Leading Economic Determinants of Foreign Trade Volume in Turkish Agriculture Sector

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Abstract

We empirically analyze the main economic factors affecting the export and import levels in Turkish agriculture sector. Using monthly time series of certain domestic and international variables, we make three complementary analysis; namely, principal component analysis, causality and co-integration analysis, and multivariate GARCH analysis. The empirical findings point out the fact that foreign trade volume in Turkish agriculture sector is statistically in relation with agricultural production, consumer price index, market capitalization of the firms, and international agriculture prices.

Key words: *Turkish agriculture sector, foreign trade, principal component analysis, multivariate GARCH*

JEL Classification: Q14, 024, C5

Motivation

Turkish agricultural economy has shown fundamental changes in the last decade. The trade liberalization arising from the custom union agreement between Turkey and the EU in 1994 is the main factor in those changes (Cakmak and Ozan, 2005; Karli and Bilgic, 2004). The main effect of the liberalization process in the agriculture sector has been observed on the export-import ratio. For instance, while the export/import ratio for soft commodities was 4 in 2001, it came down to 0.3 in 2007. A broad statistical history of the foreign trade in the Turkish agriculture sector can be found in Dolekoglu (2003).

We think that finding out the leading factors determining the foreign trade volume in Turkish agriculture sector is important for policy makers and sector participants who shape the future of the sector by planning the production amount, seasonality and product diversification. We select potential domestic and international factors affecting the trade volume in agriculture sector.

We select four independent variables, namely, *agricultural production, consumer price index, United Nations food and agriculture world price index,* and *market capitalization of the firms.* Time series of the variables are deseasonalized before being used in the empirical research. As methodology, we employ *principal component analysis, Granger causality test (Granger, 1969), VAR cointegration analysis (Johansen, 1991, 1995),* and *multivariate GARCH model (Engle and Kroner, 1995).* Principal component analysis is used to find the potential variables explaining the variance in export and im-

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port levels. In the second stage, we analyze if there exist a cointegration and causality relationship between foreign trade volume and the independent variables. Finally, we conduct multivariate GARCH model to find out the volatility spillover from the economic factors on foreign trade volume in agriculture sector.

In literature, there is limited academic research on the effects of economic factors on the trade volume in Turkey. Basarir et al. (2006) examine the production performance of the Turkish agricultural sector in a broad content. Cakmak (2003) analyzes the agricultural policies and their sustainability in the Turkish agricultural sector within a historical perspective. Karli et al. (2005) argue that direct incentives in the agriculture have structural effects on the foreign trade. In our paper, we examine the effects of economic factors affecting the foreign trade volume in the Turkish agriculture sector within an econometric analysis. The empirical findings show that foreign trade volume in the Turkish agriculture sector is affected by agricultural production, consumer price index, market capitalization of firms, and international agriculture prices.

The paper is constructed as follows. In the next part, we present data and explain methodologies employed for empirical analyses. In the third part, we discuss the empirical findings especially for policy-making decisions. The paper ends with a conclusion including suggestions for future research.

Materials and Methods

Data

We use 216 monthly observations for agricultural production (TUIPMTF), consumer price index (TUCPIY), United Nations food and agriculture world price index (FAOFOODI), Istanbul Stock Exchange National 100 Index (XU100), import of Turkish agriculture sector (TUTBAI) and export of the sector (TUTBAX) from 01/1990 to 12/2007. The descriptive statistics of variables are presented in Table1. The data is received from Bloomberg, and Bloomberg ticker symbols are used as the short-names of the variables.

