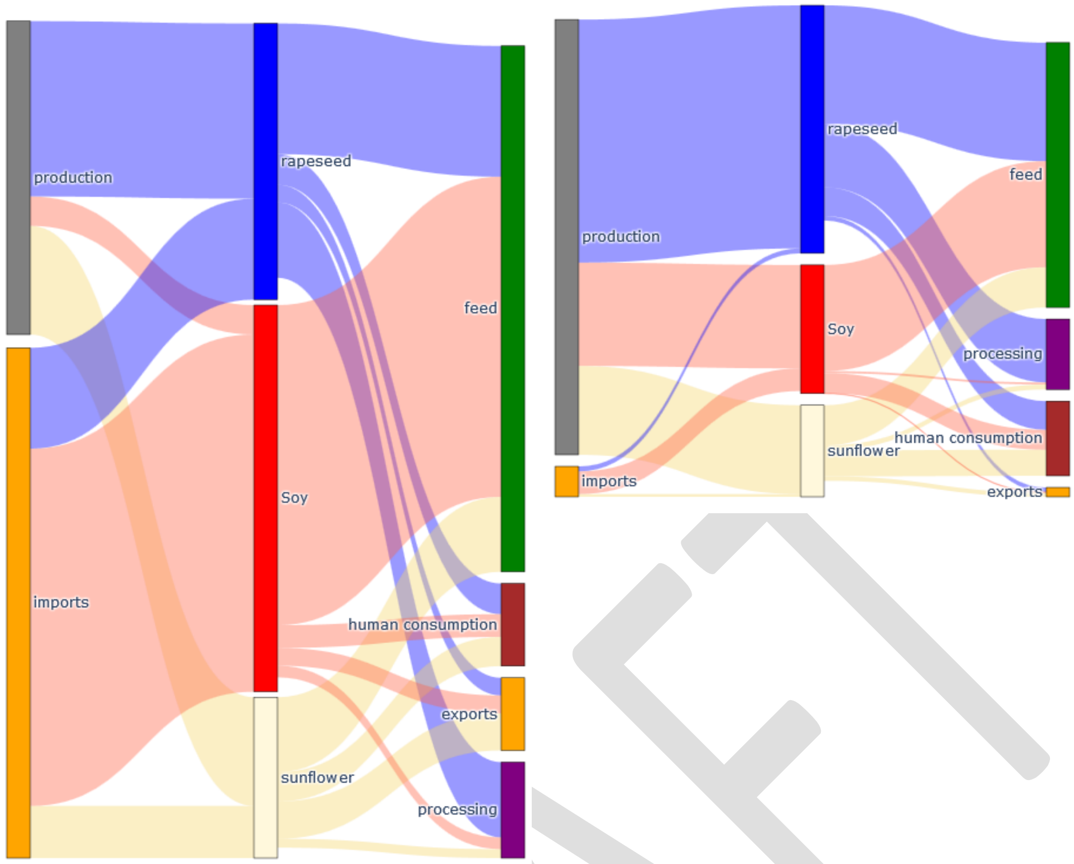
	-90%	-9%	-59%	-1%	-42%	0%	0%
Other Animal products	-6 -100%	-1881 -1%	-576 -35%	29 0%	-1336 -1%	0 0%	-5 -16%
Dairy products	-217 -93%	-42 0%	-618 -12%	455 1%	-48 -13%	0 0%	-48 -3%
Oils	-8524 -75%	138 1%	-1541 -59%	-129 -1%	-5076 -57%	-1919 -28%	-155 -18%
Oil cakes	-21086 -91%	-864 -3%	-1598 -87%	4 2%	-336 -75%	0 0%	-20019 -44%
Secondary products	-901 -34%	1175 6%	-389 -14%	141 1%	-79 -5%	-352 -12%	-223 -70%

Table 3: Changes in the market balance in the EU under the ALL_FOOD scenario (absolute changes in 1,000 tons and percentage changes)

The analysis of the market balance shows that commodities are affected very differently by the import stop. The effects throughout the market balance are higher if the import share is high in the baseline (e.g., soybean), if the commodity is part of a value chain (oilseed, oilseed cakes, animal products) and if the potential for increasing the domestic production is limited (soy bean due to climatic conditions, meat production due to the dependance on soy bean imports).

