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ORIGINAL ARTICLE

Impact of the Ruble exchange rate regime and Russia's war in Ukraine on wheat prices in Russia

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Abstract

We assess exchange rate pass-through when the Ruble exchange rate was managed in comparison with when it became free-floating. Estimates of the error correction model for milling wheat prices suggest exchange rate pass-through to be strongest in Russia's North Caucasus, the region closest to the Black Sea ports, and weakest in the remote regions of Volga and West Siberia since the Ruble exchange rate became free-floating in 2014. In contrast, we find Russian regional wheat prices and the Ruble/USD exchange rate not cointegrated when the exchange rate was managed. Further, feed wheat (Class 5) is only weakly integrated compared to wheat Classes 3 and 4 for human consumption. With Russia's invasion of Ukraine, exchange rate pass-through to Russian wheat prices has decreased sharply. Thus, the Ukraine war drives the disintegration of Russia's wheat sector from international markets and adds to the risks of supply chain disruption and geopolitical risks, which may increase export supply volatility. To strengthen trade resilience, countries that are dependent on wheat imports should diversify their import sources.

KEYWORDS

exchange rate pass-through, food security, Russia, the war in Ukraine, wheat prices

JEL CLASSIFICATION

Q02, Q13, Q17

1 | INTRODUCTION

Russia advanced from a wheat importer to the primary global wheat exporter in 2017–2018, surpassing the United States as the largest global wheat exporter (USDA, 2018). Between 2000 and 2020, Russia's wheat production more than doubled and the share of exports in its production increased to around 50% (UN COMTRADE, 2023; USDA-PSD, 2023). Russia's exports account for about 20% of world wheat exports and more than 50% of Russia's wheat exports are delivered to the highly wheat import dependent countries in Africa and the Near East. For example, in 2018, the share of Russia's wheat exports in Egypt's overall wheat imports amounted to almost 75% (UN COMTRADE, 2020).

The fast growth in Russia's wheat exports was fostered by the strong devaluation of the Russian Ruble. Having occurred after the Russian Central Bank's abandonment of the managed exchange rate regime in November 2014, this

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strongly increased the competitiveness of Russian wheat exports on international markets. Following a plummeting world oil price, which significantly shrank Russia's oil-dependent economy, Russia's annexation of Crimea in 2014, Russia's implementation of a food import ban against western countries, and the West's economic sanctions against Russia, the Ruble's value fell by roughly 70% from 2014 to 2015. On the one hand, this substantial devaluation, spurred wheat exports, but, on the other, it surged domestic inflation by increasing import prices. For instance, Russia's consumer price index increased from 7.8% in 2014 to 15.5% in 2015 (IMF, 2021).

On February 24, 2022, Russian military forces invaded Ukraine, which abruptly disrupted the global value chain for grains and led to further substantial increases in commodity prices on the world markets (Ihle et al., 2022; Legrand, 2022), reinforcing global food security challenges (Hellegers, 2022; Mottaleb et al., 2022), with consequences for populations of low-income countries particularly (Abay et al., 2023; Arndt et al., 2023; Júnior et al., 2022; Lin et al., 2023). Nonetheless, Russia's wheat trading companies have continued to export wheat to the highly import-dependent countries in the Global South, while the companies in the grain-exporting western countries have continued to compete with Russia on global grain markets. For the 2022–2023 marketing season, Russia's wheat production amounted to 95.4 million tons, allowing Russia to export a record amount of 47.8 million tons of wheat (IGC, 2023).

In the first months of the war in Ukraine, wheat imports from Russia and Ukraine to the majority of African countries had decreased (Refinitiv-Eikon, 2022; UN COMTRADE, 2022). Fourteen African countries have completely stopped importing wheat from Russia (from March to September 2022 compared to 2021). In contrast, the North African countries of Algeria, Egypt, Libya, Tunisia, and Sudan, which have close political ties with Russia, have rather increased their wheat imports from Russia (Götz & Svanidze, 2023). Price formation within Russia's domestic wheat markets also impacts the size of the Russian wheat export supply on the world market through producers' incentives, which depend on current prices on domestic markets, trade costs, and export restrictions.

Following Russia's invasion of Ukraine, the Russian Ruble devaluated from 80 to 120 Ruble/USD within 2 weeks. As a response, the Russian Central Bank implemented capital controls on the exchange rate market, and the exchange rate started to reverse in the middle of March 2022, appreciating up to the pre-war level in a few months (Itskhoki & Mukhin, 2022). This development was caused by a decline of imports (Lorenzoni & Werning, 2022), while at the same time Russia's exports of oil and natural gas sustained when capital controls prevented capital outflows. Russia accounted for a surplus amounting to $183.1 billion USD from January to August 2022, which is substantially higher compared to the $60.9 billion USD surplus observed over the same period of the previous year (UN, 2022).

As a result, the strong Ruble observed in 2022 decreased the competitiveness and slowed down wheat exports from Russia to world markets in July and August 2022 especially.[1] Moreover, Russia started to export wheat in Rubles as a response to sanctions from the West (Reuters, 2022). Nevertheless, wheat is traded in USD on the world market and Russian traders can be expected to continue accounting for the Ruble/USD exchange rate in their trading activities.

Russia's import of agricultural inputs, including crop protection products, agricultural machinery, and seeds, for which the country is highly import dependent on western countries and the European Union (EU) in particular, have been sustained since the Ukraine war. It should be noted that agricultural inputs are exempt from western economic sanctions and can continue to be traded with Russia. Nonetheless, the size of the input imports has decreased, which may have partially resulted from the devaluation of the Ruble, which has increased the price of those imported inputs. This may also have contributed to the expected decrease in Russia's wheat production by around 8% from 95.4 million tons in 2022–2023 to the forecasted 87.4 million tons in 2023–2024 (IGC, September 2023).

However, in order to comply with the western sanctions, multinational agricultural trade companies, which accounted for up to 30% of Russia's grain businesses before the Ukraine war started, put their planned investments in the Russian grain sector on hold. Investment opportunities for domestic companies may have also been reduced by western financial sanctions. Thus, the further mobilization of Russia's additional grain potential is questionable.[2]

[1] The competitiveness of Russia's wheat exports is further reduced by: (i) a variable wheat export tax, implemented by the Russian government since June 2021; (ii) high transport costs resulting from a high risk for vessels entering the Black Sea; and (iii) over-compliance of wheat importers and transport companies with sanctions, implying that less grain is bought from Russian export companies.

[2] Wheat exports from Russia might have decreased due to higher transportation costs inside of Russia after the beginning of the war in Ukraine. In particular, skyrocketing world oil prices might increase domestic gasoline prices in Russia. However, in 2022, average prices for diesel fuel and gasoline in Russia remained fairly stable. Retail gasoline prices fluctuated within the range from 50.5 to 51 Rubles per liter, while diesel prices vary from 54.4 to 55.6 Rubles per liter. Slight spikes in diesel fuel prices were observed in February and October 2022, but the growth did not exceed 1%. Since January to December 2022, the retail price of diesel fuel rose by 8% and gasoline by 0.9% (Vedomosti, 2022). These developments do rather not suggest that the oil price development had a significant influence on inner-Russian transport costs.

On July 1, 2023, the multinational agricultural trading companies of Cargill, Louis Dreyfus, Viterra, which accounted for 16% of Russia's grain exports, exited the Russian grain export market (Reuters, 2023 various issues) following operational difficulties emerging from the Ukraine war and government pressure (Miller Magazine, 2023). Although their grain trade has been continued via former local management setups within the new companies, transport challenges resulting from increased financial and security risks of ship transport from Russia's Black Sea ports have been occurring and are expected to decrease export quantities (Reuters, 2023). Nonetheless, according to estimates from the International Grains Council, wheat exports are expected to increase by around 1.5% in 2023–2024 (from 47.8 million tons in 2022-2023 to 48.6 million tons; IGC, 2023).[3]

Russia often restricts its wheat exports in order to protect its domestic markets from rising world market prices and to stabilize domestic prices. Since the outbreak of the COVID-19 pandemic in 2020, Russia's wheat exports have been subject to an export tax, periodically supplemented by an export quota (February to May) and a ban on exports to the countries of the Eurasian Economic Union in 2021. With the implementation of a floating export tax in June 2021, wheat export restrictions have become permanent. The export tax, which amounted to 70% of the difference between the wheat price and the baseline price (200 USD/t), was changed to a progressive floating wheat export tax on February 15, 2022. However, as world wheat prices surged and the Ruble significantly appreciated after the strong devaluation directly following Russia's invasion of Ukraine, the Russian government introduced a new measure on July 6, 2022, requiring the payment of the wheat export tax in Rubles instead of USD with the baseline price also set in Rubles. The current export tax system implies a 70% duty on the price difference between the wheat price and the baseline price (15,000 Ruble/t) paid in Rubles (Global Trade Alert, 2022). The relatively large wheat export tax negatively affects the profitability of wheat production and may also have contributed to the forecasted decrease in wheat production for 2023–2024.

Against this background, we investigate the influence of the Ruble/USD exchange rate on price developments in the Russian domestic wheat markets in the six main wheat producing regions of Russia (North Caucasus, Black Earth, Central, Volga, Urals, and West Siberia), focusing on the possible influence of the Ukraine war. Regional price relationships within Russia's wheat market have been investigated before, focusing on the influence of export restrictions on the relationship between the world wheat price and Russian domestic wheat prices (Götz et al., 2013, 2016). However, the importance of macroeconomic factors in the price formation of domestic wheat prices in Russia have barely been explored before. To the best of the authors' knowledge, this is the first study addressing the effects of the Ruble exchange rate on wheat prices under the free-floating exchange rate regime that was established in Russia in 2014. Burakov (2016) does not find exchange rate pass-through to wheat prices in Russia during the managed exchange rate regime over the 1999–2015 time period. Results by Liefert (2009) suggest that the exchange rate plays an important role in determining price gaps between domestic and border wheat prices in Russia.

We distinguish the period *before* and *after* the introduction of the free-floating exchange rate regime in November 2014 and consider the period of the Ukraine war separately. Applying an error correction model, we account for the different classes of wheat, that is, milling wheat of Classes 3 and 4 and feed wheat of Class 5, which are commonly sold through different channels along the wheat supply chain. We assume that different supply networks with diverse degrees of foreign currency dependency might influence the relationship between the prices of the various wheat classes and the exchange rate differently.