Table 1. Descriptive Statistics of the Variables

Statistics	TUIPMTF	TUTBAI (Import)	TUTBAX (Export)	XU100	FAOFOODI	TUCPIY
Mean	105.0889	165.7635	210.9539	11117.10	112.2375	55.55338
Median	105.1000	152.0400	198.7150	4147.000	110.8000	63.52000
Maximum	163.6000	460.7900	519.2200	57615.72	186.9000	130.6000
Minimum	47.80000	42.01000	71.72000	27.47000	87.90000	6.900000
Std. Deviation	21.32137	84.39830	82.83586	14627.37	16.64950	31.80942
Skewness	0.205193	0.969030	0.862855	1.472844	1.507378	-0.085295
Kurtosis	2.745804	4.110816	3.861104	4.194598	6.870730	2.228258
Jarque-Bera	2.097290	44.90991	33.47614	90.93725	216.6417	5.622177
Probability	0.350412	0.000000	0.000000	0.000000	0.000000	0.060139

The rationality behind selecting the dependent variables is based on economic theory and practical observations. Though there might be other variables affecting agricultural foreign trade volume, we construct our research on macroeconomic variables. As this paper has empirical aims, we do not present detailed theory. It should be noted that our combination of leading factors is a model and other models with different variables can be constructed.

The aim of the paper is to empirically prove that the model constructed on economic factors works in the practice. On the other hand, it should be useful to give a broad theoretical framework that helps in explaining the relationships between independent variables and export and import levels in the agriculture sector.

Agricultural Production: Excess production increases exports while low level of production is a reason for an increase in imports.

Consumer Price Index: Domestic demand increases during high inflationary periods and firms try to sell their products within the country with remarkable price levels. In addition, demand for imported goods is low in inflationary economies due to the purchasing power parity effect.

Market Capitalization of the Firms: In theory, the market values of firms are expected to increase as their sales do. In that framework, high share prices might be an indicator for sales. In addition, stock exchange as a sum of market capitalization of the firms listed in the market is an indicator for general systemic risk. In a risky environment, firms might choose to decrease their foreign trade volume due to unpredictable exchange rates, investment and funding costs.

World Agriculture Prices: Foreign trade in a domestic economy should be a function of agricultural goods prices in international markets. We use United Nations food and agriculture world price index as a benchmark index for world agriculture prices.

Monthly changes in the variables are shown in Figure1. There exists seasonality in data related to agriculture; namely agriculture import, export, production and world price index.

The unit root tests for the time series are conducted with Newey-West bandwidth selection using Bartlett kernel. Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table 2. Unit Root Tests for the Time Series

Method	Statistic	Prob.	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t	5.63313	1.0000	6	1274
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	4.05434	1.0000	6	1274
ADF - Fisher Chi-square	9.01049	0.7020	6	1274
PP - Fisher Chi-square	61.5227	0.0000	6	1295

Methodology

The main objective of this paper is to examine the long-term consistency and short-term linkages among the variables. Principal component analysis, Granger causality test (Granger, 1969), VAR cointegration analysis (Johansen, 1991, 1995), and multivariate

GARCH model (Engle and Kroner, 1995) are used for the empirical analysis. The methodologies are explained in a short framework below.

