Supply response for wheat in Turkey: a vector error correction approach

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Abstract

The supply response of overall wheat production was analysed using a cointegration approach for the period 1960 and 2009. The amount of wheat produced was analysed with respect to the production amount of the previous period, to the land devoted to wheat production and the producer price. The dynamics of the long-run equilibrium led to the incorporation of a cointegration modelling. The findings indicated that farmers are not responsive to the price changes and the wheat supply is shaped according to structural characteristics of wheat production. The short-run equilibrium is offset by more than 90% in the current period, which was shaped by the past decisions on price, production amount and production lands. This means that the long-run equilibrium is reached by more than 90% in the period concerned.

Keywords: Wheat, Price Analysis, Cointegration, Turkey

Résumé

La réponse de l'offre de la production totale de blé a été analysée en utilisant une approche de cointégration pendant la période entre 1960 et 2009. La quantité de blé produit a été analysée par rapport à la quantité produite pendant la période précédente, la surface dédiée à la production de blé et aux prix de production. La dynamique de l'équilibre à long terme a déterminé un modèle de co-intégration. Les résultats indiquent que les agriculteurs ne sont pas sensibles aux changements de prix. L'offre de blé se base sur les caractéristiques structurales de la production. L'équilibre à court terme est compensé actuellement à raison de 90% sur la base de décisions concernant les prix, la quantité de production et la surface cultivée. Ceci signifie que l'équilibre à long terme dépasse 90% pour la période à l'étude.

***Mots clé**: Blé, Analyse des Prix, Cointégration, Turquie*

1. Introduction

Dynamics of agricultural production has long been a research topic with regards to supply planning. In order to make proper plan of supply of an agricultural product, it is a necessity to see its sensitivity to fluctuations of price and incentives passed to the producer. Agricultural pricing policy has been a crucial tool in order to increase both farm production and farm incomes and the effects of the pricing policy could best be assessed by analysis of the quantity response to price changes [1-3]. Therefore, supply response is a tool used to evaluate the effectiveness and success of pricing policies regarding allocation of farm resources and provides inputs for formulation of economic policy in agricultural production field.

Departing from this framework, this paper aimed to undermine the effects of real price changes on supply of wheat in Turkey in the long and short run. Wheat, being a multi-annual farm product and the most significant cereal crop of Turkey, is expected to reveal a trend-based relationship and dependence on the series of farm prices. Accordingly, the supply response of Turkish wheat was modelled within a cointegration framework considering the period between 1960 and 2009.

Supply response is being studied on product level and on aggregate level in the literature. Product level studies focus on the change in composition of the product or the area planted in some cases with respect to the change in the commodity price. The aggregate measures incorporate change in total agricultural output with respect to the change of agricultural prices against industrial prices, and they are less frequently seen in the literature as commodity level interpretations gained more emphasis. Product level supply response to price fluctuations and to non-price factors related to production such as weather change, input prices and supplies and technology are analysed to improve the understanding of price mechanism on micro level. These efforts are mostly directed to uncover whether additional taxation of sector would contribute to overall economic welfare or price incentives would increase the amount produced significantly.

The recent works in the agricultural economics field mostly focus on cointegration and error correction studies of time series data. Some of the recent works are as follows. The supply response of rubber farmers to prices and other factors in Nigeria was analysed using cointegration and vector error correction technique for the period from 1970 to 2008 [4]. Response of rubber farmers to price was low with an estimated elasticity of 0.373 for the short-run and 0.204 for the long-run. Price sustainability and emergence of other supply led to the low responsiveness and; promotion of sustainable marketing outlets and high value and high quality products for export were suggested.

Vector error correction approach was used to examine supply response of potato in Bangladesh between 1980 and 2006. The elasticity was found as 0.45 for the short run and as 0.62 for the long run. This indicated that price policies are effective in promotion or distraction of potato production in Bangladesh [5].

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A farmer level Nerlovian response function was estimated for 2004 and 2007 for rice in Cambodia. The estimated production function revealed that input use such as fertilisers and technology investments are determinant in rice production [6].

An analysis over the relationship between wheat acreage and a price factor (support price) and a non-price factor (fertiliser off take) for Pakistan between 1976-77 and 2007-08 revealed inelastic but significantly negative relationships between wheat acreage and corresponding factor through a Nerlovian adjustment model [7].

A Nerlovian adjustment model for Nigerian rice between 1967 and 2004 revealed that time trend has significant influence on area, amount of production and yield of rice. Yet, price elasticity ranged between 0.23 and 0.33 from short to long-run indicating inelastic rice supply with respect to price [8].