3.1.1.2. Market balance for oilseeds

Oilseeds are especially affected by the import stop and their import stop affects other commodity groups. In our simulation, the stop on soybean imports created a large (X ton) decrease in domestically available soybean quantities. Within the oilseed commodity group, this decrease was partly offset by an expansion of domestic production of soybean and rapeseed in tandem with a decrease in the overall quantities of soybean used for feed (Fig. 1).



Baseline ALL_FOOD

Figure 1: EU oilseeds (in absolute values, in terms of quantities)

Considering the oilseed product group, imports (mainly soybean) exceed domestic production (mainly rapeseed) in the baseline scenario. Considering individual crops in this group, the same is true for soybean, but not for rapeseed and sunflower whose imports are exceeded by domestic production. These proportions lead to soybean being the predominant oilseed within the EU, followed by rapeseed and then sunflower seed. By far the largest fraction of oilseed, oils and cakes are channeled into animal feed. The fraction used for human consumption, exports and processing (e.g., in biodiesel) combined only comprise a small part of the total available quantities.

Under the ALL_FOOD scenario, we found that the expansion of domestic production following the import stop was mainly driven by increased production in rapeseed and soy. However, this increase could not compensate entirely for diminished soybean imports. As a consequence, rapeseed became the predominant oilseed in the EU market and the overall supply of oilseeds on the EU market decreased. Not only did the overall quantity of oilseeds used for animal feed decrease, but also the composition of fed oilseeds changed, with rapeseed again the largest staple and soybean the second largest. Cereals and pulses are also important crops for animal feed and were also subject to the import stop. However, for these crops, the EU has only negligible import shares in the baseline scenario and the changes in their supply are small (data not shown).

Exports are dominated by sunflower seed in the baseline and decreased to close to zero for all oilseeds in the ALL_FOOD scenario. This decrease is a consequence of the relative scarcity of oilseeds in the EU**.** Sunflower and rapeseed became scarcer not only because their own imports have stopped but also because they were used as substitutes for soybean following the strong disruption of its imports.

Therefore, exports of sunflower, rapeseed and soybean decreased substantially following the import stop.

In the ALL_FOOD scenario, human consumption of oilseed products remained almost unchanged. This is explained by the relative price insensitivity of the demand functions in the CAPRI model as well as by the fact that only a small fraction of EU consumers' food spending is dedicated to oilseed products.

Like human consumption, the oilseed quantities used for processing, e.g., into biodiesel did not change a lot in the ALL_FOOD scenario compared to the substantial changes observed in feed use, either in overall quantities or in the composition.

We can therefore show that not only commodities are affected very differently by the import stop, but also the uses of these commodities.

3.1.1.3. Producer price changes

Prices show the scarcity of products. Hence, the price increases from the import stop depict how much the import stop increased this scarcity and how much imports alleviate the scarcity in the baseline. For all products subject to an import stop, scarcity and prices increased in the EU, but at very different magnitudes.

