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# Global Wheat Market Dynamics: What Is the Role of the EU and the Black Sea Wheat Exporters?

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**Abstract:** Over the last two decades, three countries in the Black Sea Region—Russia, Ukraine, and Kazakhstan—became global leaders in grain production and trade, and replaced the USA and France as the most previous largest wheat exporting countries. In this study we investigate world wheat price linkages and identify the current "price leaders" of the global wheat market. This empirical analysis is focused on the price relationships between eight of the largest wheat exporting countries and uses a cointegration framework and a vector error-correction model. The results show that, regarding price formation on the world wheat market, the French price is more important for transmitting price signals to other wheat export markets compared to the USA. Furthermore, our results indicate that, despite being leaders in wheat export volumes, the Black Sea wheat prices in Russia and Ukraine adjust to price changes in France, the USA, and Canada. Albeit unrealistic in the short run, the creation of the futures market in the Black Sea region might significantly improve the participation of Black Sea markets in price formation of the global wheat market.

**Keywords:** price transmission; Black Sea; EU; wheat market; global markets; grain trade



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## 1. Introduction

The global wheat market has grown dynamically over the last two decades. Since 2000, the global wheat export volume has increased by 98 million tons (t), amounting to 203 million t in 2020, whereas between 1980 and 2000, wheat exports increased by 23 million t only [1]. One of the major factors in the recent wheat export growth is the emergence of the Black Sea countries (Russia, Ukraine, and Kazakhstan) as important players in the world wheat market [2]. In particular, these countries account for about half of the total increase in wheat exports over the last 20 years. Broken down by country, Russia accounts for 35% of this growth in global wheat exports, followed by Ukraine (12%) and Kazakhstan (4%). In contrast, Australia and the USA had declining shares in the growth of wheat exports.

Many of the major wheat producing countries in Europe and North America (France, Germany, the USA, and Canada) have already reached high yields, although wheat yields are still about half of the European average in the emerging Black Sea markets and Argentina, in which higher productivity gains are already being observed, which will most likely continue [3]. Apart from potential gains in wheat yields, there is also ample potential for the recultivation of formerly abandoned agricultural land in the post-Soviet countries of the Black Sea region [4]. However, low wheat market efficiency, high domestic costs of wheat transportation, and large distances in Russia are the factors hindering the full mobilization of this production and export potential [5,6].

France and the USA are the most important wheat markets for wheat futures trading. Wheat is traded on the Chicago Board of Trade (CBOT), the Kansas City Board of Trade (KCBT), and the Minneapolis Grain Exchange (MGEX) in the USA, and on the Euronext in France. Wheat futures traded on the CBOT and Euronext are used as benchmarks for wheat prices in general. Janzen und Adjemian [7] indicated that even though the American futures markets remain dominant, the Paris commodity exchange has gained importance in the last decade. More specifically, since 2015, wheat price on the American futures markets begin to follow wheat prices on the Euronext futures market [8]. In contrast, commodity futures markets are rudimentarily developed in other large wheat exporting countries. Moreover, the influence of futures prices on wheat prices in these countries is not always confirmed. For instance, Heigermoser et al. [9] showed that wheat price volatility of the Russian export markets is determined by exchange rate fluctuations and various domestic factors, but not the CBOT futures prices.

Therefore, there is mixed evidence concerning price leadership on the world wheat market in terms of futures and spot markets. From the perspective of the futures markets, France and the USA are unequivocally the leaders of the wheat market; however, in terms of the physical trade of wheat, the Black Sea region has gained large importance globally. Hence, this study is aimed at investigating price formation and price interdependencies within the world wheat market. In particular, within the cointegration framework, price relationships between wheat markets in Argentina, Australia, Canada, France, Kazakhstan, Russia, Ukraine, and the USA are investigated. Cointegration analysis using a vector error correction model (VECM) provides information on the degree and magnitude of price transmission and price adjustments between wheat prices on the international wheat market. We use monthly export prices for the eight largest wheat exporting countries covering the period from July 2011 to August 2020. We have intentionally excluded the period before July 2011 to disregard the effect of export restrictions on the wheat price formation of world markets. The effect of the wheat export ban has been extensively investigated by Svanidze et al. [10], Götz et al. [11,12], and Götz et al. [13], finding that export restrictions in Russia and Ukraine insulated the domestic wheat prices from the world wheat price and increased transaction costs of domestic trade and instability in the domestic markets.

Certainly, price relationships at the world wheat market have been investigated before. Exclusively focusing on the analysis of price transmission between the wheat export prices in Canada, France, Russia, Ukraine, and the USA, Goychuk and Meyers [14] found that Russian wheat prices were cointegrated with wheat prices in France and the USA but not with Canada. Ukrainian wheat prices were exclusively integrated with French wheat prices. However, their study considered wheat price relationships for the 2004–2010 period, whereas we analyze more recent developments on the world wheat markets after 2010. Moreover, the results of Goychuk and Meyers [14] might not be suitable for generalizing as the first decade of the millennium was characterized by numerous export restrictions [15].

Looking at the time period between 1989 and 1999, Ghoshray [16] highlighted the importance of wheat quality in explaining the strength of price relationships in the world wheat market. Examining price linkages between the different types of wheat in Argentina, Australia, Canada, the EU, and the USA, Ghoshray [16] found that the American wheat price lead prices at the world market including the EU price. In contrast to Ghoshray [16], we add to the existing literature on global grain market integration by providing an up-to-date analysis that includes wheat prices from the Black Sea region. Although Svanidze et al. [17] and Heigermoser et al. [18] included the Black Sea exporters in their analysis of the world wheat prices, both of the studies exclusively focused on the price relationships between the wheat importing and exporting countries. In particular, they found that the Black Sea markets have become increasingly important for the price formation of the domestic wheat markets in net-importing countries of the South Caucasus and Central Asia [17], as well as Egypt [18]. In contrast to those studies, we exclusively focus on the price relationships between the exporting countries on the world wheat market.

