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## EXPERIENCE OF DEVELOPMENT AND APPLICATION OF EXPERT SYSTEMS FOR ECONOMIC MACROPARAMETERS FORECASTING AND OPERATION

Alexey Voloshyn, Victoria Satyr

*Annotation:* In this article there are considered problems of forecasting economical macroparameters, and in the first place, index of inflation. Concept of development of synthetical forecasting methods which use directly specified expert information as well as calculation result on the basis of objective economical and mathematical models for forecasting separate "slowly changeable parameters" are offered. This article discusses problems of macroparameters operation on the basis of analysis of received prognostic magnitude.

*Key words:* decision tree method, index of inflation, expert information, operation.

*ACM Classification Keywords:* H.4.2 Information Systems Applications: Types of Systems: Decision Support.

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### Introduction

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In articles [Voloshyn, 2003, 2005, 2006, 2007, 2008] presented on "Knowledge-Dialog-Solution" (KDS) conferences there is developed concept of "subjective multideterminism" [Voloshyn 2006, 2007] for qualitative forecasting of economic macroparameters and in the first place of inflation index. This concept is based on the fact that effect is determined by the variety of interdependent reasons (objective and subjective). Reasons themselves (factors, parameters) and intensity of their interaction are determined subjectively (by expert judgment) and are presented by "illegible" decision tree (by its tops and arcs appropriately), "effect" (result of forecasting) is resented by leaves of the tree. There are developed instruments that allow to execute tree derivation (to insert and to eliminate tops, specify rating of arcs), to find more probable development of scenario of predictable process, to define magnitude of predicting parameter "illegibly". The construction of an applied system of support of decision-making is reduced to highlighting by experts of problems and sub problems (tops of the tree) and links between them (arcs of the tree). Experts determine the weights (probabilities) of transitions between tops. It is acceptable to get unclear expert estimations achieved by the Boolean variables described by the values of function of belonging (by vectors of the real numbers from 0 to 1). Every expert sets three estimations – optimistic, realistic and pessimistic, the scaling of which is effected taking into account the psychological type of the expert. The type is determined on the basis of psychological tests built into the system. Such psychological tests help to determine the coefficients of «veracity», «independence», «caution», etc.

The tree is built on the basis of collective estimations of experts using the method of pair comparisons. The construction of a resulting tree requires the use of the algebraic methods of treatment of expert information, and the Hemming metrics and measure of lacks of coincidence of grades of objects is used as distance between ranges. A resulting tree is determined as the Kemeny-Snella median or as a compromise [Voloshyn, 2005]. In the case of setting priorities in an unclear form the elements of matrix are set through the functions of belonging.

The algorithms of successive analysis of variants [Voloshyn, Panchenko, 2002] allowing to process trees with hundred tops are offered for determining optimum ways within the tree.

At KDS conferences there were voiced and published in [Voloshyn, 2007] predictable magnitude of inflation index I Ukraine diverging from actual for 3-5%.

Particularly in June of 2007 at KDS-07 inflation index on 01.01.2008 was set calculated in the first quarter of 2007: "National Bank of Ukraine predicts inflation in Ukraine in 2007 at the rate of 7%, government – 8%. Our prediction is 17.3%. We just need to wait for the beginning of KDS-08 conference and to compare our predictions". As it's known actual rate Of inflation was 16.6%. If to take into account that inflation index was considered by us as "unclear" parameter and magnitude 17.3% - "the most probable" (maximizing membership function) received result is worth attention. And with previous "coincidences" mentioned above to the authors' opinion it is worth scrupulous attention.

