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Do International Agricultural Commodity Prices Have an Effect on the Stock Market Index? A Comparative Analysis Between Poland and Turkey

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Uluslararası Tarımsal Emtia Fiyatlarının Borsa Endeksi Üzerinde Etkisi Var Mıdır? Polonya ve Türkiye Arasında Karşılaştırmalı Bir Analiz

Abstract

This study analysed the effects of international wheat, rice, sugar, and beef prices on Turkish and Polish stock exchange markets through the quantile regression and cointegration regressions methods from December 2008-November 2020. As a result of the analysis, it cannot be said that agricultural commodities do not affect stock market indices. Also, empirical evidence suggests that the impact of agricultural commodities on the Turkish stock market is more significant than on the Polish stock market. This may be because Poland's economic ecosystem is more industrialised than Turkey's. Further, these findings indicate that agricultural commodities have both similar and different effects on the stock market indices of these two countries.

Keywords : Agricultural Commodity, Stock Market Index, Quantile Regression.

JEL Classification Codes : Q14, G10, C30.

Öz

Bu çalışmada, uluslarası buğday, pirinç, şeker ve sığır eti fiyatlarının Türkiye ve Polonya borsalarına etkileri kantil regresyon ve eşbütünleşme regresyonları yöntemleri ile Aralık 2008-Kasım 2020 dönemi için analiz edilmiştir. Analizler sonucunda tarımsal emtiaların borsa endeksleri üzerinde hiçbir etkisinin olmadığı söylenemez. Ayrıca amprik kanıtlar, tarımsal emtiaların Türkiye borsası üzerindeki etkisinin Polonya borsasına göre daha fazla olduğunu göstermektedir. Bunun nedeni Polonya'nın ekonomik ekosisteminin Türkiye'den daha fazla sanayileşmiş olması olabilir. Ayrıca, bu bulgular tarımsal emtiaların bu iki ülkenin borsa endeksleri üzerinde hem benzer hem de farklı etkileri olduğunu göstermektedir.

Anahtar Sözcükler : Tarımsal Emtia, Borsa Endeksi, Kantil Regresyon.

1. Introduction

Billions of people rely on agricultural products as their primary food source. Agricultural products are also used as raw materials and semi-finished products. Besides this significant role, the farm industry also provides considerable employment worldwide.

According to the U.N. (2019) report, the world population is expected to reach 9.8 billion in 2050 and 11.2 billion in 2100, a major food problem. In addition, the enrichment of the countries and thus their citizens and the increase in their welfare levels is another factor that can increase the demand for agricultural products. Global warming (FAO, 2017: 61; Jiang et al., 2020: 197), depletion of water resources (Hashemi, 2015: 308), climate change (El-Beltagy & Madkour, 2012: 1-2), a decline in arable land (Gomiero, 2016: 4) and rural-to-urban migration (Satterthwaite et al., 2010: 2814) can have a negative impact on the cultivation and collection of agricultural products. Global imbalances likely to arise in the supply of and demand for farm products can cause a severe increase in the prices of farm products. In this respect, the international prices of agricultural products, which are called the strategic products of the future, have the potential to have significant effects on the economies and financial markets of the countries. The impact of agricultural commodities on the stock markets can be realised through two channels, direct and indirect. Accordingly, increases or decreases in agricultural commodity prices may cause an increase or decrease in the income of enterprises engaged in agricultural production or marketing listed on the stock exchange, which may directly affect the stock market performance of the relevant enterprises. Secondly, increases or decreases in agricultural commodity prices affect the economic indicators of countries, such as exports, imports, employment, and inflation. Positive/negative developments in macroeconomic indicators arising from these commodities may indirectly cause increases or decreases in the stock market index.

This study examines the behaviour of the stock market index by considering international agricultural commodity prices. Accordingly, the study's first aim is to model the impact of international agricultural commodity prices on the stock market index. Hence, international wheat, rice, sugar, and beef prices are included in analyses as explanatory variables. Previous scientific studies examined the interaction between the stock market index and wheat, sugar, and cotton prices. There is scarcely any study that takes beef prices to handle. This aspect adds an original dimension to the study by including the beef price variable in the analysis. There are several reasons for choosing these agricultural products. First of all, crops such as rice and wheat (Siwar et al., 2014; Dawe, 2010), which are at the forefront of fighting hunger and poverty in the world, play an important role in solving the problem of food and nutrition security (Sahu et al., 2015). Today, wheat is the most widely grown crop globally, on more than 218 million hectares. Its trade in the world exceeds any other crop. Wheat occupies a central place in human nutrition, providing 20% of daily protein and food calories (Giraldo et al., 2019). While Poland ranks 10th among exporting countries with 1 billion dollars of wheat export in 2020, Turkey ranks 3rd among importing countries with 2.3 billion dollars of imports as of the same year. Rice is the second most widely grown cereal crop and is the staple food for more than half of the world's population

(Bandumula, 2018; Siwar et al., 2014). In addition, rice is the main source of employment and livelihood for one-fifth of the world's population, or more than one billion households in Asia, Africa, and the Americas (Gadal et al., 2019). Poland and Turkey are net importers of rice. Sugar produced from sugar beet and sugar cane is an important agricultural product used directly or indirectly as a sweetener in food and beverages and bioenergy production. The European Union ranks 3rd in sugar production globally, and Poland ranks 3rd in sugar beet production after France and Germany as of 2019 (Vladu et al., 2021). Emphasising the economic, social, and environmental importance of sugar production for Poland (Hyrszko & Szajner, 2017), they stated that the sugar industry is a strategic part of the food economy. In Turkey, as of 2019, sugar imports are higher than its exports, and Poland ranks 3rd among the countries from which sugar imports (metric tons) (USDA, 2019). On the other hand, beef is the most important source of animal protein in Turkey. Domestic red meat production has remained insufficient due to the increasing population and number of tourists. Turkey imports this deficit in live cattle and red meat, meeting 76% of its red meat imports from Poland in 2018 (Et ve Süt Kurumu, 2018). Poland is one of the important red meat exporting countries globally and in Europe. In the reports[1],[2],[3], published by international economic organisations and international finance and consultancy firms, attention is drawn to the serious economic potential of these two countries in the future. For example, in the long-term forecasts in these reports, it is estimated that Turkey will be the 12th largest economy globally with a GDP of approximately 3 trillion Dollars in 2030 and the 11th largest economy in the world with a GDP of 5.2 trillion Dollars in 2050. Similarly, it is noted that Poland will be the 26th largest economy in the world in 2030, with a GDP of 1.5 trillion dollars. These reports also state that Poland is the largest food supplier in Europe. For these reasons, it was focused on these two countries with significant historical, geopolitical, and economic potential in their regions. It was desired to reach empirical evidence about the possible effects of changes in agricultural product prices on the financial markets of these countries. The second aim is to determine which agricultural commodities have the most influence and direction on the stock markets by conducting a comparative analysis between these two countries. This study makes an important contribution to the literature. It uses conditional quantile regression and cointegration regression methods to study the effect of international agricultural commodity prices on the stock market indices of the two countries. According to the main conclusion, it cannot be said that agricultural commodity prices do not affect the stock market index. These findings are similar to the previous studies (Kotyza et al., 2021; Nguyen et al., 2020; Iyke & Ho, 2021; Boako et al., 2020; Bohl & Sulewski, 2019; Misecka et al., 2019; Chen, 2016; Girardi, 2015). In addition, the effects of agricultural commodities on the BIST100 index are more than the WIG20 index. Also, empirical evidence suggests that these effects differ significantly in size and direction. In this respect, the effect of

