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Do Black Sea maize prices influence maize futures price discovery in Hungary? An analysis of the relationship between Hungarian and Black Sea maize prices

As the Black Sea Region (BSR) has recently emerged as a major world grain exporter region, this study assesses the possible influence of BSR maize prices on maize futures prices in Hungary. To measure the linear relationship between these prices the Pearson's correlation was used, and to estimate their cointegration the Johansen test was performed for the period April 2011 to December 2013. Prices of Paris (MATIF) and Chicago (CBOT) maize futures were also included in the analysis for comparison. The results suggest that BSR maize prices had little or no influence on futures price discovery in Hungary during the period investigated. From this it can be concluded that (a) BSR supply and demand conditions bore negligible importance for market participants, and (b) Budapest Stock Exchange maize futures may not be efficient tools for hedging price risks associated with Hungarian maize exports to third countries where prices are derived from quotes at BSR seaports. On the other hand, MATIF maize futures prices had a measurable impact on the pricing of maize futures in Hungary, although this connection disappeared for the period April-December 2013. The same was true for CBOT maize futures prices which Hungarian maize futures prices were also cointegrated with in a revised 2012/2013 crop year (April-March). Some possible causes of the dis-association of these markets observed recently are discussed.

Keywords: price correlation, price cointegration, maize, Hungary, Black Sea Region

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Introduction

The Black Sea Region (BSR) has recently emerged as a major world wheat, barley and maize exporter region[1]. The BSR includes three countries that are net exporters of maize, namely Romania, Ukraine and Russia. The relationship between BSR maize prices and maize prices of other maize exporter countries, in particular Hungary, has not been studied yet. This can be explained to a great extent by difficulties of obtaining accurate price data with few or no gaps from the BSR.

Hungary is a land-locked country connected with the Black Sea by the River Danube, which, after crossing the country, passes through or borders Croatia, Serbia, Bulgaria, Romania, Moldova and Ukraine. The River Danube is extensively used for shipping dry bulk commodities including grains both up- and down-stream. Thus it is a 'price-transmitter': bids for Hungarian maize are often calculated from price quotes, spot or forward, at ports of delivery minus the cost of transport from the stores to the nearest Danube terminal, barge freight and handling.

Hungary has traditionally been a maize producer and exporter country with exports averaging 57.4 per cent of total maize production during the 2010/11-2012/13 crop years (October-September). While maize has had a relatively stable sowing area with around 1.2 million hectares and production has shown a stagnating trend (although with substantial variations from year to year), the volume of net maize exports has increased significantly since the beginning of the new Millennium. This change is primarily owing to the continuous fall in livestock numbers, in particular of pigs (Popp *et al*., 2008) (Table 1).

Of the 11.33 million tonnes of maize shipped abroad in total from Hungary during the 2010/11-2012/13 crop years, 13.2 per cent was sold to neighbouring Romania. Romania has been producing surplus maize in recent years, becoming the major maize exporter country of the EU to third countries (Table 2) with a share of 43.7 to 67.5 per cent during the 2010/11-2012/13 (October-September) period. It is often claimed by grain traders in Hungary that a significant amount of Hungarian maize delivered to Constanța, a major seaport and grain handling terminal in Romania connected with the River Danube by the Cernavodă Canal, would be re-exported to third countries mostly in the Middle East and North Africa.

During the past few years, Ukraine has become the principal maize producer and exporter BSR country at the global level, joining the group of Brazil and Argentina in the second row behind the United States. The production of

Table 1: Maize production and exports of Hungary (million tonnes).

Crop year (Oct-Sept)	Production	Net exports	Exports to Romania
2000/01-2002/03*	6.32	1.65	0.88
2010/11	6.99	4.28	0.39
2011/12	7.99	5.12	0.87
2012/13	4.76	1.93	0.23
2013/14**	6.73	2.95	0.15

* Averages; ** Estimates
Data source: KSH

Table 2: Maize production and exports of Romania (million tonnes).

