Forecasting Economic Indices of Agricultural Enterprises Based on Vector Polynomial Canonical Expansion of Random Sequences

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Abstract. Calculating method for forecasting economic indices of agricultural enterprises on the basis of vector polynomial exponential algorithm of extrapolation of the realizations of random sequences is worked out. The model of prognosis allows estimate the results of enterprise functioning (to estimate future gross profit, gross production) after its reorganization (change of land resources, manpower resources, fixed assets). Prognostic model does not impose any restrictions on the forecast random sequence (linearity, stationarity, Markov behavior, monotonicity, etc.) and thus allows fully take into consideration stochastic peculiarities of functioning of agricultural enterprises. The simulation results confirm high efficiency of introduced calculating method. The scheme reflecting the peculiarities of functioning of the forecast model are also introduced in the work. The method can be realized in the decision support systems for agricultural and non-agricultural enterprises with various sets of economic indices.

Keywords. calculation method, random sequence, canonical decomposition, forecasting economic indices

Key Terms. computation, mathematical model

1 Introduction

Many decision-making processes in different areas of economy (management of enterprises, transport logistics, finance forecasting, investment under uncertainty and so on) are based on the different mathematical models, experienced theoretical

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methods and modern intelligent algorithms [1-6]. For guaranteeing efficient performance of an enterprise on the market, it is necessary to form the strategy and tactics of enterprise development correctly, to ground the plans and management decisions. To do this is possible only based on effective diagnostics and prognostication of current and future economical situation at the enterprise. Western specialists have the priority in the investigation of the possibilities of the management on the basis of the forecasting of enterprise economic state. Bever (the USA) started theoretical development and building of prognostic models, then it was continued in the works of Altman (the USA) [7-8], Alberichi (Italy), Misha (France) and others [9-10]. More contemporary trend in the building of the algorithms of economic indices forecasting is the usage of stochastic methods of extrapolation. The relevance of such approach is explained with the influence of great number of accidental factors on the results of enterprise functioning (weather conditions, accidental variations of demand and supply, inflation etc.), under the influence of which the change of economic state indices obtains accidental character. It is especially important to take into account stochastic peculiarities of economic indices during the solving of the problems of prognostication of the state of agricultural enterprises.

But the existing models of prognosis impose considerable limitations on the accidental sequence describing the change of economic indices [11-16] (Markovian property, stationarity, monotony, scalarity etc.). Thereupon the problem of the building of the forecast model under the most general assumptions about the stochastic properties of the accidental process of the change of the indices of enterprise economic state arises.

2 Aim and the Raising of Problem

The aim of this work is the development of the efficient and robust method for forecasting agricultural enterprise indices. The main requirement to the forecasting method is the absence of any essential limitations on the stochastic properties of the accidental process of economic indices change.

3 Theoretical Conception of the Proposed Forecasting Method

The most universal method (from the point of view of the requirements to the investigated accidental sequence) is a method that based on the mechanism of canonical expansions [17-18]. The main primary indices of the economic state of agricultural enterprises are the gross profit, gross output, land resources, labour resources, fixed assets that is why the object of the investigation is the vector accidental sequence with five dependant constituents (if necessary the number of figures and their qualitative composition may be changed). Preliminary investigations (the check of dependence of accidental values on the basis of statistical data about the work of agricultural enterprises in Nikolaev region) showed that the accidental sequences describing the change of the economic state of the enterprises which relate to the intensive [19] type of the development during the interval of eleven years that corresponds to the processing of twelve annual indices for the great number of the enterprises of the mentioned type have the most stable and significant stochastic relations. For such vector accidental sequence the canonical expansion has the following look [20]:

$$X_h(i) = M\left[X_h(i)\right] + \sum_{\nu=1}^{i}\sum_{\lambda=1}^{5} V_\nu^{(\lambda)} \varphi_{h\nu}^{(\lambda)}(i),\ i = \overline{1,12},\ h = \overline{1,5}, \quad \textbf{(1)}$$

where $X_1(i),\ i = \overline{1,12}$ - gross profit;

$X_2(i),\ i = \overline{1,12}$ - gross output;

$X_3(i),\ i = \overline{1,12}$ - land resources;

$X_4(i),\ i = \overline{1,12}$ - labour resources;

$X_5(i),\ i = \overline{1,12}$ - fixed assets.

