

AD/A-000 622

LOGICAL STRUCTURE AND VERIFICATION OF
PREDICTIONS

V. Kosolapov

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

30 October 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

Unclassified

Security Classification

AD/A-000 622

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

| | |
|---|--|
| 1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE
LOGICAL STRUCTURE AND VERIFICATION OF PREDICTIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
V. Kosolapov

| | | |
|------------------------|------------------------------|-----------------|
| 6. REPORT DATE 1971 | 7a. TOTAL NO. OF PAGES 14 | 7b. NO. OF REFS |
|------------------------|------------------------------|-----------------|

| | |
|---|---|
| 8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d. | 9a. ORIGINATOR'S REPORT NUMBER(S) FTD-HC-23-2345-74 |
| | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. DISTRIBUTION STATEMENT
Approved for public release;
distribution unlimited.

| | |
|-------------------------|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Foreign Technology Division Wright-Patterson AFB, Ohio |
|-------------------------|---|

13. ABSTRACT
05

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. Department of Commerce
Springfield VA 22151

EDITED TRANSLATION

FTD-HC-23-2345-74

30 October 1974

LOGICAL STRUCTURE AND VERIFICATION OF PREDICTIONS

By: V. Kosolapov

English pages: 9

Source: Sovet Ekonomicheskoy Vzaimopomoshchi.
Postoyannaya Komissiya po Kooordinatsii
Nauchnykh i Tekhnicheskikh Issledovaniy.
Teoriya i Praktika Prognozirovaniya Raz-
vitiya Nauki i Tekhniki v Stranakh-Chlen-
akh Sev, 1971, pp. 137-142

Country of Origin: USSR

Translated under: F33657-72-D-0855

Requester: FTD/PDTA

Approved for public release;
distribution unlimited.

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

All figures, graphs, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

| Block | Italic | Transliteration | Block | Italic | Transliteration |
|-------|----------|-----------------|-------|----------|-----------------|
| А | <i>а</i> | A, a | Р | <i>р</i> | R, r |
| Б | <i>б</i> | B, b | С | <i>с</i> | S, s |
| В | <i>в</i> | V, v | Т | <i>т</i> | T, t |
| Г | <i>г</i> | G, g | У | <i>у</i> | U, u |
| Д | <i>д</i> | D, d | Ф | <i>ф</i> | F, f |
| Е | <i>е</i> | Ye, ye; E, e* | Х | <i>х</i> | Kh, kh |
| Ж | <i>ж</i> | Zh, zh | Ц | <i>ц</i> | Ts, ts |
| З | <i>з</i> | Z, z | Ч | <i>ч</i> | Ch, ch |
| И | <i>и</i> | I, i | Ш | <i>ш</i> | Sh, sh |
| Я | <i>я</i> | Y, y | Щ | <i>щ</i> | Shch, shch |
| К | <i>к</i> | K, k | Ъ | <i>ъ</i> | " |
| Л | <i>л</i> | L, l | Ы | <i>ы</i> | Y, y |
| М | <i>м</i> | M, m | Ь | <i>ь</i> | ' |
| Н | <i>н</i> | N, n | Э | <i>э</i> | E, e |
| О | <i>о</i> | O, o | Ю | <i>ю</i> | Yu, yu |
| П | <i>п</i> | P, p | Я | <i>я</i> | Ya, ya |

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ѣ in Russian, transliterate as yě or ě. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

**FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH
DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS**

| Russian | English |
|-----------|--------------------|
| sin | sin |
| cos | cos |
| tg | tan |
| ctg | cot |
| sec | sec |
| cosec | csc |
| sh | sinh |
| ch | cosh |
| th | tanh |
| cth | coth |
| sch | sech |
| csch | csch |
| arc sin | sin ⁻¹ |
| arc cos | cos ⁻¹ |
| arc tg | tan ⁻¹ |
| arc ctg | cot ⁻¹ |
| arc sec | sec ⁻¹ |
| arc cosec | csc ⁻¹ |
| arc sh | sinh ⁻¹ |
| arc ch | cosh ⁻¹ |
| arc th | tanh ⁻¹ |
| arc cth | coth ⁻¹ |
| arc sch | sech ⁻¹ |
| arc csch | csch ⁻¹ |
| — | |
| rot | curl |
| lg | log |

LOGICAL STRUCTURE AND VERIFICATION OF PREDICTIONS

The most difficult intellectual operation in predicting future events is the verification of the prognostication. There are various opinions on this question. Many authors consider prediction, especially in the scientific fields, to be more of an art than a rationally based activity. It is a fact that up to 70-80 percent of intermediate predictions are accurate. For example, in the period 1950-1958, 48 out of 57 planned scientific and technical accomplishments were correctly predicted, while only 9 turned out to be unpredictable.

