POLSKA AKADEMIA NAUK
INSTYTUT BADAŃ SYSTEMOWYCH

PROCEEDINGS OF THE 3rd ITALIAN-POLISH CONFERENCE ON APPLICATIONS OF SYSTEMS THEORY TO ECONOMY, MANAGEMENT AND TECHNOLOGY

WARSZAWA 1977

Redaktor techniczny
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BIAŁOWIEŻA, POLAND
MAY 26—31, 1976

EDITED BY J. GUTENBAUM

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PREFACE

The present volume comprises the papers from the 3rd Italian-Polish Conference which was held in Warszawa [illegible]. The conference organized by the Centre of Control Systems and Computation of the Italian National Research Council in Rome and the Institute for Organization, Management and Control Sciences of Polish Academy of Sciences and the Ministry of Science, Higher Education and Technology in Warsaw was the third conference of this type.

The first one took place in Kraków (Poland) in 1972, the second in Pugnochiuso (Italy) in 1974.

This conference, like both the previous ones, gathered the leading representatives of many scientific centres from Italy as well as from Poland, representing also the different aspects of the systems analysis applied to the economic, management, data processing and technological systems.

From one part, such meetings enrich the exchange of views and experiences between the specialists from both countries what is the condition [illegible] to both sides, favour the natural path, the summarization of the [illegible] and [illegible] the contribution to the essential development of the quantitative methods and the perspectives of [illegible] of large computer systems.

The meaning of such meetings, however, goes far beyond this; what is happening during the conference between the established contacts are also fruitful in form of common scientific research works and — last but not least — begin the friendly links between the scientists of both countries which last for years.

The proceedings of the conference were divided into three parts:

1. Optimization and Control Theory;
2. Systems Theory in Economics;
3. Technological, Managerial and Information Systems.

While the first two parts are of rather homogeneous character, the third part contains the papers concerning the different types of models — for the economic, technological, management and data processing systems.

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ORGANIZATION ASPECTS OF THE SYSTEM OF FORECASTING THE LEVEL OF FULFILLMENT OF ECONOMIC PLANS

One of the main aims of econometric forecasting in a country with planned economy is that of providing economic planners and other authorities with reliable forecasts of the future level of fulfillment of economic plans. Information stemming from such forecasts gives valuable guidelines for current management and for construction of future plans. One can point out the following advantages of using econometric forecasts in practical work of economic institutions:

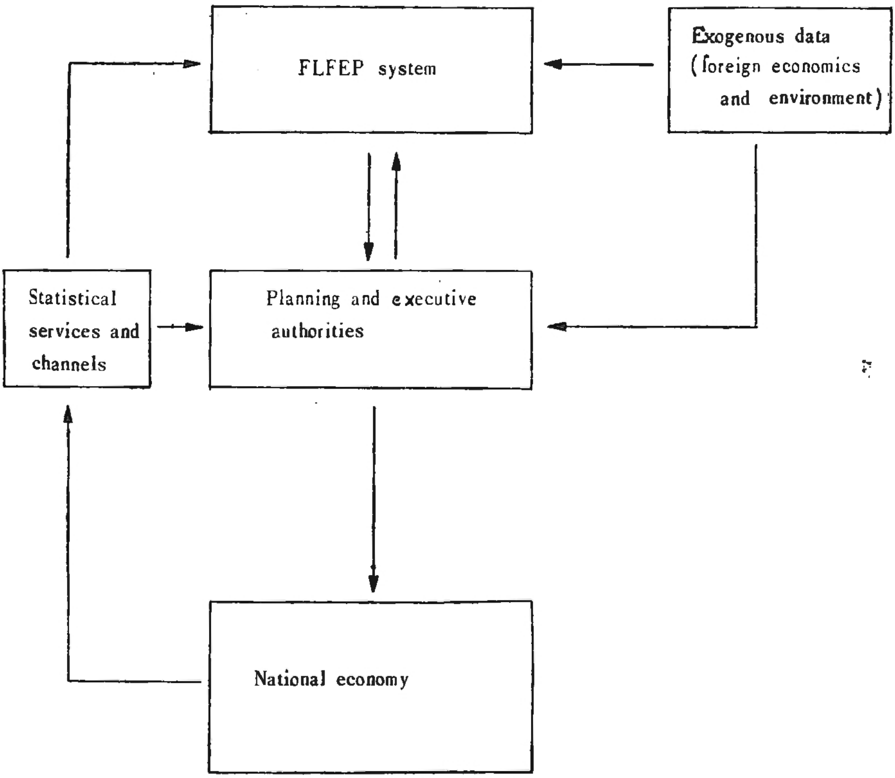
1. Forecasts of future fulfillment of economic plans give reliable insight into the expected (or most probable) level of key variables at the end of the current plan period.
2. If the forecasts lead to the conclusion that the real levels of several variables will fall short of their planned levels it becomes possible to make decisions aimed at countering early enough the negative tendencies discovered by the forecasting inference.
3. When the forecasts point out to the possible overfulfillment of planned targets it becomes possible to strenghten these positive trends and to make early decisions about the best use of surpluses thus obtained.
4. Using forecasts referring to the expected level of fulfillment of the current plan one can usually build a much more earlistic plan for the future plan periods.