1 *<https://stats.oecd.org/Index.aspx?DataSetCode=EO109_LTB>, 25.05.2021.*

2 *HSBC Global Research, The World in 2050: Quantifying the shift in the global economy, <https://warwick.ac.uk/fac/soc/pais/research/csgr/green/foresight/economy/2011_hsbc_the_world_in_2050_-_quantifying_the_shift_in_the_global_economy.pdf>, 25.05.2021.*

3 *PwC, The long view: how will the global economic order change by 2050?, <https://www.pwc.com/gx/en/world-2050/assets/pwc-world-in-2050-summary-report-feb-2017.pdf>, 25.05.2021.*

agricultural products on the stock market index is not homogeneous and may vary from country to country. It can be said that the effect of agricultural commodities on the stock market is the exporter-importer status of that product, the intensity of domestic demand, and cultural factors.

The study is organised into five sections. The first theoretical section provides an overview of the relationship between agricultural commodity prices and the stock market index. The second section summarised the findings obtained from previous studies, and a literature review was done. The third section explains the empirical methodology of the response of the Polish and Turkish stock exchanges to international agricultural commodity prices. The fourth section includes the research results on the effects of farm commodities on the stock market indices of these two countries and the size and direction of these effects. The final section of the manuscript presents the results.

2. Literature Review and Hypothesis Development

A literature summary on the subject made over different periods and methods is presented in Table 1 below.

Table: 1
Summary of Empirical Studies Examining the Effects of Agricultural Commodities on Equity/Stock Market Index

Study	Period	Method	Findings
Kotyza et al., 2021	2000 2020	Bai-Perron regression model with structural breaks	The relationship between the S&P GSCI Sugar Index and the S&P 500 VIX index, which was not significant before the 2008 global financial crisis, took a substantial and negative direction with the crisis period. In addition, no structural change was observed in the relationship between these variables during the COVID-19.
Bahloul & Khekmakhem, 2021	2007 2020	Basic statistical analysis, VAR and GARCH	There is a positive correlation between agricultural commodity indices and Islamic stock indices. A strong spillover transfer has occurred between commodities and Islamic stock indices with the pandemic process.
Nguyen et al., 2020	1988 2017	Basic statistical analysis, AFMA, and GARCH	As a result of the analysis, it was emphasised that there is a positive correlation between wheat and cotton prices and the stock market index.
Ouyang & Zhang, 2020	2006 2019	Basic statistical analysis, ARMA, and GJR-GARCH	It is stated that there is a positive correlation between wheat and cotton prices and Shanghai Stock Exchange and S&P 500 index.
Iyke & Ho, 2021	1650 2005	Basic statistical analysis, Unit root test, and ARCH	Rice has a positive effect on financial markets except for the USA, wheat has a predominantly positive impact, and meat positively affects these markets.
Mohanty & Mishra, 2020	2015 2016	OLS, Joint, and multiple variance ratio tests	It was stated that cotton oil and stock market index were negatively correlated before the merger of different stock exchanges in India in 2015 and positively related after the merger.
Liang & Ma & Li & Li, 2020	1991 2019	Basic statistical analysis, PCA, factor analysis, MSFE	It is stated that sugar, cotton, and wheat positively correlate with the S&P 500 index.
Kaur & Dhiman, 2019	2007 2017	ARDL bounds test and causality tests	It has been suggested that there is a positive relationship between wheat prices and the stock market index.
Bohl & Sulewski 2019	2006 2017	Statistical analysis, ARCH, and GARCH	A positive relationship was found between wheat prices and the S&P 500 index.
Misecka et al., 2019	2009 2015	ARDL bounds test	They found a negative relationship between wheat prices and the S&P 500 index in the short and long terms.
Main & Irwin & Sanders & Smith, 2018	1990 2014	Cost-of-carry Model	It was stated that cotton and rice have a negative effect on the risk premiums of commodity futures contracts.
Vandone & Peri & Baldi & Tanda, 2018	2001 2014	Multifactor market model, GARCH	It is seen that agricultural commodities significantly affect stock prices, and these effects change over time. It was stated that agricultural betas became positive during the 2008 crisis, and stocks were positively sensitive to changes in agricultural product prices.
Candila & Farace, 2018	1993 2018	ARCH, GARCH, VIRF	There is a positive spillover effect from sugar and wheat prices towards stock market indices in Latin American countries (5 countries).
Öztek & Öcal, 2017	1990 2012	STCC-GARCH	It was stated that there is a positive but weak correlation between the S&P AG agricultural commodity index and the S&P 500 index.