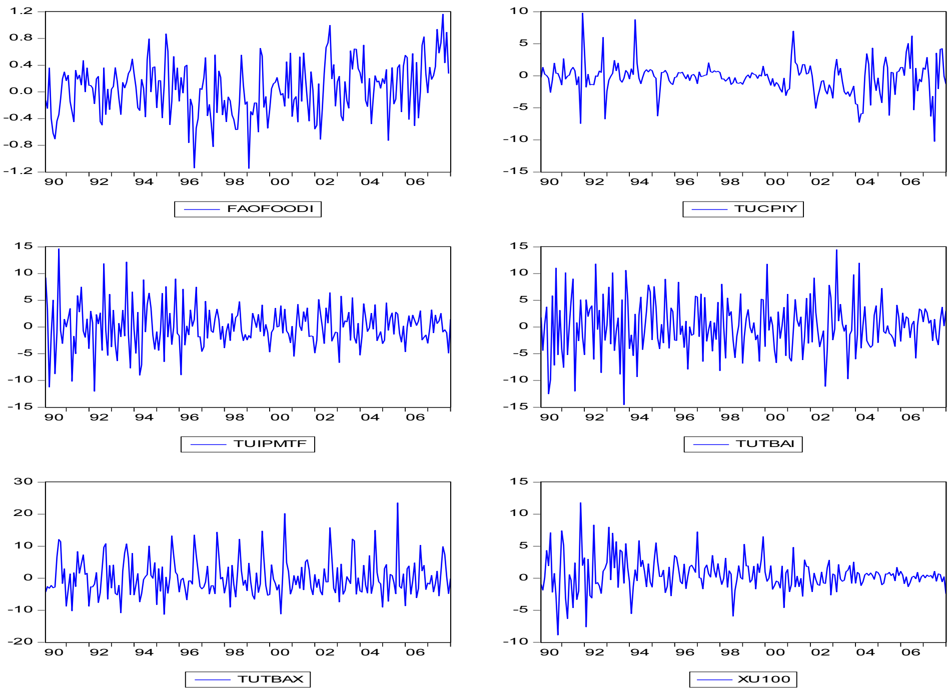

Figure 1. Monthly Changes in the Variables

Principal Component Analysis

Principal components analysis models the variance structure of a set of observed variables using linear combinations of the variables. These linear combinations, or components are used in subsequent analysis, and combination coefficients, or loadings are used in interpreting the components. In the principal components context, let Σ be the cross-product moment (dispersion) matrix of Y, and perform the eigenvalue decomposition:

$$\sum = L \Lambda L' \quad (1)$$

where L is the p x p matrix of eigenvectors and Λ is the diagonal matrix with eigenvalues on the diagonal. The eigenvectors, which are given by the columns of *L*, are identified up to the choice of sign. Note that since the eigenvectors are by construction orthogonal, $L'L = LL' = I_m$.

We may set $U = YLD^{-1}$, $V{=}L$, and $D = (n\Lambda)^{1/2}$, so that:

$$A = n^{\beta/2} YLD^{-\alpha}$$
$$B = n^{-\beta/2} LD^{\alpha} \quad (2)$$

"A" may be interpreted as the weighted principal components scores, and B as the weighted principal components loadings. Then the scores and loadings have the following properties:

$$A'A = n^{\beta} D^{-\alpha} L'Y'YLD^{-\alpha} = n^{\beta}(n\Lambda)^{-\alpha/2}(n\Lambda)(n\Lambda)^{-\alpha/2} = n^{\beta}(n\Lambda)^{1-\alpha}$$
$$B'B = n^{-\beta} D^{\alpha} L'LD^{\alpha} = n^{-\beta}(n\Lambda)^{\alpha} \quad (3)$$
$$BB' = n^{-\beta} LD^{2\alpha} L' = n^{-\beta} L(n\Lambda)^{\alpha} L'$$

Through appropriate choice of the weight parameter α and the scaling parameter β, you may construct scores and loadings with various properties.

Granger Causality Analysis

The Granger (1969) approach to the question of whether x causes y is to see how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation. y is said to be Granger-caused by x if x helps in the prediction of y, or equivalently if the coefficients on the lagged x 's are statistically significant. Eviews 6.0 software program runs bivariate regressions of the form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_t y_{t-l} + \beta_1 x_{t-1} + \ldots + \beta_l x_{-l} + \varepsilon_t$$
$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_t x_{t-l} + \beta_1 y_{t-1} + \ldots + \beta_l y_{-l} + u_t \quad (4)$$

for all possible pairs of (x,y) series in the group. If there is Granger causality from Y to X, then some of the β coefficients should be non-zero; if not, all of the β coefficients are zeros.

Cointegration tests

The finding that many macro time series may contain a unit root has caused the development of the theory of non-stationary time series analysis. The concept of cointegration test proposed by Engle and Granger (1987) is a two step process: first any long run equilibrium relationship between the variables is established, and then a dynamic correlation model of returns is estimated. The fundamental aim of cointegration analysis is to detect any common stochastic trends in the data, and to use these common trends for a dynamic analysis of correlation returns. The vector autoregression-based cointegration tests using the methodology are developed in Johansen (1991, 1995). Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (5)$$

where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t is a vector of innovations. This vector autoregression (VAR) equation can be rewritten as

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \quad (6)$$

where, $$\Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{7}$$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank r < k, then there exist k x r matrices α and β each with rank r such that $\Pi = \alpha \beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