Many investigators consider it feasible to work out scientifically based predictions of the development of the economy or of agriculture in general, of the general characteristics of a scientific or technical process, or of the development of the capacity of various scientific and technical sectors. E. Yanch worked out an analysis of many of the methods used in practice to predict events and demonstrated that the majority of them give results with rather high validity.

Therefore, the number of prognostications that materialize is quite impressive. However, at the same time, not a few do not. Obviously the opinion that prediction is an art is based on these occurrences. After all, the fact that many predictions are realized does not prove that predictions as a whole are reliable. The verification of the prediction according to actual events is made more impractical since

then the prediction cannot be used as a criterion for choosing between alternatives in the decision-making process. Thus, even as the prediction is being worked out, a need arises to verify it.

Prediction is the process of generating scientific information about the future and consists of a series of logical steps: choice and manipulation of primary sources, information analysis to determine trends in the development of events, determination of the relative importance of weighting factors, etc. At all of these stages the planner to one or another degree investigates the reliability of intermediate results.

In practice, definite empirical relationships have been worked out for predicting, by means of which the reliability of a prognosis can be evaluated. For example, to verify assumptions on which a prediction of the realization of some event in the near future has been made the following expression exists:

$$M = RF \cdot RC \sum_{i=j}^n \frac{T_i}{(1+r)^i},$$

where M -- maximum expenses;

RF -- probability of the attainment of technical success;

RC -- probability of economic success;

i -- no. of years needed for the accomplishment of the prediction;

T_i -- amount of revenue accumulated at the end of each year;

r -- normal return.

The general drawback of this type of method of verifying a prediction is the subjectivity of setting the weighted factors, the absence of objective criteria for choosing the directions events are likely to take, and the freedom allowed in sampling indicators. Therefore, by means of such empirical relationships it is practical to verify only predictions that are to apply to the near future.

Nevertheless, the need to verify prognoses for the next 15 to 20 years exists. Here the problem arises of non-relativity of various assumptions in science as they relate to those theoretical systems of knowledge the elements of which they project. Do such assumptions exist in science, such that they are equally valid in every theory for which they are an indispensable element? This question does not coincide with the pseudo-questions of the universality of truth: here we mean equivalency, equality of the components of every theory (and science in general). In contemporary science equivalent truths take the form of specific invariable quantities: let's say, definite assumptions, which do not depend either on the method of realization nor on the logical form in which they appear in the theory, enter into Einstein's theory of relativity both in general and specifically, (for example, the speed of light diffusion as the greatest possible speed for any body), and these remain constant basic characteristics of reality inherent in several different areas. Knowing the invariable permits verification of reliability: if such a law can be established, then it is reliable without any conditions. The role of non-variables in contemporary science is particularly important because in it multiple-group theories of distance worked out by F. Klein and his well-known

Erlangen program have a fundamental role. According to this program, the content of any geometric (in a wider sense--any scientific-) theory is set by the state of congruence of two objects--so that objects linked by transformation to that same group are said to be congruent. Quantities determined in the course of physical experiments and consistent with the non-variants of the groups are "interpreted as dynamic constants, which create laws of conservation". To establish non-variance, which is not dependent on the way in which a given phenomenon is measured--is to explain that phenomenon in light of one or another law of conservation. Empirical interpretation as a prerequisite for theory loses its importance, and those experimentally measured quantities which correspond to the non-variants of the groups and are determined by the laws of conservation attain a preeminent role.

Means of verifying predictive structures are intimately linked with the peculiarities of the language used to work them out. Therefore, it is a good idea to classify the logical structures of predictions by some index of their verifiability with regard to other indices.

Implicative predictive structures are the most elementary and are frequently used as constituents of other structures. Absolute implication is related to the formal structure $A \supset B$.

Watered-down implicative structures of the type of the expression $A \supset B \supset C$ are usually used in prediction. Implicative structures were viewed by means of modal logic incorporating the concepts of necessity

and possibility as early as Aristotle, but debates on the topic continue to the present time. From a strictly logical standpoint using an empty set of samples for determining B as a logical result is unacceptable. In Lukasevich's system of logic, as well as in Les'nevski's work an empty range of situations does not exist. However, in situations with incomplete structures they are used, in spite of the triviality of the data obtained. Structures of this type are verified by interpretation of empirical functions isolated from groups of documentary data (patent information, etc.).

Inductive predictive structures can be divided (depending on the method of verification) into structural-, deductive- and natural-inductive. In general the inductive structure has the form: $(a_1, a_2, a_3, \dots, a_n) \rightarrow a_{n+1}$.