We also compare the influence of the exchange rate with the world wheat price on domestic Russian wheat prices. Furthermore, to complement the analysis of the exchange rate pass-through to wheat prices in Russia, we extend the analysis to the wheat market in France, which is among the leading wheat exporters and, therefore, serves as an empirical benchmark in our study. In contrast to the Russian Ruble, the Euro exchange rate has remained rather stable throughout the underlying time period.

This study also adds to the strand of literature examining the exchange rate's influence on agricultural prices, which was first investigated by Schuh (1974). While some authors have followed a price transmission approach (Frank & Garcia, 2010; Hatzenbuehler et al., 2016; Ma et al., 2015; Mao et al., 2021; Swift, 2004), others have applied a price volatility framework to address this issue (Jumah & Kunst, 2001; Ott, 2014; Serra & Gil, 2013).

Only a few papers analyze exchange rate pass-through to domestic grain prices. For example, Hatzenbuehler et al. (2016) show that US corn and soybean prices are more responsive to the exchange rate under low stock conditions. Nazlioglu and Soytas (2011) find evidence for long-run causality of the exchange rate for maize and

[3] The OECD/FAO Outlook (June 2022) expects that Russia's wheat production and exports will further increase in the near, medium, and long-run future. In particular, Russia's wheat exports are forecasted to increase from 39.9 million tons in 2022–2023 to 43 million tons in 2023–2024. This mobilization of additional production potential is based on the assumption of slight increases in the wheat area harvested as well as yields per hectare. A USDA-WASDE report (2023) forecasts an increase in Russian wheat exports by around 6%, from 46 million tons in 2022–2023 to 49 million tons in 2023–2024.

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FIGURE 1 Map of wheat production regions in Russia.
Source: own illustration.

sunflower, while causality was not confirmed for wheat, cotton, and soybeans in Turkey. Furthermore, Ma et al. (2015) show that agricultural prices of wheat, colza oil, and japonica rice in China were neutral to the fluctuations of the exchange rate in the long run, except for soybeans.

In addition, the number of studies that address the importance of the exchange rate regime for exchange rate pass-through to commodity prices is limited. Bergin and Feenstra (2009) find that increased share of imports from the United States to China, which had a fixed exchange rate regime, reduced exchange rate pass-through to import prices in the United States. Furthermore, Mallick and Marques (2010) find incomplete exchange rate pass-through to Indian export prices after having transformed to a free-floating exchange rate regime. Results by Ge et al. (2010) suggest that transformation to the managed floating exchange rate regime in China influenced cotton's future prices in the United States and China.

The remainder of this paper is structured as follows: Characteristics of the Russian wheat market, export market conditions and competition are discussed in the following Section 2. The methodological framework and model estimation are presented in Section 3, while Section 4 discusses data and data properties, and Section 5 presents empirical results. Finally, conclusions and policy implications are drawn in Section 6.

2 | RUSSIAN WHEAT MARKET CHARACTERISTICS, EXPORT MARKET CONDITIONS, AND COMPETITION

Wheat production in Russia is spread over the six primary grain production regions of North Caucasus, Black Earth, Central, Volga, Urals, and West Siberia (Figure 1). North Caucasus is the main exporting region of Russia, which has direct access to the Black Sea ports. With a more than 4000 km distance to the Black Sea ports, West Siberia is the most peripheral wheat producing region. Therefore, West Siberia almost exclusively supplies wheat to the domestic wheat market, and especially to the Central region, where the wheat consuming core of Moscow is found along with a large livestock producing sector. With their distance to the Black Sea amounting to around 1900 and 2600 km, respectively, Volga and Urals are also large grain producing regions.

In this study, we propose that the effect of the exchange rate is not homogenous across domestic wheat prices in Russia. We build on Svanidze and Götz (2019), who have identified heterogeneity in the strength of price linkages within Russia's regional wheat markets, attributable to distance, transportation infrastructure, and market information systems. We acknowledge anecdotal evidence that indicates that the strong devaluation enabled Russian wheat producers to raise wheat producer prices vis-à-vis wheat export companies by exerting market power (Rusagrotrans, 2018).

The strong devaluation of the Russian Ruble in 2014–2015 increased the competitiveness of Russian traders on the world market and enabled them to earn higher incomes from wheat export activities. Due to economic sanctions imposed by the United States, EU, and other western countries, Russia was cut off from foreign investments and credits and experienced substantial capital flight, which led to the devaluation of the Ruble. In order to stabilize the Ruble's exchange rate, the Russian Central Bank increased its lending rate from 10.5% to 17% in December 2014, which was reduced to 15% in January 2015, in order to increase demand for the Ruble's counteracting devaluation (Liefert & Liefert, 2015). Moreover, Figure 2 displays the importance of the plummeting world oil price for the devaluation of the Ruble after the removal of the managed exchange rate regime. In 2020, the share of crude oil, oil products, and natural gas in total Russian exports was about 43%, while the share of agricultural and food products was 8.8% (Rosstat, 2021).

We suppose that the Russian Ruble depreciation against the USD had a strong increasing effect on regional wheat prices. This may be explained by the increase in export demand on the domestic market and wheat producers' incentives to increase their profits by raising producer prices, which requires some degree of market power.[4] Wheat production costs are supposed to have increased, since inputs, such as seeds and machinery, were partially imported or, even if they were produced domestically, they could have been nominated in foreign currency, as in the case of fertilizers. Eventually, higher production costs raise internal prices for wheat with timely delay. Therefore, the influence of macroeconomic conditions, such as

[4] In April 2018, the Ruble's devaluation led to an increase in Russian domestic wheat prices by 10% and raised incentives for wheat exports (Rusagrotrans, 2018).

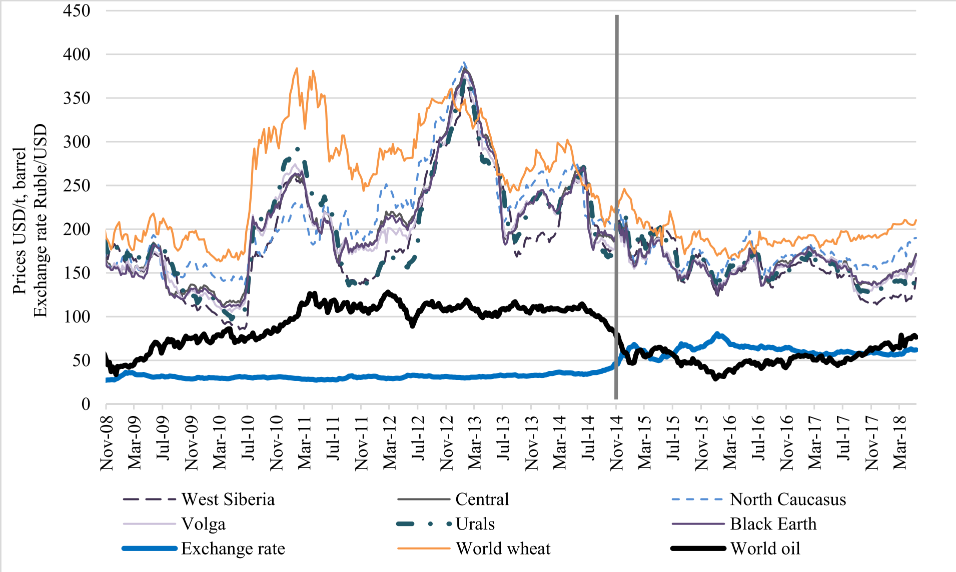

FIGURE 2 Wheat prices of Class 3, exchange rate and world oil prices.

Note: the vertical line corresponds to the change in the exchange rate regime in Russia.
Source: Russian Grain Union, Central Bank of Russia, the US Energy Information Administration (EIA), own illustration.

the exchange rate, on the wheat price developments have to be considered, especially when the fluctuation of the exchange rate is high, as in the case of Russia.

Other factors that directly determining exchange rate pass-through to commodity prices are agricultural trade policies, the market power of export markets and along food value chains, the quality of transportation systems, and the availability of market information (Liefert & Persaud, 2009). Nevertheless, exchange rates might be transmitted to domestic prices indirectly via imports and production inputs denominated in foreign currency (Al-Abri & Goodwin, 2009). However, the incomplete transmission of exchange rate changes can prevent exporting countries from attaining higher levels of wheat exports (Liefert, 2009).

As an example, the lockdown restrictions introduced due to the COVID-19 pandemic in 2020 led to a substantial decline in world oil prices, resulting in a devaluation of the Ruble. In particular, world oil prices declined by 70% within 2 months since the middle of February 2020 and reached its lowest level over the last two decades (Heigermoser & Glauben, 2020). Moreover, the Russian Ruble devaluated by 22%, from 63.6 to 77.7 Rubles against the USD (February 14, 2020, and March 28, 2020, respectively) (The Central Bank of the Russian Federation, 2022).

In the context of the war in Ukraine, grain imports from the European Union and especially France have gained in importance for wheat importing countries due to the war risks associated with wheat imports from the Black Sea region. For instance, amounting to 815,000 tons, Egypt purchased its largest wheat tender in more than a decade from France, Romania, Russia, and Bulgaria in order to increase its wheat reserves in June 2022, with France accounting for the largest share. Moreover, in the first half of 2022–2023, France heavily increased wheat exports to Algeria and Morocco. Despite higher free on board (FOB) prices of French wheat, the country has a competitive advantage in lower transportation costs due to geographical proximity to North Africa in comparison to other exporters such as Australia.

With nearly 20 million tons supplied to the world market in 2022, France is the largest wheat producer in the EU and the fourth largest wheat exporter in the world (UN COMTRADE, 2023). The mainland French territory has 56% arable land and around 10 million hectares of land is used for the production of cereals, corresponding to around half of the arable land in the country. Similar to Russia, France predominantly produces winter wheat. In addition, wheat production in France is impacted by weather anomalies, as was also observed for the case of Russia. However, the productivity of French wheat is more than two times higher compared to Russia (6.9 and 2.7 tons per ha, respectively). In 2020–2021, the main importers of French wheat were China, Algeria, Morocco, and Egypt.

A study by Heigermoser et al. (2021) reveals interdependencies between the Egyptian General Authority For Supply Commodities (GASC) tender price and Russian and French export prices. Accordingly, there is high competition between French and Russian wheat traders in the GASC tender system. Consequently, we consider the French wheat price as a suitable benchmark for comparison with the Russian wheat market. We therefore complement the analysis of the exchange rate pass-through to wheat prices in Russia, with exchange rate pass-through to wheat prices in France.

