Russian-Ukraine Conflict and the Global Food Grain Price Analysis

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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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Organized Session

IATRC Conference 2022

December 12, 2022

Note: Results presented here are from a forthcoming paper in Choices Magazine Journal

Motivation & the Problem

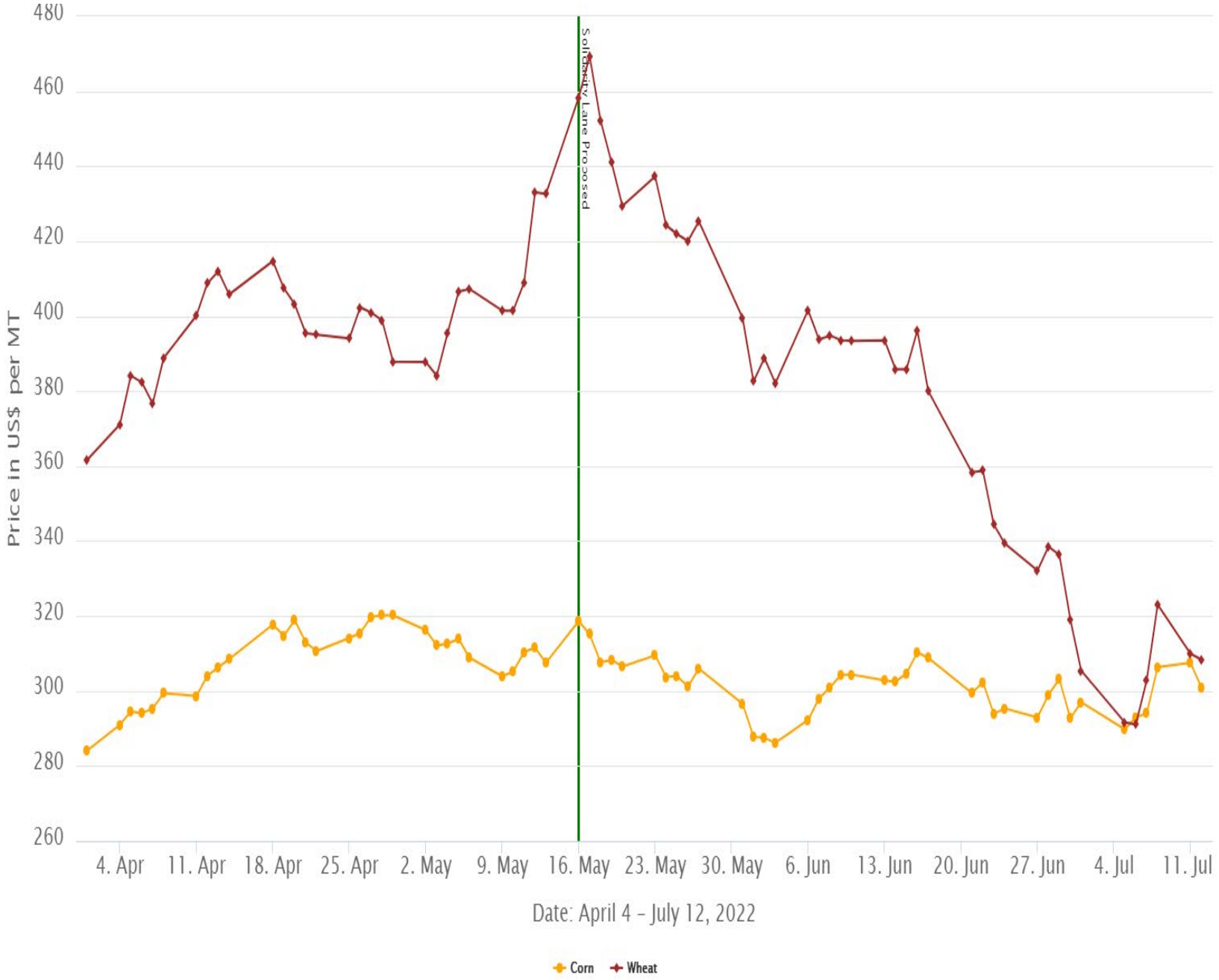
- The Russian invasion of Ukraine started on February 24th , 2022.
- Initially started as a "Special Military Operation" and ended up being a full-blown war.
- Food & Agriculture:
  - Numerous other developments were evolving to impact ag trade, just prior to the invasion
  - Ag became an integral major focal point for the immediate (and longer-term) impacts
  - 22 MMT of food grains (corn, wheat, sunflower) were stuck (in spring 2022) in silos due to ports closure in Ukraine as a result of war.
- Purpose:
  - What would be the price impact if these additional grain (6.8 MMT of corn, 5.6 MMT of wheat) flows into the international market with the reopening of ports?
  - We use two methods:
    - Equilibrium displacement model,
    - short- and long-term option-based market scenarios for prices and distribution of prices.

