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MANAGEMENT OF AN AGRICULTURAL ENTERPRISE ON THE BASIS OF ITS ECONOMIC STATE FORECASTING

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Abstract: On the basis of the mechanism of accidental sequences canonical expansions the algorithm of the economic state of agricultural enterprise forecasting is obtained which allows to estimate the results of its work in future under the realization of a certain reorganization (change of land resources, labour resources, fixed assets).

Keywords: accidental sequence, canonical expansion, algorithm of extrapolation.

INTRODUCTION

Economic state is the most important criterion of business activity and reliability of an enterprise that determines its competitive ability and potential in effective realization of the economic interests of all participants of economic activity. For ensuring of successful work the management of an enterprise needs to be able to estimate and forecast realistically its economic state as well as partners and competitors. The models of forecasting are the one instrument of the determination of current enterprise state or possibilities of its development. But such practice in the management of Ukrainian enterprises is absent. Mainly the experts whose methods don't have clear scientific ground and have the name "nosology" which means intuitive approaches basing on personal working experience are occupied with the forecasting at enterprises and banks. 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 started theoretical development and building of prognostic models, then it was continued in the works of Altman (the USA) [Altman 1994], [Altman and other 1997], Alberichi (Italy), Misha (France) and others [Granger and other 1986], [Hall 1994]. 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. But the existing models of prognosis impose considerable limitations on the accidental sequence describing the change of economic indices [Trifonov and other 1998], [Ryabushkin 1987], [Teyl 1971], [Szmuksta-Zawadzka 2013], [Prędki 2013], [Połoński 2012] (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.

AIM AND THE RAISING OF PROBLEM

The aim of this work is the development of the technology of agricultural enterprise management on the basis of the algorithm of the forecasting of the indices of its work. The main requirement to the forecasting algorithm is the absence of any essential limitations on the stochastic properties of the accidental process of economic indices change.

THE SOLVING OF PROBLEM

The most universal from the point of view of the requirements to the investigated accidental sequence is the method that bases on the mechanism of canonical expansions [Pugachev 1962], [Kudritskiy 2001]. 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) showed that the accidental sequences describing the change of the economic state of the enterprises which relate to the intensive [Sirenko 2010] 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:

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

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 $\varphi_{h\nu}^{(\lambda)}(i)$, $\nu=\overline{1,12},\ \lambda=\overline{1,5},\ h=\overline{1,12},\ i=\overline{1,5}$:

$$V_\nu^{(\lambda)} = X_\lambda(\nu) - M\left[X_\lambda(\nu)\right] - \sum_{\mu=1}^{\nu-1}\sum_{j=1}^{5} V_\mu^{(j)} \varphi_{\lambda\mu}^{(j)}(\nu) - \tag{2}$$

$$-\sum_{j=1}^{\lambda-1} V_\nu^{(j)} \varphi_{\lambda\nu}^{(j)}(\nu),\nu=\overline{1,12};$$

$$D_\lambda(\nu) = M\left[\left\{V_\nu^{(\lambda)}\right\}^2\right] = M\left[\left\{X_\lambda(\nu)\right\}^2\right] - M^2\left[X_\lambda(\nu)\right] - \tag{3}$$

$$-\sum_{\mu=1}^{\nu-1}\sum_{j=1}^{H} D_j(\mu)\left\{\varphi_{\lambda\mu}^{(j)}(\nu)\right\}^2 - \sum_{j=1}^{\lambda-1} D_j(\nu)\left\{\varphi_{\lambda\nu}^{(j)}(\nu)\right\}^2,\ \nu=\overline{1,12};$$

$$\varphi_{h\nu}^{(\lambda)}(i) = \frac{M\left[V_\nu^{(\lambda)}\left(X_h(i) - M[X_h(i)]\right)\right]}{M\left[\left\{V_\nu^{(\lambda)}\right\}^2\right]} = \frac{1}{D_\lambda(\nu)}(M\left[X_\lambda(\nu)X_h(i)\right] - \tag{4}$$

$$-M\left[X_\lambda(\nu)\right]M\left[X_h(i)\right] - \sum_{\mu=1}^{\nu-1}\sum_{j=1}^{5} D_j(\mu)\varphi_{\lambda\mu}^{(j)}(\nu)\varphi_{h\mu}^{(j)}(i) -$$

$$-\sum_{j=1}^{\lambda-1} D_j(\nu)\varphi_{\lambda\nu}^{(j)}(\nu)\varphi_{h\nu}^{(j)}(i),\ \lambda=\overline{1,5},\nu=\overline{1,i}.$$

