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LONG YEARS APICULTURE DATA MODEL OF TURKEY: AN ECONOMETRIC TIME SERIES ANALYSIS

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ABSTRACT

The empirical studies in the field of apiculture are rare both in Turkey and abroad. Nevertheless the importance of apicultural productions for nutrition and industry is growing. In this study we are modeling long years' apiculture data of Turkey. The employed methodology is a compound of econometric structural modeling combined with time series approach of ARMA. At the first step we have estimated a Cobb-Douglas production function for each of honey and wax production series. Then the residuals are tested for unit roots and searched for ARMA structures. Cobb-Douglas functions of honey and wax productions are significant with relevant ARMA modeling of residuals.We have found that, the elasticities of honey and wax productions against the old type hives are negative while their elasticities against new types are 0.45 and 0.35 respectively. Overall the results are indicative of inelasticity of productions for the number of colonies. This is a clear setback for the productivity of apiculture industry given the high rank Turkey's production and colony numbers in the world ranking. More sophisticated methods should be searched in order to develop productivity and competitiveness of Turkish apiculture in the world markets.

Key words and Phrases: Apiculture, Cobb-Douglas Functions, ARMA Modeling.

INTRODUCTION

One of the earliest empirical study in the field of apiculture dates back to 1970s in Turkey. Isyar (1974) used a 10 years data to estimate a preliminary econometric model of Turkey.Empirical studies in the field of apiculture are relatively rare in the international literature as well. One of the modelingstudies comes from Willett (1991). She has presented a national beekeeping-industry model of USA, assuming rational expectations. Willett and French (1991) presented a dynamic econometric model of the U.S. beekeeping industry for policy analysis and economic projections.

Parlakay *et al,* (2008) in their studycalculated trends values by using colony numbers, honey productionand foreign trade so as to evaluate the beekeeping industry in Turkey. Cvitković *et al,* (2009) determined the basic economic parameters of honey production export and import in Croatia and worldwide. They also estimated the market value of Croatian beekeeping as a whole for the year 2007. Vural and Karaman (2010) analyzed technical and economic aspects of apiculture industry in Turkey. In this paper, the effect of old and new type beehive use for the honey production in Turkey was examined. Recently, empirical econometric research has started to take into account the potential bias and loss of efficiency by employing the spatial econometrics methods which incorporate the spatial dependence into model specification. Using classical linear and spatial econometrics regression models Koshiyama *et al,* (2011)studied socio-economic, technological, management and geographic factors that have influenced the honey prices.

The present study has several motivations. First of all, we aim to make a first attempt for modeling the apiculture data of Turkey. The elasticity of honey and wax productions with respect to various types of hive inputs can be evaluated for policy purposes. The results of analysis can be used for economic analysis such as competitiveness, sustainability and efficiency or productivity of Turkish apiculture industry.

The construction of the paper is as follows: In the next section we present a brief review of apiculture studies in the modeling context. In the third section, the main methodological ideas employed in the study, namely Cobb-Douglas production function, ARMA modeling, ADF unit root test etc. are presented. In the fourth section we present the data and main results of the study, combined with important inference and implications. Last section is devoted for overall conclusions.

MATERIALS AND METHODS

The source of our annual apiculture data is Turkish Statistical Institute (TURKSTAT). It spans from 1936 up to 2012 and consists from annual numbers of beehives (both old and new types) and honey and wax production as metric tons. In sum, the data set of 77 annual observations is a comfortably sufficient sample dimension for a time series analysis. We have worked with logarithmic series, which is a usual practice to deal with the heteroscedasticity problem of time series.

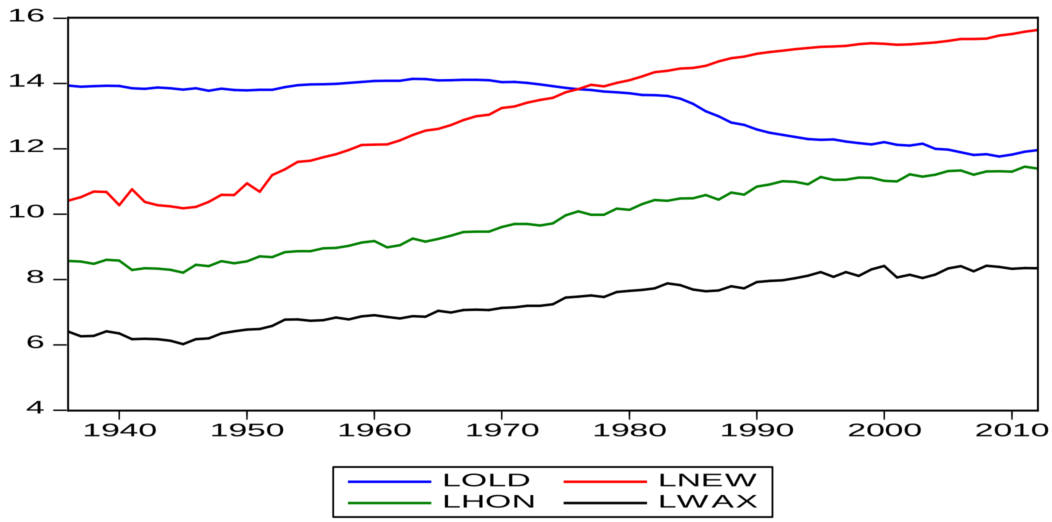

Figure 1.Annual apiculture series of Turkey 1936-2012.