This paper is structured in the following way: Section 2 overviews recent developments on the world wheat market. Section 3 describes the methodology and data used for the analysis. Sections 4 and 5 provide empirical results with discussion and conclusions, respectively.

## 2. The State of Play on the World Wheat Market

The world wheat market has dramatically evolved in recent decades (Figure 1). Wheat exports almost doubled from 101 million t in 2000 to 199 million t in 2020. Even higher exports are forecasted for the 2021/22 marketing year at 203 million t [1]. The increase in wheat exports has mostly been triggered by a rise in food consumption in developing countries, driven by growing populations and incomes [19]. This tendency is expected to remain into the next decade as per capita wheat consumption is expected to increase in the developing and least developed countries, whereas it is expected to stagnate in developed countries. Thus, the demand for imported wheat is mainly expected to increase in the Middle East and North Africa, as well as in Sub-Saharan Africa and Southeast Asia [20]. Wheat exports are projected to increase to 220 million t by 2030, up by 17 million t, with the major sources of this increased export capacity being Russia, Ukraine, Australia, and Argentina [19].

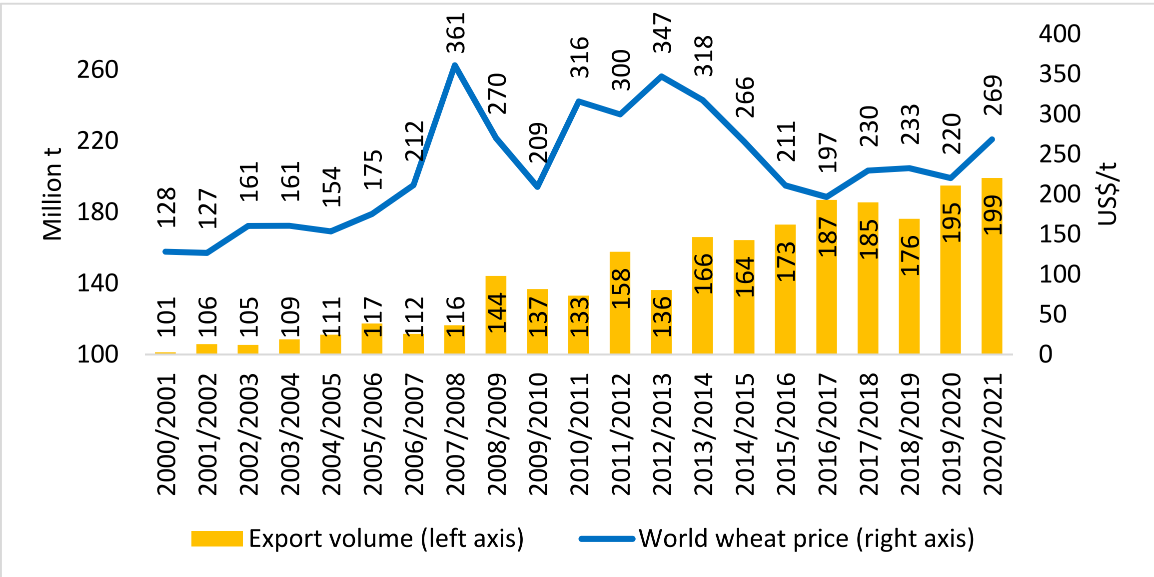


**Figure 1.** World wheat exports and prices (2000–2020). Note: World wheat price is represented by the American export price of No. 2 hard red winter wheat at the USA Gulf ports in Louisiana. Data source: [1,21]. Own illustration.

As Figure 1 shows, wheat prices (as well as the prices of many commodities) increased dramatically during the 2007/08 world food price crisis, accompanied by export restrictions implemented by wheat exporting countries [22]. After this period, wheat prices decreased until 2010 when droughts, mainly in the Black Sea region countries, introduced another shock to the world wheat market that was again followed by severe export restrictions such as Russia's complete export ban for the entire 2010/11 marketing year [23]. Since then, wheat prices have been on a declining trend and wheat exports have been growing. In particular, wheat prices declined from about USD 350/t in 2013 to USD 200/t in 2016, whereas wheat exports have increased from 136 million t to 187 million t during this period. Since 2016, wheat prices have been increasing again on the world market (Figure 1), especially high (about USD 270/t) in 2020. Wheat exports also achieved the highest volume in that year at almost 200 million t.

Australia, Argentina, Canada, France, Kazakhstan, Russia, Ukraine, and the USA are the largest wheat exporting countries in the world (Figure 2). In 2020, they accounted for 153 million t of wheat exports, which corresponds to 77% of the total wheat exports in this year (Figure 3). The combined share of the Black Sea markets (Russia, Ukraine, and Kazakhstan) amounts to 31% together. Among these eight countries, Russia accounts for the largest share (19%), followed by Canada and the USA (13% each), France (10%), Ukraine (9%), Australia and Argentina (5% each), and Kazakhstan (3%). However, the composition of country shares was to a large degree different in recent years. During this period, the USA and Australia lost their dominant position, decreasing their wheat export shares from 21% and 16% in 2005 to 13% and 5% in 2020, respectively. In contrast, Russia and Ukraine have gained further importance, increasing their wheat export shares from 8% and 5% in 2005 to 19% and 9% in 2020, respectively (Figure 3). Canada and France, as well as Argentina and Kazakhstan, retained the size of their wheat export market share of between about 10–15% and 3–5%, respectively.

