THE METHODOLOGICAL BASES OF PREDICTION IN ECONOMIC GEOGRAPHY

ZBYSZKO CHOJNICKI

Adam Mickiewicz University, Institute of Geography, Poznań, Poland

ABSTRACT. Prediction is methodologically characterised from the viewpoint of its external, instrumental functions in economic – geographical research. The article contains 1) a presentation of terminological and reconstructional assumptions; 2) a detailed statement of the concepts used and a the formulation of a basic methodological model of prediction; 3) an analysis of the nomothetic justification of predictions based on theories in economic geography; 4) the characteristics of the heuristic, model-based justification of predictions, and an analysis of prediction models in economic geography; 5) an analysis of futurological projection and reflection which supplement the model approach; and finally; 6) a discussion of the relationship, between prediction and planning, and of prediction situations linked with planning.

1. Prediction as the forecasting of future events, together with explanation, form the two main components of the scientific approach to knowledge. Consequently, it is possible to consider prediction as a criterion which may indicate the fulfilment by geography as a subject of the basic aims of science. Prediction also forms a link between geography and its applications, because of its importance in practical decision-making and planning. Hence, prediction is both a consequence of, and a means of assessing, a paradigm of geography, which would accept the unity of the methodological structure, and the basic theoretical and practical aims of scientific activity.

As in science as a whole, in geography prediction has a dual role. The internal or autonomous role of prediction in the process of scientific research, seen generally, is related to the checking of theoretical knowledge using predictions. The second, external role, played outside the actual process of scientific research, is related to the provision of information about future events. Of course, this has great practical importance, since effective action and planning are conditional on prediction.

In its first, autonomous, role, prediction may be analysed on the basis of the general methodological principles of the empirical sciences, and forms an integral elements in the empirical investigation of scientific knowledge. Scientific laws and theories may be evaluated on the basis of their predictive power (cf. Hesse 1974, Nikitin 1970). However, such an approach to the methodology of prediction is poorly developed in relation to the similar approach to explanation.

In its second role, prediction may be considered in the light of its contribution to the solution of various problems, especially social and economic problems. In this area, econometrics has made the most progress, but chiefly concerned itself with short- and medium-term predictions. In the last few years, the establishment of a separate methodological discipline has been proposed to examine how prediction is carried out in various different disciplines (Rolbiecki 1972).

In attempting to present the methodological characteristics of prediction in social and economic geography I shall concentrate on prediction seen externally, as an instrument which may be used, in an appropriately justified way, to make forecasts of future events, and to evaluate the accuracy of those forecasts. The logical reconstruction of prediction will be used to describe its methodological character.

Prediction, although it itself is a general sort of method, is carried out through the use of other particular methods. The presentation of these methods involves reference to certain logical and methodological structures (deductive and probability inference, descriptive research findings and laws and theories), to procedures used with analogous structures, like explanation, and to interpretation of mathematical theories (probability theory) and heuristic reasoning methods (mathematical statistics). Thus, prediction has a highly complicated character, especially since it not only constitutes a method of reasoning, but also of investigation.

It is generally accepted that heuristic processes are very difficult to reconstruct logically or cast in algorithmic form. Clearly, this makes such a reconstruction of prediction more complicated, as well as hindering the formulation of methodological rules for prediction.

2. The concept of prediction has many possible interpretations. Because of this, the components of prediction will be spelt out in detail, in order to obtain a less ambiguous concept, and one which incorporates the reconstruction of characteristics vital for the definition of predictions instrumental role in social and economic life.

The concept of prediction may be expressed as follows: 1) a prediction is a declaration made by a predictor about the occurrence of a certain event, or set of events, in the future; the predictor may be either an individual or a group; 2) this declaration is either a true or a false statement, but its logical value can not be determined at the moment when the prediction is being made; 3) the event which is the subject of the prediction must relate to a definite moment or period of time (cf. Czerwiński 1975, Theil 1970). Lack of such a relationship makes it impossible to verify the prediction, since it will not then be known when the accomplishment of the predicted event is supposed to take place. Consequently, both analytical statements, and such synthetic statements which do not lend themselves to verification because of the lack of a definite time element, should be excluded from predictions.

