Chaotic Behaviour of Economic and Social Macro Indicators in Hungary

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It is well known that from the middle of the 80s, the post-socialist countries have been in transition, in which enconomy and society are burdened by chaotic situations. To investigate this is of interest from the aspect of methodology of futures research. Our analyses show that in this century the Hungarian society and economy could not have been in a state of chaos in the theoretical and mathematical sense. Only a tendency to chaotic behaviour can be shown in the case of a few data series.

Key words: chaos, prediction, futures

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1.Futures research and chaos theory

Futures research regards chaos theory as a means to develop a real interdisciplinary approach and modelling method. Chaos theory can offer a solid base on which to develop new procedures in futures studies, too. It can help to reveal the factors which cause the irregular movement and to find the laws which form the basis of a new order. It shows and proves that in chaotic or slightly chaotic systems, the demand for and possibility of elaborating a single (and most probable) future alternative must be renounced. Scientific prediction becomes impossible in this case, that is, it is impossible to make a prediction by exact means regarding a single new state of a given system and/or its future behaviour. 〔5〕

However, the impossibility of prediction, that is, of calculating the most probable future, does not mean the impossibility of forecasting: the elaboration of different futures alternatives (the qualitatively differing future variants) and scenario-building remains possible. As Prigogine has pointed out: "The future is not included in the past. Even in physics, as in sociology, only various possible 'scenarios' can be predicted." 〔8〕

The methods of chaos theory-non-linear difference and differential equations, and equation system-systematically show under what conditions a system can become chaotic, when bifurcation can start (i.e. when two different trajectories can develop), what possible new development paths can arise and into what new states a system can be directed.

Chaos theory may be significant in forecasting for two further reasons 〔6〕 :

— It can help to determine the conditions and circumstances under which the future state of a system cannot be traced. At the same time it can help to find how the chaotic behaviour can be directed to a regular path more desirable for mankind through frequently applied small modifications in the preconditions and circumstances (if modifications are repeated a sufficient number of times in a model, the right path can be found).

— Chaos theory could be a new way of thinking, a new methodology and a method to reveal how random phenomena can be forecasted in a more precise way.

Chaos theory can be used to unfold possible futures, because it can help

— timing the search for possible futures with characteristics completely different from the past and present (it helps to determine when to separate the future from past and present and when to seek new alternative futures);

— seeking, finding and describing the types of possible futures;

— looking for the roots of possible futures already existing, but still not in typical form;

— linking these roots (germs) to possible futures in a model.

The fact that it is not possible to make a single, most probable prediction in chaotic systems does not mean that control is impossible. The behaviour of systems in a non-equilibrium state can always be controlled if the observer (modeller, forecaster) is a part of the system. Society is a system of which man is an inherent part. Conscious people can control the behaviour of society, as a system.

Human society is the system which it is the most important to control from the aspect of the human being. At the same time, society is the system which can be controlled by human means. Although society is a non-equilibrium, dynamic, non-linear and indeterministic system and its evolutionary development cannot be predicted, its future states can be revealed and it also has the feature of controllable evolution. [3]

In the dynamic movement of the society, one of the countless possible internal fluctuations may be amplified, spread with great speed and become dominant. In this way various interests, values, demands and social groups (which were on the periphery) may rise to a dominant social position. These may strengthen numerous new paths of development, thereby making society controllable from within. In this aspect the future orientation of every day people is of very important. [7]

Even in periods of chaos, futures researchers look confidently to the future. They do not give up forecasting activity, but focus their attention and work on seeking a new philosophy, methodology and methods. In this situation the appropriate new paradigm for futures research can be found in chaos theory.

Chaos and forecasting are thus not contradictory concepts but an entirely new situation demanding the search for new ways of approaching the future: renouncing the demand and possibility of making predictions, and accepting the need and possibility of revealing qualitatively different alternative futures and scenarios. Flexible adjustment to the new situation is desirable not only for futures researchers but also for the decision-making sphere that uses the results of futures research, that is, the forecasts.

2. Empirical study of the chaotic behaviour of Hungarian macro indicators

2.1 Aim of the study

Using one of the mathematical methods of chaos theory-non-linear difference equation-we examined how chaotic behaviour can be deduced from concrete data series and how possible paths of their future evolution can be revealed. Our investigation was aimed at seeking chaos in the theoretical and mathematical sense. We speak of chaos in the mathematical sense when the attractor of n points, i.e. point of attraction (where n lasts to infinity) appears in the behaviour of a system. The appearance of an attractor with two points (bifurcation) indicates the possibility that chaotic behaviour could emerge.

In the course of the investigation we sought an answer to three questions.

1. When did the possibility of chaos appear in the long data series examined, when did the phenomenon of bifurcation arise (that is, the possibility that qualitatively differing paths would emerge), and which branch of the bifurcation line did the actual values most closely apporach ?
2. Is there any phenomenon indicating chaos in the present Hungar-

ian society and enconomy ?

3. What possible future paths can be traced for the different macro indicators with the help of the study ?

2.2 The macro indicators examined

The indicators examined in the study cover a wide spectrum of change and development of the society and economy. Since this was the first study of its kind ever done in Hungary, the aim was to gain the broadest possible picture of whether chaos appears in Hungarian society only in the everyday sense or whether there are also signs of the presence of chaos in the theoretical and mathematical sense.

Because a study of this kind involves the analysis of the longest possible or multielement time series, it was considered expedient to include only indicators for which at least 30 data were available. Applying this criterion, 39 macro indicators were examined. These included demographic and production figures, employment, investment, financial and education indicators, as well as indicators on health status and tourism. Although we would have liked to examine a wider range of indicators characterising, for example, the state of the environment or financial flows, the data series available were too short.

2.3 Method used

It is known from the literature of mathematics and futures research that chaotic behaviour appears in the upper phase of a logistic curve. [2 and 4] A logistic curve was fitted to the total time series by the known formula:

$$x_{t+1} = k.x_t.(1-x_t) \qquad (1)$$

where

x_t, x_{t+1} — a single point of the time series

k — coefficient of the logistic curve.

The "k"value in the formula is the elasticity of yearly growth, the growth capacity. In other words, "k" is the self-organising coefficient.

Our aim has been to search and-if it was emerged-to interprete the chaos (the chaotic behaviour), if the function for the time series has not been known.

We have based our research on two theorems of Feigenbaum [1]

— Feigenbaum showed that any difference equation whose right-hand side is basically concave, like function G

$$x_{t+1}=k.x_t.(1-x_t)=G(x_t) \quad (2)$$

will rapidly settle down and it will behave quantitatively similarly as equation above.