Solidarity Lane

- Efforts to create the Grain Corridor (Solidarity Lanes) commenced on May 16
- Immediately US prices fell sharply, in anticipation of concurrence
  - Futures fell sharply, particularly for wheat
  - Export FOB basis values fell similarly
  - Price changes after May 16:
    --Futures fell by 300c/b (or more)
    --Basis declined from 270 to 140 (130c/b)

    Total change: 265c/b (97$/mt), or, 18%

Source: DTN ProphetX, and AgriCensus



Equilibrium Displacement Model

- Demand System:

$$EQ_{U,D} = \eta_U EP_U - \eta_U \delta_U$$

$$EQ_{W,D} = \eta_W EP_W - \eta_W \delta_W$$

- Supply System:

$$EQ_{U,S} = \varepsilon_U EP_U - \varepsilon_U k_U$$

$$EQ_{W,S} = \varepsilon_W EP_W - \varepsilon_W k_W$$

- Market Clearing Condition:

$$\left(\frac{Q_{U,S}}{Q_{W,S}}\right) EQ_{U,S} + \left(\frac{Q_{W,S}}{Q_{U,S}}\right) EQ_{W,S} = \left(\frac{Q_{U,D}}{Q_{W,D}}\right) EQ_{U,D} + \left(\frac{Q_{W,D}}{Q_{U,D}}\right) EQ_{W,D}$$

- Price:

$$EP_U = EP_W \text{ or } EP_U - EP_W = 0$$

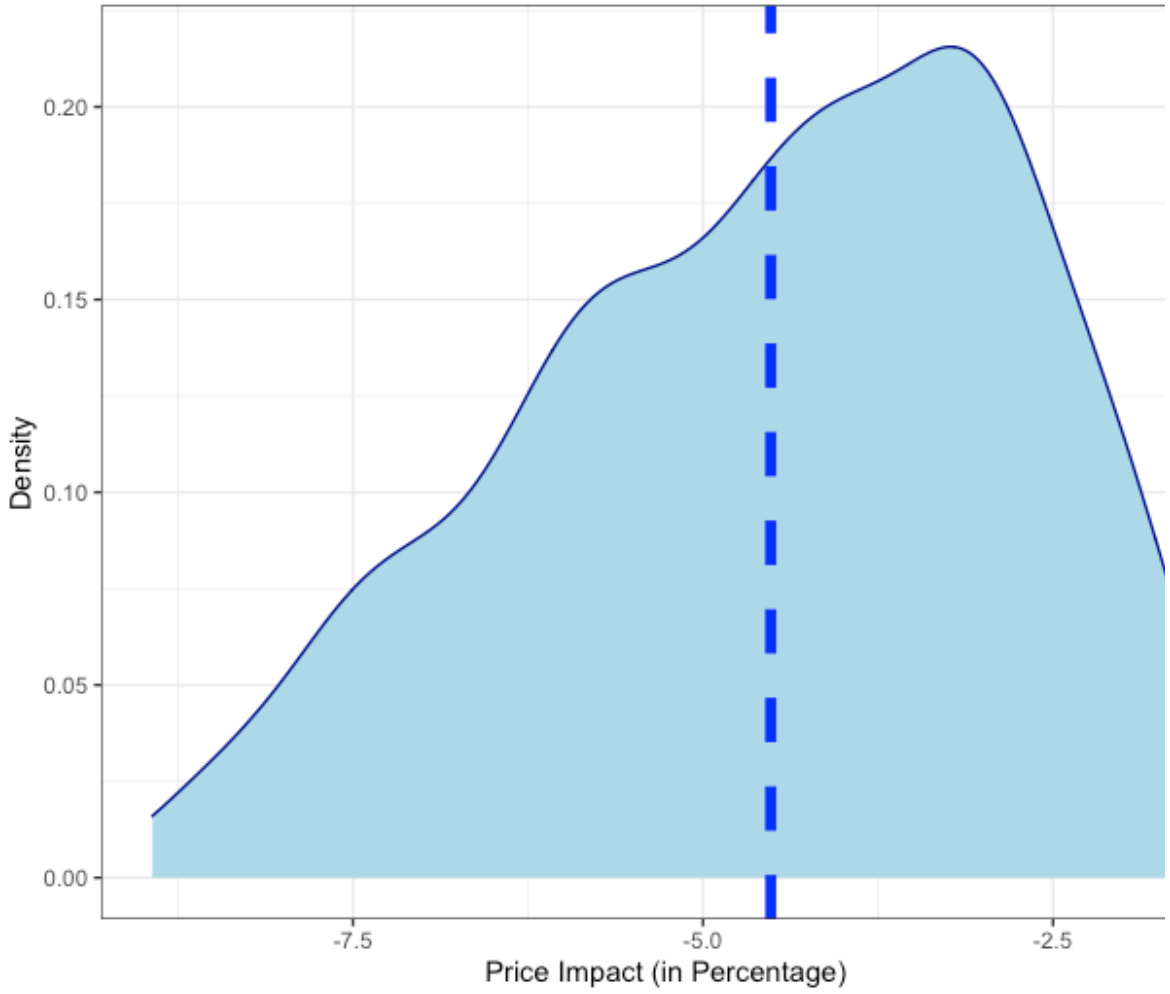
Elasticity Ranges Used for ED Analysis

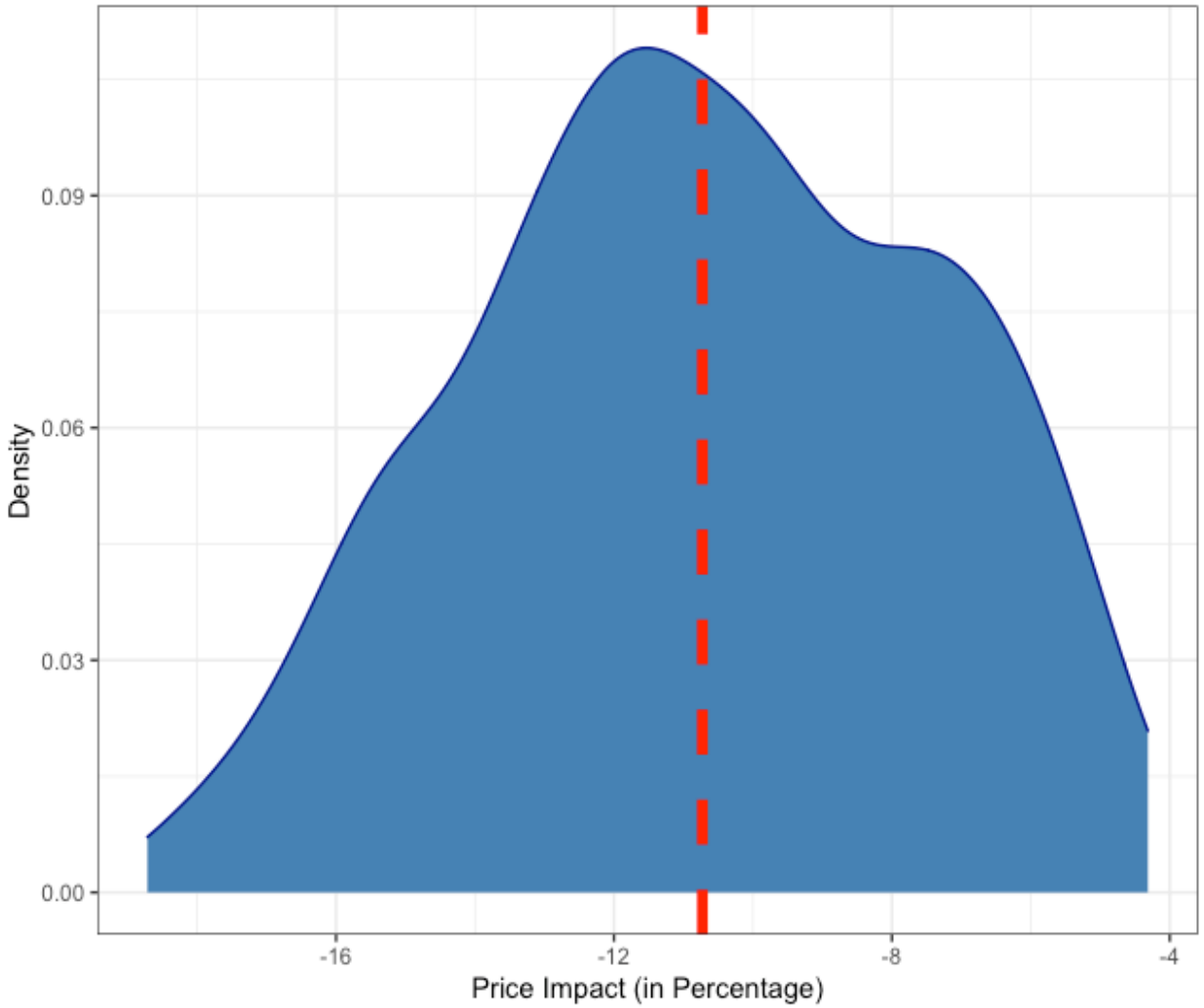
Source: Commodity and Food Elasticities Database (USDA) and industry experts

	Corn		Wheat	
	Supply Elasticity	Demand Elasticity	Supply Elasticity	Demand Elasticity
Ukraine	0.25 – 0.35	-0.50 – -0.35	0.40 – 0.50	-0.57 – -0.35
World	0.15 – 0.25	-0.60 – -0.30	0.35 – 0.40	-0.50 – -0.30

EDM Results (percentage reduction in prices)

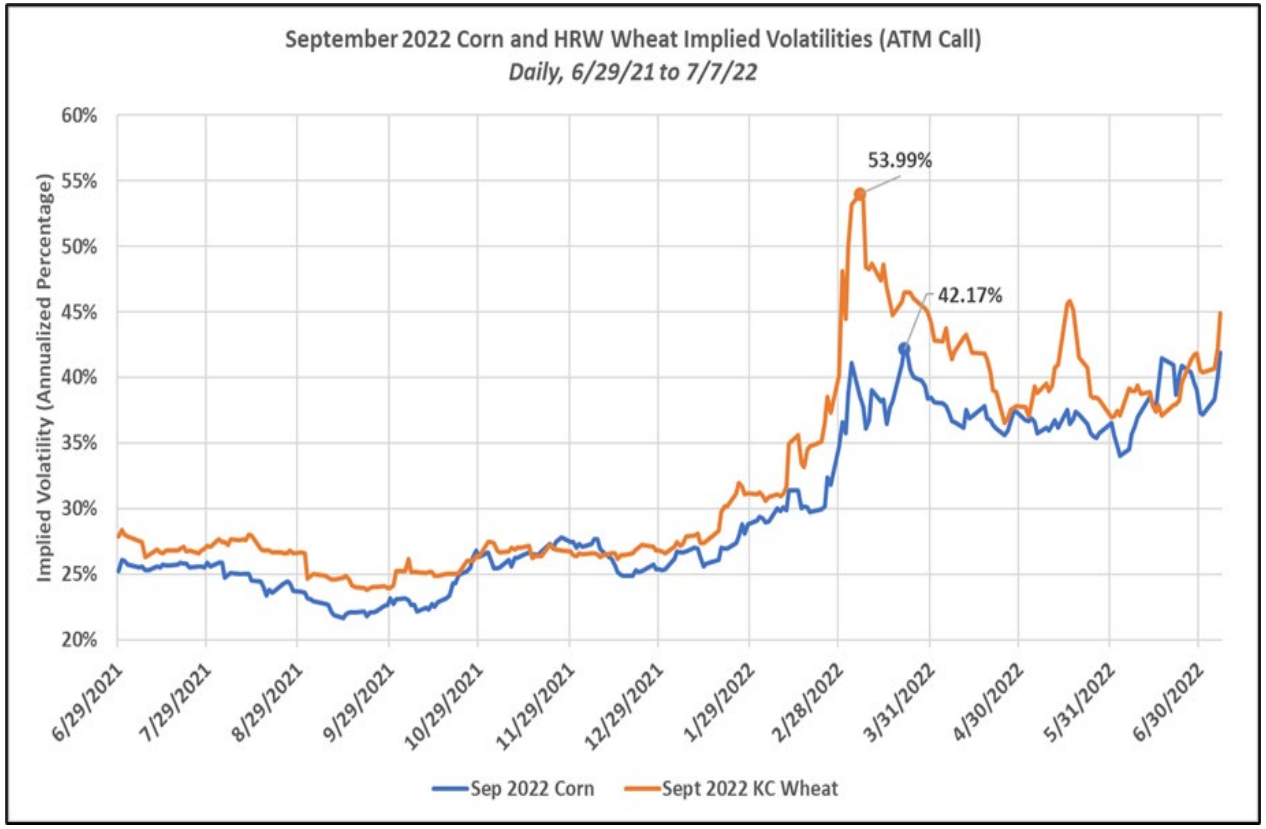
- Corn (-4% on avg, -2 to -8%)
- Wheat (-11% on avg, -5 to -17%)