3 | METHODOLOGICAL FRAMEWORK AND MODEL ESTIMATION

To investigate the exchange rate pass-through to Russian wheat prices, we employ a two-step error correction model (ECM) developed by Engle and Granger (1987). In our model framework, the wheat price in one of the Russian wheat production regions (endogenous variable) is depicted as a function of the exchange rate and world wheat price (exogenous variables):

$$P_t^d = \beta_0 + \beta_1 ER_t + \beta_2 P_t^w + \varepsilon_t \tag{1}$$

$$\Delta P_t^d = \delta_0 \varepsilon_{t-1} + \sum_{k=1}^{K} \left\{ \delta_{1k} \Delta P_{t-k}^d + \delta_{2k} \Delta ER_{t-k} + \delta_{3k} \Delta P_{t-k}^w \right\} + \omega_t \tag{2}$$

where P_t^d is the domestic wheat price in the corresponding Russian region, ER_t is the Ruble/USD exchange rate, P_t^w is the world wheat price, and ε_t and ω_t are statistical error terms. Equation (1) characterizes the long-run price equilibrium between the regional wheat price, the Ruble/USD exchange rate, and the world wheat price. Parameters β_1 and β_2 denote the exchange rate pass-through and long-run price transmission elasticity, measuring the percentage change in the regional wheat price associated with a 1% change in the exchange rate and world wheat price, respectively.

We assume that the exchange rate is exogenous to domestic wheat prices in Russia. This assumption is motivated by the rather low share (3.2%) of cereal crops in Russia's total export revenues, whereas crude oil exports amounted to 51.3% in 2020 (Rosstat, 2021). Further, we assume that the world wheat price is exogenous to the Russian wheat prices,[5] which is an assumption based on the findings of the existing literature. Based on results of the test on weak exogeneity for the 2011–2019 time period, Heigermoser et al. (2021) find a leading role of the French wheat export price in the Egyptian GASC tender market, despite the high market share of wheat exporters in the Black Sea region and Russia. This is confirmed by results of Svanidze and Duric (2021) suggesting that the French wheat export market transmits price signals to the Russian market but not vice versa. Also, the raising role of the EURONEXT wheat futures market in France for price discovery on the world wheat market compared to the CBOT in the USA is confirmed by Janzen and Adjemian (2017), who argue that the French futures market better reflects the market fundamentals in the Black Sea wheat market.

Considering that the highest share of Russian wheat exports is supplied to the Middle East and North Africa (MENA) region, we consider the French export price as the corresponding world wheat price for Russian domestic wheat prices. Also, Russian wheat prices might adjust to French wheat prices due to an underdeveloped futures market in the Black Sea region.

Equation (2) depicts short-run dynamics, where ε_{t-1}, error correction term, is the lagged residual from the long-run price equilibrium (1) representing temporary deviations from the long-run parity relationship and k is the number of lags. The short-run speed of adjustment parameter, δ_0, indicates the speed at which domestic wheat prices in Russia adjust to eliminate temporary deviations and restore the long-run price equilibrium. The ECM is estimated individually for each Russian wheat production region (North Caucasus, Black Earth, Central, Volga, Urals, and West Siberia) and wheat class (Class 3, Class 4, and Class 5).

To assess the influence of the exchange rate on Russian wheat prices in the context of the war in Ukraine, we build on the price transmission framework applied by Baffes et al. (2019), and employ the ECM with price differentials accordingly. The ECM assumes that the underlying nonstationary variables are cointegrated if they share a common long-run stochastic trend so that their linear combination is a stationary process. However, if the presence of the long-run equilibrium between the Russian wheat price, the exchange rate, and the world wheat price is not confirmed by the Johansen test, the unit root test may be applied to the error correction term retrieved from the long-run equilibrium between the Russian wheat price and the world wheat price to check for cointegration. Therefore, the presence of a stationary error term indicates cointegration between two non-stationary price series.

Nevertheless, Equation (1) shows a few limitations. First, commodity prices usually contain a unit root that may invalidate econometric tests. In this case, validity of the model may be checked by the Engle and Granger procedure (Engle & Granger, 1987). Furthermore, if β_2 is not equal to one due to high transfer costs, price differentials may be growing, despite the cointegration of the price series. The existing literature indicates the weakness of a non-unity slope coefficient as the interpretation of price cointegration (Baffes, 1991; Baffes, 2019; Barrett, 1996).

[5] The importance of Russian wheat prices in price discovery on the world market due to increased grain exports needs further investigation.

In this case, price differentials may be tested for a unit root instead:

$$\left(P_t^d - P_t^w\right) \sim I\,(0) \tag{3}$$

Therefore, the effect of the war in Ukraine on the relationship between Russian wheat prices and the exchange rate can be estimated within an ECM model with price differentials in the short-run dynamics:

$$\Delta P_t^d = \alpha_0 + \rho_0\left(P_{t-1}^d - P_{t-1}^w\right) + \rho_1 \Delta P_{t-k}^d + \rho_2 \Delta ER_{t-1} + \rho_3 \Delta ER_{t-1} * D^{war} + \rho_4 \Delta P_{t-1}^w + \varphi_t \tag{4}$$

where $(P_{t-1}^d - P_{t-1}^w)$ represents the parameter estimates of the lagged price difference between the Russian wheat price and the world wheat price. These price differentials imply the presence of an error correction mechanism in the framework of the Engle-Granger theorem (Engle & Granger, 1987). D^{war} is the dummy variable of the war in Ukraine, taking the value of 1 after February 24, 2022, and 0 otherwise.

4 | PRICE DATA AND TIME SERIES PROPERTIES

Our empirical analysis is based on the weekly prices of Russian wheat (Ruble/t) for Classes 3, 4, and 5 for each of the six wheat producing regions. Wheat of Class 3 is the most widely traded type of wheat for human consumption within Russia, whereas wheat of Class 4 is primarily exported to the international market, and wheat of Class 5 is used as a feed grain in Russia.

To explicitly take into account the possible influence of the change to the floating exchange rate regime, we conduct an econometric analysis for two sub-periods separately: the first subset from September 12, 2008, to November 7, 2014, and time period for the second subset is between November 14, 2014, and January 27, 2017, corresponding to the period with a freely floating exchange rate regime after the abolishment of the managed exchange rate.

We consider the time period from November 14, 2014, to January 27, 2017, as a period of substantial devaluation of the Russian Ruble, induced by the plummeting world oil prices in 2014–2015. In order to reduce the impact of the world oil price changes on the Russian economy, the Russian government returned to the fiscal rule at the end of January 2017. In particular, the oil and gas revenues that were received in excess of the cut-off price on the world market should be distributed to the Russian National Wealth Fund.[6] On the other hand, when world oil and gas prices are below the cut-off price, the National Wealth Fund's revenues should be directed to cover the budget deficit. The Russian government preserved additional oil and gas revenues when oil prices exceeded the 40 USD per barrel mark and carried out currency purchase/sale operations on the open market. As a result, since February 2017, there has been a noticeable decrease in the correlation between the exchange rate dynamics and world oil prices.

Furthermore, we build our analysis of the effects of the Ukraine war on data for the time period November 14, 2014 to September 16, 2022, which includes the time period when wheat exports were strongly and permanently restricted (Figure 3, Figure A1 and Table 1).

Additionally, we use milling wheat prices (Euro/t) from France (La Pallice) as a corresponding benchmark for Russian wheat prices. La Pallice is a deep-water port in France. Therefore, French domestic wheat prices from La Pallice are comparable to wheat prices in North Caucasus, which has direct access to the Black Sea port. We utilize the Ruble/USD and Euro/USD as corresponding exchange rates in our analysis. The French Rouen spot wheat price (FOB USD/t) serves as a corresponding world wheat price provided by the Agriculture and Horticulture Development Board (Figure A2). We use the standard Rouen wheat price from the International Grain Council as a corresponding world wheat price to investigate the effect of the war in Ukraine[7] (Figure A3). All variables are transformed into natural logarithms, and we impute missing observations with the average values of the preceding and succeeding values.[8]

We apply the Dickey-Fuller generalized least squares (GLS) test (Elliott et al., 1996) to check time series

[6] The stabilization fund of the Russian Federation was founded in 2004. It was divided into the Reserve Fund and the National Wealth Fund in 2008. In 2018, the Reserve Fund became part of the National Wealth Fund (Russian Ministry of Finance, 2023).

[7] The recent French Rouen wheat price (FOB/USD) is not available on the AHDB's website.

[8] From September 12, 2008, to November 7, 2014, 14 (4.3%) and 32 (9.9%) price observations are missing for all regional Russian wheat prices (Classes 3, 4, and 5) and the world wheat price, respectively. From November 14, 2014, to January 27, 2017, six (4.3%) price observations are missing for North Caucasus, Volga, Urals, and West Siberia and five (5.1%) observations for Black Earth and Central (Classes 3, 4, and 5), whereas 10 (8.6%) price observations are absent for the French Rouen spot wheat price from the AHDB. There are three (0.93%) and two (0.48%) missing values for the Ruble/USD exchange rate for time period from September 12, 2008, to November 7, 2014, and from November 14, 2014, to September 16, 2022, respectively. From November 14 to September 16, 2022, there is one (0.24%) missing observation for the Standard Rouen wheat price from the International Grain Council.

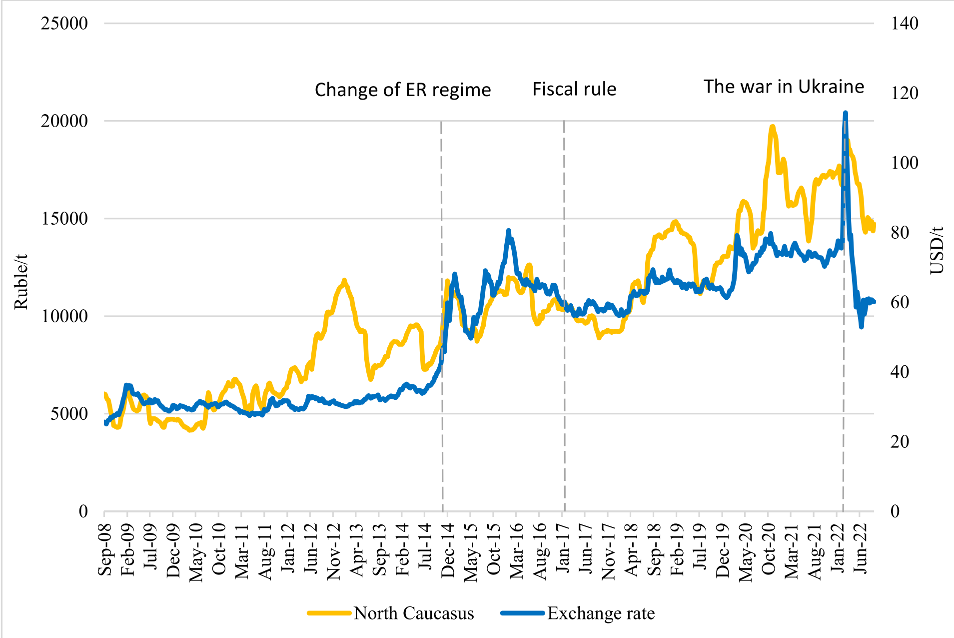

FIGURE 3 Wheat prices of Class 3 in North Caucasus and the Ruble/USD exchange rate.