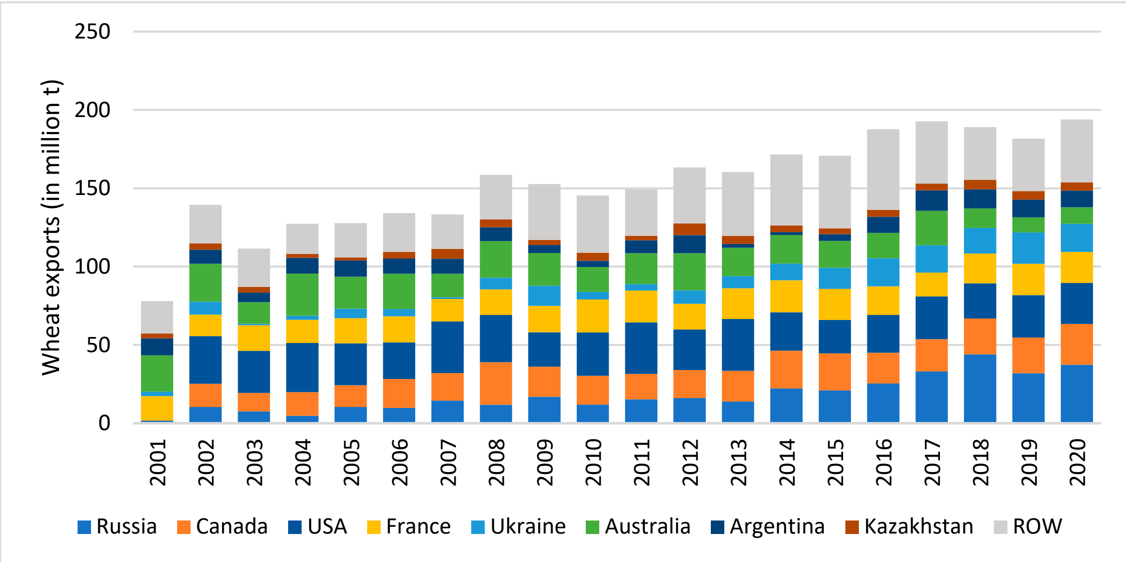


**Figure 2.** Selected leading world wheat exporting countries (2001–2020). Abbreviation: ROW, rest of the world. Data source: [24]. Own illustration.

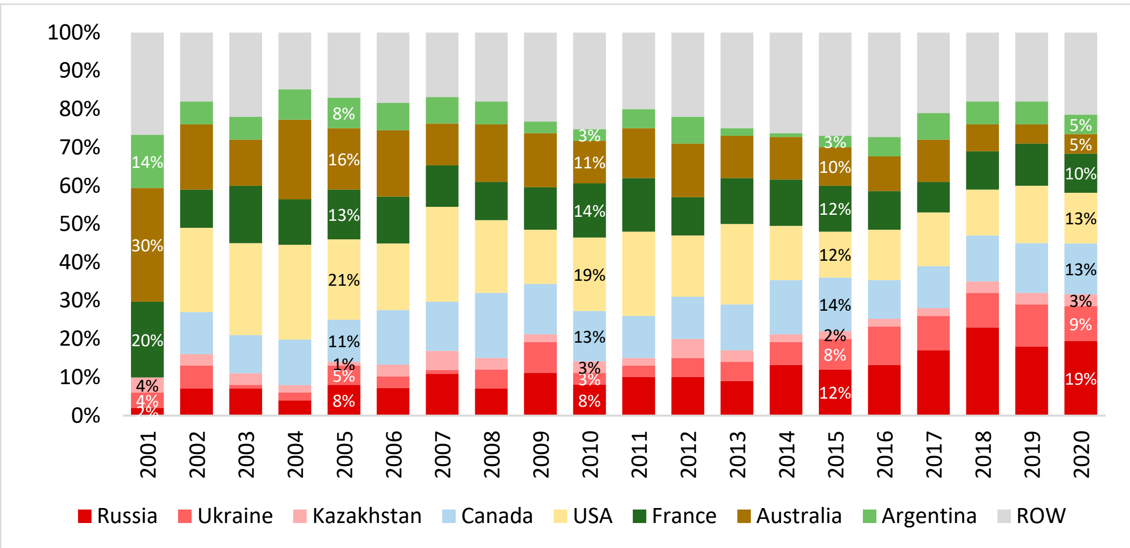


**Figure 3.** Shares of selected leading wheat exporting countries (2001–2020). Data source: [24]. Own illustration.

Although wheat prices in France and the USA are benchmark world wheat prices, the position of these countries in the physical trade of wheat globally has weakened over the last decade, as French and USA wheat exporters now need to compete with the Black Sea exporters that are serving the import markets at lower costs. For the case of France's wheat trade, Jaghdani et al. [25] found increasingly changing trading partners and a lower persistency of trade relations in recent years. In addition, France, Russia, and Ukraine are all competing to win the state tenders organized by Egypt's General Authority For Supply Commodities (GASC) and supply wheat to Egypt, which is by far the largest wheat importing country in the world. Most of the tenders are won by trading companies in Russia and Ukraine. For example, in 2020, Egypt imported 60% (5.8 million t) of its wheat from Russia, 26% (2.5 million t) from Ukraine, and 7% (0.6 million t) from France [26]. Heigermoser et al. [18] found interdependencies between the GASC prices and the export prices in Russia and France, with a leading role from France (but not Russia) in the formation of the tender prices.