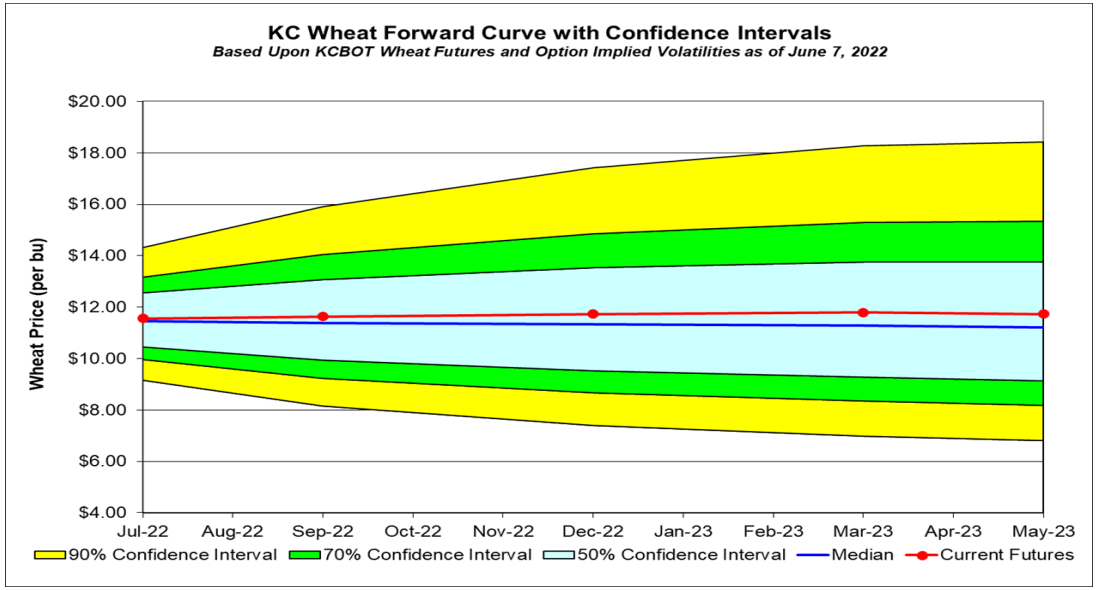
Short and Long-Term Option-Based Market Scenarios for Corn and Wheat Prices

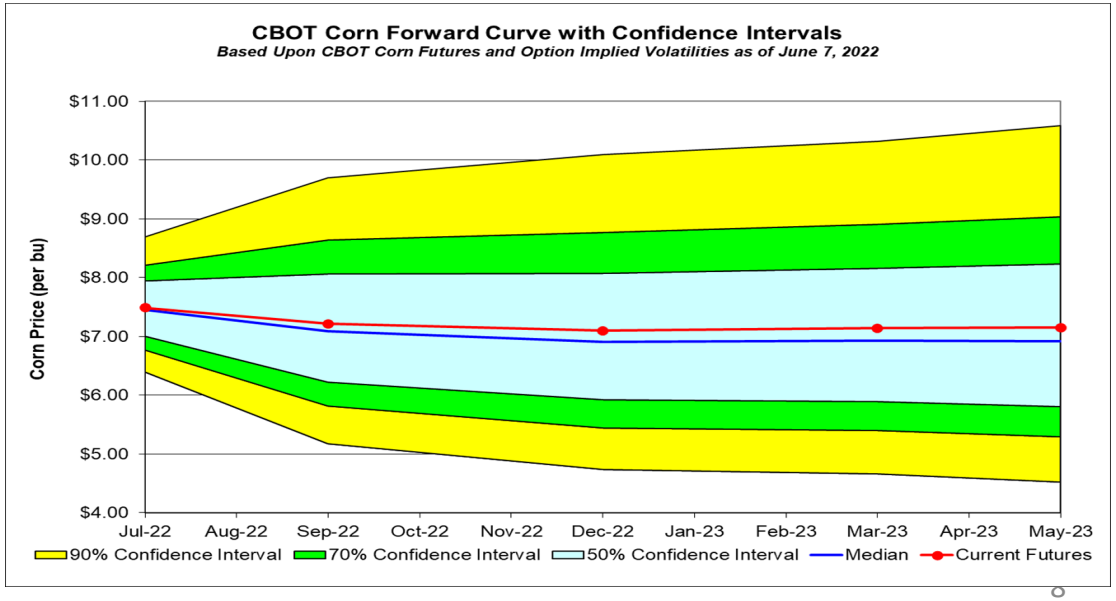
- Futures and options can also be used to generate price impacts;
  - Options Implied Volatilities (IV) can be used to create projected distributions of prices
- Implied volatilities
  - Increased substantially at beginning of the invasion (from normal values about .15
  - IV's moderated down, but, remained elevated through the negotiations which were completed July 14 (and then renegotiated for the 2nd round on Nov 19)



