

**RESEARCH ARTICLE**

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## Forecasting the Competitiveness of Major Wheat Exporters Amidst the Russia and Ukraine Crisis

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### ABSTRACT

Major concerns about the food security involving wheat production emerged when the conflict between Russia and Ukraine worsened because both countries were the main suppliers of wheat to 38 countries. This study aims to explore the competitiveness level of wheat production countries and the future exporters that may lead to global wheat production during the Russia-Ukraine crisis. This study analyzed the comparative advantages of the five largest wheat exporters from 2001 to 2021 using the revealed comparative advantage (RCA) and revealed symmetrical comparative advantage (RSCA) indices to examine the current level of wheat export competitiveness of the five major exporters. This study also predicts the three major wheat-producing countries (excluding Russia and Ukraine) using 83-month observations to forecast the autoregressive integrated moving average in the next six months. The findings disclosed that all major wheat countries were strongly competitive, and the forecast unveiled that Australia is capable to lead the wheat producing countries in the next six months. This evaluation was derived from the ARIMA approach's forecast, demonstrating Australia to be statistically greater than the USA and Canada.

**Keywords:** Agriculture; Competitiveness; Food security; Prediction; Wheat

### INTRODUCTION

Wheat is the most common source of protein and energy for people worldwide, making it a truly essential staple grain. Different types of crops have varying levels of nutrients, and wheat (*Triticum aestivum* L.) is regarded as the most significant source of vegetable protein in the human food supply because it contains more protein than other cereals (corn or rice) (Nowak-Węgrzyn et al., 2019). According to Guo, Lei, Wang, Song, and Yang (2018), wheat is the world's third most essential cereal, with demand expected to escalate by approximately 70% over the next few decades (2020–2050) due to population growth and rising household incomes (Vitale, Adam, & Vitale, 2020). As mentioned by Ortiz, Outhwaite, Dalin, and Newbold (2021), the world population is estimated to reach 10 billion people by 2050; thus, the food security agenda is now a highly interesting topic for many researchers worldwide.

Even though wheat is a global food source, making it a vital commodity (DeHaan & Van Tassel, 2022), wheat production is concentrated in a few countries. Only eight countries (i.e., Russia, the United States, Canada, France, Ukraine, Australia, Argentina, and Germany) accounted for an astounding 86% of global wheat exports, and only three countries (Russia, the United States, and Canada) accounted for nearly 68% of global wheat reserves (UN Comtrade Database, 2022). Furthermore, some of the world's poorest and most vulnerable countries rely on these three countries for more than half of their wheat imports (Husain, 2022). Although wheat cultivation remains a priority for exporting nations, there are concerns about wheat security for future generations as a result of rapid global population increase, climate change, and the most recent COVID-19 pandemic.

According to World Health Organization (2020) and Galanakis (2020), the COVID-19 disaster has had a far-reaching impact worldwide. Most countries implemented lockdown and mobility restriction policies during the COVID-19 pandemic to control the rapid spread of the virus (Aditya, Goswami, Mendis, & Roopa, 2021). Amjath-Babu, Krupnik, Thilsted, and McDonald (2020) claimed that import and movement restrictions have hampered domestic and international supply chains for seeds, agrochemicals, machinery, and fertilizers, causing the COVID-19 disruption pathways of the food production system.

The fight against COVID-19 continues, and several countries have entered the COVID-19 endemic phase (Pontoh et al., 2022). Following the opening of many countries' borders, the global economy is expected to recover slowly. As the world entered an endemic phase, the Russia and Ukraine war has become the most recent source of global concern (Chaaya et al., 2022; Qureshi, Rizwan, Ahmad, & Ashraf, 2022). The Russia-Ukraine conflict has affected many countries, and it would be a significant setback for the global economy because of the disruption in the global food supply chain (Abay et al., 2023; Jagtap et al., 2022; United States Department of Agriculture, 2024). As a result, the world has been concerned about global food security (Behnassi & El Haiba, 2022; Hellegers, 2022).

In addition, Uwishema et al. (2022) asserted that thousands of Russian troops and military hardware began amassing on the Russia-Ukraine border by the end of 2021. On February 24, 2022, the Russian president decided to launch a large-scale invasion of Ukraine, escalating the conflict. The Russian-Ukrainian conflict has harmed the global economy, causing a massive inflation wave in critical commodities, such as wheat, oil, coal, natural gas, and some metals (Jagtap et al., 2022; Mastroeni, Mazzoccoli, Quaresima, & Vellucci, 2022).

