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Consequences of the Russian-Ukraine War for the Wheat Industry

Stephen Devadoss and William Ridley

Selected presentation for the International Agricultural Trade Research Consortium's (IATRC's) 2022 Annual Meeting: Transforming Global Value Chains, December 11-13, 2022, Clearwater Beach, FL.

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Paper presented at the December 2022 IATRC conference in Clearwater Beach, Florida.

Introduction

- Russia's invasion of Ukraine began in February 2022
- Ukraine is the world's ninth largest producer and fifth largest exporter of wheat
- War hampered Ukraine's ability to harvest and export wheat
- Because of Covid and supply chain issues global wheat prices were already high
- War caused the wheat price to rise further

Introduction (Contd.)

Wheat Prices

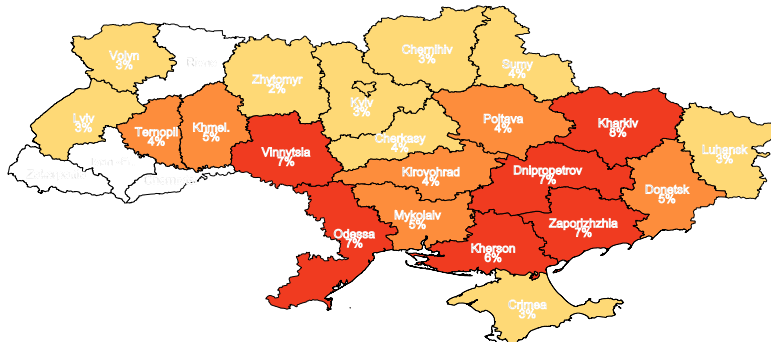


- Wheat prices rose 28% in the early phase of the war

Introduction (Contd.)

- Hard hit provinces: Donetsk, Luhansk, Kherson, Zaporizhzhia, and Kharkiv

Areas of Ukraine Wheat Production



- Attacks on ports along Black Sea (Odessa and Mariupol) hindered exports
- July Turkish-mediated negotiations allowed exports in bits and pieces

Objectives

1. Develop and implement a spatial equilibrium model (SEM) of global wheat production, consumption, and trade

2. Assess the impacts of the Russia-Ukraine war on international wheat markets

Global Wheat Market

- International wheat trade accounts for \$51.4 billion
 - Trails only soybeans in the ranking

Leading Wheat Producers, Exporters, and Importers

Production (million USD)		Exports (million USD)		Imports (million USD)	
China	49,074	Russia	7,918	Egypt	2,694
India	33,094	U.S.	6,318	Indonesia	2,616
Russia	14,581	Canada	6,318	Turkey	2,335
U.S.	9,143	France	4,529	China	2,260
Iran	8,868	Ukraine	3,594	Italy	2,039
Canada	6,399	Australia	2,698	Algeria	1,829
France	6,042	Germany	2,106	Philippines	1,573
Pakistan	5,876	Argentina	2,029	Japan	1,525
Ukraine	4,637	Kazakhstan	1,137	Nigeria	1,484
Turkey	4,392	Poland	1,047	Brazil	1,459
World	189,661	World	44,834	World	44,834

Global Wheat Market (Contd.)

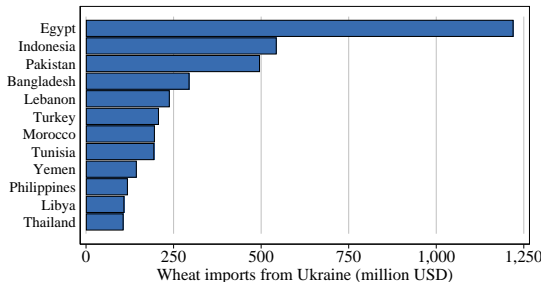
- Ukraine plays a vital role in the global wheat market

- Ukraine's wheat production was 19.5 million tons in 1992 compared to 24.9 million tons in 2020, a 27.6% increase

- Ukraine's wheat exports were 767 thousand tons in 1992, but 18.1 million tons in 2020, meteoric 2,259% increase

Global Wheat Market (Contd.)