Inductive structures are verified by the completion of an effective process, which leads to a definite result. When the Delphi method is used, that is, when the usually occurring events are extrapolated to the future, many inaccurate assumptions are introduced into the prediction. In general it is impossible to separate these assumptions from valid ones: absolute verification of the prediction can be accomplished only by its realization in the real world. Therefore, it is possible to eliminate false assumptions from the prediction only by proving that the formal proof is incorrect: in this case a negation of the assumption describes an unattainable goal.

The deductive-inductive method of verification consists of proving that:

relationship p has a place for K is K is an axiom;

relationship p has a place for samples K , if K is obtained with the rule of the outcome.

The structural-deductive method consists of the following: we assume that sequence K_1, \dots, K_n , which yields the proof exists, we will show that each K_k possesses a definite characteristic if each preceding one possessed that characteristic.

In the course of verification of inductive predictive structures it becomes important to establish the probability of the truth of assumptions. In connection with this it is reasonable to use in some cases the induction model of J. M. Keynes. Probability p_n of an inductive generality g of observed events x_1, x_2, \dots, x_n is determined in the context of some system of facts h : $p = p(g/h \wedge (\wedge x_1 \wedge x_2 \wedge \dots, \wedge x_n))$. The prerequisite for the model is the establishment of precise facts $p_0 = p(g/h)$, set up by the inductive generality within the conditions of the system of facts h . In this case we have the equation:

$$P_n = \frac{P_0}{P_0 + (1 - P_0) P(x_1 \wedge x_2 \wedge \dots \wedge x_n | g \wedge h)}$$

From this equation the following situations obtain:

$$P_n = 1, \text{ if } P_0 = 1 \tag{1}$$

$$P_n = 0, \text{ if } P_0 = 0 \quad (2)$$

$$P_n \rightarrow 0, \text{ if } P_0 \text{ is fixed} \quad (3)$$

$$P_n = P(x_1 \wedge x_2 \wedge \dots \wedge x_n) (\bar{g} \wedge h), \quad (4)$$

if P_0 is fixed.

Case (1) takes place when inductive generality g results from system of facts h or if $p(x_1 \wedge x_2 \wedge \dots \wedge x_n) (\bar{g} \wedge h) = 0$, that is, x_1, x_2, \dots, x_n , observed in context h , are inconsistent with the negation of inductive generality g .

Variant (2) refers to the inconsistency of g with a system of existing information h ; variants (3) and (4), when p_0 is fixed and p_n approaches 0 and 1 at various rates, produce various "degrees of reasonable assurance" in the validity of the predictive assumptions.

A succession of intermediate values of p_n allows its degree of reliability to be assessed (and partially, increased).

In conclusion it must be pointed out that verification of inductive predictive structures is usually done by means of the formalized language of the logic of probability.

Deductive predictive structures are most frequently used for modelling real-world problems and are thereby removed from retrospective assumptions which are subject to incomplete empirical justification and accuracy to actual events (for example, trends in the development

of economic indices, predicted by scientific means).

Verification of deductive predictive structures can be viewed as a self-regulating process of extrapolation from the future to the present: the regulating device being the state of the real world forecast by the model. Retrospective assumptions from the projection transfer to the actual world by a reverse process, while verified assumptions from the actual situation pass into the projected world by a forward channel. In these channels not only useful information is transferred, but also 'white noise' and 'noise' full of useful signals moves. One of the aims of verification of deductive projection structures is the eliciting of useful information from this noise.

The more complete the empirical checking of retrospective assumptions about events projected in the prediction is, the more careful it can be said to be verified. The simplest form of deductive projection structure is:

$$G(a, b, c \dots \supset h) \supset h \text{ and } G \rightarrow (a, b, c \rightarrow h) \rightarrow h,$$

where G is a theoretical scientific law.

Statistical-inductive projections using series (classes) of the type: $(a_1, a_2, a_3, \dots, a_n) \wedge (p, q, r, \dots, v)h$ are particularly interesting.

However, in general they result in the verification of natural-

inductive structures or structures based on infinite inductions.

The logical projection structures we have discussed can be further verified by semantic, syntactic and pragmatic analysis of the assumptions made. One of the illusions giving the appearance of validity to projections is the acceptance on faith of statements without proof. Accepting statements on faith is based on a pragmatic view of the existing situation.

Therefore, pragmatic premises must be eliminated and projections carefully analyzed. In order to make projections valid strict rules of what assumptions are included and excluded must be observed. Some of these rules are investigated in the work by this author "Informational and logical analysis of scientific research".

Essential to the application of the rules mentioned above is the observation that strict differentiation between analytical and synthetic premises is not made in present projections. In connection with this, premises cover a wide range between purely analytical and purely synthetic, and the expression of the projection of the future is an empirical-theoretical one based on incomplete information of the actual situation onto the future. Therefore, it is necessary to apply the rules of inclusion and exclusion of premises in order to make projections correspond to the actual state of affairs.