The elements of canonical expansion are the accidental coefficients $V_\nu^{(\lambda)},\ \nu = \overline{1,12},\ \lambda = \overline{1,5}$ and nonrandom coordinate functions $\varphi_{h\nu}^{(\lambda)}(i)$, $\nu = \overline{1,12},\ \lambda = \overline{1,5}$:

$$V_\nu^{(\lambda)} = X_\lambda(\nu) - M\left[X_\lambda(\nu)\right] - \sum_{\mu=1}^{\nu-1}\sum_{j=1}^{H} V_\mu^{(j)} \varphi_{\lambda\mu}^{(j)}(\nu) - -\sum_{j=1}^{\lambda-1} V_\nu^{(j)} \varphi_{\lambda\nu}^{(j)}(\nu), \nu = \overline{1,12}; \quad \textbf{(2)}$$

$$D_\lambda(\nu) = M\left[\left\{V_\nu^{(\lambda)}\right\}^2\right] = M\left[\left\{X_\lambda(\nu)\right\}^2\right] - M^2\left[X_\lambda(\nu)\right] - -\sum_{\mu=1}^{\nu-1}\sum_{j=1}^{H} D_j(\mu)\left\{\varphi_{\lambda\mu}^{(j)}(\nu)\right\}^2 - \sum_{j=1}^{\lambda-1} D_j(\nu)\left\{\varphi_{\lambda\nu}^{(j)}(\nu)\right\}^2,\ \nu = \overline{1,12}; \quad \textbf{(3)}$$

$$\varphi_{h\nu}^{(\lambda)}(i) = \frac{M\left[V_\nu^{(\lambda)}\left(X_h(i) - M[X_h(i)]\right)\right]}{M\left[\left\{V_\nu^{(\lambda)}\right\}^2\right]} = \frac{1}{D_\lambda(\nu)}(M\left[X_\lambda(\nu)X_h(i)\right] - -M\left[X_\lambda(\nu)\right]M\left[X_h(i)\right] - \sum_{\mu=1}^{\nu-1}\sum_{j=1}^{H} D_j(\mu)\varphi_{\lambda\mu}^{(j)}(\nu)\varphi_{h\mu}^{(j)}(i) - -\sum_{j=1}^{\lambda-1} D_j(\nu)\varphi_{\lambda\nu}^{(j)}(\nu)\varphi_{h\nu}^{(j)}(i),\ \lambda = \overline{1,5}, \nu = \overline{1,i}. \quad \textbf{(4)}$$

Coordinate functions $\varphi_{h\nu}^{(\lambda)}(i), h, \lambda = \overline{1,5},\ \nu, i = \overline{1,12}$ have the following properties:

$$\varphi_{h\nu}^{(\lambda)}(i) = \begin{cases} 1, & h = \lambda \quad \& \quad \nu = i; \\ 0, & i < \nu \text{ or } h<\lambda \,\&\, \nu = i. \end{cases} \quad \textbf{(5)}$$