Note: Officially, the Russian government returned to the fiscal rule in July 2017. However, the government has already set a cut-off price at the end of January 2017.
Source: Russian Grain Union, Central Bank Russian Federation, own illustration.

TABLE 1 Data bases of the analyses.

Research focus	Managed exchange rate regime	Free-floating exchange rate regime	The war in Ukraine
Time period	From Sep 12, 2008 to Nov 7, 2014	From Nov 14, 2014 to Jan 27, 2017	From Nov 14, 2014 to Sep 16, 2022
Number of observations	322	116	410
Price series, Sep 2008 to Sep 2022	**Source**		
Russian wheat (Ruble/t)	Russian Grain Union		
French wheat (Euro/t)	Agriculture and Horticulture Development Board		
World wheat (USD/t)	Agriculture and Horticulture Development Board, International Grain Council		
Exchange rate (Ruble/USD)	The Central Bank of the Russian Federation		
Exchange rate (Euro/USD)	Federal Reserve System (Central Bank of the US)		

properties. The results of the test are presented in Tables A1–A6.

5 | EMPIRICAL RESULTS

5.1 | Test on cointegration

We apply the cointegration test by Johansen (1995) to Russian regional wheat prices, the Ruble/USD exchange rate, and the world wheat price for the time period with a managed exchange rate regime and a free-floating exchange rate regime separately. The existence of one common linear trend for all price series implies that prices must be cointegrated, and there must be (n-1) cointegrating vectors, which is two in our case. For wheat of Classes 3, 4, and 5 in the six different regions of Russia, the empirical results of the cointegration test indicate the absence of two cointegrating vectors between the Ruble/USD exchange rate, the world wheat price, and the Russian wheat prices during the period with the managed exchange rate regime. However, cointegration between the price series is confirmed

TABLE 2 Johansen trace test results, Russian wheat prices, the exchange rate, and the world wheat price.

Price series	Managed exchange rate regime			Free-floating exchange rate regime		
	Specification	Trace statistic	*P*-value	Specification	Trace statistic	*P*-value
Wheat of class 3						
North Caucasus	1 lag, intercept (restricted), no trend	7.99	.82	1 lag, intercept (restricted), no trend	20.66	.04
Black Earth	1 lag, intercept (restricted), no trend	8.57	.77	1 lag, no intercept or trend	12.39	.04
Central	1 lag, intercept (restricted), no trend	8.32	.79	1 lag, no intercept or trend	12.32	.04
Volga	2 lags, intercept (restricted), no trend	8.09	.81	1 lag, intercept (restricted), no trend	21.17	.03
Urals	2 lags, intercept (restricted), no trend	7.74	.84	1 lag, intercept (restricted), no trend	19.57	.06
West Siberia	2 las intercept (restricted), no trend	8.89	.74	1 lag, no intercept or trend	11.52	.06
Wheat of Class 4						
North Caucasus	1 lag, intercept (restricted), no trend	8.26	.80	1 lag, intercept (restricted), no trend	21.16	.03
Black Earth	1 lag, intercept (restricted), no trend	8.64	.76	1 lag, intercept (restricted), no trend	21.01	.03
Central	1 lag, intercept (restricted), no trend	8.43	.78	1 lag, no intercept or trend	12.71	.04
Volga	2 lags, intercept (restricted), no trend	8.23	.80	2 lags, intercept (restricted), no trend	10.86	.55
Urals	3 lags, intercept (restricted), no trend	7.64	.85	2 lags, intercept (restricted), no trend	10.45	.59
West Siberia	2 lags, intercept (restricted), no trend	9.13	.72	1 lag, intercept (restricted), no trend	21.26	.03
Wheat of Class 5						
North Caucasus	1 lag, intercept (restricted), no trend	8.19	.80	2 lags, intercept (restricted), no trend	18.84	.07
Black Earth	2 lags, intercept (restricted), no trend	8.66	.76	1 lag, no intercept or trend	12.41	.04
Central	1 lag, intercept (restricted), no trend	8.39	.79	1 lag, no intercept or trend	12.47	.04
Volga	4 lags, intercept (restricted), no trend	6.39	.93	1 lag, intercept (restricted), no trend	16.05	.17
Urals	2 lags, intercept (restricted), no trend	8.05	.81	2 lags, intercept (restricted), no trend	10.17	.62
West Siberia	2 lags, intercept (restricted), no trend	8.87	.74	1 lag, intercept (restricted), no trend	18.39	.08

Note: Trace statistic and *P*-value for at most one cointegration vector.

in 10 out of 18 cases within the free-floating exchange rate regime[9] (Table 2).

5.2 | Exchange rate pass-through under the free-floating exchange rate regime

To assess exchange rate pass-through to the Russian domestic wheat prices, we apply the ECM model frame-

[9] In addition, we estimate the Johansen test with wheat prices of Class 3 from all six wheat producing regions and the exchange rate as the exogenous variable. The empirical findings confirm cointegration only between North Caucasus, Black Earth, Central, Volga and Urals. However, the estimation results of the multivariate vector error correction model do not yield economically interpretable results.

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TABLE 3 Exchange rate pass-through to Russian wheat prices (free-floating exchange rate regime).

Price series	Exchange rate pass-through (β_1)	World wheat price transmission elasticity (β_2)	Intercept (α)	Speed of adjustment (δ_1)
Wheat of Class 3				
North Caucasus	.60	.17	5.85	−.09*** (.03)
Black Earth	.35	.20	6.68	−.09*** (.02)
Central	.35	.25	6.42	−.09*** (.02)
Volga	.32	.11	7.26	−.14*** (.03)
Urals	–	–	–	–
West Siberia	–	–	–	–
Wheat of Class 4				
North Caucasus	.64	.31	4.88	−.06** (.02)
Black Earth	.49	.32	5.36	−.05*** (.01)
Central	.47	.33	5.41	−.06*** (.02)
Volga	–	–	–	–
Urals	–	–	–	–
West Siberia	.22	.53	5.37	−.07*** (.02)
Wheat of Class 5				
North Caucasus	–	–	–	–
Black Earth	.55	.33	5.02	−.04** (.01)
Central	.50	.33	5.20	−.05** (.02)
Volga	–	–	–	–
Urals	–	–	–	–
West Siberia	–	–	–	–

Notes: '-' no cointegration.
Standard errors in parentheses, significance at 1%*** and 5%** level.

work to cointegrated time series variables during the free-floating exchange rate regime. Table 3 shows the estimated parameters of the ECM as specified in Equations (1) and (2). Parameter estimates of the ECM indicate that wheat prices of Class 3 in North Caucasus (.60)are integrated most strongly with the exchange rate followed by Black Earth (.35), Central (.35) and Volga (.32). We trace this back to the vicinity of North Caucasus to the Black Sea ports. Exchange rate pass-through to wheat prices of Class 4 is also highest in North Caucasus (.64), while cointegration was not confirmed in the remote regions of Volga and Urals. In contrast to wheat prices of Classes 3 and 4, exchange rate pass-through to wheat prices of Class 5 (feed wheat) is not identified in North Caucasus, while estimated parameters for other regions closer to the Black Sea port (Black Earth and Central) amount to .55 and .50, respectively.[10]

Additionally, Table 3 shows that the size of the estimated transmission elasticities is higher for the exchange rate compared to the world wheat price in all cases, except for wheat prices of Class 4 in West Siberia. In particular, the exchange rate pass-through is more than three times higher than the price transmission elasticity of the world wheat price (.60 and .17, respectively) for Russian wheat prices of Class 3 in North Caucasus.[11]

Our findings make evident that corrections of deviations from the long-run equilibrium are not instantaneous with weekly adjustment rates, ranging between 4% for wheat of Class 5 in Black Earth and 14% for wheat of Class 3 in Volga. Furthermore, all short run speed of adjustment parameters have the expected negative sign and are statistically significant at the 5% level.

[10] In addition, we apply the Wald test to estimate the equality of long run parameters from Equation 1 between Russian wheat prices from various production regions. These results show that 6 out of 13 exchange rate pass-through parameters are not equal at the 5% level, while test results do not allow for the rejection equality of all price transmission elasticity parameters with respect to world wheat price (Table A7).

[11] In addition, we estimate a panel error correction model between Russian wheat prices of Class 3, the exchange rate and world wheat price. Estimation findings confirm the results of the time series model; these results are available upon request.

TABLE 4 Exchange rate pass-through, Russia and France.

Price series	Exchange rate pass-through	World wheat price transmission elasticity	Speed of adjustment
Russia			
North Caucasus (Class 3)	.60	.17	−.09*** (.03)
North Caucasus (Class 4)	.64	.31	−.06** (.02)
France			
La Pallice (milling wheat)	−.87	1.11	−.23** (.09)
Wald test on equality of long run parameters			
	Z-statistic	P-value	
Exchange rate			
North Caucasus (Class 3) - La Pallice	12.29	.00	
North Caucasus (Class 4) - La Pallice	12.10	.00	
World wheat price			
North Caucasus (Class 3) - La Pallice	−10.13	.00	
North Caucasus (Class 4) - La Pallice	−7.91	.00	

Standard errors in parentheses, significant at the 1%***, 5%**, and 10%* level.