— Feigenbaum also showed that the period doubling phenomenon is not dependent on the particular form of the function G.

In difference equations similar to the above, if the point of equilibrium becomes unstable, further stable fixed points appear and the phenomenon of bifurcation (double period) *arises*. Bifurcation occurs at the critical k parameter values. If $k>2.8$, first a two-point attractor appears, then the motion of x_t approaches a fourpoint attractor and so on. The critical k values are known as doubling periods. If $k>3.57$, the number of periods becomes infinite and total chaos arises. [1]

The Ljapunov coefficient which measures the speed at which the two forks diverge is used as the index of chaos. The mean Ljapunov coefficient along one fork is the mean length of the shifts over t time. If the mean Ljapunov coefficient of a dynamic system is less than 0, the system is stable; if it is greater, the system has a tendency to chaotic behaviour or is chaotic. The higher its value, the more chaotic the data series.

As a first step, the logistic curve was fitted to the time series used in the investigation, with the help of the least squares method. Changing the value of k between 1 and 4 at intervals of 0.001, the fit with the least error was sought. This fit was carried out for the basic data given in natural units or indices, for the base indices, for the logarithms of the basic data, and for the normalised (between 0 and 1) values of them. In many cases the data expressed as logarithms show the trend more clearly than the basic data or the base indices. The error of the function approximation is low and of the same magnitude. It stays under 20% in every presented case.

In the next step, taking the data of the time series examined -using the logistic equation to determine the individual x_t values by the recursive process-the doubling periods of the time series were examined to see whether the individual bifurcation paths meet the actual values.

Taking the data of the time series examined, an approximating method was used to determine the Ljapunov coefficients. Using different k values-with values closely approaching the attractor obtained after 300-600 recursive steps-the mean logarithm of the change was calculated, giving a quite good approximation to the Ljapunov coefficient. The coefficient was negative for the majority of the data series. It was very close to 0 for a few indicators and in one case was positive.

Using the k value calculated for the given time series, the consequence future obtained by extrapolation was estimated. With different k values-$k>2.8$-further possible future paths were developed. On the basis of Feigenbaum's proof we have examined at the values 2.8, 3.0, 3.4, 3.5 and 3.57 of k the behaviour of the functions. These values are not always the critical values of k but they are in the surroundings of them so they are able to show the change of the behaviour of the approaching function. The forecasted calculations were made for the period up to 2020.

2.4 The behaviour of the time series

The findings of our investigation show that the behaviour of the time series can be characterised taking the following criteria into account:

— the value of k fitted to the theoretical logistic curve,

— the width of the band of mathematically possible trajectories (i.e. growth paths),

— the relationship of the actually realised path to the mathematically possible growth paths,

— the relationship of the consequence future to the possible (mathematically generated) growth paths.

Those time series are *not chaotic* which have k values between 1.0 and 1.5, very broad possible growth paths and where the realised and the consequence future path fall outside the domain of the possible, mathematically generated growth paths. (See, for example, Fig. 1 and 2)

Those macro indicators are regarded as having a tendency to chaotic behaviour which have k values between 1.5 and 2.8, with broad (or not very broad) possible growth paths and where the consequence future runs close to or within the domain of the mathematically possible growth paths. Among these, the *slightly chaotic indicators* only approach the spectrum of possible paths and have k values between 1.5 and 2.1. (See, for example, Fig. 3, 4) In contrast, the moderately chaotic indicators move within the domains of possibility and have k values of between 2.1 and 2.8. (See, for example, Fig. 5, 6, 7 and 8)

Those indicators are *chaotic* which have k values higher than 2.8, a broad band of possible growth paths, and where the realised and the consequence future paths fluctuate within the possible paths. If the value of k is higher than 3.5 *total chaos* (i.e. *highly chaotic behaviour*) arises. (See Fig. 9 and 10)

Among the data series examined, the following do not show chaotic behaviour at all, i.e. they are stable over the long term: population, number of live births and deaths, number of active earners in industry and the construction industry, number of active earners in the other branches of the economy (transport, postal services, telecommunications, commerce, water affairs), index of employees in the electricity industry, gross electricity industry output index, gross agricultural output index, number of telephone main stations, paper consumption, per capita real income index, per capita consumption index, number of participants in primary, secondary and tertiary education, industrial output index, unemployment rate, inflation rate, change in nominal interest rate, change in real interest rate, data series for number of tourists arriving in Hungary, number of Hungarians travelling abroad and number of commercial places of accommodation.

Among the indicators with a tendency to chaotic behaviour, that is, which are unstable over the long term, the following are slightly chaotic: net national product index, net national income index, economically active population, electricity production, volume of investments index, gross electricity consumption, number of full-time teachers and educators, number of hospital beds, number of doctors, number of deaths due to suicide, self-injury, number of crimes committed. The following were moderately chaotic: GDP index, number of home units built, deaths due to cardiovascular diseases, number of registered alcoholics.

Highly chaotic behaviour (i.e. *total chaos*) was found only for the data series on the number of beds in commercial places of accommodation, with a self-organising coefficient value well below the average (3.76).

60% of the macro indicators examined do not behave chaotically and one indicator shows entirely chaotic behaviour. Among the indicators with a tendency to chaotic behaviour, 70% are slightly chaotic and 30% moderately chaotic.

3. Conclusions

In this century the Hungarian society and economy could not have been in a state of chaos in the theoretical and mathematical sense. Only a tendency to chaotic behaviour can be shown in the case of a few data series. Social and economic indicators were represented in roughly equal proportions among the non-chaotic indicators and those showing a tendency to chaos. However, since the great majority of the non-chaotic indicators are economic indicators it can be considered that the risk of social crisis is greater than that of economic crisis.

The relationship between the realised and possible growth paths shows that the possibility existed in the past too for an indicator to take a different path than the one actually realised. It would appear that in the case of the stable processes, no result was produced by intervention of whatever kind. In the case of the indicators showing slightly and moderately chaotic behaviour, efforts to influence them did not succeed in shifting the phenomena concerned to a better path. Nevertheless, there is a possibility of directly influencing reality in the case of indicators that are unstable or tending to instability.

The present unfavourable conditions are stabilised in the consequence future. This declining future social and economic path indicates that the formal change of system needs to be filled with content since as yet only decline and dismantling have occurred in the real processes. The shift to a new path must be sought in the chaotic areas and in those which are moderately and slightly chaotic (i.e. having a tendency to chaotic behaviour). Since these areas tending to chaotic behaviour were identified mainly on the basis of mathematical criteria, other methods should also be used to seek such methods.