The algorithm of extrapolation on the basis of canonical expansion has the look [20]:

$$m_h^{(\mu,l)}(i)=\begin{cases} M[X_h(i)], \mu=0, \\ m_h^{(\mu,l-1)}(i)+\left[x_l(\mu)-m_l^{(\mu,l-1)}(\mu)\right]\varphi_{h\mu}^{(l)}(i), l\neq 1, \\ m_h^{(\mu,5)}(i)+\left[x_1(\mu)-m_1^{(\mu-1,5)}(\mu)\right]\varphi_{h\mu}^{(1)}(i), l=1, \end{cases} \quad \textbf{(6)}$$

where $m_h^{(\mu,l)}(i)=M\left[X_h(i)/x_\lambda(\nu),\ \lambda=\overline{1,5},\ \nu=\overline{1,\mu-1};\ x_j(\mu), j=1,l\right],\ h=\overline{1,5},$ $i=\overline{k,12}$ - is the linear optimal quantity by the criterion of the minimum of the average square of the error of the prognosis is the estimation of the future values of the investigated sequence under the condition that the values are known $x_\lambda(\nu),\ \lambda=\overline{1,5},\ \nu=\overline{1,\mu-1};\ x_j(\mu),\ j=\overline{1,l}$.

Essential deficiency of the forecast model (6) is the assumption of existence of only linear stochastic relations in the sequence $X_h(i),\ h=\overline{1,5},\ i=\overline{1,12}$, describing the process of change of economic indices of agricultural enterprises. The analysis of statistical data about the work of agricultural enterprises of Nikolaev region showed that the stochastic relations till the fourth order $M\left[\overset{o}{X}{}_h^l(\nu)\overset{o}{X}{}_m^s(i)\right]\neq 0,\ \nu,i=\overline{1,12},\ l+s\leq 4,\ h,m=\overline{1,5}$ are essential for such a sequence. Non-linear canonical model of the investigated sequence with taking account of non-linear relations takes the form [21]:

$$X_h(i)=M\left[X_h(i)\right]+\sum_{\nu=1}^{i-1}\sum_{l=1}^{5}\sum_{\lambda=1}^{3}W_{\nu l}^{(\lambda)}\beta_{l\lambda}^{(h,1)}(\nu,i)+\sum_{l=1}^{h-1}\sum_{\lambda=1}^{3}W_{il}^{(\lambda)}\beta_{l\lambda}^{(h,1)}(i,i)+W_{ih}^{(1)},\ i=\overline{1,12}. \quad \textbf{(7)}$$

Random coefficients $W_{\nu l}^{(\lambda)},\ \nu=\overline{1,12},\ l=\overline{1,5},\ \lambda=\overline{1,3}$ and nonrandom coordinate functions $\beta_{l\lambda}^{(h,s)}(\nu,i),\ \nu,i=\overline{1,12},\ l,h=\overline{1,5},\ \lambda,s=\overline{1,3}$ are determined with the help of expressions:

$$W_{\nu l}^{(\lambda)}=X_l^{\lambda}(\nu)-M\left[X_l^{\lambda}(\nu)\right]-\sum_{\mu=1}^{\nu-1}\sum_{m=1}^{5}\sum_{j=1}^{3}W_{\mu m}^{(j)}\beta_{mj}^{(l,\lambda)}(\mu,\nu)- \quad \textbf{(8)}$$

$$-\sum_{m=1}^{l-1}\sum_{j=1}^{3}W_{\nu m}^{(j)}\beta_{mj}^{(l,\lambda)}(\nu,\nu)-\sum_{j=1}^{\lambda-1}W_{\nu l}^{(j)}\beta_{lj}^{(l,\lambda)}(\nu,\nu),\ \nu=\overline{1,12};$$

$$D_{l,\lambda}(\nu)=M\left[\left\{W_{\nu l}^{(\lambda)}\right\}^2\right]=M\left[X_l^{2\lambda}(\nu)\right]-M^2\left[X_l^{\lambda}(\nu)\right]- \quad \textbf{(9)}$$

$$-\sum_{\mu=1}^{\nu-1}\sum_{m=1}^{5}\sum_{j=1}^{3}D_{mj}(\mu)\left\{\beta_{mj}^{(l,\lambda)}(\mu,\nu)\right\}^2-\sum_{m=1}^{l-1}\sum_{j=1}^{3}D_{mj}(\nu)\left\{\beta_{mj}^{(l,\lambda)}(\nu,\nu)\right\}^2-$$

