

Heigermoser, Maximilian; Götz, Linde; Svanidze, Miranda

**Article — Published Version**

## Price formation within Egypt's wheat tender market: Implications for Black Sea exporters

Agricultural Economics

**Provided in Cooperation with:**

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale)

*Suggested Citation:* Heigermoser, Maximilian; Götz, Linde; Svanidze, Miranda (2021) : Price formation within Egypt's wheat tender market: Implications for Black Sea exporters, *Agricultural Economics*, ISSN 1574-0862, Wiley, Oxford, Vol. 52, Iss. 5, pp. 819-831, <https://doi.org/10.1111/agec.12656>

This Version is available at:

<https://hdl.handle.net/10419/242478>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by-nc/4.0/>

# Price formation within Egypt's wheat tender market: Implications for Black Sea exporters

Maximilian Heigermoser | Linde Götz | Miranda Svanidze

Department Agricultural Markets,  
Leibniz Institute of Agricultural  
Development in Transition Economies  
(IAMO), Halle (Saale), Germany

## Correspondence

Maximilian Heigermoser, Leibniz Institute  
of Agricultural Development in Transition  
Economies (IAMO), Theodor-Lieser-Str. 2,  
06120 Halle (Saale), Germany.  
Email: [heigermoser@iamo.de](mailto:heigermoser@iamo.de)

## Data Appendix Available Online

A data appendix to replicate the main esti-  
mations is available in the online version of  
this article. Please note: Wiley-Blackwell  
is not responsible for the content or func-  
tionality of any supporting information  
supplied by the authors. Any queries (other  
than missing material) should be directed  
to the corresponding author for the article.

## Abstract

Black Sea wheat exporters, led by Russia, dominate Egypt's wheat imports via a tender system. The tenders are managed by the GASC and their outcomes are communicated worldwide by financial news agencies. Building on a transaction-specific dataset on GASC tenders (2011 - 2019), results of our cointegration analysis find wheat export markets of Russia, France and the USA highly integrated with the GASC tender price. Estimates from the multivariate VECM indicate strong price interdependencies between the GASC tender price and Russian and French export prices, indicating fierce competition in the GASC tender market. Despite the high market share of wheat exporters in the Black Sea region and Russia in particular, tests on weak exogeneity suggest a leading role of the French wheat export price. We further find that leadership of US wheat prices is weak in the GASC tender market.

## KEYWORDS

Black Sea region, multivariate cointegration, spatial market integration, wheat

## JEL CLASSIFICATION

Q11, Q13, Q17

## 1 | INTRODUCTION

Over the past two decades, the expanding grain production in the Black Sea region has resulted in growing wheat exports, particularly to the Middle East and North Africa (MENA) region. Egypt, the world's largest wheat importer, became a key destination market for Black Sea exporters such as Ukraine, Romania, and especially Russia, which became the world's largest wheat exporter in 2017/18. Half of Egypt's wheat imports are managed by the General Authority for Supply Commodities (GASC), a state procurement agency for food commodities. The GASC regularly issues tenders to purchase considerable quantities of wheat on international markets, which are closely watched

by the global grain industry. In particular, Thompson Reuters and numerous other business news and consulting agencies routinely provide detailed information on trading companies participating in the tenders, the price offers submitted, as well as the volumes and origins of the wheat offers accepted by the GASC.

The interest in GASC tenders coincides with Russia moving to become the largest wheat exporter in the world. As futures markets for Black Sea wheat, which could facilitate price discovery are still underdeveloped, reliable information on actual prices in this rather opaque market is scarce. In this situation, GASC wheat tenders provide up-to-date information on price levels in the Black Sea wheat market and foster competition between trading companies

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial](https://creativecommons.org/licenses/by-nc/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

© 2021 The Authors. *Agricultural Economics* published by Wiley Periodicals LLC on behalf of International Association of Agricultural Economists

engaging in the tender calls, which drives the submitted price offers towards competitive levels. GASC tenders regularly reveal the trading companies that are able to deliver wheat to Egyptian ports close to the Suez channel at the lowest cost, which usually implies competitiveness also beyond this vital chokepoint of global grain trade.

Given the informational value of GASC tender prices and Egypt's key geographical position within global wheat markets, our study addresses the following research questions: To what degree is the GASC tender market integrated with major export markets and what is the extent, i.e. the geographic boundaries, of this market? What are the characteristics of price formation processes in the GASC tender market? In particular, which price relationships and price leadership can be determined? These research questions are particularly relevant since the Black Sea region has advanced to be the global center of physical wheat exports, with Russia and Ukraine jointly accounting for 29% of global wheat exports in 2019/20 (USDA, 2020). This significance is expected to increase even further, as Russia in particular bears large additional grain production and export potential (Schierhorn et al., 2014; Svanidze & Götz, 2019). On the other hand, the GASC is one of the largest importing institutions within the international wheat market, implying a high concentration of wheat import demand in the Black Sea market.

To shed light on the presented research questions, we study the relationship between the GASC tender price and export prices of the top eight global wheat exporters employing the Johansen (1988) multivariate cointegration framework. We determine the extent of the GASC tender market and its integration with the Black Sea and further major wheat export markets, particularly the USA and France. Furthermore, price interdependencies and (weak) exogeneity of particular market locations are investigated. We construct a continuous series of GASC tender prices based on a unique database of transaction-specific records on prices, quantities, countries of origin and companies supplying wheat to the GASC within the tender system between July 2005 and June 2019. This study is unique in investigating how prices in grain export markets relate to prices negotiated within a state tender system, which is common among grain-importing countries in the MENA region.

This research contributes to the still limited number of analyses investigating the integration of grain markets in the Black Sea region. Existing studies to-date typically follow a bivariate cointegration approach. Götz et al. (2013), Götz et al. (2016), and Djuric et al. (2015) find that Russian, Ukrainian and Serbian wheat markets are strongly integrated with the international wheat market, while taking into account the disintegrating effects of

export restrictions. Goychuk and Meyers (2014) determine that French and US export prices adjust to Russian export prices within the time period of 2004 through 2010. Arnade and Hoffmann (2019) establish that the Black Sea region plays an important role for the international maize markets price discovery, especially in periods of high exports. Araujo-Enciso and Fellmann (2020) show that the harvest failures in the Black Sea region can have severe effects on food security in the import-dependent MENA region. Svanidze et al. (2019) find that wheat import prices of South-Caucasian and Central Asian countries adjust to Black Sea export prices. This is in line with further research generally suggesting that export prices lead import prices when grain markets are considered (Hassanzoy et al., 2016; Rosa et al., 2014). Export prices are, however, found to adjust to import prices in the international rice market (Jamora & von Cramon-Taubadel, 2015). To the best of our knowledge, this is the first study that investigates Black Sea wheat markets following a multivariate cointegration approach.