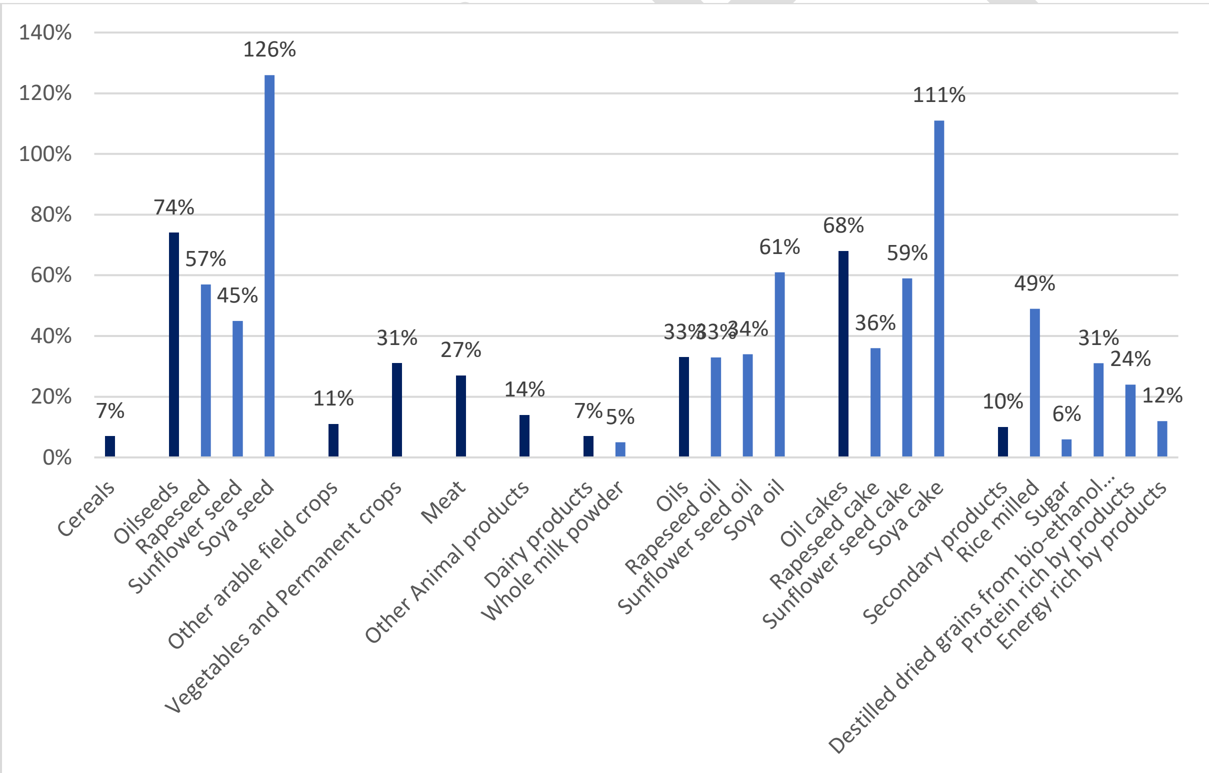


Figure 2: Producer price changes in the EU under the ALL_FOOD scenario (percentage changes)

The domestically available quantities of soybean were decreased by the import stop more than that of rapeseed and sunflower seed and accordingly soybeans exhibited the highest price increase. This proportion applies also to the oils and oilseed cakes of soybean, sunflower seed and rapeseed.

Following the import stop, the price change for cereals in the EU was negligible. This is because the import share is small in the baseline scenario and therefore the import stop caused only minimal market disruption. The same pattern could be observed for other products.

Other notably high increases in producer prices within the product groups can be found for pulses, "other fruits", sheep and goat meat, rice, biodiesel, DDGS and protein-rich feed. Of these, pulses and rice have moderately high import shares in the baseline scenario of XX% and XX%. Lower levels of import penetration are seen for "other fruits" and sheep and goat meat, but these levels are still high relative to other commodities in the same commodity group.

Although biodiesel is not subject to an import ban, the price of oilseeds, which are needed for biodiesel production, strongly increased following implementation of the import stop and therefore, biodiesel prices increase, too.

3.1.2. Implications for global trade and the rest of the world

An EU import stop does not only affect the EU but also the EU's trading partners and the rest of the world. First, I analyze the developments in trade between the EU and the rest of the world. This includes the change in quantities traded between the EU and the rest of the world, the changes in the market prices in the different world regions, as well as the value of net trade between the EU and the rest of the world. In this part of the analysis any trade diversion and changes in the trade between third countries is excluded. Secondly, I examine the developments within the regions, taking a closer look at the changes in producer and consumer prices, as well as the welfare effects within each region and sector.

3.1.2.1. The developments in trade between the EU and the rest of the world

The net trade flows between the EU and other world regions decrease in both directions. This can affect the EU's trading partner substantially. Exports are a way to generate additional income on the level of the national economy and imports are an expenditure.

The EU import stop means the loss of income from exports for the EU's trading partners. As the EU's exports decrease in consequence of the import stops, trading partners also lose products they formerly bought from the EU. This lack can be negative for consumers as it limits their product choice and raises prices. For producers, however, this decrease in imports from the EU is equivalent to less competition and they profit from higher prices.

3.1.2.1.1. The quantities traded between the EU and the rest of the world change

This table shows that imports to and exports from the EU decrease for all regions and all products that are subject to the EU import stop.