## 3. Materials and Methods

The analysis of price transmission between two spatially separated markets is related to the notion of market integration and market efficiency ([27,28]). Following Fackler and Goodwin [28], spatially separated markets are considered as highly integrated and efficient markets if they are characterized by the full transmission of price changes between markets in the long run, whereas temporary deviations from the long-run price equilibrium may occur due to the unpredictable price shocks that are gradually eliminated via profitable trade arbitrage. The underlying theory of spatial market equilibrium for a homogeneous good builds on the idea that trade flows between spatially separated markets ensure the transmission of price information across markets. In particular, any price difference exceeding the transaction cost of trade will be quickly eliminated via profitable trade arbitrage, resulting in the physical movement of a good from the surplus to the deficit market. This process of short-term price adjustment continues until the price differential becomes smaller than the transaction costs, bringing markets again to the state of the long-run price equilibrium. Apart from the physical trade of a good, access to price information and linkages via third markets can also improve price convergence across markets [29–31].

To analyze market integration and the transmission of price changes between different markets, we first estimate the following long-run price equilibrium equation (cointegration equation):

$$P_t^i = \beta_0 + \beta_1 P_t^j + \varepsilon_t \quad (1)$$

where $P_t^i$ and $P_t^j$ denote the natural logarithm of prices in markets $i$ and $j$, respectively. $\varepsilon_t$ represents the stationary disturbance term, i.e., $E\left(\varepsilon_t \middle| P_t^i, P_t^j\right) = 0$. The long-run price equilibrium is characterized by the intercept $\beta_0$ and the long-run price transmission elasticity $\beta_1$, which measures the magnitude of price shock transmissions from one market to another. The theoretical value of the long-run price transmission elasticity ($\beta_1$) varies between zero and one, with $\beta_1 = 1$ indicating that price information is completely transmitted from one market to another.

The concept of a long-run price equilibrium is a static notion. Naturally, prices in different markets often diverge from this parity due to unexpected market shocks. If the prices are not in their equilibrium, market agents will make use of this price difference. By causing price adjustment processes, prices are brought back to their price equilibrium level. Therefore, integrated markets are characterized by a complete transmission of price changes in the long-run; however, short-run transitory inefficiencies are allowed.

Before estimating market integration, we first identify whether individual price series are non-stationary by using the Augmented Dickey–Fuller (ADF) unit root test [32]. We use the Johansen test for linear cointegration [33] to examine cointegration and thus the existence of long-run price equilibrium for the price pairs containing non-stationary price series. If the price series are linearly cointegrated, a multivariate and bivariate vector error correction model (VECM) developed by Johansen [33] is estimated to quantify the short-run price dynamics and retrieve the price transmission elasticities in the next step. A dynamic VECM offers the measuring of the speed at which prices converge back to the long-run equilibrium. The vector error correction model takes the following form:

$$\Delta \boldsymbol{P}_t = \gamma \varepsilon_{t-1} + \sum_{k=1}^{K} \delta_k \Delta \boldsymbol{P}_{t-k} + \boldsymbol{\omega}_t \tag{2}$$

where $\Delta$ is the first difference operator and $\boldsymbol{P}_t = \left(P_t^i,\ P_t^j\right)'$ is a vector of prices. $\varepsilon_{t-1}$ represents the error correction term (ECT) variables, which are the residuals from Equation (1) lagged by one period. $\gamma = \left(\gamma_i,\ \gamma_j\right)'$ denotes a vector of the speed of adjustment parameters that measures the speed at which deviations from the long-run equilibrium are eliminated. $\Delta \boldsymbol{P}_{t-k}$ represents a vector of lagged values of the first difference of price series with lags $k = 1, \ldots, K$ ensuring that the model residuals are serially uncorrelated. $\boldsymbol{\delta}_k$ contains corresponding dynamic short-run parameters. $\boldsymbol{\omega}_t$ is a conventional residual term with $\boldsymbol{\omega}_t \sim \mathrm{N}\left(\mathbf{0},\ \sigma^2\right)$.

For the variables that are cointegrated, the Granger-cause type of relationship exists at least in one direction [34]. The Granger causality test identifies whether one time series is useful for forecasting another via seeking the direction of causality between prices. For this reason, we estimate the following equation for testing Granger causality:

$$P_t^i = \alpha + \sum_{m=1}^{M} \delta_m P_{t-m}^i + \sum_{n=1}^{M} \theta_n P_{t-n}^j + \varphi_t \tag{3}$$

where $P_t^i$ depends on its own $M$ lagged values as well as on the $M$ lagged values of the $P_t^j$ variable. The Wald test is used to test the null hypothesis of whether the lagged values of $P_t^j$ do not Granger-cause $P_t^i$ by restricting all $\theta_n$ coefficients to zero. Rejection of the null hypothesis indicates that the $P_t^j$ variable Granger-causes the $P_t^i$ variable. However, if variables contain the unit root and are cointegrated, the Toda and Yamamoto procedure [35] should be applied to ensure that the Wald test statistic follows its asymptotic $\chi^2$ distribution with the usual degrees of freedom.

To analyze the global wheat market integration and price developments, and to identify the role of the EU and Black Sea markets in particular, the following wheat exporting countries (global players) are considered: Argentina, Australia, Canada, France, Kazakhstan, Russia, Ukraine, and the USA. Even though wheat production seasons are different between those hemispheres, wheat is traded globally year-round. Prices presented on the futures market account for information on global market changes including developments on the northern and southern hemisphere. Thus, the analysis indirectly accounts for differences in production seasons.

The data set includes eight export prices for the leading wheat export countries, comprising 110 monthly observations for each price series covering the period from July 2011 to August 2020 (Table 1, Figure 4). The price series for Canada contains missing observations for the period between May 2012 and December 2012, and January 2014 and May 2014 (13 observations in total). The missing observations are substituted with the values drawn from the cubic spline interpolation technique [36]. All price series are reported in USD per ton. A detailed description of the price data and characteristics of the price series are provided in Table 1.