$$-\sum_{j=1}^{\lambda-1}D_{lj}(\nu)\left\{\beta_{lj}^{(l,\lambda)}(\nu,\nu)\right\}^2,\ \nu=\overline{1,12};$$

$$\beta_{l\lambda}^{(h,s)}(\nu,i)=\frac{M\left[W_{\nu l}^{(\lambda)}\left(X_h^s(i)-M[X_h^s(i)]\right)\right]}{M\left[\left\{W_{\nu l}^{(\lambda)}\right\}^2\right]}= \tag{10}$$

$$=\frac{1}{D_{l\lambda}(\nu)}(M\left[X_l^{\lambda}(\nu)X_h^s(i)\right]-M\left[X_l^{\lambda}(\nu)\right]M\left[X_h^s(i)\right]-$$

$$-\sum_{\mu=1}^{\nu-1}\sum_{m=1}^{5}\sum_{j=1}^{3}D_{mj}(\mu)\beta_{mj}^{(l,\lambda)}(\mu,\nu)\beta_{mj}^{(h,s)}(\mu,i)-$$

$$-\sum_{m=1}^{l-1}\sum_{j=1}^{3}D_{mj}(\nu)\beta_{mj}^{(l,\lambda)}(\nu,\nu)\beta_{mj}^{(h,s)}(\nu,i)-$$

$$-\sum_{j=1}^{\lambda-1}D_{lj}(\nu)\beta_{lj}^{(l,\lambda)}(\nu,\nu)\beta_{lj}^{(h,s)}(\nu,i),\ \lambda=\overline{1,h},\ i=\overline{1,12},\ \nu=\overline{1,i}.$$

Vector algorithm of extrapolation [22-24] for the considered quantity of the components and order of stochastic relations on the basis of canonical expansion (7) takes the form:

$$m_{j,h}^{(\mu,l)}(s,i)=\begin{cases}M\left[X_h(i)\right],\ \mu=0;\\ m_{j,h}^{(\mu,l-1)}(s,i)+\left(x_j^l(\mu)-m_{j,j}^{(\mu,l-1)}(l,\mu)\right)\beta_{j,l}^{(h,s)}(\mu,i),\ l>1,\ j<5;\\ m_{j,h}^{(\mu,3)}(s,i)+\left(x_{j+1}(\mu)-m_{j,j+1}^{(\mu,1)}(3,\mu)\right)\beta_{j+1,1}^{(h,s)}(\mu,i),\ l=1,\ j<5;\\ m_{5,h}^{(\mu,3)}(s,i)+\left(x_1(\mu+1)-m_{5,1}^{(\mu,3)}(3,\mu+1)\right)\beta_{1,1}^{(h,s)}(\mu+1,i),l=1,\ j=5.\end{cases} \tag{11}$$

$m_{j,h}^{(\mu,l)}(1,i)=M\left[X_h(i)/x_\lambda^n(\nu),\ \lambda=\overline{1,5},n=\overline{1,3},\nu=\overline{1,\mu-1};x_\lambda^n(\mu),\lambda=\overline{1,j},n=\overline{1,l}\right]$ is optimal by the criterion of minimum of mean-square error of prognosis estimation of future values of economic index with ordinal number h provided that for the prognosis values $x_\lambda^n(\nu),\ \lambda=\overline{1,5},\ n=\overline{1,3},\ \nu=\overline{1,\mu-1};\ x_\lambda^n(\mu),\ \lambda=\overline{1,j},\ n=\overline{1,l}$ are used.

Altogether 165 values $x_h^{\lambda}(i),h=\overline{1,5},\ i=\overline{1,11},\ \lambda=\overline{1,3}$ and 5220 not equal to zero weight coefficients $\beta_{l\lambda}^{(h,s)}(\nu,i),\ \nu,i=\overline{1,12},\ 1,h=\overline{1,5},\ \lambda,s=\overline{1,3}$ are used in the algorithm of prognosis (11).