5.3 | Exchange rate pass-through to Russian wheat prices in comparison to France

We compare exchange-rate pass-through for Russian wheat prices with wheat prices in France (La Pallice). The results of the Johansen test indicate that French wheat prices are integrated with the USD/EUR exchange rate and the world wheat price (Table A8). The empirical results indicate that the USD/EUR exchange rate pass-through to wheat prices in La Pallice amounts to −.87 and higher compared to Russia (.60 and .64 for Classes 3 and 4, respectively) (Table 4). Exchange rate pass-through parameters for France have a negative sign, which is opposite to what is observed for wheat prices in Russia. This difference results from quoting USD in Rubles for the Ruble/USD exchange rate and Euro in USD for the USD/EUR exchange rate. The negative connection between the USD exchange rate and agricultural prices was confirmed by a number of studies (e.g., Baffes & Dennis, 2013; Gardner, 1981). Regarding the long-run price transmission elasticity of the world wheat price to domestic prices, this is higher in France (1.11), even exceeding the magnitude of the exchange rate pass-through compared to Russia, amounting to .17 and .31 for wheat of Class 3 and Class 4, respectively.[12] Moreover, the speed of adjustment parameters indicates that a temporary price disequilibrium is eliminated faster by wheat prices in La Pallice (−.23) in comparison to wheat prices in North Caucasus (−.09 and −.06).

In addition, we estimate historical volatility of the RUB/USD and the USD/EUR exchange rate for Russia and France, respectively. Figure 4 presents the estimated historical USD/RUB exchange rate volatility in every trade year.[13]

The estimated historical volatility parameters of the Ruble exchange rate show that exchange rate volatility is highest in the 2014-2015 trading year (4.1), which is more than two times higher than for the USD/EUR exchange rate for the same period. Moreover, in the 2015-2016 trading year, the Ruble exchange rate volatility is more than three times higher in comparison to the Euro exchange rate (3.1 and 1.0, respectively). In the 2016–2017 marketing year, the Ruble exchange rate volatility is almost two times higher than for the Euro exchange rate.

5.4 | The effect of the war in Ukraine

We further proceed our empirical analysis by investigating the effects of the war in Ukraine on the relationship between the exchange rate and domestic wheat prices. Empirical results of the Johansen test do not confirm

[12] The Wald test confirms that the parameters of the exchange rate pass-through and estimates of the long-run price transmission elasticity with respect to the world wheat price for the Russian and French wheat prices are not equal at the 1% significance level.

[13] Exchange rate historical volatility is estimated non-parametrically as the returns standard deviation (σ_i) in every trade year: $\sigma_i = 100\sqrt{\frac{1}{T}\sum_{t=1}^{T}(p_t - \bar{p}_t)}$, where p_t denotes exchange rate return in time t calculated as $p_t = ln(\frac{P_t}{P_{t-1}})$ with p_t being the USD/RUB exchange rate and $\bar{p}_t$ denoting the mean of exchange rate: $\bar{p}_t = \frac{1}{T}\sum_{t=1}^{T} p_t$.

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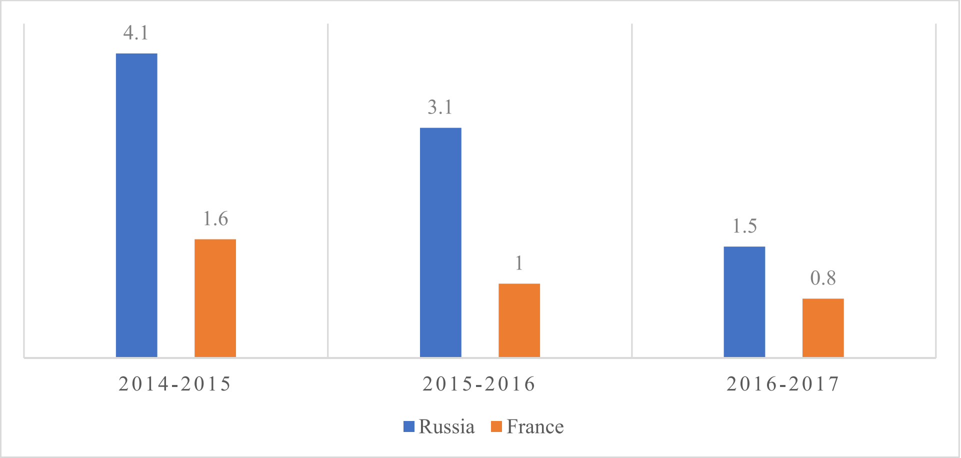

FIGURE 4 Historical RUB/USD and USD/EUR exchange rate volatility.

Note: Estimation period for each trade year from the beginning of July to the end of June.
Source: Own illustration.

TABLE 5 Johansen test (Russian wheat, the exchange rate and world wheat price).

Price series	Specification	Trace statistic	*P*-value
Nov 14, 2014–Sep 16, 2022			
Wheat of Class 3			
North Caucasus	1 lag, intercept (restricted) no trend	10.27	.61
Black Earth	2 lags, intercept (restricted) no trend	9.31	.70
Central	2 lags, intercept (restricted) no trend	8.90	.74
Volga	3 lags, intercept (restricted) no trend	8.09	.81
Urals	4 lags, intercept(restricted) no trend	6.49	.92
West Siberia	2 lags, intercept (restricted) no trend	7.20	.88
Wheat of Class 4			
North Caucasus	2 lags, intercept (restricted) no trend	11.64	.48
Black Earth	2 lags, intercept (restricted) no trend	9.55	.68
Central	2 lags, intercept (restricted) no trend	8.65	.76
Volga	3 lags, intercept (restricted) no trend	8.28	.80
Urals	3 lags, intercept (restricted) no trend	6.73	.91
West Siberia	2 lags, intercept(restricted) no trend	7.15	.88
Wheat of Class 5			
North Caucasus	2 lags, intercept (restricted) no trend	10.40	.60
Black Earth	2 lags, intercept (restricted) no trend	8.93	.74
Central	1 lag, intercept (restricted) no trend	6.82	.90
Volga	3 lags, intercept (restricted) no trend	8.93	.74
Urals	2 lags, intercept (restricted) no trend	6.51	.92
West Siberia	3 lags, intercept (restricted) no trend	7.50	.86

Note: Trace statistic and *P*-value for at most one cointegration vector.

cointegration between Russian wheat prices, the exchange rate and the world wheat price from November 14, 2014, to September 16, 2022 (Table 5). We explain this finding with Russia's wheat export restrictions, which have been in place since the Covid-19 pandemic, implying that the Russian wheat market became less integrated with the world wheat market (please see Section 1 for more detailed information). This assumption is in line with the existing literature, which confirms that the integration of the Russian wheat market with the world wheat market loosened during export restrictions in 2007–2008 (Götz et al., 2013) and the 2010–2011 trade year (Götz et al., 2016). We therefore assess the effect of the war on the relationship between the exchange rate and Russian wheat prices within the ECM framework as specified in Equation (4).

Results of the GLS test suggest that price differentials between Russian wheat prices and the world wheat price and error correction terms are stationary at the 5% significance level (Table 6). Therefore, we conclude that Russian wheat prices of Classes 3, 4, and 5 are cointegrated with the world wheat price within the framework of the Engle and Granger procedure.

Further, the estimated short-run dynamics for wheat prices of Class 3 reveal that the influence of the exchange rate is the highest in Central (.15), North Caucasus (.13) and Black Earth (.13), while this effect was not identified for Volga, Urals, and West Siberia (Table 7). We trace this back to the fact that North Caucasus, Black Earth and Central are the regions spatially closest to the Black Sea ports. Also, Central is the main wheat consumption region of Russia. Empirical findings reveal a decreasing effect of the war in Ukraine on the exchange rate's influence, which is the highest in Central (−.13) and North Caucasus (−.11). Moreover, empirical results do not confirm an impact of the war on the relationship between the exchange rate and Russian wheat prices of Class 3 in the remote regions of Volga, Urals, and West Siberia.

The empirical findings for wheat of Class 4, which is usually exported to the world wheat market, identify the highest influence of the exchange rate on wheat prices in North Caucasus (.17) and Central (.16), which is similar to results for wheat of Class 3. Furthermore, the decreasing effect of the war in Ukraine on the relationship between Russian wheat prices and the exchange rate is identified only in Central (−.16). This implies that the exchange rate's influence has come to a full stop during the Ukraine war in the Central region.

Furthermore, the estimation results for wheat of Class 5 (feed wheat) confirm the pattern that an influence of the exchange rate is the highest in the regions spatially closest to the world market, that is, North Caucasus (.18) and Black Earth (.12), while this effect is the lowest in Urals (.09) and was not confirmed in West Siberia. Parameters for the Central and Volga regions are similar to each other and amount to .11 and .12, respectively. Moreover, the effect of the war is not revealed for wheat prices of Class 5.

Moreover, the empirical results reveal the most substantial influence of the world wheat price on Russian wheat prices in the main grain exporting regions of North Caucasus for all wheat classes (.11 for Classes 3 and 4 and .09 for Class 5).

6 | CONCLUSIONS AND POLICY IMPLICATIONS

This study has investigated the Ruble/USD exchange rate pass-through to regional domestic Russian wheat prices. Our results do not confirm exchange rate pass-through until the managed exchange rate regime was transformed to a free-floating regime in November 2014. Our empirical results show that the exchange rate pass-through to wheat prices of Classes 3 and 4 is the highest in North Caucasus, which has direct access to the Black Sea port, in comparison to other regions. Moreover, exchange rate pass-through to Russian wheat prices is not confirmed for the most remote regions of Urals (all wheat classes) and West Siberia (Classes 3 and 5). These findings are in line with Götz et al. (2016), which identify strong integration of the wheat market in North Caucasus, within direct access to the international markets, to the world wheat market, in case trade is freely possible. Differently, the integration of regional markets in the remote regions of Urals and West Siberia in the world wheat market could not or only weakly be confirmed, which is traced back to the minor role international trade plays and thus the larger importance of local market factors, such as local weather disturbances, for price formation. Moreover, Svanidze and Götz (2019) identify that distance plays an important role in the regional spatial integration of the Russian wheat market.

Our empirical results reveal that in contrast to wheat prices of Classes 3 and 4, exchange rate pass-through to wheat prices of Class 5 is not identified in the main wheat exporting region of North Caucasus. We trace this back to the fact that wheat of Class 5 is used as feed wheat for livestock production inside of Russia and thus is traded mainly within Russia but rarely exported to the world market. Therefore, in addition to the distance to the world market, exchange rate-pass through to Russian wheat prices might also depend on the quality of wheat, which differs in the degree to which the wheat is traded internationally. Different to wheat of Classes 3 and 4, wheat of Class 5 is used for feeding animals and may be substituted by maize and soybean meal, which are both traded on the world market as well.