	European Union		Non-EU Europe		Africa		North America		Middle and South America		Asia		Australia and New Zealand	
	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp
Cereals	-22230	-13136	-990	-9297	-6697	-8836	-432	-1597	-323	-1844	-4682	-482	-12	-174
Oilseeds	-17332	-2532	-2494	-3824	-16	-21	-10	-4470	-2	-5876	-9	-506	-1	-2635
Other arable field crops	-6398	-2240	-1556	-1364	-604	-4104	0	-603	-1	-147	-79	-158	0	-22
Vegetables and Permanent crops	-16218	-7181	-3128	-1198	-2561	-1783	-516	-481	-218	-6406	-591	-6040	-167	-310
Meat	-678	-4147	-1199	-65	-962	-9	-33	-32	-24	-303	-1814	-42	-115	-227

Other Animal products	-5	-575	-213	-2	-153	-1	-6	-1	-5	0	-195	-1	-3	0
Dairy products	-218	-619	-163	-165	-102	-7	-56	-4	-43	-3	-245	-7	-10	-32
Oils	-8524	-1540	-568	-1516	-608	-160	-134	-13	-30	-1345	-189	-5490	-11	0
Oil cakes	-21085	-1599	-1203	-3387	-122	-22	-86	-784	-2	-16301	-185	-591	-1	0
Secondary products	-899	-388	-117	-366	-194	-9	-9	-50	0	-85	-64	-382	-4	-7

Table 4: change in trade flows with the EU (in 1000 tons)

When the decreases in exports to the EU were larger than the decreases in imports from the EU, net exports to the EU decreased. In some cases, these changes made former net exporters to net importers e.g., non-EU Europe for cereal, oilseed, oils and oilseed cakes. The pattern of decreases deteriorates the relations of exports that generate income for an economy and imports that lets money flow out of the economy into the EU. This pattern is especially apparent in the case of Middle and South America and Australia and New Zealand, where all substantial changes in net trade were negative.

The opposite can be witnessed in the trade especially with vegetables, meat, eggs (under the category of “other animal products”), dairy products and oils. For these commodities, trade with the EU also decreases in both directions, but more in imports from the EU than in exports to it. As these products generally hold more value-added than then raw products such as cereals or oilseeds, this change in net trade could be associated with positive income effects for the farming sector in the respective regions if the decrease in imports is substituted by domestic production and not imports from another region or a decrease in consumption. Notably, the decrease in net exports can be observed strongest for Africa, followed by Asia and Non-EU Europe.

3.1.2.1.2. Changes in the value of net trade

The changes in import and export flows affected prices. Prices in the EU generally increased, showing a similar pattern as in Figure 2 on the producer prices, while they fell in other regions. The latter is due to the decrease of net import demand from the EU (see table 1). As the price changes were only moderate for the large part, the change in traded quantities tended to define the change in the traded value of the world regions with the EU.

The EU import stop always led to a decrease in overall global trade and always led to trade diversion, leading to increased trade among the rest of the world. For some countries and commodities this even caused an increase in trade.

Taking the change in prices and trade diversion into account, the value of net trade shows in which sectors regional income from net trade increases and in which it decreases.

