

Registration form (basic details)

1. Details of applicant

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2. Title of research proposal

Different problems, different methods. The development and conditions of application of methods of statistical analysis

3. Summary of research proposal

The history of statistics shows the continuous rise of new, ambitious methods of statistical analysis in the social sciences. However, in the same time criticism emerges on the use of statistics in the social sciences (Gifi 1990), particularly concerning the question in what way people deal with complex behaviour (Van Zwet 1999). Van Dijkum states that some parts of reality are too complex and too dynamic to be modelled adequately with current methods of analysis. For handling those parts he calls for a new type of statistical methods (Dijkum 1998b, 1999). System theory with dynamic feedback-models gives a new challenging approach to the question how we can study complexity mathematically (Dijkum 1997b, Zouwen & Dijkum 2001). But the question how to verify (or falsify) feedback-models statistically, is not yet answered.

The aims of this research program are the following. On the one hand we need to understand with what aims current methods of statistical analysis were developed in the social sciences. We have to understand and clarify their conditions of application in order to use them adequately and therefore fruitfully. On the other hand we need to develop methods of statistical analysis that accounts for the complexity of feedback relations.

Using the history of statistics and application of statistics in the exact sciences as the field of exploratory research, answers and inspirations may be found. With the concept of recursive (or circular) causality (Maruyama 1963, Aulin 1990, Dijkum 2001a) as a starting point we will explore methods of statistics, both in the natural sciences as well in the social sciences.

Keywords: methodology, statistics, history, social systems, causality.

4. NWO Council area

Other. The proposed research is multidisciplinary in character. Because the history and foundations of statistics and its use in the social and behavioural sciences are subject of research several council areas are involved: humanities, social/behavioural sciences and exact sciences.

5. Host institution

Department of Methodology and Statistics, Faculty of Social Sciences, Utrecht University,
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Research proposal

Description of the proposed research

a. Research topic

The motive

One problem in social research is different from the other. And one method of statistical analysis is different from the other. The history of statistics shows also the continuous rise of new promising methods of analysis: starting with simple correlation to more recent methods of statistical analysis such as nonlinear multivariate analysis and multiway analysis.

A theoretical question is: what were the incentives for these methods to develop and what makes them into an unity? Another question that can also be put forward is: what method to use for what problem? The rise of userfriendly computer software for statistics makes it possible to choose among a wide range of methods, including more advanced ones. But with this freedom of choice the risk of uncritical use of methods of statistical analysis is also larger. Last but certainly not least we can ask whether existing methods are conclusive and sufficient: is there a type of problems they do not yet cover?

An indication that these questions are not being asked and answered, at least not enough, is the criticism always so pregnantly put forward. Famous are the words of Disreali "There are lies, damned lies and statistics", but also "A statistician is a person who draws a mathematically precise line from an unwarranted assumption to a foregone conclusion" (author unknown, cited in Gaither 1996) are worth to be remembered and touch a moment of truth. Sharp remarks come from the UCLA-research group (Gifi, 1990) "The number of correlations that has been computed since Pearson must run in the zillions, but no theory has yet come out of this mountain of numbers." The Dutch emeritus professor in mathematical statistics Van Zwet (1999) goes so far in pointing out that it may be possible that a statistician has to admit that when he deals with complex matters he has no answers. In his inaugural lecture Meester (2000) concludes that false interpretations of the base of statistics e.g. the calculus of probability (see also Dieks 1992) are possible, even in prestigious journals as Nature. According to him, worldviews are part of the practice of reasoning about chance.

From the domain of methodology of the social sciences, van Dijkum warns for the mystification of popular methods of statistical analysis such as the calculation of (Pearson) correlation, linear regression analysis and factor analysis. Some parts of reality seem to be too complex and too dynamic to be modelled adequately with those methods of analysis. For handling those parts he calls for a new type of statistical methods (Dijkum 1998b, 1999).

What is the problem?

In particular Van Zwet's and Van Dijkum's remarks about the inadequacy of existing methods of statistical analysis to handle complex matters point to a new problem. This seems to be indicated by the history of the social sciences as well.

In these sciences one sees the rise and fall of theories, which try to incorporate the complexity of human behaviour. For example, already soon in the history of psychology one realised that the relation between the intensity of a physical provocation (stimulus) and the subjective perception of it (sensation) by an individual was not linear. According to Fechner (1889) a sense organ is adapting itself to the intensity of the stimulus, and as a consequence, there is a feedback between the intensity

of the stimulus and the sensitivity of the sense organ. At the end one can express this in a differential equation between stimulus and response with as outcome a logarithmic relation between the magnitude of a physical provocation (for example noise) and the subjective perception of it (loudness expressed in decibels). In development psychology theories were formulated in which there was no simple relation between behaviour on one side and the knowledge one had to regulate that behaviour on the other side. According to Piaget (1936) there was a reciprocal feedback relation e.g. a circular interaction, between behaviour and cognition of children that evolved in time.