For some of the indicators, the future lines projected without change from th past remain below the possible bifurcation lines that can be generated by changing the value of "k". This can be observed, for example, in the case of the population figures, for the number of active earners in industry and the construction industry, and for per capita real income and consumption, indicating that in the case of these indicators, the consequence future can represent only a minimum (extreme) value for the future possibilities.

In a few cases (such as number of live births, number of deaths, the volume of investments index, the consumption index and the figures on the economically active population) the consequence future line is located between (around) the lower bifurcation lines. The future line projected without change, e.g. in the case of the number of home units built, is located above the lower bifurcation lines but does not reach the upper forks. These indicators have the inherent possibility of following more favourable future paths.

Regarding the consequence future, the "good" indicators among the social, health and deviancy indicators decline then become stabilised, but along the lower bifurcation lines. The "bad" ones become stabilised, after minimal improvement, shifting from the band of upper bifurcation lines to the band of middle or lower bifurcation lines. In other words, their automatic improvement can also be expected. These indicators can also be influenced directly in the future, i.e. they can be taken up or brought down to the paths of upper or lower bifurcation lines. Forecasting calculations indicate that there is not merely one single path open to the Hungarian society and economy; rather there is a possibility of moving on many different paths.

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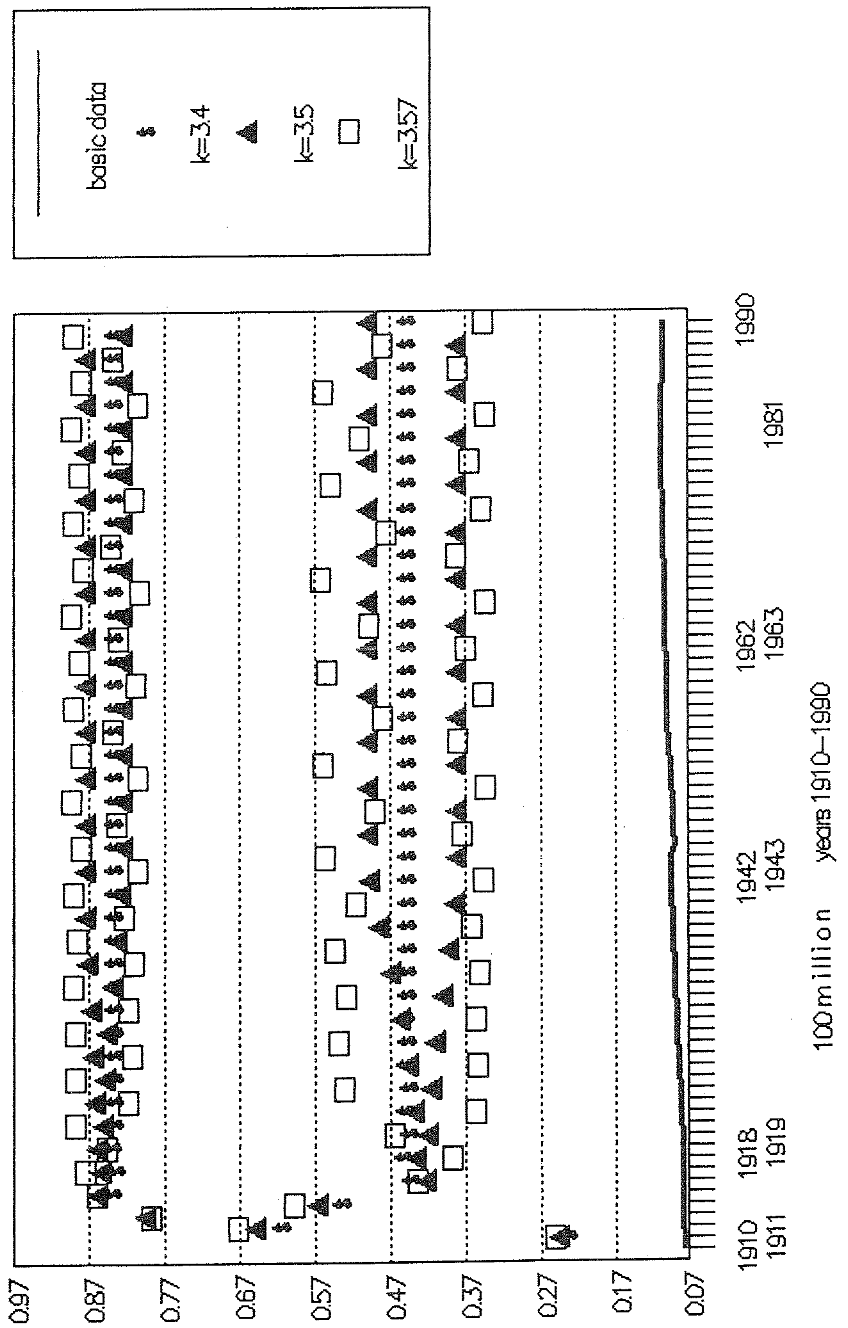