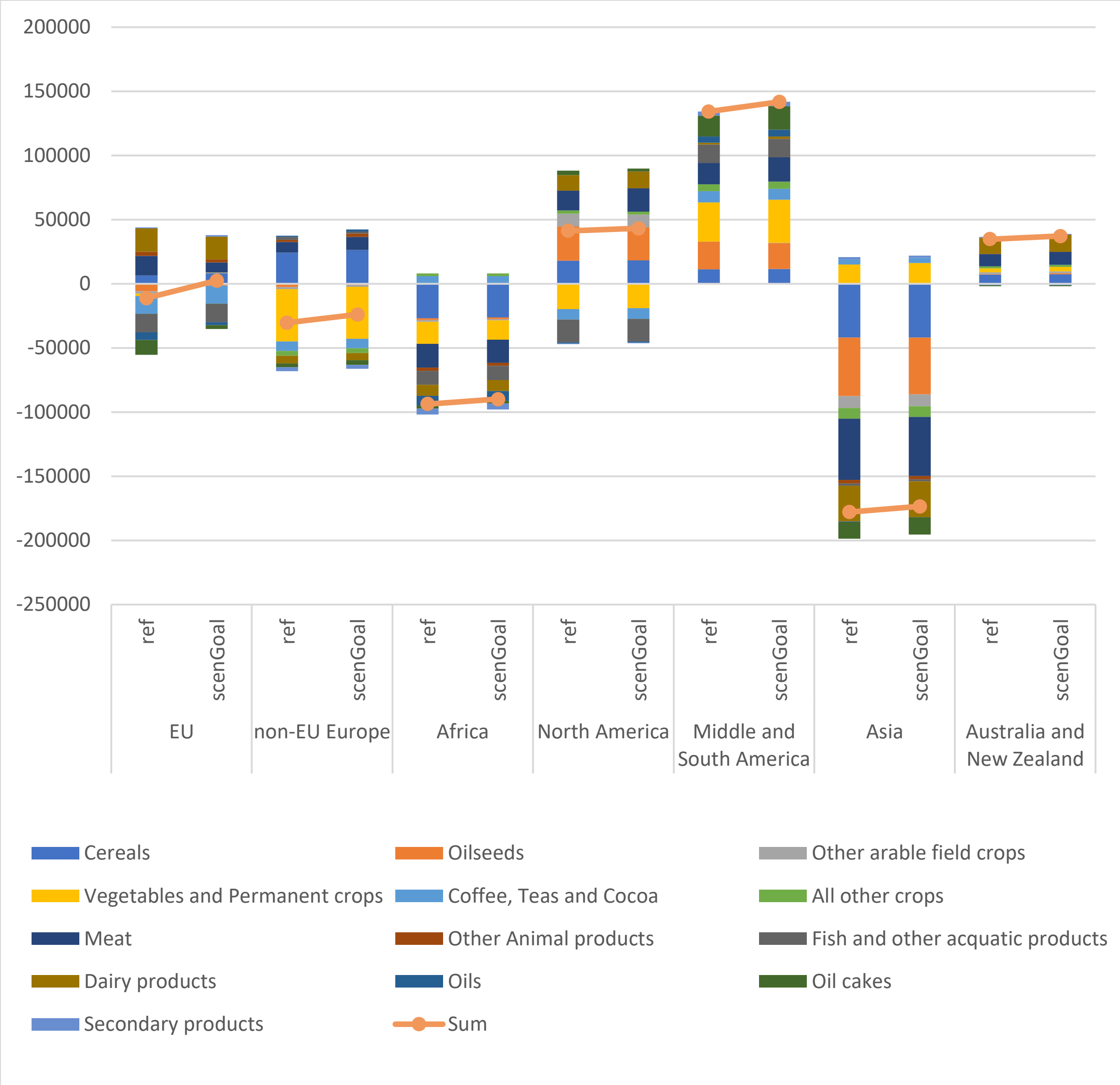


Figure 3: Absolute changes in the value of net trade (in Mio Euro)

For all world regions an increase in the income from net trade is observed. However, the increases are only small to marginal. In the cases of non-EU Europe, Africa and Asia this increase is a reduction of their economies' net expenses in trade, whereas the Americas and Australia and New Zealand increased their net incomes from trade. The EU's income from net trade was reduced.

This pattern is the opposite of the pattern observed when examining the quantities traded between the EU and the other world regions. There, the changes in quantities pointed towards an improvement of the EU's trade balance, as imported quantities decreased more than the exports, whereas all other world regions showed a deterioration and stronger decreases in the export than in the import quantities. However, considering the different commodity prices, the change in prices following the import stop and trade diversion, corrects this impression.

For non-EU Europe, the increase in income from net trade stems mainly from the increase in the value of net exports of cereals and of meat and in the decrease in the value of net imports of oilseeds. For Africa, it stems from the decrease in the value of net imports in vegetables. For North America, it stems from the increase in the value of net exports in meat, as well as from the decreases in the value of net exports of oilseeds and oilseed cakes. For Middle and South America, it stems from the increase in the value of net exports for vegetables, meat and oil cakes. However, there is a decrease in the value of net exports in oilseeds. For Asia, it stems from the decrease in the value of net imports for oilseeds and meat, as well as from the increase in the value of net exports in vegetables.

Hence, it can be observed that cereals, vegetables, meat, oilseeds and oilseed cakes are the main drivers of the changes in income from trade. The development of the respective value of net trade follows largely the development of the traded quantities, when trade diversion is in included and not only trade with the EU is analyzed. However, trade in oilseeds in Middle and South America as well as in Asia does not follow that rule. In Middle and South America the net exports of oilseeds increased and in Asia, the net imports of oilseeds decreased. As the global prices for oilseeds decreased, the value of net exports after all decreased for Middle and South America and the value of net imports increased for Asia.