The production of honey proceeds over the wax, and there is a clear slowdown in the speed of increase beginning with 1980s.Several points can be deduced from the visual inspection of the above graph. The number of old type hives are in a steady decrease starting with 1970s while the number of new type hives are on a steady increase with the start of 1950s.

We employed a combination of econometric and time series modeling approach, in the sense that initial model is an econometric model and residuals are modeled as an ARMA modeling. This two-step modeling approach specification is

$$Y_t = X_t \beta + u_t, \quad A(L)u_t = B(L)\,\pounds_t, \quad t = 1, 2, \ldots, T \qquad (1)$$

Here Y_t is the dependent variable, X_t is the vector of independent variables, β is a vector of parameters, u_t is the random disturbance term, $A(L) = 1 - a_1 L - a_2 L^2 - \ldots - a_p L^p$ and $B(L) = 1 + b_1 L + b_2 L^2 + \ldots + b_q L^q$ are lag polynomials at appropriate p and q lengths and ε_t is a white noise. For a stationary disturbance term u_t, any ARMA modeling can be represented in short as $u_t \sim ARMA(p, q)$. This approach can be handled with any econometric software such as Eview which is employed in the present study. As a starting point econometric model we use Cobb-Douglas production function. Cobb-Douglas production function postulates that any production Q_t at time t is a weighted geometric average of inputs Z_1 and Z_2 as follows:

$$Q_t = A\, Z_{1t}^{\beta_1} Z_{2t}^{\beta_2}\, e^{u_t}, \quad t = 1, 2, \ldots, T \qquad (2)$$

Where e is the natural log base, u_t is a disturbance term with zero mean and constant variance. In the context of apiculture data, Q_t stands for the level of annual honey or wax production, Z_{1t} and Z_{2t} stand for old and new type beehives respectively.As the least squares estimation procedure possesses BLUE (best, linear, unbiased estimator) properties, we need to linearize the model (1). Themodel is linearized using log transformation as below

$$\ln Q_t = \ln A + {}_1 \ln Z_{1t} + {}_2 \ln Z_{2t} + u_t \qquad (3)$$

Having changed name of variables as $Y_t = \ln Q_t$, $X_{1t} = \ln Z_{1t}$, $X_{2t} = \ln Z_{2t}$ and the intercept reparameterized as $\beta_0 = \ln A$, the linear model will be given as

$$Y_t = {}_0 + {}_1 X_{1t} + {}_2 X_{2t} + u_t \qquad (4)$$

This is a multivariable linear regression model and it can now be estimated using least squares method. After this stage, ARMA (Autoregressive Moving Average) modeling sets in. First of all, the residuals should be stationary in that, the mean, variance and autocovariances at any lag should be independent of time point, that is, they should be constant. To insure the stationarity condition of residuals, an augmented Dickey-Fuller test can be handled using

$$\Delta e_t = a_0 + a_2 t + \gamma e_{t-1} + \sum_{i=1}^{k} \delta_i \Delta e_{t-i} \qquad (5)$$

If the test value for the gamma parameter estimate is less than critical MacKinnon theoretical values in algebraic terms, then we conclude that, the residuals are stationary. If residuals are stationary we can go forward to check their ACF and PACF values for some reasonable lag lengths in order to determine the AR and MA orders of residual ARMA modeling. As a rule of thumb, the number of significant ACF values is an indicative for number of MA terms, while the number of significant PACF values is considered to be an indicator for the number of MA terms.The significance of ACF and PACF for any lag K is tested by Ljung-Box (1978) as

$$Q_{LB} = T(T-2)\sum_{k=1}^{K} r_k^2 /(T-k) \qquad (6)$$

If $Q_{LB} > \chi_K^2$ then the null hypothesis of $H_0 : \rho_1 = \rho_2 = \ldots = \rho_K = 0$ is rejected. For a thorough evaluation of ARMA modeling we refer to Box and Jenkins (1976).

RESULTS and DISCUSSION

The existence of increasing or decreasing trend in the series is indicative of non-stationarity in the series. Nevertheless, the degree of integration in the series should be checked by unit root tests. The table below summarizes the ADF test results.