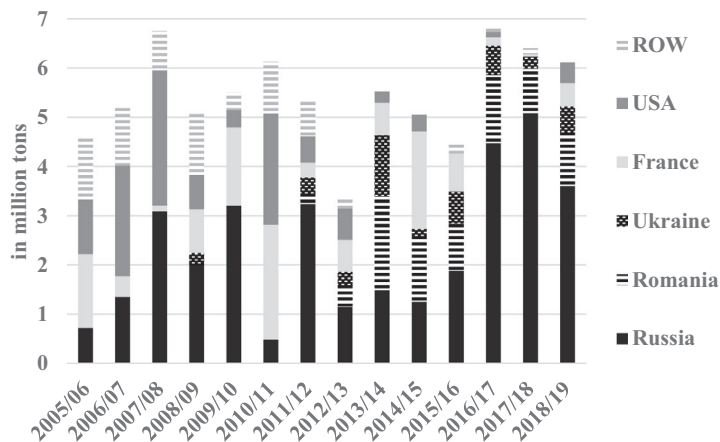
Some existing studies employ multivariate cointegration models to analyze the integration and interdependencies in global wheat markets. Ghoshray (2006) finds US wheat export prices to lead export price developments in the international market, accounting for quality differences between wheat classes. By contrast, Mohanty et al. (1999), not explicitly distinguishing between different quality classes, conclude that one single export price leading the global wheat market does not exist. Arnade and Vocke (2015) investigate seasonal variations in wheat price leadership and find that Southern Hemisphere exporters dominate price discovery in the first half of the year, while US prices lead in the second half, after the Northern Hemisphere harvest. In an earlier study, Goodwin (1992) argues that transportation costs between market locations cannot be disregarded if the Law of One Price (LOP) in international wheat markets is investigated. In this study, we evaluate the role of transportation costs based on freight cost data recorded in the GASC tender data-base and transportation costs implied in the multivariate VECM. Employing the Johansen cointegration framework, further multi-locational agricultural commodity markets are investigated in Asche et al. (2012), Pierre and Kaminski (2019), Ihle et al. (2012), and González-Rivera and Helfand (2001).

This article is organized as follows: In the next section, we provide background information on the GASC wheat tender market, while the methodological framework is presented in section three. In section four, the data-base used in the analysis is described and estimation results are discussed in section five. Finally, we provide concluding remarks in the sixth section.

**FIGURE 1** Countries of origin of GASC wheat imports, 2005/06 to 2018/19

Note: Seasonal imports are aggregated based on the tender date, not the delivery date. ROW denotes “Rest of World” and aggregates imports from Argentina, Australia, Canada, Germany, Kazakhstan and Poland.

Source: Zerno Online (2019)



## 2 | EGYPT'S WHEAT TENDER MARKET

Egypt's state procurement agency for food commodities (GASC) manages around half of the country's wheat imports, while the other half is handled by private trading companies (Ghoneim, 2015). Over the past five seasons, the GASC imported around 5.5 million tons (mt) of wheat per season via its tender system. Wheat tenders are typically held every 10 to 12 days between June and February, but rarely issued in March through May, when the agency procures domestically produced wheat (McKee, 2013). Announcing a tender, the GASC asks authorized trading companies to submit one or several sealed price offers to supply wheat cargos of 55,000 to 60,000 t. The offers must contain a “free on board” (FOB) price and a separate freight offer, both denoted in USD per ton. The delivery to an Egyptian port is typically scheduled 4 to 6 weeks after the tender date. The companies may source wheat solely from origins approved by the GASC based on its quality standards. On average, the agency buys three to four cargos per tender.

Similar organizations and tender systems exist in the majority of countries in the MENA region. The most notable further agencies are the Algerian *Office Algérien Interprofessionnel des Céréals* (OAIC) and the Saudi Arabian *Saudi Grains Organisation* (SAGO, see Table A1 in the online appendix for details). However, the GASC stands out versus other such agencies in four respects: tenders are issued at a relatively high and regular frequency; large and standardized amounts of wheat are purchased; transparency on tender results is rather high; and the top three wheat exporters, namely Russia, France and the USA, are all approved to participate in the tenders.

Figure 1 displays the countries of origin of GASC wheat imports between 2005/06 and 2018/19. The share of the Black Sea exporters Russia, Romania and Ukraine constantly increases over this period, ultimately reaching 94%, 99% and 85% in 2016/17 through 2018/19. In 2010/11,

Russia completely bans all wheat exports after severe harvest shortfalls, resulting in higher imports from France and the USA. Over the whole displayed period, 43% of GASC wheat imports originate from Russia, followed by France (16%) and the USA (15%). However, after 2011/12 the GASC purchases only minor quantities from France. An exception is the 2014/15 season, when French wheat accounted for 35% due to a record crop in the country. The USA had been the largest supplier to the GASC prior to the 2006/07 season; however, after 2010/11 it sells wheat to the GASC only occasionally. By contrast, both Romania and Ukraine gain market shares from 2011/12 onwards after the GASC had approved the two countries as additional suppliers in an effort to ‘boost competition amongst Black Sea origin wheat’ (Reuters, 2011). Romania and Ukraine successfully compete with Russia in the 2012/13 season through to 2015/16. However, from 2016/17 through to 2018/19, Russian wheat clearly dominates GASC imports, reaching shares of 65%, 81%, and 59%, respectively.

While Black Sea exporters are the most important suppliers of wheat to the GASC, Egypt is conversely the top destination market for wheat from Russia, Romania and Ukraine. Over the past decade, the share of wheat exported to Egypt amounted to 25%, 20%, and 15% of their total wheat exports, respectively (see also Figure A1 in the online appendix). The share of wheat exports by France to Egypt decreased from 7% (2009 to 2013) to 4% (2014 to 2018) and by the USA from 5% to 1% of their total wheat exports, respectively (UN Comtrade Database, 2019).

In the time period underlying this study, the GASC closed transaction deals with 15 to 22 trading companies per season, while numerous additional companies submitted price offers that were not accepted by the agency. The top five companies supplying wheat to the GASC were the Louis Dreyfus Company (with a share of 10.9% in GASC's wheat imports), Glencore (7.6%), Ameropa (6.9%), GTCS (6.9%) and Cargill (6.5%). The degree of concentration in the GASC tender market is characterized by the

concentration ratio and the Herfindahl-Hirschmann index (HHI, Rhoades, 1993) for each season (see Table A2 in the online appendix). Results suggest low concentration among sellers participating in GASC tenders. We interpret this as further evidence for strong competition among wheat suppliers in the GASC tender market, ensuring competitive price offers.

### 3 | METHODOLOGICAL APPROACH

Spatial market integration analysis typically investigates the relationship between prices for one homogenous commodity at  $n$  different locations. If a homogenous commodity is physically traded between  $n$  locations within one market, and prices in these locations follow a common trend, i.e. share the same long-run information (González-Rivera & Helfand, 2001), a spatially integrated market exists. The physical flow of goods from surplus location  $i$  to deficit location  $j$  is triggered if the price difference between  $i$  and  $j$  exceeds the costs of transporting the good between the locations. This process of spatial arbitrage causes the co-movement of prices at the different locations and ensures that deviations from the common long-run equilibrium only occur in the short-run until corrected. The Law of One Price (LOP) describes this spatial price relationship. Considering the bivariate case of  $n = 2$ , the LOP in its weak (strong) form states that the difference between prices at locations  $i$  and  $j$  does not exceed (is equal to) the costs of transporting the commodity between the locations (Fackler & Goodwin, 2001). In a multivariate framework with  $n > 2$ , two market locations can also be integrated indirectly if trade flows to or from other market locations occur.

Bivariate models are frequently estimated to analyze the spatial market integration of various price pairs. This approach is justified if one of the  $n$  ( $n > 2$ ) locations is a central market exogenous to all other market locations, while independent price interlinkages between non-central locations do not exist. However, as the number of considered locations increases, market prices are likely determined simultaneously at various locations (i.e. price series are endogenous in the system). To account for interdependence structures that are more complex, the relationships between  $n$  locations are investigated within a multivariate cointegration framework (Johansen, 1988). Herein, an integrated market with  $n$  locations shows exactly  $n - 1$  cointegration vectors, which implies pairwise cointegration of prices at any two market locations (Johansen & Juselius, 1994). In a bivariate approach,  $(n^2 - n)/2$  price pairs could be considered that can, however, only be normalized differently to represent a maximum of  $n - 1$  cointegration relationships. The caveat

of a bivariate approach is that the  $n - 1$  long-run price transmission elasticities can vary in size depending on the choice of the considered price pairs, which is theoretically implausible (Asche, Guttormsen, & Gjolberg, 2012). Within a multivariate approach, this problem is avoided.