Multivariate GARCH Model

We employ MGARCH model to display the conditional cross-moments of the variables by considering time-varying volatility spillover effect. We use BEKK model for the multivariate analysis, which employs variance-covariance matrix of equations depending on the squares and cross products of innovation εt and volatility Ht for each variable lagged one month (Worthington and Higgs, 2001). The BEKK parameterization for the MGARCH model can be explained as in the Equation (8):

$$Ht = B'B + C'\varepsilon t\ \varepsilon t\text{-}1C + G'Ht\text{-}1G \tag{8}$$

In the equation, bij are elements of an n × n symmetric matrix of constants B, the elements cij of the symmetric n × n matrix C measure the degree of innovation from variable i to variable j, and the elements gij of the symmetric n × n matrix G indicate the persistence in conditional volatility between variable i and variable j. This can be expressed for the bivariate case of the BEKK as:

$$\begin{bmatrix} H_{11t} H_{12t} \\ H_{21t} H_{22t} \end{bmatrix} = B'B + \begin{bmatrix} c_{11} c_{12} \\ c_{21} c_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1t-1}^2 \varepsilon_{1t-1}\varepsilon_{2t-1} \\ \varepsilon_{2t-1}\varepsilon_{1t-1}\varepsilon_{2t-1}^2 \end{bmatrix} \begin{bmatrix} c_{11} c_{12} \\ c_{21} c_{22} \end{bmatrix} + \begin{bmatrix} g_{11} g_{12} \\ g_{21} g_{22} \end{bmatrix}' \begin{bmatrix} H_{11t-1} H_{12t-1} \\ H_{12t-1} H_{22t-1} \end{bmatrix} \begin{bmatrix} g_{11} g_{12} \\ g_{21} g_{22} \end{bmatrix} \tag{9}$$

In the Equation (9), instead of examining bij, cij and gij individually,. the functions of the parameters constituting the intercepts and the coefficients of the lagged variance, covariance, and error terms are under co-examination (Kearney and Patton, 2000; Worthington and Higgs, 2001). Under the assumption of normally distributed random errors, the log-likelihood function for the MGARCH model can be written as in Equation (10):

$$L(\theta) = -\frac{Tn}{2} + \ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\left(\ln|H_t| + \varepsilon_t'|H_t^{-1}|\varepsilon_t\right) \tag{10}$$

In the equation, T is the number of observations, n is the number of financial time series, θ is the vector of parameters that should be estimated.

Empirical Findings

Principal Component Analysis

The results of principal components analysis show that 64.83 % of the variance of the variables can be explained by the same factor and 16.59 % of the variance is a result of the second factor (Table 3).

Table 3. Eigenvalues of the variables (Sum = 6, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	3.889890	2.894631	0.6483	3.889890	0.6483
2	0.995259	0.510392	0.1659	4.885149	0.8142
3	0.484867	0.185798	0.0808	5.370016	0.8950
4	0.299069	0.086374	0.0498	5.669085	0.9448
5	0.212695	0.094475	0.0354	5.881780	0.9803
6	0.118220	---	0.0197	6.000000	1.0000

The principal components of these variables are obtained by computing the eigenvalue decomposition of the observed variance matrix. The first principal component is the unit-length linear combination of the original variables with maximum variance. Subsequent principal components maximize variance among unit-length linear combinations that are orthogonal to the previous components.

Table 4. Eigenvectors (loadings)

Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
FAOFOODI	0.326910	0.696814	-0.151869	0.334584	-0.505634	-0.130013
TUCPIY	-0.406702	0.503828	0.089342	0.274365	0.445487	0.546839
TUIPMTF_SA*	0.407412	-0.388916	0.147774	0.787118	0.179130	0.096338
TUTBAI_SA	0.434793	0.203520	-0.483707	-0.155066	0.669166	-0.252455
TUTBAX_SA	0.386944	0.241444	0.825784	-0.266820	0.179363	-0.081835
XU100	0.472195	-0.098164	-0.176709	-0.313025	-0.183937	0.777401

*"…._SA" refers to "seasonally adjusted".