Crop year (Oct-Sept)	Production	Net exports	Non-EU exports	Self-sufficiency
2000/01-2002/03*	6.40	-0.15	0.08	93%
2010/11	8.72	1.26	0.61	114%
2011/12	10.48	2.28	2.18	129%
2012/13	5.61	1.29	0.96	107%
2013/14**	10.35	2.61	1.27	140%

* Averages; ** Estimates
Data source: Tallage

[1] There are several definitions of the Black Sea Region. In grain trading, from the aspect of exports, the term most often refers to Bulgaria, Romania, Russia and Ukraine, i.e. countries that ship large volumes of cereals (and products of the oilseeds complex) abroad through their ports at the Black Sea.

Table 3: Maize production and exports of Ukraine.

Crop year (Oct-Sept)	Production (million tonnes)	Net exports (million tonnes)	% share of	
			Global exports	FSU exports
2000/01-2002/03*	3.89	0.47	0.7	92.2
2010/11	11.92	4.97	5.5	96.2
2011/12	22.84	15.11	13.0	86.7
2012/13	20.92	12.69	13.4	84.9
2013/14**	30.90	19.95	16.0	81.8

* Averages; ** Estimates; FSU: Former Soviet Union countries
Data source: USDA (data of global exports used for the calculations are aggregates of local marketing years)

Table 4: Maize production and exports of Russia.

Crop year (Oct-Sept)	Production (million tonnes)	Net exports (million tonnes)	% share of	
			Global exports	FSU exports
2000/01-2002/03*	1.27	-0.26	0.0	0.8
2010/11	3.08	-0.08	0.0	0.7
2011/12	6.96	1.98	1.7	11.6
2012/13	8.21	1.87	2.0	12.8
2013/14**	11.64	3.95	3.2	16.4

* Averages; ** Estimates; FSU: Former Soviet Union countries
Data source: USDA (data of global exports used for the calculations are aggregates of local marketing years)

maize in Ukraine has increased from 11.92 million tonnes in 2010/11 to an all-time record of 30.90 million tonnes in 2013/14 while, parallel to this, net exports have surged from 4.97 million tonnes to an estimated 19.95 million tonnes. Indeed, the share of Ukraine in global maize exports jumped from 5.5 per cent in 2010/11 to an estimated 16.0 per cent in 2013/14 (Table 3). Ukraine has emerged as the major maize supplier to the EU, especially to those of its Member States which have a considerable deficit in this particular grain crop (i.e. Spain, Portugal etc.), elbowing out Argentina and Brazil from these markets. According to Eurostat data, Ukraine gained a 66.3 and a 62.3 per cent share in EU maize imports in 2011/12 and 2012/13 (October-September), respectively, shipping, in absolute terms, 4.12 and 7.09 million tonnes to the different Member States.

Ukraine has an overwhelming, although declining share in the maize exports of the post-Soviet (FSU) states, mainly due to the increase in maize production and exports of neighbouring Russia. In Russia, the production of maize has expanded rapidly too in the past few years reaching an unprecedented 11.64 million tonnes in 2013/14 against the 3.08 million tonnes harvested in 2010/11. The country has become a net exporter of maize with an estimated 3.95 million tonnes shipped abroad in 2013/14 (Table 4). According to Eurostat data, the EU imported 0.68 and 0.59 million tonnes of maize from Russia in 2011/12 and 2012/13 (October-September), respectively.

Hungary is considered a 'price-receiver' since the export price of maize is predominantly set by larger competitors on the world market. Owing to the boost in BSR maize exports we hypothesise BSR maize export prices to be connected with and have an increasing influence on maize futures prices in Hungary[2]. If so, maize futures contracts traded in the Grain Section of the Budapest Stock Exchange (BÉT) could be appropriate tools for grain traders in Hungary to hedge their price risks associated with maize exports to third countries where prices are derived from quotes at BSR seaports.

[2] There are no maize futures contracts listed on any of the exchanges of the BSR maize exporter countries.

Methodology

To measure the linear relationship between maize futures prices in Hungary and BSR maize prices, the Pearson's correlation was used. To assess the possible influence of BSR maize prices on maize futures prices in Hungary, firstly the Augmented Dickey-Fuller (ADF) test was applied to verify whether the price series were integrated of order one (were non-stationary and their differences were stationary), and then the Johansen test for cointegration was performed. (Individual variables, which permanently change due to many developments, are cointegrated when a long-run equilibrium relationship represented by some linear combination of them exists.) The Johansen test was recently applied by Olson and O'Brien (2013) and by Goychuck (2013) for estimating the cointegration of BSR and other wheat prices, and of BSR and other wheat and barley prices, respectively. Earlier applications of the test include Brooks and Melyukhina (2003) for estimating the cointegration of Russian and other wheat, barley and sunflower prices.