The expression for mean-square error of extrapolation with the help of algorithm (11) by known values $x_j^n(\mu),\ \mu=\overline{1,k};j=\overline{1,5};\ n=\overline{1,3}$ is in the form:

$$E_h^{(k,3)}(i)=M\left[X_h^2(i)\right]-M^2\left[X_h(i)\right]-\sum_{\mu=1}^{k}\sum_{j=1}^{5}\sum_{n=1}^{3}D_{jn}(\mu)\left\{\beta_{jn}^{(h,1)}(\mu,i)\right\}^2,i=\overline{k+1,12}. \tag{12}$$

This expression is equal to dispersion of a posteriori casual sequence $\left\{X_h(i)/x_\lambda^n(\nu),\ \lambda=\overline{1,5},n=\overline{1,3},\nu=\overline{1,\mu-1};x_\lambda^n(\mu),\lambda=\overline{1,j},n=\overline{1,l}\right\}$.

In Fig. 1 the scheme reflecting the peculiarities of functioning of the forecast model (11) is represented.

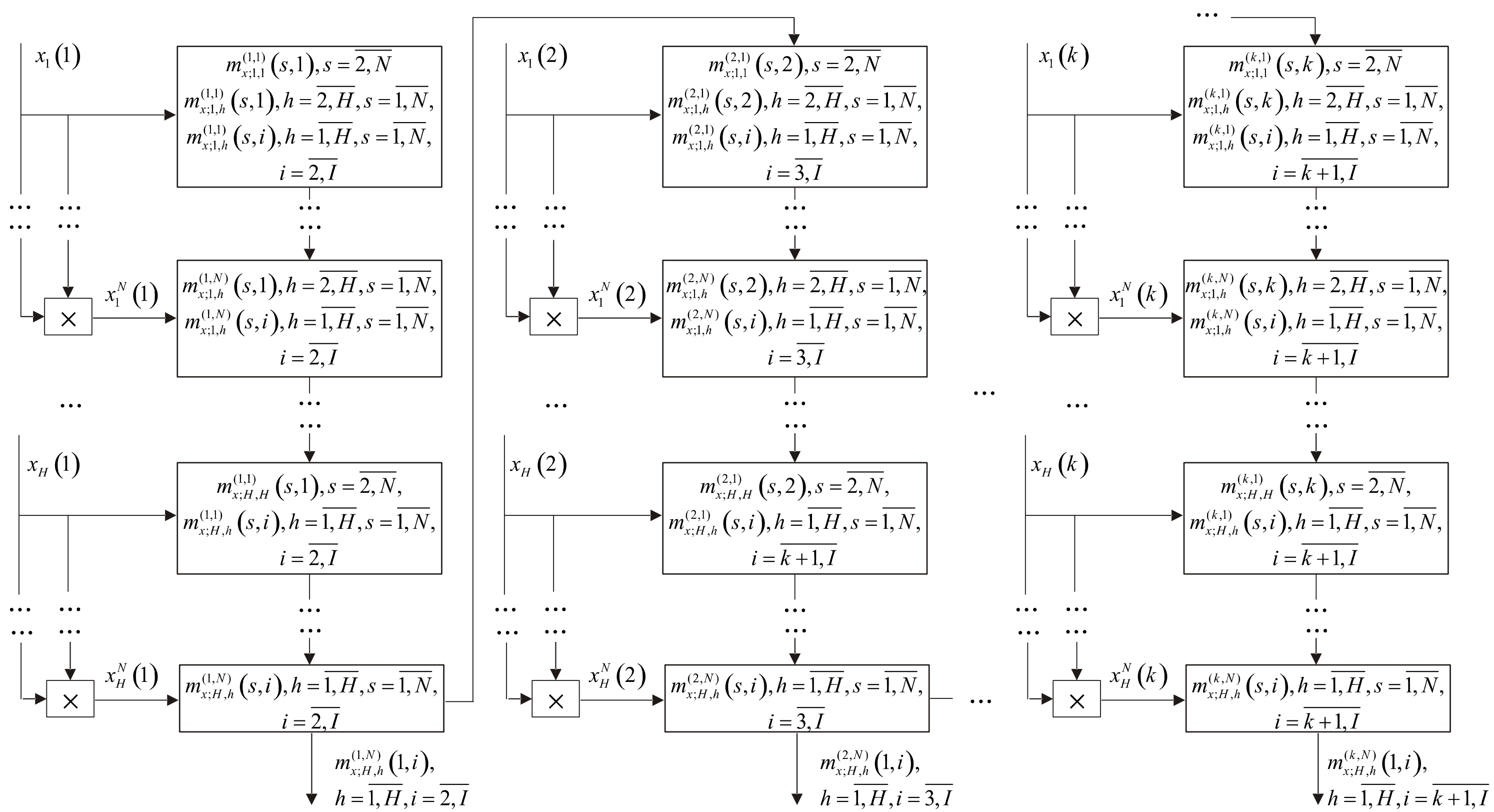

Fig. 1. Scheme of functioning of the forecast model (11) $(N=3,\ H=5)$

Method of prognostication of future values of economic indices on the basis of the forecast model (11) presupposes realization of the following stages:

Stage 1. Gathering of statistical data about the results of enterprises functioning;

Stage 2. Estimation of moment functions $M\left[X^{s}(i)\right]$, $M\left[X_{j}^{l}(\nu)X_{h}^{s}(i)\right]$ on the basis of cumulated realizations of random sequence describing the process of change of economic indices;

Stage 3. Calculating of the parameters of the algorithm of extrapolation (11);

Stage 4. Estimation of future values of economic indices on the basis of the forecast model (11);

Stage 5. Estimation of the quality of the solving of the forecast problem for investigated sequence with the help of the expression (12).

4 Results of Numerical Experiment