Table 1. ADF Unit Root test results for the levels and first differences of apiculture series.

Series	ADF Statistics	MacKinnon one-sided prob.	DW for ADF regression
LOLD	-1.146729	0.2271	2.175495
LNEW	3.355743	0.9997	2.097388
LHON	3.880717	1.0000	2.101177
LWAX	2.752491	0.9984	2.058700
DLOLD	-2.511701	0.0126	2.205868
DLNEW	-2.437890	0.0153	1.953484
DLHON	-9.976721	0.0000	1.989393
DLWAX	-10.00072	0.0000	2.001619

Note: Test Critical Values 1 % level -2.596586, 5% level -1.945260 and 10 % level -1.613912

Durbin-Watson (1971) statistics in the last column being close to 2 means that there is no autocorrelation structure in the residuals of auxiliary ADF unit root regressions. All the MacKinnon (1991) one sided probability values are greater than even 10 % significance level. We conclude that all four series have unit roots on the levels or they are non-stationary. We have performed same unit root test for the first differences and the results are presented in the second half of table above. MacKinnon one sided probability values are indicative of stationary. The resulting stationary series can be observed from the figure 2 below. We conclude that all four series are integrated of order one, that is I (1).

These results have established the existence of cointegration relations between variables, which says that if the residuals of any linear combination of variables are stationary then the variables are co-integrated. In fact, the Johansen (1991) cointegration tests which were due to space limit not reported here show that there are at most two linear combinations within the variables involved. We are now in a comfortable position to estimate the relevant production functions. We have two production functions, one for honey and another for wax data.

As far as parameter estimates are concerned all the coefficients are significant even 1 % significance level. Both models assume a very high level of determination coefficient. Residuals are supposed to be white noise in that they should not show any autocorrelation behavior. To this end Durbin Watson (1971) statistics should be around 2. Honey production residuals more or less can be said not to have autocorrelations. However wax residuals being close to 1, seems to have positive autocorrelations. At this stage, we should check the stationarity of residuals by an ADF unit root test. The results are presented in Table 6 below.

Having significance level greater than 5 %, we are not able to reject the null hypothesis of no autocorrelation structure for the residuals of LHON equation, but we are able to reject the same null hypothesis for the LWAX equation. That means that there is an autocorrelation structure and this should be exploited. Eview allows for different ARMA specifications of the error term. Therefore we should look for alternative specifications. According to the rule of thumb advised by Box and Jenkins (1976), just one period lag AR or MA terms would suffice. The alternative but significant LWAX models combined with ARMA specifications are presented in Table 5 below, where we have two competing models. Both are of good qualities in terms of coefficient significance and residual autocorrelations. However, even slightly it might be, the model with one autoregressive coefficient presented in the first panel seems to be outperforming the second one in terms of AIC values.

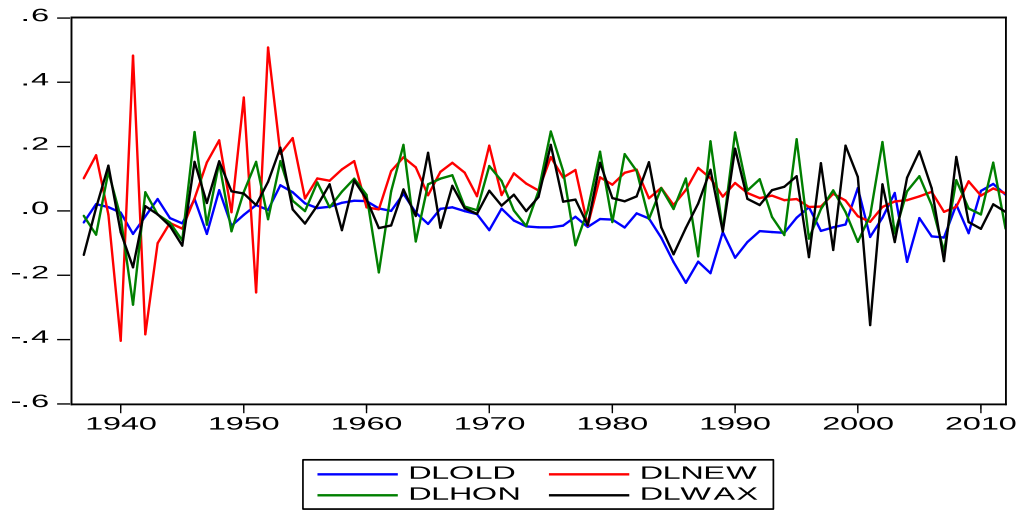

Figure 2.Stationary apiculture series of Turkey with first differences.