Since the conflict began, wheat prices have risen by around 40% (Guénette, Kenworthy, & Wheeler, 2022), destabilizing the global agricultural market (Carriquiry, Dumortier, & Elobeid, 2022). It has wreaked havoc on agriculture (both countries are major producers of agricultural commodities globally), causing disruptions in the food supply chain, particularly for countries relying heavily on wheat (Pörtner et al., 2022). Ukraine is a key player in agricultural and food production in Europe and beyond. Ukraine's land utilization for agriculture reached 70%, equivalent to that of other European nations such as the United Kingdom (World Data Center, 2022). This conflict lies in the annexation of Ukrainian territory by Russia, a move that has far-reaching consequences not only for the region but also

for global geopolitics and economics. Ukraine is one of the world's major wheat exporters, and the Russian attack on Ukraine caused the country to be unable to produce wheat at optimal levels, leading to the wheat crisis.

Moreover, the wheat crisis has escalated dramatically as numerous countries initiated sanctions against Russia. In a retaliatory move, Russia exacerbated the situation by halting the export of wheat to the international market. The impact of financial and trade sanctions imposed on Russia has made this country more aggressive in supplying wheat to the global market. Accordingly, the Russian president decided to impose a total ban on wheat exports, causing global wheat prices to rise (Svanidze, Götz, & Serebrennikov, 2022). According to Saâdaoui, Ben Jabeur, and Goodell (2022), the conflict between Russia and Ukraine has caused disruption and even long-term damage to Ukraine's wheat fields, which constitute a global supply.

Because of the circumstances, other wheat-exporting countries have a greater comparative advantage and are closer to the concept of competitiveness. Many studies have been conducted on wheat commodity competitiveness. For instance, Sa'diyah and Darwanto (2020) pointed out that export competitiveness is a crucial component in determining the potential market share in the global market. Narayan and Bhattacharya (2019) utilized relative export competitiveness in the Indian region and focused on wheat, rice, sugar, and cotton. Meanwhile, Arghiroiu, Cristea, and Alecu (2015) employed the revealed comparative advantage (RCA) and discovered that Romania has been competitive in almost all cereals, including wheat, maize, barley, and sorghum. Popescu, Nicoale, Nica, Vasile, and Andreea (2017) obtained the same competitive result using the Balassa index to calculate wheat exports in Romania.

Research conducted on the Canadian wheat commodity using the competitive method of RCA unveiled that wheat has a strong competitive advantage, as expected from one of the world's major wheat exporters (Sarker & Ratnasena, 2014). Şelli, Zan, and Er (2010) applied the same method to compare the competitiveness of Turkey and the European Union in wheat trade from 2004 to 2008. The comparison of Turkey and Hungary in the wheat commodity using the RCA from 2009 to 2018 revealed that Hungary has a higher degree of specialization than Turkey (Ceylan, 2019).

A recent study by Rumankova, Kuzmenko, Benesova, and Smutka (2022) analyzed the competitiveness of the wheat commodity aggregations of the monitored countries regarding production indicators using the RCA and Grubel-Lloyd index, focusing on selected European countries, such as Slovakia, Belgium, the Netherlands, Czech Republic, France, and Czechia. However, the research did not focus entirely on major wheat exports when the commodity was in short supply due to the Russia-Ukraine war.

As mentioned by Pörtner et al. (2022), many countries worldwide previously highly dependent on wheat supply from Russia and Ukraine may suffer due to the disrupted trade flows. Thus, the food system transformation is crucially required to solve this issue. As a result, many governments and intergovernmental organizations worldwide strongly condemned the Russian invasion. In response, new sanctions were imposed on Russia, significantly and

negatively impacting the Russian and global economies (Götz, Glauben, & Brümmer, 2013; Qureshi et al., 2022).

