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Dynamics of Agricultural Areas Availability in the Republic of Moldova for the Development of the Agricultural Sector

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***Abstract*—In order to identify the most probable and timely development options, the economic and social forecasts become pertinent remedies for determining the development objectives either of the branch or of the society. Therefore, the forecasts become decisive factor in the activities of scientific formulation and argumentation of the strategy and tactics of economic and social growth, and the efficiency of economical international affairs management. The analysis of the foreign trade of the Republic of Moldova showed that the biggest share in the national exports is agrarian and agro-food products. That's why the present article perform a depth study in analyzing and determining the potential of agrarian sector development using modeling and forecasting techniques based on time series adjustment, regression and correlation functions to predict trend and development potential of the agriculture sector.The present article perform a depth study in analysing and determining the potential of agricultural areas development using modelling and forecasting techniques based on time series adjustment, regression and correlation functions to predict trend and development potential of the agriculture sector.**

***Keywords*—econometric models, methods, development, dynamics, region, potential, evolution, agricultural areas, agricultural housholder, distribution, census, investments**

I. INTRODUCTION

In order to ensure successful development conditions it is necessary to determine by the extent sufficient knowledge and data of the available researched object. Thereafter, for a deeper knowledge of the position and role of the agricultural sector in the republic's economy, we will approach agricultural areas using modeling and forecasting techniques, based on time series adjustment and regression and correlation functions.

The analysis of the land availability dynamics related to agricultural activities in the Republic of Moldova regions shows a continuous reduction of agricultural area (Figure 1), and the minimization of their share in the total country area. For these reasons, we consider opportune to analyze the dynamics of agricultural areas and agricultural households in the Republic of Moldova in order to have a clear image of the essential factors evolution that directly influences the development of the agricultural sector.

The graphical representation of the agricultural areas evolution in the Republic of Moldova indicates quite suggestive the recessive dynamics of agricultural availability (Figure 1).

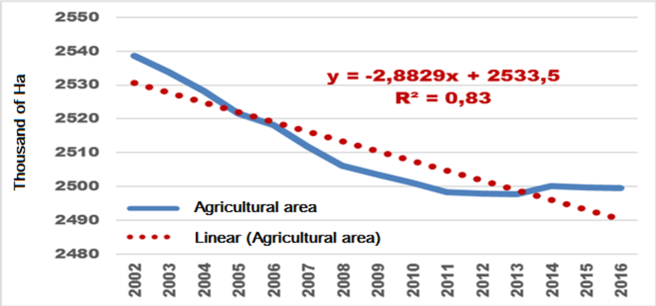

Fig. 1. The Republic of Moldova agricultural area dynamics in the (2002-2016) and the related linear trend (Source: Developed by the author based on data from the National Bureau of Statistics [1])

For a broader analysis of research issues, the works of world-renowned scientists were consulted: Ansoff I, Bertil O., De Breson X., Hu I., Dreyer B., Desai M., Dunning J H. Gottfried H., Kruger, W, YuchtmaN, E., Seashore, E., etc., [2], [3], [4], [5], [6], [7], [8], as well as the works of researchers from Republic of Moldova and Romania: Belostecinic Gr., Stratan A., Țâu N., Coretchi, B, etc. [9], [10], [11], [12], [13].

TABLE I. REPUBLIC OF MOLDOVA AGRICULTURAL AREAS - EMPIRICAL DATA, ADJUSTED ACCORDING TO THE LINEAR MODEL

Year	**Total area (thousand ha)**	**Agricultural land (thousand i ha)**	**AgriculturallLand quota (%)**	**Time parameter**	**Adjusted values (f.liniară)**	**Error (linear f.)**
		yi	gi	t	Y(lin)	e_i(lin)
A	1	2	3	4	5	6
2002	3384,6	2538,7	75,01	1	2530,63	8,07
2003	3384,6	2533,8	74,86	2	2527,75	6,05
2004	3384,6	2528,3	74,70	3	2524,87	3,43
2005	3384,6	2521,6	74,50	4	2521,98	-0,38
2006	3384,6	2518,2	74,40	5	2519,10	-0,90
2007	3384,6	2511,8	74,21	6	2516,22	-4,42
2008	3384,6	2506,2	74,05	7	2513,34	-7,14
2009	3384,6	2503,6	73,97	8	2510,45	-6,85
2010	3384,6	2501,1	73,90	9	2507,57	-6,47
2011	3384,6	2498,3	73,81	10	2504,69	-6,39
2012	3384,6	2498,0	73,80	11	2501,80	-3,80
2013	3384,6	2497,8	73,80	12	2498,92	-1,12
2014	3384,6	2500,1	73,87	13	2496,04	4,06
2015	3384,6	2499,7	73,86	14	2493,16	6,54
2016	3384,6	2499,6	73,85	15	2490,27	9,33
Total						