**Table 1.** Data description on wheat prices.

| Country | Price Type | Observation | Period | Source |
|---|---|---|---|---|
| **Argentina** | No. 2 wheat, export free on board, monthly, USD/t, Trigo Pan (up river) port | 110 | 07/2011–08/2020 | International Grains Council |
| **Australia** | Australian standard soft white wheat (ASW), export free on board, monthly, USD/t, eastern states | 110 | 07/2011–08/2020 | International Grains Council |
| **Canada** | No. 1 Canadian western hard red spring (CWRS), export free on board, monthly, USD/t, St. Lawrence | 110 | 07/2011–08/2020 | International Grains Council |
| **France** | Grade 1 wheat, export free on board, monthly, USD/t, Rouen | 110 | 07/2011–08/2020 | International Grains Council |
| **Kazakhstan** | Grade 3 milling wheat, export delivered at place, monthly, USD/t, Saryagash station | 110 | 07/2011–08/2020 | APK-Inform Agency |
| **Russia** | Milling wheat, export free on board, monthly, USD/t, deep-sea ports (Novorossiysk) | 110 | 07/2011–08/2020 | APK-Inform Agency |
| **Ukraine** | Milling wheat, export free on board, monthly, USD/t | 110 | 07/2011–08/2020 | APK-Inform Agency |
| **USA** | No. 2 hard red winter wheat, export free on board, monthly, USD/t, USA Gulf ports, Louisiana | 110 | 07/2011–08/2020 | International Grains Council |

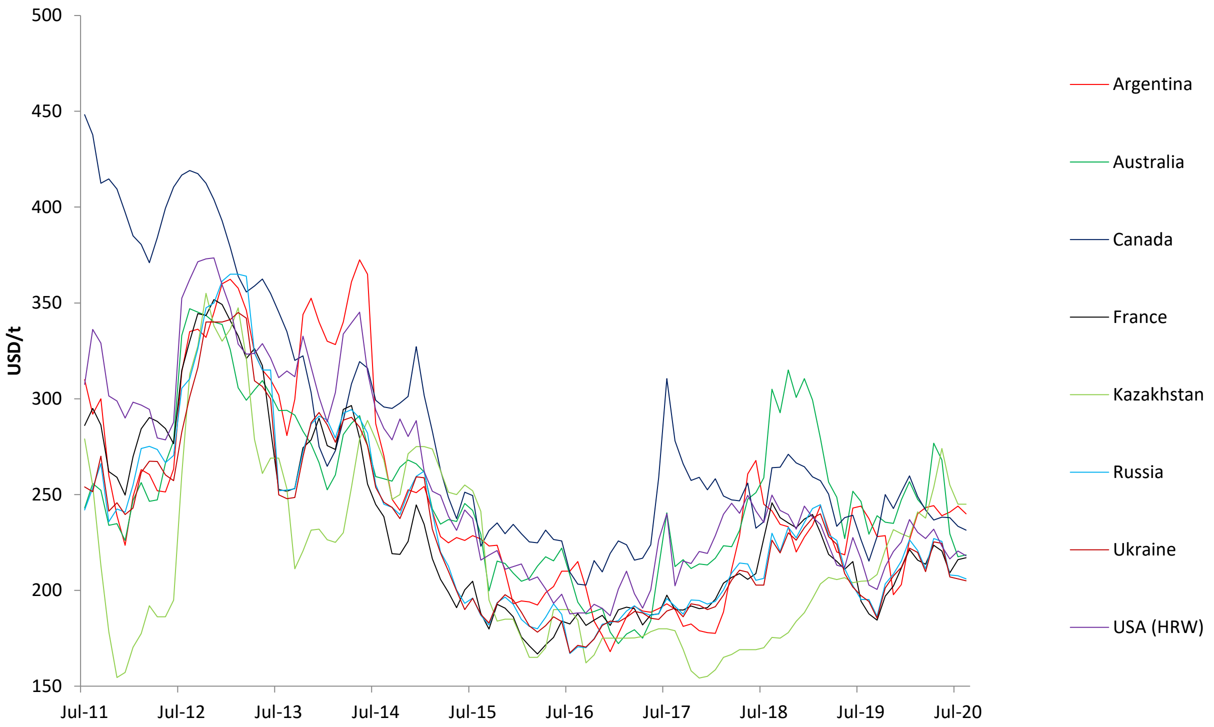


**Figure 4.** World wheat prices (2011–2020). Source: See data sources in Table 1.

## 4. Results and Discussion

In terms of assessing the times series properties of the price series, the results of the unit root test (Table 2) indicate that the null hypothesis of non-stationary price series cannot be rejected for all wheat prices in levels but can be rejected for prices in first differences at the 5% significance level. This indicates that the price series are integrated in order one.

**Table 2.** Augmented Dickey–Fuller test for prices in levels and first differences.

| Price Series | Deterministic Component | Lags | Test Statistic | Δ Price Series | Deterministic Component | Lags | Test Statistic |
|---|---|---|---|---|---|---|---|
| $P_t^{arg}$ | Constant | 1 | −2.196 | $\Delta P_t^{arg}$ | None | 2 | −7.130 *** |
| $P_t^{aust}$ | Constant | 1 | −1.987 | $\Delta P_t^{aust}$ | None | 0 | −9.143 *** |
| $P_t^{can}$ | Constant | 2 | −1.807 | $\Delta P_t^{can}$ | None | 1 | −7.756 *** |
| $P_t^{fr}$ | Constant | 1 | −1.849 | $\Delta P_t^{fr}$ | None | 0 | −7.907 *** |
| $P_t^{kaz}$ | Constant | 5 | −2.610 * | $\Delta P_t^{kaz}$ | None | 1 | −6.496 *** |
| $P_t^{rus}$ | Constant | 1 | −1.481 | $\Delta P_t^{rus}$ | None | 0 | −9.097 *** |
| $P_t^{ukr}$ | Constant | 1 | −1.492 | $\Delta P_t^{ukr}$ | None | 0 | −8.749 *** |
| $P_t^{USA}$ | Constant | 0 | −1.402 | $\Delta P_t^{USA}$ | None | 0 | −9.789 *** |

Note: Lag length selection is based on the Akaike information criterion. * $p < 0.10$, *** $p < 0.01$.