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

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

The algorithm of extrapolation on the basis of canonical expansion has the look [Atamanyuk 2005], [Atamanyuk and other 2012]:

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

where $m_h^{(\mu,l)}(i) = M\left[X_h(i) / x_\lambda(\nu),\ \lambda = \overline{1,5},\ \nu = \overline{1,\mu-1};\ x_j(\mu), j = \overline{1,l}\right],\ h = \overline{1,5},$ $i = \overline{\mu+1,12}$ - 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 for random parameters $X_\lambda(\nu)$ are known $x_\lambda(\nu),\ \lambda = \overline{1,5},\ \nu = \overline{1,\mu-1};\ x_j(\mu),\ j = \overline{1,l}$. In [Atamanyuk 2009] in the form of a theorem is proved that the algorithm has optimal characteristics.

As it follows from (4) the values $\varphi_{h\nu}^{(\lambda)}(i), h, \lambda = \overline{1,5},\ \nu, i = \overline{1,12}$ are determined through auto- and mutually correlated functions of the investigated vector accidental sequence. In the Table 1 the values of autocorrelated function are

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

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2002	1	0,99	0,70	0,42	0,79	0,74	0,49	0,72	0,63	0,46	0,55	0,43
2003	0,99	1	0,72	0,42	0,74	0,74	0,52	0,70	0,64	0,48	0,59	0,46
2004	0,70	0,72	1	0,57	0,67	0,58	0,70	0,69	0,70	0,66	0,78	0,60
2005	0,42	0,42	0,57	1	0,38	0,36	0,45	0,21	0,41	0,36	0,19	0,18
2006	0,79	0,74	0,67	0,38	1	0,81	0,55	0,91	0,80	0,72	0,53	0,41
2007	0,74	0,74	0,58	0,36	0,81	1	0,72	0,73	0,92	0,81	0,51	0,44
2008	0,49	0,52	0,70	0,45	0,55	0,72	1	0,51	0,74	0,73	0,49	0,41
2009	0,72	0,70	0,69	0,21	0,91	0,73	0,51	1	0,77	0,80	0,74	0,55
2010	0,64	0,64	0,70	0,41	0,80	0,92	0,74	0,77	1	0,91	0,60	0,59
2011	0,47	0,48	0,66	0,36	0,72	0,81	0,73	0,80	0,91	1	0,71	0,46
2012	0,55	0,59	0,78	0,19	0,53	0,51	0,49	0,74	0,60	0,71	1	0,71
2013	0,43	0,46	0,60	0,18	0,41	0,44	0,41	0,55	0,59	0,46	0,71	1

presented ($M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(i)\right],\ \nu=\overline{1,12},\ i=\overline{1,12}$) for the first constituent.

For the period of 2002-2012 the values of the autocorrelated functions $M\left[\overset{o}{X}_h(\nu)\overset{o}{X}_h(i)\right],\ \nu=\overline{1,11},\ i=\overline{1,11},\ h=\overline{1,5}$ determined by means of the processing of statistic data (indices of the activity of Nikolaev region agricultural enterprises during 2002-2012). For 2013 $M\left[\overset{o}{X}_h(\nu)\overset{o}{X}_h(12)\right],\ \nu=\overline{1,11},\ h=\overline{1,5}$ are calculated on the basis of the determinate models:

$$M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(12)\right]=0,718M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(11)\right]\text{-}0,053M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(10)\right]+ \\ +0,2128M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(9)\right]-0,105M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(8)\right],\ \nu=\overline{1,11}, \tag{7}$$