Fig. 1 Population of Hungary

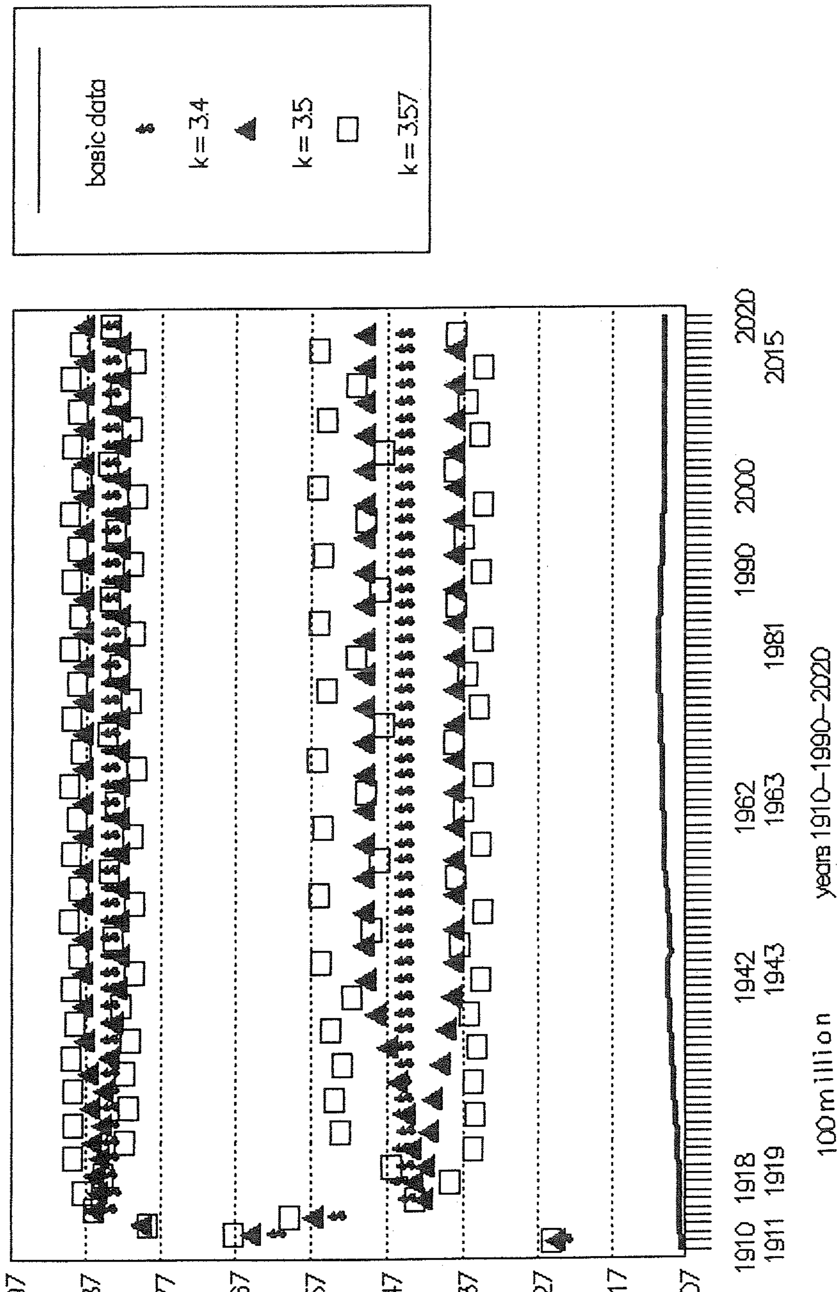

Fig. 2 Population of Hungary - forecasting

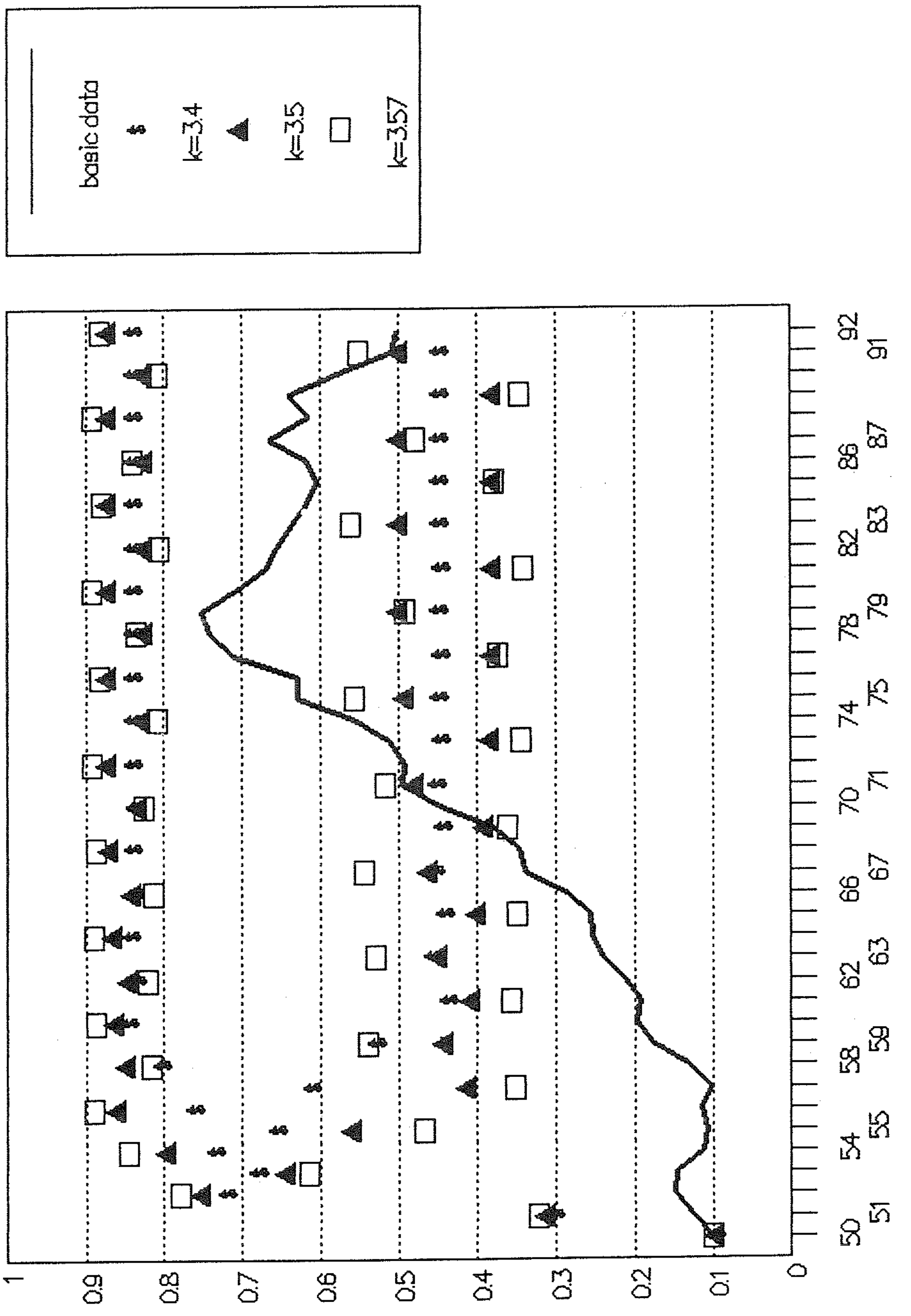