2. Material and Methods

2.1. Data

Before proceeding, a portrait of the Turkish wheat sector should be provided. The amount of wheat produced was 8.45 million tonnes in 1960 and it was recorded as 20.60 million tonnes in 2009. The aggregate rise in total wheat produced including durum wheat and other types of wheat was 144 % in 50 years. In addition, the rise in area produced was 5.2 % from 7.70 million hectares to 8.10 million hectares due to data retrieved from agricultural statistics of the Turkish Statistical Institute. The change in the amount produced, area used for cultivation and yield are demonstrated in Figure 1, which also reveals the trend based change in the considered figures.

2.2. Modelling Framework

The supply response modelling of single commodities is made through three different methodologies within the literature. Direct structural analyses are based on inference from the equilibrium of input demand and input supply functions and relates the equilibrium with the production function. Yet, the mostly used direct reduced form analyses are based on partial adjustment and expectations for price and quantities. This method is known as the Nerlovian adjustment model. Nerlovian model explains the production function with an equation formed out of price expectations and supply shifters which are non-price factors affecting the supply [9].

$$\begin{aligned} Q_t^* &= a + bP_t^* + cZ_t \\ Q_t^* &= desired\ level\ of\ output\ for\ time\ t \\ P_t^* &= expected\ real\ price\ for\ time\ t \\ Z_t &= vector\ of\ non-price\ exogenous\ variable \end{aligned} \tag{1}$$

Especially for agricultural products, the expectations for the desired level of output and for price are determined in connection with the past series of the variables. This can be explained such that the farmers make decisions on production of the corresponding product in previous period(s) and they cannot revise their decisions in the production period.

After making the modifications regarding adaptive expectations framework a model for level of exogenous variables is reached. The short-run and long-run elasticity of production with respect to price and other concerned non-price factors can be measured through the equations formed. While the elasticity is a measure to be interpreted from logarithmic estimation, the model is estimated in level form and the direct reduced form of estimation including lagged variables in the regression could be read as the elasticity of production according to the literature visited [10].

$$Q_t - Q_{t-1} = \delta(Q_t^* - Q_{t-1}) \tag{2}$$

$$P_t^* = \theta P_{t-1} + (1-\theta)\, P_{t-1}^* \tag{3}$$

By inserting the 2nd and 3rd equations in the 1st equation, we reach the supply response function based on expectations.

$$Q_t = A_0 + A_1 P_{t-1} + A_2 Q_{t-1} + A_3 Z_t \tag{4}$$

In this representation while A_1 refers to short-run price elasticity, $A_1/1\text{-}A_2$ refers to long-run price elasticity [10].

However, as the variables are used in level form, the researchers are mainly faced with the problem of non-stationarity. More specifically, single OLS estimation with non-stationary data produces spurious regressions [11]. This means that the regression between time series that are trended over time may produce high goodness of fit statistics and may seem highly correlated, yet the relationship is mostly meaningless [12].

Therefore, the third methodology depends on cointegration of integrated time series [13, 14]. Error correction model (ECM) is based on cointegration of explained and explanatory variables that have time trend characteristics and that are both in the same order [10]. ECM methodology leads to the formulation of a model out of stationary variables and enables statistical inference without imposing any restrictions on short-run behaviour of the variables [3, 15]. The ECM method is based upon the ordinary least squares coefficient of the lagged dependent variable in an autoregressive distributed lag model augmented with leads of the explanatory variables [16] and stems from a stable long-run relationship of the variables [3].

When the economic relationship between quantity supplied and price are defined as:

$$Q_t = a + bP_t + u_t \tag{5}$$

and Q_t and P_t are found out to be integrated of order 1 due to the findings of unit root tests [17], there is a possibility to find a linear equation that explains the relationship between the two cointegrated variables [10].

$$\Delta Q_t = \alpha_0 + \alpha_1 \Delta P_t + \gamma u_{t-1} \quad (6)$$

$$\Delta Q_t = \alpha_0 + \alpha_1 \Delta P_t - \gamma(Q_{t-1} - a - bP_{t-1}) \quad (7)$$

$$Q_t = (\alpha_0 + \gamma a) + \alpha_1 P_t - \alpha_1 P_{t-1} + (1-\gamma)Q_{t-1} + \gamma b P_{t-1} \quad (8)$$

$$Q_t = (\alpha_0 + \gamma a) + \alpha_1 P_t + (1-\gamma)Q_{t-1} + (\gamma b - \alpha_1)P_{t-1} \quad (9)$$

With this Granger representation it was achieved to model the problem enabling the short run and long run adjustments. Meanwhile, the impediments of the Nerlovian adjustment model are overcome [15].