If forecast data are to be currently used in planned economy and total information stemming from such inference is to be efficiently used by authorities managing the economic life, the process of building forecasts must be incorporated within a special, self-contained system. We shall refer henceforward to such a system as the system of forecasting the level of fulfillment of economic plans, or briefly to the FLFEP system.

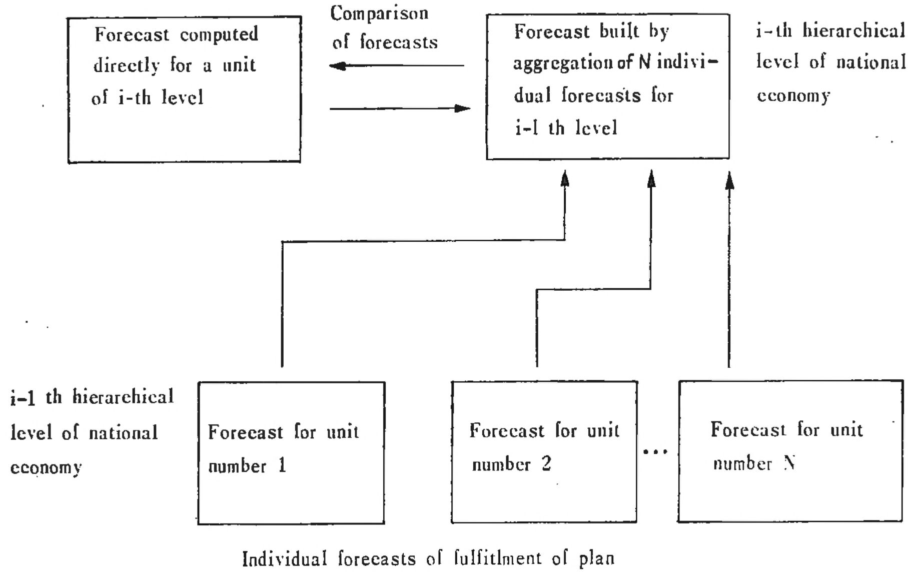
For an efficient operation, the FLFEP system must obey several conditions relative to its organization and to methodology used. In the present paper we shall be mainly concerned with the first ones, since methodological questions, i.e. questions connected with the choice of a particular method of forecasting are roughly similar even in countries with different economic systems.

As the starting point for our arguments we advance the opinion that the FLFEP system must be closely connected with the network of planning bodies. This means that there should be specialists in econometric forecasting working in the central planning institution, in economic industries, in branch--of-industry boards and also at enterprise level, at least as far as large enterprises are concerned. Information stemming from forecasts should be incorporated by planning and managerial channels in order to provide adequate basis for short run and medium run decisions. In turn, statistical up-to-date information about the actual state of economic life should be immediately supplied to forecasters, thus ensuring that econometric inference about the future be based on the most recent knowledge. This will consequently result in decreasing the forecasting time-lead, which-as is well known-is one of the main factors affecting the accuracy of forecasting inference.

The assumed interrelation between the economy, the planning and management institutions and the FLFEP system is shown on graph number 1. It is important to emphasize that the FLFEP system must be supplied with highly qualified specialists, i.e. with people having both good knowledge of econometric theory and good knowledge and experience of economic sector whose activity is to be forecast.