Implications of Forward Curve Projections

- KC wheat results: maximum downside potential
  - Next month: between $2.40 to $3.10 (5th and 1st percentiles)
  - 6 months forward: drop increases to $4.35 to $5.55
- CBOT corn results: maximum downside potential
  - Next month: between $1.10 to $1.50 (5th and 1st percentiles)
  - 6 months forward: a drop of between $2.35 to $3.05
- Results: place some downside limits to the likely price impact given current information.





Results

- **Objective:** Analyze price impact on global corn and wheat prices as a result of Ukraine grain exports flowing into global market due to reopening of ports (22 mmt)
- For each MMT of Ukraine grain flowing into global market, the global price will decline by 0.62% for corn and 1.96% for wheat.
- Wheat: greater price decline ranging between 5-17%
- Corn: price decline by about 2-8%.
- Much of the change was already reflected in option premiums and implied volatilities.
- Implied volatilities elevated to extremely high values during the war, in anticipation of increased risk
- Results suggest (from July 7):
  - Wheat: from a spot price of $9.12,
    - there is a 5% chance that prices could fall below $5.75 (decline of $3.37) by mid-December and could fall below $5.18 (decline of $3.94) by mid-May 2023.
  - Corn: from a spot price of $7.35
    - there is a 5% chance that prices could fall below $3.92 (decline of $3.43) by mid-December 2022 and could fall below $3.73 (decline of $3.62) by mid-May 2023.

Implications

- Russian invasion has had a significant impact on global food grain prices (futures, basis and freight), threatening food security and food inflation globally, especially impacting poor countries.
- Numerous outstanding and evolving issues, including
  - Development of alternative routes come at a greater costs, but are an option to the now constrained Grain Corridor (Odessa area ports)
  - Higher cost of exporting and more restricted capacities than traditional
  - Escalation in volatility in both futures and basis will result in greater risk for market participants, and many opportunities for trading firms with concurrent increased profits.
  - Emerging trade policy developments will have corresponding impacts on international grain flows (e.g., Chines phyto for Brazil corn; relaxation on EU policies potentially on import tariffs from Ukr, and GM content; among others)

Thank you!!

Ukraine's Historical Exports and Prospective Increase Due to Port Opening

	Normal Exports (MMT)	Prospective increase in exports due to port opening (MMT)	% Change in Exports
Corn			
Minimum	9	6.8	75
Mean	20	6.8	34
Maximum	30	6.8	23
Wheat			
Minimum	7	5.6	80
Mean	15	5.6	37
Maximum	21	5.6	27

Forecasting Using Black-Scholes and Market Prices

- *Option implied volatility (iv)* – the volatility estimate derived by finding the estimate that sets the option pricing model (Black-76) equal to the market premium.
- The forward standard deviation (σ) can be derived for any forecasted time period (*t* in years) by the following equation:

$$\sigma = \sqrt{t} \cdot iv \cdot f \text{ where } f \text{ is the current futures price.}$$

- The forward curve can be constructed by plugging the current futures price (*f*) as the mean (μ) and the implied standard deviation (σ) into a lognormal(μ,σ) distribution for the specific futures maturity.
- Any time gaps in the futures forward curve (corn, soybeans, etc.) can be filled in by using linear interpolation functions on the simulated maturities.

KC Wheat Futures Forward Curve – June 7th, 2022

Today's Date	6/7/2022				
Forward Month	Jul-22	Sep-22	Dec-22	Mar-23	May-23
Futures Expiry Date	7/15/2022	9/15/2022	12/15/2022	3/15/2023	5/15/2023
Futures Price	$ 11.5550	$ 11.6250	$ 11.7325	$ 11.7850	$ 11.7275
Implied Volatility	42.12%	39.13%	36.62%	34.09%	32.00%
Days to Expiry	38	100	191	281	342
Years to Expiry	0.104	0.274	0.523	0.770	0.937
Implied St. Deviation	$ 1.5704	$ 2.3807	$ 3.1080	$ 3.5250	$ 3.6326

KC Wheat Price Distribution (per bushel)