This paper examined the competitiveness of the five largest wheat exporters during the Russia–Ukraine conflict. This study aims to (1) estimate the resilience of the five major wheat exporting countries; (2) assess the level of wheat export competitiveness among the five leading wheat exporters during the trade sanctions imposed on Russia and the logistical problems that occurred in Ukraine; and (3) predict which country will fill the gap in the wheat shortage if the political crisis between Russia and Ukraine continues. These questions are essential for two reasons. First, according to the UN Comtrade Database, Ukraine and Russia were two of the most significant players in the increasingly consolidated global wheat market in 2020. These two countries were responsible for slightly less than 30% of the global wheat exports. Many individuals refer to them as the world’s breadbasket.

Secondly, Russia and Ukraine provided 20% of the total food commodities acquired by the World Food Program, playing a key role in ensuring adequate levels of food safety in developing countries. According to Food and Agriculture Organization [FAO] (2022b), Russia and Ukraine are the top wheat suppliers to 38 countries, including some of the world’s least developed and poorest countries. It has sparked global concern, as both wheat-exporting nations have taken steps to restrict or halt exports (Glauben et al., 2022; Laborde, 2022).

Consequently, this study analyzed the competitiveness of the world’s leading wheat exporters using competitive methods. It investigated the resilience of the top five wheat exporting nations by comparing their net wheat exports and by forecasting whether wheat export can help policymakers address problems related to food security due to the war between Ukraine and Russia.

## RESEARCH METHOD

This study utilized secondary data from the World Bank, World Integrated Trade Solution, and UN Comtrade on the exports and imports of wheat and meslin commodities with the HS 1001 (4-digit code).

### Revealed Comparative Advantage

This study calculated the RCA index based on wheat external sale values for the top five wheat exporters from 2001 to 2020. Formula 1 was employed to calculate the RCA index:

$$RCA_{in}^t = \left( \frac{X_{ij}^t / X_i^t}{X_{wj}^t / X_w^t} \right) \quad (1)$$

$X$  denotes exports,  $i$  and  $j$  represent countries (selected five major wheat exporters) and the industry (wheat commodity), respectively, and  $w$  signifies the world.

The index considers the size of a country’s economy or market, allowing for a more robust comparison of output across countries and industries worldwide. Following the value by the RCA index of Balassa, the country with 0 to 1 values is declared to have no competitive

advantage at all. Additionally, those with values of 1 to 2 are considered low competitive, and those with values of 2 to 4 have a moderate competitive advantage. Meanwhile, countries with values greater than 4 have a very strong competitive level (Mohamad et al., 2024; Prasada & Dhamira, 2022).

### Revealed Symmetric Comparative Advantage Index

In this regard, Mohamad and Zainuddin (2021) converted the RCA index into the revealed symmetric comparative advantage index (RSCA) to address the asymmetry issue, which has the economic implications as Formula 2:

$$RSCA_{in}^t = \left( \frac{X_{ij}^t / X_i^t}{X_{wj}^t / X_w^t} - 1 \right) // \left( \frac{X_{ij}^t / X_i^t}{X_{wj}^t / X_w^t} + 1 \right) \quad (2)$$

The RSCA values range from -1 to 1. The RSCA index converts the RCA index interval values (0 and ∞). The primary advantage of this index is that it assigns the same weight to changes below and above unity.

### Autoregressive Integrated Moving Average

The autoregressive integrated moving average (ARIMA) model is a popular statistical tool for forecasting time series. The ARIMA (p, d, q) model has three parameters: p represents autoregressive (AR), d denotes the number of differencing, and q implies the moving average (MA). If the data are non-stationary series, a unit root test can be performed in the first order to create a stationary (p, 1, q) model. The following is an example of model estimation (Formula 3):

$$\Delta X_t = c + \alpha_1 \Delta X_{t-1} + \dots + \alpha_p \Delta X_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \dots - \theta_q \varepsilon_{t-q} \quad (3)$$

This study employed the Box Jenkin linear time series approach, which was developed in 1970 by two statisticians, George Box and Gwilym Jenkins, using the ARIMA models to discover the most accurate time series prediction. The method seeks the model with the highest R-square and the lowest Akaike information criterion (AIC) and Schwartz information criterion (SIC) values to disclose the optimal forecasting model (Box, Reinsel, Jenkins, & Ljung, 2015; Mohamad & Ab-Rahim, 2024). The prediction compared three countries (i.e., Australia, Canada, and the United States) using monthly data of export trade values from January 2016 to November 2022 (83 monthly data observations) to forecast for six months ahead.