The EU reduces its imported quantities more drastically than its exports and therefore also improves its incomes from net trade.

The fact that income from trade seems to have increased for all regions at the same time can be led back to the general increase in global prices.

3.1.2.2. Welfare changes

Apart from influencing the income from trade, the import stop also affected the welfare of the EU and its trading partners. The net welfare changes incorporate the changes in domestic prices for both the consumer and the producer side, as well as the produced and consumed quantities. These are also related to the quantities traded, but not only with the EU. There is no obvious correlation between the direction of change in the trade value with the EU and of the net welfare changes.

In some cases, this can be attributed to the price changes and the net importing resp. net exporting position of a country. The Americas and Australia and New Zealand are net exporters of oilseed and welfare decreases for this commodity group can be observed as prices decrease. The opposite is true of Africa, a net oilseed importer that profits from a decrease in oilseed prices. Africa also profits from the decrease in cereal prices as it is a net cereal importer. For Asia welfare increases can be observed for vegetables and secondary products (rice), for which Asia is both a large net exporter and profits even from small price increases.

We can observe that there is notable redistribution especially in the EU to where welfare is generated. The change in EU welfare dominates the change in global welfare.

Figure 4: Welfare in Mio Euro. Absolute changes compared to baseline.

3.1.3. Changes in global GHG emissions

The import stop in the EU for most commodities was met by increases in domestic production. A production increase can come through intensification, meaning an increased use in inputs or an expansion of agriculturally used land. These mechanisms are not mutually exclusive, and both increase greenhouse gas emissions. The import stop therefore led to a re-allocation of production. Commodities are no longer produced where they are cheapest, but this often corresponds to where they can be produced at the lowest environmental costs, too, as optimal climatic conditions and efficient technology decrease both economic and environmental costs.

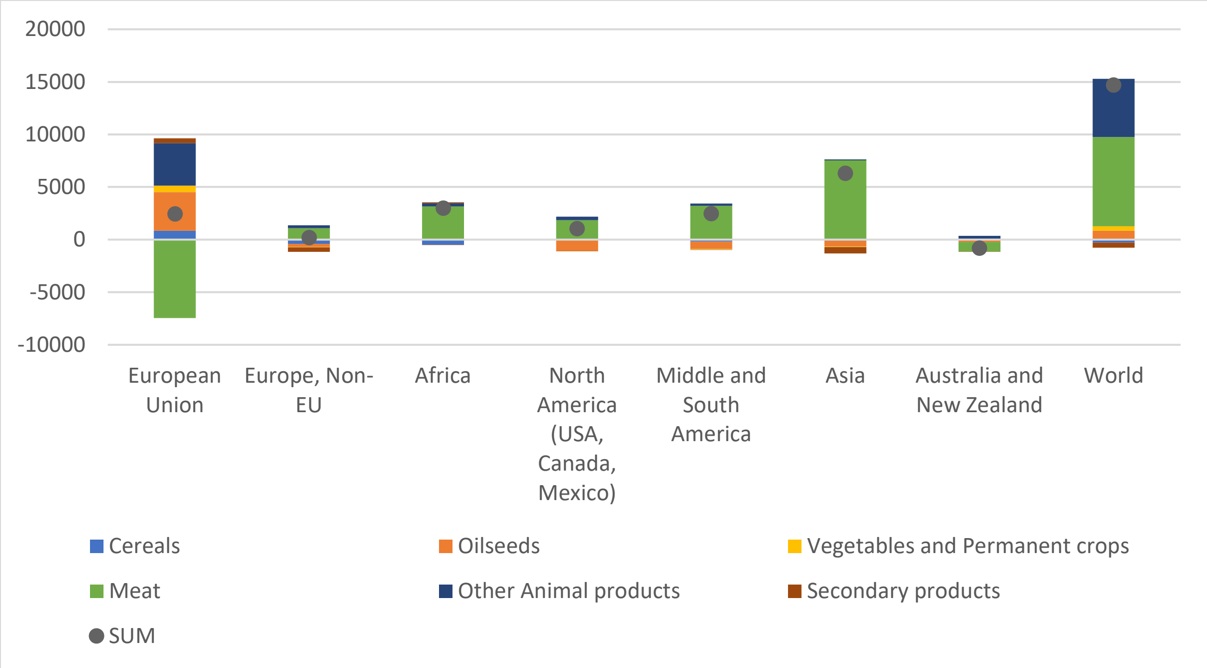


Figure 5: Changes in greenhouse gas emissions in millions of tons of CO2-eq.