	Forward Month (as of 15th of month)				
Percentile	**Jul-22**	**Sep-22**	**Dec-22**	**Mar-23**	**May-23**
1%	$ 8.3582	$ 7.1070	$ 6.1880	$ 5.7145	$ 5.5399
5%	$ 9.1655	$ 8.1598	$ 7.3897	$ 6.9761	$ 6.8091
10%	$ 9.6272	$ 8.7833	$ 8.1230	$ 7.7589	$ 7.6006
15%	$ 9.9518	$ 9.2307	$ 8.6585	$ 8.3361	$ 8.1859
20%	$ 10.2176	$ 9.6025	$ 9.1091	$ 8.8253	$ 8.6831
25%	$ 10.4512	$ 9.9334	$ 9.5143	$ 9.2678	$ 9.1337
30%	$ 10.6656	$ 10.2402	$ 9.8936	$ 9.6840	$ 9.5582
35%	$ 10.8682	$ 10.5330	$ 10.2585	$ 10.0864	$ 9.9692
40%	$ 11.0640	$ 10.8186	$ 10.6172	$ 10.4837	$ 10.3755
45%	$ 11.2567	$ 11.1022	$ 10.9762	$ 10.8830	$ 10.7843
50%	$ 11.4497	$ 11.3886	$ 11.3413	$ 11.2907	$ 11.2024
55%	$ 11.6461	$ 11.6824	$ 11.7186	$ 11.7138	$ 11.6367
60%	$ 11.8490	$ 11.9887	$ 12.1148	$ 12.1599	$ 12.0952
65%	$ 12.0624	$ 12.3138	$ 12.5384	$ 12.6389	$ 12.5882
70%	$ 12.2915	$ 12.6658	$ 13.0009	$ 13.1640	$ 13.1294
75%	$ 12.5437	$ 13.0571	$ 13.5191	$ 13.7553	$ 13.7396
80%	$ 12.8305	$ 13.5070	$ 14.1206	$ 14.4450	$ 14.4526
85%	$ 13.1732	$ 14.0510	$ 14.8554	$ 15.2927	$ 15.3304
90%	$ 13.6173	$ 14.7667	$ 15.8347	$ 16.4303	$ 16.5111
95%	$ 14.3033	$ 15.8952	$ 17.4060	$ 18.2739	$ 18.4303
99%	$ 15.6847	$ 18.2497	$ 20.7863	$ 22.3084	$ 22.6526

KC Wheat Price Change Distribution (per bushel)

	Forward Month (as of 15th of month)				
Percentile	**Jul-22**	**Sep-22**	**Dec-22**	**Mar-23**	**May-23**
1%	$ (3.1968)	$ (4.5180)	$ (5.5445)	$ (6.0705)	$ (6.1876)
5%	$ (2.3895)	$ (3.4652)	$ (4.3428)	$ (4.8089)	$ (4.9184)
10%	$ (1.9278)	$ (2.8417)	$ (3.6095)	$ (4.0261)	$ (4.1269)
15%	$ (1.6032)	$ (2.3943)	$ (3.0740)	$ (3.4489)	$ (3.5416)
20%	$ (1.3374)	$ (2.0225)	$ (2.6234)	$ (2.9597)	$ (3.0444)
25%	$ (1.1038)	$ (1.6916)	$ (2.2182)	$ (2.5172)	$ (2.5938)
30%	$ (0.8894)	$ (1.3848)	$ (1.8389)	$ (2.1010)	$ (2.1693)
35%	$ (0.6868)	$ (1.0920)	$ (1.4740)	$ (1.6986)	$ (1.7583)
40%	$ (0.4910)	$ (0.8064)	$ (1.1153)	$ (1.3013)	$ (1.3520)
45%	$ (0.2983)	$ (0.5228)	$ (0.7563)	$ (0.9020)	$ (0.9432)
50%	$ (0.1053)	$ (0.2364)	$ (0.3912)	$ (0.4943)	$ (0.5251)
55%	$ 0.0911	$ 0.0574	$ (0.0139)	$ (0.0712)	$ (0.0908)
60%	$ 0.2940	$ 0.3637	$ 0.3823	$ 0.3749	$ 0.3677
65%	$ 0.5074	$ 0.6888	$ 0.8059	$ 0.8539	$ 0.8607
70%	$ 0.7365	$ 1.0408	$ 1.2684	$ 1.3790	$ 1.4019
75%	$ 0.9887	$ 1.4321	$ 1.7866	$ 1.9703	$ 2.0121
80%	$ 1.2755	$ 1.8820	$ 2.3881	$ 2.6600	$ 2.7251
85%	$ 1.6182	$ 2.4260	$ 3.1229	$ 3.5077	$ 3.6029
90%	$ 2.0623	$ 3.1417	$ 4.1022	$ 4.6453	$ 4.7836
95%	$ 2.7483	$ 4.2702	$ 5.6735	$ 6.4889	$ 6.7028
99%	$ 4.1297	$ 6.6247	$ 9.0538	$ 10.5234	$ 10.9251

CBOT Corn Futures Forward Curve – June 7th, 2022

Today's Date	6/7/2022				
Forward Month	Jul-22	Sep-22	Dec-22	Mar-23	May-23
Futures Expiry Date	7/15/2022	9/15/2022	12/15/2022	3/15/2023	5/15/2023
Futures Price	$ 7.4900	$ 7.2150	$ 7.0976	$ 7.1400	$ 7.1500
Implied Volatility	28.96%	36.85%	32.22%	27.98%	27.19%
Days to Expiry	38	100	191	281	342
Years to Expiry	0.104	0.274	0.523	0.770	0.937
Implied St. Deviation	$ 0.6998	$ 1.3915	$ 1.6540	$ 1.7529	$ 1.8815

CBOT Corn Price Distribution (per bushel)