## RESULTS AND DISCUSSION

### Wheat Competitiveness (RCA and RSCA)

Figure 1 demonstrates the RCA index for the five largest wheat exporters to the international market from 2001 to 2021. Australia began with the highest export volume between levels 5 and 10 of the RCA index, indicating an extreme comparative advantage. However, it depicted a downward trend until 2021 but remained at the highest level of

competitiveness. From 2001 to 2021, Canada was the only wheat exporter, with an increasing trend. In contrast, the United States had a nearly identical pattern from the beginning and never reached a value of 5, which is highly competitive, until 2021. The RCA index fluctuation caused the shock of sudden increases or decreases in wheat exports. In other words, the United States had the most stable production over the last 20 years, followed by Canada.

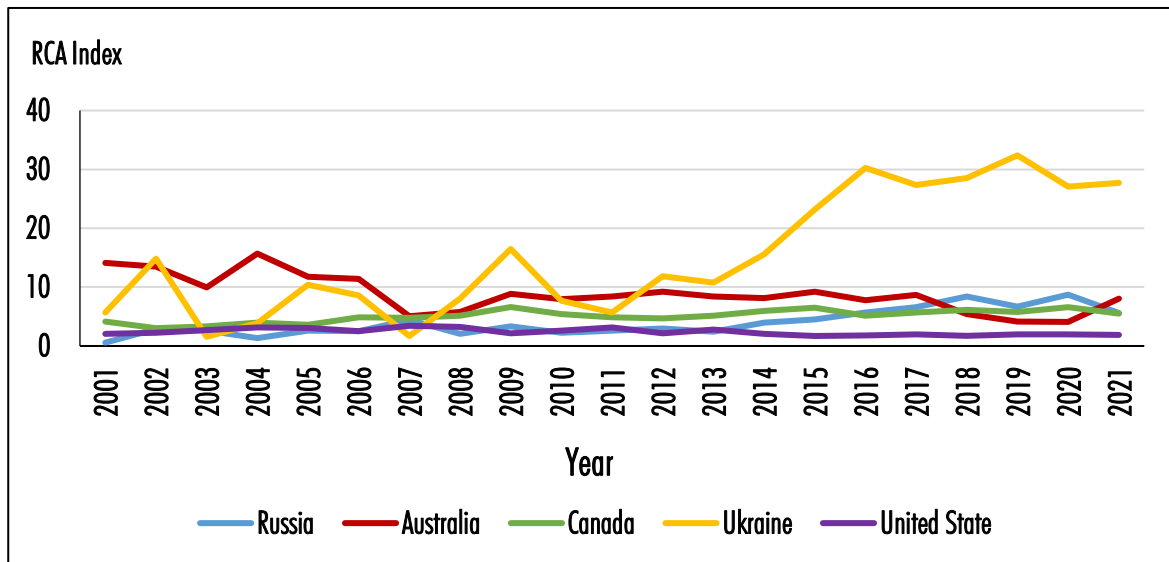


FIGURE 1. REVEALED COMPARATIVE ADVANTAGE (RCA)

Ukraine had the most dynamic RCA index chart of the five exporters, with the sharpest fluctuations. Even though wheat production in Ukraine rose, it was the most volatile. Ukraine's wheat production was historically harmed by climate change, but after a year, the country produced a large amount of wheat in 2014 (Kogan et al., 2013; Röder, Thornley, Campbell, & Bows-Larkin, 2014). As illustrated in Fig. 1, Ukraine's RCA index appears to be volatile but never losing competitiveness. Meanwhile, Russia had an increasing trend since 2001, but since the severe conflict in 2020, economic restrictions have taken place, lowering its RCA level in 2021 and causing its competitiveness to drop to the same level as Canada.

The RSCA index for five major wheat exporters is depicted in Figure 2. The RSCA made a minor adjustment to keep the comparative index range between 1 and  $-1$ . If a country's RSCA score is greater than zero and positive, it has a comparative advantage in wheat exports; otherwise, it has no comparative advantage. According to the RSCA index results, Russia emerged as the only country with no competitive value in 2001; however, starting in 2002 until 2021, its wheat production was high. These results are consistent with those of Kiselev and Romashkin (2021), who studied Russia as a wheat exporter.

