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CSH Policy Brief

How the war in Ukraine might affect global food supply

Ukraine is among the world's largest exporters of agricultural products that account for more than a fifth of the country's export volume of 49.5 billion USD. If the war in Ukraine leads to interruptions of the agricultural production and subsequent exports should stop, several other countries will be affected and can be confronted with shortages of food supply. Negative effects are not limited to Ukraine's direct trading partners alone. Here we present an assessment of the expected losses various countries might suffer.

We consider direct trade relations between Ukraine and other countries as well as indirect effects from countries that act as intermediaries the potential losses of domestic production due to missing inputs from Ukraine. We find that a loss of agricultural production in Ukraine due to the Russian invasion poses a serious threat to food security in several countries of the Mideast and Northern Africa. Substantial losses of up to 83% in maize, 99% in soybeans, and 45% in wheat are found for some countries. In Europe, Latvia and Poland could be confronted with losses of 83% in maize and 81% in soybeans, respectively. Indirect effects induce losses in the meat production in some European countries. Results are available in interactive format <https://vis.csh.ac.at/ukraine-supply-shock/>

Background

Ukraine is the world's 51st largest exporter [1]. Apart from the trade of iron ore, its economy is focused on the agricultural sector. Figure 1 compares the main exports of Ukraine with those of Germany. This comparison highlights the importance of the Ukrainian agricultural sector. Especially grains and oil seeds feature prominently among the country's agricultural exports. Ukraine is the largest exporter of sunflower seed oil and the fourth largest exporter of maize, superseded only by Brazil, the United States, and Argentina. Table 1 provides a summary of goods for which Ukraine ranks high among the world's exporters and the total amount Ukraine exports of this good. The table also specifies countries that suffer the largest losses under the assumption of a complete loss of that product's production in Ukraine.

Products and supply chain. Maize, wheat, and soy are basic commodities that can either be consumed directly or fed to life stock and thereby converted to higher proteins in meat, milk, or eggs. Maize, wheat, and soy can be considered as starting points of a production processes or in supply chains. Sunflower seed oil, on the other hand, is the endpoint of a production process.

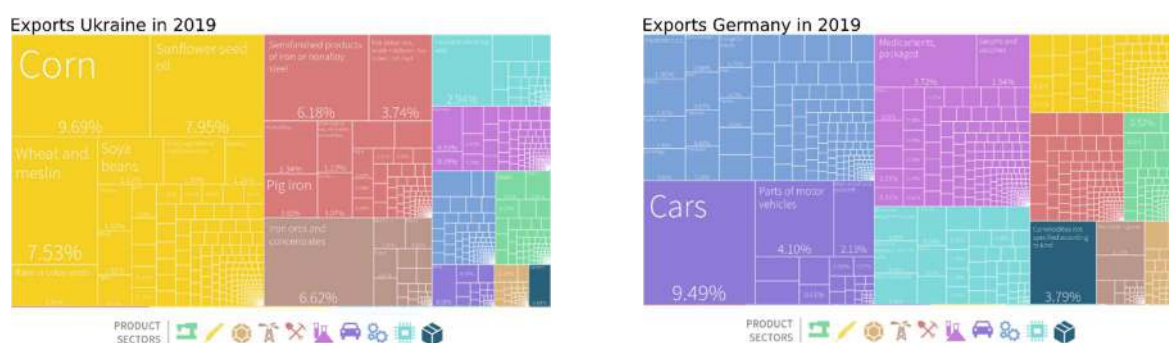


Figure 1. Comparison of exports of Ukraine (left) and Germany (right). Ukraine's exports are mainly agricultural products (yellow), metals (red) and minerals (brown). For comparison, Germany exports more complex products, such as machinery (blue), vehicles (violet), chemicals (magenta), and electronics (turquoise). Source: Atlas of Economic Complexity [2].

Trading partners. Ukraine engages in trade with different countries. Its major trading partners are in the Mideast, North Africa, and Europe. The recent Russian invasion is a serious threat also to the agricultural production and is likely to cause damages in infrastructure, land, labor availability and consequently will result in losses. As these losses propagate along supply chains and affect trade relations, they will affect other countries. We distinguish between *direct* effects (i.e., trade) and *indirect* ones that arise as secondary effects in the production processes in supply networks or through intermediaries in trade.

The CSH perspective

Our aim is to forecast *direct* (losses in direct exports) and *indirect* effects on agricultural production around the globe. The *indirect* contributions include two situations. In the first situation, country (A) imports goods from country (B) that receives these goods from Ukraine (U) (Fig 2a). In situation two, country (A) is confronted with a lack of inputs to its domestic production process that come from the Ukraine. (A) then suffers losses in products not directly imported from Ukraine (Fig 2b).