Graph number 1



Graph number 2

Since the FLFEP system is supposed to cover the whole national economy, not only its central level but also all its sectors, branches and larger enterprises, it is important to ensure in practice full consistency of such matters as definitions of economic variables subject to forecasting, frequencies of making forecasts, time leads, required degrees of accuracy of inference etc. Once such consistency is achieved it will become possible to deepen the process of forecasting by using (and compairing) two types of forecasts. The first type consists of forecasts computed by using data referring to the particular economic unit. Forecasts of the second type will consist of aggregates of forecasts relevant to economic units of the lower hierarchical level.[1] The process of building and compairing these two types of forecasts is shown on graph number 2.

Let y_{Tp1} and y_{Tp2} be two such forecasts obtained for an economic variable Y. If the difference $y_{Tp1} - y_{Tp2}$ is small, i.e. its absolute value is smaller than a predetermined number $\delta > 0$ accepted a priori as a level of admissible discrepancy of forecasts, then there should be no objection to accept as final inference the arithmetic means of the two forecasts. Furthermore, such final forecast can be attached to a high degree of credibility.

If, on the other hand, the difference between the two forecasts exceeds (in its absolute value) the preassigned number δ, this can be viewed as a warning

[1] A typical example may be provided by a forecast of branch-of industry output based on branch data and by an aggregate forecast of output obtained by using forecasts referring to outputs of firms belonging to this branch.

signal that may be some important factors have been neglected in the process of forecasting and appropriate checks should therefore be performed.

Since the FLFEP system must be self-consistent the work of different forecasting units within the system must be synchronized in time, so as to provide forecasts for economic units belonging to the same hierarchical level in such a way that:

1. All the units (e.g. all enterprises) belonging to the same level are provided with respective forecasts simultanoeously.

2. Such forecasts are complied with adequate time lead, so as to make possible their aggregation in order to permit comparisons of with the two types of forecasts discussed above.

3. All the forecasts computed within the FLFEP system must be admissible, i.e. their degree of accuracy must be high enough for practical purposes. Usually this accuracy is measured by the variance of forecasting errors and admissibility condition reduces to the requirement that this variance be smaller than a predetermined number ν_0. The numerical value of ν_0 depends on practical considerations, ν_0 being such a number that forecasts with variance exceeding it are too unreliable to start any action.

Building the FLFEP system requires solving also the following problems:

1. What kind of economic variables should be subject to forecasting?

2. What should be the frequency of such forecasts?

3. What should be the maximum lenght of forecasting lead?

4. In which way should the newer information be compared and (eventually) reconciled with the earlier one?

We shall try to provide answers to these questions. When looking for these solutions the following underlying arguments will be kept in mind: 1. The FLFEP system must be economic in the sense of saving unnecessary operational costs. 2. The inference into the future level of fulfillment of plan must be efficient, where efficiency is meant as extracting maximum possible information from statistical sample and from accumulated past forecasting experience. Such experience consists primarily in earlier forecasts and in forecast errors referring to the same predicted variable Y. It is worthwhile to stress that a thourough analysis of past prediction errors leads sometimes to detection of important factors influencing the variable Y and which so far were unknown to the econometrian. Data on past errors offer sometimes opportunities to device special corrections to new forecasts, increasing thus the accuracy of the new inference into the future[1] .

We turn now to the question which economic variables should be subject to forecasting within the framework of the FLFEP system. The argument we shall advocate here for is that forecasting must be simultaneous in the sense that it must embrace all the relevant variables considered in the economic plan. It follows hence that as a rule the forecaster will deal with vectors of variables and not with single ones. It must be emphasized also that whenever the predicted variables are interrelated it pays to forecast them simultaneously,

[1] See for instance the present author's paper [1].

i.e. by using a multi-equation econometric model and not by proceeding with each variable separately. Although the computational problems become more complicated the degree of accuracy of forecasts is thus more increased the higher is the correlation between the predicted variables. Furthermore (and this is perhaps the main reason for advocating for simultaneous prediction) it is to be pointed out that forecasts of vectors of variables give a much better insight into the future state of economic life than it would be possible to obtain by using separate forecasts for a small number of variables.

The second characteristic feature of the FLFEP system is its continuity. Continuity means that forecasting process is being repeated in time at equal intervals of time[1]. This results in new forecasts being added to the previous ones every month or every quarter, providing new estimates for periods for which there exist already earlier forecasts and also supplying the system with inference about time periods which until now were too distant to enable reasonable and accurate inference about the state of economics then.