Following Johansen (1988), a multivariate cointegrated system can be represented as a vector error correction model (VECM). The basic intuition of a VECM is that present price changes are a function of lagged deviations from long-run equilibria shared by cointegrated prices, lagged price changes, as well as a constant. Formally, a VECM is represented by

$$\Delta \mathbf{p}_t = \boldsymbol{\mu} + \boldsymbol{\Pi} \mathbf{p}_{t-1} + \sum_{i=1}^k \boldsymbol{\Gamma}_i \mathbf{p}_{t-i} + \mathbf{e}_t \quad (1)$$

where  $\mathbf{p}_t$  corresponds with a  $n$ -dimensional vector of prices in natural logarithm for a good traded at  $n$  different locations, while  $\Delta \mathbf{p}_t$  denotes the price changes from period  $t - 1$  to period  $t$  and  $\boldsymbol{\mu}$  represents a vector of constant terms. The  $n \times n$  matrix  $\boldsymbol{\Pi}$  has reduced rank  $r = n - s$ , with  $s = 1$  if all  $n$  prices share exactly one common trend. The matrix  $\boldsymbol{\Pi}$  can be rewritten as  $\boldsymbol{\Pi} = \boldsymbol{\alpha} \boldsymbol{\beta}'$ , where  $\boldsymbol{\alpha}$  and  $\boldsymbol{\beta}$  are both  $n \times r$  matrices. The matrix  $\boldsymbol{\beta}$  contains the (normalized) cointegrating vectors characterizing long-run equilibria for  $r$  linear combinations of prices. To include a constant in the cointegration relationships, the matrix characterizing the long-run equilibrium relationship has been modified to  $\boldsymbol{\Pi} \mathbf{p}_{t-1} = \boldsymbol{\alpha} (\boldsymbol{\beta}_1' \mathbf{p}_{t-1} + \boldsymbol{\beta}_0)$ , where the  $\boldsymbol{\beta}_1$  matrix includes the coefficients measuring the magnitude of the cointegration relationships and the  $\boldsymbol{\beta}_0$  vector contains the constant terms.<sup>1</sup> The loading matrix  $\boldsymbol{\alpha}$  contains the speed of adjustment coefficients denoting the speed at which  $\Delta \mathbf{p}_t$  moves to correct  $r$  past short-run disequilibria. To ensure that the  $n$ -dimensional error term  $\mathbf{e}_t$  is serially uncorrelated,  $k$  lagged price changes are included in the model. The  $n \times n$  matrix  $\boldsymbol{\Gamma}_i$  thus denotes the reaction of  $\Delta \mathbf{p}_t$  to price changes lagged by  $i$  periods, with  $i = 1, 2, \dots, k$ .

Referring to the definition of market integration proposed by González-Rivera and Helfand (2001), we expect the rank of matrix  $\boldsymbol{\Pi}$  to be  $r = n - 1$ , which implies  $r$  cointegrating vectors and one common stochastic trend. If this condition holds, the cointegrating vectors can be normalized to represent pairwise cointegration between any

<sup>1</sup> To give better intuition, consider the bivariate (i.e.  $n = 2$ ) case with  $r = 1$  cointegration relationship.  $\Delta p_t^1$  then depends on the deviations from the long-run price equilibrium it shares with  $p_t^2$ . The long-run equilibrium can be represented as  $p_t^1 = \beta_0 + \beta_1 p_t^2 + \varepsilon_t$ . In the bivariate case,  $\varepsilon_{t-1}$  denotes the disequilibrium, or the error correction term. In a multivariate VECM,  $\Delta p_t$  can be a function of various (i.e.  $r > 1$ ) lagged disequilibria.

TABLE 1 Database utilized in the spatial market analysis

Group	Country	Price type	Data Source
GASC	Egypt, tender prices	Highest accepted CFR offer, monthly, USD/t	Zerno Online (2019)
Black Sea exporters	Kazakhstan, milling, Aktau port	FOB, monthly, USD/t	FAO (2019)
	Russia, milling, deep-sea ports	FOB, monthly, USD/t	FAO (2019)
	Ukraine, milling	FOB, monthly, USD/t	FAO (2019)
Non-Black Sea exporters	Argentina, Trigo Pan, up river	FOB, monthly, USD/t	FAO (2019)
	Australia, ASW, Eastern states	FOB, monthly, USD/t	FAO (2019)
	Canada, CRWS, St Lawrence	FOB, monthly, USD/t	FAO (2019)
	France, grade one, Rouen port	FOB, monthly, USD/t	FAO (2019)
	USA, no. 2 SRW, Gulf ports	FOB, monthly, USD/t	FAO (2019)

Note: The sample period ranges from July 2011 to June 2019. CFR and FOB denote 'cost and freight' and 'free on board' and refer to prices at importing and exporting port facilities, respectively (see ICC, 2019).

Source: Authors' illustration.

two analyzed price series (Johansen & Juselius, 1994). After normalization, the coefficients of the  $j^{th}$  column of the  $\beta$  matrix,  $j = 1, \dots, r$ , correspond to the long-run price transmission elasticity, a measure of the degree of long-run price transmission, in the  $j^{th}$  cointegration relationship. The closer the coefficients are to unity, the stronger is the market integration between the respective locations and the more likely the LOP is to hold. The elements in the  $j^{th}$  row of the loading matrix  $\alpha$  represent the short-run characteristics of price transmission. Each of the  $n$  prices within the multivariate framework adjusts to each of the  $r$  past disequilibria (error correction terms) within the system. The closer the adjustment parameters are to unity in absolute value, the faster the speed at which the respective price adjusts to correct a deviation from a long-run equilibrium. In a cointegrated system, a large adjustment parameter thus indicates that the respective price is strongly adjusting to changes of another price and is thus following it. By contrast, low (close to zero) adjustment rates of a price indicate only slight adjustment to changes of other prices, which suggests that the respective price is leading the price developments in the system.

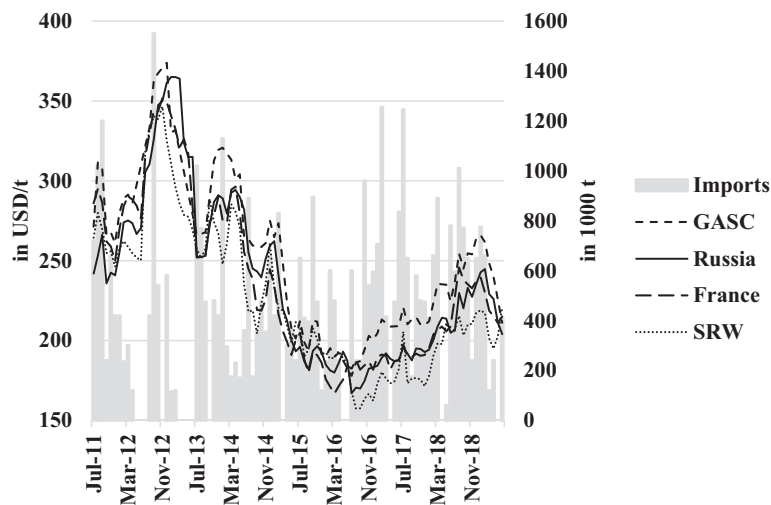
The extent of the GASC wheat tender market is specified based on the largest set of prices (including the GASC tender price) for which the condition of common long-run information (i.e. a  $\Pi$  matrix of rank  $r = n - 1$ ) holds, following a sequential specific-to-general approach (Gonzalez-Rivera & Helfand, 2001; Jha et al., 2008; Rashid, 2004; Sekhar, 2012). We start the cointegration analysis considering the GASC tender price and one export price exclusively ( $n = 2$ ). If  $n - 1$  cointegrating vectors are identified within this system, further export prices are successively added until the inclusion of an additional price series results in  $r < n - 1$  or  $r = n$  cointegrating vectors. The order in which export prices are added

to the multivariate framework corresponds to the size of the export country's share in the GASC tender market, i.e. countries with the largest share are considered first.