The International Grains Council (IGC) kindly provided us with their daily FOB Black Sea[3] feed maize price series for the period 2010-2013 for research. The IGC prices are indicative and do not represent actual transactions. We refrained from using any of the data for 2010 due to the grain export restrictions imposed by Russia (export ban) and Ukraine (export quota) between August 2010 and January 2011, a six-month period for which no indicative maize prices were calculated by the IGC.

For Hungary the front month[4] daily closing price series of maize futures traded at the BÉT were used. For comparison, the front month daily closing price series of maize futures traded at the Paris Bourse (MATIF) and at the Chicago Board of Trade (CBOT) were also included in the analysis.

Owing to seasonality, it is appropriate to tailor the price series of grains subject to any analysis to crop years which usually begin at or just after harvest time. For this study, in order to use the remaining IGC data the most economically, the October-September crop years for maize were shifted to April-March. Thus, price correlations in two whole revised crop years and a nine-month fragment of a third revised crop year could be examined instead of two whole crop years and a three months long fragment of a third crop year. The logic that supports this shift is that maize sowing begins in April in Hungary and also in the maize exporter BSR countries as well as in France and the United States. This is the time of the year when expectations regarding the new crop begin to be formed but these influence not only new crop futures price discovery. According to the Theory of Price of Storage

[3] FOB is an acronym for the international commercial term 'Free on Board' meaning that the seller pays for the transportation of the good to the port of shipment, plus loading costs. In this case, the term FOB BSR refers only to Ukrainian and Russian ports at the Black Sea.

[4] The front month is the contract month of a futures contract with the closest expiration (delivery) date. Front month contracts are generally the most liquid of futures contracts, and have the smallest spread between the futures price and the spot price of the underlying commodity.

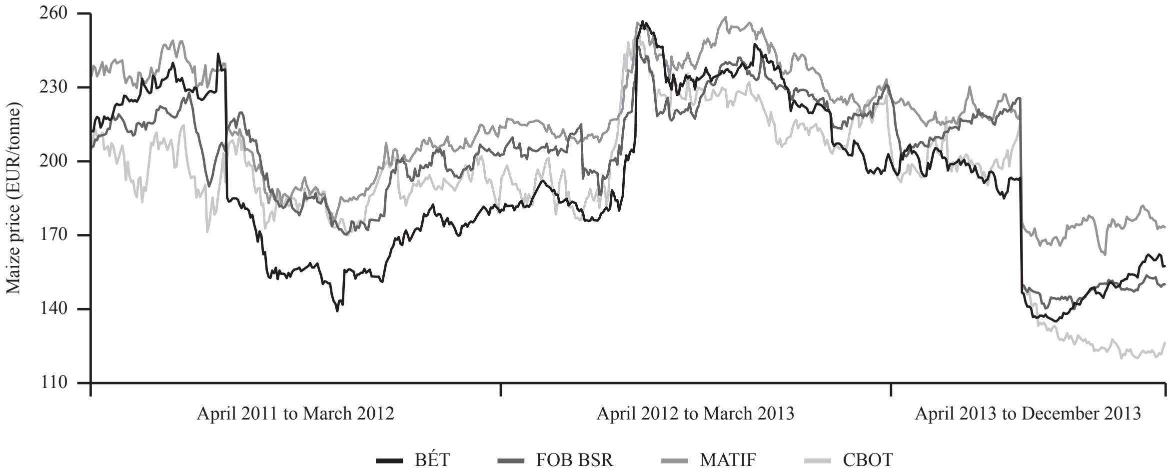

Figure 1: The adjusted series of front month daily closing prices of maize futures in Budapest (BÉT), Paris (MATIF) and Chicago (CBOT), and of the indicative FOB BSR maize prices of the IGC converted to EUR per tonne for the period April 2011 to December 2013.
Source: own calculations

(Working, 1949), expectations about the new crop impact the intertemporal price relations[5] and affect the price of an old crop futures contract usually about the same degree as of a new crop futures contract. Consequently, to begin the price series for the analysis with old crop front month futures in these revised crop years can be considered appropriate.