Top Ten Importers of Ukrainian Wheat



- Asian, Middle Eastern, and African countries rely heavily on Ukrainian wheat
- Pakistan (49%), Lebanon (62%), Egypt (23%), Indonesia (26.2%)
- Given that wheat accounts for 20% of global caloric intake, the war has threatened global food security

Model

- Stylized three-region: Ukraine (U), a competing exporter (C), and the Rest of the World (ROW) importer (R):

$$S_i = S_i(P_i, \mathbf{Z}_i) \quad i = U, C, \text{ and } R \quad (1)$$

$$D_i = D_i(P_i, \mathbf{Y}_i) \quad i = U, C, \text{ and } R. \quad (2)$$

$$S_U(P_U, \mathbf{Z}_U) = D_U(P_U, \mathbf{Y}_U) + X_{UR} \quad (3)$$

$$S_C(P_C, \mathbf{Z}_C) = D_C(P_C, \mathbf{Y}_C) + X_{CR} \quad (4)$$

$$S_R(P_R, \mathbf{Z}_R) + X_{UR} + X_{CR} = D_R(P_R, \mathbf{Y}_R). \quad (5)$$

$$P_R = \left(P_U + \rho_i^{\bar{X}} \right) \tau_{UR} \quad (6)$$

$$P_R = P_C \tau_{CR}. \quad (7)$$

Analyses

$$dP_R = \frac{-\frac{\partial S_U}{\partial Z_U^1} dZ_U^1 - \left(\frac{\partial S_U}{\partial P_U} - \frac{\partial D_U}{\partial P_U}\right) dX_{UR} + dX_{UR}}{|A|},$$

$$|A| = \left(\frac{\partial S_U}{\partial P_U} - \frac{\partial D_U}{\partial P_U}\right) \left[\frac{1}{\tau_{CR}} \left(\frac{\partial S_C}{\partial P_C} - \frac{\partial D_C}{\partial P_C}\right) + \left(\frac{\partial S_R}{\partial P_R} - \frac{\partial D_R}{\partial P_R}\right)\right] > 0$$

- $\frac{-\frac{\partial S_U}{\partial Z_U^1} dZ_U^1}{|A|} > 0$, a reduction in Ukraine's wheat supply increases ROW price
- $\frac{-\left(\frac{\partial S_U}{\partial P_U} - \frac{\partial D_U}{\partial P_U}\right) dX_{UR}}{|A|} > 0$, Ukraine wheat-export limit increases ROW price
- $\frac{dX_{UR}}{|A|} < 0$, competing country's wheat exports lower ROW prices

Analyses (Contd.)

$$\bullet dX_{CR} = \frac{-\frac{1}{\tau_{CR}} \left(\frac{\partial S_C}{\partial P_C} - \frac{\partial D_C}{\partial P_C} \right) \left(\frac{\partial S_U}{\partial P_U} - \frac{\partial D_U}{\partial P_U} \right) dX_{UR}}{|A|} > 0$$

$$\bullet dP_C = -\frac{\frac{\partial S_U}{\partial Z_U^1} dZ_U^1 - \left(\frac{\partial S_U}{\partial P_U} - \frac{\partial D_U}{\partial P_U} \right) dX_{UR} + dX_{UR}}{|A| \tau_{CR}} > 0$$

Spatial Wheat Equilibrium Model

- $p_i^S = v_i + \eta_i Q_i^S, \quad i = 1, \dots, n$
- $p_i^D = \lambda_i - \omega_i Q_i^D, \quad i = 1, \dots, n$

- SEM objective function: net social monetary gains

$$\sum_{i=1}^n (\lambda_i - \omega_i Q_i^D) Q_i^D - \sum_{i=1}^n (v_i + \eta_i Q_i^S) Q_i^S - \sum_{i=1}^n \sum_{j=1}^n X_{ij} T_{ij} - \sum_{i,j} X_{ij} (\rho_j^D - \rho_i^S) + \sum_{i,j} X_{ij} \left(\frac{\rho_j^D}{1 + \tau_{ij}} - \rho_i^S \right)$$

Spatial Wheat Equilibrium Model (Contd.)

- Excess demand constraint: $\sum_{i=1}^n X_{ij} \geq Q_j^D \quad \forall j$
- Excess supply constraint: $\sum_{j=1}^n X_{ij} \leq Q_i^S \quad \forall i$
- Export limits: $\sum_{j=1}^n X_{ij} \leq \bar{X}_i \quad \forall i$
- Optimal consumption constraint: $p_i^D = (\lambda_i - \omega_i Q_i^D) \leq \rho_i^D \quad \forall i$
- Optimal supply constraint: $p_i^S = v_i + \eta_i Q_i^S \geq \rho_i^S \quad \forall i$
- Spatial arbitrage: $(\rho_i^S + T_{ij} + \rho_i^{\bar{X}}) (1 + \tau_{ij}) \geq \rho_j^D \quad \forall ij$
- Non-negativity constraints:
 $Q_i^D \geq 0, \quad Q_i^S \geq 0, \quad X_{ij} > 0, \quad \rho_i^S \geq 0, \quad \rho_i^D \geq 0, \text{ and } \rho_i^{\bar{X}} \geq 0$

Data and Countries

- 42 wheat-producing and -consuming countries/regions
 - 34 distinct countries and 8 regional aggregations