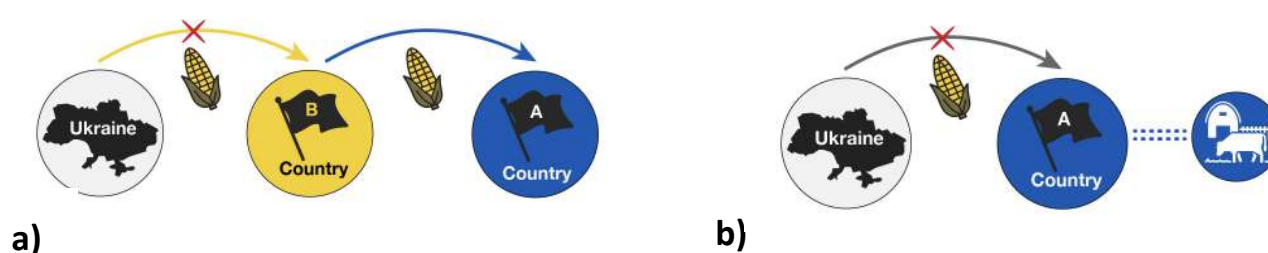


Figure 2. Indirect effects can occur via two different channels: a) Countries import goods from third party countries. These countries in turn import from Ukraine, which cannot meet the demand due to a production shock. b) Countries import basic products from Ukraine and use these as inputs to produce other goods. If the inputs are lacking, losses in the produced products can occur even though these products are not traded with Ukraine.

Network data – production processes. To disentangle direct and indirect impacts and their respective severity, a complexity economics perspective on international food trade networks is used. For this task we use **global trade network** data for agricultural products [3]. In this network, direct dependencies are immediately visible, indirect dependencies can be inferred.

In a next step, we convert products to **production processes**. Production processes turn goods into other goods, for example, basic crops are fed to life stock and are thereby converted into protein sources like meat, milk, or eggs. We consider 125 agricultural products and 118 different production processes. Products include staple foods like wheat, maize, and rice, which cover two thirds of the human caloric intake [4]. Using world global network data and the appropriate conversion factors allows us to simulate how agricultural and food products (basic, intermediary, and final products) are produced in any given country and how they are traded internationally.



Figure 2. A **production process** converts products in other products. In this example, grains as a basic product are converted into cattle as an intermediate product in a first production process. In a second production process, cattle serve as an input to produce milk and meat as final products.

Shock simulation. To assess the expected losses origination from a specific product, we first calibrate a baseline scenario based on trade and production data. We then run a computer simulation in a scenario where we impose a hypothetical shock on Ukraine by destroying the production of that specific product. We separately measure the direct and indirect effects on every country relative to the baseline scenario for every product. For each country and every shocked product, we compare the total amount available in the baseline scenario with the amounts in the shocked scenario and compute the *relative loss* (in %) of a given product in a specific country. This *relative loss* is the shock that every country effectively feels in the availability of all products, given that a specific product is no longer produced in Ukraine. We subdivide the total relative loss in the *direct* part due to trade with Ukraine itself, and a remaining *indirect* part. The results are collected in Table 1. (Indirect losses are the difference between total losses and direct losses; not shown in the Table.)

When we shock a specific product in Ukraine, we assume that 100% of the amount usually produced in Ukraine will no longer be available. Clearly, such a complete production loss reflects a worst-case scenario. Further, it neglects the possibilities that countries shift to other suppliers or to substitute goods by others in a production process. For example, countries can substitute Ukrainian maize by soybeans from Brazil for their pork production.

Implications of production loss in Ukraine

The war in Ukraine is likely to cause major disruptions in the entire Ukrainian agricultural production. Since Ukraine is the largest exporter of **sunflower seed oil**, effects on its supply are expected. Figure 3 shows in a stylized world map direct and indirect effects of a 100% supply shock of sunflower seed oil on the world. The size of the circles signifies the relative losses. It is immediately visible that countries in the Near East and Africa experience the largest losses. However, also Baltic, and Southern European countries are strongly affected. Most of the losses originate from direct imports of sunflower seed oil from Ukraine. Since sunflower seed oil is a final product, the indirect effects are almost negligible.