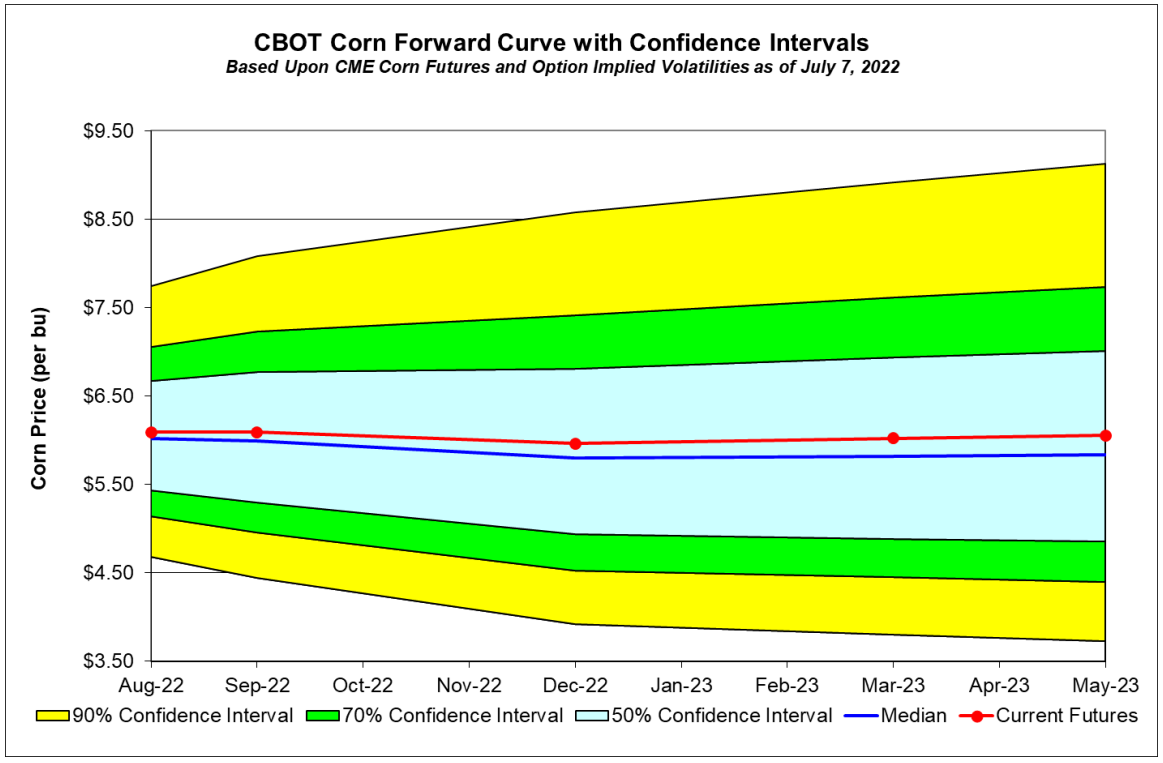
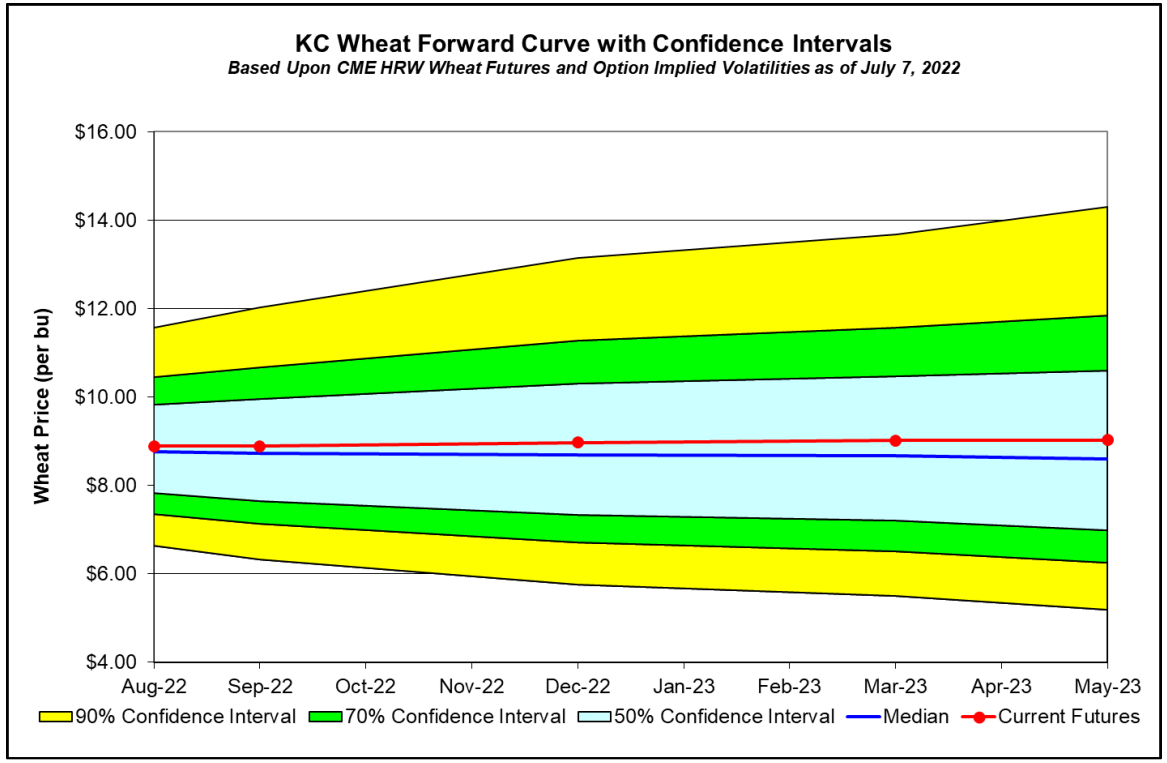
	Forward Month (as of 15th of Month)				
Percentile	**Jul-22**	**Sep-22**	**Dec-22**	**Mar-23**	**May-23**
1%	$ 6.0035	$ 4.5418	$ 4.0485	$ 3.9498	$ 3.7874
5%	$ 6.3973	$ 5.1736	$ 4.7354	$ 4.6577	$ 4.5178
10%	$ 6.6177	$ 5.5455	$ 5.1480	$ 5.0856	$ 4.9631
15%	$ 6.7707	$ 5.8115	$ 5.4465	$ 5.3963	$ 5.2881
20%	$ 6.8947	$ 6.0319	$ 5.6961	$ 5.6567	$ 5.5615
25%	$ 7.0030	$ 6.2277	$ 5.9192	$ 5.8901	$ 5.8073
30%	$ 7.1017	$ 6.4089	$ 6.1271	$ 6.1079	$ 6.0372
35%	$ 7.1944	$ 6.5815	$ 6.3262	$ 6.3169	$ 6.2584
40%	$ 7.2834	$ 6.7496	$ 6.5212	$ 6.5219	$ 6.4759
45%	$ 7.3707	$ 6.9163	$ 6.7155	$ 6.7265	$ 6.6934
50%	$ 7.4575	$ 7.0844	$ 6.9124	$ 6.9341	$ 6.9146
55%	$ 7.5454	$ 7.2566	$ 7.1151	$ 7.1481	$ 7.1431
60%	$ 7.6358	$ 7.4359	$ 7.3271	$ 7.3724	$ 7.3831
65%	$ 7.7303	$ 7.6258	$ 7.5528	$ 7.6116	$ 7.6396
70%	$ 7.8312	$ 7.8312	$ 7.7983	$ 7.8720	$ 7.9195
75%	$ 7.9415	$ 8.0591	$ 8.0722	$ 8.1631	$ 8.2331
80%	$ 8.0662	$ 8.3206	$ 8.3885	$ 8.4999	$ 8.5970
85%	$ 8.2141	$ 8.6362	$ 8.7728	$ 8.9101	$ 9.0414
90%	$ 8.4039	$ 9.0504	$ 9.2815	$ 9.4544	$ 9.6335
95%	$ 8.6935	$ 9.7011	$ 10.0903	$ 10.3230	$ 10.5830
99%	$ 9.2637	$ 11.0505	$ 11.8022	$ 12.1733	$ 12.6239