#### 4 | DATA CHARACTERISTICS AND PROPERTIES

The analysis is conducted for a data-base consisting of nine monthly wheat price series, namely the GASC 'cost and freight' (CFR) wheat tender price and eight FOB wheat export price series of the world's largest wheat exporting countries (see Table 1, and Table A3 in the online appendix for descriptive statistics). The data set lasts from July 2011—after the Russian grain export ban, when no wheat export prices were recorded—through to June 2019. Within our investigation period, the GASC issued 201 tenders and purchased 694 wheat cargos.

The monthly GASC wheat tender price series is constructed based on a comprehensive data-base comprising information on each individual wheat tender transaction (see Figure 2). We select the highest "cost and freight" (CFR) price accepted by the GASC within all wheat tenders issued in 1 month as the respective GASC wheat tender price, which is motivated by the following theoretical considerations: Exporters from different countries provide price-quantity offers to the GASC within an open wheat tender, theoretically representing the wheat supply curve of the GASC wheat tender market. The GASC wheat tender equilibrium price  $p_t^{eq}$  is given by  $ask_t^{acpt} \leq p_t^{eq} < ask_t^{rjct}$ , with  $ask_t^{acpt}$ , the highest offer price accepted, and  $ask_t^{rjct}$ , the lowest offer price rejected by the GASC. Since rejected price offers ( $ask_t^{rjct}$ ) are not recorded in the tender transaction data-base, the highest accepted offer price



**FIGURE 2** GASC imports and CFR tender prices and selected FOB export prices

Source: FAO (2019), Zerno Online (2019)

( $ask_t^{act}$ ) represents the best approximation of the specific market equilibrium price.<sup>2</sup>

The resulting tender price series contains 16 missing values (16.7% of the observations of the price series), corresponding to the periods when no wheat tenders were issued. As missing values are also observed in consecutive months, linear interpolation is not feasible here. We therefore employ a linear imputation technique (similar to Goodwin, 1992, and Svanidze et al., 2019) and simulate the missing values building on French export prices, which are highly correlated with the GASC tender prices.<sup>3</sup>

The analysis covers monthly FOB wheat prices of Russia, USA, Canada, France, Ukraine, Argentina, Australia and Kazakhstan, which jointly account for 90% of global wheat exports (USDA, 2020). Comparing the exporters' shares in global wheat exports and the Egyptian tender market, Table A4 in the online appendix shows that the US share in the Egyptian wheat tender market has recently decreased to 2.2%. As discussed in section two, Romania also exports considerable quantities of wheat to Egypt. However, since data on Romanian wheat prices could not be accessed for the time period underlying our analysis, Romania is not covered in this study. Russia typically

exports soft winter wheat of class four with a protein content of between 12% and 13%, while France also exclusively exports soft wheat. To ensure comparability, we select soft red winter (SRW) wheat to represent wheat exported by the USA, although hard red winter (HRW) wheat is the class primarily exported from the USA. SRW wheat has a lower protein content compared to HRW wheat and is the class preferred by the GASC.<sup>4</sup>

Prior to our cointegration analysis, the time series properties of the nine wheat price series are examined. The order of integration of each series is determined employing Augmented Dickey-Fuller unit root (Dickey & Fuller, 1979) and the Kwiatkowski-Phillips-Schmidt-Shin stationarity tests (Kwiatkowski et al., 1992). The lag length in the ADF and KPSS test is determined by the Schwarz Information Criterion and the Newey-West bandwidth method, respectively. Both tests suggest that all price series are non-stationary mostly at the 1%, and at least at the 5% level of significance. The Kazakh price series is an exception with a rejection of stationarity only at the 10% significance level (see Table A5 in the online appendix). The non-stationarity of the data motivates us to investigate the price relationships within a cointegration framework.

## 5 | ESTIMATION RESULTS

### 5.1 | Integration and extent of the GASC wheat tender market

The extent of the GASC tender market is determined by sequential trace tests for multivariate cointegration,

<sup>2</sup> For comparison, we have also constructed a series of average tender prices, as well as a series based on the lowest CFR price within 1 month. While the model results do not change qualitatively, the estimated price transmission elasticities and speed of adjustment parameters are smaller in size. We interpret this as evidence for the highest CFR price containing the largest informational value on the export markets under consideration.

<sup>3</sup> As a robustness check, all subsequent estimations were also conducted using a linearly interpolated series of GASC tender prices. The results do not change fundamentally, and the overall conclusions of the paper remain unaffected. Additionally, we estimated the VECM with interaction dummy variables to filter out the effect of the missing observations (see Table A6 in the online appendix). Also here, the results do not change significantly and the overall conclusions remain unaffected. Detailed estimation results are available from the authors upon request.

<sup>4</sup> The GASC frequently adjusts the minimum protein levels it requests from suppliers. In February 2018, the levels were adjusted to 11.5% for wheat from Russia, Romania and Ukraine and 11% for French and US-SRW wheat, respectively (Reuters, 2018)

**TABLE 2** Johansen (1988) likelihood ratio test for the number of cointegrating vectors

Market locations (n) included	Rank (r) of matrix $\Pi$	Trace statistic
GASC; Russia	0	27.12***
	1	2.66
GASC; Russia; France	1	16.95*
	2	3.29
GASC; Russia; France; USA	2	16.24*
	3	3.20
GASC; Russia; France; USA; Ukraine	3	15.11
	4	2.56
GASC; Russia; France; USA; Argentina	3	12.67
	4	4.01
GASC; Russia; France; USA; Kazakhstan	3	15.02
	4	3.98
GASC; Russia; France; USA; Canada	3	10.55
	4	3.75
GASC; Russia; France; USA; Australia	3	11.20
	4	3.32

Note: Null hypothesis for trace test is  $r = h$  against the alternative of  $r > h$ , with  $h$  specified in the second column. Sample period lasts from July 2011 to June 2019 (96 observations). The lag length in the VAR models is set to three to ensure that error terms are serially uncorrelated. Critical values are from Osterwald-Lenum (1992). \*\*\*, \*\*, \* denote rejection of null hypothesis at 1%, 5%, and 10% level of significance, respectively.

Source: Authors' estimations.

following the specific-to-general approach outlined in section four.<sup>5</sup> Results suggest that Russia, the biggest supplier of wheat to the GASC, clearly belongs to the tender market (Table 2). The wheat markets of France and the USA are included in the multivariate system since the respective null hypotheses of  $n \leq 2$  and  $n \leq 3$  cointegration vectors is rejected at the 10% significance level. We explain the weaker evidence for cointegration of France and the USA by the lower frequency of their wheat exports to Egypt. The test results for Ukraine, Argentina, Kazakhstan, Canada and Australia indicate that their inclusion would result in  $r < n - 1$  cointegration vectors. This implies that the respective price series do not belong to the

<sup>5</sup> As a robustness check, we also conducted sequential trace tests following a general-to-specific approach, consecutively excluding price series on the basis of resulting increases in the model log likelihood. This approach also determines that the system containing GASC, Russian, French and US prices represents the largest set of prices containing  $n - 1$  cointegrating relationships. Detailed results are available from the authors upon request.

same economic market. Therefore, Ukraine, Argentina, Kazakhstan, Canada and Australia are not included in the multivariate system. We explain the exclusion of Ukraine from the GASC tender market by its geographical proximity to Russia's wheat export market, leading to a high correlation of .996 between Russian and Ukrainian wheat export prices. Thus, the two price series likely share an additional, independent common trend implying  $r < n - 1$ .<sup>6</sup> The exclusion of Argentina, Kazakhstan, Canada and Australia from the GASC tender market is in line with their rather low share in GASC wheat tenders. Further, Canada and Kazakhstan predominantly export higher protein wheat, while the exclusion of the Southern Hemisphere exporters Argentina and Australia likely results from greater geographical distance, as well as seasonal factors (Arnade & Vocke, 2015). We conclude that there exist three cointegrating vectors in the system that includes the GASC, Russia, France and the USA. Prices in these four locations are cointegrated in all possible pairings and share one common stochastic trend.<sup>7</sup>