At present (April, 2008) inflation in Ukraine is topic number one. For the first quarter of 2008 inflation in Ukraine has become the highest amongst all Former Soviet Union countries (CIS), specified in budget magnitude of 9.6% are already exceeded (9,7%). Cabinet of Ministers of Ukraine has worsened forecast of inflation growth according to the results of 2008 from 9, 6% to 15,3% which is mentioned in the Cabinet of Ministers of Ukraine Resolution No. 581 dated June 27, 2008 "Adoption of Amendment to the Cabinet of Ministers of Ukraine Resolution No. 976 dated July 27, 2007", posted on the site of the government as UNIAN broadcasts. The government also changed forecast of price index for industrial production manufacturers according t the result of that year from 19, 2% to 24, 6%. As it was notified in accordance with data of State Statistics Committee inflation in Ukraine from May to April was 1, 3% by May, 2007 – 31, 1%. In April, 2008 by April of the previous year it was 30, 2%, in January-April till analogous period of 2007- 24, 4%. From the beginning of current year till April growth of consumer prices was 13, 1%. Inflation in April contrary to that in March, 2008 was 3,1%. Growth of price index for manufacturers in Ukraine in January-May, 2008 contrary to January-May, 2007 was 31, 7%. According to data of State Statistics Committee growth of manufacturers' prices in May contrary to April, 2008 was 3, 7% and to December, 2007 – 24,2%. Cabinet of Ministers of Ukraine improved forecast of nominal GDP according to the results of 2008 from 921,2 to 956,8 billion hryvnas without change of its growth at the rate of 6,8%.

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### **Operation of predictable parameters**

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While controlling socio-economic processes especially in the period of transition it is necessary to foresee inflation rate alongside with other factors. Inflation substantially and sometimes vitally influences on flow of real income of population, formation of investment climate, pace of industry and agriculture development, execution of budget's income, exchange rates and so on.

Forecasting models we have review earlier [Voloshyn, 20

03, 2005, 2006, 2007] can be referred to the class of "Positive" that answer the question "What will be?". Though experts evaluating degree of parameters' interaction to some extent take into consideration its change at forecasting interval, these models can be considered "time-independent" (or stationary). "Normative" models answer the question "How shall it be?" and must recommend amending "stationary" scenario. In our models it is realized by the following reformations in "decision-making tree" - by determination of "narrow places" (arcs and tops that down to the limit influence on the result) with the purpose of recommendation of "correction" of causes degree interaction (in particular inserting and eliminating tops) for receiving desirable magnitudes of forecasting parameter (for example, value pf inflation index mustn't exceed 10%). In addition, suggested models and program instruments of their realization accordingly differ from suggested in the previous realizations at the following point. For "objectification" [Voloshyn, 2006, 2007] of decision-making process in predictable model some ratings of arcs are determined on the basis of relative economical and mathematical models (see further). From formally mathematical point of view "correction" of decision-making tree is analysis of its sensitivity [Voloshyn, 2006] but if correction of arcs' rating can be called traditional analysis insertion-elimination of tops needs development of ad hoc algorithms.

**Forecasting and operation of inflation in “bottlenecks”**

Hundreds of monographs and thousands of articles are devoted to the research of inflation. We will shortly describe main factors effecting inflation that were used by us in a varying degree for forecasting of inflation rate [Barro, 1998], [Greene, 2000], [Baumol, 2001], [Poroshenko, 2008].

**First**, worldwide tendency of the last years is impetuous increase in price for supplies and energy resources. Index of world prices for supplies that is calculated by investment bank Goldman Sachs in 2006 grew for 26%, and in 2007 for 41% in the connection with what bank’s experts introduced the term of “agflation” (sudden increase in price for agricultural production).

**Second**. Increase in price for fuel is also long-term tendency. On 16th of April, 2008 oil price broke another record achieve USD 115 for barrel.

**Third**. Also more serious problem in Ukraine is impetuous expansion of foreign liabilities of bank. Only for 2007 amount of drawn by banks foreign credits grew almost twice – from USD 14 to USD 31 billion. As these means are used for consumer lending such debt is becoming powerful factor of inflation.

**Forth**. Inflation wouldn’t be so noticeably sped-up if economy of Ukraine responded key criteria of market economy. In particular there are not used possibilities for progressive expansion of labour productivity.

In the purpose of “objectiveness” in modified variant of expert system for forecasting parameters a priori change of which isn’t spasmodic (for example, in demography, see figure 1) there are used regression models.