[a.] Source: Developed by the author based on data from the National Bureau of Statistics [1]

II. METHOD

Further, there will be performed an analysis using the trend models, in order to identify the expression legitimacy in time of the agricultural land availability and to adjust the terms of the time series,

$$y = f(t) + e \qquad (1)$$

where: y - the values of the phenomenon that are forecast; t - time parameter;e - variable expressing model residues

Therefore, in the case of available agricultural area, a dynamic series will be addressed: $\{y_i ; t_i\} \quad \forall \ i = \left(\overline{1, n}\right)$ - the number of empirical terms (years) of the time series.

The linear model will be a first adjustment model for the range of agricultural areas available in the period 2002-2016:

$$y = a + bt + e \qquad (2)$$

Where a, b represents the trend model parameters, with the significance: a – the intercept; b – the modification of resultant variables y, as a result of changing the variable t

III. RESULTS AND DISCUSSION

The identification of the regression model and estimators' determination of this model was done with the data analysis tools within the MS Excel table processor. The linear trend model presents results (considered on the regression model reliability indicators) provided in the regression analysis from the Table 2 [14].

According to the above information, the linear trend model is represented by the relation:

$$\hat{y} = \hat{a} + \hat{b}t = 2533.5 - 2.88t \qquad (3)$$

Hence, the agricultural areas (according to the adjusted data) at the initial moment of the analysis (t = 0), was about a = 2533.5 thousand ha and corresponds to the 2002 year. The average annual change in the period 2002-2016 was of -2.88 thousand ha and means an average annual reduction of agricultural land.

As mentioned above, the quality of the model is quite acceptable, which is proven by the correlation intensity indicators and statistical tests applied to the estimators of the model parameters (a and b) - the T test [15]:

Determination report:

$$R^2_{y/t} = 1 - \frac{\sum\left(y_i - Y_t\right)^2}{\sum\left(y_i - \bar{y}\right)^2} = 0.830 \qquad (4)$$

according to which about 83% of the agricultural area variation is explained by the variation of the time parameter;

Multiple correlation coefficient:

TABLE II. THE RESULTS OF THE REGRESSION ANALYSIS, ACCORDING TO THE LINEAR TREND MODEL

SUMMARY OUTPUT			ANOVA						
Regression Statistics				***df***	***SS***	***MS***	***F***	***Significance F***	
Multiple R	0,911058		Regression	1	2327,042	2327,042	63,48232	2,34E-06	
R Square	0,830026		Residual	13	476,535	36,65654			
Adj. R Square	0,816951		Total	14	2803,577				
Standard Error	6,054465								
Observations	15								
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 99,0%***	***Upper 99,0%***	
Intercept	2533,516	3,289743	770,1259	1,13E-31	2526,409	2540,623	2523,607	2543,426	
	-2,88286	0,361823	-7,96758	2,34E-06	-3,66453	-2,10119	-3,97277	-1,79295	

b. Source: Developed by the author based on data from the National Bureau of Statistics [1]

TABLE III. ELEMENTS OF THE ANOVA TEST

Dispersion components	The sum of the squares	Number of degrees of freedom	Corrected dispersion
Total (TSS)	$\sum_1^n (y_i-\bar{y})^2$	$n-1$	$S^2_{tot}=\frac{\sum_1^n (y_i-\bar{y})^2}{n-1}$
Factorial (ESS)	$\sum_1^n (\hat{y}_i-\bar{y})^2$	k	$S^2_{fact}=\frac{\sum_1^n (\hat{y}_i-\bar{y})^2}{k}$
Residual (RSS)	$\sum_1^n (y_i-\hat{y})^2$	$n-k-1$	$S^2_{rez}=\frac{\sum_1^n (y_i-\hat{y})^2}{n-k-1}$

c. Source: Developed by the author based on data from the National Bureau of Statistics [1]

$$R_{y/t}=\sqrt{1-\frac{\sum(y_i-Y_t)^2}{\sum(y_i-\bar{y})^2}}=0.911$$

It indicates a strong1 intensity of the connection between the correlated variables (agricultural areas Y and time t).