Also in sociology one realised the importance of the idea of feedback for their study of the society (Kaplan 1952). In the practice of research, one studied for example the feedback between: the choice for a profession, one's values and interaction with peers (Gremy 1971); or the frequency of interaction with peers and affection for peers (Kirk 1967). Because such feedback relations led most of the time to complicated mathematical (differential) equations one used computer simulation to get an idea of the dynamics of those relations. On a more abstract level leading sociologists such as Boudon (1967) and Coleman (1964) came to the conclusion that time dependent reciprocal interactions between individuals, groups and organisations had to be expressed in the dynamics of differential equations.

In system-dynamics those differential equations are the mathematical kernel of models with which the interaction in groups, organisations and society e.g. social systems can be studied (Forrester 1969, Meadows 1991). Software such as STELLA, POWERSIM, MADONNA, MATLAB and MATHEMATICA makes it possible to handle sets of differential equations, even sets of non-linear differential equations. With the latter new possibilities to study complex (social) behaviour entered the social sciences.

The development of system theory with dynamic feedback-models gives a new challenging answer to the question how we can study complexity in a mathematical way (Dijkum 1997b, Zouwen & Dijkum 2001). But a new problem has also come forward: how to verify (or falsify) feedback-models? Moreover, when one is confronted with uncertainty about research data because of errors in measurement, or stochastic fluctuations in the sources of data, how can we verify feedback-models statistically? That means, how can we in a first step specify (calibrate), with the aid of a dataset, a feedback model statistically? And, how can we in a second step verify, with the aid of another dataset, that feedback model statistically? In practice of research of the social sciences those questions are difficult to answer (Dijkum 1998b, 2000, 2001b, Mens Verhulst 2002)

Although a number of adequate theoretical starting points for a search into complexity can be found in the social sciences, there is a gap between promising dynamic theories and (dominating) current statistical methods of analysis most of the time based on static, linear models of data. The problem is that most statistical methods of analysis in the social sciences- even non-linear multivariate statistics-, e.g. their presupposed models of data do not fully take into account the principle of feedback and the time dependent character of the development of variables in a social system. With their presupposed data models it is difficult to specify and verify (or falsify) dynamic models. Moreover, one cannot use those methods to specify and verify complex feedback loops in social systems, that is in the end use those methods for the estimation of parameters of recursive non-linear differential equations.

Relevance and innovation

The relevance and innovative character of this research proposal lies here. On the one hand we need to understand with what aims current methods of statistical analysis were developed in the social sciences. We have to understand and clarify their conditions of application in order to use them adequately and therefore fruitfully. On the other hand we need to identify and develop methods of statistical analysis that accounts for the complexity of feedback relations.

Three questions of research

In trying to fulfill those needs we first turn to the history of the social sciences and ask ourselves how current methods of statistical analysis in the social sciences (MSAS) were developed and why most methods are not well suited to analyse complex social systems.

One can postulate that behind most of social research a linear concept of causality is hidden. After a period of intense historical dispute about the logic of the social sciences, -started at the beginning of the 20th century by the Vienna Circle, continued by Popper later on-, restrictions in the reasoning about cause and effect entered the practice of social research. One can speculate that those restrictions were due to Popper's simplified falsificationism, or suppose that the origin of those methodological restrictions are to be sought in Reichenbach's work (Dijkum 2001a). Anyway: present-day literature about methods of social research seems to follow the line of reasoning of Reichenbach when he stated that cause as a variable will influence effect as a variable, but not the other way around. In this point of view there is no feedback relation possible between cause and effect. In present-day social sciences literature cause-effect relations is most of the time viewed as, or rather, reduced to one-way linear dependencies of effects on causes. As a consequence those linear relations can be and are statistically analysed as linear correlations between variables.

This results in three questions. In the first place we have to examine how MSAS has been developed in a technical sense, especially concerning the question how and why the conditions of application of MSAS - conditions related to the limited possibilities of MSAS in order to use MSAS fruitfully and correctly - were introduced in the history of statistics.