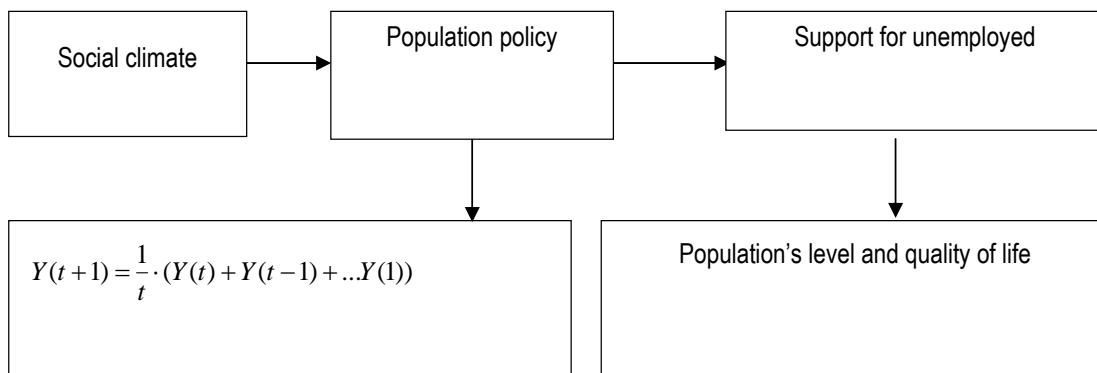


Figure 1.

Preliminary tests of models demonstrated that forecasting for trend equations doesn’t present any correct predictions because dynamics of inflation rate changes is difficult. That is why single-factor regression models were chosen. Multiple factors should be taken into consideration during forecasting including government, bank and financial structures policy, real changes in economy, world markets situation, position of developed countries governments concerning Ukraine sand many other factors. Regression equation looks like  $Y=a+bx$ , where Y is composite Consumer Price Index in percentage by previous December (predictable rate); a- fragmenton equal to

initial value of dependent variable;  $b$  – inclination that shows how much inflation rate is changing with the change of factor  $x$  per unit.

The following regression models are used. The simplest model based on plain averaging is

$$Y(t+1) = (1/t) * [Y(t) + Y(t-1) + \dots + Y(1)],$$

and unlike the simplest “naïve” model which is conformed with “tomorrow it will be as it’s today” principle this model is based on “tomorrow it will be as it is today for the latest time”. Such model is for sure more resistant to fluctuations because mavericks about the mean are smoothed. However, this method is as simple ideologically as “naïve” models and it has almost the same defects. In the above presented formula it is supposed that row is averaged during quite long period of time. However, as a rule values of time series from the recent times characterize forecast than “older” values of this row. Then moving average  $Y(t+1) = (1/(T+1)) * [Y(t) + Y(t-1) + \dots + Y(t-T)]$  can be used for forecasting. Its meaning is that model sees only recent past (per  $T$  time counts deep) and being based only on these data it makes prediction. For forecasting exponential mean-value method was also used. Formula describing this model looks like  $Y(t+1) = a * Y(t) + (1-a) * ^AY(t)$ , where  $Y(t+1)$  is a forecast for the following period of time;  $Y(t)$  – operational significance at the period of time;  $^AY(t)$  – previous forecast at the moment  $t$ ;  $a$  – consonant of evening-out ( $0 < a <= 1$ ).

Inflation influences not only on debt relationship of such subjects like households, bank, entrepreneurial and financial sectors but also on debt relationship between state and households and entrepreneurial sector (national domestic debt) and intergovernmental debt relationship. Consequently, the next connection we are going to consider will be inflation and national debt. Reasons of limited capacities of national debt loss of value in the modern conditions are:

- Increase of state short term debts portion;
- Increase of sensitivity rate (elasticity coefficient) of reaction of interest rate value on inflation rate;
- Provision with long-term and intermediate credits not in corpore at once but by tranches that allows considering inflation processes influence on loan amount.

There were considered influence of inflation on long-term loans. Let’s discuss influence of inflation on contracts that determine salary level. Labor market supply and demand have common determinant (according to the neoclassical theory) which is actual salary level. Agreeing on its amount, employers and employees react in a definite way on conditions that have been formed at the labor market. If, for example, gross domestic product rate (GDP) and employment are high salary tends to increase. And vice versa – if GDP and employment decreases salary is increasing slowly. Phillips’ wage curve represents connection between salary inflation (loss of value) and GDP decelerating and can be expressed by formula :  $q = \lambda(Y - Y^*)$ , where  $\lambda$  is sensitive coefficient (elasticity) of salary response on changes of GDP amount,  $Y$  – GDP real volume,  $Y^*$  - potential.