Method is approbated on the basis of statistical data of functioning of agricultural enterprises in Nikolaev region during the period 2004-2015 (74 enterprises with gross profit 200-900 thousands grivnas). Moment functions $M\left[X_{h}^{s}(i)\right]$, $M\left[X_{j}^{l}(\nu)X_{h}^{s}(i)\right]$ were estimated by known formulae of mathematical statistics for sections 2004, 2005, …, 2014. Data about the work of the enterprises for 2015 were supposed to be unknown and the estimation of moment functions $M\left[X_{h}^{s}(12)\right]$, $M\left[X_{j}^{l}(\nu)X_{h}^{s}(12)\right]$ for the last section (corresponding to 2015) was carried out on the basis of determinate models with the use of four previous years (2011-2014) in tabular processor Microsoft Excel (instrument "Search for solutions"). For example, in Table 1 the values of autocorrelated function $M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(i)\right]$, $\nu=\overline{1,12}$, i=$\overline{1,12}$ for the component $X_{1}(i)$, i=$\overline{1,12}$ (gross profit) are represented.

For 2015 values $M\left[\overset{o}{X}_{h}(\nu)\overset{o}{X}_{h}(12)\right]$, $\nu=\overline{1,11}$ are obtained on the basis of determinate model:

$$M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(12)\right]=0,718M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(11)\right]\text{-}0,053M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(10)\right]+ \quad \textbf{(13)}$$

$$+0,2128M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(9)\right]-0,105M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(8)\right],\ \nu=\overline{1,11},$$

Coordinate function $\beta_{11}^{(1,1)}(\nu,i)$ $\nu,i=\overline{1,12}$ (Table 2) corresponds to correlated function $M\left[\overset{o}{X}_{1}(\nu)\overset{o}{X}_{1}(i)\right]$, $\nu=\overline{1,12}$, $i=\overline{1,12}$.