Product	Ukraine's rank among exporters	Exports in 1,000 tons	Most affected countries (white); EU countries (blue)	Total losses (%)	Direct losses (%)
Sunflower seed oil	1 st	3,072	Algeria	88.5	88.0
			Nepal	84.6	84.1
			Oman	84.5	83.8
			Malta	65.1	63.4
Maize	4 th	15,911	Latvia	83.8	74.6
			Estonia	78.1	70.1
			Syria	70.9	70.6
			Latvia	83.8	74.6
Soybeans	7 th	1,416	Lebanon	99.1	99.1
			Belarus	82.9	82.3
			Poland	81.2	80.8
			Poland	81.2	80.8
Wheat	7 th	7,905	Egypt	45.8	23.6
			Moldova	26.9	3.70
			Kenya	19.4	13.2
			Greece	0.4	0.1

Table 1. Agricultural products for which Ukraine is among the world's top exporters. The table shows the relative losses in the most affected countries inside (blue) and outside the European Union (white). The total loss occurring in a country is composed of direct losses (trade with Ukraine) and indirect ones that occur either via imports from third party countries themselves supplied by Ukraine (intermediaries), or that are due to missing inputs to domestic food production.

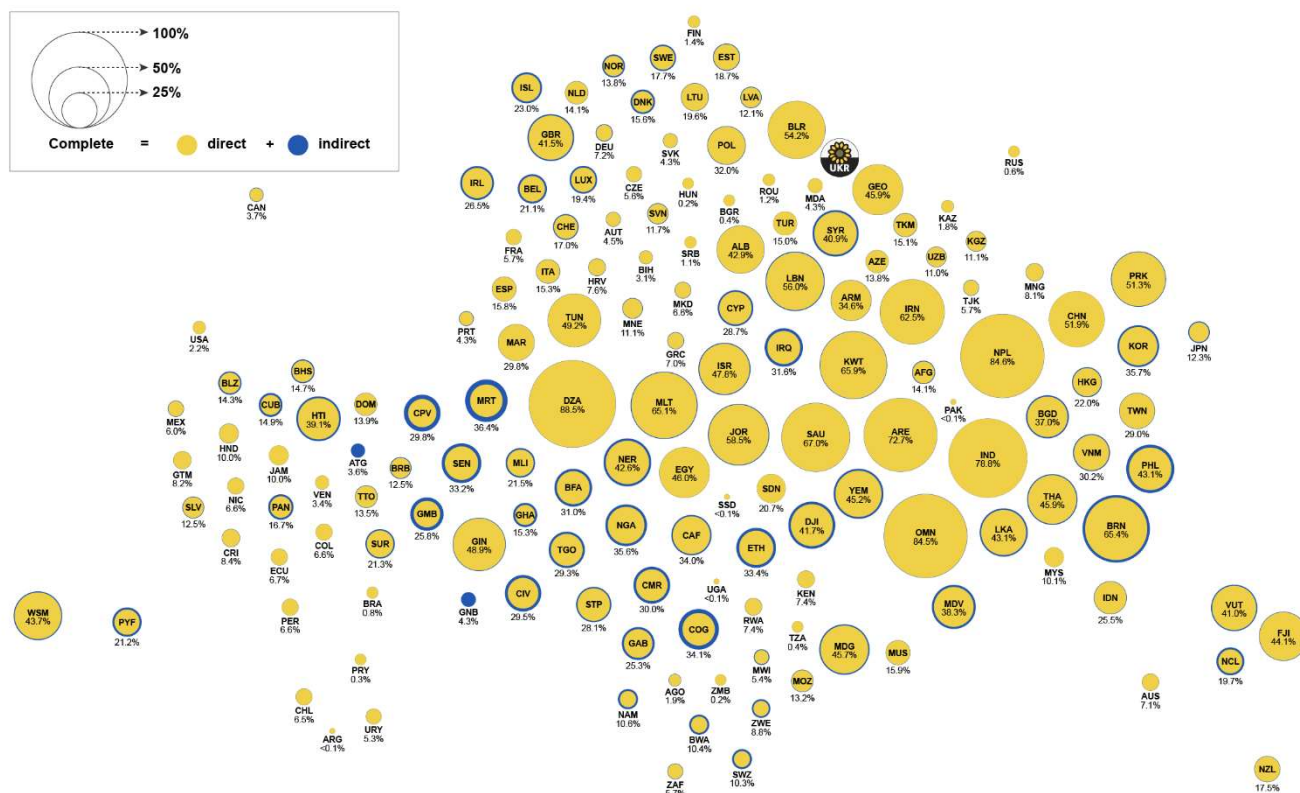


Figure 3. Effects on sunflower seed oil availability in different countries if Ukraine (black) loses 100% of its sunflower seed oil production (given that other countries do not change trading partners or use substitute products). For sunflower seed oil, the direct trade contribution (yellow) dominates, indirect effects (blue) are less important. Countries are ordered by their approximate geolocation. Largest relative losses occur in African and Mideastern countries. European countries are less affected. See <https://vis.csh.ac.at/ukraine-supply-shock/> for an interactive version of the map.