CBOT Corn Price Change Distribution (per bushel)

	Forward Month (as of 15th of Month)				
Percentile	**Jul-22**	**Sep-22**	**Dec-22**	**Mar-23**	**May-23**
1%	$ (1.4865)	$ (2.6732)	$ (3.0491)	$ (3.1902)	$ (3.3626)
5%	$ (1.0927)	$ (2.0414)	$ (2.3622)	$ (2.4823)	$ (2.6322)
10%	$ (0.8723)	$ (1.6695)	$ (1.9496)	$ (2.0544)	$ (2.1869)
15%	$ (0.7193)	$ (1.4035)	$ (1.6511)	$ (1.7437)	$ (1.8619)
20%	$ (0.5953)	$ (1.1831)	$ (1.4015)	$ (1.4833)	$ (1.5885)
25%	$ (0.4870)	$ (0.9873)	$ (1.1784)	$ (1.2499)	$ (1.3427)
30%	$ (0.3883)	$ (0.8061)	$ (0.9705)	$ (1.0321)	$ (1.1128)
35%	$ (0.2956)	$ (0.6335)	$ (0.7714)	$ (0.8231)	$ (0.8916)
40%	$ (0.2066)	$ (0.4654)	$ (0.5764)	$ (0.6181)	$ (0.6741)
45%	$ (0.1193)	$ (0.2987)	$ (0.3821)	$ (0.4135)	$ (0.4566)
50%	$ (0.0325)	$ (0.1306)	$ (0.1852)	$ (0.2059)	$ (0.2354)
55%	$ 0.0554	$ 0.0416	$ 0.0175	$ 0.0081	$ (0.0069)
60%	$ 0.1458	$ 0.2209	$ 0.2295	$ 0.2324	$ 0.2331
65%	$ 0.2403	$ 0.4108	$ 0.4552	$ 0.4716	$ 0.4896
70%	$ 0.3412	$ 0.6162	$ 0.7007	$ 0.7320	$ 0.7695
75%	$ 0.4515	$ 0.8441	$ 0.9746	$ 1.0231	$ 1.0831
80%	$ 0.5762	$ 1.1056	$ 1.2909	$ 1.3599	$ 1.4470
85%	$ 0.7241	$ 1.4212	$ 1.6752	$ 1.7701	$ 1.8914
90%	$ 0.9139	$ 1.8354	$ 2.1839	$ 2.3144	$ 2.4835
95%	$ 1.2035	$ 2.4861	$ 2.9927	$ 3.1830	$ 3.4330
99%	$ 1.7737	$ 3.8355	$ 4.7046	$ 5.0333	$ 5.4739

Results of Option-based market scenarios for

- Corn



- Wheat