Table 1. Autocorrelated function of the component $X_1(i)$, i=$\overline{1,12}$

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2004	1	0,99	0,70	0,42	0,79	0,74	0,49	0,72	0,63	0,46	0,55	0,43
2005	0,99	1	0,72	0,42	0,74	0,74	0,52	0,70	0,64	0,48	0,59	0,46
2006	0,70	0,72	1	0,57	0,67	0,58	0,701	0,69	0,70	0,66	0,78	0,60
2007	0,42	0,42	0,57	1	0,38	0,36	0,45	0,21	0,41	0,36	0,19	0,18
2008	0,79	0,74	0,67	0,38	1	0,81	0,55	0,91	0,80	0,72	0,53	0,41
2009	0,74	0,74	0,58	0,36	0,81	1	0,72	0,73	0,92	0,81	0,51	0,44
2010	0,49	0,52	0,70	0,45	0,55	0,72	1	0,51	0,74	0,73	0,49	0,41
2011	0,72	0,70	0,69	0,21	0,91	0,73	0,51	1	0,77	0,80	0,74	0,55
2012	0,63	0,64	0,70	0,41	0,80	0,92	0,74	0,77	1	0,91	0,60	0,59
2013	0,46	0,48	0,66	0,36	0,72	0,81	0,73	0,80	0,91	1	0,71	0,46
2014	0,55	0,59	0,78	0,19	0,53	0,51	0,49	0,74	0,60	0,71	1	0,71
2015	0,43	0,46	0,60	0,18	0,41	0,44	0,41	0,55	0,59	0,46	0,71	1

Table 2. Coordinate function $\beta_{11}^{(1,1)}(\nu,i)$ $\nu,i=\overline{1,12}$

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2004	1	0,89	0,54	0,55	0,62	0,43	0,45	0,89	0,858	0,90	2,36	2,65
2005	0	1	2,25	-1,46	-2,40	0,27	5,47	-2,71	3,55	1,83	2,85	4,70
2006	0	0	1	5,09	1,17	-1,53	-0,03	-2,77	-0,23	-5,52	2,34	5,07
2007	0	0	0	1	0,17	0,26	0,94	0,18	0,77	1,05	-0,57	-1,17
2008	0	0	0	0	1	0,48	1,27	1,06	1,05	2,01	-2,37	0,69
2009	0	0	0	0	0	1	-1,81	0,74	3,53	0,37	9,31	2,86
2010	0	0	0	0	0	0	1	-0,68	1,44	3,18	-6,74	-3,39
2011	0	0	0	0	0	0	0	1	1,29	2,21	-3,30	0,93
2012	0	0	0	0	0	0	0	0	1	3,88	0,19	-8,44
2013	0	0	0	0	0	0	0	0	0	1	1,99	-4,96
2014	0	0	0	0	0	0	0	0	0	0	1	0,50
2015	0	0	0	0	0	0	0	0	0	0	0	1

In Table 3 weight coefficients $\beta_{13}^{(1,1)}(\nu,i)$ $\nu,=\overline{1,11},\ i=\overline{2,12}$ determining the influence of values $x_1^3(i),\ i=\overline{1,11}$ of gross profit in high-order third degree on future values of this parameter are represented.

Table 3. Values of coordinate function $\beta_{13}^{(1,1)}(\nu,i)$ $\nu,=\overline{1,11},\ i=\overline{2,12}$