Al-Maadid & Caporale & Spagnolo, 2017	2003 2015	VAR-GARCH	Before the 2006 food crisis, wheat and sugar negatively correlated with the S&P 500 index and a positive correlation after the crisis.
Nicola & Pace & Hernandez, 2016	1970 2013	Correlation analysis, M-GARCH	It was stated that there was a positive relationship between the S&P500 index and rice, wheat, and sugar prices.
Jordan & Vivian & Wohar, 2016	1985 2011	ARDL, Principal component analysis, MSE	As a result of the study, it was stated that there is a positive interaction between wheat prices and the Canadian stock market.
Chen, 2016	1983 2013	VECM, VAR	He stated a positive relationship between wheat prices and stock prices and the stock market index.
Girardi, 2015	1986 2013	Dynamic conditional correlation analysis and ARDL Bounds test	According to the findings, there is a positive relationship between the S&P 500 index and wheat, soybean oil, rice, and sugar.
Black, Klinkowska & Mcmillan & Mcmillan, 2014	1973 2012	Basic statistical analysis, Unit root test, Cointegration tests, RMSE, MAE	It was pointed out that there was a significant and negative relationship in the first half, and there was no meaningful relationship in the last half of the analysis period between the S&P 500 and S&P GSCI index.
Sadorsky, 2014	2000 2012	VARMA-AGARCH, DCC-AGARCH	It has been stated that there is a positive relationship between stocks and wheat prices.
Mensi & Beljid & Boubaker & Managi, 2013	2000 2011	ARCH, MGARCH & VAR-GARCH	They revealed a positive correlation between wheat prices and the S&P 500 index.
Creti & Joets & Mignon, 2013	2001 2011	DCC-GARCH	It was stated that there is a positive correlation between cotton and wheat prices with the volatility of the S&P 500; however a negatively correlated relation during the 2007-2008 crisis period.

According to the information obtained from the literature summary shown above, it has been observed that the agricultural commodities considered within the scope of the research have the potential to affect the stock market index. Hypotheses developed in line with the a priori information provided by the literature review and the correlation analysis are specified in Table A1 in Appendix.

3. Methodology

This article seeks to answer the following research question: "Do international agricultural commodity prices impact the stock market index?" Accordingly, it is aimed to use a quantile regression model to investigate the effects of international prices of wheat, rice, sugar, and beef which may be the driving forces of the stock market index, at different quantiles. This model, developed by Koenker and Bassett (1978), is widely used in finance and economics letters, given its ability to reveal the skew connection between financial and economic factors and to model the quantities of a random variable as functions of observed factors (Dawar et al., 2021: 289). Using quantile regression can provide a correct investigation of the connection between variables than the OLS model (Youssef & Mokni, 2020: 5). In other words, instead of determining the effect of the explanatory variable on the mean value of the explained variable, quantile regression helps determine the effect of the independent variable on the dependent variable across different quantiles. Quantile regression shows multiple regression functions corresponding to each quantile of the dependent variable (Hoang et al., 2019: 82). Compared to OLS regression, quantile regression has some advantages. First, instead of merely conditional expectations (mean values) of the dependent variable, quantile regression can define the whole picture of the conditional distribution of the dependent variable (Sirin & Yilmaz, 2020: 6). Different quantiles usually have different regression coefficients; in other words, explanatory variables have different effects on different amounts of dependent variables (Zhang et al., 2021: 244; Dawar et al., 2021: 289; Azimli, 2020: 2; Lin & Xu, 2018: 16; Mishra & Moss, 2013: 364). Quantile regression does not ask for random error terms to exactly fulfil classical econometric suppositions, such as zero mean, homoscedasticity, and normal distribution (Xu & Lin, 2020: 2). For non-normally distributed variables, the predicted values of the parameters in quantile regression are more powerful (Huang et al., 2020: 4; Youssef & Mokni, 2020: 4; Zivkov et al., 2020:16). The mathematical representation of the quantile regression model can be demonstrated as follows (Sevillano & Jareno, 2018).

$$y_i = x_i^{'}\beta_\theta + u_{\theta i}, \tag{1}$$

where y_i denotes the explained variable, β_θ denotes the kx1 unknown vector of regression parameters to be predicted for different values of θ (which can vary from 0 to 1), x_i denotes the kx1 vector of independent variables, and $u_{\theta i}$ denotes unknown error terms. Conditional quantiles of the y_i variable to x_i can be expressed as follows.

$$Q_\theta(y_i \mid x_i) = x_i^{'}\beta_\theta \tag{2}$$

To estimate the β_θ vector, an optimisation problem is considered in which the following function is minimised concerning β:

$$\left\{ \sum_{t:y_t > x_t^{'}} \theta \left| y_t - x_t^{'}\beta \right| + \sum_{t:y_t > x_t^{'}} (1-\theta) \left| y_t - x_t^{'}\beta \right| \right\} \tag{3}$$

The QR applies the generalised moments or linear programming method with the simplex algorithm. In this way, the sum of the weighted absolute error terms is minimised, and the positive and negative residuals are differently weighted according to the chosen quantile. In light of this information, the quantile regression model created in this study to measure the effect of international wheat and rice prices on the stock market index is given below.

$$\begin{aligned} logbist100_{j,t} &= \beta_{0,t}^{\theta} + \beta_{1,t}^{\theta} logrice + \beta_{2,t}^{\theta} logwheat + \beta_{3,t}^{\theta} logsugar + \beta_{4,t}^{\theta} logbeef + e_{j,t} \\ logwig20_{j,t} &= \beta_{0,t}^{\theta} + \beta_{1,t}^{\theta} logrice + \beta_{2,t}^{\theta} logwheat + \beta_{3,t}^{\theta} logsugar + \beta_{4,t}^{\theta} logbeef + e_{j,t} \end{aligned} \tag{4}$$

where $\beta_{0,t}^{\theta}$, $\beta_{1,t}^{\theta}$, $\beta_{2,t}^{\theta}$, $\beta_{3,t}^{\theta}$ and $\beta_{4,t}^{\theta}$ denote estimated quantile regression coefficients and θ denotes the regression quantile that takes values between 0.1 and 0.9. Besides, t represents time, ε_j represents the random error of unit (such as company, stock market) j.

Fully Modified Least Squares Method (FMOLS), Dynamic Least Squares Method (DOLS), and Canonical Cointegration Regression (CCR) models, known as cointegration regression, are methods that provide information about the direction, magnitude, and significance of this relationship between variables while the existence of a long-term relationship is detected. The most important advantage of these methods is that they eliminate the internality problem and use the covariance of the error terms to eliminate the issues arising from the long-term correlation. Phillips and Hansen (1990) proposed the FMOLS estimator uses preliminary estimates of symmetric and one-sided long-run covariance matrices of residuals. Let the cointegration equation be expressed as follows, including $(y_t, X_t^{'})$ vectorial time series.

$$y_t = X_t^{'}\beta + D_{1t}^{'}\gamma_1 + u_{1t} \tag{5}$$

In the model $\hat{\lambda}_{12}^{+} = \hat{\lambda}_{12} - \hat{\omega}_{12}\hat{\Omega}_{22}^{-1}$ is a bias correction term, and $Z_t = (X_t^{'}, D_t^{'})^{'}$, the FMOLS estimator is expressed by the equation (6).