Taking into account inflationary expectations equation of Phillips’ curve changes into  $q = Pe + \lambda(Y - Y^*)$ , where  $Pe$  - expected inflation rate. There is presented fragment of mathematical model built in decision tree on the figure 2.

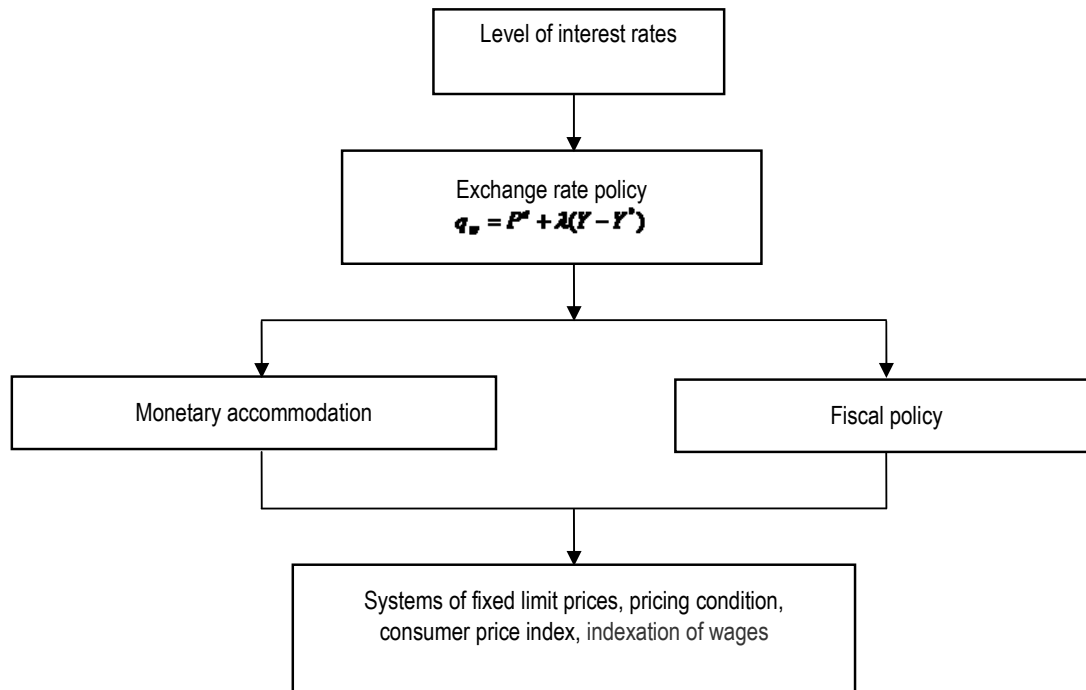


Figure 2

The last equation means that at any prescribed GDP level salary increases faster than anticipated inflation rate. It is supposed that nominal wage increases at 1% faster for every additional percent of anticipated inflation.

Said about demands answer to the question "Why do enterprises agree for such salary acceleration?" Such behavior of entrepreneurs is explained by the fact that increase of nominal wage will not be vulnerable for them if prices for their production are growing at the same rate. In such case both entrepreneurs and employees are in such conditions in which they would be if there is no inflation.

Consequently, wage-push expects anticipated inflation. But as we already know inflation can be unexpected. In such case employees realize wage-push and inflation of their salaries only after some time and will demand relevant compensation. In such situation compensation becomes recovery of losses only in case of unexpected inflation that wasn't taken into consideration in previous labor contract. Collective arrangements entered by trade unions that have requirement of wage indexing with adjustment for inflation also bring particular confusion on the matter if this compensation is for previous inflation or the expected one.

This condition is very important for the further forecasting of inflation rates. If labor rates for the next year expresses inflation rate of the previous year and prices are based on the actual salary so today inflation will express yesterday's one and inflation rates will change slowly.