2.3. Model and Data Characteristics

For the concerned wheat supply production, recurrent decision making process of the multi-annual production directly leads to the formulation of the long-run supply relationship as following:

$$Q_t = \propto_1 + \alpha_2 Q_{t-1} + \alpha_3 P_{t-1} + \alpha_4 A_{t-1} + \alpha_5 T_t + \alpha_6 D_{95} + \varepsilon_t \quad (10)$$

The relevant variables are:

$Q_t = Wheat\ production\ in\ year\ t\ in\ million\ tonnes$
$Q_{t-1} = Wheat\ production\ in\ year\ t-1\ in\ million\ tonnes$
$P_{t-1} = Real\ producer\ price\ per\ kg\ in\ year\ t-1$
$A_{t-1} = Area\ cultivated\ per\ million\ hectares\ in\ year\ t-1$
$T_t = Time\ trend\ from\ 1\ to\ 49$
$D_{95} = 1\ for\ observations\ t > 1, 0\ otherwise$

Here the price variable, which was considered in real terms, was taken in TL per kg terms for the ease of the interpretation. The structural dummy was created in order to measure the impact of the tight fluctuation in prices that appeared by 1995, which mostly resulted from the characteristics of the price index and index calculation system. The data between 1960 and 2009 is retrieved from statistical databases and E-Views 5 statistical package was used for estimation and analysis.

Prior to estimation of the long-run model, the quantitative variables of the model are tested for their unit roots and the degree of integration for the variables are determined via ADF (Augmented-Dickey Fuller) testing procedure [17]. The null hypothesis of the testing is non-stationarity of the concerned variable and the procedure is as following.

$$\Delta X_t = \alpha_0 + \delta X_{t-1} + \sum \beta \Delta X_{t-1} l + e_t \quad (11)$$

Here ΔX_t is the first difference of the variable and δ is the test coefficient. Checking out the unit roots and cointegration level of the variables, the short-run equilibrium of the supply response is estimated through difference estimation. This means that, depending on the integration level of the variables, the short-run supply response is estimated for first differences of all the variables concerned in the static equation. This procedure is called Vector Error Correction (VEC) mechanism, indicating the short-run dynamics of the wheat supply and transfer of the marketing and production signals between periods.

2.4. Stationarity Testing and Integration

First the visual inspection was made by using correlograms and Q-statistics; the findings are demonstrated in Table 1.

Table 1. *Q-statistics.*

Variable	Q-stat	p(Q)
Q_t	39.527	0.00
Q_{t-1}	40.454	0.00
P_{t-1}	38.541	0.00
A_{t-1}	36.917	0.00

The probability of estimated Q-statistics and partial correlation coefficients that die directly after the first lag are interpreted as a preliminary proof of the first order autocorrelation for the static variables. In addition, all variables are tested for their levels and first differences in order to determine the degree of integration and the test results are reported in Table 2.

Table 2. *ADF Stationarity Testing Results.*

Variable	Estimated ADF	ADF – 1 %	ADF – 5 %	p-value
Q_t	-1.87	-3.57	-2.93	0.34
Q_{t-1}	-2.01	-3.57	-2.93	0.28
P_{t-1}	-0.92	-3.57	-2.93	0.77
A_{t-1}	-1.73	-3.57	-2.93	0.41
$D(Q_t)$	-6.27*	-2.62	-1.95	0.00
$D(Q_{t-1})$	-6.03*	-2.62	-1.95	0.00
$D(P_{t-1})$	-4.75*	-2.62	-1.95	0.00
$D(A_{t-1})$	-3.89*	-2.62	-1.95	0.0002

Critical value of ADF tests are based on Mackinnon (1996) one sided p-values referred by E-Views 5 automatically. *, Significant at 1%.

The test results indicate that all variables involved in the model are I(1), integrated of order 1. To test whether the non-stationary variables are cointegrated for short-run interpretation or they are spuriously related, the residuals of the static equation need to be examined [18].

2.5. Cointegration

The residuals of the static equation (10) are tested for their unit roots in order to make inferences about the cointegration of series in the short run. Through cointegration testing, it was evaluated whether a linear combination of the detected non-stationary series are stationary and produce meaningful outcomes [5]. The test indicated the following results for the relationship between difference of residuals and their first lag, which is demonstrated in Table 3.