The RCA and RSCA data unveiled that all five countries remained strongly competitive. However, the situation was hard when the United States and Europe announced to renew and make the economic sanctions stricter against Russia in 2021 (Korosteleva, 2022). The scenario became more concerning as Ukraine's logistical issues arose, making it difficult for the country to export wheat to the international market.

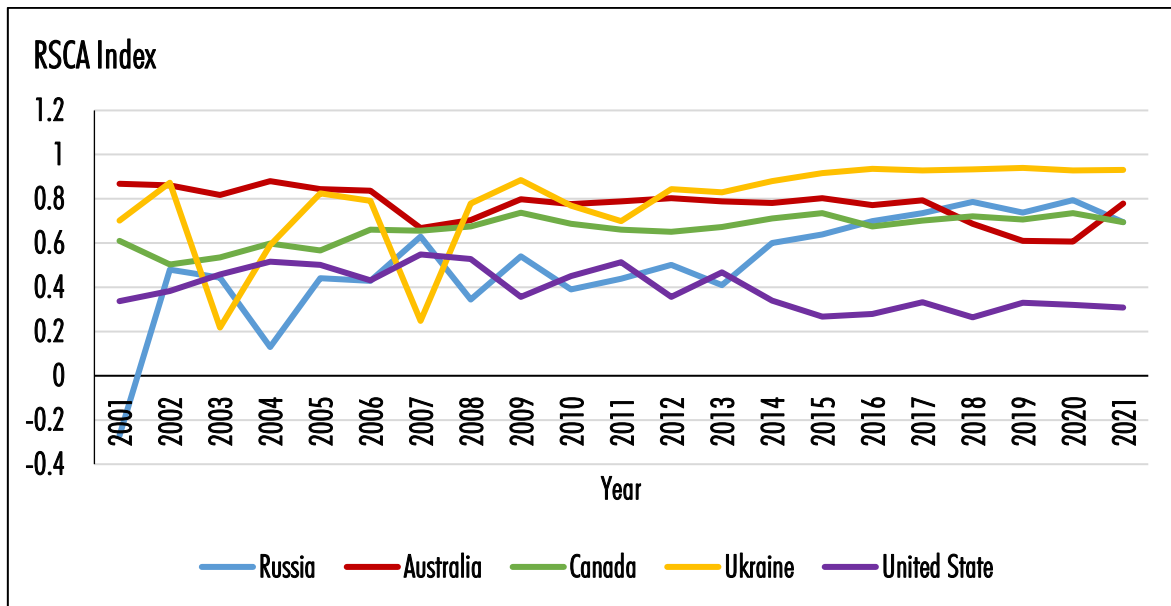


FIGURE 2. REVEALED SYMMETRIC COMPARATIVE ADVANTAGE (RSCA)

Following the political crises of two of the top five wheat exporters, it was necessary to accept a shortage of wheat supply in the global market, affecting wheat prices recently (Lin et al., 2023). The persistent price fluctuation has also been linked to the COVID-19 outbreak issues, as the data in this study began in March 2020, and COVID-19 cases were still prevalent during the first wave (Elleby, Domínguez, Adenauer, & Genovese, 2020; Soriano et al., 2021).

Furthermore, India, the world’s second-largest population of approximately 1.4 billion people (World Bank, 2022), has implemented a ban on wheat exports beginning in mid-May 2022 due to food security concerns (FAO, 2022a). The concern of wheat production in India has also been reported in facing global climate change (McDonald et al., 2022). It signifies that the Russia-Ukraine war has imposed domino effects on global food security (Bentley et al., 2022). Therefore, if the war lasts long, the world must prepare to discover potential wheat-importing countries.

This study discusses the prediction of the wheat commodity further using the export data for three countries. According to Pörtner et al. (2022), the uncertainty in wheat production from Russia and Ukraine has alarmed the global market due to the ongoing war. The world needs to prepare a food transformation system to demand stability of essential commodities. Therefore, the discussion focuses on the prediction of wheat exporters using the ARIMA method to gain useful information on which major countries can fill the gap when there is a shortage of wheat supply in the market. Thus, Russia and Ukraine were excluded because of their unstable wheat production.