Subsequently, we tested whether wheat prices, which are non-stationary, are cointegrated using the Johansen's bivariate test of cointegration (Table 3). The results indicate that the world wheat market is not fully integrated, with only half of the total number of price pairs being cointegrated. We identify cointegration for 14 of 28 price pairs at the 5% significance level. Among those markets, Argentina, France, Russia, Ukraine, and the USA are the most integrated world wheat markets (Figure 5). France, Russia (the European part), and Ukraine, the three largest wheat markets in continental Europe, are integrated with each other and each of them are also individually integrated with the wheat markets of Argentina (South America) and both Canada and the USA (North America); however, they are disintegrated with wheat markets in Australia and Kazakhstan. Among the world wheat markets, Kazakhstan is a completely disintegrated market as the wheat export prices of Kazakhstan are not cointegrated with the wheat prices of any of the other seven large wheat exporting countries. Furthermore, we observe a "geographical divide" in the world wheat market. In particular, Australia is integrated only with Argentina in the southern hemisphere, whereas Canada is integrated with a small number of markets, namely France, Russia, and Ukraine in the northern hemisphere.

Next, the results of the likelihood ratio test of weak exogeneity [37] indicates that France is the leading wheat market globally, transmitting price signals to other markets in Argentina, Canada, Russia, Ukraine, and the USA, and not vice versa (Table 3). On the contrary, wheat prices in Argentina react to price information originating in other countries. Interestingly, in contrast to France, wheat prices of the USA react to the Black Sea wheat price information, while the Black Sea wheat prices in Russia and Ukraine adjust to price changes in France, Canada, and the USA.

The price transmission analysis is conducted between the cointegrated wheat export prices of the world wheat market for 14 price pairs within the bivariate VECM for the July 2011–August 2020 period. For every price pair, the number of lags identified by the Akaike information criterion is used to ensure that the residuals are serially uncorrelated (Table 4).

The results indicate that the world wheat market's degree of price transmission and market integration are considerably high. The highest price transmission elasticities are 0.996 and 0.995, which corresponds to the full price transmission between the wheat markets in Russia and Canada, and the USA and France, respectively. Russia is the largest wheat exporting country nowadays and both France and the USA are the leading wheat price benchmarks, with their Euronext and CBOT exchanges playing prominent roles in the price discovery of the world wheat market [38]. A substantially high degree of price transmission is also identified for the price pairs Ukraine–France and Ukraine–USA. We attribute this to Ukraine's dynamically increasing wheat exports in recent years. Our results also indicate that Australia is the least integrated wheat market after Kazakhstan, which is a completely separated wheat market. In particular, Australia is only integrated with Argentina and the degree of integration is the lowest among 14 cointegrated price pairs: only 81.8% of price changes are transmitted from Australia to the wheat market in Argentina. Price transmission is also relatively low for the price pair Argentina–France, as 91.3% of price changes are transmitted in the long-run from wheat markets in France to

Argentina, whereas for other market pairs, price transmission elasticities are higher than 0.95, indicating that for those price pairs, the degree of price transmission is at least 95%.

**Table 3.** Johansen's test of linear cointegration and weak exogeneity.

| Price Pairs | Cointegrated? | Lags | $H_0$: Rank = 0/$H_0$: Rank $\leq 1$ Test Statistic | $p$-Value | Weak Exogeneity Test Test Statistic |
|---|---|---|---|---|---|
| Argentina–Australia | Yes | 1 | 17.62/3.26 | 0.02/0.07 | 5.97 **/1.16 |
| Argentina–France | Yes | 2 | 16.45/3.02 | 0.04/0.08 | 10.28 **/1.02 |
| Argentina–Russia | Yes | 1 | 24.27/2.21 | 0.00/0.14 | 14.51 ***/0.10 |
| Argentina–Ukraine | Yes | 1 | 28.57/2.20 | 0.00/0.14 | 16.00 ***/0.70 |
| Argentina–USA | Yes | 1 | 17.12/2.87 | 0.03/0.09 | 9.88 ***/0.14 |
| Australia–Canada | No | 1 | 13.27/5.49 | 0.11/0.02 | - |
| Australia–France | No | 2 | 15.05/2.73 | 0.06/0.10 | - |
| Australia–Russia | No | 1 | 14.62/2.04 | 0.07/0.15 | - |
| Australia–Ukraine | No | 1 | 14.28/1.97 | 0.08/0.16 | - |
| Australia–USA | No | 1 | 10.24/2.89 | 0.26/0.09 | - |
| Canada–Argentina | No | 1 | 14.59/3.66 | 0.07/0.05 | - |
| Canada–France | Yes | 3 | 16.05/1.79 | 0.04/0.18 | 5.25 **/2.26 |
| Canada–USA | No | 1 | 12.90/3.72 | 0.12/0.05 | - |
| USA–France | Yes | 1 | 18.58/3.12 | 0.02/0.08 | 3.94 **/0.82 |
| Russia–Canada | Yes | 3 | 21.79/2.68 | 0.00/0.10 | 11.72 ***/1.12 |
| Russia–France | Yes | 1 | 23.28/2.71 | 0.00/0.10 | 8.47 ***/0.25 |
| Russia–Ukraine | Yes | 3 | 21.73/2.44 | 0.00/0.12 | 1.58/0.05 |
| Russia–USA | Yes | 1 | 20.35/1.86 | 0.01/0.17 | 6.27 **/3.14 * |
| Ukraine–Canada | Yes | 3 | 19.06/2.91 | 0.01/0.09 | 9.69 ***/1.06 |
| Ukraine–France | Yes | 1 | 19.90/2.90 | 0.01/0.09 | 8.07 ***/0.01 |
| Ukraine–USA | Yes | 1 | 21.25/1.89 | 0.01/0.17 | 7.76 ***/2.81 * |
| Kazakhstan–Argentina | No | 1 | 15.75/5.03 | 0.05/0.02 | - |
| Kazakhstan–Australia | No | 1 | 14.20/4.00 | 0.07/0.05 | - |
| Kazakhstan–Canada | No | 1 | 12.66/4.30 | 0.14/0.04 | - |
| Kazakhstan–France | No | 3 | 16.67/3.70 | 0.03/0.05 | - |
| Kazakhstan–Russia | No | 3 | 15.12/3.45 | 0.06/0.06 | - |
| Kazakhstan–Ukraine | No | 1 | 14.78/2.27 | 0.06/0.13 | - |
| Kazakhstan–USA | No | 2 | 9.55/2.45 | 0.32/0.12 | - |