Our empirical results indicate that the exchange rate pass-through to wheat prices in North Caucasus is lower compared to wheat prices in La Pallice, France. Moreover, our results suggest that the influence of the world wheat price is stronger on French wheat prices than on domestic Russian wheat prices. Also, we find empirical evidence that the exchange rate influenced Russian wheat prices more strongly compared to the world wheat price in most cases within the free-floating exchange rate regime. This might be explained by the repeated implementation

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TABLE 6 DF-GLS unit root test (Russian wheat prices and world wheat price).

	Constant and trend		Constant	
Price Series	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Nov 14, 2014–Sep 16,				
Wheat of Class 3				
Price differentials				
North Caucasus	1	−4.05***	1	−3.27***
Black Earth	1	−4.07***	1	−3.98***
Central	1	−3.94***	1	−3.84***
Volga	1	−3.64***	1	−3.54***
Urals	1	−3.59***	1	−3.56***
West Siberia	1	−3.42**	1	−2.73***
Error correction term				
North Caucasus	1	−3.93***	1	−3.63***
Black Earth	1	−3.78***	1	−3.72***
Central	1	−3.63***	1	−3.58***
Volga	1	−3.27**	1	−3.25***
Urals	1	−3.29**	1	−3.26***
West Siberia	1	−3.03**	1	−2.80***
Wheat of Class 4				
Price differentials				
North Caucasus	1	−4.14***	1	−3.55***
Black Earth	1	−4.16***	1	−3.78***
Central	1	−4.00***	1	−3.63***
Volga	1	−3.82***	1	−3.43***
Urals	1	−3.90***	1	−3.65***
West Siberia	1	−3.70***	1	−2.54**
Error correction term				
North Caucasus	1	−3.97***	1	−3.83***
Black Earth	1	−3.71***	1	−3.72***
Central	1	−3.55***	1	−3.55***
Volga	1	−3.27**	1	−3.29***
Urals	1	−3.38**	1	−3.38***
West Siberia	1	−3.09**	1	−2.74***
Wheat of Class 5				
Price differentials				
North Caucasus	1	−3.93***	1	−3.59***
Black Earth	1	−3.66***	1	−3.44***
Central	1	−3.60***	1	−3.36***
Volga	1	−3.35**	1	−3.12***
Urals	1	−3.35**	1	−3.21***
West Siberia	1	−3.89***	1	−3.36***
Error correction term				
North Caucasus	1	−3.64***	1	−3.65***
Black Earth	1	−3.37**	1	−3.39***
Central	1	−3.29**	1	−3.30***
Volga	1	−3.02**	1	−3.02***
Urals	1	−3.08**	1	−3.07***
West Siberia	1	−3.47**	1	−3.42***

Note: Null hypotheses: Presence of unit root.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE 7 The effect of the war in Ukraine.

Price series	Price differential (ρ_0)	Exchange rate (ρ_2)	Effect of the war (ρ_3)	World wheat (ρ_4)
Wheat of Class 3				
North Caucasus	−.07	.13***	−.11*	.11***
Black Earth	−.01**	.13**	−.10	.02
Central	−.01**	.15***	−.13*	.03
Volga	−.01**	.08	−.06	.04
Urals	−.01**	.07	−.02	.01
West Siberia	−.01**	.02	.006	.02
Wheat of Class 4				
North Caucasus	−.01	.17***	−.11	.11***
Black Earth	−.01**	.11**	−.10	.04
Central	−.01**	.16***	−.16**	.02
Volga	−.01**	.11**	−.08	.03
Urals	−.01***	.06	−.02	.006
West Siberia	−.01**	.02	.009	.03
Wheat of Class 5				
North Caucasus	−.002	.18***	−.10	.09**
Black Earth	−.002	.12**	−.11	.03
Central	−.002	.11**	−.09	.006
Volga	−.001	.12***	−.09	.04
Urals	−.001	.09**	−.03	−.007
West Siberia	−.002	.04	−.01	.03

Notes: Effect of the war in % calculated as percentage of parameter effect of the war (ρ_3) to parameter of exchange rate (ρ_2).
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

of wheat export restrictions by Russia, which decrease world market price transmission and ensure that local market conditions (e.g., regional supply and demand) gain in importance vis-à-vis world market factors. Also, large distances to the ports and deficient transport infrastructure in Russia may influence this finding.

Results on the importance of macroeconomic conditions for domestic wheat prices in emerging (Russia) and developed (France) countries that export wheat complement insights provided by Liefert and Persaud (2009), which focused on developing countries. Moreover, our findings regarding exchange rate pass-through to domestic grain prices are in line with Hatzenbuehler et al. (2016), which identified exchange rate pass-through to corn and soybean prices in the USA. However, exchange-rate pass through to wheat prices in Turkey was not identified in the study by Nazlioglu and Soytas (2011). This might indicate that exchange rate pass-through is more important for grain exporting countries, especially the United States, France, and Russia, than for grain importers such as Turkey. In addition to wheat, Burakov (2016) investigated the Ruble exchange rate pass-through to other kinds of agricultural commodities, that is, buckwheat, grain crops, potatoes, oat, rye, and barley. Considering the time period from January 1999 to October 2015, the existence of a long-run relationship with the Ruble exchange rate is only confirmed for buckwheat, the only crop among those that was imported by Russia.

Trade policies and poor market conditions cause incomplete exchange rate pass-through to domestic agricultural prices. These poor market conditions might be related to physical infrastructure, such as transport, road, and storage systems, or to institutional or commercial infrastructure, such as systems of law, finance, and market information (Liefert & Persaud, 2009). Moreover, spatial market efficiency and transport infrastructure play an important role for interregional trade from surplus regions to deficit regions (Svanidze & Götz, 2019), especially in the periods of harvest shortfalls (Svanidze et al., 2021). Therefore, exchange rate pass-through to wheat prices in remote regions could be strengthened by investing in market conditions such as transportation infrastructure and market information services to improve their functioning. Second, incomplete exchange rate pass-through in the closest regions to the world market might indicate market power of Russian producers and traders on domestic markets, which might also be connected to poor market conditions (compare Section 2).

Thus, the empirical results of our study have policy implications for the Russian government. To mobilize Rus-

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sia's additional unutilized wheat production (Schierhorn et al., 2014; Swinnen et al., 2017) and export (Svanidze & Götz, 2019) potential, it is important to ensure that the exchange rate changes are largely transmitted to domestic wheat prices in the most remote regions of Urals and West Siberia. Therefore, the functioning of the grain supply chain should be improved by investing in transportation infrastructure and market information services.

Exchange rate pass-through is important to ensure that the market remains in equilibrium and that the market adjusts to macroeconomic changes to guarantee efficient resource allocation. Therefore, a lower degree of exchange rate pass-through in Russia in comparison to France might imply a higher risk of disequilibrium and thus inefficient resource allocation. This is particularly relevant for Russia where the Ruble exchange rate variability is higher compared to the Euro exchange rate in France. Consequently, domestic prices in Russia do not sufficiently adjust to changes in the exchange rate market, with respective consequences for domestic production incentives, which might result in a large variability of export supply, with possible negative consequences for the import countries.

Our results further reveal that with Russia's invasion of Ukraine, the influence of the exchange rate on Russian wheat prices has decreased strongly. In particular, for wheat of Class 3, it has come to a full stop in the Central region and become substantially inhibited in North Caucasus and Central. We trace back the weakened influence of the exchange rate on domestic wheat prices in Russia to the following three factors: first, wheat export restrictions and the substantial increase in transaction costs resulting from, for example, the increased insurance costs for ships in the Black Sea region due to war risk and the risk of importers facing secondary sanctions, which have dampened the influence of the world market price and thus the exchange rate. Second, the Ruble appreciation observed from March to June 2022 might have been passed through to a lower degree to domestic wheat prices than a depreciation, since this implies the decrease of the domestic price level, which decreases wheat producers' revenues.[14] Therefore, the Russian wheat market was on a "wait-and-see" mode as it was also observed on the world market in the first months after the Russian invasion of Ukraine (Legrand, 2022). And third, the influence of exchange rate changes on domestic wheat prices was also dampened by switching to a Ruble-denominated export tax system and the new baseline price (15,000 Ruble/t) at the beginning of July 2022. More specifically, when the Ruble appreciates, the size of the export tax decreases, counteracting the negative effects of the exchange rate appreciation on wheat export sales.[15] In contrast, when the Ruble depreciates, the 15,000 Ruble reference price expressed in USD decreases, whereas the corresponding export tax increases, hence making it "more bearable" for Russian wheat exporters to pay higher taxes as the depreciated Ruble has made the Russian wheat more competitive on the world market. The flexible export tax system designed as such implies that the size of the export tax adjusts to exchange rate variations, eventually reinforcing that the exchange rate pass-through to domestic wheat prices in Russia is hampered. As a result of the combined effect of these three factors, Russian wheat exports in July and August 2022 were about 22% lower in comparison to the previous year (Refinitiv-Eikon, 2022), despite a record wheat harvest in 2022.

It can be expected that the high Ruble/USD exchange rate volatility will sustain in the short-run future since political and thus macroeconomic risks will remain high during the Ukraine war. For example, additional sanction packages implemented by western countries would have a strengthening effect on the Russian Ruble exchange rate given that they would ensure that Russia's import possibilities would become more limited. The appreciation of the Russian Ruble would decrease the competitiveness of Russia's wheat exports to international markets and would thus induce decreasing effects on Russia's wheat exports. Conversely, if Russian exports of oil and gas would shrink, the Ruble/USD exchange rate would depreciate, which would increase wheat export competitiveness and thus foster Russia's wheat exports. Also, it can be expected that the large dependence of Russia's economy on oil and gas exports will be sustained, which will continue to drive the Ruble exchange rate volatility due to generally highly volatile world market prices for oil and gas.

However, if the exchange rate pass-through and the integration in world wheat markets remain low and if they potentially even further decrease, while the exchange rate volatility remains high, the disintegration of Russia's grain sector might amplify. In a disintegrated grain sector, world market price developments are less transmitted to the domestic market, such that incentives for grain production in the medium-run and investments in the Russian grain sector in the long-run may weaken, with respective negative consequences for the wheat import-dependent countries in the Global South.

The risk of disintegration of the Russian wheat market from international markets and thus decreased wheat exports from Russia coupled by increased volatility

[14] The asymmetric effect in the Ruble's exchange rate pass-through to Russian wheat prices, however, was not confirmed within an ECM model framework and by the Wald test (November 14, 2014, to September 16, 2022). These results are available upon request.