Let λ denote the frequency of forecasts for a given variable Y. It can be shown[2] that λ should be contained within the interval $[\lambda_{max}, \lambda_{min}]$, where

$$\lambda \quad = \max\left(\frac{L}{h_*}, \frac{L}{\Delta_1}, \frac{L}{P}\right) \tag{1}$$

$$\lambda \quad = \frac{L}{R} \tag{2}$$

In formula (1) L denotes the length of time span under consideration, h^* is the maximum possible forecasting lead, P is time span of the shortest economic plan whose implementation is to be forecast, while Δ_1 stands for time necessary for starting practical action aimed at improving the fulfillment of the economic plan under control. In formula (2) L has the same meaning as in (1) while R denotes the shortest time interval occurring between issuing new statistical data regarding the behaviour of the economic system.

If λ obeys the inequalities (1) and (2) the frequency of forecasting is such that the FLFEP system supplies planners and economic managers with necessary information, though perhaps the frequency λ is not optimum.

The optimum value of λ can be sought if some reasonable assumptions are made with respect to costs of operating the FLFEP system and with respect to losses due to starting practical actions when such actions are based on wrong forecasts. The author has solved this problem in [1] using the following assuumptions:

1. Operation costs of the system are given by the formula

$$K = \alpha_1 + \alpha_2 \cdot \lambda \cdot L \tag{3}$$

[1] In the case of vector forecasts these intervals need not be the same for oll the individual variables although such situation simplifies many aspects of the working pattern of the FLFEP system.

[2] See reference and [2] and [3].

2. The loss function is of the form $\varphi(u) = C.|u|$, where u denotes the error of forecast and C is a positive constant.

3. Practical decisions are based on forecasts with forecasting lead h and it is assumed that $h = \frac{1}{\lambda}$.

4. The distribution of forecasting errors is normal with zero mean and standard deviation σ_h, where σ_h is a differentiable function of h, such that its first and second derivatives are positive.

Under these conditions it can be shown that the optimum value of λ is provided by the solution of the equation

$$\alpha_2 + C\sqrt{\frac{2}{\pi}} \cdot \frac{d\sigma(\lambda)}{d\lambda} = 0 \tag{4}$$

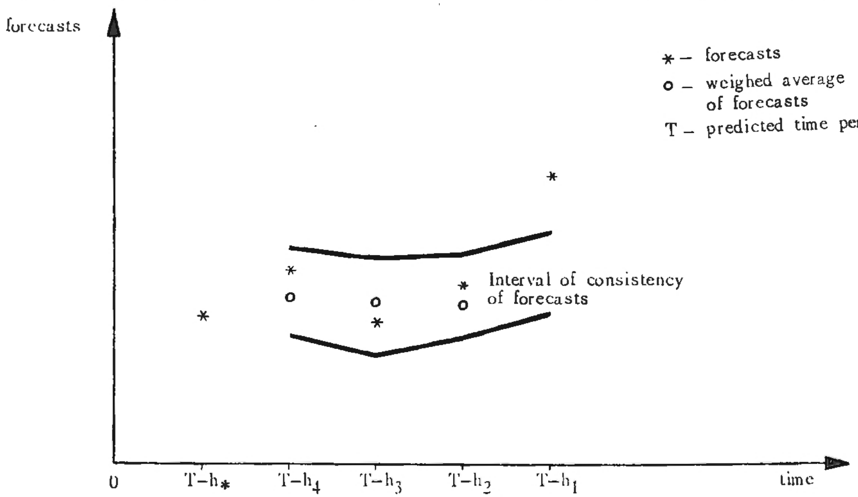
with respect to λ.

Let now T be a fixed predicted time period. Under the assumption that the forecasting process is repetitive there usually will be available a sequence casts

$$y_{Tp}(h_*), \ldots, y_{Tp}(h_2), y_{Tp}(h_1) \tag{5}$$

such that $h_1 < h_2 < \ldots < h_*$ and $y_{Tp}(h)$ denotes forecast for time T computed with forecasting lead h. The forecasts forming sequence (5) will be henceforward referred to as incoming forecasts. Analysis of sequences of type (5) throws significant additional light on the possible behaviour of the predicted variable Y_T.

A useful device for the analysis of incoming forecasts is provided by special control charts, the simplest type of which is shown on graph number 3.