### Forecasting Results for Wheat Exporters

The wheat export trade value was calculated using monthly data from January 2016 to November 2022 (83 observations). Before performing the unit root test, natural logarithms were conducted on all data on wheat export trade value for three countries in EViews to gain a more accurate prediction. The LAUS variable represents Australia’s logarithms for wheat

export, the LCAN proxy is Canada's logarithms for wheat export, and the LUSA indicates the USA's logarithms for wheat export. Table 1 exhibits the significance of the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) test results for the three countries. The PP unit root test clearly revealed that all three countries had a significant level of 1%, and the ADF test also reported significant and stationary results.

TABLE 1. UNIT ROOT TEST

Unit root test	Variables	PP		ADF	
		I(0)	I(1)	I(0)	I(1)
Constant and Trend	LAUS	-2.9185	-10.1886***	-2.9705	-3.1448***
	LCAN	-6.016***	-18.5159***	-3.191*	-15.6245***
	LUSA	-6.357***	-21.5754***	-6.357***	-3.6338**
Without Constant and Trend	LAUS	0.1562	-10.2894***	0.1144	-2.6023***
	LCAN	1.3666	-17.5981***	0.8042	-15.6616***
	LUSA	0.9133	-20.3521***	1.7187	-3.2904***

Note: \*, \*\*, and \*\*\* indicate significance at 10%, 5%, and 1%, respectively.

TABLE 2. COMPARISON OF THE ARIMA MODELS

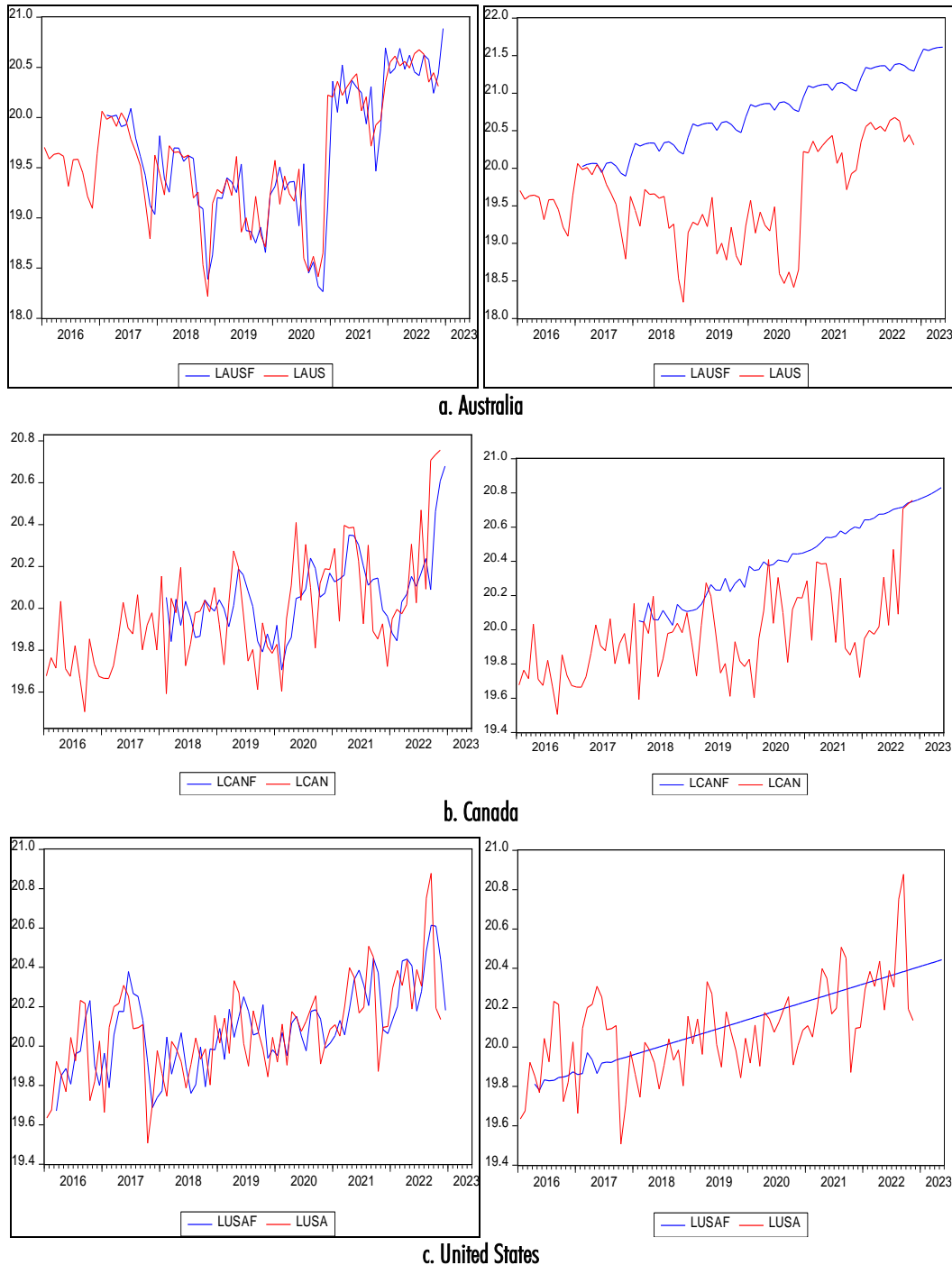
Country	ARIMA Model	Significant Coefficients	Sigma <sup>2</sup>	Adjusted R <sup>2</sup>	AIC	SBIC
Australia	(7,1,7)	1	0.1143	0.0319	0.7723	0.8897
	(7,1,12)	2	0.0986	0.1651	0.6391	0.7565
	(12,1,12)*	3	0.0881	0.2533	0.5833	0.7007
	(12,1,7)	2	0.0924	0.2174	0.5843	0.7017
	(7,1,24)	2	0.0992	0.1600	0.6725	0.7899
	(12,1,24)	2	0.0946	0.1991	0.6136	0.7310
Canada	(1,1,1)	2	0.0400	0.2551	-0.2787	-0.1613
	(11,1,1)	2	0.0400	0.2556	-0.2776	-0.1602
	(13,1,1)	2	0.0396	0.2622	-0.2855	-0.1681
	(24,1,1)*	3	0.0358	0.3332	-0.3564	-0.2390
	(24,1,24)	1	0.0476	0.1138	-0.0545	-0.0629
	(1,1,24)	2	0.0377	0.2977	-0.3182	-0.2008
United States (USA)	(1,1,1)	2	0.0324	0.3028	-0.4491	-0.3317
	(2,1,1)	2	0.0363	0.2189	-0.3720	-0.2546
	(1,1,2)	3	0.0358	0.2298	-0.3819	-0.2645
	(2,1,2)	3	0.0396	0.1475	-0.2607	-0.1433
	(1,1,12)*	3	0.0344	0.2604	-0.3974	-0.2800
	(2,1,12)	2	0.0385	0.1716	-0.2908	-0.1734
	(11,1,1)	2	0.0370	0.2030	-0.3446	-0.2272
	(11,1,2)	1	0.0455	0.0216	-0.1526	-0.0352
(11,1,12)	1	0.0386	0.1691	-0.2855	-0.1681	