Table 2.Estimation of production functions

Dependent	Independent	Coefficient	Std. Er.	t-Stat.	Prob.	R-sq.	DW
LHON	C	8.120702	0.379454	21.401	0.0000	0.99	1.81
	LOLD	-0.319333	0.020643	-15.469	0.0000		
	LNEW	0.452509	0.009338	48.460	0.0000		
LWAX	C	4.942149	0.405688	12.182	0.0000	0.98	1.16
	LOLD	-0.159986	0.022070	-7.2488	0.0000		
	LNEW	0.340555	0.009983	34.112	0.0000		

Table 3.Unit root test for the residuals of production functions

Model	Variable	Coefficient	Std. Error	t-Statistic	Prob.	DW
LHON	RES(-1)	-1.154381	0.113704	-10.15249	0.0000	2.062977
LWAX	RES(-1)	-0.595535	0.103947	-5.729204	0.0000	-1.958045

ADF test results confirm the stationarity of residuals for both equations, which implies that residuals can be searched for ARMA modeling. To this end, we need the ACF and PACF of the residual series.

Table 4. Residuals ACF and PACF

	Residuals of Honey Function					Residuals of Wax Function			
	ACF	PACF	Q-Stat	Prob		ACF	PACF	Q-Stat	Prob
1	-0.155	-0.155	1.8630	0.172	1	0.404	0.404	13.092	0.000
2	-0.214	-0.243	5.4793	0.065	2	0.253	0.107	18.300	0.000
3	0.277	0.216	11.629	0.009	3	0.209	0.089	21.879	0.000
4	0.114	0.163	12.692	0.013	4	0.081	-0.057	22.432	0.000
5	-0.057	0.101	12.960	0.024	5	-0.070	-0.148	22.852	0.000
6	0.055	0.059	13.215	0.040	6	-0.127	-0.094	24.245	0.000
7	0.121	0.086	14.451	0.044	7	-0.214	-0.138	28.233	0.000
8	-0.042	-0.023	14.603	0.067	8	-0.255	-0.102	33.961	0.000
9	0.139	0.158	16.290	0.061	9	-0.233	-0.049	38.813	0.000
10	-0.116	-0.167	17.481	0.064	10	-0.305	-0.167	47.237	0.000

Note: 2 standard deviation significance band for acf orpacf values is $2(1/\sqrt{77}) = 0.228$.

Table 5.Alternative wax models

Independent	Coefficient	Std. Er.	t-Stat.	Prob.	R-sq.	DW	AIC
C	4.858945	0.619426	7.8442	0.0000	0.985	2.034	-1.892
LOLD	-0.156456	0.033448	-4.6775	0.0000			
LNEW	0.343044	0.015499	22.133	0.0000			
AR(1)	0.403468	0.106132	3.8015	0.0003			
C	4.995232	0.510086	9.7929	0.0000	0.984	1.896	-1.842
LOLD	-0.162113	0.027757	-5.8404	0.0000			
LNEW	0.338706	0.012548	26.992	0.0000			
MA(1)	0.351820	0.108819	3.2330	0.0018			

In Table 5, we have two competing models. Both are of good qualities in terms of coefficient significance and residual autocorrelations. However, even slightly it might be, the model with one autoregressive coefficient presented in the first panel seems to be outperforming the second one in terms of AIC values. Now we can get together two final models, LHON and LWAX for interpretations.

The explicit representations of estimated models are:

$$LHON = 8.120 - 0.32\,LOLD + 0.45\,LNEW$$

$$LWAX = 4.86 - 0.16\,LOLD + 0.34\,LNEW$$

$$e_t = 0.40\,e_{t-1}$$

Technological productivity in honey production is almost two times that of wax production. In both models the elasticity of production with respect to old type hives are negative. This negative effect is more pronounced in the case of honey production. The elasticity of honey production with respect to new type production is 0.45 which means that, a 1% increase in the number of new type hives will increase the honey production less than 1%. That is, honey production is less elastic against the hive numbers.

The important point regarding the old type hives is that, the maintenance of such hives cannot be acknowledged on commercial grounds. It is just a continuation of tradition. The technological productivity in both equations accounts for the increases in production more than hive inputs itself.That could be explained by learning by doing, otherwise return to scales is under unity, which means that decreasing returns to scale is prevailing.

Conclusions: We have found that technological productivity is greater than 1 for both production functions. We have attributed this to the phenomenon of learning by doing. The elasticity of honey and wax production to old types hives seen to be negative meaning that on commercial basis their maintenance is not rational. The elasticities of production with respect to new type hives are positive but less then unity, means that inelastic. This is a clear setback for the productivity of apiculture industry given the high rank Turkey's production and colony numbers in the world ranking. More sophisticated methods should be searched in order to develop productivity and competitiveness of Turkish apiculture in the world markets.

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