Note: Lag length selection is based on the Akaike information criterion. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. "-" = no cointegration. To test the weak exogeneity of the $P_t^i$ $\left(P_t^j\right)$ variable with respect to the $\beta$ cointegration parameters, we impose binding restriction on the speed of adjustment parameter of the variable $H_0$: $\gamma_i = 0$ ($\gamma_j = 0$). The rejection of the null hypothesis leads to the conclusion that the respective variable is not weakly exogenous in the system of equations.

**Table 4.** Estimated parameters of VECM.

| Price Pairs (Price 1–Price 2) | Lags | Cointegration Parameter | Speed of Adjustment Price 1 | Speed of Adjustment Price 2 |
|---|---|---|---|---|
| Russia–Canada | 3 | 0.996 | −0.149 *** | 0.046 |
| USA–France | 1 | 0.995 | −0.148 ** | 0.061 |
| Ukraine–France | 1 | 0.989 | −0.251 *** | 0.011 |
| Ukraine–USA | 1 | 0.982 | −0.181 *** | 0.125 * |
| Argentina–Russia | 1 | 0.975 | −0.225 *** | 0.017 |
| France–Russia | 1 | 0.967 | −0.047 | 0.280 *** |
| Argentina–USA | 1 | 0.966 | −0.190 *** | −0.021 |
| USA–Russia | 1 | 0.965 | −0.123 * | 0.170 *** |
| Ukraine–Argentina | 1 | 0.963 | −0.045 | 0.251 *** |
| Canada–France | 3 | 0.957 | −0.112 *** | 0.071 |
| Ukraine–Canada | 3 | 0.956 | −0.129 *** | 0.047 |
| Ukraine–Russia | 3 | 0.952 | 0.093 | 0.567 |
| Argentina–France | 2 | 0.913 | −0.207 *** | −0.053 |
| Australia–Argentina | 1 | 0.818 | −0.065 | 0.142 *** |

Note: Price pairs are sorted by the value of the cointegration parameter in descending order. The lag length selection is based on the Akaike information criterion. * $p < 0.10$. ** $p < 0.05$. and *** $p < 0.01$.