The making of predictions is by no means a purely scientific matter. They are also made on the basis of practical experience, for instance weather forecasting by reading the abundant signs in nature. This experience may be obtained by the predictor personally, or passed on by others.

As a scientific activity, prediction should be rationally based, it should be justified. This results from the critical postulate, which requires that only statements which are adequately justified can be accepted (Dąmbska 1963).

The justification of prediction has not often been examined methodologically, especially from the point of view of prediction's instrumental role. Consequently, a number of difficulties arise in the reconstruction of the justification method, particularly around justification schemes and their logical properties.

It seems that the general prediction justification scheme should be sought in the structure of explanation as a reflective activity like prediction (cf. Popper 1959, also Hempel 1965). If it is accepted that the logical structure of prediction is analogous to that of explanation, then it is based on the derivation of statements describing the predicted events, on the derivation of the predicandum from the conjunction of general statements (accepted or admitted on trial) describing regularities together with individual statements describing the initial conditions forming the predicans. The general scheme of prediction may thus be constructed

Predicans	regularities and initial conditions
↓	derivation
predicandum	predicted event

Further specification and differentiation of the scheme depends principally on the character of the predicans, and on the interpretation of the derivation relationship.

The predicans is formed by a group of theoretical and observational premises, which can take two forms, firstly laws and historical generalisations, and certain individual statements, or secondly descriptive, reconstructive, models and their empirical consequences. The interpretation of the derivation of the predicted event as a relationship between the predicans, the theoretical and observational premises, and the predicandum, raises a number of debatable methodological points, especially with reference to the role of probability inference. Derivation – inference – should be defined broadly, so as to include both deductive and probability inference.

In accordance with the above definitions, the predicandum encompasses events which are the subject of predictive activity. It is also held by some that processes may be predicted, but this can be subsumed into the above definition by treating processes as series of events in time.

The difference between the two sorts of premises included in the predicans has significance for the reliability of forecasts. They also bear on the making of inferences, and may be classified as laws and theories, as against descriptive, reconstructive, models. They form the frames for, in the first case nomothetic, and in the second, heuristic, model-based predictive activity.

The difference between these two approaches is pragmatic in character. It may be expressed in this way, that while laws, as reconstructions of regularities, are solidly established theoretically and empirically, partly through their predictive capacity, and represent developed, completed knowledge, descriptive models have a hypothetical character are specified tentatively, and often call for further improvement. They represent knowledge under development in an incomplete form, both in relation to the model's construction, and to its empirical applications (Wójcicki 1974).

3. Not entering into an analysis of the logical structure of the nomothetic justification of predictions, it can be stated that it has a form analogous to that of Hempel's covering law model, the basis for explanation (1965).

The predictive power of the nomothetical justification of prediction primarily depends on the variety of law statements involved, on information about the initial conditions, and on the type of inference. Of particular value for their predictive power are strictly universal laws, like causal laws. It should also be noted that many laws, in spite of their openness, can not be used in making predictions of individual events because they are either incomplete or numerically undeterminable, despite the fact that they can be used in explanation.

The predictive power of the nomothetic justification of prediction also depends on the preciseness of the premises concerning the initial factual conditions. They describe the occurrence of particular factual states, which may fulfil the premises laid out in the law statements. The fulfilment of these conditions may occur later in time, and may also be the subject of prediction, or an assumption upon which the accomplishment of the predicted event is conditional: in this way one may make conditional predictions.

The nomothetic justification of prediction forming the optimal methodological model of prediction, encounters certain basic difficulties in economic geography, because of the low predictive power of existing nomothetic statements, laws and historical generalisations. These statements are formulated on the basis of the relevant theories, as their theoretical or factual components are connected by a deductive relationship (cf. Chojnicki and Wróbel 1967, also Sztompka 1973). Hence, it is also necessary to consider the predictive role of nomothetic statements with reference to theories in economic geography.

Two varieties of systematised knowledge are accepted as theories in economic geography.

The first group is made up of theories per se, taken as sets of nomothetic statements, laws, and historical generalisations, linked by deduction relationships. Among these theories should be included, in the first place, classical location theory: the work of Thünen (1826), Weber (1909), Lösch (1940), and Christaller (1933), and developments of it, like that of Isard (1956: cf. also Lloyd and Dicken 1972, Korcelli 1974, von Böventer 1963, and Webber, Symanski and Root 1975). The nomothetic statements of these theories have an idealised character, and call for an appropriate measure of concretisation, in order to bring them closer to reality. For instance, Weber's theory formed the basis for Isard and Capran (1949) to make predictions of the development of the North American iron and steel industry, and Christaller's theory was used by Thijsse (1963) to describe the development of the Dutch settlement pattern.