[15] When the Ruble appreciates, the USD equivalent baseline price of 15,000 Ruble/t increases, which reduces the taxable base and, respectively, the size of export tax.

presents several additional risks with regards to Russian wheat exports since the Ukraine war. In particular, the risk that wheat exports become more volatile since transport along the export supply chain in the Black Sea is disrupted due to war activities, for example attacks on port infrastructure facilities. Also, there is a risk that Russian wheat exports could decrease temporarily due to an increase of the permanent wheat export tax level. Also, the government might again impose a minimum wheat export price, as recently tried for wheat tender exports, which might reduce the demand for Russian wheat. Further, there is also a risk that wheat exports could be reduced due to a reduction of ship transport capacity following the exclusion of multilateral wheat export companies from the Russian grain sector that play a large role in the organization of the sea transport of grains. Moreover, there is even a risk that grain export businesses follow economic rules less but rather geopolitical aims of the government, the primary of which is increasing its influence of the management of the Russian export companies. In order to strengthen trade resilience of the highly import-dependent countries in the Global South, situations of a high dependence on wheat imports from Russia should be decreased by trade diversification beyond the Black Sea region.

To increase food availability in the MENA region, which is the main destination of Russian wheat exports, buffer stocks might be an effective policy measure for mitigating negative consequences of price shocks in times of macroeconomic instability and volatile grain prices. Furthermore, governments should provide food aid and financial transfers (Berndt et al., 2022) to vulnerable households. Larson et al. (2014) argue that strategic wheat reserves can be effective in mitigating price volatility in the MENA region, but targeted transfers to vulnerable households might be a more efficient policy measure. In the context of the current food crisis, the government of Egypt opened its strategic wheat stocks and expanded social security programs to protect vulnerable low-income populations (Abay et al., 2023). Also, increasing local wheat production might further diversify risks. However, those measures are not free of costs, and might increase food prices, and thus measures to increase supply chain resilience need to be well balanced to actually improve food security.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Appendix A

Time series properties

Results of the GLS and Phillips-Perron (PP) unit root tests with constant and trend as well as without trend suggest that all price series are non-stationary at 5% during the managed exchange rate regime (Tables A1 and A2). Furthermore, results of the tests show that all price series are stationary at first differences. Results of the tests indicate that price series in levels are stationary in several cases during the free-floating exchange rate regime (Tables A3 and A4).

However, the GLS test results with price series in the first differences show that all price series are stationary at the 5% significance level, except for wheat prices of Classes 3 and 4 in West Siberia during the free-floating exchange rate regime. The PP test results with price series in the first differences show that all price series are stationary. Finally, results of unit root tests with constant and trends for the time period November 14, 2014, to September 16, 2022 show stationarity of price series in several cases. The test results with price series in first differences reveal that all price series are stationary (Table A5 and A6); we therefore conclude that all variables are integrated of order one.

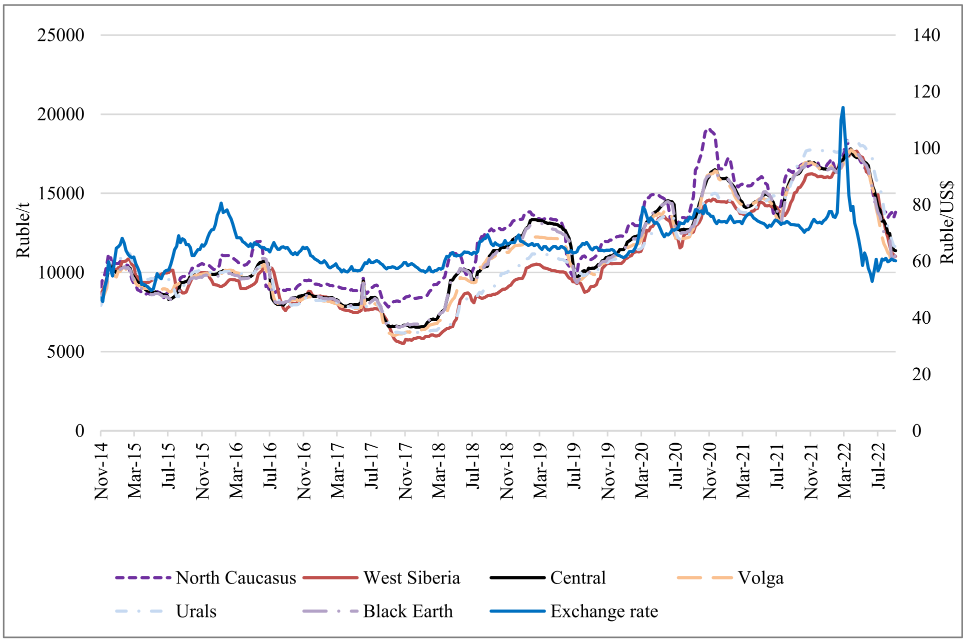

FIGURE A1 Wheat prices of Class 4 and Ruble/USD exchange rate.

Source: Russian Grain Union, the Central Bank of Russian Federation, own illustration.

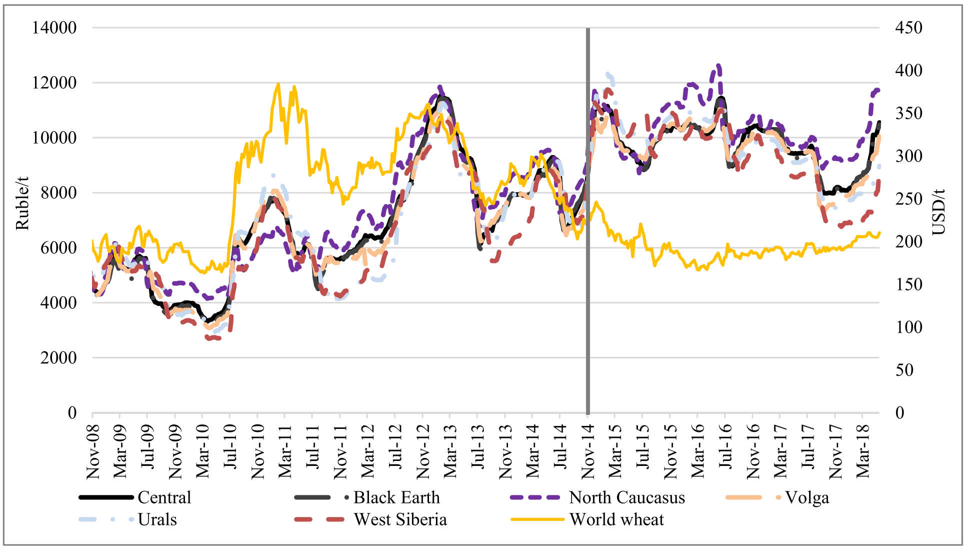

FIGURE A2 Wheat prices of Class 3 and the world wheat price.

Note: the vertical line corresponds to the change in the exchange rate regime in Russia.
Source: Russian Grain Union, Agriculture and Horticulture Development Board (AHDB), own illustration.

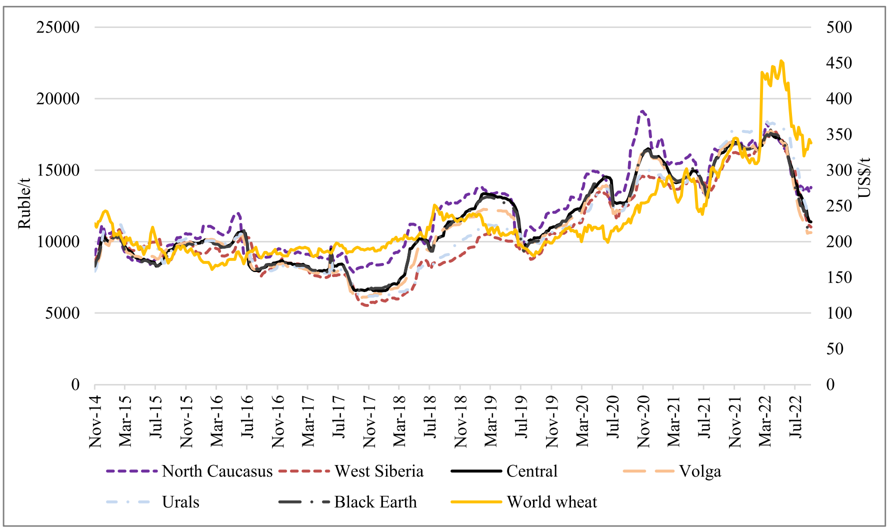

FIGURE A3 Wheat prices of Class 3 and the world wheat price.

Source: Russian Grain Union, International Grain Council, own illustration.

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TABLE A1 DF-GLS unit root test (managed exchange rate regime).

Price series	Constant and trend		Constant		1st difference	
	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Sep 12, 2008–Nov 7, 2014						
Wheat of Class 3						
North Caucasus	1	−2.40	1	−1.45	0	−9.32***
Black Earth	1	−2.53	1	−1.90*	0	−7.39***
Central	1	−2.38	1	−1.75*	0	−7.94***
Volga	2	−2.39	2	−1.79*	1	−6.95***
Urals	2	−2.51	2	−1.98**	1	−5.77***
West Siberia	2	−2.28	2	−1.86*	1	−5.82***
Wheat of Class 4						
North Caucasus	1	−2.83*	1	−1.52	0	−7.29***
Black Earth	1	−2.85*	1	−1.68*	0	−6.32***
Central	1	−2.44	1	−1.44	0	−8.13***
Volga	2	−2.59	2	−1.61	1	−6.74***
Urals	2	−2.55	2	−1.91*	1	−5.44***
West Siberia	2	−2.06	1	−1.43	1	−5.88***
Wheat of Class 5						
North Caucasus	1	−2.57	1	−1.14	0	−8.92***
Black Earth	2	−2.73*	2	−.95	1	−6.25***
Central	1	−2.55	1	−.88	0	−7.66***
Volga	3	−2.47	3	−.86	2	−6.80***
Urals	2	−2.53	2	−1.68*	1	−5.62***
West Siberia	2	−2.22	2	−1.72*	1	−5.89***
Exogenous variables						
Exchange rate (USD/Ruble)	2	−1.46	2	1.19	1	−7.23***
World wheat	1	−1.51	1	−1.51	0	−14.97***

Abbreviation: DF-GLS, Dickey-Fuller generalized least squares.
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE A2 Phillips-Perron unit root test (managed exchange rate regime).

