Forecasting Ukraine's agricultural exports during war: insights into the Black Sea grain trade

NBU Seminar

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USask

August 27, 2024

Motivation

- Importance of Ukraine for global agricultural markets (one of leading exporters of sunflower products, corn, wheat, barley)
- Exports and agricultural production since February 2022 characterized by uncertainty
- Initial blockade (Feb - June 2022)
- Solidarity Lanes (May 2022)
- Black Sea Grain Deal (July 2022 - July 2023)
- Our research interest and focus: Ukraine's **unilateral Black Sea Grain Corridor**

Research Objective

- Context: Ukraine's unilateral Black Sea Grain Corridor.
- **Can ML methods be used to provide accurate forecasts of Ukraine's agricultural exports?**
- **Dataset:** Vessel-level export data from Ukraine's ports
- BSGD vs. the Unilateral BSGC
- **Methodology:** Use of XGBoost as main forecasting model

Solidarity Lanes (May 2022)

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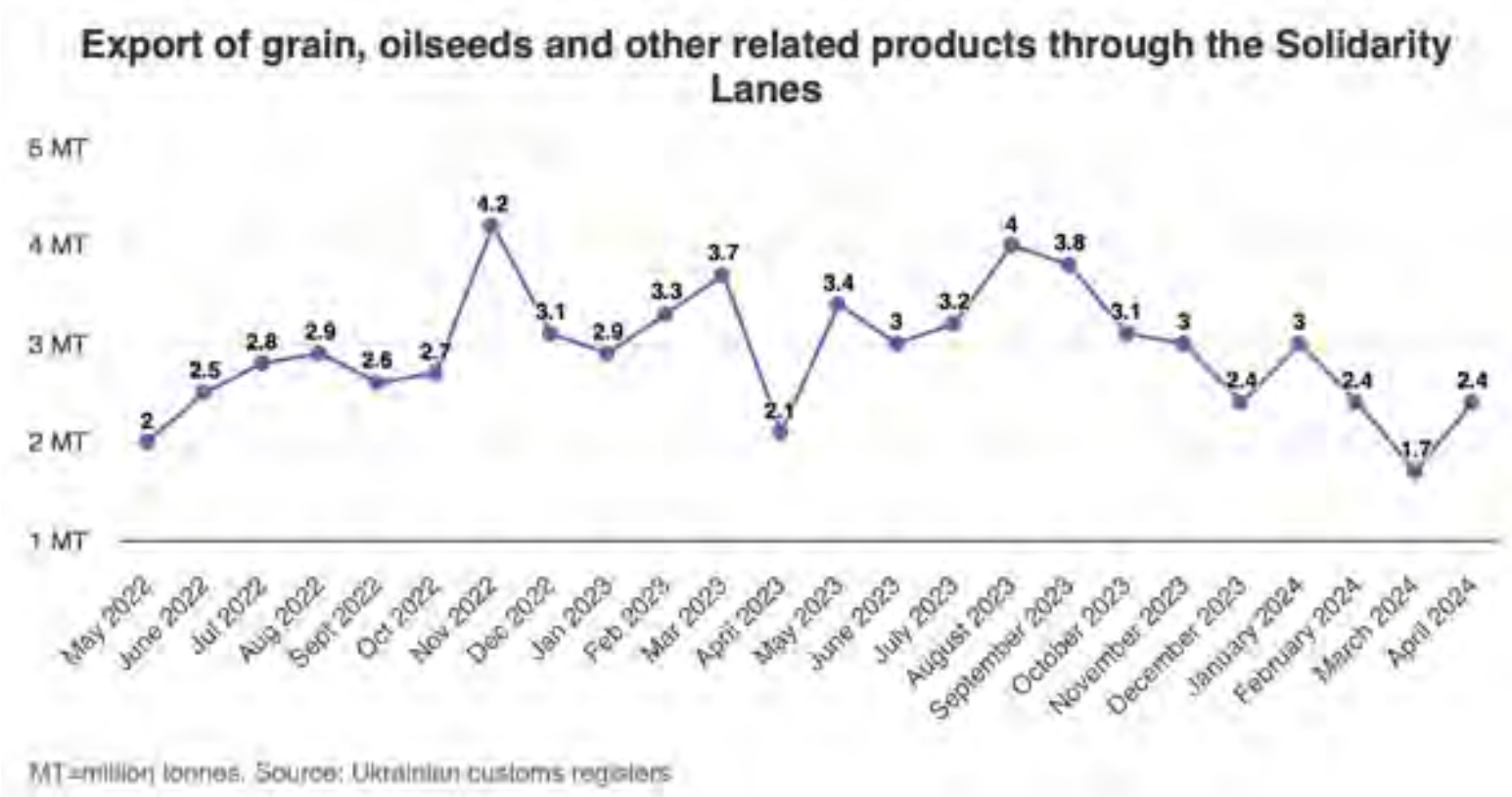
Solidarity Lanes



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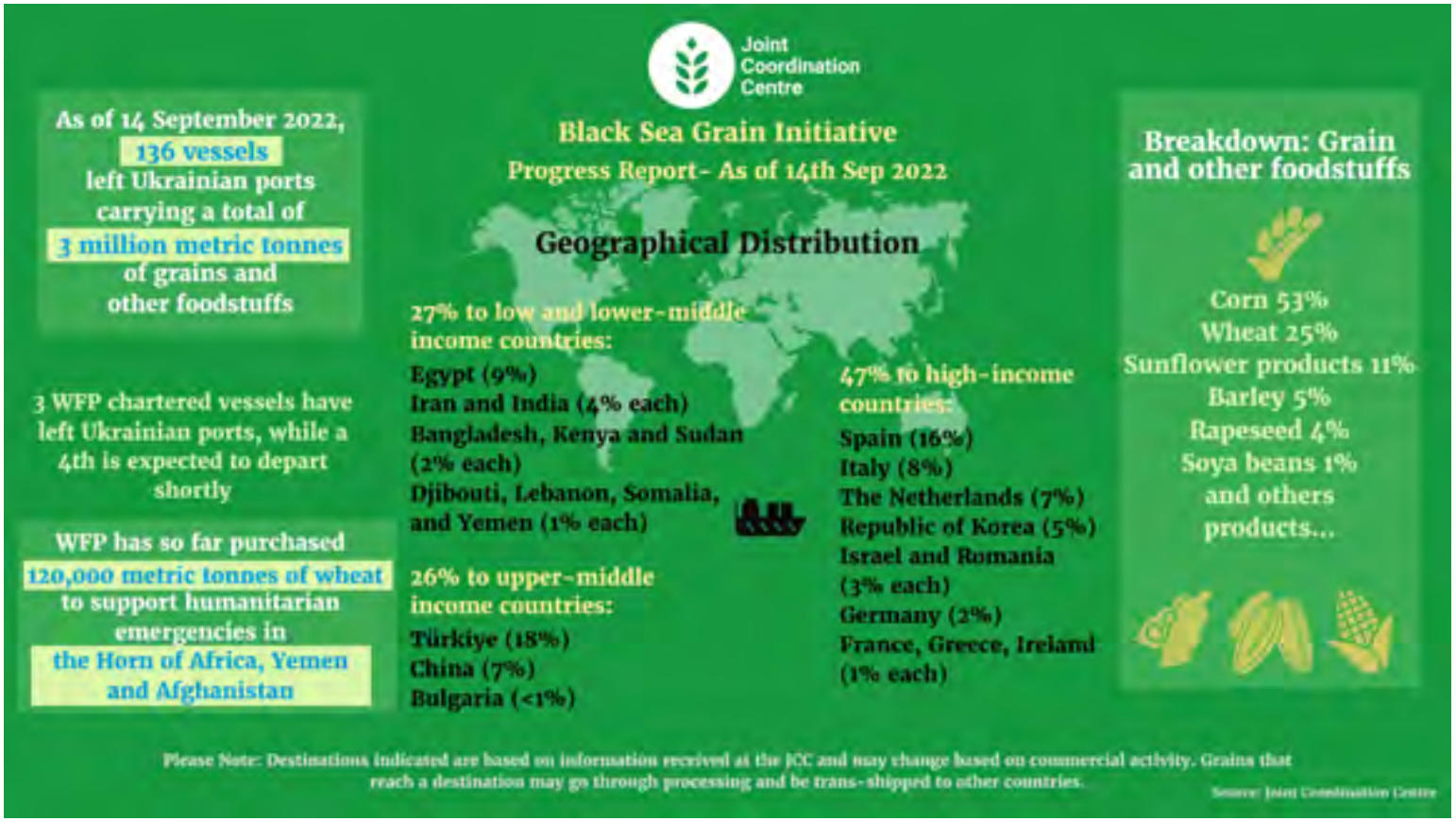
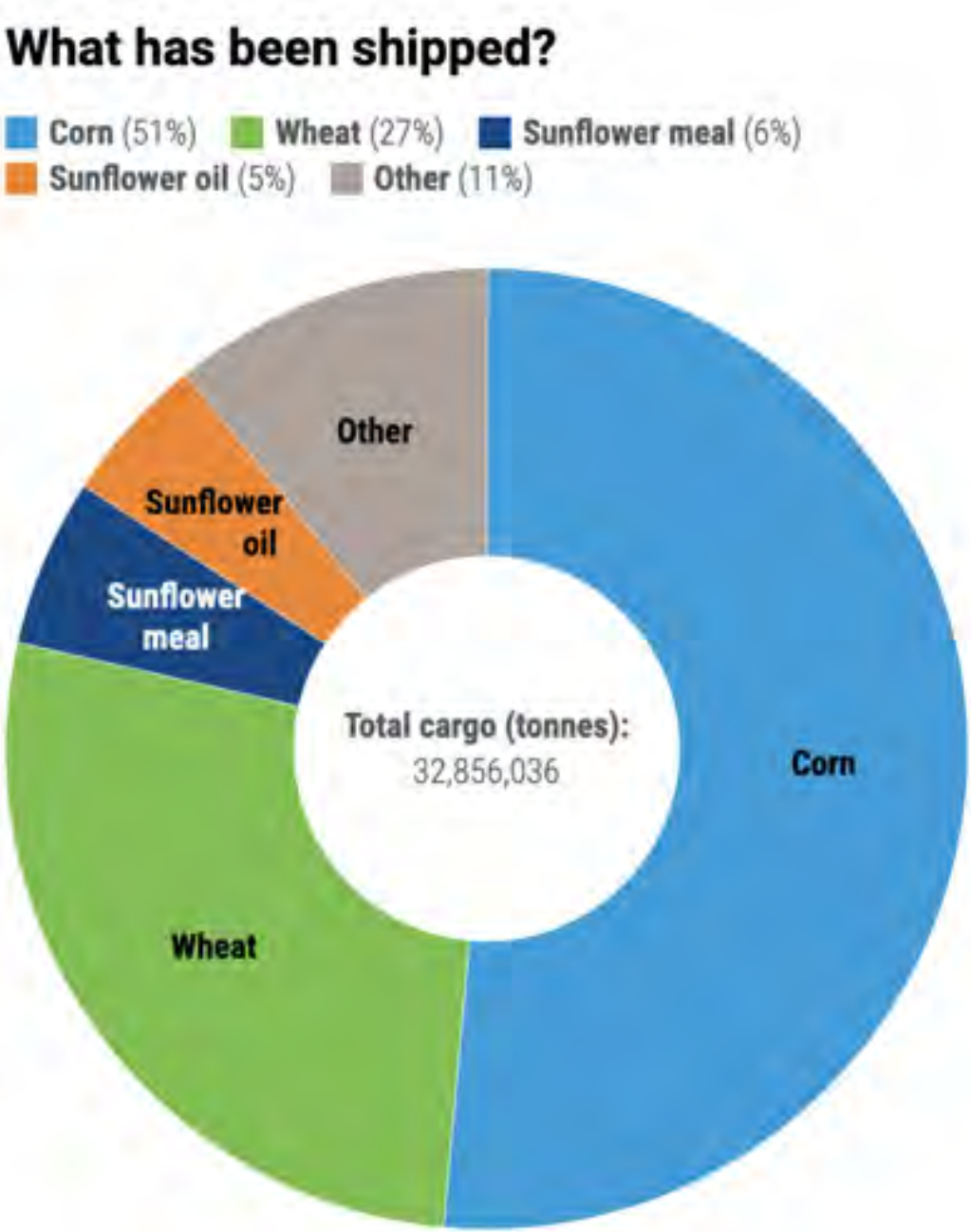
Black Sea Grain Deal - signed 27 July 2022