Fig. 3 Volume of investments index

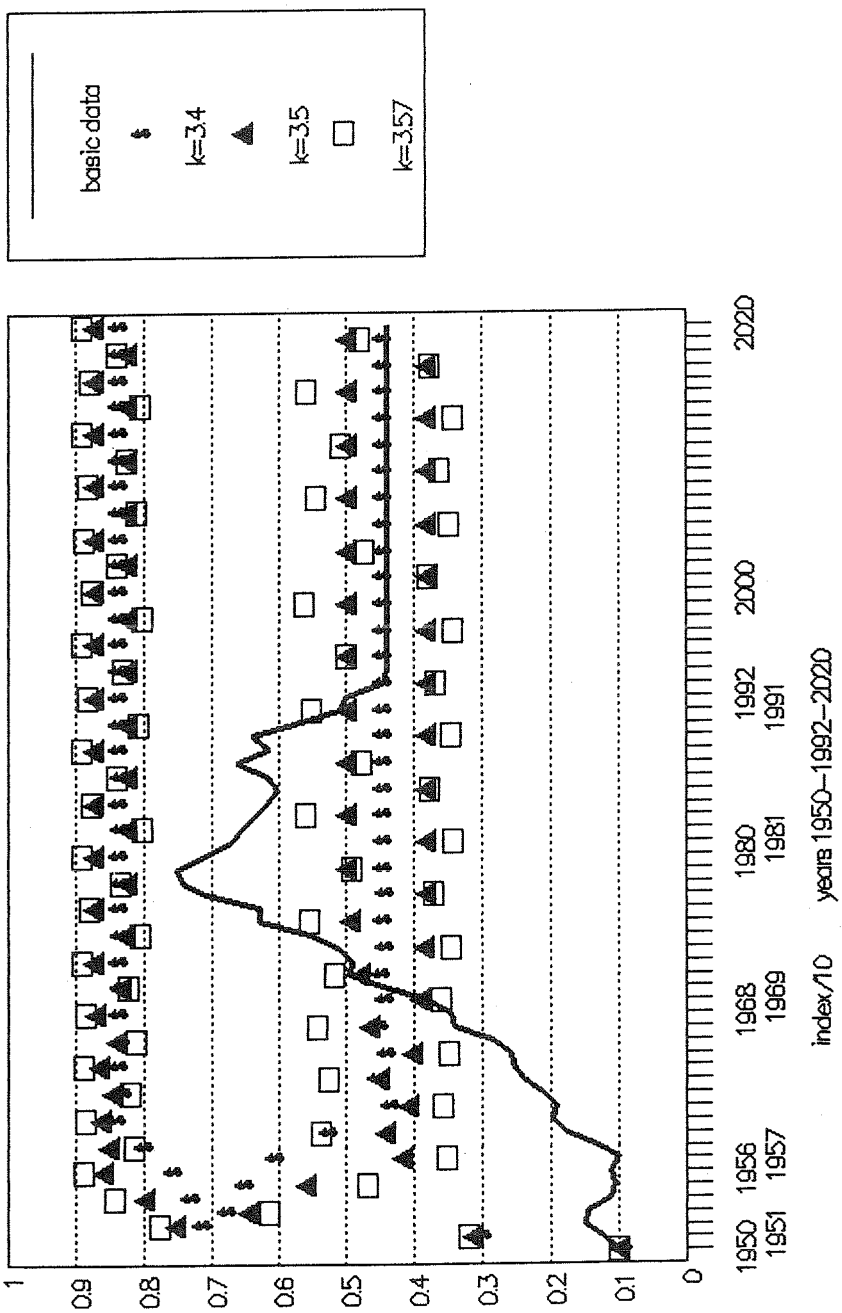

Fig. 4 Volume of investments index - forecasting

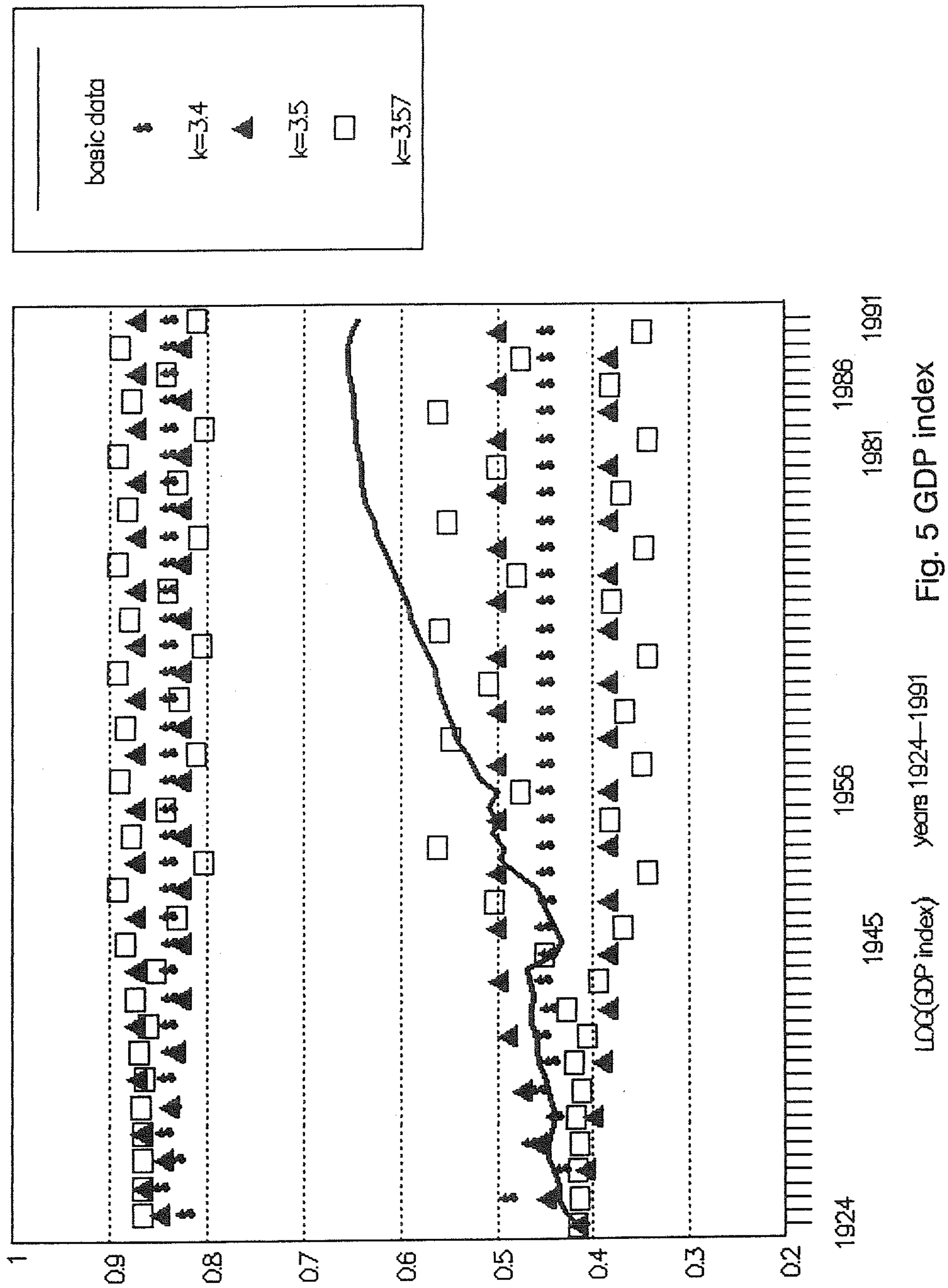

Fig. 5 GDP index