Price series	Constant and trend: Specification (lag length)	Constant and trend: Test statistic	Constant: Specification (lag length)	Constant: Test statistic	1st difference: Specification (lag length)	1st difference: Test statistic
Sep 12, 2008–Nov 7, 2014						
Wheat of Class 3						
North Caucasus	6	−2.86	6	−1.31	9	−9.03***
Black Earth	10	−2.66	10	−1.50	7	−7.31***
Central	10	−2.60	10	−1.49	3	−8.01***
Volga	10	−2.50	10	−1.52	4	−10.00***
Urals	12	−2.39	12	−1.76	7	−8.36***
West Siberia	11	−2.33	11	−1.56	6	−8.96***
Wheat of Class 4						
North Caucasus	6	−3.02	6	−1.44	10	−8.37***
Black Earth	10	−2.52	10	−1.48	7	−6.72***
Central	10	−2.45	10	−1.45	1	−8.07***
Volga	11	−2.48	10	−1.49	7	−10.44***
Urals	12	−2.37	12	−1.71	9	−8.93***
West Siberia	11	−2.27	11	−1.52	7	−9.59***
Wheat of Class 5						
North Caucasus	7	−2.58	7	−1.33	10	−8.75***
Black Earth	11	−2.28	11	−1.46	5	−9.66***
Central	11	−2.30	11	−1.48	3	−8.35***
Volga	10	−2.23	10	−1.48	1	−8.71***
Urals	12	−2.40	12	−1.68	10	−10.00***
West Siberia	12	−2.38	12	−1.59	10	−9.98***
Exogenous variables						
Exchange rate (USD/Ruble)	10	−1.47	9	−.70	8	-13.37***
World wheat	6	−1.68	6	−1.59	2	−14.92***

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE A3 DF-GLS unit root test (free-floating exchange rate regime).

Price series	Constant and trend		Constant		1st difference	
	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Nov 14, 2014–Jan 27, 2017						
Wheat of Class 3						
North Caucasus	1	−2.36	1	−1.97**	1	−2.70***
Black Earth	1	−3.28**	1	−2.27**	0	−2.78***
Central	1	−3.15**	1	−2.16**	0	−2.89***
Volga	4	−2.68	4	−1.42	1	−2.15**
Urals	1	−2.00	1	−1.60	1	−3.58***
West Siberia	1	−2.42	1	−1.98**	1	−1.46
Wheat of Class 4						
North Caucasus	1	−2.47	1	−2.29**	0	−3.03***
Black Earth	1	−2.45	1	−2.15**	0	−2.36**
Central	1	−2.23	1	−1.96**	0	−3.75***
Volga	1	−1.61	1	−1.40	1	−2.44**
Urals	1	−1.56	1	−1.30	1	−3.09***
West Siberia	1	−2.73*	1	−2.36**	0	−3.69***
Wheat of Class 5						
North Caucasus	2	−2.79*	2	−2.59***	1	−3.09***
Black Earth	1	−2.23	1	−2.00**	0	−3.39***
Central	1	−2.09	1	−1.89*	0	−3.45***
Volga	1	−1.71	1	−1.53	1	−2.14**
Urals	2	−1.43	2	−1.40	2	−1.81*
West Siberia	1	−2.37	1	−2.06**	1	−1.78*
Milling wheat, France						
La Pallice	0	−1.68	0	−1.10	0	−10.63***
Exogenous variables						
Exchange rate (Ruble/USD)	1	−1.56	1	−.88	2	−3.87***
Exchange rate USD/Euro	2	−1.51	2	−.17	1	−8.02***
World wheat	0	−1.97	0	−.90	0	−11.31***

Abbreviation: DF-GLS, Dickey-Fuller generalized least squares.
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE A4 Phillips-Perron unit root test (free-floating exchange rate regime).

Price series	Constant and trend		Constant		1st difference	
	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Nov 14, 2014–Jan 27, 2017						
Wheat of Class 3						
North Caucasus	6	−2.22	6	−2.26	1	−6.47***
Black Earth	5	−2.99	5	−3.02**	10	−4.65***
Central	6	−3.17*	6	−3.20**	5	−5.05***
Volga	6	−3.13	6	−3.20**	4	−6.55***
Urals	6	−3.33*	6	−2.68	0	−6.35***
West Siberia	6	−4.09***	6	−3.11**	3	−6.41***
Wheat of Class 4						
North Caucasus	5	−2.23	5	−2.21	1	−6.32***
Black Earth	6	−2.64	6	−2.31	1	−5.24***
Central	6	−2.75	6	−2.30	4	−5.75***
Volga	6	−2.78	6	−2.06	1	−5.60***
Urals	6	−3.66**	7	−2.30	1	−6.08***
West Siberia	6	−3.65**	6	−2.41	2	−5.37***
Wheat of Class 5						
North Caucasus	6	−2.10	6	−2.06	5	−6.91***
Black Earth	6	−2.44	6	−2.03	4	−4.85***
Central	6	−2.55	6	−2.00	4	−5.39***
Volga	7	−2.63	7	−1.90	2	−5.40***
Urals	7	−2.91	7	−1.68	5	−6.63***
West Siberia	7	−3.52**	7	−2.28	2	−5.22***
Milling wheat, France						
La Pallice	5	−1.81	5	−2.01	5	−11.54***
Exogenous variables						
Exchange rate						
(Ruble/USD)	6	−2.56	6	−2.93**	5	−8.37***
Exchange rate USD/Euro	6	−2.89	6	−3.01**	12	−7.66***
World wheat	2	−2.06	0	−2.33	0	−11.90***

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

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TABLE A5 DF-GLS unit root test (the war in Ukraine).

Price series	Constant and trend		Constant		1st difference	
	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Nov 14, 2014–Sep 16, 2022						
Wheat of Class 3						
North Caucasus	1	−3.03**	1	−.88	1	−3.85***
Black Earth	2	−2.17	2	−.80	4	−2.10**
Central	2	−2.16	2	−.77	3	−3.26***
Volga	3	−2.07	3	−.85	3	−3.20***
Urals	4	−2.08	2	−.49	3	−2.71***
West Siberia	2	−1.67	2	−1.03	3	−3.14***
Wheat of Class 4						
North Caucasus	2	−3.18**	2	−1.07	2	−2.92***
Black Earth	2	−2.35	2	−1.08	3	−2.38**
Central	2	−2.26	2	−1.07	3	−3.18***
Volga	3	−2.24	3	−1.16	3	−3.16***
Urals	2	−1.74	2	−.77	3	−2.64***
West Siberia	2	−1.83	2	−1.20	3	−3.13***
Wheat of Class 5						
North Caucasus	2	−2.99**	2	−1.32	1	−5.29***
Black Earth	1	−2.12	1	−1.22	1	−4.82***
Central	1	−1.93	1	−1.19	3	−2.99***
Volga	2	−2.31	2	−1.37	2	−2.65***
Urals	3	−2.21	3	−1.30	2	−2.63***
West Siberia	2	−2.16	2	−1.35	3	−2.11**
Exogenous variables						
Exchange rate (Ruble/USD)	1	−2.58*	1	−1.19	5	−3.53***
World wheat	0	−1.32	0	−.71	5	−4.11***

Abbreviation: DF-GLS, Dickey-Fuller generalized least squares.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE A6 Phillips-Perron unit root test (the war in Ukraine).

Price series	Constant and trend		Constant		1st difference	
	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic	Specification (lag length)	Test statistic
Nov 14, 2014–Sep 16, 2022						
Wheat of Class 3						
North Caucasus	8	−2.64	8	−1.66	3	−11.40***
Black Earth	10	−1.96	10	−1.45	7	−14.65***
Central	11	−2.00	10	−1.46	8	−15.19***
Volga	11	−1.72	11	−1.44	10	−18.02***
Urals	12	−1.57	12	−1.33	11	−17.57***
West Siberia	12	−1.63	12	−1.27	10	−14.97***
Wheat of Class 4						
North Caucasus	7	−2.62	7	−1.65	0	−12.93***
Black Earth	11	−1.98	11	−1.66	8	−14.66***
Central	11	−1.97	11	−1.64	9	−14.88***
Volga	12	−1.78	12	−1.64	11	−17.30***
Urals	12	−1.64	12	−1.48	11	−17.22***
West Siberia	12	−1.70	12	−1.40	10	−14.40***
Wheat of Class 5						
North Caucasus	8	−2.20	8	−1.66	1	−11.47***
Black Earth	12	−1.83	12	−1.70	4	−10.14***
Central	12	−1.78	12	−1.67	6	−10.68***
Volga	13	−1.58	13	−1.62	7	−9.95***
Urals	13	−1.55	13	−1.48	9	−11.91***
West Siberia	11	−1.90	11	−1.72	9	−13.32***
Exogenous variables						
Exchange rate (Ruble/USD)	6	−3.78**	6	−3.72***	6	−13.82***
World wheat	4	−2.76	4	−.85	8	−17.86***

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

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TABLE A7 Wald test for the comparison of long run parameters.

	Exchange rate				World wheat			
	Beta 1	Beta 2	*Z*-statistic	*P*-value	Beta 1	Beta 2	*Z*-statistic	*P*-value
Wheat of Class 3								
North Caucasus-Black Earth	.60	.35	2.83	.00	.17	.20	−.30	.76
North Caucasus-Central	.60	.35	2.63	.00	.17	.25	−.68	.49
North Caucasus-Volga	.60	.32	3.30	.00	.17	.11	.61	.54
Black Earth-Central	.35	.35	−0.08	.93	.20	.25	−.45	.64
Black Earth-Volga	.35	.32	0.30	.76	.20	.11	1.11	.26
Central-Volga	.35	.32	0.37	.70	.25	.11	1.54	.12
Wheat of Class 4								
North Caucasus-Black Earth	.64	.49	1.34	.17	.31	.32	−.11	.90
North Caucasus-Central	.64	.47	1.46	.14	.31	.33	−.15	.87
North Caucasus-West Siberia	.64	.22	3.75	.00	.31	.53	−1.71	.08
Black Earth-Central	.49	.47	0.14	.88	.32	.33	−.03	.96
Black Earth-West Siberia	.49	.22	2.42	.01	.32	.53	−1.61	.10
Central-West Siberia	.47	.22	2.22	.02	.33	.53	−1.53	.12
Wheat of Class 5								
Black Earth-Central	.55	.50	.31	.75	.33	.33	−.02	.97

Note: Table contains parameters for Russian wheat prices which cointegrated with exchange rate and world wheat price (Table 2).

TABLE A8 Johansen trace test results: France.

Price series	Specification	Trace Statistics	*P*-value
France	1 lag, intercept (restricted), no trend	22.93	.02

Note: Trace statistic and *P*-value for at most one cointegration vector. Time period: November 14, 2014–January 27, 2017.