$$\hat{\theta}_{FMOLS} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left(\sum_{t=2}^{T} Z_t Z_t^{'} \right)^{-1} \left(\sum_{t=2}^{T} Z_T y_t^{+} - T \begin{bmatrix} \hat{\lambda}_{12}^{+'} \\ 0 \end{bmatrix} \right) \tag{6}$$

The Dynamic Least Squares Method (DOLS) was developed by Saikkonen (1991) and Stock-Watson (1993). The method determines the long-term coefficients between the variables by adding ΔX_t premise and lagged values of the difference of the independent variables to the model.

$$y_t = X_t^{'}\beta + D_{1t}^{'}\gamma_1 + \sum_{j=-q}^{r} \Delta X_{t+j}^{'}\delta + \upsilon_{1t} \tag{7}$$

Estimating the DOLS model using equality (7) is performed with the help of $\hat{\theta}_{DOLS} = \left(\hat{\beta}, \hat{\gamma}^{'}\right)^{'}$ ordinary least squares in the form of prime. Park (1992) expressed that the canonical least-squares method is close to FMOLS estimation. Here is the estimator of CCR,

$$\hat{\theta}_{CCR} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left(\sum_{t=2}^{T} Z_t^{*} Z_t^{*'} \right)^{-1} \sum_{t=1}^{T} Z_t^{*} y_t^{*} \tag{8}$$

expressed as equation (8).

4. Findings

4.1. Data, Preliminary Examination, And Basic Statistical Tests

Focusing on the effects of agricultural commodity prices on the stock market index, this study compared the wheat, rice, sugar, and beef prices with Turkey's stock market

BIST100 price index and Poland's stock market WIG20 price index between 2008 M12 and 2020 M11. Commodity prices data were retrieved from the World Bank official website, BIST100 index data from the Central Bank of Turkey, and WIG20 data from the MarketWatch website. All data in the study are seasonally adjusted using Census X-13 and Moving Average Methods. The data were included in analyses by taking their logarithms. Descriptive statistical information is required to obtain general and concise information about the data used in the study. Table 2 presents summary statistics for stock market indices and international series of agricultural commodity prices as results of the correlation analysis between the two stock markets and these commodities.

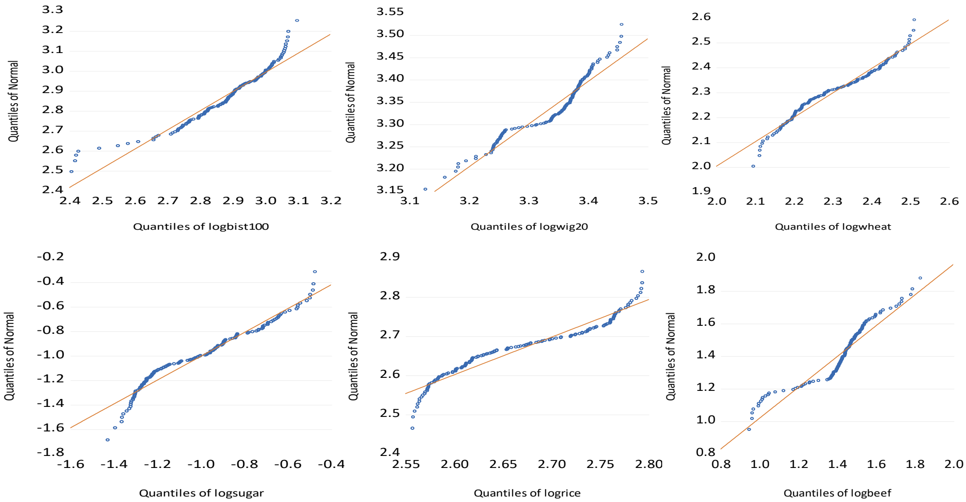
Table: 2
Basic Statistical Information and Correlation Analysis Results

	logbist100	logwig20	logwheat	logsugar	logrice	logbeef
Panel A: Basic statistical data						
Mean	2,874	3,339	2,298	-1,000	2,665	1,414
Median	2,892	3,361	2,279	-1,004	2,648	1,439
Maximum	3,096	3,455	2,510	-0,474	2,793	1,828
Minimum	2,405	3,126	2,095	-1,428	2,556	0,945
Std, Dev,	0,140	0,068	0,108	0,254	0,074	0,172
Skewness	-1,136	-0,812	0,196	0,329	0,246	-0,861
Kurtosis	4,736	2,991	1,932	1,993	1,641	4,252
Jarque-Bera	49,095	15,831	7,762	8,682	12,530	27,204
Probability	0,000***	0,000***	0,020**	0,013**	0,001***	0,000***
Panel B: Correlation analysis						
Correlation vs logbist100	1	0,165	-0,274	-0,427	-0,630	0,789
Correlation vs logwig20	0,165	1	0,464	0,195	-0,093	0,376

*Note: Significance: *** 1%, ** 5%.*

The same or close mean and median values indicate a symmetrical distribution, suggesting that the variables are normally distributed. Another clue as to whether the data are normally distributed is the skewness and kurtosis values close to 0 and 3 (You et al., 2017: 5). However, as seen in Panel A, all variables' skewness and kurtosis values are far from these. Indeed, since Jarque-Bera test probability values are $p<0.01$ for logbist100, logwig20, logrice, and logbeef and $p<0.05$ for logsugar and logwheat, it can be said that not all variables show a normal distribution, at this point, another tool can be used the Q-Q plot. A Q-Q plot is a probability plot that visually checks if data follow a normal distribution. The closer the points to the $y=x$ line on the Q-Q plot, the more likely data are typically distributed (Xu & Lin, 2020: 6; Lin & Xu, 2018: 20). Otherwise, skewed data distribution is indicated. Figure 1 below presents the Q-Q probability distribution plots of the variables.

Figure: 1
Q-Q Probability Distribution Graphs of Variables



As can be inferred from Figure 1, all variables do not exactly lie on the x=y line, and therefore, these variables are not normally distributed. According to another result in Panel A, the variable with the highest standard deviation is sugar. This finding suggests that the sugar variable is the highest risk and return (loss) investment instrument. Indeed, among the available variables, the most significant difference between maximum and minimum values belongs to this variable. According to Panel B, there is a positive correlation between the Polish stock exchange and other agricultural commodities except for rice. There is a negative correlation between the Turkish stock market and other agricultural commodities, except beef.