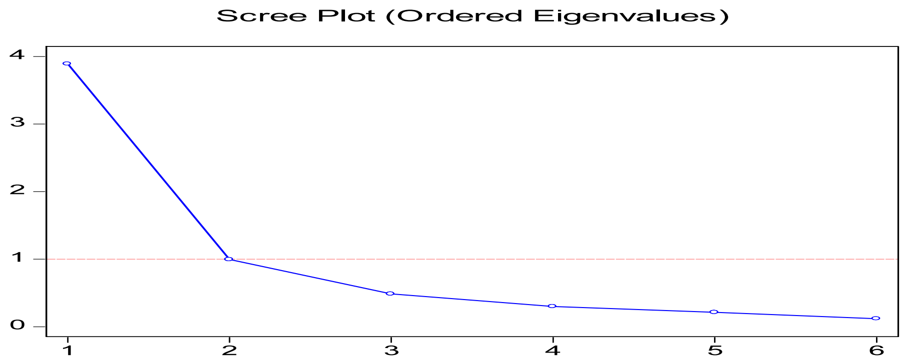

Figure 2. Ordered Eigen Values

As the factor loadings indicate, variances of the import and export levels, ISE100 index, agricultural production and world agricultural prices seems to be affected by the same factor while consumer price index has a different factor loading. The result is just an indicator about the relationship among the variables. The more remarkable results will be reached by the causality analysis.

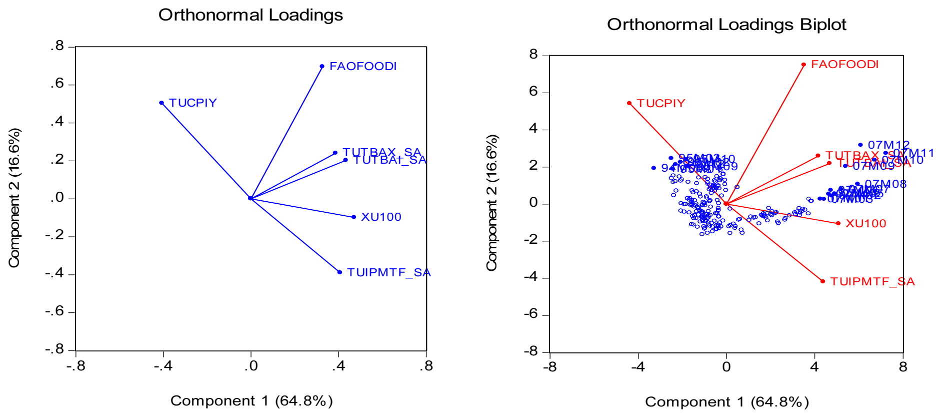

Figure 3. Orthonormal Loadings and Their Biplot

Results of Causality Tests

Results of Granger causality tests display the following statistically significant results at 99 % significance level. There exists causality between agricultural production and export and import levels. While agricultural production affects both import and export levels, only the export level affects the production. There exists bilateral causal relationship between the systematic risk (ISE-100) and import level while the export level moves independently from the systematic risk. In addition, following empirical facts, a 95 % significance level is reached by the test results. The domestic agricultural production is a function of the world agricultural prices, while the amount of domestic products does not affect international prices. While the production level has causal effects on the market capitalization of the firms, the reverse causality does not hold.

The causality tests give reasonable results as compared to the theory. Lastly, we use multivariate GARCH analysis to examine if there are conditional correlations between the independent variables and export and import levels indicating long-run relationships.

Multivariate GARCH Analysis

Multivariate GARCH analysis shows the conditional correlation among variables in the long-run. We will discuss the test results by considering the fact that there were economic crisis in 1994, 1998 and 2001 in Turkey. The results of the multivariate GARCH model are presented in graphical format showing the time in the x axis and power of the correlation in the y axis in Figure 4.