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2004	$9*10^{-6}$	$-1*10^{-7}$	$-3*10^{-7}$	$-5*10^{-7}$	$-3*10^{-7}$	$-2*10^{-7}$	$-8*10^{-6}$	$-3*10^{-6}$	$-1*10^{-6}$	$-3*10^{-7}$	$-4*10^{-7}$
2005	0	$-1*10^{-4}$	$-1*10^{-4}$	$1*10^{-5}$	$-3*10^{-4}$	$3,5*10^{-5}$	$7*10^{-5}$	10^{-4}	$6*10^{-5}$	$-2*10^{-4}$	$8*10^{-5}$
2006	0	0	$-1*10^{-5}$	$2*10^{-6}$	$-3*10^{-6}$	$-9*10^{-7}$	$2*10^{-8}$	$6*10^{-6}$	$-6*10^{-6}$	$-9*10^{-6}$	$-7*10^{-7}$
2007	0	0	0	$2*10^{-8}$	$-9*10^{-8}$	$2*10^{-9}$	$3*10^{-8}$	$7*10^{-8}$	$8*10^{-9}$	$4*10^{-9}$	$3*10^{-7}$
2008	0	0	0	0	$-8*10^{-8}$	$2*10^{-8}$	$2*10^{-8}$	$7*10^{-7}$	$3*10^{-7}$	$4*10^{-7}$	$3*10^{-8}$
2009	0	0	0	0	0	$-8*10^{-7}$	$-6*10^{-7}$	$-7*10^{-7}$	$-4*10^{-8}$	$-3*10^{-7}$	$-9*10^{-8}$
2010	0	0	0	0	0	0	$8*10^{-9}$	$8*10^{-6}$	$5*10^{-7}$	-10^{-8}	$-4*10^{-7}$
2011	0	0	0	0	0	0	0	$2*10^{-5}$	$8*10^{-7}$	$-2*10^{-6}$	$8*10^{-6}$
2012	0	0	0	0	0	0	0	0	$2*10^{-8}$	$4*10^{-7}$	$-3*10^{-6}$
2013	0	0	0	0	0	0	0	0	0	$3*10^{-8}$	$-7*10^{-6}$
2014	0	0	0	0	0	0	0	0	0	0	$9*10^{-6}$

As it can be seen in Table 3 values $\beta_{11}^{(3)}(i),\ i=\overline{1,11}$ are relatively small but this doesn't mean that given weight coefficients don't influence on the forming of the estimation of future value as $\beta_{11}^{(3)}(i),\ i=\overline{1,11}$ are multiplied in the process of calculations by values $x_1^3(i),\ i=\overline{1,11}$ (values of the sixth-seventh order).

For functioning of the forecast model (11) on the basis of statistical data 25 tables of weight coefficients analogous to Tables 2-3 were calculated.

During the application of the method of economic indices prognostication for 2016 optimal order of non-linear relations of the investigated random sequence is unknown. But taking into consideration that N=4 is invariable during 11 years there is quite high probability that given parameter will remain on the same level.

Values in Table 4 reflects the change of relative error of prognostication of gross profit of enterprise (component $X_1(i),\ i=\overline{1,12}$) during 2015 depending on the order of stochastic relations used in model (11).

Table 4. Relative error of prognostication of gross profit

Order of stochastic relations	2	3	4
Relative error	6,9 %	3,3 %	1,5 %

Thus the results of the experiment showed (Table 4) that application of nonlinear relations in the forecast model allows increase considerably the quality of economic indices prognostication.

5 Conclusion

Calculating method of the estimation of future values of economic indices of agricultural enterprises functioning is obtained in the work. The algorithm of extrapolation of vector random sequence based on nonlinear polynomial canonical expansion is assumed as a basis of the method. The optimal algorithm of the extrapolation of the economic indices of agricultural enterprises, which as well as canonical expansion put into its base doesn't impose any essential limitations on the stochastic properties of economic indices. In addition to pre-aggregate indicators (gross output, land resources, manpower, plant and equipment) a range of parameters can be used as the components of investigated random sequence (weather conditions, prices of resources, etc) influencing the effectiveness of the functioning of agricultural enterprises. The results of the numerical experiment showed that the forecast model possesses high accuracy characteristics at the expense of maximal taking into consideration of stochastic qualities of random sequence of economic indices change. Schemes of calculation of the parameters of the forecast model and estimations of future values of economic indices on its basis are introduced in the work. Expression for the mean-square error of extrapolation allows to estimate the quality of the forecast problem solving.

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