4.2. Stationary and Cointegration Analysis

At this stage of the study, the stability of the data was tested with unit root tests. Time series data; when their mean, variance, and covariance do not change over time and remain the same, they are called stationary (Hor, 2015: 110). In the study, conventional ADF and ADF unit root tests with structural break were used to determine the stationarity of the series, and the results are presented in Table A2 in Appendix. Accordingly, all variables are stationary in their I (1) first difference. It was necessary to carry out cointegration tests to determine whether the variables will be included in the Quantile regression analysis with their level values or their first differences and whether there is a long-term equilibrium relationship between the variables. Therefore, cointegration analysis was performed with the Johansen Cointegration test, which allows the determination of the cointegration relationship between stationary variables at I (1) levels. The results are presented in Table A3. According to the Johansen cointegration results for Turkey, there is no relationship between the trace statistics and the most extensive eigenvalue statistics. The null hypothesis is that a connection at most is rejected at the 5% significance level. According to the test results, there are two cointegration vectors between the series. The null hypothesis stating that there is no cointegration relationship between the variables for Poland is rejected. According to these results, there is a cointegrated relationship between the stock market index in Turkey and Poland and the variables of international rice, wheat, sugar, and beef prices. As stated by (Greene, 2019: 1080; Gujarati, 2011: 236), variables can be used in regression analyses with level values since they tend to be stable in the long run.

4.3. Quantile Regression Analysis

All variables used in the study are not normally distributed, as inferred from the J-B test results and the Q-Q distribution plots. The quantile regression method has absolute advantages in investigating the relationship between non-normally distributed variables. For this reason, the quantile regression method was employed in the study to model the effect of international agricultural products on the stock market index. Quantile regression can determine the exact impact of independent variables on the explained variable across various quantiles. At this stage of the study, nine different quantiles (0.1, 0.2, …, 0.9) were determined to apply the regression analysis. The findings obtained for Turkey and Poland from the quantile regression analysis in Table 3 follow.

Table: 3
Quantile Regression Estimation Results

	Quantile Levels								
Variables	0,10	0,20	0,30	0,40	0,50	0,60	0,70	0,80	0,90
Panel A: Turkey									
c	5,074 (0,000)***	4,235 (0,000)***	3,613 (0,000)***	2,842 (0,000)***	2,402 (0,000)***	2,707 (0,000)***	2,454 (0,000)***	2,107 (0,000)***	2,196 (0,000)***
logrice	-1,016 (0,000)***	-0,621 (0,013)**	-0,368 (0,123)	-0,140 (0,468)	0,017 (0,912)	-0,137 (0,365)	-0,077 (0,576)	0,104 (0,470)	0,088 (0,621)
logwheat	-0,022 (0,809)	-0,162 (0,091)*	-0,190 (0,042)**	-0,171 (0,058)*	-0,202 (0,015)**	-0,125 (0,097)*	-0,104 (0,131)	-0,170 (0,016)**	-0,186 (0,024)**
logsugar	0,137 (0,000)***	0,052 (0,407)	-0,006 (0,921)	-0,078 (0,137)	-0,119 (0,008)***	-0,133 (0,000)***	-0,160 (0,000)***	-0,200 (0,000)***	-0,191 (0,000)***
logbeef	0,421 (0,000)***	0,463 (0,000)***	0,450 (0,000)***	0,505 (0,000)***	0,553 (0,000)***	0,502 (0,000)***	0,529 (0,000)***	0,520 (0,000)***	0,539 (0,000)***
Pseudo R^2	0,597	0,523	0,477	0,463	0,464	0,473	0,488	0,473	0,457
Adj,R^2	0,585	0,509	0,462	0,448	0,449	0,458	0,473	0,458	0,441
S, E, of regress,	0,135	0,104	0,087	0,077	0,078	0,082	0,089	0,100	0,117
Panel B: Poland									
c	3,805 (0,000)***	3,600 (0,000)***	3,869 (0,000)***	3,482 (0,000)***	3,600 (0,000)***	3,895 (0,000)***	3,749 (0,000)***	3,504 (0,000)***	3,081 (0,014)**
logrice	-0,625 (0,000)***	-0,578 (0,000)***	-0,670 (0,000)***	-0,463 (0,000)***	-0,427 (0,002)***	-0,443 (0,004)***	-0,292 (0,135)	-0,232 (0,381)	-0,088 (0,814)
logwheat	0,492 (0,000)***	0,518 (0,000)***	0,520 (0,000)***	0,427 (0,000)***	0,356 (0,000)***	0,273 (0,003)***	0,177 (0,067)*	0,217 (0,050)**	0,217 (0,107)
logsugar	0,071 (0,057)*	0,039 (0,147)	0,024 (0,293)	0,028 (0,328)	0,038 (0,308)	0,067 (0,195)	0,059 (0,407)	0,053 (0,555)	0,051 (0,683)
logbeef	0,055 (0,274)	0,060 (0,130)	0,038 (0,300)	0,091 (0,015)**	0,070 (0,089)*	0,056 (0,190)	0,038 (0,475)	0,036 (0,503)	0,074 (0,366)
Pseudo R^2	0,361	0,381	0,364	0,298	0,229	0,174	0,152	0,157	0,197
Adj,R^2	0,343	0,363	0,346	0,278	0,207	0,151	0,128	0,133	0,174
S, E, of regress,	0,081	0,068	0,061	0,053	0,051	0,055	0,064	0,071	0,083

*Notes: Significance: *** 1%, ** 5%, * 10%, Figures in parentheses are p-values.*

The effect of rice on the Turkish stock market is heterogeneous. There is a negative and significant effect at low quantile levels and a positive and insignificant effect at high quantile levels. Although rice is produced and exported in Turkey, it is mainly imported. Reasons such as rice being an important food in the country and high demand are expected to reflect on the sales positively; thus, publicly listed companies that produce, sell, or import-export rice are profitable. Rice has a negative relationship with the Polish stock market index. This relationship is statistically significant, especially at low and medium quantile levels. Accordingly, rice has the power to have a negative effect on the stock market of both countries.