Black Sea Grain Deal - Summary Data



Impact on Crop Prices

End of Black Sea Grain Initiative - 17/7/23

World · **CBC Explains**

What Russia's threats to Black Sea grain ships mean for the Ukraine war, global food supplies

After quitting UN-brokered grain export deal, Moscow threatens Black Sea food shipping

Thomson Reuters · Posted: Jul 19, 2023 4:43 PM CDT | Last Updated: July 19, 2023

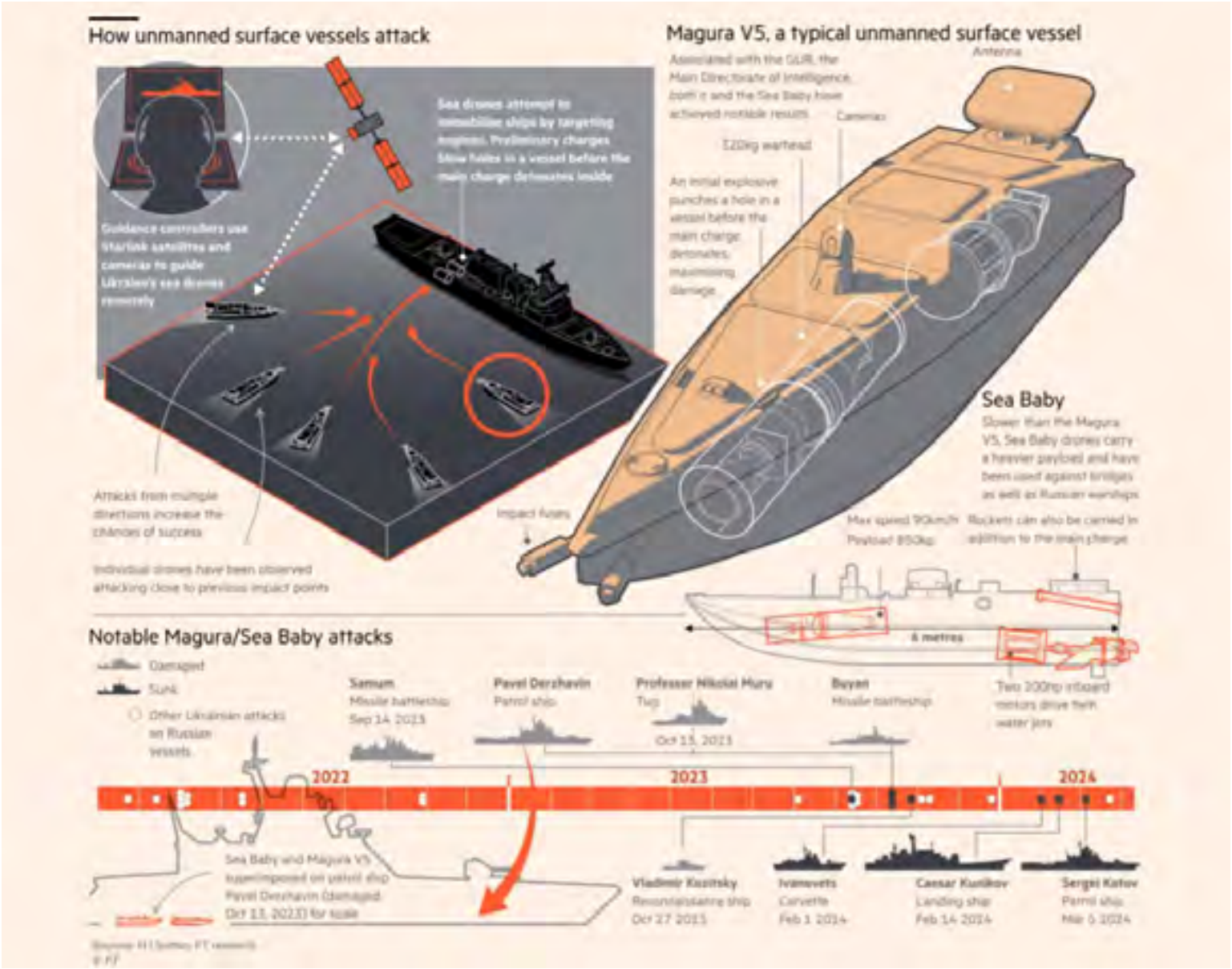
Russia says it will let a wartime deal that allows Ukraine to export grain via the Black Sea to expire. The UN says the arrangement helped keep food prices down and feed the world's poorest countries.

Black Sea Grain Corridor

Source: Financial Times

Snake Island

Sea Drones

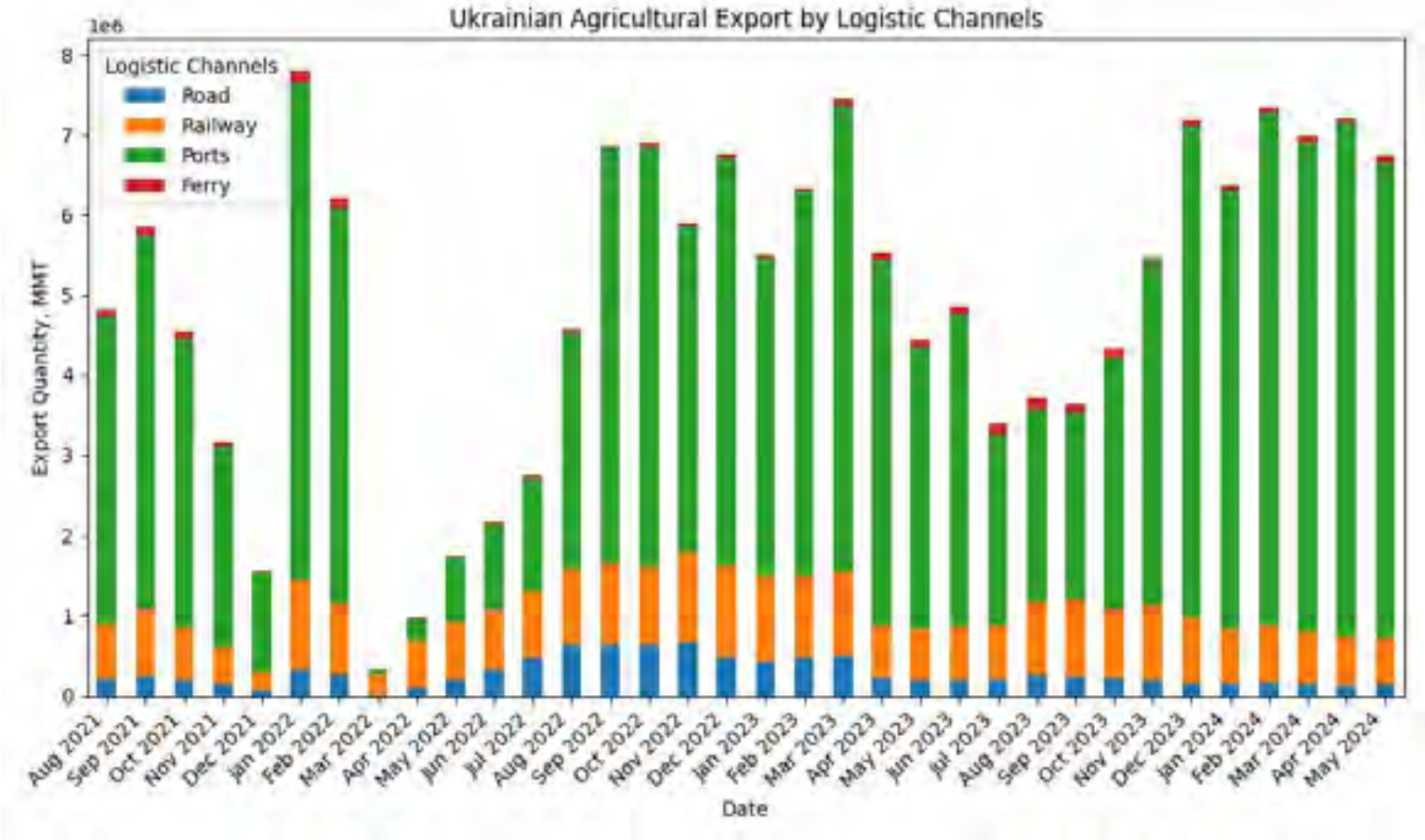


Source: Financial Times

Black Sea Grain Corridor vs BSGI

Source: Financial Times

Sea transport of growing importance



Also because...

February 25, 2024

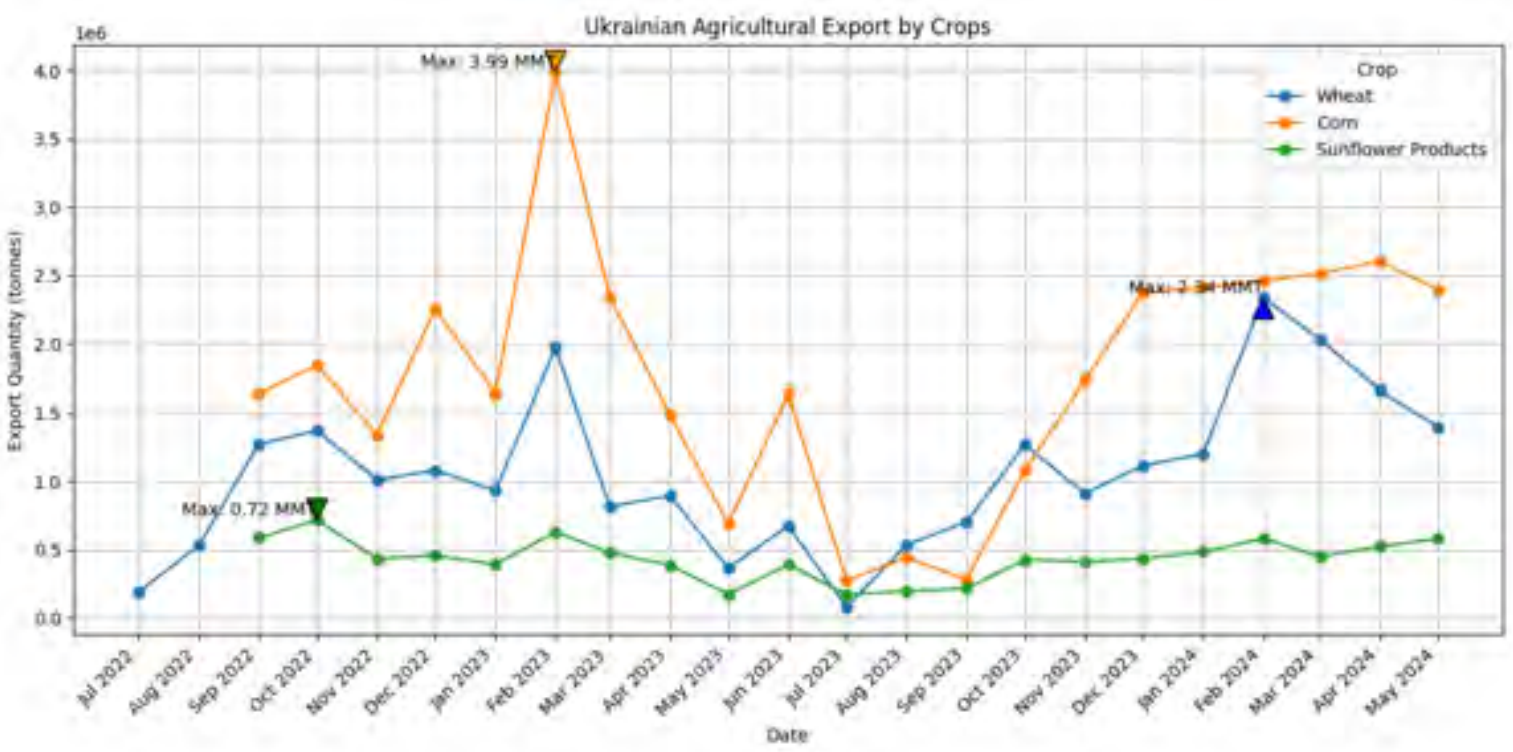
By Reuters

Deputy Prime Minister Says 160 Tons Of Ukrainian Grain Destroyed In Poland

Police officers, customs officers, and railway workers stand next to piles of corn spilled from train cars in the Polish village of Kotomierz, near the Ukrainian border, on February 25.