The  $n - 1$  normalized parameter estimates of the cointegration relationships are presented in Table 3. The  $\beta_1^i$  coefficients characterizing the long-run price transmission elasticities between the GASC tender price and the export prices of Russia, France and the USA equal .88, .89, and .91, respectively. Following Asche et al. (2012), the LOP is tested using a multivariate likelihood ratio (LR) test distributed as  $\chi^2(3)$  by jointly restricting  $\beta_1^1 = \beta_1^2 = \beta_1^3 = 1$ . The test statistic of 5.80 (p-value: .122) does not allow for rejection of the null hypothesis of complete price transmission within the whole multivariate system in the long-run. This provides evidence for a highly integrated market. However, LR tests on the LOP holding for single market locations individually (i.e.  $\beta_1^i = 1$ ), suggests that the respective null hypothesis for the GASC-Russia and GASC-France price pairs can be rejected at the 5% significance level.

The GASC tender price is a CFR import price equal to the sum of the FOB price observed in an exporting location and the costs of transporting wheat to Egypt. Thus, if  $\beta_1^i$  is restricted to 1 for  $i = 1, 2, 3$ , the constant term  $\beta_0^i$  is expected to reflect the respective transportation costs. As

<sup>6</sup> We also conducted subsequent VECM estimations replacing Russian with Ukrainian export prices. The results were qualitatively similar. This finding suggests that subsequent findings regarding to Russian prices can be generalized to further Black Sea exporters such as Ukraine and Romania, which grow wheat of a similar quality.

<sup>7</sup> Applying more recently developed wavelet methodologies to daily price data, Nigatu and Adjemian (2020) show that wavelets are equipped to portray more complex time-varying price interdependence patterns that linear cointegration tests might disregard. However, as the conducted Johansen tests suggest linear cointegration in our case, we leave the question of non-linearity of price relationships to future research.



**TABLE 3** Market integration and transportation costs in the GASC tender market

Price pair containing GASC and exporter $i$ :	Russia	France	USA
<i>Long-run price equilibrium</i>			
Price transmission elasticities ( $\beta_1^i$ )	.883 [.040]	.885 [.045]	.914 [.076]
Constant term for unrestricted $\beta_1^i$ ( $\beta_0^i$ )	.706 [.220]	.696 [.247]	.577 [.410]
<i>Law of One Price (LOP)</i>			
Joint LOP test ( $\beta_1^1 = \beta_1^2 = \beta_1^3 = 1$ )	(.122)		
Individual LOP test ( $\beta_1^i = 1$ )	(.022)	(.044)	(.313)
Constant term for $\beta_1^i$ restricted to 1 ( $\beta_0^{i, restr}$ )	.069 [.011]	.075 [.013]	.116 [.017]
<i>Implied vs. observed freight costs</i>			
Average observed export price ( $\bar{p}^i$ )	237.9 USD/t	236.9 USD/t	227.1 USD/t
Average observed freight cost ( $\overline{tc}^{i, obs}$ )	13.5 USD/t	15.5 USD/t	29 USD/t
Implied transaction costs ( $tc_i^i = \beta_0^{i, restr} \times \bar{p}^i$ )	16.5 USD/t	17.8 USD/t	26.3 USD/t
LR test on equality of implied and observed freight costs ( $\beta_0^{i, restr} = \frac{\overline{tc}^{i, obs}}{\bar{p}^i}$ )	(.133)	(.168)	(.173)

Note: Cointegrating vectors are normalized to represent pairwise cointegration with GASC tender prices.

Standard errors are in []. P-values are in (). Multivariate likelihood ratio test of the LOP distributed as  $\chi^2(3)$ .

Source: Authors' estimations.

all prices are denoted in natural logarithm, the transportation costs implied in  $\beta_0^i$  are a constant proportion of the FOB price.<sup>8</sup> We compare the average transportation costs implied by the constant terms ( $tc_i^i$ ) with the observed average freight rates recorded in the GASC tender data set ( $\overline{tc}^i$ ), which amounted to 13.5, 15.5, and 29 USD/t for the transport of wheat from Russia, France and the USA to Egypt, respectively. The implied transportation costs (given by  $\beta_0^i * \bar{p}^i$ , with  $\bar{p}^i$  equal to the mean of prices observed at location  $i$  as given in Table A3) are equal to 16.65, 18.95, and 27.25 USD/t, for Russia, France and the USA, respectively. The  $\chi^2$  test does not allow rejecting the null hypotheses on statistical equality of the implied and observed transportation costs for Russia, France and the USA, respectively. We interpret this as evidence for high substitutability and thus small quality differences between the wheat classes included in the model.<sup>9</sup>

<sup>8</sup> Besides arbitrage costs, substitution costs that result from quality differences between goods traded within one market will also be reflected in the constant terms (see Asche et al., 1999).

<sup>9</sup> We additionally estimate a VECM including HRW prices instead of SRW for the USA. While the price transmission elasticity parameter remains unaffected, the respective intercept term turns negative when the elasticity is restricted to unity. This suggests that the FOB price for higher-quality HRW wheat is on average higher than the GASC import price, which comprises an FOB price for lower-quality soft wheat plus freight costs. This result illustrates the quality segmentation of the international wheat market and affirms that SRW wheat is the appropriate quality class in the given context. Detailed results are available from the authors upon request.

## 5.2 | Interdependencies and price leadership

We estimate a multivariate VECM to assess the interdependencies between the GASC tender price and the export prices of Russia, France and the USA (Table 4). Each VECM equation contains the error correction terms of the three cointegration relationships, as well as three lags for each endogenous price series on the right-hand side of the equation. The number of lags was selected based on the Akaike Information Criterion (AIC). Portmanteau autocorrelation and White heteroscedasticity tests indicate that the model residuals are free from autocorrelation and heteroscedasticity.

The estimated speed of adjustment coefficients suggest strong interdependencies between the GASC tender price and export prices of Russia and France, while the US export price adjusts to price changes in the other market locations at a lower speed. The Russian wheat price corrects disequilibria with the GASC tender price at the highest speed observed in the VECM (-.7). The GASC tender price adjusts to deviations from its equilibrium with French (Russian) export prices, correcting 53% (31%) of a deviation within 1 month. The slow adjustment of the US wheat export price to the price changes in the other market locations is statistically significant only for the equilibrium shared with the GASC tender price (-.22).

Moreover, our results show that particular export prices adjust to error correction terms from multiple cointegration relationships. These additional, 'off-diagonal' adjustments represent a unique extension of multivariate over bivariate VECM and denote one exporter's price adjustment to deviations from a long-run price equilib-

TABLE 4 Adjustment parameter estimates from multivariate VECM

Deviations from long-run equilibrium of price pair	Russia	France	USA	GASC
Russia-GASC	-.70*** [.13]	-.36** [.15]	-.31 [.20]	-.31** [.15]
France-GASC	.37** [.13]	.10 [.14]	.29 [.19]	.53*** [.14]
USA-GASC	.10 [.08]	.09 [.09]	-.22* [.12]	.00 [.09]
Weak exogeneity tests	26.36*** (.00)	6.23 (.10)	7.31* (.06)	14.42*** (.00)
Adjusted R <sup>2</sup>	.44	.17	.14	.14
Autocorrelation	135.97 (.75)			
testHeteroscedasticity test	322.25 (.18)			

Note: Three lags are included in the VECM. Lag-adjusted sample runs from November 2011 to June 2019. \*\*\*, \*\* and \* denotes statistical significance at the 1%, 5%, and 10% level. Standard errors in []. P-values in (). Test statistics of LR tests for weak exogeneity distributed as  $\chi^2(3)$ . Portmanteau test statistic for no autocorrelation up to lag 12 distributed as  $\chi^2(148)$ . Joint White heteroscedasticity test distributed as  $\chi^2(300)$ .