The effect of wheat on the Turkish stock market index is homogeneous. This effect is statistically meaningful in all other quantile levels except for the 1st and 7th quantile levels. According to (Istikbal, 2020: 88), Turkey, which ranks 11th in the world production of wheat, is the sixth-largest country in the world in terms of the economic value of wheat. Wheat is the second most-produced product in the country with an annual capacity of 20 million tons and is a major export item. Turkey has become the largest flour exporter, processing wheat purchased from abroad and transforming it into agricultural products that create added value. Accordingly, an increase in international wheat prices negatively affects the index, based on the thought that this may decrease the income of publicly listed companies or affiliates of these companies. Wheat, moreover, has a statistically meaningful, positive impact on WIG20 at all other quantiles except the 9th level. However, this effect decreases as quantiles increase. Accordingly, wheat is considered a more important product than rice for Poland's economy. Indeed, as (Iwanska et al., 2020: 1) report, wheat accounts for 22% of all the agricultural land in Poland and is the most important crop. In terms of farm production and income, Poland, an important country, exported the 15th highest dollar value worth of wheat in 2019, with an export income of 431.5 million dollars. On the other hand, Turkey exported the highest dollar value worth of wheat in the same year, with an export income of 2.3 billion dollars[4].

The international price of sugar has a negative effect on the Turkish stock market. This effect is significant at all other quantile levels except 10% and 20% quantile levels. According to 2019 data, while Turkey's sugar exports about 10 million dollars, it imports 65 million dollars. This imbalance in foreign trade figures regarding sugar is negatively priced in the stock market. Sugar has no statistically significant effect on the Polish stock market. However, there appears to be a positive effect at all quantile levels. This may be due to the fact that Poland has also been a net exporter of the foreign sugar trade, especially in recent years.

Beef positively affects the Turkish stock market, which is statistically significant at all the quantile levels. In previous years, Turkey has been self-sufficient concerning beef supply and demand, while its importer's position since 2010. As there are not much more alternatives to red meat, the need for beef is very high in Turkey. The effect of beef on the

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[4] *<http://www.worldstopexports.com/wheat-imports-by-country/>, 25.05.2021.*

Polish stock market is positive, and it is statistically meaningful at medium quantile levels. Poland is a major beef exporter country. This situation is positively priced in the stock market. However, the impact of beef on the stock market is more remarkable in Turkey. This may be due to the low demand for beef in Poland. According to the data for 2019, beef consumption per capita in Poland is 3.5 kg, and pork consumption is 38 kg[5].

According to data presented in Table 3, the coefficient of determination (Pseudo R^2) calculated for quantile regression models was obtained as higher for the model created for the Turkish stock market at all quantiles than for the model developed for the Polish stock market. In other words, quantile regression models designed for the Turkish stock market could better explain the relationship between the developments in the prices of five studied agricultural products and the changes in the stock market index. Nevertheless, models at different quantiles created for the Polish stock market yielded fewer error rates.

Wald test statistics shown in Table 4 for both countries are statistically significant at 1% and 5% levels; therefore, the null hypothesis is rejected that all slopes are equal (slope homogeneity) across quantiles. Table 4 presents the results of the symmetry test across quantiles. The null hypothesis of the Wald test is that the distribution is symmetrical. $H_0 = \beta_{1,r=\theta} + \beta_{1,r=(1-\theta)} = 2\beta_{1,r=0.5}$ According to the test statistics, both countries could not reject the null symmetry hypothesis between quantiles. In other words, this indicates that the coefficients are symmetrical to the coefficient of the median. Accordingly, it shows that the explanatory variables, international wheat, rice, sugar, and beef prices, have a homogeneous effect on the stock market indexes. In other words, in models with different quantile levels, the values of the explanatory variables at θ and (1- θ) levels converge to the median value.

Table: 4
Results of Quantile Slope Equality and Symmetric Quantiles Tests

Quantile Slope Equality Test			Symmetric Quantiles Test	
Countries	test statistics	prob.	test statistics	prob.
Turkey	99,427	(0,000)***	24,720	0,212
Poland	53,247	(0,011)**	11,040	0,945

*Notes: Significance: *** 1%, ** 5%. The model is estimated at the 0.5 quantile level. Test quantiles are 0.10, 0.20, …, 0.90.*

4.4. Cointegration Regressions Results

The primary method used in the study is quantile regression analysis. To confirm the results obtained from this analysis, analyses were made with FMOLS and DOLS CCR models, and robust empirical evidence was obtained regarding the direction and significance of the effect of independent variables on dependent variables.

5 *<https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Poland%202019%20Livestock%20and%20Products_Warsaw_Poland_01-13-2020>, 25.05.2021.*

According to Table 5. cointegration regression results, logwheat and logbeef variables statistically affect the Turkish stock market in all three models. While the logwheat variable has a negative impact on the models, the logbeef variable has a positive effect. The logsugar variable revealed a significant negative effect only in the DOLS model. The percentage of agricultural commodity prices explaining the stock market index for Turkey was found to be around 70% for all three models.

When we examine the effects of commodity prices on the Polish stock market, it is seen that there are different reactions to the Turkish stock market. While logrice significantly decreases the stock market index, logwheat is positive in all three models. logsugar, on the other hand, showed a significant positive impact on the stock market index in FMOLS and CCR models. Unlike the Turkish stock market, logbeef does not significantly affect any model for Poland. In addition, the percentage of disclosure of the relevant stock market by commodity prices was around 40%.

The applications of quantile regression and cointegration regressions on how the Turkish and Polish stock markets are affected by commodity prices support each other in terms of the signs of the variables. It has been determined that the stock markets of both countries are negatively affected by rice prices; on the other hand, wheat prices have a negative effect on the Turkish stock market but positively impact the Polish stock market. In addition, when the percentage of agricultural commodity prices explaining the stock market index is examined, it is seen that commodity prices explain the index at the level of 70% in Turkey and 40% in Poland. These results reveal that the economic dynamics of the two countries are different from each other.

Table: 5
Cointegration Regressions Estimation Results

	Turkey			**Poland**		
	FMOLS	**DOLS**	**CCR**	**FMOLS**	**DOLS**	**CCR**
c	2,853 (0,000)***	2,751 (0,000)***	2,864 (0,000)***	3,791 (0,000)***	3,691 (0,000)***	3,785 (0,000)***
logrice	-0,105 (0,676)	-0,056 (0,841)	-0,112 (0,648)	-0,545 (0,003)***	-0,508 (0,019)**	-0,542 (0,003)***
logwheat	-0,269 (0,057)*	-0,268 (0,084)*	-0,265 (0,054)*	0,443 (0,000)***	0,433 (0,000)***	0,441 (0,000)***
logsugar	-0,085 (0,136)	-0,103 (0,091)*	-0,083 (0,132)	0,079 (0,049)**	0,072 (0,119)	0,080 (0,043)**
logbeef	0,592 (0,000)***	0,558 (0,000)***	0,591 (0,000)***	0,044 (0,466)	0,056 (0,484)	0,046 (0,429)
Adj.R^2	0,705	0,732	0,705	0,430	0,434	0,431
S.E. of regress.	0,073	0,067	0,073	0,052	0,051	0,052

*Notes: Significance: *** 1%, ** 5%, *10%. Figures in parentheses are p-values.*

4.5. Discussions On Analysis Results

According to the results of the econometric analysis conducted within the scope of the study, it cannot be said that agricultural commodities do not affect stock market indices. The results were obtained by comparing the two countries such as Poland and Turkey. From this aspect, findings and results are specific to these two countries.