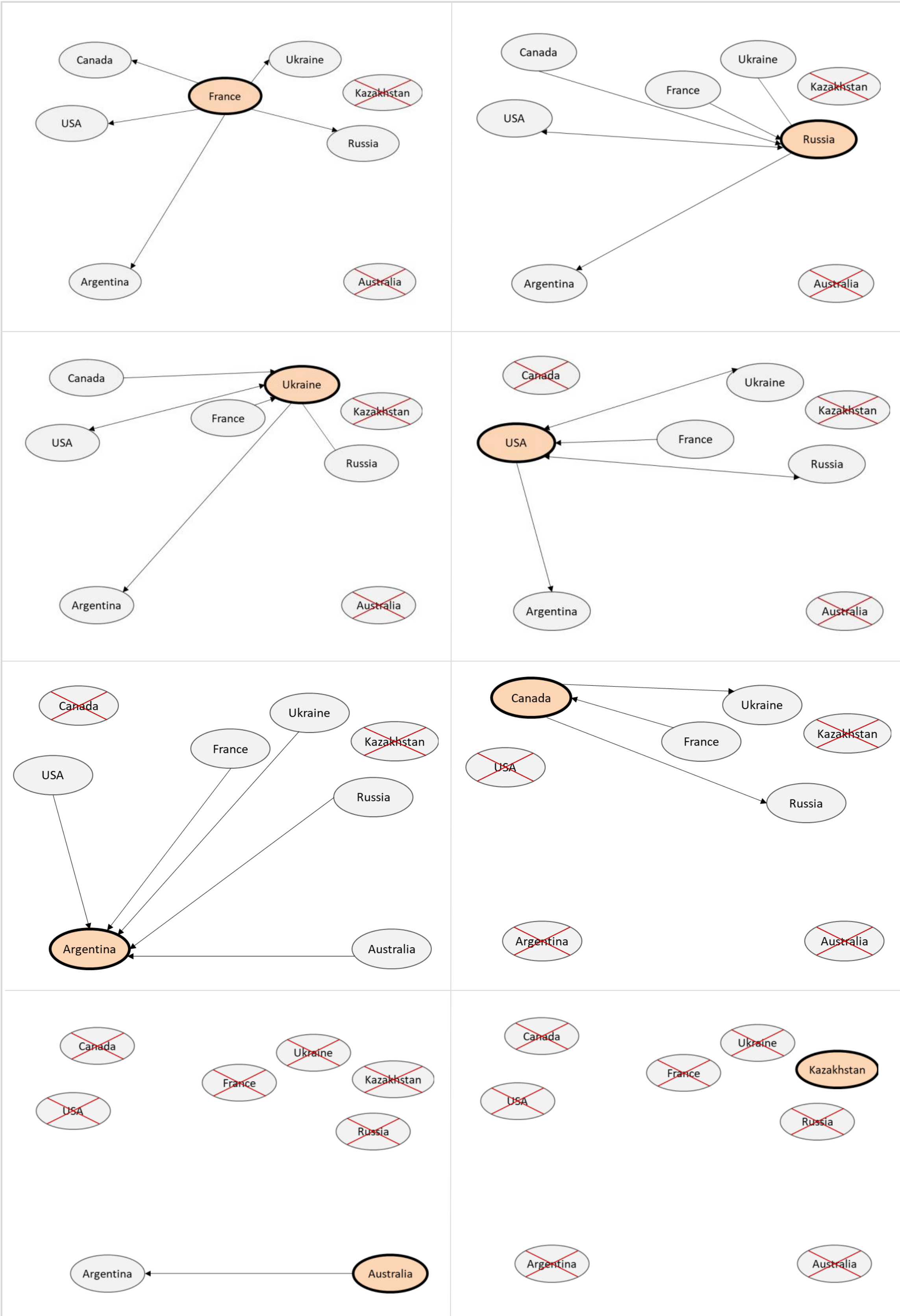


**Figure 5.** Schematic view of the cointegration channels (based on the results of the test of linear cointegration). Note: The arrows indicate the direction of price transmission based on the results of the weak exogeneity test. For example, the arrow for the Australia–Argentina market pair indicates that wheat prices in Australia transmit price shocks to the Argentinian wheat market.

The speed of adjustment parameters indicates that among the cointegrated market pairs, wheat prices in Argentina, Canada, Russia, and Ukraine adjust to wheat prices in France and the USA, indicating the leading role of the wheat export prices of France and the USA on the world wheat market for price discovery. The magnitude of the price adjustment is also the largest with wheat prices in France and the USA. For Argentina, Russia, and Ukraine, the adjustment parameters vary between 0.18 and 0.28, indicating that, on average, 18% to 28% of the price disequilibrium is eliminated in one month, whereas this parameter is equal to 11.2% between Canada and France. Interestingly, our results show that the American wheat price adjusts to price changes in the French wheat market and not vice versa (0.148). Moreover, price adjustment for the wheat prices in Argentina, Russia, and Ukraine is also quicker with the wheat prices for France (0.207, 0.251, and 0.280, respectively) compared to the American wheat prices (0.190, 0.170, and 0.181, respectively). Furthermore, the results indicate that American wheat prices adjust to price changes in the Black Sea wheat markets. Even though this adjustment is rather weak (around 0.12 at the 10% significance level) compared to adjustments of the Russian and Ukrainian wheat prices to changes in the American wheat prices (0.17 and 0.18, respectively), to some degree this result still provides evidence for the importance of the Black Sea wheat markets in the wheat price determination of the American wheat market.

These results indicate that the French wheat market is a leading market in terms of the price determination at the world wheat market level, followed by the USA. Our results confirm similar findings by Janzen and Adjemian [7] and Ahmed [8], indicating that global wheat market price leadership moved from the USA to the MATIF futures market in France.

The Black Sea wheat prices also adjust to price changes in the Canadian wheat markets but more slowly compared to wheat prices in other markets. Specifically, the adjustment parameters are 0.129 and 0.149 for the price pairs Ukraine–Canada and Russia–Canada, respectively.

Our results also indicate that the wheat price in Argentina adjusts to other wheat prices on the world wheat market, with around 15–25% of the price disequilibrium being eliminated in one month for all the wheat prices; however, the adjustment speed is the slowest with Australia.

Concerning the price adjustment between wheat prices in Russia and Ukraine, even though the Black Sea wheat markets are integrated with each other and we identify the largest adjustment parameters for the price pair Russia–Ukraine (0.567), this parameter is statistically insignificant. Thus, this result indicates that the process of eliminating the price disequilibrium cannot be observed with monthly data as the insignificance of the speed of adjustment parameter implies that the price adjustment is completed in the period of less than a month.

## 5. Conclusions

In this article, we investigated the relationships between the monthly export prices of the leading wheat exporting countries of the world wheat market for the period of July 2011 to August 2020. In particular, we examine price relationships between the wheat export prices of Argentina, Australia, Canada, France, Kazakhstan, Russia, Ukraine, and the USA. We use linear VECM to identify price linkages in the world wheat market, although regime-switching cointegration models are able to account for non-linearities in the price transmission. For example, Jamora and von Cramon-Taubadel [39] investigate threshold-type relationships between the domestic and international rice prices.

The results confirm that, regarding price formation, the French market is the leading wheat market transmitting price signals to other markets in Argentina, Canada, Russia, Ukraine, and the USA. On the other side, French prices on their own do not react to price information from those markets.

Furthermore, the results indicate that the Black Sea wheat prices in Russia and Ukraine adjust to price changes in France, the USA, and Canada. This implies that, even though the Black Sea countries have their dominant position in the world wheat market in terms of wheat export quantities, their influence on the price formation and price discovery on the world wheat market is still limited. This function is successfully fulfilled by futures wheat markets in France and the USA. However, creation of the futures market in the Black Sea region might significantly change the status quo on the global wheat market.

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