Source: Authors' estimations.

rium shared by the GASC tender price and the export price of a competing origin. Russian prices show statistically significant adjustment of 37% to disequilibria in the France-GASC cointegration relationship, similar to the French export price adjusting to the Russia-GASC cointegration relationship by almost the same degree (-.36). These results suggest strong competition between the two largest wheat suppliers in the GASC tender market, namely France and Russia.

Testing for weak exogeneity corresponds to jointly restricting the three adjustment parameters of each column of Table 4 to zero. Results indicate that weak exogeneity of Russian and GASC prices can be rejected at the 1% significance level, suggesting that Russian and GASC prices adjust to price developments in the whole market. However, regarding France and the USA, we cannot reject weak exogeneity at the same level of confidence. The test provides some evidence that French and—at a lower level of confidence—US prices are weakly exogenous to the cointegration system.<sup>10</sup> We interpret this finding as indication that price offers by Black Sea wheat sellers to the GASC are intentionally set at a level closely related to the competing French wheat export price. This explanation implies that the Russian wheat market is not perfectly competitive, which was also suggested in Pall et al. (2013).

### 5.3 | Comparison of multivariate with bivariate VECM results

To gain insights into the differences between a bivariate and a multivariate approach, we estimate three

bivariate VECMs, each containing the GASC tender price and the wheat export price observed in Russia, France and the USA, respectively (Table 5). We find the long-run price transmission elasticities obtained from the multivariate approach ( $\beta_1^i$ ) presented in Table 3 to be similar in size compared to the estimates retrieved from the bivariate approach ( $\beta_1^j$ ) presented in Table 5). Results of  $\chi^2$  tests on statistical equality of the long-run price transmission elasticities ( $\beta_1^i = \beta_1^j$ ) suggest that the respective coefficients are in no case significantly different from each other.

While the speed of adjustments coefficients obtained from the bivariate models are qualitatively similar, as well, they exhibit a downward bias compared to the multivariate models in the majority of cases. This finding is in line with a similar comparison conducted by González-Rivera and Helfand (2001), who report that bivariate models underestimate the comparable speed of adjustment coefficients in 13 out of considered 14 cases. While the estimation of bivariate models would not result in qualitatively different overall conclusions in case of this dataset, multivariate tests are still necessary to detect and potentially prevent bias resulting from misspecified bivariate models. Further, the chosen multivariate approach offers additional insights into off-diagonal adjustment processes, which provide a more comprehensive analysis of the interdependencies between competing exporters compared to bivariate models.

## 6 | IMPULSE-RESPONSE ANALYSIS

As a direct interpretation of the adjustment coefficients obtained from multivariate cointegrated systems can be difficult, impulse response functions (IRF) can provide a straightforward visualization of the interrelations between the considered variables (Lütkepohl & Reimers, 1992; Lütkepohl & Saikkonen, 1997). Within an impulse

<sup>10</sup> As outlined above, a weakly exogenous market is not sufficient to justify the use of bivariate models. Only if “we were to find both a single exogenous state and all other locations responding only to error correction terms involving this exogenous state” (González-Rivera and Helfand, 2001), a bivariate approach would be justified. The second condition is not fulfilled in our case.

TABLE 5 Bivariate VECM estimations

	Russia-GASC	France-GASC	USA-GASC
Price transmission elasticity (PTE), $\beta_1^j$	.891 [.038]	.891 [.045]	.950 [.085]
Constant term ( $\beta_0^j$ )	.659 [.209]	.664 [.244]	.387 [.461]
Speed of adjustment GASC	-.041 [.130]	.383*** [.111]	.103 [.082]
Speed of adjustment Exporter	-.477*** [.118]	-.015 [.111]	-.219** [.104]
Equality of bivariate and multivariate PTE estimates ( $\beta_1^i = \beta_1^j$ )	(.837)	(.891)	(.690)

Note: Three lags are included in each VECM. Lag-adjusted sample runs from November 2011 to June 2019. \*\*\*, \*\* and \* denotes statistical significance at the 1%, 5%, and 10% level. Standard errors in []. P-values in ().

Source: Authors' estimations.

response analysis, the response of an individual variable to a shock in another variable is presented relative to a baseline scenario, where the system is not affected by any shock (Koop et al., 1996). Following a convention outlined by Lütkepohl and Reimers (1992), the effect of a variable shock is considered temporary if it reverts to zero, while the effect is considered permanent if the affected variable stabilizes at a new equilibrium in response to the initial shock. While permanent effects are common in cointegrated autoregressive systems like VECM, the impulse responses obtained from classic vector autoregressive (VAR) systems are expected to revert to zero, i.e. to be temporary (Naka & Tufte, 1997).

One important shortcoming of standard IRFs is that they require the imposition of an ordering of the considered variables. This ordering determines the temporal sequence by which each variable can affect other variables within a multivariate autoregressive system. However, within our analysis any ordering of the considered price series appears arbitrary, while the results obtained from an impulse response analysis can vary considerably depending on the chosen ordering.<sup>11</sup> Addressing these shortcomings of standard orthogonalized IRFs, Pesaran and Shin (1998) propose generalized impulse response functions (GIRF). GIRFs do not require an ordering of the variables and produce one unique set of impulse responses, which is invariant to any ordering of the variables (Ihle et al., 2012). Due to this advantage, we opt to present GIRF in the following.

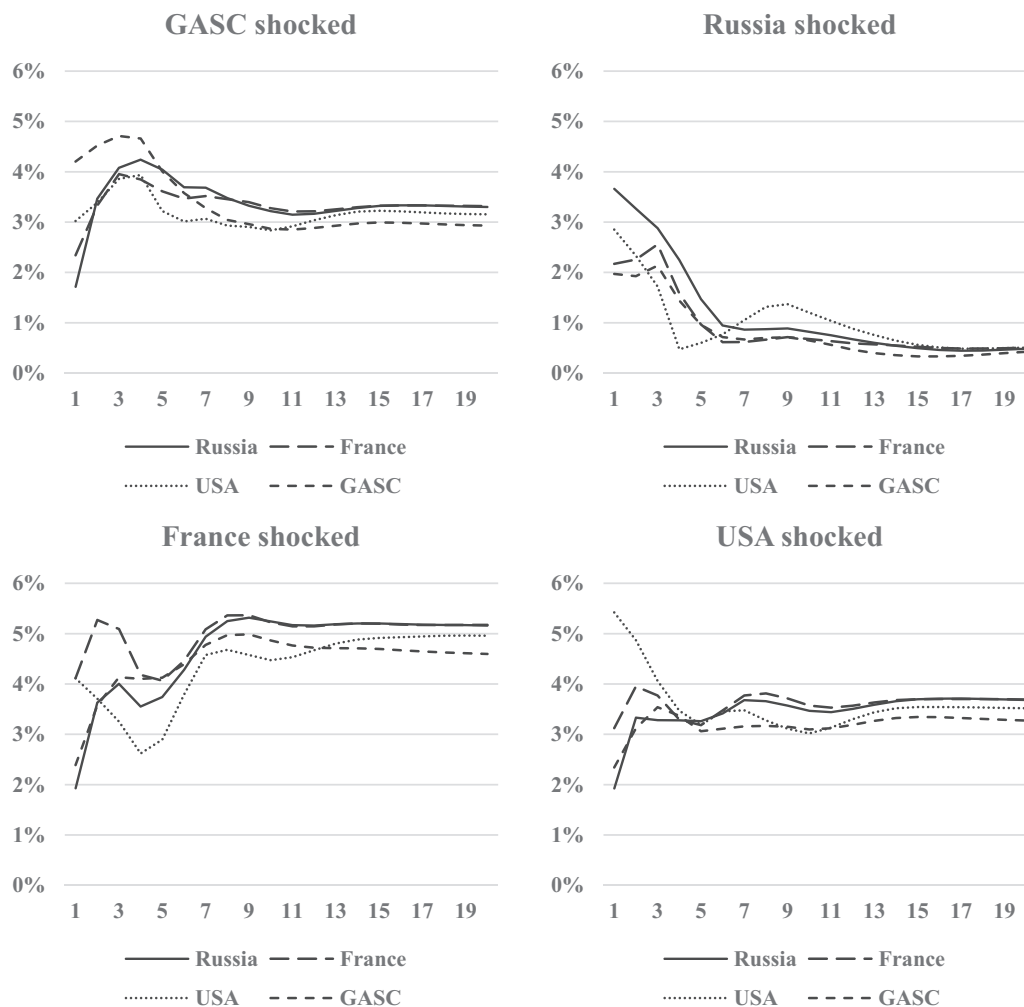
Figure 3 displays the responses of each variable to unit shocks of one standard deviation originating from the four considered market locations over a time horizon of 20 months. Most notably, shocks originating in the Russian market have a temporary effect on the other prices, which reverts to zero after 6 months. By contrast, price shocks originating in all three other market locations show per-