$$M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(12)\right]=1,435M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(11)\right]-0,01M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(10)\right]+ \\ +0,082M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(9)\right]-0,011M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(8)\right]-0,485,\ \nu=\overline{1,11}, \tag{8}$$

$$M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(12)\right]=0,997M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(11)\right]\text{-}\ 0,002M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(10)\right]+ \\ +0,002M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(9)\right]-0,015M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(8)\right],\ \nu=\overline{1,11}, \tag{9}$$

$$M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(12)\right]=0,995M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(11)\right]+0,003M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(10)\right]+ \\ -0,001M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(9)\right]-0,002M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(8)\right],\ \nu=\overline{1,11}, \tag{10}$$

$$M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(12)\right]=0,786M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(11)\right]\text{-}\ 0,056M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(10)\right]+ \\ -0,017M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(9)\right]+0,059M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(8)\right],\ \nu=\overline{1,11}, \tag{11}$$

The parameters of the equation (7)-(11) satisfy the minimum of the average error of approximation (relative error of the forecast is not more than 1 %).

In the Table 2 coordinate function $\varphi_{1\nu}^{(1)}(i),\ \nu,i=\overline{1,12}$ corresponding to autocorrelated function $M\left[\overset{o}{X}_1(\nu)\overset{o}{X}_1(i)\right],\ \nu=\overline{1,12},\ i=\overline{1,12}$ and determining the degree of the influence of former values of gross profit for future values is presented.

Table 2. Value of the coordinate function $\varphi_{1\nu}^{(1)}(i),\ \nu,i=\overline{1,12}$

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2002	0,89	0,54	0,55	0,62	0,43	0,45	0,89	0,858	0,90	2,36	2,65
2003	1	2,25	-1,46	-2,40	0,27	5,47	-2,71	3,55	1,83	2,85	4,70
2004	0	1	5,09	1,17	-1,53	-0,03	-2,77	-0,23	-5,52	2,34	5,07
2005	0	0	1	0,17	0,26	0,94	0,18	0,77	1,05	-0,57	-1,17
2006	0	0	0	1	0,48	1,27	1,06	1,05	2,01	-2,37	0,69
2007	0	0	0	0	1	-1,81	0,74	3,53	0,37	9,31	2,86
2008	0	0	0	0	0	1	-0,68	1,44	3,18	-6,74	-3,39
2009	0	0	0	0	0	0	1	1,29	2,21	-3,30	0,93
2010	0	0	0	0	0	0	0	1	3,88	0,19	-8,44
2011	0	0	0	0	0	0	0	0	1	1,99	-4,96
2012	0	0	0	0	0	0	0	0	0	1	0,50
2013	0	0	0	0	0	0	0	0	0	0	1

Additionally to the Table 2 in the model (6) the values $\varphi_{h\nu}^{(\lambda)}(i), h,\lambda=\overline{1,5},\ h\neq\lambda,\ \nu,i=\overline{1,12}$ which allow to consider mutual stochastic relations between the constituents $X_h(i),\ h=\overline{1,5}$ (for example, the influence of land resources on gross profit, labour resources on gross output etc.) are used.

The future values of the mathematical expected value of the investigated vector accidental sequence {X} are estimated with the usage of the determinate model

$$M\left[X_h(12)\right]=2,392M\left[X_h(11)\right]-1,923M\left[X_h(10)\right]+ \\ +1,087M\left[X_h(9)\right]-0,105M\left[X_h(8)\right],\ h=\overline{1,5}. \tag{12}$$

The parameters of the equation (12) as well as in (7)-(11) are determined from the condition of the minimum of the average error of approximation. For agricultural enterprises of Nikolaev region related to intensive type of development the mathematical expectations are $M\left[X_1(12)\right]=4276,9$, $M\left[X_2(12)\right]=12844,5$.

In all in the algorithm of the prognosis (6) 55 entrance values $x_h(i), h=\overline{1,5},\ i=\overline{1,11}$ and 1775 that are not equal to zero balance coefficients $\varphi_{h\nu}^{(\lambda)}(i), h,\lambda=\overline{1,5},\ \nu,i=\overline{1,12}$ are used.