Around 160 tons of Ukrainian grain was destroyed at a Polish railway station amid large-scale protests in what Ukrainian Deputy Prime Minister Oleksandr Kubrakov on February 25 called an act of "impunity and irresponsibility." Polish farmers protesting this month against what

Top 3 Ukrainian Crops by the amount of maritime exports



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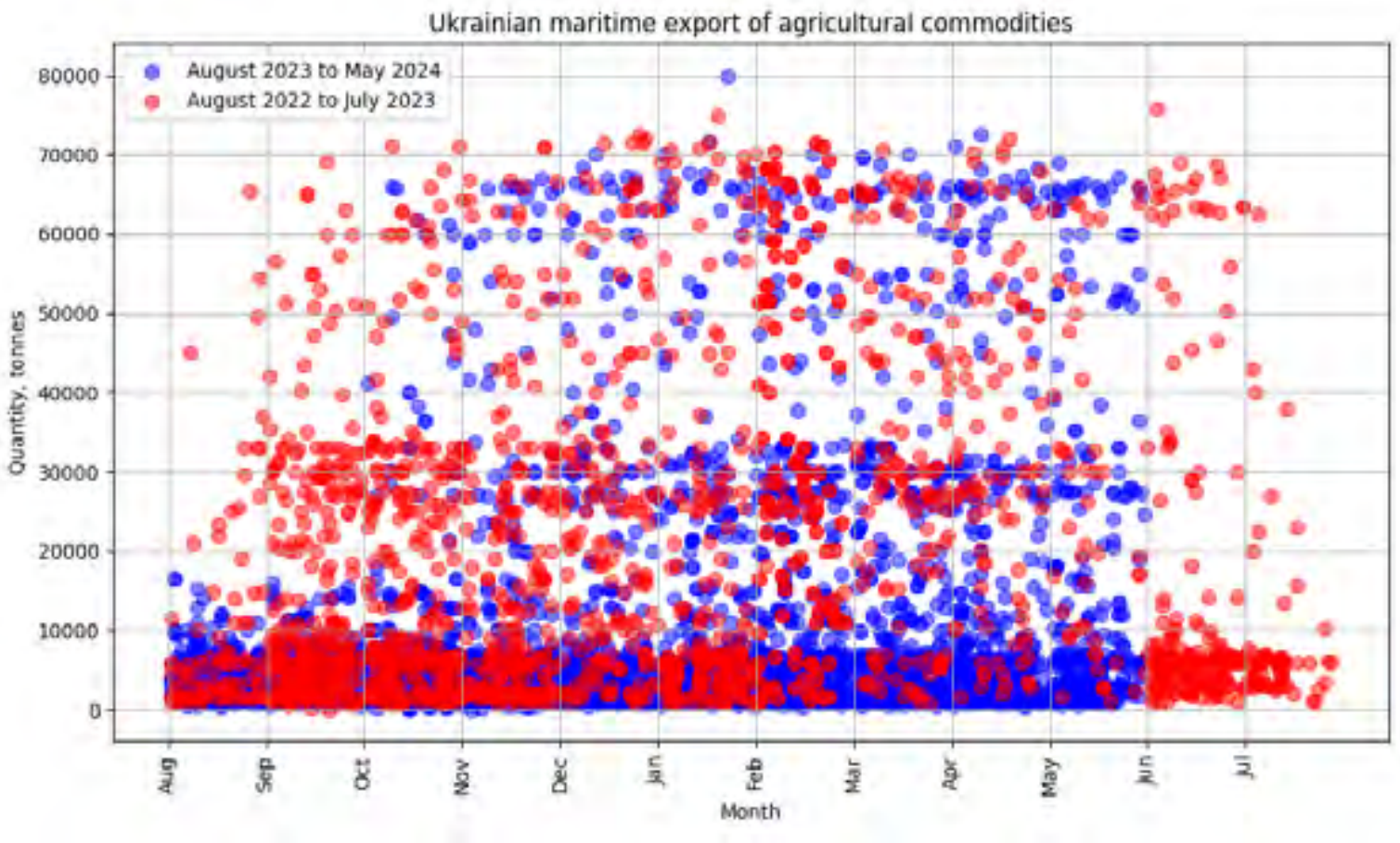
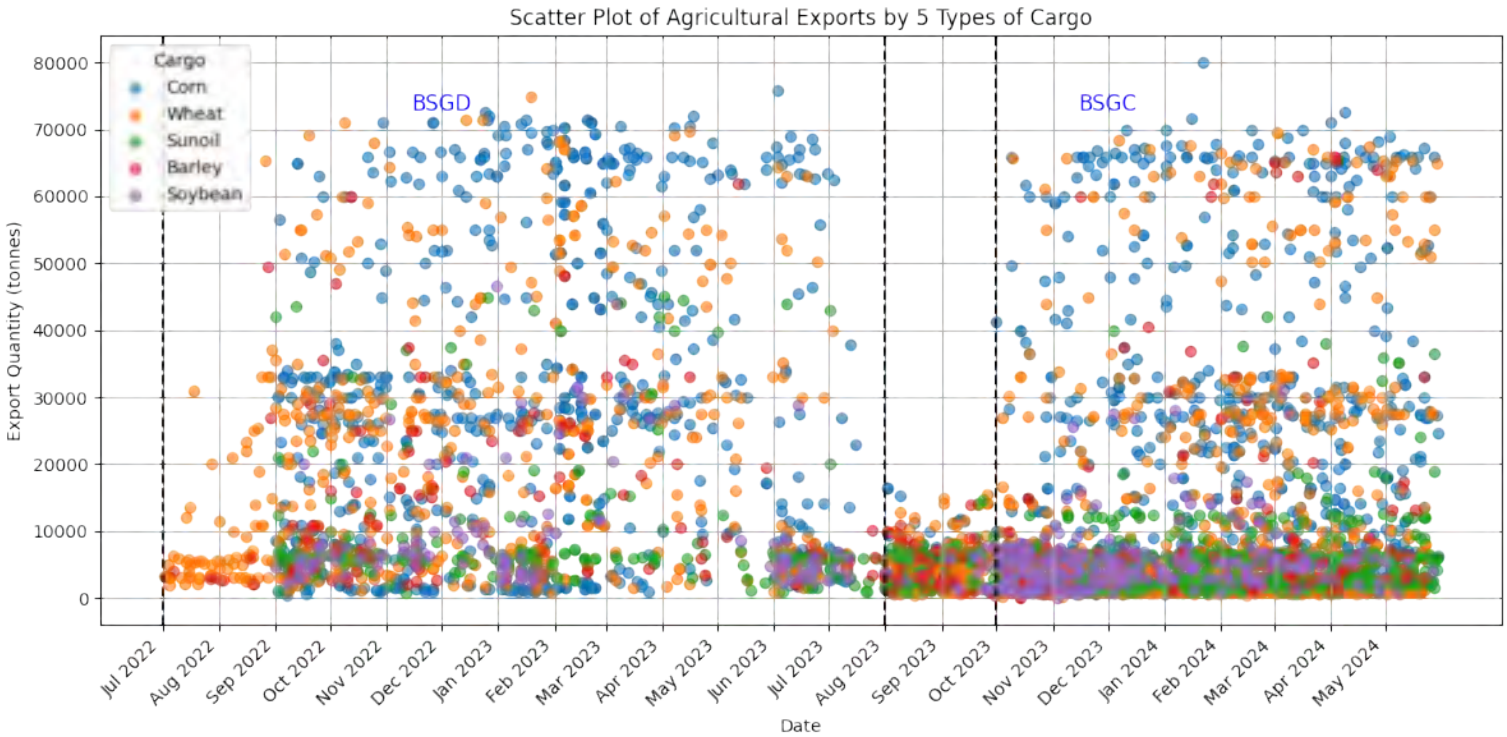
Ag Export during the operation of two sea routes



Top 5 export agricultural crops during the BSGD and the Unilateral BSGC



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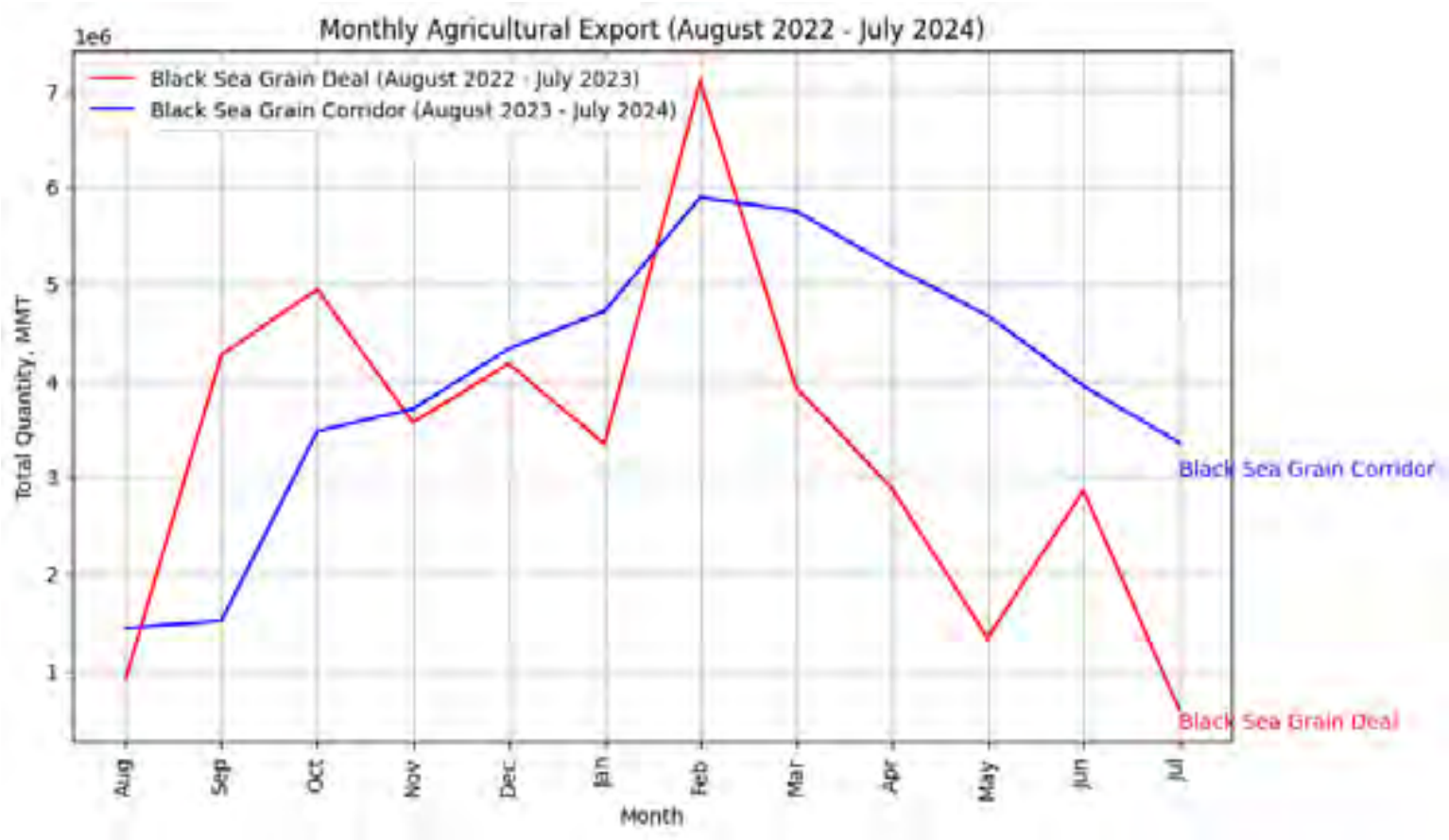
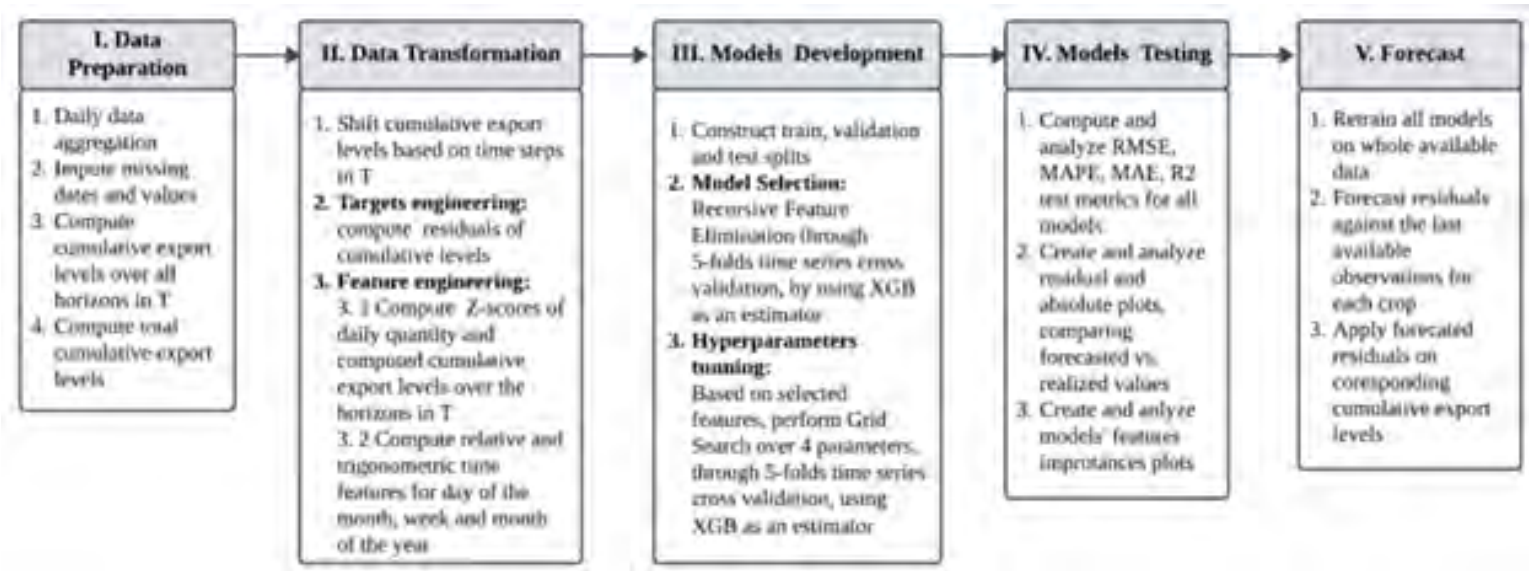
Comparison of the BSGI and the Unilateral BSGC