Without going into a detailed consideration of this type of theory, it should be said that they have low predictive power, this lack being caused by their several weaknesses. These include: 1) the general and imprecise way in which statements are formulated, especially those of an idealised type, e.g. Weber's law of transport orientation, which causes great difficulty in relating them to reality; 2) the unconditional way in which nomothetic statements are formulated, hence the imprecise definition of the initial conditions; 3) the use of ceteris paribus as an assumption excluding other factors; 4) the quasi-statistical character of statements expressed by terms like "in general", "most frequently", which should be given a numerical form, the lack of which makes it impossible to determine the probability of the occurrence of the events under consideration.

The second group is formed by a certain systematisation of the statements, which do not form theories per se, despite being so named on occasion. They are approaches to certain problems, formed by sets of norms pointing to the need either to meet certain assumptions, or picking out variables which demand analysis, together with conceptual schemes which form analytical categories, and the relationships between them. The theory of spatial equilibrium proposed by Isard (1969) is a good example of this sort of conceptual scheme (cf. also Dean, Leahy and Mc Kee 1970). Such schemes can form an introductory stage in the building of theories per se, or of models, but they are not in themselves theories. The statements of which they are constructed are primarily definitional, and do not possess predictive power.

It however seems that even considerable progress in the construction of theories in economic geography, and in the formulation of nomothetic statements, will not ensure an equal measure of progress as far as prediction is concerned. In considering social and economic reality, nomothetic justification incur some specific disadvantages. These stem from: 1) the interdigitation of socio-economic phenomena, which means that prediction must be based on many laws, which in turn makes it very difficult to determine the relevant factual conditions; 2) the difficulty of closing socio-economic systems, which may lead to lack of control over interaction crossing the boundaries of the system; 3) the difficulties of estimating the requisite statistical parameters; 4) the introduction of new factors into the development process, as a result of which regularities derived from laws are not met in reality; this concerns the frequently encountered caveat in social and economic prediction that uncertainty exists because of the danger of something new arising.

4. The heuristic, model-based justification of predictions has become the principal method of prediction concerning social and economic events. As Isard has stated "... perfect projection and understanding of society would necessitate a complete general interdependence theory fully tested and set down explicitly in quantitative, operational form. No such theory currently exists or is likely ever to be attained. For short of such a general theory and its operational framework, the analyst must have recourse to approximation. His methodology must involve the quantitative expression of as much interdependence as he can encompass, the testing of such expression against other logical constructs and empirical materials, and the successive reformation and retesting of his initial quantitative expression" (1960, pp. 593–594).

Descriptive, reconstructive models form the basis for prediction using this approach.

The variety of structures taken by descriptive models, and the variety of goals they serve, makes it difficult to define such models unambiguously (cf. Chojnicki 1967). While not going into a methodological analysis of the concept of the model and its scientific function, it should be stated that descriptive models can be used to reconstruct regularities entering into the segment of reality under analysis, but this reconstruction is of a preliminary form, and does not set out to portray the full essential structure of reality, or all its fundamental aspects (cf. Nowak 1972). A model may thus contain variables which are not of great importance in the shaping of regularities, or may not exhaust the set of such variables.

There is a great deal of variation in model-building. It is not very likely that several model-builders, approaching the same problem, would end up with identical models. This happens because the heuristic function of models leads to individual model-builders attempting to grasp certain regularities in relation to pre-theoretical assumptions of various degrees of significance, which are used to solve the problem under consideration.

In contrast to nomothetic scientific structures – laws and theories providing developed, completed knowledge which may be used to justify predictions, descriptive models have both a heuristic and a justifying character, since they are concerned with the preparation of knowledge through the formulation of statistical relationships, which in turn form the premises for justifying predictions.