A second major export product of Ukraine is maize. Figure 5 shows that Baltic and Southern European countries together with African countries and the Near East take the largest amounts of this commodity from Ukraine.

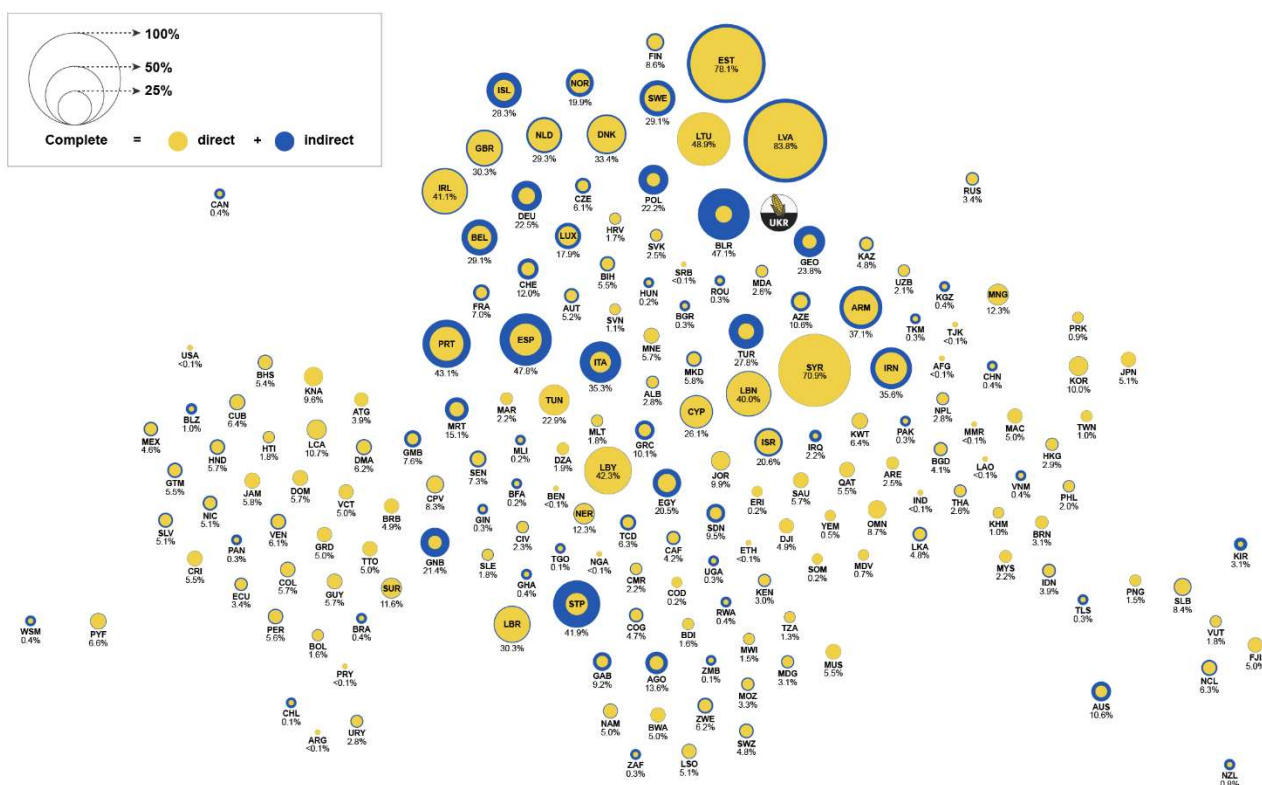


Figure 5. Losses in global **maize** availability in different countries if Ukraine (black) loses 100% of its maize production (if countries do not change suppliers or substitute maize with other products). Indirect effects (blue circles) play a major role on top of the losses expected from direct trade (yellow). Direct losses are noticeable in the Mideast and the Baltic countries. Indirect effects occur in Southern Europe. See also <https://vis.csh.ac.at/ukraine-supply-shock/>

Their losses do not only originate from direct trade. Indirect effects are indicated by blue circles that show a significant role in countries like Italy, Spain, Poland, Bulgaria, or Turkey. Indirect effects include the lack of maize (seeds) for the domestic maize production and the lack of maize in third party countries that import it from Ukraine.

Additional effects arise because maize is used as fodder, mainly for pigs and poultry. Countries that use Ukrainian maize to feed life stock experience losses in animal products following an agricultural failure in Ukraine, even though they do not trade animal products directly with Ukraine.