General information about the Methodology

- Row data for each marine vessel from the seaports of Ukraine (starting from 2022)
- Selected crops: wheat, corn, sunflower products
- Forecasting period: 12 months (July 2024 - June 2025)
- Hybrid forecasting approach:
  - ARIMA for model inputs aggregation
  - Machine learning (XGBoost) for model estimation

Forecasting methodology stages flowchart



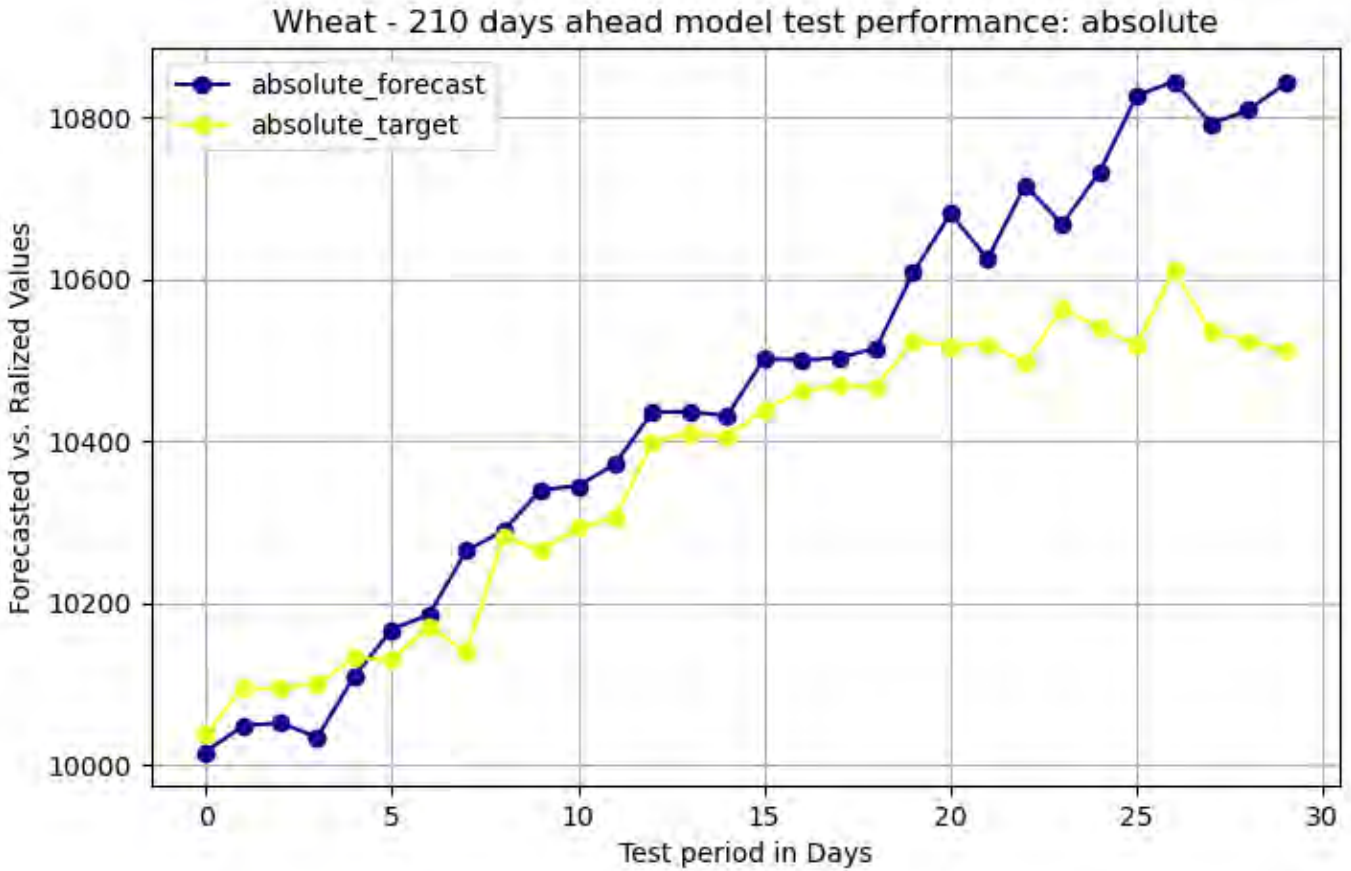


Figure 1: Forecasted vs. realized absolute values of 210 days ahead wheat model

Wheat Production according to the USDA, IGC, SovEcon forecast 2024/2025 MY

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Wheat Export according to the USDA, SovEcon and own forecast for 2024/2025 MY

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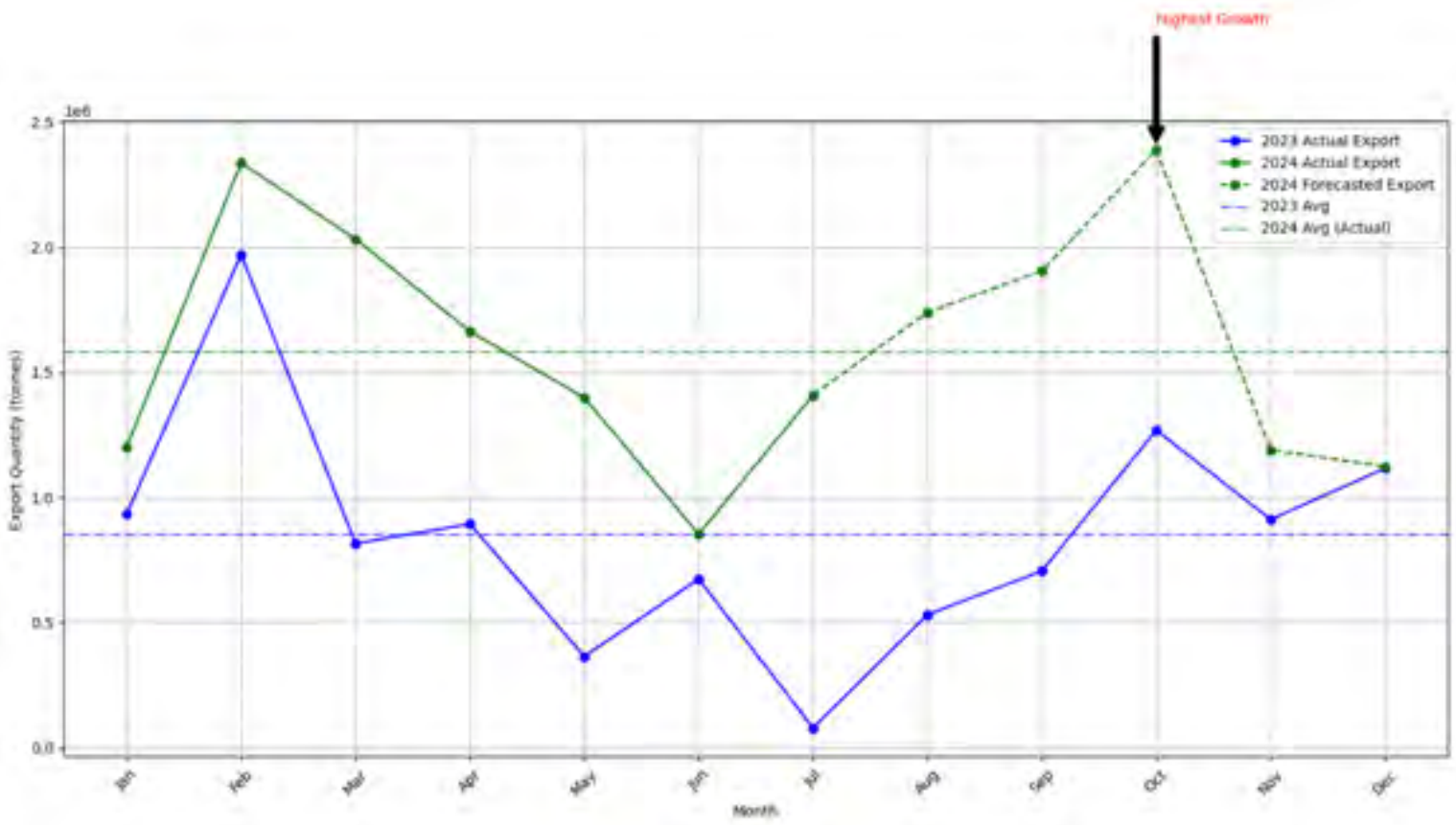
Our Forecasts