In Table A4, the validity of the hypotheses developed in line with the literature review and correlation analysis preliminary information as a result of the econometric analysis are presented within the scope of the research question. Accordingly, the effect of agricultural commodities on the Turkey stock exchange is more than on the Polish stock exchange. In other words, the potential of farming commodities to affect the stock market is higher in Turkey. This relationship shows oscillations in a certain and narrow area. The effect of the rice variable on the stock market index is heterogeneous. With a negative effect at low quantile levels, this effect gradually diminished and turned into a positive effect. Estimated coefficients for wheat and sugar variables show that these variables negatively impact the Turkish stock market. This effect is very clear and significant at all quantile levels. The two products need to underline that Turkey is a net importer in this context. Beef prices positively and significantly affect the stock market index at all quantile levels. At this point, it must be said that the high demand for beef in Turkey. This can be attributed to the increase in population (2008=70.4 Million, 2019=83.4 Million)[6] and the increase in the number of foreign tourists (2008=26.3 Million, 2019=45 Million)[7] in Turkey.

On the other hand, in Poland, rice prices have a negative effect on the stock market index at all quantile levels. Accordingly, the importance of rice for the Polish economy and consumers is gradually decreasing. The estimated coefficients of the wheat and beef variables positively affect the Polish stock market. This may be due to the fact that Poland is an important exporting country for these two products. However, the effect of the wheat variable on the stock market index is gradually decreasing. The effect, which increased to the median in beef, decreased afterwards.

On the other hand, while sugar prices positively affect the Polish stock market, this is only significant at the first quantile level. Therefore, the potential for changes in the international price of sugar to affect the Polish stock market is very limited. These findings can be said to be consistent with existing studies (Ouyang & Zhang, 2020; Misecka et al., 2019; Kaur & Dhiman, 2019; Bohl & Sulewski, 2019; Nicola et al., 2016; Chen, 2016; Girardi, 2015; Creti et al., 2013).

According to the results of cointegration regressions, it has been determined that wheat prices have a negative effect, and beef prices positively affect the Turkish stock market. On the other hand, rice and sugar prices did not significantly affect them. The rice price had a negative effect on the Polish stock market, and the wheat price had a positive effect. Unlike Turkey, beef price in Poland does not significantly affect the stock market index.

The factors that are thought to have an effect on the results obtained are discussed below. Accordingly, it can be said that the importer-exporter positions of the two countries for these products and the high domestic demand for these products are effective. Each

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6 *<https://data.worldbank.org/indicator/SP.POP.TOTL?locations=TR>, 25.05.2021.*

7 *<https://www.tursab.org.tr/istatistikler/turist-sayisi-ve-turizm-geliri>, 25.05.2021.*

country's economic, political, sociological, and cultural dynamics can show similarities and significant differences in this context. For these reasons, it is considered that it would be more appropriate to analyse the reflections of the relevant agricultural products on the stock exchange index separately. The increase in the international price of wheat in Poland, an important exporter country of wheat, has a positive effect on the exchange of this country in Turkey, an important wheat importer country; this effect is the opposite. Again, due to cultural values, the demand for beef varies in both countries, so its effect (coefficient) on the stock market index is different in direct proportion to the demand. Therefore, the reflections of agricultural commodities on country economies and financial markets may show heterogeneity.

It can be thought that the industrialisation levels of countries are another determining factor for the effects of agricultural products on the stock market index. As a matter of fact, in Turkey, all agricultural products have the same or similar effects on the stock market index. Other agricultural products, excluding the sugar variable, are effective on the stock market index in Poland. In addition, the effect of farm products on the stock market index is more remarkable in Turkey than in Poland. This may be due to the fact that Poland's economic ecosystem is more industrialised. In the context of the mentioned above, it can be said that it would be more appropriate to make comparative analyses by grouping the countries according to their cultural differences and industrialisation levels while analysing the effects of agricultural commodities on the country's stock markets/ financial markets.

Another issue that needs to be addressed in the study is that the macroeconomic effects, other commodities (such as oil, gold), and other domestic and international factors that may impact the stock market index are not considered. The study focused on the effect of agricultural commodities on the stock market index, considering the effects of other factors as constant. In this context, agricultural commodities, which are regarded as important strategic commodities of the future, can affect countries, economies, and financial markets both today and in the future. It is crucial to research these issues regarding food safety, foreign trade, and employment and consider the potential to affect the financial markets.

It can be thought that this study gives significant results in finance theory, especially in risk management. The Turkey stock exchange is the stock market that offers the opportunity to gain higher gains (losses), especially between two stock market indices. In addition, the findings provide valuable information about possible portfolio diversification strategies that minimise investment risk while maximising profit. Gold and oil are already considered as part of portfolio investment strategies. This phenomenon can be applied to basic food types and included in portfolio diversification. In addition, a long position can be taken to invest in futures contracts based on agricultural products, and this strategy offers more gain (loss) opportunities on the Turkey stock exchange than on the Polish stock market. Especially considering that it is negatively correlated with the Turkish stock exchange, sugar can be included in portfolios for hedging purposes.