As well as the *Fisher test*, through which is testing the model (adjustment) overall quality:

$$F_{calc}=\frac{(TSS-RSS)/(k-1)}{RSS/(n-k)}=\frac{ESS/(k-1)}{RSS/(n-k)}>>>F_{1-\alpha}\,(p-1,n-k). \quad (5)$$

The necessary elements for determination of the Fisher statistics are presented in the Table 3.

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[1] , there is no significant connection;
, there is a weak connection;
, there is a medium intensity connection;
, there is a strong connection;
, there is a relatively deterministic (functional) connection.

The results of the ANOVA - Fisher test indicate a sufficiently high calculated value of Fisher statistics [15]: $F_{calc}=63.48>>F_{1-\alpha}\,(p-1,n-k)$, with a fairly high significance - $\alpha=1-p=2.34\cdot10^{-6}$, so that the model appears to be quite well specified.

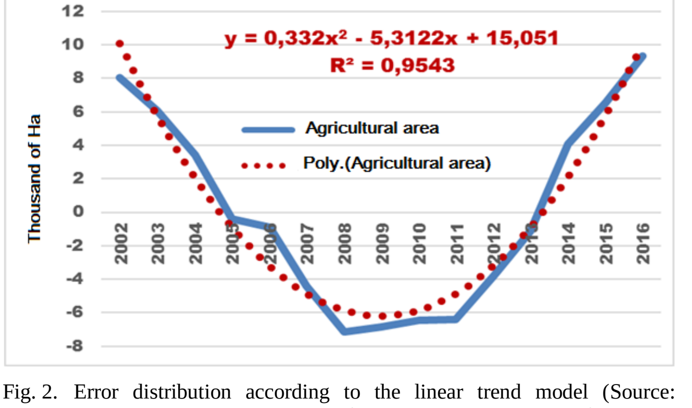

Fig. 2. Error distribution according to the linear trend model (Source: Developed by the author based on data from the National Bureau of Statistics [1])

Therefore, the linear trend model describes well the agricultural areas dynamics in the Republic of Moldova

TABLE IV. THE RESULTS OF THE REGRESSION ANALYSIS, ACCORDING TO THE POWER TREND MODEL

SUMMARY OUTPUT			ANOVA					
Regression Statistics				***df***	***SS***	***MS***	***F***	***Significance F***
Multiple R	0,97172		Regression	1	0,000418	0,000418	220,1388	1,58E-09
R Square	0,944239		Residual	13	2,47E-05	1,9E-06		
Adj. R Square	0,93995		Total	14	0,000443			
Standard Error	0,001378							
Observations	15							
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 99,0%***	***Upper 99,0%***
Intercept (ln*Y*)	7,841203	0,000946	8292,124808	4,31E-45	7,83916	7,843246	7,838354	7,844051
(*T*)	-0,00699	0,000471	-14,8370759	1,58E-09	-0,00801	-0,00597	-0,00841	-0,00557

d. Source: Developed by the author based on data from the National Bureau of Statistics [1]

from 2002-2016. However, the error distribution diagram has an almost perfect legitimacy according to the parabolic function (figure 3), although it is assumed that they should randomly manifest, so that a part of the legion of manifestation in time of the approached phenomenon by the linear function contains errors. In these circumstances we will approach other adjustment function - the power trend function, given by the relation:

$$y = at^b + e \tag{6}$$

And the regression function given by the relations:

$\hat{y} = \hat{a}t^{\hat{b}}$, sau în formă logaritmată - $\ln(\hat{y}) = \ln(\hat{a}) + \hat{b}\ln(t)$ (7)

The estimation of this model will be done similarly to the estimation procedure of the linear trend model. The results are presented in the Table 4 and Figure 3.