Table. Forecasted Export Levels in kilotons, reference date: 1st of July 2024

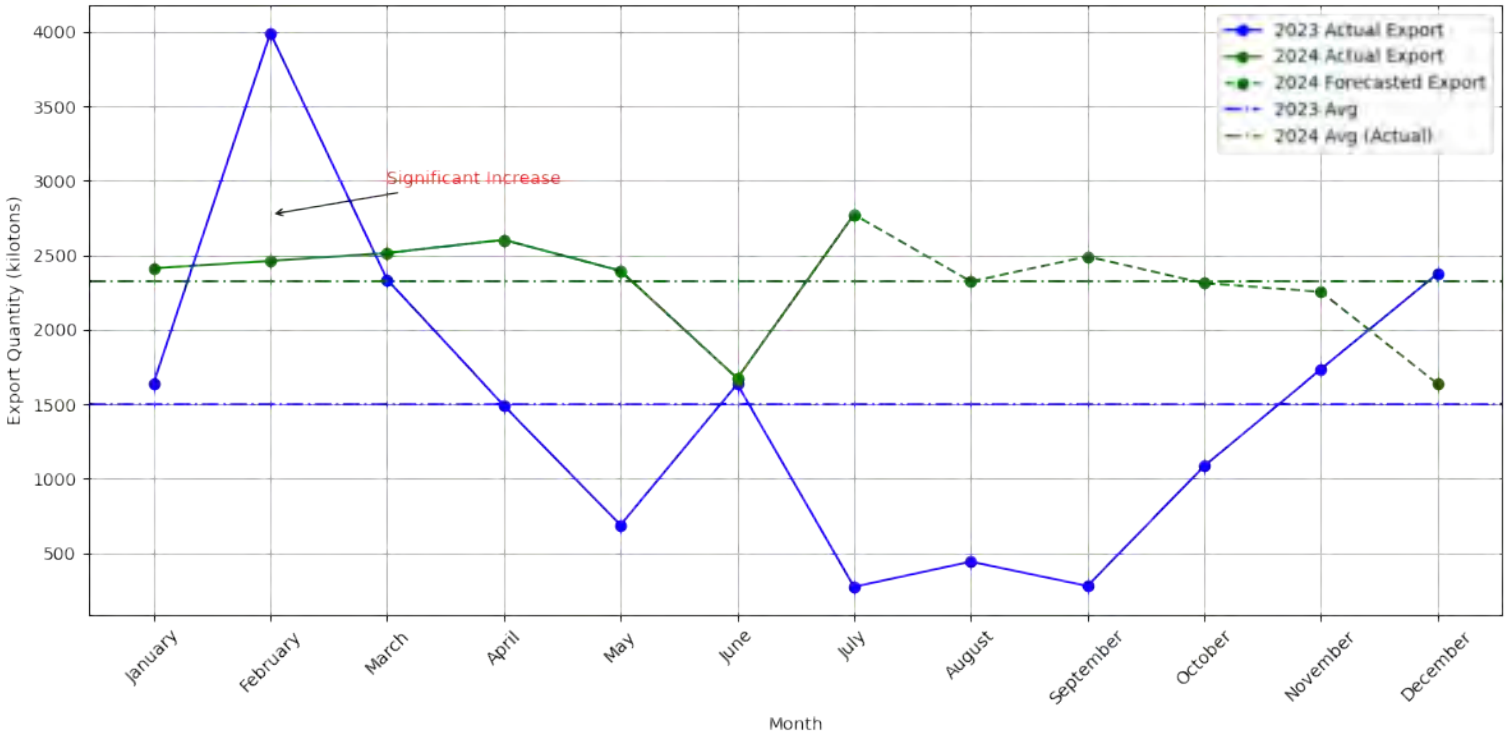
FORECASTED LEVELS BY...	WHEAT	CORN	SUNOIL
1ST OF AUGUST, 2024	1,408.69	2,300.78	224.32
1ST OF SEPTEMBER 2024	3,149.28	3,645.11	640.84
1ST OF OCTOBER 2024	5,054.07	6,246.73	1,049.03
1ST OF NOVEMBER 2024	7,444.13	8,521.05	1,454.65
1ST OF DECEMBER 2024	8,634.82	11,202.47	1,921.35
1ST OF JANUARY 2025	9,758.87	13,681.97	2,272.96
1ST OF FEBRUARY 2025	10,724.90	15,934.56	2,685.52
1ST OF MARCH 2025	11,190.33	17,604.70	3,078.29
1ST OF APRIL 2025	12,430.00	18,760.04	3,407.05
1ST OF MAY 2025	13,061.07	19,129.31	3,580.70
1ST OF JUNE 2025	13,641.25	19,485.01	3,768.65
1ST OF JULY 2025	13,762.30	19,693.77	3,902.48

Sources: Calculated using the authors' own forecasting results.

Forecasted Wheat Export Levels by Sea



Forecasted Corn Export Levels by Sea



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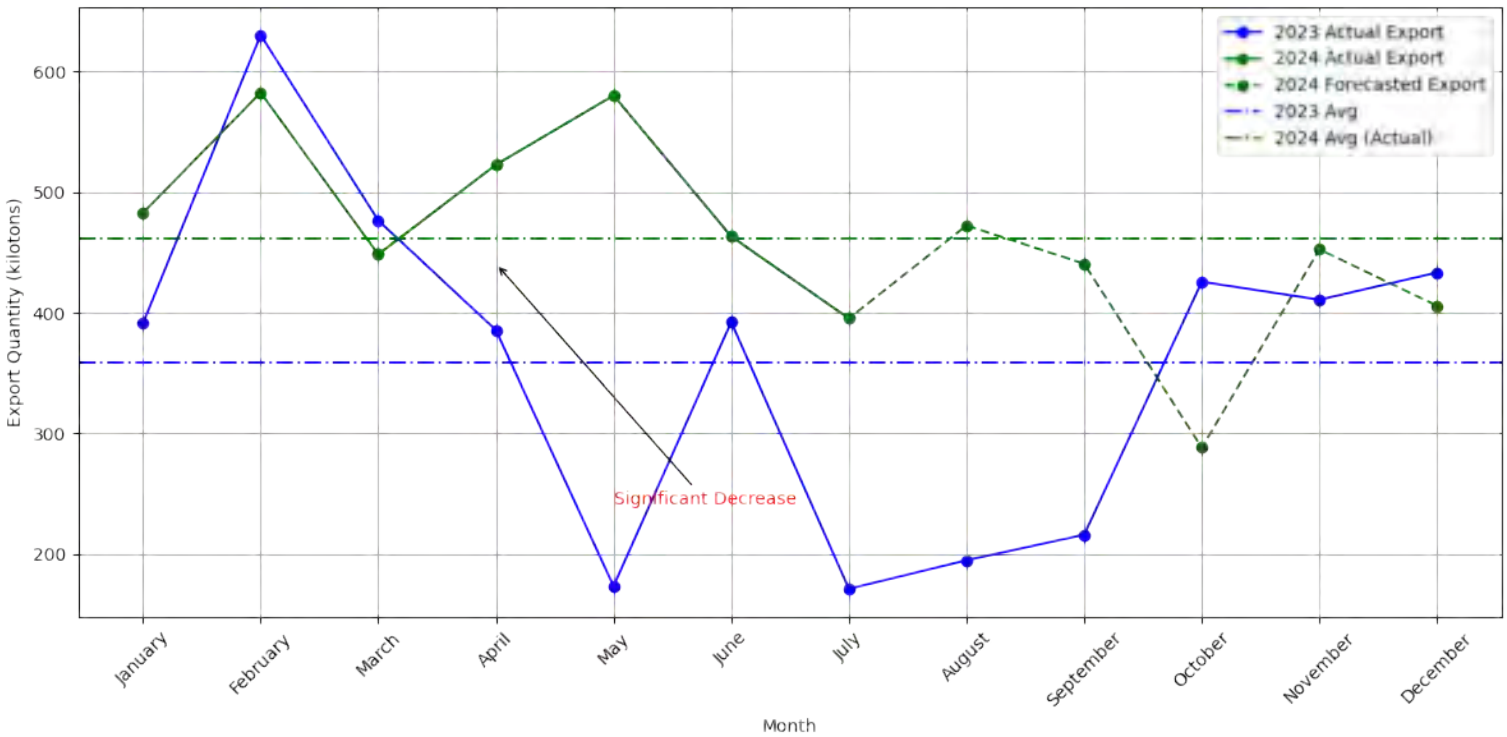
Forecasted Sunflower Products Export Levels by Sea



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July Forecasts vs. Realized Exports

- **Wheat**
  - Forecast: 1.41 MMT
  - Realized: 1.28 MMT
- **Sunflower Products**
  - Forecast: 224 KMT
  - Realized: 254 KMT
- **Corn**
  - Forecast: 2.3 MMT
  - Realized: .883 MMT

Some (potential) lessons from Saskatchewan?

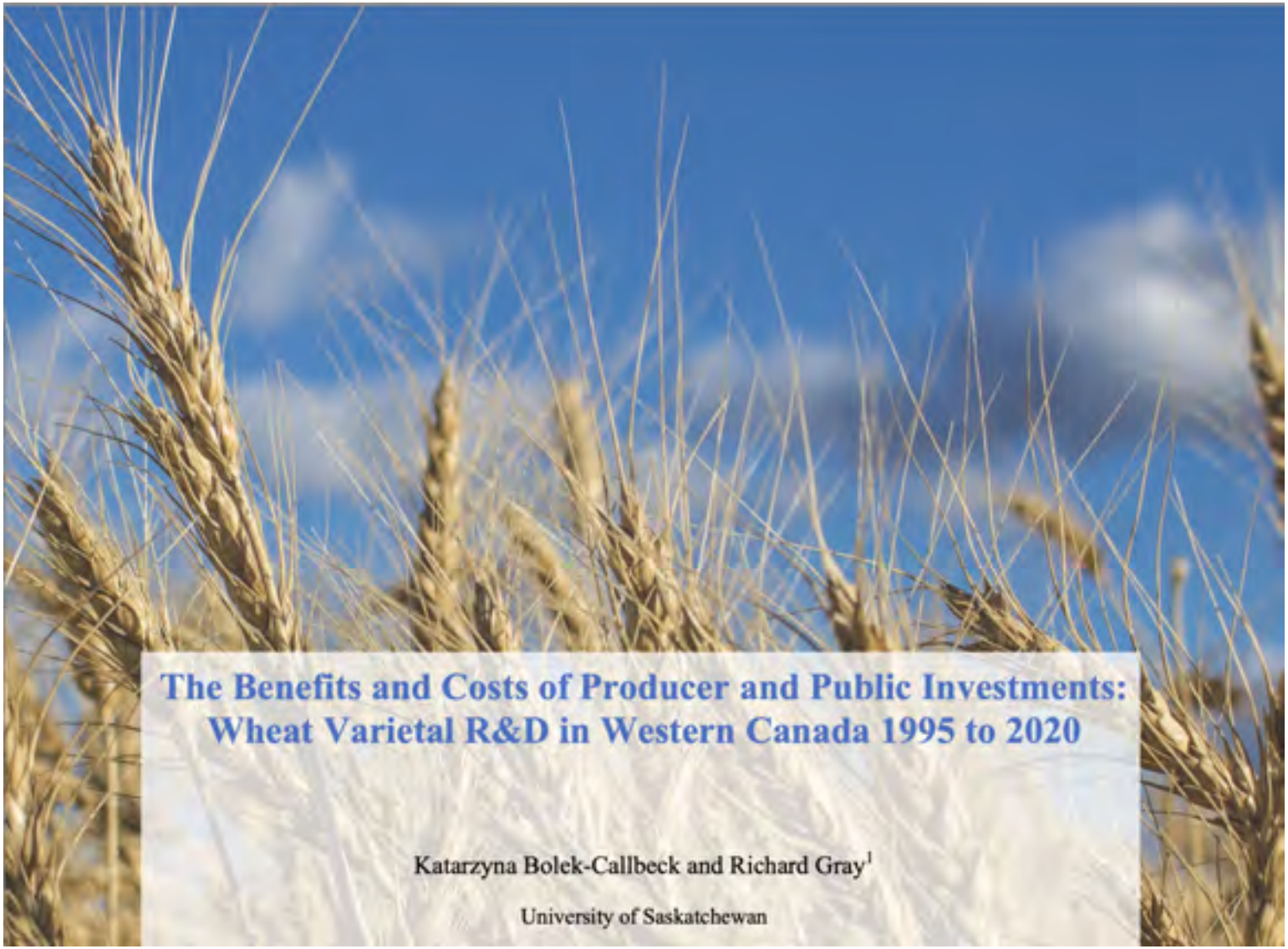
Some (potential) lessons from Saskatchewan?