Figure 5 shows that greenhouse gas emissions increase in all regions of the world, leading to a global increase that is predominantly driven by the reallocation of meat production. Meat production decreased in the EU and in Australia and New Zealand and so did exports from the EU. Meat production increased in the rest of the world in reaction to the EU's decrease in meat exports to the world regions. Notably, global meat production decreased but still GHG emissions related to meat production increased. Hence, the increase in emissions can only be explained by the less GHG efficient production.

Even though meat production decreased in the EU, the production increases in oilseeds and other animal products led to an overall increase in GHG emissions in the EU, too.

4. Discussion and Policy Implications

To my knowledge, this study is the first comprehensive analysis of the potential consequences of a comprehensive and extensive decrease in trade for the agricultural sector. A comparison with other studies can be made for certain aspects. For example, the dependencies of the EU on soybean imports are addressed by Hörtenhuber et al., 2011, Weightman et al., 2011, Sasu-Boakye et al., 2014. Gocht et al. simulated the impact of an import stop of cereals and soybeans by the EU following the ruling of the European Court of Justice on genome-edited crops, finding similar effects as presented in this paper. Wang et al., 2022 analyzed a global decrease in trade and its environmental impact, but did not differentiate between single agricultural products. Our study serves as a magnifying glass on this sector, that is unique in the way it uses land and affects the climate through land use changes and is of strategic importance for economic development in poorer world regions.

Some products were more affected than others by the import stop.

In the import stop scenario, EU prices increased for all products, but the extent of the increase was very product specific. Prices increased more when the import share for these products are large, when the potential for production expansion in the EU is limited (e.g., due to climatic conditions or political framework) and when the product is not only consumed directly but is also part of a value chain (e.g., soybean in meat production and biodiesel processing).

From these differences in price increases, we could deduct that the increase in scarcity was different for each product. As this scarcity was not influenced by the supply side (How relevant was the loss of imported quantities?), but also by the demand side (How hard is it to substitute for the lower available quantities of this product in human consumption, processing, animal feed …?), I combine the overall effect of these mechanisms under the term "comparative need to compensate". The changes in the comparative need to compensate are mirrored, e.g., by the changes in domestic production. The comparative need to compensate for the loss of soybean imports is high, so domestic production of soybeans increases strongly, whereas the comparative need to compensate is much smaller for wheat. Hence, domestic production of wheat decreases, even though the wheat price increased.

An EU import stop led to negative environmental consequences.

The increase in prices led to an increase in domestic production through intensification (more use of fertilizer) and extensification of agricultural land use. This led to an increase in the nutrient surplus in the soil in the EU and to an increase greenhouse gas emissions associated to agriculture in the EU, leading to a global emission increase.

These environmental implications of trade were discussed in several other publications. Many of them conclude that international division of labor through trade reduces overall emissions. Wang et al., 2022 employed an even more radical scenario of global protectionism and found that both agricultural and overall emissions increase. Lu et al., 2020, however, analyzed the "trade war" between the US and China, focusing on soybeans and they, too, found increases in global GHG emissions. Ackerman et al., 2007 and Zhang et al., 2017a share these conclusions that trade leads to lower global GHG emissions. However, Wiedmann and Lenzen, 2018 and Lin et al., 2019 found the opposite, namely that more trade leads to higher global GHG emissions. Their analyses referred to all economic sectors and the GHG emissions were driven by a trade-induced increase in consumption. As food consumption increase only by a small amount, this mechanism does not apply to our findings regarding agriculture.

The policy implications are that trade can be a tool to increase global efficiency regarding GHG emissions. With the global market mechanism production can be allocated to the place where it is associated with the lowest GHG emissions. To enable this market mechanism to function, any policy intervention that distorts the transmission of this relative advantage to the price should be abolished. These interventions are tariffs and non-tariff barriers to trade that do not aim at internalizing environmental externalities like GHG emissions. Unequal social standards and environmental laws are also factors that distort the transmission of the environmental comparative advantage to the price and should therefore be harmonized.