For the increase of the effectiveness of the calculating processes during the prognosis by extrapolator (6) it is advisably to use the calculating procedure the substance of which is the fulfillment of the following stages:

Step 1. For the fixed point t_ν (initially $\nu=1$) the dispersions $D_\lambda(\nu)$ (initially $\lambda=1$) of the accidental coefficients $V_\nu^{(\lambda)}$ with the help of the expression (3) are determined;

Step 2. Using the obtained at the previous step value $D_\lambda(\nu)$ coordinate functions $\varphi_{h\nu}^{(\lambda)}(i)$ for $h=\overline{\lambda,5};\ i=\overline{\nu,12}$ by the formula (4) are calculated;

Step 3. The condition $\lambda<5$ is checked. If the outcome is positive, λ is increased by one $\lambda=\lambda+1$ and the transition to Step 1 is fulfilled. Otherwise the calculating process is continued by the transition to the next Step 4.

Step 4. The check of $\nu<12$ is fulfilled. If the condition is performed, the value ν is increased by one $\nu=\nu+1$, the parameter λ is given the value one $\lambda=1$ and the transition to Step 1 is fulfilled. If the condition is not carried out, it means that the parameters of the extrapolator are determined for all points of discretization in which accidental process is viewed and the transition to Step 5 is fulfilled;

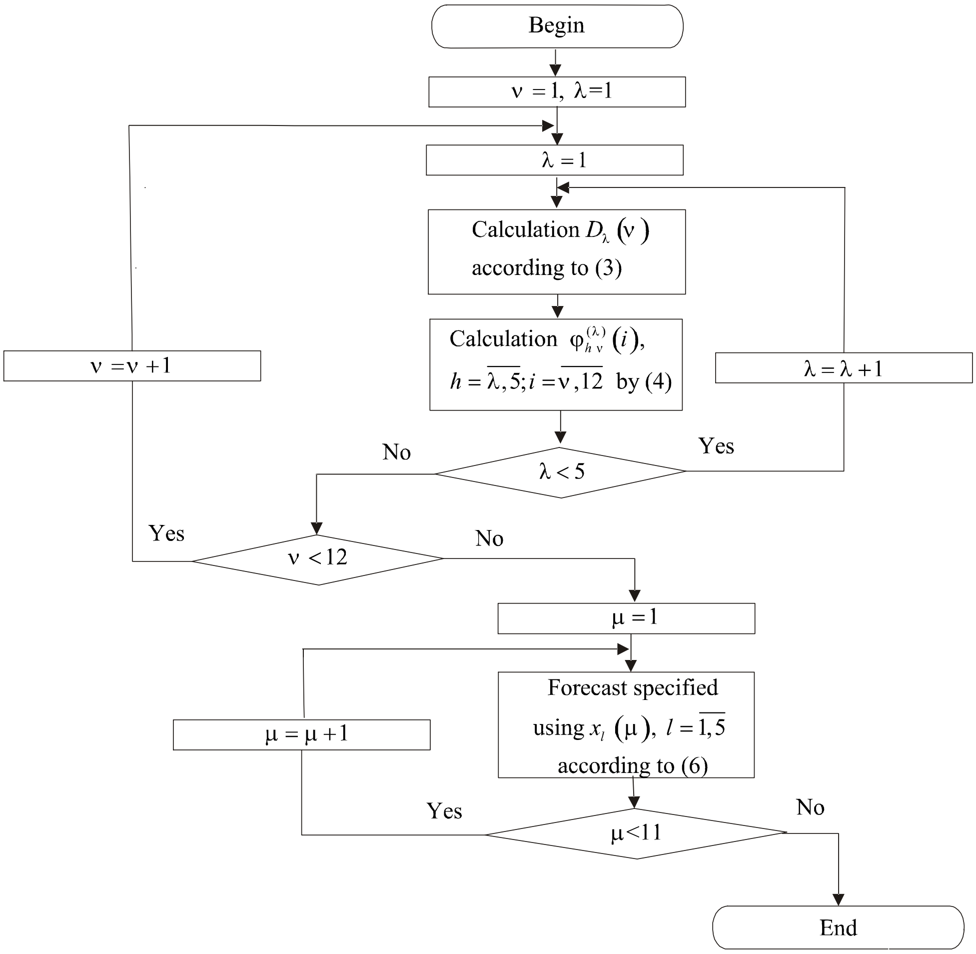
Step 5. The estimation of the future value of the investigated process is specified by the introduction into the calculating process the next value $x_l(\mu),\ l=\overline{1,5}$ (initially $\mu=1$). For $l=1$ the third expression of the formula (6) is used, for $l=\overline{2,5}$ the second one is used;