The justification of predictions calls for knowledge of the descriptive model, in particular the statistical specification of the relationships. Statistical relationships are characterised by two types of components, other than the analytical form of the equations used. These are: 1) the numerical values of the structural parameters of the model, parameters determining the numerical form of the regularity described by the model; 2) the numerical values of the parameters of the stochastic structure hypothesised, the properties of the distributions of random variables occuring in the model, for example, the variance of the random component (error), the variance and covariance of the estimates of structural parameters, and the possibility of autocorrelation in the random component (error). Only once these elements of the model are known is it possible to determine the extent to which the probability of the prediction can be justified (Pawłowski 1963).

The justification of a prediction on the basis of knowledge of the descriptive model from which it was made, has an extrapolatory character, the inference from a sample of the occurrence of an event which does not belong to the sample. Its general form is closely related to the probabilistic variety of the nomothetical scheme. The structural form of the model, the equation and its parameters, plays the role of theoretical premises, and knowledge of the predetermined, explanatory variables, the role of the initial conditions. The process of inference involves the generation of probabilities, based on knowledge of the parameters of the stochastic structure, and thus permits the prediction's adequacy to be evaluated.

It is difficult to summarise the main features of extrapolation as a method, which has been developed for example in the theory of econometric prediction (cf. Pawłowski 1968, also Theil 1970). The methods are differentiated according to the features of the model, particular with reference to their (1) single or multiple equation and (2) cross-section or static versus developmental or dynamic form.

With reference to the first characteristic, and particularly multiple equation models, the value and applicability of two types of model, recursive and dependent, is the subject of a debate, concerning their causal interpretation (cf. Wald 1964, Blalock 1971).

In the light of the second characteristic, it is worth mentioning the application of a particular class of dynamic models, stochastic process models, which are creating new possibilities for justifying predictions concerning spatio-temporal change.

The model-based making and justifying of predictions has become a substitute for the nomothetic approach. In fact, it is often difficult to tell the two approaches apart, chiefly because many descriptive models are concretised forms of theories per se.

Many and varied descriptive models have been written up in economic geography (e.g. Chorley and Haggett 1967, Abler, Adams, and Gould 1972, Colenutt 1970, Termote 1967, Wilson 1968, 1974, Chojnicki 1967, Olsson 1969, and Isard 1960). A division should be made among models used for spatio-economic prediction according to their cross-section, or dynamic character (cf. Harvey 1967).

Among these models, cross-section models form the largest class. They have a structural form, and are timeless in that time is introduced into the model indirectly via the explanatory variables. Extrapolation based on such models must assume that the structural relationships will continue to exist unchanged, and also demands knowledge of the explanatory variables in the future, hence their prediction, in order to be able to determine the value of the predicted variable.

Cross-section models may be classified as causal or symptomatic (Pawłowski 1971). Causally interpreted models are the best instruments for prediction, for example regional econometric models used for regional prediction. Symptomatic models describe various forms of interaction, for instance the very widely used regression based gravity model (e.g. Chojnicki 1966, Olsson 1970, Cesario 1975, and Wilson 1971). They do not involve a causal interpretation of the relationships, stopping short at determining purely statistical dependencies. Extrapolation from these models has however low predictive power, mainly because of the instability of their structural parameters, the speed with which they become out-of-date, and uncertainties associated with the explanatory variables. Similar difficulties occur in extrapolation using regional models based on the estimation of interdependent equations (cf. Klein 1969, and Richter 1972).

Input-output models form a separate class, in that they are similar to cross-section models, but are deterministic in character. In regional economic studies, regional and interregional input-output models may be used to predict certain macroeconomic variables, such as regional income or product, together with interregional links between the activities of the economic system. Without going into details, it should be said that the assumptions made using this model are likely to be met in practice for short periods of time (cf. Isard 1960, Sulmicki 1959; for examples cf. Edwards and Gordon 1970).

Dynamic models belong to a complicated group concerning growth and spatial processes, among which two types, development trend models, and stochastic process models can be discerned.

Models of the first type, which include time directly as an explanatory variable, are not often used in spatio-economic prediction in their classical form as trend models. This is because of their limiting assumptions concerning the stationarity of the analytical form of the model and its parameters. In order to escape from these constraints, many other models have been proposed which avoid these problems. Autoregressive models, in which the predicted variable is a function of the value of the same variable at previous time periods plus random disturbance, seem to be very promising (e.g. Spivey and Wecker 1971, Curry 1970a, b, Rees 1970, Cliff and Ord 1970, and Dunn, Williams and Spivey 1970).