An EU import stop had income implications for countries.

Due to the import stop, the EU's trading partners experienced a decrease in income from exports to the EU. However, the EU itself showed a decrease in exports because of its own import stop. Therefore, the EU's trading partner also experience less imports from the EU and substitute for this through an increase in domestic production. This mechanism applies especially to animal production. As this is a field with high value-added, some of the income loss in other regions is compensated for.

These findings fit into the literature on infant industry argument and on import substitution industrialization. Ever since these concepts were developed (Hamilton, 1791, Mill, 1848, List, 1856) they experience waves of academic and political interest especially in development economics e.g. (Baldwin, 1969, Bhagwati, 1986, Mayer, 1984).

Our findings suggest that EU export restrictions could be a way to achieve import substitution industrialization in developing countries and complement classical instruments like import tariffs or subsidization in the developing country. Export restrictions could be a logical continuation of the abolishment of the highly export subsidies for European agriculture. However, the potential for actual development of the respective sector must be carefully analyzed as infant industry protection can also have harmful effects if it draws production factors to less profitable sectors and increases consumer prices.

Interactions of import bans of single products reinforced their respective effects.

The effects of a comprehensive, far-reaching import stop were higher than the sum of the effects of the single product import stops. By combining the import stop of different products together into one policy, one potential channel for reaction (i.e., increased imports of a substitute) was restricted. Therefore, the import stops of the single products escalated each other when implemented simultaneously.

This finding indicates that the implication of imposing or lifting a trade restriction for a specific product can differ depending on which trade restrictions are in place for other products. Including one additional product in a broad tariff increase can have larger effects than the policy assessment for the trade disruption of this single product might suggest.

In the current global trade regime, the opposite case more frequent. Tariffs are reduced as part of free trade agreements. But also in this case the analysis is helpful. Liberalizing trade for only one product can make a restrictive trade regime much less harmful.

When discussing our findings, we need to acknowledge their limitations. The most consequential caveat may be the utilized human consumption module. The default human consumption module in CAPRI is calibrated to observed consumed quantities at observed prices. This calibration results in rather high quantities of price-independent consumption and therefore, in rather low reaction to prices changes. This approach is adequate for simulations that are closer to the status quo, but for substantial changes as induced by our scenario, a more flexible modelling of human consumption would be fitting. Therefore, by using the default CAPRI human consumption modelling, we probably overestimated the price changes.

Another potential reason for the overestimation of price changes is the so-called "small share problem", arising from utilizing the Armington assumption in the market module. A small share of imports or supply in the baseline, stays relatively small in the simulation and reacts only moderately even to substantial price changes (Kuiper, Tongeren, 2007).

Due to fishing quotes, no potential for production expansion in fish is assumed. Again, this is a realistic assumption in the short run, but in a comprehensive import stop and high increases in prices, a change in legislation and/or an extension of aquaculture would be expected. Hence, price changes for fish are most certainly overestimated and were therefore, also not presented in this paper.

For a meaningful interpretation of the increase in GHG emissions from agricultural production, this increase should be compared against emissions saved from the reduced transport associated with a decrease in EU trade, also considering increase trade between third countries due to trade diversion.

By analyzing a trade stop scenario that is very far-reaching both in terms of the products affected and the extent of the import reductions, I could exhibit the interactions and mechanisms within the agricultural sector and how they affect countries, producer, consumers and the environment differently. These learnings can be applied to more moderate, real-life scenarios and help assess their implications.

To sum up, my results show that the negative effects of the import stop scenario dominate. Consumers in the EU faced less choice in products and higher prices. As the EU exported less, consumer prices outside of the EU decreased only to a small extent or remained unchanged, and consumers' choices were also limited. Producers in the rest of the world lost the income from exporting to the EU and suffered from the drop in prices. However, substituting for the decrease in EU exports led to the development of value-adding animal production in some regions with positive income implications for producers there. In terms of economic development, we found the import stop to be at least a lose-lose-win scenario.

From an environmental perspective, trade can bring the most efficient global division of labor in terms of both prices and climate. To achieve this efficiency, anything distorting from it needs to be accounted for. This includes the abolishment of tariffs or non-tariff barriers and the internalization of environmental damage by carbon taxes or carbon border adjustments, as well as the harmonization of social standards. This can improve the availability of foo, economic well-being and climate protection.

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