Missing data for exchange trading holidays not longer than one day were linearly interpolated, and weekends and exchange trading holidays longer than one day (around Christmas time) were excluded from the series. Time periods during which front month futures asynchronously switched from old to new crop at the different exchanges were also eliminated due to the usual drop in (the normal backwardation of) prices (i.e. from 15 July to 31 August in 2011/12, from 16 July to 31 August in 2012/13, and from 10 July to 31 August in 2013/14[6]). Thus the number of days (N) for which the correlation of and cointegration between maize prices were examined totalled 227, 216 and 152 for the revised 2011/12, 2012/2013 and 2013/14 crop years, respectively. Since in the revised 2013/14 crop year only the first nine months (less the time interval for switching between old and new crop futures) could be examined, the price series for 2011/12 and 2012/13 were also shortened to the period between April and December to check whether the results of both the correlation and cointegration tests would be significantly different from those of the two whole crop years. The number of days for which the analyses were repeated totalled 154 for both the revised 2011/12 and 2012/2013 crop years.

All prices were converted to their EUR per tonne equivalents using the official daily exchange rates published by the European Central Bank (Figure 1).

The calculations were made using the 3.1.1 version of the R software; for the ADF and Johansen tests version 0.10-32 of the *tseries* package and version 1.2-8 of the *urca* were applied, respectively.

[5] Intertemporal price relations are defined as relations at a given time between prices applicable to different times.

[6] In 2013/14, instead of 15 July when September became the front month maize futures contract at the CBOT, data were eliminated from 10 July onwards because FOB BSR maize prices apparently switched to the new crop at that early date.

Results

The values of the Pearson's correlation show that the linear relationship between BÉT maize futures and FOB BSR maize prices became stronger during the period April 2011 to December 2013. However, the same applies for BÉT and CBOT maize futures prices in which case this change was more robust. But through the whole time period, BÉT maize futures prices most frequently moved parallel with MATIF maize futures prices (Table 5).

Regarding FOB BSR maize prices, the correlation between these and all front month futures prices considered became stronger during the three revised crop years (Table 6). FOB BSR maize prices as well as BÉT maize futures prices were more closely connected with CBOT futures

Table 5: Values of the Pearson's correlation between the front month daily closing prices of maize futures in Budapest (BÉT) versus Paris (MATIF) and Chicago (CBOT), and the indicative FOB BSR maize prices of the IGC.

Period	FOB BSR	MATIF	CBOT
Apr 2011 to Dec 2013	0.86	0.96	0.77
Apr 2011 to Mar 2012	0.82	0.97	0.56
Apr 2012 to Mar 2013	0.87	0.94	0.77
Apr 2013 to Dec 2013	0.95	0.97	0.93
Apr 2011 to Dec 2011	0.83	0.98	0.64
Apr 2012 to Dec 2012	0.90	0.95	0.84

Source: own calculations

Table 6: Values of the Pearson's correlation between the indicative FOB BSR maize prices of the IGC and the front month daily closing prices of maize futures in Budapest (BÉT) versus Paris (MATIF) and Chicago (CBOT).

Period	BÉT	MATIF	CBOT
Apr 2011 to Dec 2013	0.86	0.93	0.93
Apr 2011 to Mar 2012	0.82	0.85	0.76
Apr 2012 to Mar 2013	0.87	0.92	0.77
Apr 2013 to Dec 2013	0.95	0.98	0.97
Apr 2011 to Dec 2011	0.83	0.86	0.84
Apr 2012 to Dec 2012	0.90	0.94	0.80

Source: own calculations

Table 7: Approximate p values of the Augmented Dickey-Fuller test statistics (trend version) for the front month daily closing prices of maize futures in Budapest (BÉT), Paris (MATIF) and Chicago (CBOT), and the indicative FOB BSR maize prices of the IGC.