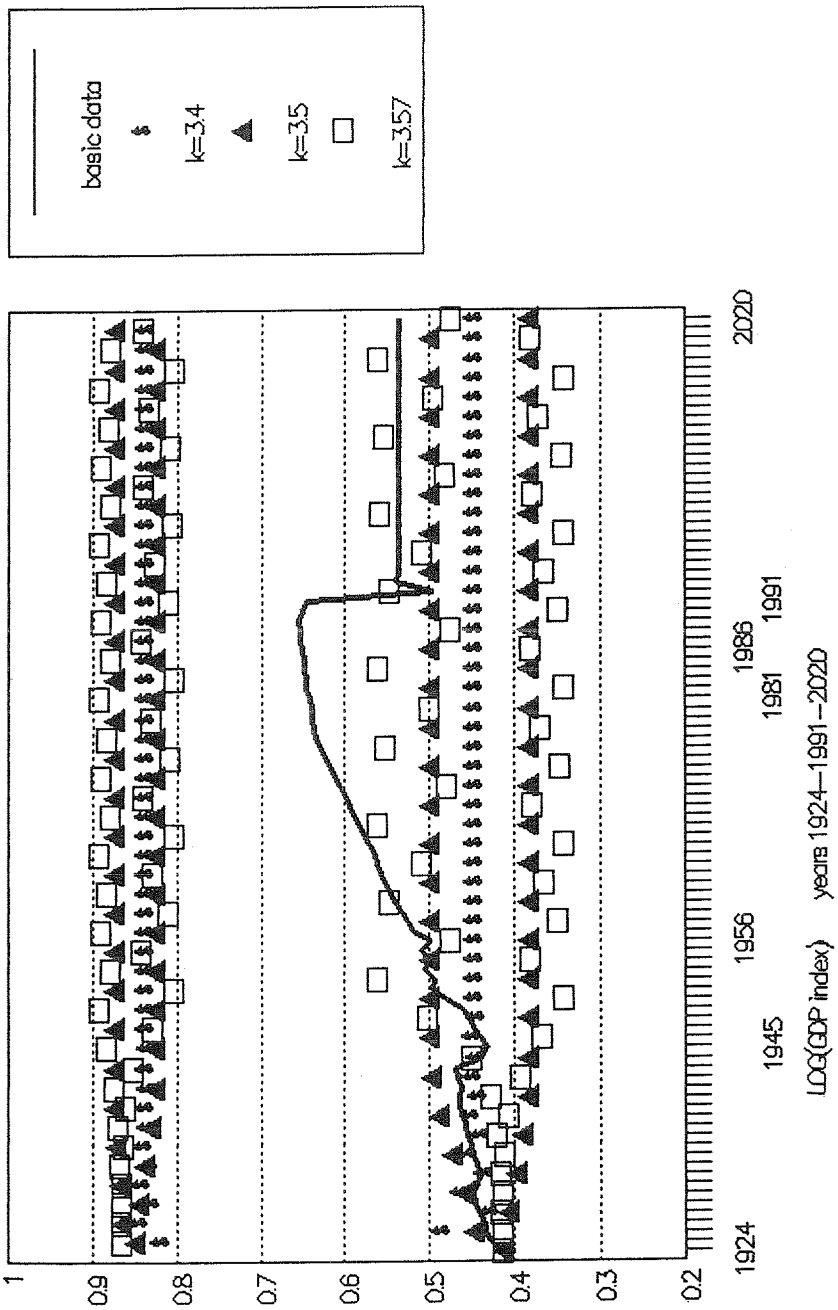

Fig. 6 GDP index - forecasting

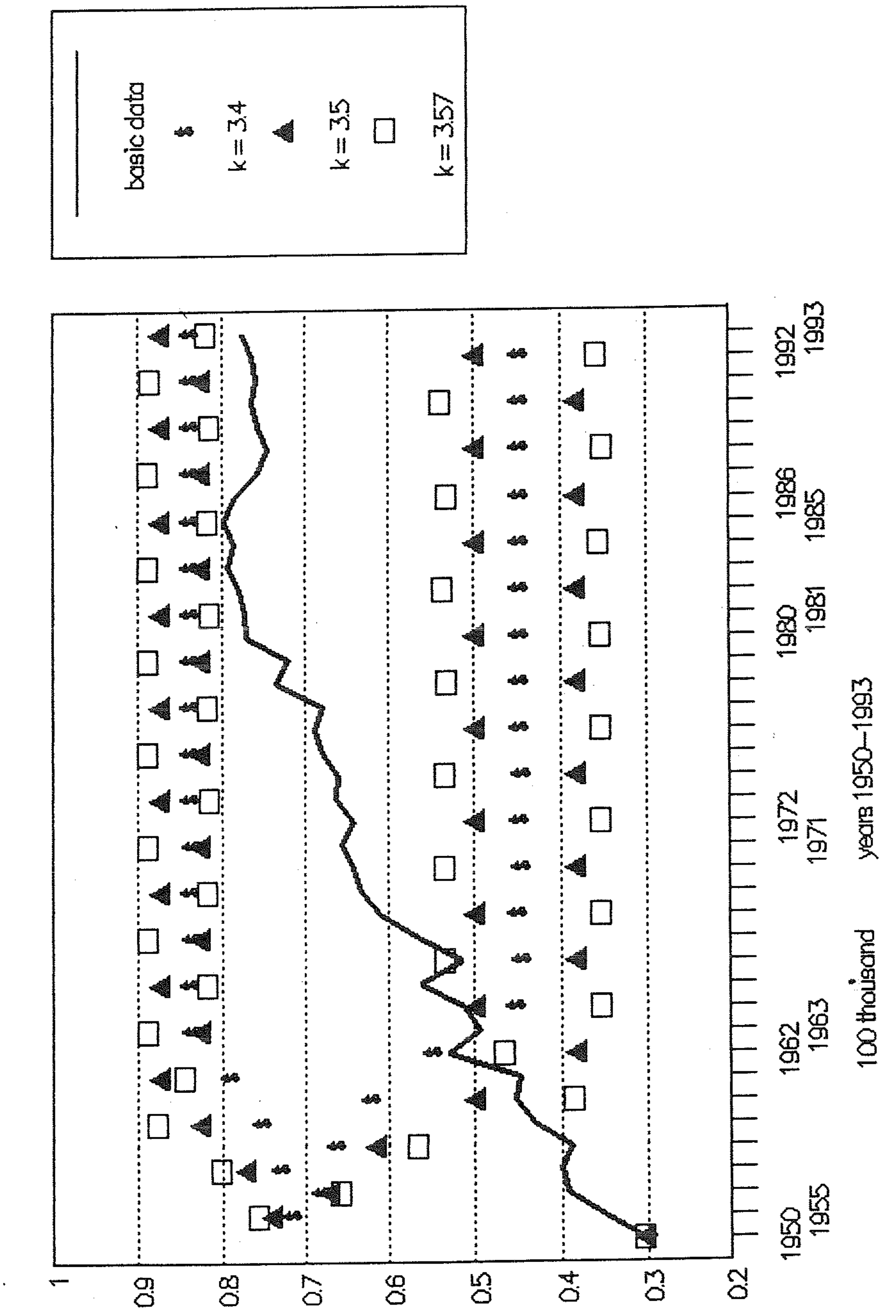

Fig. 7 Number of death due to cardiovascular diseases