Stochastic process models may form the basis for prediction, if it is accepted that the spatio-temporal process under study may be interpreted as a particular stochastic process. Inference about the value of the predicted variable thus depends on the extrapolation of the relevant stochastic process (cf. Hepple 1974, Kemeny and Snell 1960, 1962). Until now, applications of stochastic process models have concentrated on Markov chains and simulation models. Attempts to use Markov chains to predict the spatial pattern of journeys-to-work and of migration have however encountered serious difficulties and limitations, concerned with the interpretation of the stationarity of the transition probability matrix (cf. Smith 1961, Marble 1964, Rogers 1966, Brown 1970). The removal of these limitations for adequate spatial prediction requires among other things the modification of the sequential linear operators, in order to obtain a reasonable conceptual approach to the relocation process to account for neighbourhood and contingency effects (Olsson and Gale 1968). Equally, the use of simulation models has been chiefly analytical or descriptive, and has not yet yielded the desired results. Hägerstrand has suggested that the real use of simulation models lies in the pedagogic field, and not in the field of practical decision-making (Chisholm et al 1970, p. 463).

On the basis of this review of models used for the prediction of social and economic events, it is possible to assert that there exist a considerable number of ways of including their spatial aspects (Haggett 1973). The specific features of spatial models are normally examined in the form of regional or locational categories. However, the lack of a unified conceptual scheme of these features makes it difficult to systematise them on the basis of an analysis of their influence on the predictive power of extrapolation.

Over longer periods of time, both the heuristic, model-based, and the nomothetic justification of predictions tend to be of little value in the forecasting of socio-economic phenomena. This is caused by the loss of relevance of the model's parameters, which results from changing relationships, brought about by the activity of new factors, the emergence of which cannot be dealt with statistically. This brings about a situation in which predictions apply only within a limited time horizon. Hence, cross-section models of spatial-economic phenomena only allow one to justify short-term predictions, and dynamic models – especially development trend models, medium-term predictions. The time horizons of individual predictions also depend on the character of the exogenous variables. Because of this, spatio-economic predictions face specific uncertainties, with reference to the non-stationarity of structural relationships in space, and especially relationships covering the behaviour of individuals in space. These include location decisions, such as change of residence, journeys-to-work, and recreation journeys, connected with movement in space, and result from, on the one hand, goal-oriented activity undertaken in given spatial conditions, and on the other hand, the subjective process of the perception and interpretation of space. Spatial relationships of a technical or institutional character entering into aggregated regional development models, or inter-regional models, are more lasting, as are relationships connected with the natural environment, which are, however, more difficult to include in socio-economic models.

Of course, from a practical point of view, the greatest possible extension of prediction time horizons is very desirable, but for the moment neither heuristic, model-based prediction nor nomothetic prediction seem to hold out much hope.

The justification of long-term predictions based on descriptive models involves non-trivial uncertainty. Over a long period, it is very unlikely that the assumption, of the model or law, that the system is stationary will be met. In the real world, socio-economic systems are affected by change, which sometimes occurs very rapidly, altering their spatial structures. Rapid changes in system structure come about in connection with the emergence of new forces, resulting from the action of various factors, such as technical, organisational, political and social factors. In the case of social factors the changes

are the result of the observation and evaluation, by participating individuals and groups, of socio-economic activity.

Prediction based on system stationarity has, thus, a somewhat conservative character. In order to thrust aside this stationarity, it is necessary to be able to deal with processes which are just emerging, and this steps beyond the possibilities of the statistical approach to modelling (Garrison 1973, cf. also Emery 1968; for examples cf. Dziewoński 1971, and Berry 1970). Our current methodology lets us down here, since forecasting new forces is closer to discovery than to justification, and indeed, there is no logical structure for handling this form of scientific discovery. This is an avenue of further methodological research which lies outside the scope of this paper.

5. The consideration of the prediction of socio-economic phenomena as a purely reflective activity is rather too restricted. In reality, we have to deal with more complicated forms of prediction, in which human goal-oriented activity may shape future socio-economic phenomena to a marked degree. The prediction of these phenomena is closely connected with planning (cf. Saushkin 1967, 1973).