Note: \* Selected as the most appropriate ARIMA model.

The countries importing wheat from Russia and Ukraine should look for other wheat suppliers. Since Australia, Canada and the USA have become three major wheat exporters, this study employed ARIMA to predict which of these three countries can gain the market



share and fill the gap in wheat commodity caused by the Russia and Ukraine war. As listed in Table 2, six ARIMA models were reported for Australia and Canada, and nine models were reported for the United States. All the models utilized the first difference order reported as the stationary value from the unit root test. A suitable model must have the most significant coefficient value, low volatility value, the highest adjusted  $R^2$ , and the lowest value of AIC and SBIC. In the ARIMA models for Australia, the AR (7 and 12) and MA (7, 12, 24) were tested to determine the appropriate model. Based on the criteria, the (12, 1, 12) model appeared to be the most appropriate for predicting wheat export.



**FIGURE 3. PREDICTION FOR WHEAT EXPORT USING THE STATICS AND DYNAMIC TESTS FROM THE SELECTED ARIMA MODEL (A-C)**

The ARIMA model of Canada was reported to have three significant coefficient values; the (24, 1, 1) was the most appropriate model to predict Canadian wheat export. Then, for the ARIMA model of the United States, three models had three significant coefficient values of (1, 1, 2), (2, 1, 2), and (1, 1, 12). The most appropriate model for the United States was (1, 1, 12) because it had the highest adjusted  $R^2$  value and the lowest value of SBIC, AIC, and volatility.