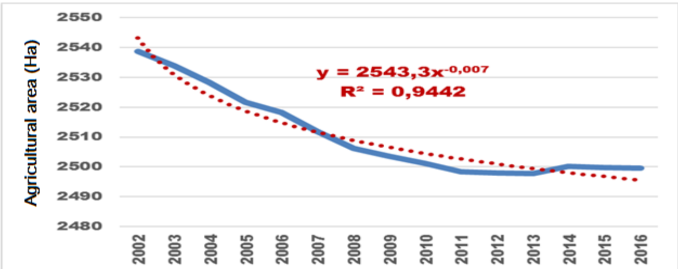

Fig. 3. Agricultural area dynamics in the Republic of Moldova (2002-2016) and the related power trend (Source: Developed by the author based on data from the National Bureau of Statistics [1])

Hence, the power trend model has the form:

$$\hat{y} = \hat{a}t^{\hat{b}} = 2543{,}3 \cdot x^{0.007} \tag{8}$$

Therefore, the agricultural area, adjusted with the power trend model, at the initial moment of the analysis (t = 0), was about a = 2543.3 thousand ha, which corresponds to 2002, and during the period 2002-2016 it decreased on average by about 0.699% per year.

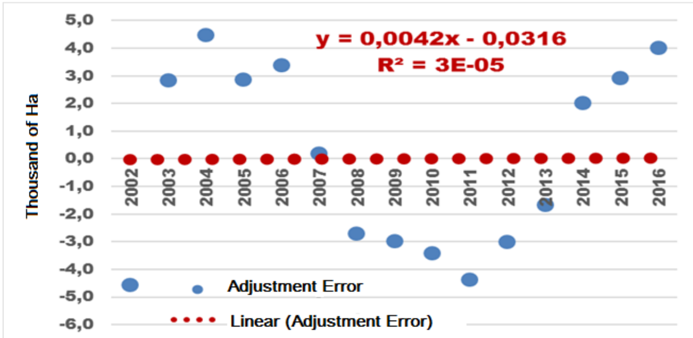

Fig. 4. Error distribution according to the power trend model (Source: Developed by the author based on data from the National Bureau of Statistics [1])

In this case, the values, adjusted on the base of power trend, describe much better the agricultural areas dynamic, and generates adjustment error lower than the linear trend model (figure 4), determining, in this context, a much more favorable model quality than in the previous case. The presented situation can also be argued by the creditworthiness indicators of the model, among which [15]:

Determination report - $R^2_{y/t} = 0.944$, according to which about 94,4% from the agricultural areas variation is due to the time parameter variation.

Multiple correlation coefficient - $R_{y/t} = 0.972$, with the significance of a functional connection between the correlated variables.

Fisher Test - $F_{calc} = 220.14 >>> F_{1-\alpha}(p-1, n-k)$, in a massive significance conditions - $\alpha = 1 - p = 1.58 \cdot 10^{-9}$, so that the model becomes much

TABLE V. REPUBLIC OF MOLDOVA AGRICULTURAL AREAS - EMPIRICAL AND ADJUSTED DATA ACCORDING TO THE POWER MODEL

Years	Total area (thousand ha)	Agricultural land (thousand i ha)	Agricultural land quota (%)	Time parameter	logarithmic time parameter	Adjusted values (power f.)	Error (power f.)	Adjusted lower limit	Adjusted upper limit
		yi	gi	t	Ln(t)	Y(power)	e_i(power)		
A	1	2	3	4	7	8	9	10	11
2002	3384,6	2538,7	75,01	1	0,000	2542,81	-4,11	2538,70	2543,26
2003	3384,6	2533,8	74,86	2	0,693	2531,23	2,57	2529,19	2532,76
2004	3384,6	2528,3	74,70	3	1,099	2524,03	4,27	2520,99	2526,63
2005	3384,6	2521,6	74,50	4	1,386	2518,92	2,68	2515,19	2522,30
2006	3384,6	2518,2	74,40	5	1,609	2514,95	3,25	2510,70	2518,94
2007	3384,6	2511,8	74,21	6	1,792	2511,71	0,09	2507,04	2516,20
2008	3384,6	2506,2	74,05	7	1,946	2508,98	-2,78	2503,95	2513,88
2009	3384,6	2503,6	73,97	8	2,079	2506,60	-3,00	2501,27	2511,88
2010	3384,6	2501,1	73,90	9	2,197	2504,51	-3,41	2498,91	2510,11
2011	3384,6	2498,3	73,81	10	2,303	2502,64	-4,34	2496,80	2508,53
2012	3384,6	2498,0	73,80	11	2,398	2500,94	-2,94	2494,90	2507,11
2013	3384,6	2497,8	73,80	12	2,485	2499,40	-1,60	2493,16	2505,80
2014	3384,6	2500,1	73,87	13	2,565	2497,98	2,12	2491,57	2504,61
2015	3384,6	2499,7	73,86	14	2,639	2496,66	3,04	2490,09	2503,50
2016	3384,6	2499,6	73,85	15	2,708	2495,43	4,17	2488,71	2502,47
Total									
2017			**73,70**	**16**		**2494,46**		**2487,43**	**2501,50**
2018			**73,67**	**17**		**2493,40**		**2486,22**	**2500,60**
2019			**73,64**	**18**		**2492,40**		**2485,08**	**2499,74**
2020			**73,61**	**19**		**2491,46**		**2484,01**	**2498,94**
2021			**73,59**	**20**		**2490,57**		**2482,99**	**2498,17**