- Saskatchewan: land area 600 sq. km.
- 60.3 million acres (40 percent of Canadian total), brown, light brown and 'chornozem' soil types
- Major producer and exporter of wheat, rapeseed ('canola'), barley, peas
- **Strong investment in public plant breeding - Crop Development Center at USask, Ag Canada**

Saskatchewan Ag Exports - 2023

Value of major Saskatchewan agri-food exports to the world, 2023 (CAD$ millions)			
Commodity	2021	2022	**2023**
Non-durum wheat	2,623.7	2,844.1	**3,753.3**
Canola oil	2,679.6	3,501.9	**3,546.5**
Canola seed	3,590.9	2,717.8	**3,167.3**
Durum	1,498.4	1,817.8	**1,987.7**
Lentils	1,709.4	1,958.2	**1,982.4**
Canola meal	866.6	907.3	**1,199.8**
Peas	1,048.4	1,136.1	**986.2**
Barley	672.8	543.9	**579.0**
Oats	298.5	304.3	**365.9**
Chickpeas	147.6	248.1	**272.4**
Cereal grains (hulled, rolled, flaked)	212.4	350.1	**265.9**
Live cattle	152.4	228.8	**207.7**
Flaxseed	273.0	186.7	**181.9**
Malt	92.7	124.5	**170.0**
Canary seed	99.7	115.8	**99.9**
Total agri-food exports	17,486.2	18,454.2	**20,238.6**

Wheat breeding benefits



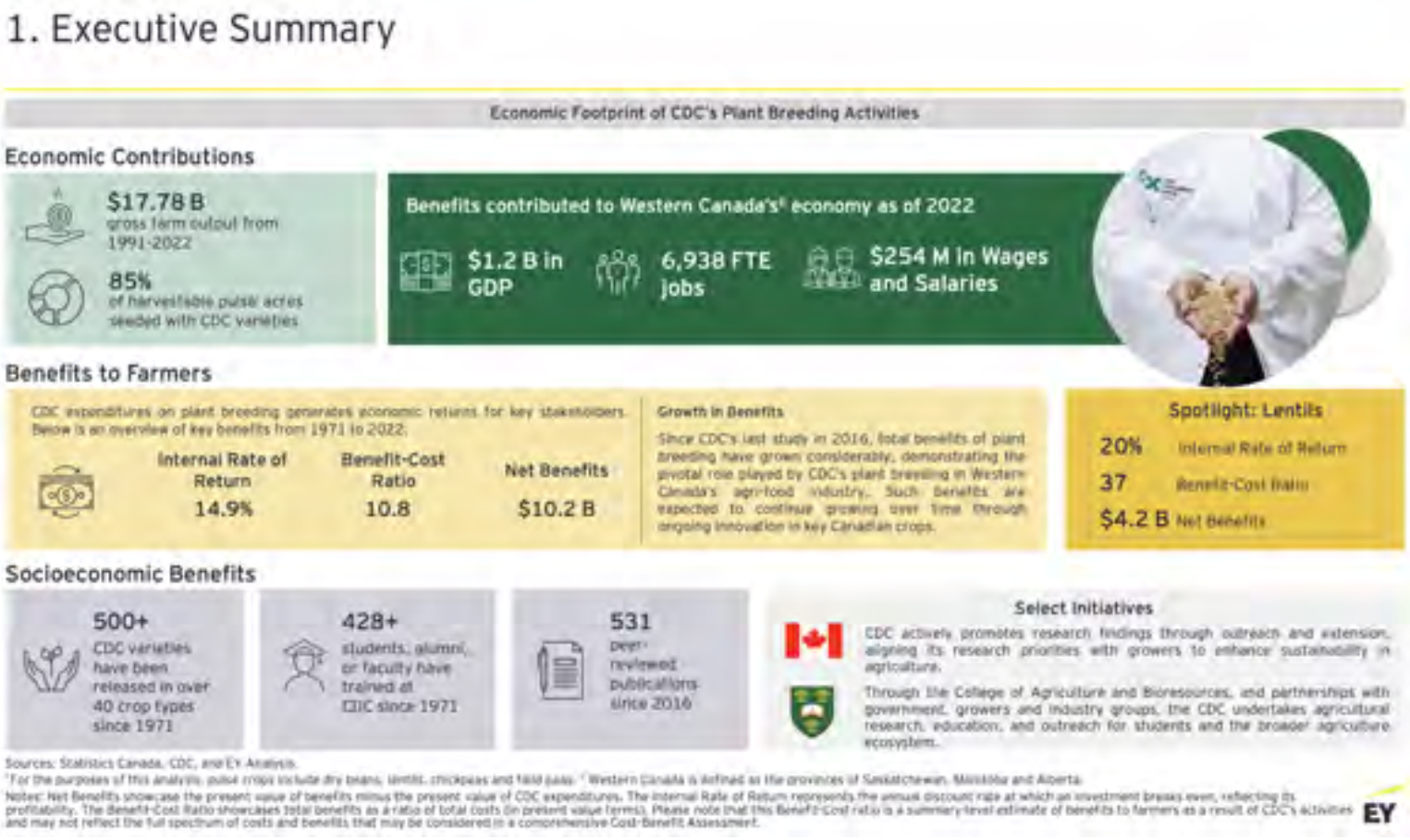
WGRF Wheat and Barley ROI

Table E.1: Producer Benefit/Cost Ratio and Internal Rate of Return for WGRF Wheat and Barley Investments 1995-2030 (2011 dollars)

Varietal	Benefits[a] ($ '000)		Costs[b] ($ '000)		Producer	
Type/Class	Producer	Total	Producer	Total	B/C[c]	IRR[d]
All Wheat	2,360,615	2,455,040	115,721	116,987	20.40	36%
CWRS	1,159,661	1,206,047	37,257	37,729	31.13	42%
CWHW	9,799	10,191	4,406	4,545	2.22	
CWAD	864,952	899,550	24,088	24,721	35.91	44%
CPS	-	-	24,877	24,877	-	
CWES	2,327	2,420	10,378	10,384	0.22	
CWRW	16,725	17,394	13,239	13,239	1.26	
CWSWS	41,801	43,473	1,471	1,497	28.42	
All Barley	171,945	181,058	22,758	23,553	7.56	28%
2-R Malt	75,476	79,476	11,598	12,012	6.51	26%

a. Total Surplus includes both producer and consumer benefits.
b. Producer Costs are those incurred by producers in developing WGRF funded varieties while total include the consumer's share.
c. Benefit/Cost Ratio for producers is the benefits that accrue to the producers divided by the share of the costs of R&D development that are borne by the producers.
d. Internal Rate of Return is the interest rate that equates the stream of benefits to the stream of costs.

Benefits of Crop Development Centre Breeding



1. Executive Summary

Economic Footprint of CDC's Plant Breeding Activities

Economic Contributions

$17.78 B
gross farm output from 1991-2022

85%
of harvestable pulse acres seeded with CDC varieties

Benefits contributed to Western Canada's[2] economy as of 2022

- **$1.2 B in GDP**
- **6,938 FTE jobs**
- **$254 M in Wages and Salaries**

Benefits to Farmers

CDC expenditures on plant breeding generates economic returns for key stakeholders. Below is an overview of key benefits from 1971 to 2022:

Internal Rate of Return	Benefit-Cost Ratio	Net Benefits
14.9%	10.8	$10.2 B

Growth in Benefits

Since CDC's last study in 2016, total benefits of plant breeding have grown considerably, demonstrating the pivotal role played by CDC's plant breeding in Western Canada's agri-food industry. Such benefits are expected to continue growing over time through ongoing innovation in key Canadian crops.

Spotlight: Lentils

- **20%** Internal Rate of Return
- **37** Benefit-Cost Ratio
- **$4.2 B** Net Benefits

Socioeconomic Benefits

500+
CDC varieties have been released in over 40 crop types since 1971

428+
students, alumni, or faculty have trained at CDC since 1971

531
peer-reviewed publications since 2016

Select Initiatives

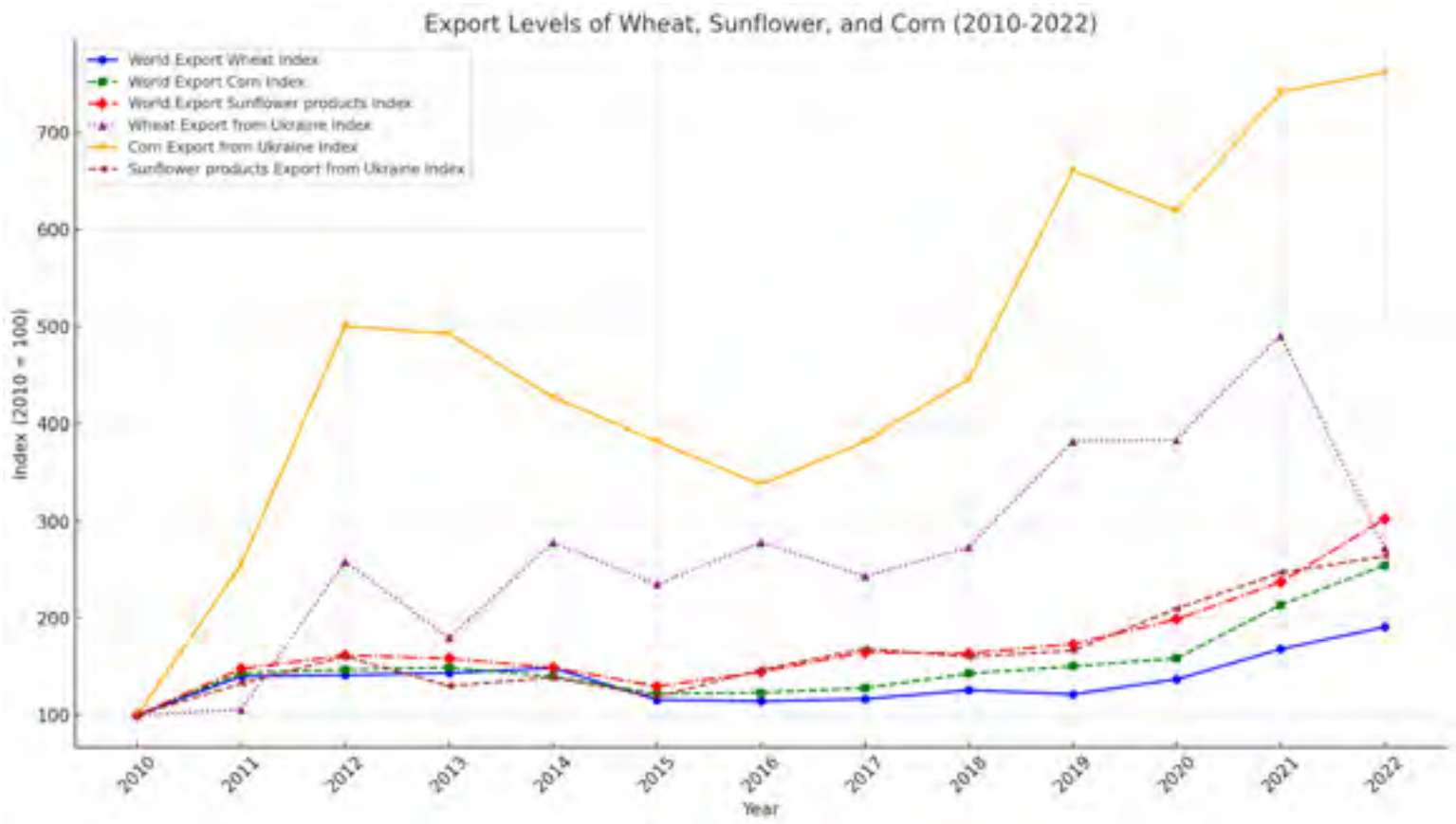
CDC actively promotes research findings through outreach and extension, aligning its research priorities with growers to enhance sustainability in agriculture.

Through the College of Agriculture and Bioresources, and partnerships with government, growers and industry groups, the CDC undertakes agricultural research, education, and outreach for students and the broader agriculture ecosystem.