The conditional correlations between agricultural import and export levels and world agricultural prices are high and the direction depends if there exists crisis in the economy or not. However, the export level is more volatile probably due to some seasonality. The foreign trade level has conditional correlation between consumer price index, however, especially since the 2001 crisis; the direction is on the negative way. The correlations between import and export levels and agricultural production have increased

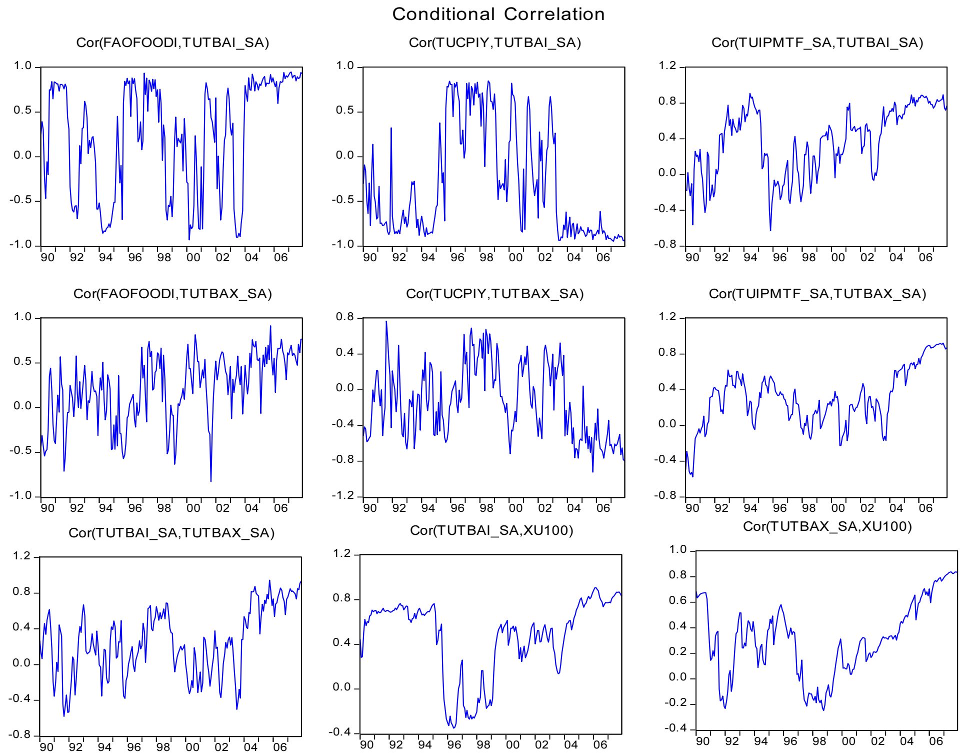

Figure 4. Conditional Correlations between the Independent Variables and Import and Export Levels

since the 2003 in which recovery started in the economy after the 2001 crisis. The conditional relationship between the import level and market capitalization of the firms sharply turned negative during the crisis while it was stable around 0.4-0.6 in normal conditions. The export volume, on the other hand, has shown an increasing conditional correlation since 1998 crisis. The conditional correlation between export and import levels is volatile and seems to show seasonal volatility.

Conclusion

Foreign trading volume in Turkish agricultural sector has been volatile as the factors affecting the volume are various and interrelated. In this empirical paper, we try to find out the leading economic factors that might have influence on the import and export levels of agricultural products in Turkey. We conduct three complementary statistical analyses, namely principal component analysis, causal integration analysis and multivariate GARCH. We theoretically rationalize that the export and import volumes in the sector might be related to agricultural production, consumer price index, market capitalization of the firms, and international agriculture prices.

Principal component analysis shows that the variance (64.83 %) of the selected variables is the result of one factor. Variances in the import and export levels, ISE100 Index, agricultural production and world agricultural prices are affected by the same factor. On the other hand, consumer price index has a different factor loading. Those results motivate us to analyze the causality and cointegration among the variables.

Granger causality tests show that agricultural production affects both import and export levels, but only the export level affects the production. The correlations between foreign trade volume and agricultural production have increased since 2003. In addition, there exists bilateral causal relationship between the systematic risk and import levels, but conditional correlation turns negative during the crisis. What's more, as theoretically expected, the domestic agricultural production is a function of the world agricultural price level. The conditional correlations between foreign trade volume and world agricultural prices are high and the direction depends on the existence of a crisis in the economyFuture research can concentrate on alternative variables affecting the foreign trade volume in agriculture sector. In addition, a research based on detailed theoretical framework can be constructed. On the methodological side, wavelet analysis might be employed to examine the time-scale effects of the macroeconomic variables on foreign trade volume in the sector.

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