e. Source: Developed by the author based on data from the National Bureau of Statistics [1]

better specified, with a distribution of model errors, that does not follow such a bad legitimacy.

Characterized as a relevant model for adjusting the area of agricultural land in the Republic of Moldova for the period 2002-2016,[16] next we will try to point assessments that will be based on the power trend model. Thereby, a simple extension of the time parameter will allow us to determine the forecast values for the next years (column 8 of table 5).

In order to ensure an advanced credibility for the predicted agricultural areas values, the interval forecast will be elaborated, by correcting the adjusted values with the confidence limits [14]:

$$Y_{T+p} = \hat{Y}_{T+p} \pm t_{crit} \cdot S_{\hat{Y}} \sqrt{\frac{n+1}{n} + \frac{(t_p - \bar{t})^2}{(t_i - \bar{t})^2}} \quad (9)$$

where: $S_{\hat{Y}} = \sqrt{\frac{\sum_1^n (y_i - \hat{Y}_i)^2}{n-k}}$, $\forall k = 2$ - represents the estimator of the square mean deviation of the error of the trend model.

Therefore, the agricultural areas confidence intervals, for the retrospective period (2002-2016) and for the prospective period (2017-2021) will be the following:

$$\hat{Y}_{T+p} - t_{crit} \cdot S_{\hat{Y}} \sqrt{\frac{n+1}{n} + \frac{(t_p - \bar{t})^2}{(t_i - \bar{t})^2}} \le Y_{T+p} \le \le \hat{Y}_{T+p} + t_{crit} \cdot S_{\hat{Y}} \sqrt{\frac{n+1}{n} + \frac{(t_p - \bar{t})^2}{(t_i - \bar{t})^2}} \quad (10)$$

The values of the lower and upper limits of the agricultural areas forecast with a probability of p = 0.99, for the retrospective period (2002-2016) and the prospective period (2017-2021), are presented in the table 5 columns 10 and 11, and the graph representation (figure 5) shows quite suggestively the empirical (real) situation for the period 2002-2017, the point values of the forecast for the period 2017-2021, and the confidence limits for them.

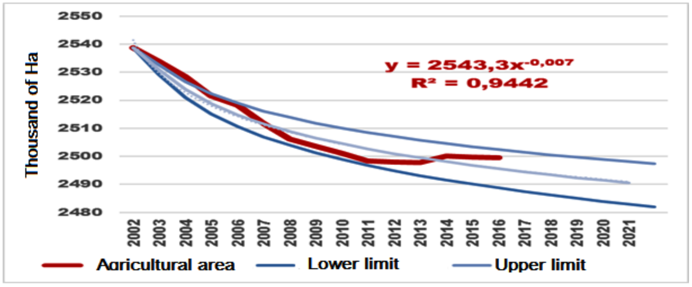

Fig. 5. The evolution of agricultural areas in the period 2002-2016 and the forecast according to the power trend model for the period 2017-2021 (Source: Developed by the author based on data from the National Bureau of Statistics [1])

IV. Conclusions

In the described circumstances, the author could say with a probability of 99%, that in the future the Republic of Moldova agricultural areas will be reduced, but with slower rates, so that towards the forecast horizon (2021) the area will be around 2482.99 and 2498.17 thousand ha, which will represent approximate weights, between 73.3% and 73.8%, lower with 1.67 and 1.22 percentage points (pp) compared to 2002 and with 0.20 and 1.15 pp lower than in 2016.

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