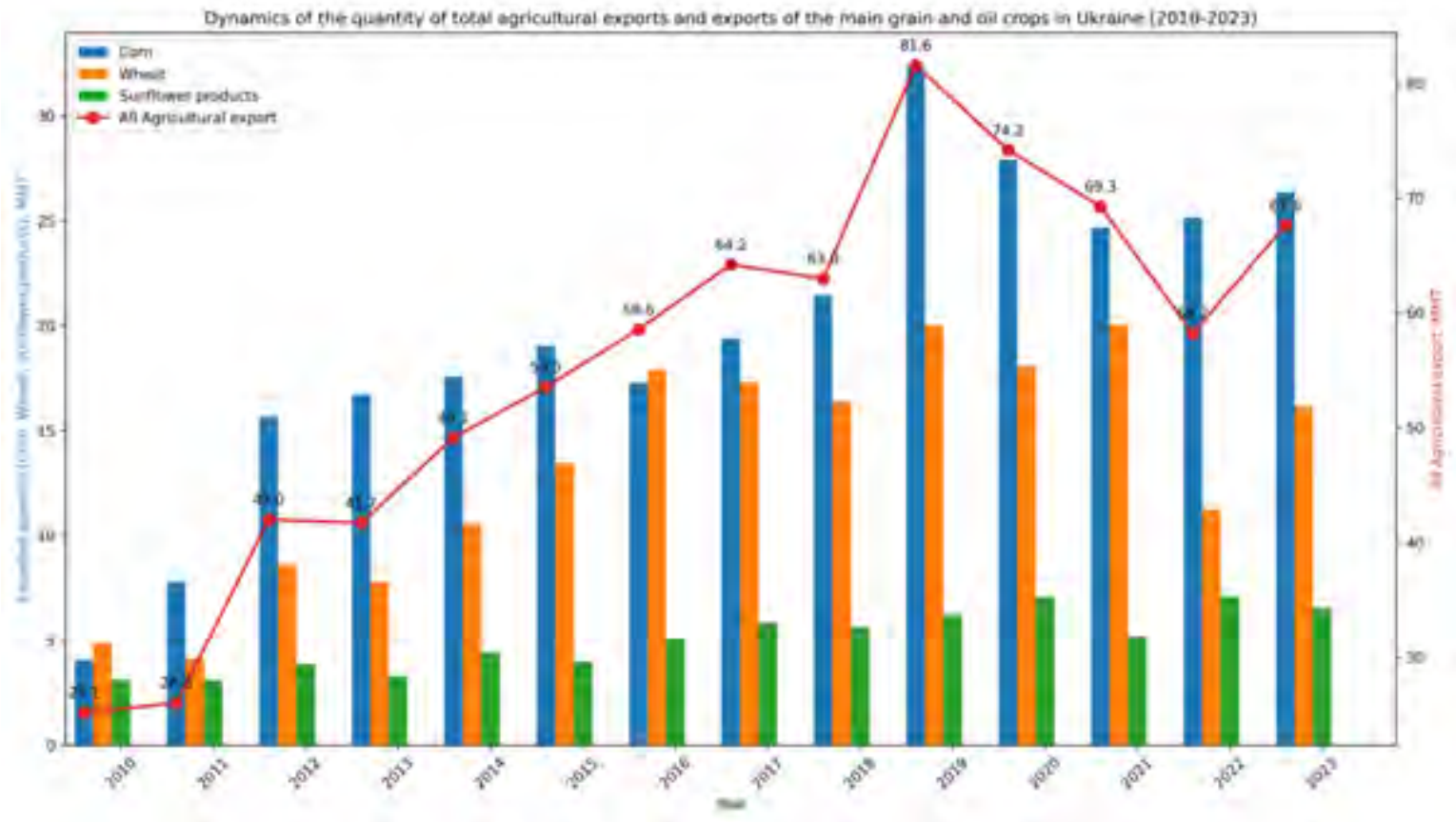
Sources: Statistics Canada, CDC, and EY Analysis.
[1] For the purposes of this analysis, pulse crops include dry beans, lentils, chickpeas and field peas. [2] Western Canada is defined as the provinces of Saskatchewan, Manitoba and Alberta.
Notes: Net Benefits showcase the present value of benefits minus the present value of CDC expenditures. The Internal Rate of Return represents the annual discount rate at which an investment breaks even, reflecting its profitability. The Benefit-Cost Ratio showcases total benefits as a ratio of total costs (in present value terms). Please note that this Benefit-Cost ratio is a summary-level estimate of benefits to farmers as a result of CDC's activities and may not reflect the full spectrum of costs and benefits that may be considered in a comprehensive Cost-Benefit Assessment.

EY

Export index of wheat, corn and sunflower products in the world and in Ukraine



Pre-war total agricultural export trends



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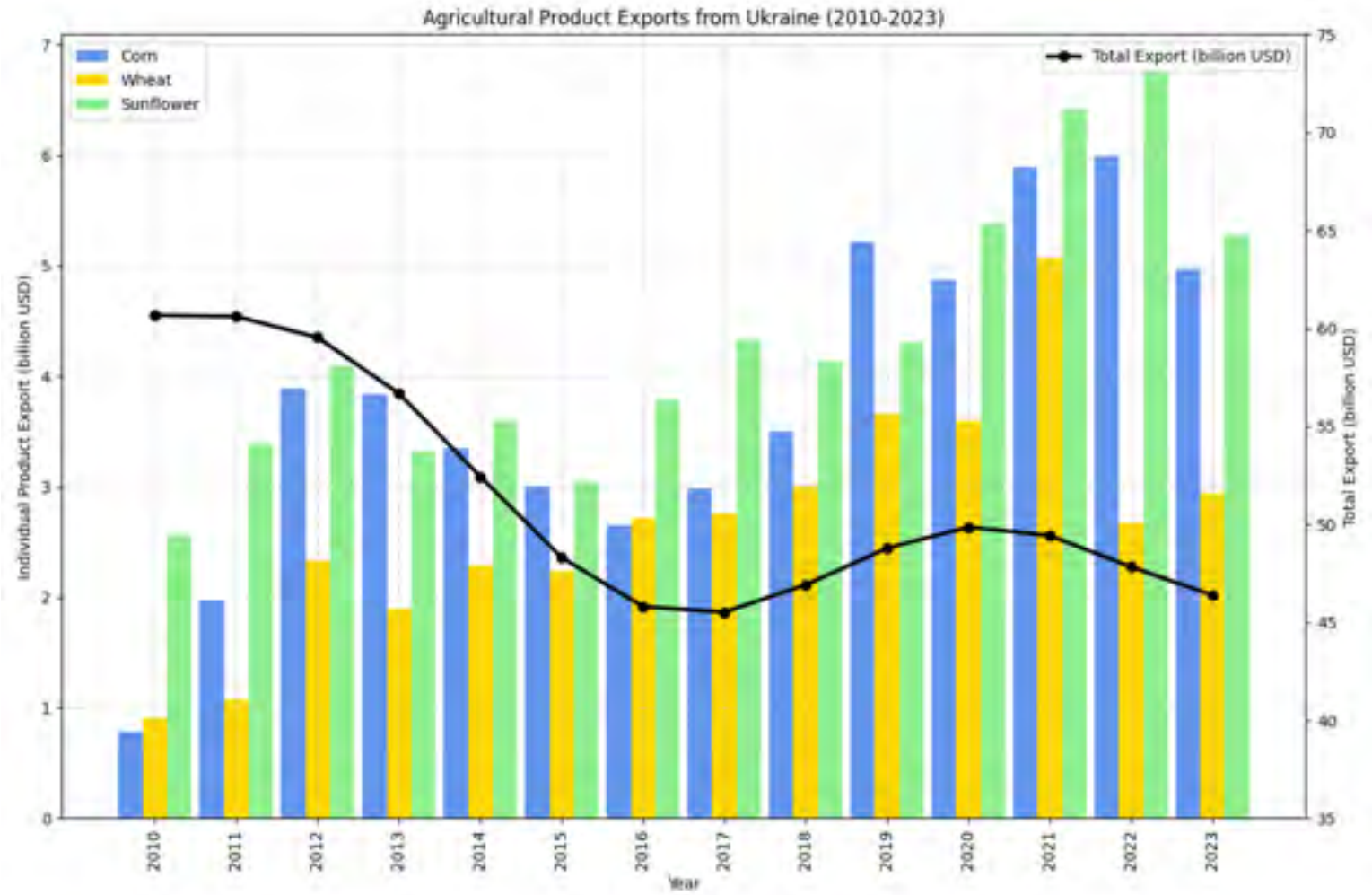
Trends in Ukrainian agricultural exports



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Impacts of the War on Ukraine's Ag Sector

- Loss of agricultural land
- Mining of farmland
- Theft of grain (billions of USD)
- Reduced profitability of Ukrainian producers
- Logistical challenges