Figure 6 exemplifies this for the case of Portugal. If Ukrainian maize production should fail, Portugal is expected to lack this input and suffer substantial losses of its meat and eggs production. The figure also indicates that these items are not traded directly with Ukraine (total loss identical with indirect loss).

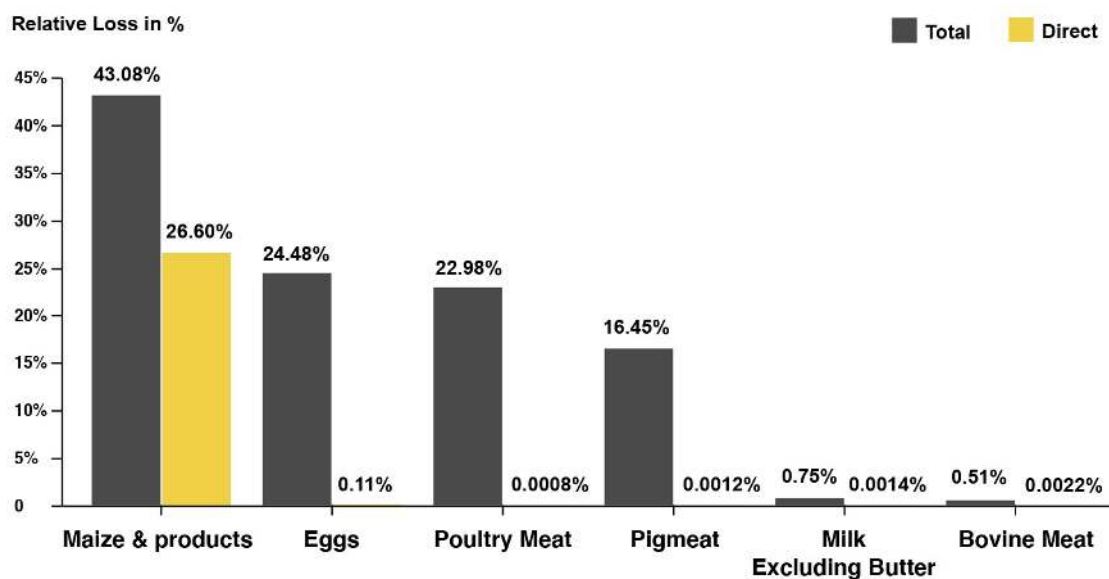


Figure 6. The failure of maize production in Ukraine can propagate through supply chains and affect downstream products. Here we show how the loss of availability of Ukrainian maize in Portugal affects the production of pork meat, poultry meat, and eggs. Losses of up to 20% due to these indirect effects can be expected. Note that this is not what will happen, since there will be market-based substitutions that we do not consider in the simulations.

Conclusion

Agricultural products feature prominently among Ukraine's exports. We present estimates for the direct and indirect losses on the availability of food in countries around the globe under the assumption that Ukraine loses 100% percent of its production of a given agricultural product.

We find remarkably pronounced effects. A loss of agricultural production in Ukraine due to the Russian invasion poses a serious threat to food security in several countries of the Mideast and Northern Africa. Substantial losses of up to 83% in maize (Latvia), 99% in soybeans (Lebanon), and 45% in wheat (Egypt) are found. For details see Table 1. In Europe, Latvia and Poland could be confronted with losses of up to 83% in maize and 81% in soybeans, respectively.

Reductions of maize supply are expected to be felt most in the Baltic countries and the Mideast. A failure of Ukrainian supply can propagate through the production processes and induce a shortage of pork meat. The example of Portugal shows that this indirect effect can cause relative losses of more than 15% in pork and more than 20% the production of poultry and eggs. Sunflower seed oil is expected to be severely affected, relative losses of up to 88% could occur in countries like Algeria.

Note that we assume that countries neither change suppliers nor substitute products as inputs for production. This is certainly unrealistic, however, still, the results indicate the amounts that have to be substituted. In reality, such a worst-case scenario in terms of actual shortages will be ameliorated by substitutions and switching of suppliers. Also note that market mechanisms might amplify food shortages in less wealthy countries of the global south.

In summary, the Russian invasion of Ukraine poses a significant threat to global food security. Especially in less wealthy countries expected shortages might become relevant and effective as substitutions might be harder to obtain than for rich countries.

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About the CSH

The Complexity Science Hub Vienna was founded with the aim of using Big Data for the benefit of society. Among other things, the CSH systematically and strategically prepares large data sets so that they can be used in agent-based models. These simulations allow the effects of decisions in complex situations to be tested in advance and systematically assessed. Thus, the CSH provides fact-based foundations for an evidence-based governance.

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