Table 3. *Outputs of Cointegration Test*

Dependent variable: D(e)	
e(-1)	-1.02
t(p(t))	-6.86 (0.00)

Therefore, the dependent and independent variables are said to be cointegrated in the short-run. As a cointegrating relationship was found, it is possible to estimate the short-run equation in the following VEC modelling [18].

$$D(Q_t) = \beta_0 + \beta_1 D(Q_{t-1}) + \beta_2 D(P_{t-1}) + \beta_3 D(A_{t-1}) + \beta_1 ECM + M_t \qquad (12)$$

Here, the variables are estimated in their first difference and the error correction coefficient retrieved from the static long-run relationship was included in the model as an estimator.

3. Results and Discussions

The long-run relationship is as following, of which the parameter statistics are demonstrated in Table 4.

$$Q_t = -12.59 - 0.044{*}Q_{t-1} + 0.12{*}P_{t-1} + 2.63{*}A_{t-1} + 0.26{*}T_t - 3.61{*}D_{95}$$

Table 4. *Long-run relationship estimates.*

Variable	Parameter Estimate	Standard Error	P-value
Q_{t-1}	-0.043771	0.173155	0.8016
P_{t-1}	0.118930	0.087868	0.1830
A_{t-1}	2.625029	0.669453	0.0003
T_t	0.260135	0.056184	0.0000
D_{95}	-3.612105	1.363681	0.0113
A_0	-12.58503	4.573414	0.0086
R^2	0.90	**F-statistic**	80.72 (0.00)
D-W	1.9949	**Mean dependent v.**	16.038

The lagged variables are used in the estimated wheat production amount relationship, as the production decisions of wheat are mostly made in the previous period and they are not altered on real time basis due to change in any of the variables. In addition, considering the multi-annual structure of the wheat production, the amount of production in the previous period is related with the current production. Yet, the relationship has a negative sign as wheat could be replaced with its substitutes such as barley, cotton or maize. In another way, as an increase of wheat supply is attached to a declination in its price, the producers prefer to produce other products and they become eligible for this substitution in the long-run. The possibility to use substitutes is a main condition that can be attributed to the negative constant of the estimation.

In addition, the amount produced rises considerably with respect to time, which can also be attributed to the population rise. Also rise in cultivation area affects the production positively in time. The only consideration is the declination experienced after 1995. This is also attributable to generation of substitutes. Yet, the price impacts the amount positively but the impact is almost negligible when the unit of price is revised as per kilogram.

The short-run relationship is as following and the estimation outcome is provided in Table 5.

$$Q_t = 0.19 - 0.033{*}D(Q_{t-1}) + 0.12{*}D(P_{t-1}) + 1.96{*}D(A_{t-1}) - 0.91{*}ECM$$

Table 5. *Short-run relationship estimates.*

Variable	Parameter Estimate	Standard Error	P-value
$D(Q_{t-1})$	0.03303	0.179891	0.8552
$D(P_{t-1})$	0.11917	0.105200	0.2636
$D(A_{t-1})$	1.96244	1.090968	0.0791
ECM(-1)	-0.91101	0.236883	0.0004
A_0	0.18936	0.219562	0.3932
R^2	0.39	**F-statistics**	6.982 (0.00)
D-W	1.9983	**Mean dependent v.**	0.2833

The relationship is worth to diagnose, besides having a low goodness of fit. The elasticity of current production with respect to previous production is rather low as 3.3%. Besides, responsiveness to price is again low. The price elasticity is around 12% for both the short and the long run and insignificant. But, the overall significance of the system indicates that wheat supply is price inelastic.

The amount of land devoted to wheat production affects the supply conditions of the following year. This also means that the decision to set aside new pieces of land for wheat production is completely interrelated with the production decision of the next year with 1% significance in the long run and 10% significance in the short run.

The error correction coefficient of 0.91 indicates the speed of adjustment from short-run to long-run equilibrium and has the negative sign as expected and it is strictly significant at 1%. In addition, it was not so surprising to encounter that more than 90% of the disequilibrium is offset towards the long-run equilibrium in one year and the production decisions are revised due to the new equilibrium.

4. Conclusions

In summary, the paper aimed to disaggregate the exogenous effects on wheat quantity supplied in Turkey between 1960 and 2009. Time series analytic techniques were used to undermine the quantitative effects of price and non-price factors of wheat production.

Accordingly, it was found that wheat supply is mostly affected from the previous year's supply conditions. Being a major staple, price has very limited impact over the production decision of farmers. Production area impacts over the supply via one year delay, which is also indication of the situation that wheat production decisions are given prior to the real production period. Wheat supply is price inelastic both in the short and long run. The trend rise in the wheat supply is related with the population change and the prices are not used as a main indicator for supply decisions for wheat production.

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