manent effects, as prices settle at new equilibria, around 8 months after the initial shocks. Typically, the responses of all four prices stabilize at similar values in the long-run, while often showing similar patterns also in the short-run. The US-SRW price, however, shows more distinct short-run responses to shocks originating in Russia and France, compared to the other responses. Conversely, shocks originating from the US market prompt rapid responses in the other market locations, which settle at new equilibria already 2 months after the shock. However, compared to shocks originating in the GASC and the French markets, these new equilibria are considerably lower than the initial shock in the US price. These findings likely result from the minor share of US wheat on the GASC wheat tender market relative to its share on the overall world wheat market (see Table 2). Further, quality differences might play a role, as the majority of wheat exported from the USA is hard wheat, while Russia and France export soft wheat, which better meets the quality requirements set in GASC tenders. It is worth underlining that our results only apply to the global market for soft wheat.

## 7 | SUMMARY AND CONCLUSIONS

This study on international wheat market integration is unique in considering the prices at which the Egyptian GASC purchases large amounts of wheat within its tender system. Building on a transaction-specific dataset on GASC tenders for the time period of July 2011 through to June 2019, results of the multivariate cointegration analysis suggest that Russia, France and the USA, the three largest wheat exporters worldwide, are strongly cointegrated with the GASC tender price. Conversely, Ukraine, Argentina, Kazakhstan, Canada and Australia cannot be included in the multivariate cointegration framework. We find the LOP to hold in the GASC tender market, indicating that price changes are fully transmitted between market locations. The impulse response analysis has made evident that GASC tender prices play a key role in price discovery

<sup>11</sup> In a case of  $n = 4$  variables, there exist  $n! = 24$  possible orderings of the variables. For each of the four considered variables there are thus six sets of responses to an initial shock, while there is no clear guidance on which ordering is appropriate in the considered case.



**FIGURE 3** Generalized impulse responses to a unit shock  
 Source: Authors' estimations

on international wheat markets, which research disregarding this tender data might have missed.

The speed of adjustment estimates retrieved from the VECM suggest strong interdependencies between the GASC tender price and the export prices from the two most important suppliers to the GASC, Russia and France. Disequilibria with the GASC tender price are corrected fastest by the Russian wheat price, while the speed of adjustment is low and statistically not significant for the French export price. The GASC tender price itself only adjusts to restore the long-run price equilibrium it shares with the French export price. Moreover, the Russian (French) export price shows substantial statistically significant error correction behavior to deviations from the equilibria between the French (Russian) export price and the GASC tender price, which suggests strong competition between the two major exporters. We find that US-SRW wheat prices solely adjust to the GASC tender price, and at a rather low speed, which

can be interpreted as evidence for US price leadership. However, our results also do not provide evidence for significant adjustment of wheat export prices neither in Russia nor in France towards US prices, which does not support leadership of US prices in the system. We attribute these findings to the fact that the USA has a relatively small share in the GASC tender market. Further, the GASC imports soft wheat, which is the type primarily exported from Russia and France, while the USA predominantly exports hard wheat.

Although Russia is the most important supplier of wheat to Egypt and the largest exporter worldwide, tests for weak exogeneity of single market locations provide evidence for price leadership of French export prices, as well as US export prices to a lesser extent. This finding is supported by the impulse response analysis suggesting temporary effects of shocks originating on the Russian wheat market. We interpret the price leadership of the French export price as

an indication that Russian wheat traders use French export prices, which are transparently discovered at the Euronext commodity futures exchange in Paris, as a reference when submitting price offers in GASC wheat tender. Overall, our findings are in line with the study by Janzen and Adjemian (2017), finding that the Euronext wheat futures market recently has gained importance in international wheat price discovery versus the Chicago Board of Trade, as it better reflects supply fundamentals in the Black Sea region. The chosen multivariate cointegration approach, comprising the wheat export prices of Russia, France, and the USA and one single import price, namely the GASC tender price, has proven particularly suitable to depict the GASC tender market. This is reflected in the high conformity of the transportation costs implied in the model intercepts with the observed freight costs, given unity of the long-run price transmission elasticities. This conformity also suggests that quality differences between the considered wheat prices are minimal.

The comparison of the estimated parameters of the multivariate and the bivariate VECMs shows that the price transmission elasticities and speed of adjustment coefficients retrieved from both approaches are qualitatively similar. The bivariate approach is, however, more limited, as the multivariate framework offers additional insights into adjustments between prices from different exporting countries that compete on the GASC tender market.

The results of this analysis only partly support the price leadership of US prices in the international wheat markets identified by Ghoshray (2006). Further, our findings do not confirm Goychuk and Meyers (2014) in suggesting that Russian export prices lead French and US wheat prices. However, both studies investigated price relationships solely between wheat export prices and over different time periods. We therefore assume that our findings referring to the time period 2011 through to 2019 reflect the changes in the international wheat market that resulted from the rising importance of Russia and the Black Sea region in general. As GASC tenders provide wheat traders with valuable pricing information from the rather opaque Black Sea wheat markets, it remains to be seen whether the Chicago Mercantile Exchange group's recently established Black Sea wheat futures contracts will rather be a complement or a substitute to GASC tenders. In this respect, future research should focus on price discovery and price interdependency dynamics between futures, Black Sea cash and tender prices.

#### ACKNOWLEDGMENTS

We gratefully acknowledge financial support by BMBF within the project UaFoodTrade. We thank Ludwig Striewe of ATR Landhandel for making us aware of this interesting research topic.

Open access funding enabled and organized by Projekt DEAL.