Step 6. It is checked whether all values are used for the forecast: $\mu=11$. If the condition is fulfilled, the process of calculations is finished, otherwise the value μ. Is increased by one $\mu=\mu+1$ and the transition to Step 5 is fulfilled.

The block diagram in Figure 1 illustrates the work of the algorithm.

Model (6) gives the possibility to estimate gross profit $x_1(12)$ and gross output $x_2(12)$ for 2013 for a certain enterprise basing on the data $x_h(i), h=\overline{1,5},\ i=\overline{1,11}$ of its work for eleven previous years. The comparison of the prognostic values which are obtained by means of the extrapolation algorithm with the statistic data of the results of agricultural enterprises work of Nikolaev region for 2013 indicates high effectiveness of the developed prognostic model (relative error 2-3%).

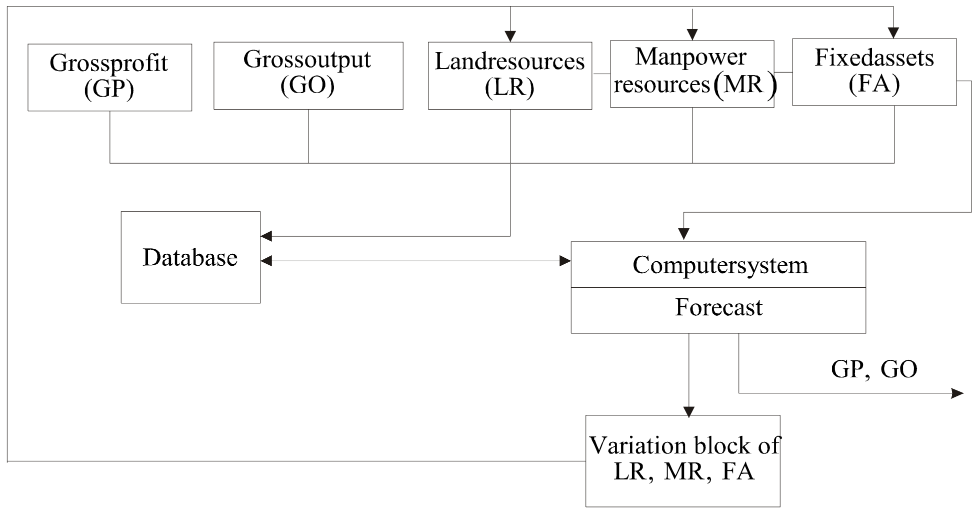
Figure 1. Block diagram of the functioning of the algorithm (6).



New known results of enterprises functioning for 2013 allows to specify the characteristics of the algorithm (6) and the extrapolator can be used for the enterprise management at the level of the parameters $x_3(12)$ - land resources in 2013, $x_4(12)$ - labour resources in 2013, $x_5(12)$ - fixed assets in 2013 for the achievement of the required effect for 2014.

The diagram of the computer system functioning on the basis of the developed technology of management is presented in Figure 2.

Figure 2. Computer system for the forecast and management of an agricultural enterprise.



CONCLUSIONS

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 is obtained.

The model of the forecast allows to estimate the results of enterprise functioning after its reorganization (the change of land resources, manpower, fixed assets).

The offered method of management may be also realized for nonagricultural enterprises with other set of economic indices.

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