Period	BÉT		MATIF		CBOT		FOB BSR	
	original series	at first difference	original series	at first difference	original series	at first difference	original series	at first difference
Apr 2011 to Dec 2013 (N=595)	0.68	<0.01	0.62	<0.01	0.73	<0.01	0.74	<0.01
Apr 2011 to Mar 2012 (N=227)	0.94	<0.01	0.65	<0.01	0.97	<0.01	0.09	<0.01
Apr 2012 to Mar 2013 (N=216)	0.89	<0.01	0.44	<0.01	0.78	<0.01	0.66	<0.01
Apr 2013 to Dec 2013 (N=152)	0.78	<0.01	0.60	<0.01	0.61	<0.01	0.55	<0.01

Source: own calculations

Table 8: Values of the Augmented Dickey-Fuller test statistics (trend version) for the front month daily closing prices of maize futures in Budapest (BÉT), Paris (MATIF) and Chicago (CBOT), and the indicative FOB BSR maize prices of the IGC.

Period	BÉT		MATIF		CBOT		FOB BSR	
	original series	at first difference	original series	at first difference	original series	at first difference	original series	at first difference
Apr 2011 to Dec 2013 (N=595, lag=8)	-1.77	-7.58	-1.90	-7.67	-1.64	-7.44	-1.62	-7.55
Apr 2011 to Mar 2012 (N=227, lag=5)	-0.96	-6.46	-1.83	-4.65	-0.72	-5.39	-3.22	-4.88
Apr 2012 to Mar 2013 (N=216, lag=5)	-1.25	-5.02	-2.34	-5.38	-1.52	-4.96	-1.79	-5.04
Apr 2013 to Dec 2013 (N=152, lag=5)	-1.51	-4.54	-1.95	-5.02	-1.91	-4.73	-2.06	-5.40

Lag order was determined by R
Source: own calculations

Table 9: Critical values of the Augmented Dickey-Fuller test.

	1%	5%	10%
Lag order=5, N=(227,216,152)	-3.99	-3.43	-3.13
Lag order=8, N=595	-3.96	-3.41	-3.12

Source: own calculations

prices during the period April-December 2011 than during the whole revised 2011/12 crop year although this phenomenon appears to be exceptional.

The ADF test verified that the prices series used were non-stationary and their differences were stationary (Tables 7, 8 and 9), conducting the Johansen test for cointegration was therefore appropriate.

The results of the Johansen test show that at the 5 per cent significance level BÉT maize futures and FOB BSR maize prices were not cointegrated through any of the time periods analysed. The lack of equilibrium relationship between these variables suggests that FOB BSR maize prices had little or no influence on maize futures price discovery in Hungary. On the other hand MATIF maize futures prices impacted maize futures price discovery at the BÉT in both the revised 2011/12 and 2012/13 crop years, while CBOT maize futures prices were cointegrated with BÉT maize futures prices only in the revised 2012/13 crop year. Although the correlation of BÉT maize futures prices was very strong with MATIF maize futures prices through the whole time period, i.e. from April 2011 to December 2013, price discovery appears to be disconnected from the Paris market in the revised 2013/14 crop year (Table 10).

FOB BSR maize prices were cointegrated with CBOT maize futures prices in both the revised 2011/12 and 2012/13 crop years as well as with MATIF maize futures prices in the revised 2011/12 crop year but, in this latter case, only when taking into account the last three months (January-March). In the revised 2013/14 crop year, however, CBOT and MATIF maize futures prices had no influence on FOB BSR maize pricing either (Table 11).

Table 10: Statistics of the Johansen test for cointegration of the front month daily closing prices of maize futures in Budapest (BÉT) versus Paris (MATIF) and Chicago (CBOT), and the indicative FOB BSR maize prices of the IGC.

Period	FOB BSR	MATIF	CBOT
Apr 2011 to Dec 2013 (N=595)	10.54	28.82	7.78
Apr 2011 to Mar 2012 (N=227)	9.85	19.92	12.88
Apr 2012 to Mar 2013 (N=216)	10.40	27.54	25.70
Apr 2013 to Dec 2013 (N=152)	5.91	5.31	4.62
Apr 2011 to Dec 2011 (N=154)	9.46	21.66	11.01
Apr 2012 to Dec 2012 (N=154)	12.89	18.77	25.35

Critical value at 5 per cent level of significance: 14.90
Source: own calculations

Table 11: Statistics of the Johansen test for cointegration of the indicative FOB BSR maize prices of the IGC versus the front month daily closing prices of maize futures in Budapest (BÉT), Paris (MATIF) and Chicago (CBOT).