#### REFERENCES

- Araujo-Enciso, S., & Fellmann, T. (2020). Yield variability and harvest failures in Russia, Ukraine and Kazakhstan and their possible impact on food security in the Middle East and North Africa. *Journal of Agricultural Economics*, 71(2), 493–516.
- Arnade, C., & Hoffmann, L. (2019). Determination of the international maize price: What is the growing role of Brazil and Ukraine? *Agricultural Economics*, 50, 735–747.
- Arnade, C., & Vocke, G. (2015). Seasonal variation in the price discovery process of international wheat. *Agribusiness*, 32(1), 15–32.
- Asche, F., Bremnes, H., & Wessells, C. R. (1999). Product aggregation, market integration and relationships between prices: An Application to world salmon markets. *American Journal of Agricultural Economics*, 81(3), 568–581.
- Asche, F., Guttormsen, A. G., & Gjøølberg, O. (2012). Testing the central market hypothesis: A multivariate analysis of Tanzanian sorghum markets. *Agricultural Economics*, 43, 115–123.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366a), 427–431.
- Djuric, I., Götz, L., & Glauben, T. (2015). Are export restrictions an effective instrument to insulate domestic prices against skyrocketing world market prices? The wheat export ban in Serbia. *Agribusiness*, 31(2), 215–228.
- Fackler, P. L., & Goodwin, B. K. (2001). Spatial price analysis. In B. L. Gardener, & G. C. Rausser (Eds.), *Handbook of Agricultural Economics* (pp. 971–1024). Elsevier Science.
- FAO. (2019). *FAO Food Price Monitoring and Assessment Tool*. Retrieved August 22, 2019, from <https://fpma.apps.fao.org/giews/food-prices/tool/public/#/home>
- Ghoneim, A. F. (2015). The political economy of food price policy in Egypt. In P. Pinstrup-Andersen (Ed.), *Food Price Policy in an Era of Market Instability* (pp. 253–274). Oxford University Press.
- Ghoshray, A. (2006). Market delineation and price leadership in the world wheat market: A cointegration analysis. *Agricultural and Resource Economics Review*, 35(2), 311–326.
- Gonzalez-Rivera, G., & Helfand, S. M. (2001). The extent, pattern, and degree of market integration: A multivariate approach for the Brazilian rice market. *American Journal of Agricultural Economics*, 83(3), 576–592.
- Goodwin, B. K. (1992). Multivariate cointegration tests and the law of one price in international wheat markets. *Review of Agricultural Economics*, 14(1), 117–124.
- Götz, L., Djuric, I., & Nivievskiy, O. (2016). Regional price effects of extreme weather events and wheat export controls in Russia and Ukraine. *Journal of Agricultural Economics*, 67(3), 741–763.
- Götz, L., Glauben, T., & Brümmer, B. (2013). Wheat export restrictions and domestic market effects in Russia and Ukraine during the food crisis. *Food Policy*, 38(1), 214–226.
- Goychuk, K., & Meyers, W. (2014). Black Sea and World Wheat market price integration analysis. *Canadian Journal of Agricultural Economics*, 62(2), 245–261.
- Hassanzoy, N., Ito, S., Isoda, H., & Amekawa, Y. (2016). The Effects of swings in global wheat prices on the domestic markets in Afghanistan. *International Journal of Food and Agricultural Economics*, 4(4), 45–58.

- ICC. (2019). *International Chamber of Commerce Incoterms rules 2010*. Retrieved August 5, 2019, from <https://iccwbo.org/resources-for-business/incoterms-rules/incoterms-rules-2010>
- Ihle, R., Brümmer, B., & Thompson, S. R. (2012). Structural change in European calf markets: decoupling and the blue tongue disease. *European Review of Agricultural Economics*, 39(1), 157–179.
- Jamora, N., & Cramon-Taubadel, S. (2015). Transaction cost thresholds in international rice markets. *Journal of Agricultural Economics*, 67(2), 292–307.
- Janzen, J. P., & Adjemian, M. K. (2017). Estimating the location of world wheat price discovery. *American Journal of Agricultural Economics*, 99(5), 1188–1207.
- Jha, R., Murthy, K. B., & Sharma, A. (2008). Market integration in wholesale rice markets in India. In Jha, R. (Ed.), *The Indian Economy Sixty Years After Independence* (pp. 233–246). Palgrave Macmillan.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2–3), 231–254.
- Johansen, S., & Juselius, K. (1994). Identification of the long-run and the short-run structure an application to the ISLM model. *Journal of Econometrics*, 63(1), 7–36.
- Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74, 119–147.
- Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, 54(1–3), 159–178.
- Lütkepohl, H., & Reimers, H.-E. (1992). Impulse response analysis of cointegrated systems. *Journal of Economic Dynamics and Control*, 16, 53–78.
- Lütkepohl, H., & Saikkonen, P. (1997). Impulse response analysis in infinite order cointegrated vector autoregressive processes. *Journal of Econometrics*, 81, 127–157.
- MacKinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11(6), 601–618.
- McKee, D. (2013). *Egyptian government's role in wheat*. Retrieved August 22, 2019, from <http://www.davidmckee.org/2013/03/27/egyptian-governments-role-in-wheat>
- Mohanty, S., Meyers, W. H., & Smith, D. B. (1999). A reexamination of price dynamics in the international wheat market. *Canadian Journal of Agricultural Economics*, 47, 21–29.
- Naka, A., & Tufte, D. (1997). Examining impulse response functions in cointegrated systems. *Applied Economics*, 29(12), 1593–1603.
- Nigatu, G., & Adjemian, M. (2020). A wavelet analysis of price integration in major agricultural markets. *Journal of Agricultural and Applied Economics*, 52, 117–134.
- Osterwald-Lenum, M. (1992). A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics. *Oxford Bulletin of Economics and Statistics*, 54(3), 461–472.
- Pall, Z., Perekhonchuk, O., Glauhen, T., Prehn, S., & Teuber, R. (2013). Residual demand measures of market power of Russian wheat exporters. *Agricultural Economics*, 45(3), 381–391.
- Pesaran, H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economics Letters*, 58, 17–29.
- Pierre, G., & Kaminski, J. (2019). Cross country maize market linkages in Africa: Integration and price transmission across local and global markets. *Agricultural Economics*, 50, 79–90.
- Rashid, S. (2004). Spatial integration of maize markets in post-liberalised Uganda. *Journal of African Economics*, 13(1), 102–133.
- Reuters. (2011). *Egypt studies buying Polish, Hungarian wheat*. Retrieved August 22, 2019, from <https://af.reuters.com/article/investingNews/idAFJ0E7AQ0IT201111127>
- Reuters. (2018). *Egypt's GASC sets new wheat terms after dispute over fees*. Retrieved November 14, 2019, from <https://af.reuters.com/article/egyptNews/idAFL8NIPS3EI>
- Rhoades, S. A. (1993). The herfindahl-hirschman index. *Federal Reserve Bulletin*, 79, 188–189.
- Rosa, F., Vasciaveo, M., & Weaver, R. D. (2014). Agricultural and oil commodities: Price transmission and market integration between US and Italy. *Bio-based and Applied Economics*, 3(2), 93–117.
- Schierhorn, F., Müller, D., Prishchepov, A. V., Faramarzi, M., & Balmann, A. (2014). The potential of Russia to increase its wheat production through cropland expansion and intensification. *Global Food Security*, 3(3–4), 133–141.
- Sekhar, C. S. (2012). Agricultural market integration in India: An analysis of select commodities. *Food Policy*, 37, 309–322.
- Svanidze, M., & Götz, L. (2019). Spatial market efficiency of grain markets in Russia: Implications of high trade costs for export potential. *Global Food Security*, 21, 60–68.
- Svanidze, M., Götz, L., Djuric, I., & Glauhen, T. (2019). Food security and the functioning of wheat markets in Eurasia: A comparative price transmission analysis for the countries of Central Asia and the South Caucasus. *Food Security*, 11(3), 733–752.
- UN Comtrade Database. (2019). *United Nations Commodity Trade Statistics Database*. Retrieved August 5, 2019, from <https://comtrade.un.org/db/default.aspx>
- USDA. (2020). *PSD Online*. Retrieved September 15, 2020, from <https://apps.fas.usda.gov/psdonline/app/index.html#/app/home>
- Zerno Online. (2019). *Zerno Traffic Online Database*. Retrieved August 22, 2019, from <http://www.zol.ru>

## SUPPORTING INFORMATION

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

**How to cite this article:** Heigermoser M, Götz L, Svanidze M. Price formation within Egypt's wheat tender market: Implications for Black Sea exporters. *Agricultural Economics* 2021;52:819–831. <https://doi.org/10.1111/agec.12656>