Figure 3 displays the predicted ARIMA models for Australia, Canada, and the United States using static and dynamic tests. The static test enabled this study to predict for one month; however, the dynamic test enabled this research to predict for six months. The Australian ARIMA model of (12, 1, 12) and the Canadian ARIMA model of (24, 1, 1) demonstrated a significantly increasing patent for both dynamic and static tests. Meanwhile, the United States predicted a decreasing patent in a static test, contradicting the dynamic prediction. Figure 4 depicts the inverse roots of AR and MA polynomials for three countries, showcasing the fulfillment of the requirement due to the absence of “white noise,” and all the MA polynomials are clearly inside the circles.

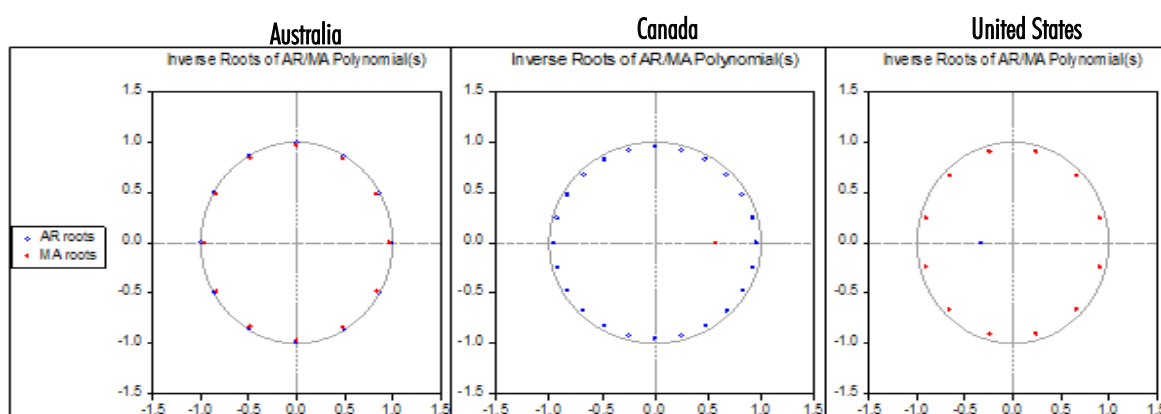


FIGURE 4. INVERSE ROOTS FROM THE PREDICTED MODELS

## CONCLUSION

The war between Russia and Ukraine has certainly impacted their export activities, especially Russia, as the economic sanctions blocked its opportunities to be involved in the trade market. The RCA and RSCA indexes of all the major wheat exporters revealed that they were highly competitive. Despite being at war, Russia and Ukraine continued to be highly competitive in RCA. However, Ukraine still had an increasing patent in 2021 compared to Russia's RCA index, experiencing a downward trend from 2020 to 2021.

This study also predicted wheat export using the ARIMA model (Box-Jenkins method) but excluded Russia and Ukraine due to war and uncertain wheat production recently. According to the ARIMA model predictions of the traded value for wheat between these three countries (i.e., Australia, Canada, and the United States), Australia had progressively strong wheat production until 2022 (as reported by the static test of the ARIMA model) and led wheat production in the first quarter of 2023 (forecasted by the static test of the ARIMA

model). In other words, if Russia and Ukraine lose their competitiveness in wheat exports due to political crises, leaving a gap (shortage) in the international trade market, the largest wheat exporters will be Australia, implying that Australia will be the leading wheat exporter in the future.

This study has predicted that the wheat market would have a new major wheat exporter. Australia will benefit economically if it increases its share of the global wheat market. Australia's stronger position in the wheat market would unavoidably change the dynamics of the global supply. Being a big producer of wheat, the nation may become a more dominating provider, upending the roles that other major exporters of wheat have traditionally played. In order to reduce the risks associated with relying on a single supply, this change may require importing countries to modify their plans and diversify their sources of wheat. Therefore, other countries that have issues gaining the wheat supply from Russia or Ukraine can plan to import wheat from Australia if there is enough production to fill the wheat shortage in the future. Hence, further research should be conducted on the market share of the countries importing the most wheat from Russia and Ukraine before the outbreak of war.

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**Authors' Contributions:** AHHM; Conceptualization, methodology, formal analysis, writing—original draft, RAR; Conceptualization, supervision, resources, final draft, funding acquisition.

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