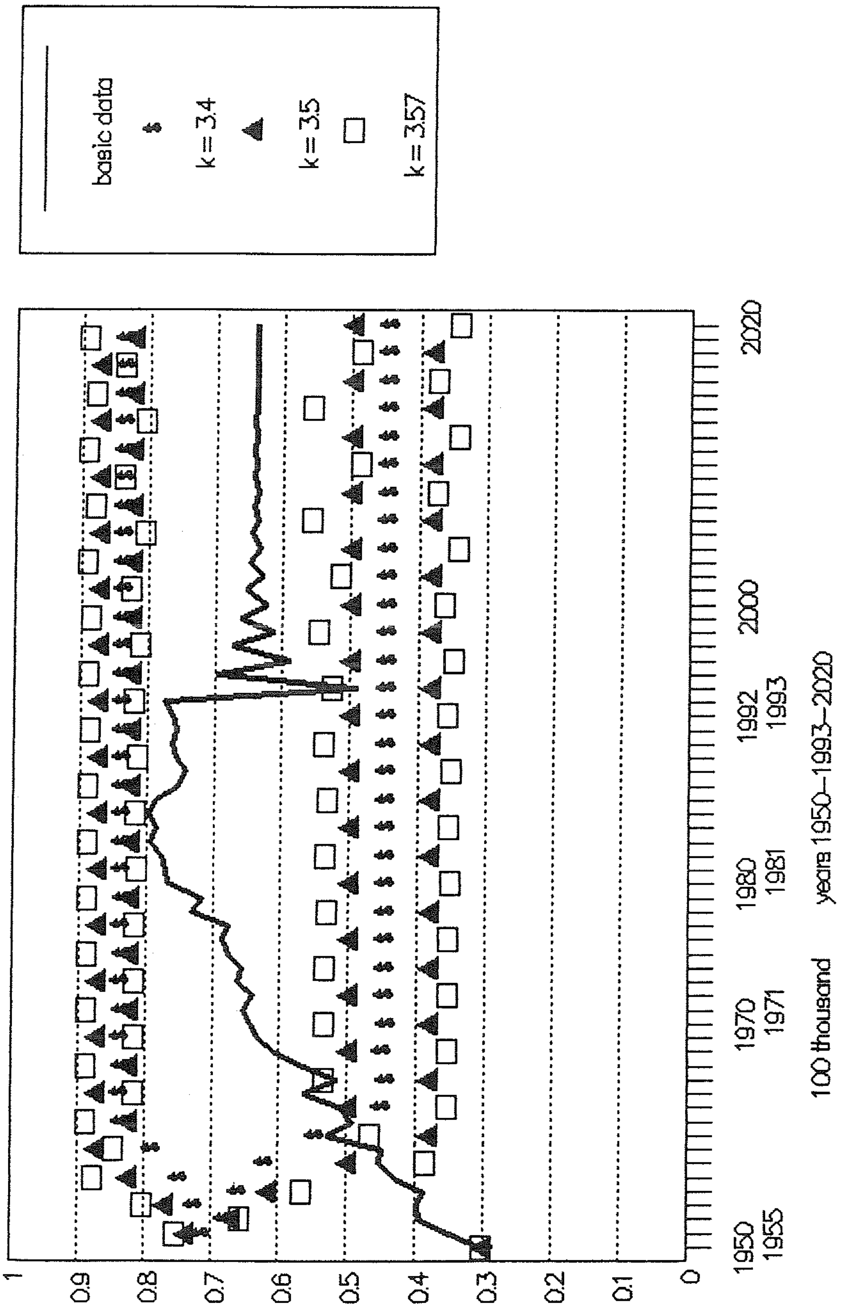

Fig. 8 Number of death due to cardiovascular diseases - forecasting

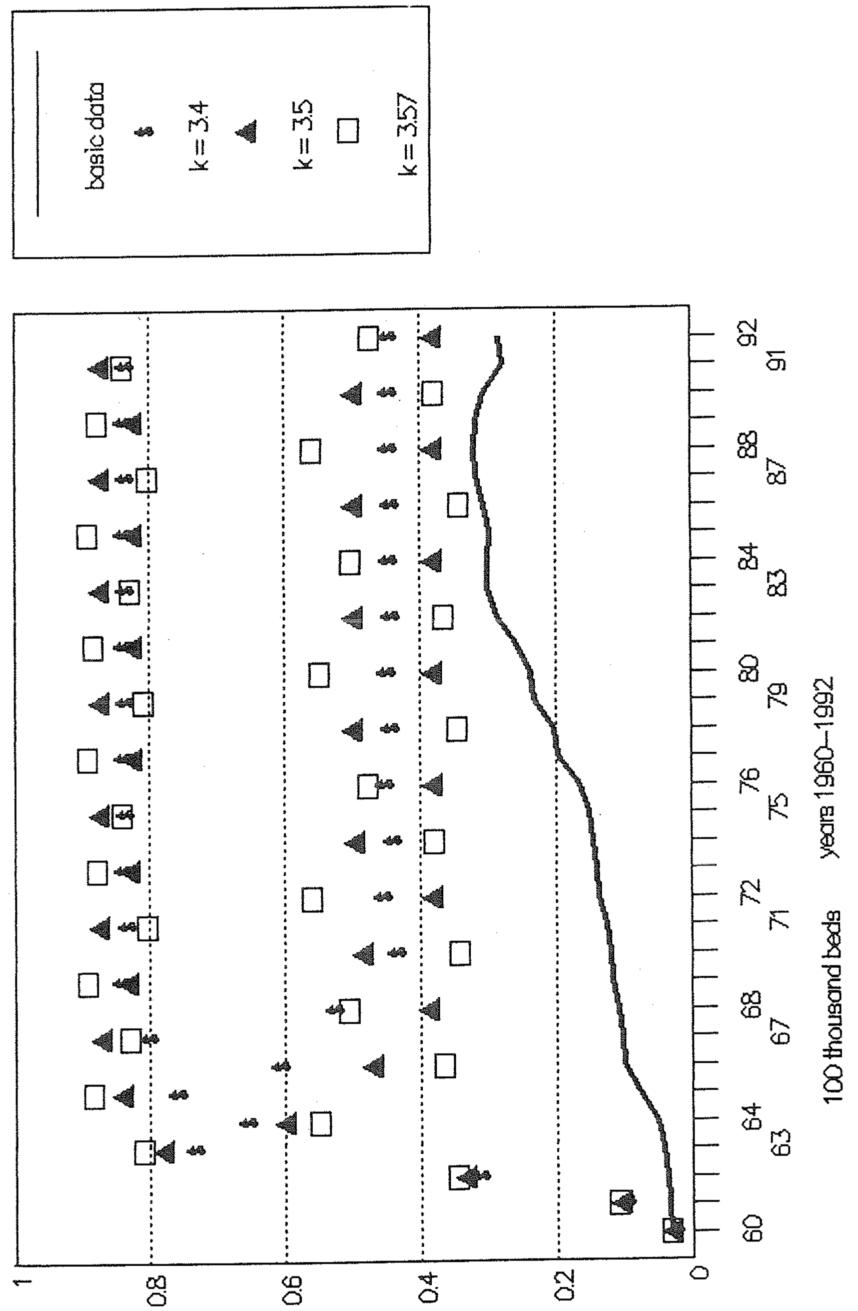