5. Conclusions

This article examines the connection between international agricultural commodity prices and stock market indices using quantile regression (Q.R.) and cointegration regression analysis. Using a Q.R. analysis can better analyse the relationship between variables than the OLS model. Quantile regression has proven to be more powerful when outliers are present and the error term is not normally distributed. The FMOLS, DOLS, and CCR methods are prevalent applications used in cases where classical regression assumptions cannot be met. The imbalance between the supply and demand for agricultural products creates national and international security problems. Due to these imbalances, commodity prices and increasing volatility can affect economies and financial markets. Therefore, close monitoring of global commodity prices is vital for both public authorities and portfolio management. This article contributes to filling a gap in the relevant literature by determining the effect of agricultural products on the stock market indices in Poland and Turkey. The data covers the period 2018M12-2020M11. Statistical and econometric analyses were performed within the basic statistical tests, correlation analysis, unit root tests, Johansen cointegration test, quantile regression, etc., and cointegration regressions analysis. The results obtained from the study can be listed as follows: (1) It cannot be said that agricultural commodities do not affect the stock market index. (2) BIST100 index offers the gains (losses) opportunity higher than the WIG20. (3) Among the agricultural products studied, sugar is the only variable that is not statistically significant on the Polish stock market in quantile regression. However, it has a meaningful positive effect on FMOLS and CCR models. Almost all agricultural products significantly affect the Turkish stock market in quantile regression. (4) Wheat, on the other hand, has different and significant effects on the stock markets of both countries. This effect is negative in Turkey, and it is positive in Poland. This situation stems from Turkey's importer, wheat, and Poland's exporter. (5) Beef, on the other hand, has a positive effect on the stock markets of both countries in quantile regression. This is because an exporter country of Poland stems from high domestic demand in Turkey. But it is found meaningful only for Turkey in cointegration regressions. (6) In general terms, it has been found empirical evidence suggests that the effect of agricultural commodities on the Turkish stock market is more remarkable than on the Polish stock market. This may be due to the fact that Poland’s economic ecosystem is more industrialised than that of Turkey. The results obtained from the study are also in line with the studies of (Kotyza et al., 2021; Nguyen et al., 2020; Iyke & Ho, 2021; Boako et al., 2020; Bohl & Sulewski, 2019; Misecka et al., 2019; Chen, 2016; Girardi, 2015).

The results obtained in this study are significant because they hint at certain suggestions for decision-making and implementing authorities. In this context, public authorities must carefully monitor agricultural commodity prices to ensure food security, prevent social unrest, and control cross-border migration movements. Secondly, our results also provide helpful information on possible portfolio diversification strategies, particularly those that minimise investment risk while maximising profit. Gold and oil are already considered in existing portfolio investment strategies. Primary food sources can also be included in portfolio diversification. Furthermore, long positions can be taken by investing in futures contracts based on agricultural products that are considered strategic products of the future, a strategy that offers more earning opportunities (loss risks) in the Turkish stock market than in the Polish stock market. Since sugar and wheat are negatively correlated with the Turkey stock exchange and rice with the Polish stock exchange, they can be included in portfolios for hedging purposes.

Our suggestions for future studies on the subject are as follows. The number of comparator countries can be increased. Analyses over homogeneous classifications created according to different industrialisation levels and cultural characteristics will provide a clearer picture. For future studies, products such as oil and oil seed-such as coconut oil, soybean oil, palm oil, and forest products such as log, and lumber, which are in different agricultural commodity groups, can also be used in the analysis.

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Appendix:

Table: A1
Theoretical Expectations and Hypotheses of The Study

Variables	Theoretical Expectations	Hypothesis
logindex|logrice	+/-	H_1: There is a meaningful relationship between the international rice price and stock market index.
logindex|logwheat	+/-	H_2: There is a meaningful relationship between the international wheat price and stock market index.
logindex|logsugar	+/-	H_3: There is a meaningful relationship between the international sugar price and stock market index.
logindex|logbeef	+/-	H_4: There is a meaningful relationship between the international beef price and stock market index.

Table: A2
Unit Root Test Results for Stationary Analysis

Traditional ADF unit root tests				**Structural break ADF unit root tests**		
Variab.	**Level** t-stat. (critical value)	**First difference** t-stat. (critical value)	**Conc.**	**Level** t-stat. (critical value) break date	**First difference** t-stat. (critical value) break date	**Conc.**
logbist100	-3,025 (-3,476)	-11,217 (-3,476)***	I (1)	-4,101 (-4,949)	-11,954 (-4,949)*** 2010M01	I (1)
logwin20	-2,210 (-3,476)	-11,342 (-3,476)***	I (1)	-3,230 (-4,949)	-11,930 (-4,949)*** 2020M03	I (I)
logwheat	-1,580 (-3,476)	-10,354 (-3,476)***	I (1)	-2,769 (-4,949)	-11,099 (-4,949)*** 2012M07	I (1)
logsugar	-2,079 (-3,476)	-0,335 (-3,476)***	I (1)	-3,839 (-4,949)	-10,513 (-4,949)*** 2010M03	I (1)
logrice	-2,203 (-3,476)	-9,738 (-3,476)***	I (1)	-4,187 (-4,949)	-10,340 (-4,949)*** 2009M07	I (1)
logbeef	-2,787 (-3,476)	-8,546 (-3,476)***	I (1)	-3,792 (-4,949)	-9,823 (-4,949)*** 2019M011	I (1)

*Note: Significance: *** 1%.*

Table: A3
Johansen Cointegration Test Results

Panel A: Turkey				
Hypothesized No, of C.E. (s)	Max-Eigen Statistic	0,05 Critical Value	Trace Statistic	0,05 Critical Value
None *	43,41519	33,87687	95,47509	69,81889
At most 1 *	34,51885	27,58434	52,05990	47,85613
At most 2	10,71202	21,13162	17,54105	29,79707
Panel B: Poland				
Hypothesized No, of C.E. (s)	Max-Eigen Statistic	0,05 Critical Value	Trace Statistic	0,05 Critical Value
None *	43,41143	33,87687	80,90150	69,81889
At most 1	18,49933	27,58434	37,49007	47,85613
At most 2	10,77330	21,13162	18,99074	29,79707

*Note: Significance: * 5%.*

Table: A4
Comparison of Econometric Model Results

		Turkey				**Poland**			
Quantiles		**Rice**	**Wheat**	**Sugar**	**Beef**	**Rice**	**Wheat**	**Sugar**	**Beef**
QR	0.10	✓		✓	✓	✓	✓	✓	
	0.20	✓	✓		✓	✓	✓		
	0.30		✓		✓	✓	✓		
	0.40		✓		✓	✓	✓		✓
	0.50		✓	✓	✓	✓	✓		✓
	0.60		✓	✓	✓	✓	✓		
	0.70			✓	✓		✓		
	0.80		✓	✓	✓		✓		
	0.90		✓	✓	✓				
FMOLS			✓		✓	✓	✓	✓	
DOLS			✓	✓	✓	✓	✓		
CCR			✓		✓	✓	✓	✓	

Notes: ✓; since the coefficient sign is statistically significant, the null hypothesis (H_0) is rejected; (empty cells) since the coefficient sign is statistically insignificant, the null hypothesis (H_0) is accepted.