- If for determining labor rates only anticipated inflation is taken into consideration the policy radical change is possible that changes expectation concerning fast change of inflation rate. Besides mentioned aspect it

is important to remember another aspect of this problem. Salary can be indexed for 100% or only partially for example for 50-60%.

- There are two ways of salary partial indexation:
- Upper bound delimiting of prices increase exceeding of which provides compensation. For example, if inflation rate exceeds 5% so from 5,1% income begins to be indexed;
- Upper bound delimiting of compensation. This way limits values that are used for compensation of prices increase by beforehand fixed percentage. Making labor contracts for 2-5 years can't provide with complete certainty change of inflation rate especially in shaky economy. That is why for adjustment for inflation there are used two the most widespread ways:
- indexation of wages in accordance with Consumer Price Index and periodic (quarterly or once a half of year) salary revision regarding its increase according to the prices increase for this period;
- prediction of periodic salary increase announced beforehand considering increase of expected prices rates.

If inflation could be predicted with complete certainty both methods would have similar consequences. But as expectations are often mistaken it is considered that indexation based on actual rates of inflation guarantees stability of actual salary more reliably than when pay-outs are decided beforehand.

Inflation influences not only on share of debtors and creditors, employees and entrepreneurs but also it effects state interests. Yes, in conditions of inflation there occurs voluntary prolongation of payments for state budget by taxpayers that allows taxpayer to settle accounts with state by undervalued money. This phenomenon of inflationary taxing in scientific literature was called "Oliver-Tanzi effect".

This effect shortly can be explained as following: any inflation decreases tax weight. It develops with more strength with growth of inflation rate and prolongation of tax payment time.

At the same time it must be noticed that inflation weakening tax weight predetermined by explained above reasons creates another, opposite tendency.

Forecasting of inflation can be done on the basis of index of consumer price change with consideration of pent-up demand. Pent-up demand is equal to population compulsory savings. They are calculated by progressive total for range of years taking into consideration of their year-on-year increase. At the same time index of required savings is equal to good circulation and services index. Year-on-year increase and good circulation, and services value ratio present hidden inflation or population cash income index and good circulation and services index ratio.

On the macrolevel inflation rate can be determined on the basis of Fisher's equation.

$$MV = PQ,$$

where M is amount of currency in circulation; V - velocity of money; P - price; Q - good sales and services value.

As inflation is caused by many factors, its level can be forecasted by development of multifactor models. As factors there may be: change in the exchange rate, growth of money supply, change of refinancing rate and so on. Popular way of forecasting inflation is also calculation of its level on the basis of GDP deflator. Thus inflation shall be explained as money's loss of value. One of the most obvious factors of inflation presence or absence, its depth is price index. As indirect indicator of inflation level are used statistic data of trade stock and amount of population money on deposit ratio (reduction of stock and increase of deposits give evidence about increase of inflationary tension rate). Forecasting of inflation is made on the basis of index of consumer prices change with taking into consideration of pent-up demand. On the macrolevel inflation rate can be determined on the basis of Fisher's equation.



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## Conclusions

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In the development of qualitative forecasting concept on the basis of unclear decision tree it is offered to use "built-up" economical and mathematical models of forecasting separate parameters in the first place determining tree's "bottlenecks". On the basis of the previous analysis of received prognostic values of inflation index in Ukraine for 2008 there are suggested the following (in first priority decrease order) controlling influences with the purpose of correction of adverse forecast of inflation index values (our previous forecast is rated at 30%): salary indexation of budget, graduated income tax levy, backing of agricultural sector, state control of monopolies ("natural" and "artificial"), introduction of minimum hourly pay, reduction of interest for bank loans, refusal from pegging of national currency to USD.

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## Authors' Information

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*Oleksiy Fedorovych Voloshyn, Kyiv Taras Shevchenko National University, Faculty of Cybernetics, Professor. Kyiv, Ukraine. E-mail: [ovoloshin@unicyb.kiev.ua](mailto:ovoloshin@unicyb.kiev.ua)*

*Victoria Valeriyivna Satyr, Kyiv Taras Shevchenko National University, Faculty of Cybernetics, postgraduate student. Kyiv, Ukraine. E-mail: [Brili@Ukr.net](mailto:Brili@Ukr.net)*