Countries Included in the Model

Country	Code	Country	Code	Country	Code
Afghanistan	AFG	India	IND	Spain	ESP
Algeria	DZA	Iran	IRN	Turkey	TUR
Argentina	ARG	Iraq	IRQ	Ukraine	UKR
Australia	AUS	Italy	ITA	United Kingdom	GBR
Bangladesh	BGD	Japan	JPN	United States	USA
Brazil	BRA	Kazakhstan	KAZ	Uzbekistan	UZB
Canada	CAN	Morocco	MOR	Rest of Asia/Oceania	XAO
China	CHN	Mexico	MEX	Rest of Central Asia	XCA
Egypt	EGY	Nigeria	NGA	Rest of East Asia	XEA
Ethiopia	ETH	Pakistan	PAK	Rest of Middle East	XME
France	FRA	Philippines	PHL	Rest of Central America	XOC
Germany	DEU	Poland	POL	Rest of Europe	XOE
Hungary	HUN	Romania	ROU	Rest of South America	XOS
Indonesia	IDN	Russia	RUS	Rest of Sub-Saharan Africa	XSS

Simulation Analysis

- Two simulations are conducted: baseline and alternate.
- The baseline simulation incorporates key policies in the wheat market pre-Russia-Ukraine War
- The alternate simulation incorporates Ukrainian wheat supply reduction and limited exports due to Russia-Ukraine War
- The 2022 FAS forecast of Ukraine's total quantity of wheat production is 19.4 million metric tons (MT)
- This reflects a decline of roughly 29% relative to the 2021 quantity of production (27.3 million MT)
- We employ the FAS forecast to restrict the total quantity of Ukrainian wheat exports to 10,000 TMT

Simulation Results

- In Ukraine, the wheat supply reduction of 7,923.82 TMT and limited exports of 10,000 TMT causes domestic prices to fall by 26.69%
- The largest price increases are seen in many importing countries (Egypt, Iran, Iraq, Uzbekistan, Mexico, Central America and Caribbean countries, and Rest of Middle East-North Africa countries)
- Price increases in the global wheat market (aside from Ukraine) are only in the range of 1.86% to 2.46%
- This is because Ukraine's share of total wheat exports is only 8% (for 2021)
- A reduction of 8,800 TMT in Ukraine's wheat exports for 2022 is only around 1% of global wheat production and therefore scarcely affects the price

Simulation Results (Contd.)

- Ukrainian wheat exports lost by many traditionally importing countries (such as Egypt, Iran, and Iraq) are replaced by wheat from other large exporters, such as the United States, Canada, and Australia
- Ukraine exports to Egypt fell by 5,030.00 TMT, to Iran by 64.97 TMT, and to Rest of Middle East by 5,003.70 TMT
- The largest increases in wheat production were seen in Russia (769.18 TMT), Canada (579.48 TMT), the United States (390.48 TMT), India (386.90 TMT), and the Rest of Europe (300.10 TMT)
- The wheat production increase in all countries sums to 3,943.74 TMT, which is less than the reduction in Ukrainian wheat supply of 7,923.82 TMT
- Russia exports more wheat to Egypt (4,830.21 TMT) and to Rest of Middle East-North Africa (4,856.54 TMT)

Simulation Results (Contd.)

- Considerable reallocations are occurring in the other countries also
- Canada significantly increases its exports to Rest of East Asia (2,871.09 TMT) but reduces its sales to China, India, Indonesia, and Rest of Asia/Oceania
- The United States diverts its exports from Turkey (3,114.90 TMT) to Rest of East Asia (3,456.54 TMT), Rest of Asia/Oceania (288.98 TMT), and Indonesia (237.92 TMT)
- Because of shortage in the world market and higher prices, demand is lower in both importing and exporting countries, except Ukraine

Simulation Results (Contd.)

- Notable importing countries that suffer from high prices and reduced imports are Egypt, Rest of Middle East-North Africa, and Rest of Sub-Saharan Africa, all countries generally prone to food insecurity
- Major demand reductions are observed in Russia (1,111.67 TMT), Rest of Europe (588.02 TMT), India (370.82 TMT), United States (361.25 TMT), and China (353.08TMT)
- Ukraine endures the largest producer surplus loss (\$1.39 billion).
- However, producers in all other countries gain, particularly major wheat-producing and -exporting countries, which include, China, India, Russia, United States, Rest of Europe, Canada, France, Germany, and Australia

Simulation Results (Contd.)

- Examination of net welfare clearly indicates that most countries lose welfare except for few wheat-exporting countries such as Russia, Canada, United States, Australia, Argentina, and France
- It's not surprising that Russia benefits from the war, as it is able to sell much of its wheat in the world market at the expense of Ukraine
- Ukraine incurs a net welfare loss of around \$248.5 million in total surplus, whereas Russia gains \$322.3 million in total surplus
- Leading wheat-consuming and -producing countries, notably, Egypt, China, and Rest of Middle East-North Africa, incur significant welfare loss