Fig. 9 Number of beds in commercial places of accomodation

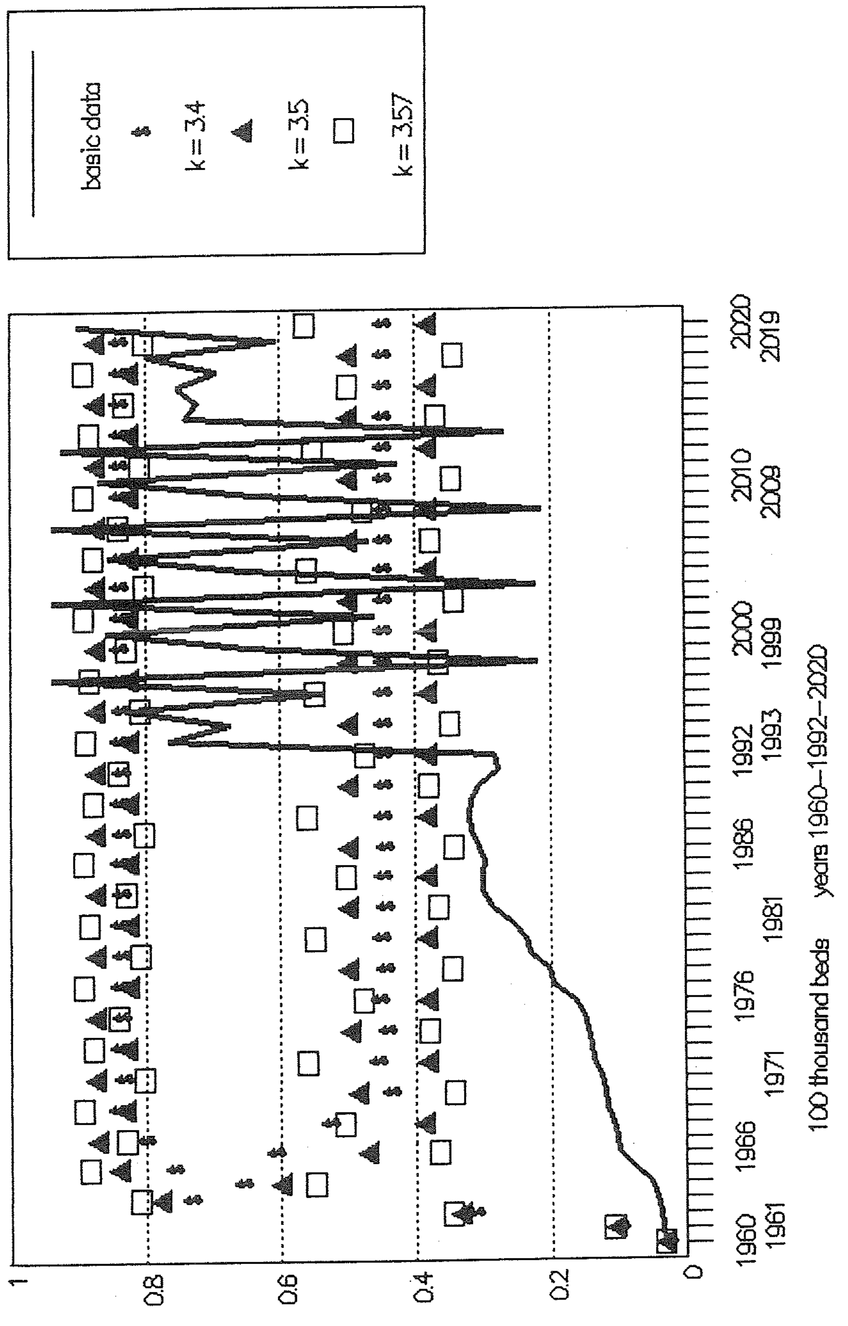

Fig.10 Number of beds in commercial places of accomodation - forecasting