Planning, like prediction, is concerned with the future. Of course, it only deals with situations in which a certain degree of control over events exists. Without entering into an attempt to describe the concept of a plan exhaustively, it should be said that it can form a proposal, or a decision, a norm concerning goa-oriented activity in the future, directed towards the achievement of certain desired results (Czerwiński 1975).

The plan as a proposal may be formed by a single version, or several alternative versions of the future state; these alternatives may contradict one another, and have different levels of optimisation. However, the plan as a decision is characterised by the choice of one alternative and a commitment to its accomplishment, in order to achieve certain desired results in the area in which the planner-decision maker is authorised to act. The difference between the plan as a proposal and as a decision may be between two stages in the planning process, which may be carried out by different units.

It is difficult to place a clear division between prediction and planning. Considering the links between them, it is possible to pick out many occasions when prediction forms an integral part of planning.

A basic feature in defining links between planning and prediction is the feasibility of control over the events under attention. This depends on the extent of the decision-maker's authority over them, and is expressed in the existence of the possibility of goal-directed activity, which can change the occurrence, range, and rate of increase of the events. The extent of such authority over events changes through time, and need not follow a monotone function. Control as goal-oriented behaviour not only calls for knowledge about the methods and conditions used in such activity, but also for knowledge of the goals of the activity, the desired results.

It is also possible to evaluate predicted events. These evaluations take the form of value judgements, which express the preferences of particular individuals or groups.

Considering the relationship between planning and prediction, three prediction situations should be distinguished. They are predictions per se, predictions as parts of proposal-type plans, and predictions as parts of decision-type plans.

Predictions per se occur when the predictor has no authority over the predicted events and cannot control them. The fulfilment of these predictions depends either on the predictive power of the laws used, and the knowledge of the initial state of the system, or on the statistical parameters of the descriptive model, together with system stationarity. The use of this variety of prediction for planning purposes is linked to its value as a condition regulating activity. It may also permit the avoidance of the negative consequences of the predicted events, if the consequences can be avoided, for instance the consequences of earthquakes. In addition, one should include here predictive situations where a certain amount of control over events exists, but where the predictor may not have any particular reason to control them, for example predictions of population migration.

Predictions as parts of proposal-type plans normally enter into the planning process (Theil 1970). The formulation of planning proposals calls for the consideration not only of future events, but also the linking of these events with various forms of activity or behaviour. A typical example is the presence of uncontrolled and controlled elements in the same system, when the alternative behaviour patterns of the controlled elements are known. This occurs in the prediction of plant yields, given the weather, an uncontrolled element, and spending on capital goods, fertilizers, and pesticides. The fulfilment of the prediction is conditioned by certain regularities, but also by the possibility of mobilising or restraining various factor formed by elements of human behaviour. These predictions may also enter into more complicated optimisation models, which attempt to determine what should be done to fulfil postulated optimal conditions. Without going into this type of model further, it should be noted that in relation to the optimisation of socio-economic structures, these predictions form a section of the preparation process of proposal-type plans.

The prediction of plan execution includes two prediction situations (cf. Sulmicki 1971). The first is concerned with situations in which the prediction attempts to forecast the effects of the execution of a decision-type plan. Such predictions mainly deal with the conditions for the accomplishment of the plan, and its assumed parameters, and is similar to prediction as an element of proposal-type plans. The second, on the other hand, is concerned with situations in which the planner makes predictions during the taking of planning decisions. Such forecasting deals not so much with the content of the decision, as with the possible intrusion of forces which could obstruct the achievement of established targets, and also forms an integral part of the planning process.

Spatio-economic prediction is clearly tending to move from prediction per se to prediction as a part of proposal-type planning. This is associated with the active part played by economic-geographic research in the transformation of socio-economic structures (cf. Leszczycki 1964). Without going into this problem more closely, it should be stated that spatial planning predictions, justified with reference to their optimal properties, are less developed than in non-spatial socio-economic research. This is the result of the many difficulties facing us, connected with the formulation of optimisation models cast in a spatial form, and with the supply of satisfactory data for their thorough treatment.

Prof. Dr. Zbyszko Chojnicki, Institute of Geography, Adam Mickiewicz University, Fredry 10, 61-701 Poznań, Poland.

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