Period	BÉT	MATIF	CBOT
Apr 2011 to Dec 2013 (N=595)	10.54	22.21	25.23
Apr 2011 to Mar 2012 (N=227)	9.85	17.73	39.91
Apr 2012 to Mar 2013 (N=216)	10.40	11.77	21.15
Apr 2013 to Dec 2013 (N=152)	5.91	13.22	9.75
Apr 2011 to Dec 2011 (N=154)	9.46	11.96	24.40
Apr 2012 to Dec 2012 (N=154)	12.89	12.31	15.97

Critical value at 5 per cent level of significance: 14.90
Source: own calculations

Discussion

The results of the Johansen test for cointegration suggest that FOB BSR maize prices had little or no influence on maize futures price discovery in Hungary during the period April 2011 to December 2013, which does not support our hypothesis. From this we conclude that (a) BSR supply and demand conditions bore negligible importance for market participants, and (b) BÉT maize futures contracts may not be efficient tools for hedging price risks associated with Hungarian maize exports to third countries where prices are derived from quotes at BSR seaports. On the other hand, MATIF maize futures prices had a measurable impact on the pricing of BÉT maize futures contracts, although this connection disappeared for the period April-December 2013. The same was true for CBOT maize futures prices which BÉT maize futures prices were also cointegrated with in the revised 2012/2013 crop year (April-March). It is interesting to note that the equilibrium relationship between FOB BSR maize and CBOT maize futures prices also broke off during the period April-December 2013. The price series analysed in this study covered a time period which proved to be too short to state with confidence that either cointegration or the lack of it may be considered the ‘normal' long-run relationship between them. But from the results of the Johansen test for the period April-December 2013 still the question arises: What could be the cause of the dis-association of these markets in the last tertial of the period April 2011 to December 2013?

Maize is a more homogenous bulk commodity than, for instance, wheat thus it can be substituted even more easily across time and production region. Therefore the lack of cointegration of its markets during the period April-December 2013 could rather be attributed to local factors. In the case of Hungary, a new market regulation coming into effect from January 2013 onwards gave authorisation to the National Chamber of Agriculture to appeal to the court for annulling, in favour of the producer, any forward contracts grain producers and traders or processors entered into before harvest[7]. Representatives of producer and inter-branch organisations reported that declaring pre-harvest forward contracts as unfairly bounding for grain producers and therefore undesirable slowed down the forward selling and buying of grains (Hungarian Grain and Feed Association, 2013) and, ultimately, escalated the volume of spot market transactions drastically in 2013. The regulation increased the risk of non-compliance of pre-harvest forward contracts for traders considerably, and that probably caused transactions costs to rise and exceed the differences between BÉT and MATIF as well as between BÉT and CBOT maize futures prices thereby extinguishing the incentive for arbitrage. Based on Barett and Li (2002), if the incentive for arbitrage is missing there is no price transmission between these markets.

In a wider context, the phenomenon of strong market dis-association observed for the period April-December 2013 coincided with a substantial decline in maize stocks in Hungary as well as in the whole EU, Ukraine and the United States[8]. In Hungary, 4.76 million tonnes or 40.4 per cent less maize were harvested in 2012 compared to the year before, while maize production in the EU fell to 58.87 million tonnes (-13.7 per cent), in Ukraine to 20.92 million tonnes (-8.4 per cent) and in the United States to 273.83 million tonnes (-12.8 per cent). Even at the global level, maize production decreased, for the first time in seven years, to 868.80 million tonnes (-1.9 per cent) in the 2012/13 crop year, and local and regional consumption of the produce had to be rationalised. We assume that factors associated with the location, storage and transportation of maize had a substantial effect on price relationships in that season.

Further research with longer data series including prices which represent actual transaction costs for each of the BSR maize exporter countries is needed to shed more light on the association of prices in these markets.

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[7] Law CXXVI of 2012 on the National Chamber of Agriculture in Hungary.

[8] In the case of the EU, only stocks of maize produced by its Member States are meant because the EU itself is a net maize importer.