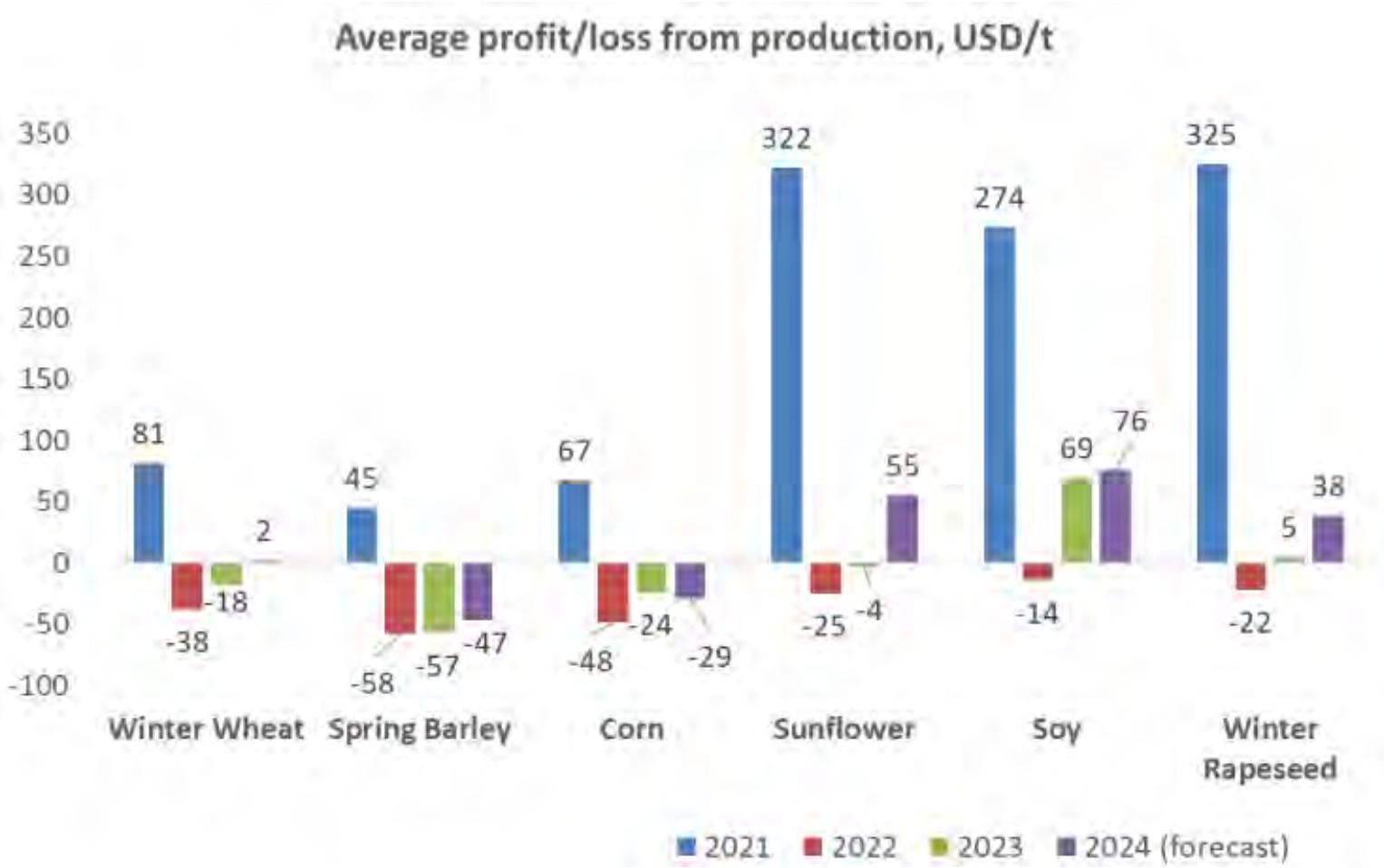
Destruction of Crops

Source: UkrInform

Damaged field near Izyum, Kharkiv region

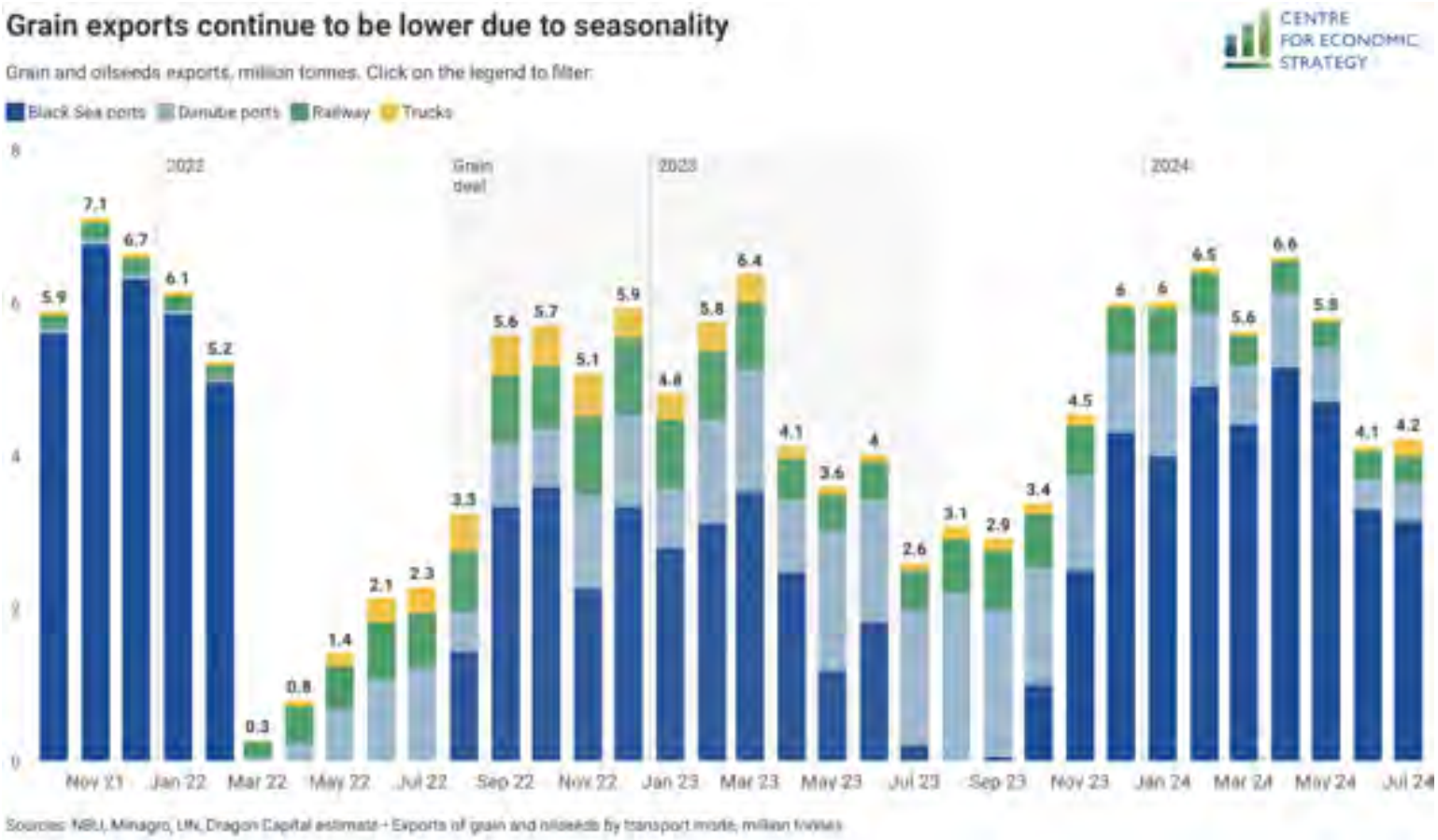
Source: MFA of Ukraine

Average Profit/Loss from Production of Major Grains and Oilseeds



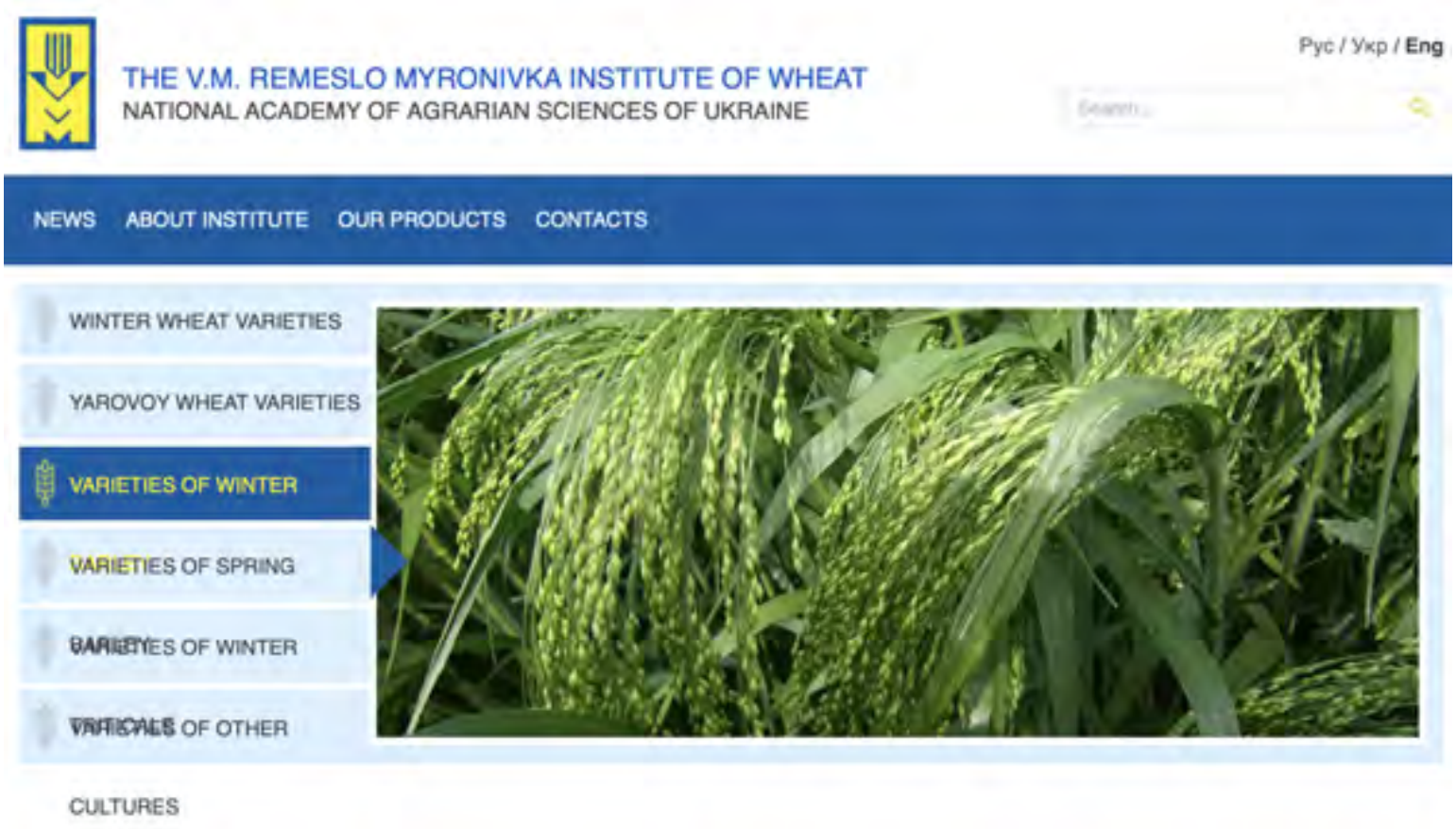
Source: USDA based on Ministry of Agrarian Policy and Food of Ukraine

Agricultural exports from 2022 - 2024

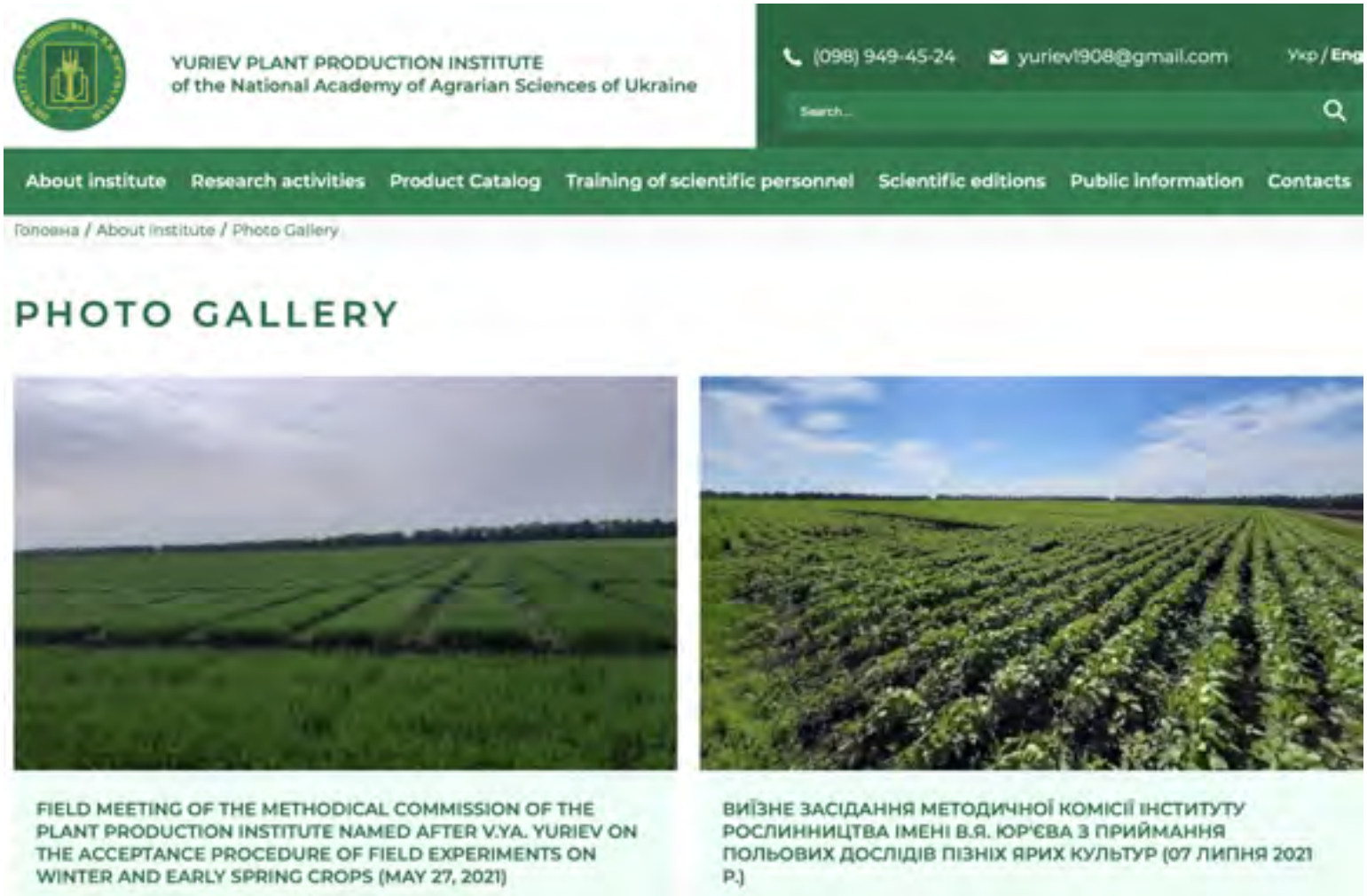


Source: CES

Myronivka Institute of Wheat



Yuriev Plant Production Institute



Relocation of Genebank

FAO and the EU support relocation of Ukraine's national seed collection to a secure site

28 April 2023

Unique plant genetic resources have been transported over a thousand kilometres from Kharkiv to the west of Ukraine.

Future Research

- **Proposals in Progress**
  - We are currently in the process of grant-writing to support future work on:
    - Improvements on our current models
    - Using ML forecasting and remote sensing to project winter wheat yields in Ukraine (collaboration with Plant Sciences);
    - Develop models to forecast wheat prices.
- **Other potential areas**
  - Forecasting non-agricultural exports
  - Incorporating agricultural exports over land routes
- **MITACS internship program**
  - Possibility to accept Ukrainian graduate students and postdocs for 6 months for internship

Questions?

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