Graph number 3

The rationale of the analysis consists in the inference whether newer forecasts are consistent with the older ones or whether they diverge in some way. If all the forecasts obtained so far are consistent with each other, i.e. if their numerical differences are small enough, their arithmetic mean may be taken as the best estimate of the (future) value of y_T, this mean being the best forecast. It may happen, however, that such consistency is lacking because there is either a trend of the incoming forecasts or the value of the last forecast has deviated sharply from the previous ones. Such inconsistency may be due to one of the following reasons:

1. One may not exclude the possibility that the inconsistency is due to random causes.

2. It may also be that the former forecasts were computed by assuming different exogenous conditions for time T than it has been assumed when computing forecasts with shorter lead, i.e. when one usually has a better general idea of what the conditions for formation of Y_T will be like.

3. It is not to be excluded that the path followed until now by the predicted variable makes it necessary to introduce some corrections to previous anticipations[1)].

As can be seen from the graph 3, the control chart of forecasts consists in plotting on the axis of abscissae time points corresponding to periods when new forecasts were made and in plotting the values of forecasts on the other axis. The observed values of incoming forecasts are denoted by stars, with points located to the right side of the graph denoting more recent forecasts, characterized by smaller forecasting lead. Small circles on the graph denote arithmetic means of forecasts obtained so far if these forecasts proved to be consistent. Consistency is decided upon by observing whether the consecutive incoming forecasts are contained within the so- called interval of consistency of forecasts. There are several possible methods of determining the location (the width) of this interval, the simplest one consisting in putting the width of the interval to be equal to 2δ and locating it symmetrically with respect to the line of arithmetic means of forecasts. In this approach δ is a predetermined number, such that from practical point of view two forecasts differing in absolute value by less than δ are thought of as equal[2)].

If there is a trend of the incoming forecasts then the best final forecast for period T is provided by extrapolation of that trend for $t = T$. If only the newest forecast has deviated by falling outside the interval of consistency of forecasts and there is no evidence that this was due to random causes it is advisable to use this newest forecast as the best estimate of the future value of Y_T. In some cases it may be preferable, however, to use as final forecast a compromise value, based on an average of the arithmetic mean of previous forecasts and of the last "deviating" forecast.

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[1] For instance the fact of observing a surplus level of labour productivity in some period $T-\varepsilon$, where $\varepsilon > 0$, makes it probale that in time T labour productivity will be higher than it was anticipated before.

[2)] The value of δ is thus determined by the user of forecasts.

To conclude this paper we shall make one remark about the parameter h_* which was defined as the maximum possible lenght of forecasting lead for which forecasts will be still admissible, i.e. their degree of accuracy will correspond to practical needs. Since the value of h_* depends on the choice of predictor it opens way to research on the dependence of h_* on the chosen method of prediction.

If forecasts are to practically useful they must warn early enough about the outlook for the future, which in turn means that h_* must be large enough to permit to start and perform actions necessary for counteracting negative trends or to strenghten positive ones. If Δ_1, denotes minimum time necessary for such practical steps then obviously there must be

$$h_x \geqslant \Delta_1 \tag{6}$$

Let us note also that Δ_1 will usually depend on the predicted variable and on the type of warning signal. If the latter holds true then h_* must be equal or larger to the largest value of Δ_1 corresponding to different types of actions.

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SUMMARY

The paper deals with the main features of the information system aimed at providing predictions of the level of fulfillment of economic plans, this system being set within the framework of the socialist planned economy.

Such predictive system should provide planners and economic managers with sufficiently accurate predictions referring to all the relevant economic variables and to all levels of the economy If such predictions are to be practically useful, howevei, the system must obey some requirements which are broadly dealt with in the paper. Special attention is devoted to the following problems:

1. The problem of adequate prediction lead.

2. The field of possible uses of prediction data for management and control of the economy.

3. The optimum frequency of building new predictions.

4. Comparability and consistency of different predictions.

5. Admissible predictions and statistical measures of the accuracy of prediction when forthcoming predictions are used for making new decisions.

Special emphasis is laid on problems of short-run prediction, i.e. prediction with prediction lead not exceeding one year.

Instytut Badań Systemowych PAN
Nakład 300 egz. Ark. wyd. 25,0. Ark. druk. 23,75. Papier druk. sat. kl. III 80 g 61×86. Oddano do składania 8 X 1976 Podpisano do druku w sierpniu 1978 r. Druk ukończono w sierpniu 1978 roku

CDW — Zakład nr 5 w Bielsku-Białej zam. 62/K/77 J-124