Secondly, we want to study what ideas of causality, implicitly or explicitly, influenced the development of MSAS. Thereby we want to investigate the hypothesis that a restrictive i.e. linear view on causality not only effected social research, but as well has effected i.e. limited the development of MSAS. We are interested in what way founding fathers of MSAS such as Quetelet, Galton, Pearson and Spearman (Boring 1957, Kenndal 1968) were influenced and limited by ideas of causality, or more in general by ideas about theory (see also: Porter 2002, Pearl 2000).

And thirdly, and most importantly, we are interested in the question whether in those early ideas about the use of statistics in the social sciences clues are to be found which were starting points for describing and testing feedback relations between variables. Can a feedback view on causality lead to new methods of statistical analysis that account for complexity? Can this be done by adding (or replacing) this view to the inspirations of the founding fathers right from the onset of the development of MSAS? Or must it be done in a different way?

b. Approach

The approach will consist of an efficient and purposeful analysis of historical, philosophical and methodological material with respect to the development of statistical methods.

In the first part we will turn to the origin and development of the calculus of probability (CP) as the underlying basis for statistics. We are interested in the question in what sense the conditions of application of MSAS are related to the conditions of application of CP. The determination of the conditions of applicability of CP then is a preliminary one.

Two questions are central to this issue: what induced the development of CP, and how could concepts applicable to simple games of chances, be so successful on other domains of research. We will first reconstruct how onsets of CP in early history were developed in the practice of gaming and gambling

(Hald 1990, Franklin 2001). Then we will turn to the first successful applications of CP, starting with the theory of errors and variation of Gauss and Legendre (Stigler 1986, Sheynin 1996), continuing in empirical natural science with the gas theory of Boltzman, and ending with evolution models in biology (Meester and Znamenski 2001, 2002). These successful applications give knowledge of the characteristics of the problems to which CP is applicable, and indicate exemplarily how and under which conditions CP can be applied.

In the second part of our study the origins and developments of characterising methods of statistical analysis in the social sciences such as (pearson) correlation, linear regression analysis and factor analysis are being traced. The theory of errors, being a successful application of CP on the one hand, is on the other hand the historical link between these methods (Quetelet 1835, Galton 1886, Freudenthal 1966, Stigler 1986). We will reconstruct how (pearson) correlation, linear regression analysis and factor analysis are derived from the theory of errors and how this introduced what conditions. On the basis of relevant historical material and existing studies we will find out what induced the development of these statistical methods in the social sciences. At the same time we investigate what goals of the social sciences were supposed to be promoted by the use of MSAS, in particular the three mentioned methods, and how these were related to the conditions of applicability of MSAS.

The hypothesis is inspected that the onsets of the development of MSAS were influenced by a static linear view on causality, implicitly or explicitly.

In contrast to the first two parts of our study, we will shift the focus from a mathematical and a philosophical accent to a philosophical and a methodological accent in the third part of the study. We agree with Dieks (1992), Meester (2000) and Pearl (2000) that the problem of the adequate use of the calculus of probability e.g. statistics has not to do with failing techniques, but with fallacies in logical and methodological reasoning. Thereby we make use of the result of the first two parts of the investigations into statistics, not only concerning the limitations which came into existence for MSAS, but also concerning the possibility of statistics to overcome those restrictions. We are especially interested in the question in what way, aside mainstream reasoning, eventually inspired by the natural sciences, feedback relations were recognised as relevant for the social sciences and how (and what) methods of statistical analysis were tried to develop to describe and verify those relations. Before that, and beside that, we will ask the question what methodological onsets are to be found in the modern use of statistics, in the late 20th and present century, to specify and verify feedback relations. With the concept of recursive (or circular) causality (Maruyama 1963, Aulin 1990, Dijkum 2001a) as a starting point we will explore modern methods of statistics, both in the natural sciences as well in the social sciences, which can be used to estimate (recursive) differential equations as points of crystallization in specifying, verifying and understanding feedback relations. Special attention will be given to the question how those estimations of quantitative relations between variables give rise to the qualitative identification of patterns of behaviour and as a consequence understanding of feedback relations. In this context the possibilities and impossibilities of non-linear differential equations to specify, verify and understand complex human behaviour are discussed. We will present that discussion in publications, in conferences and on seminars. We expect that in the end the study will result in a handbook for social scientists in using statistics for specifying and verifying feedback relations in a quantitative and qualitative way. The first section will be historical, the second section will deal with an overview of techniques and software, and the last section will show successful applications.

c. Plan of work

Because of the interdisciplinary character, and the ambition of the study the research will be conducted in consultation with colleagues from different disciplines. Colleagues who agreed on such co-operation are: Prof. Dr. J. Hox (Methodology & Statistics, Utrecht University), Dr. I. Stamhuis (History of Statistics, Free University Amsterdam), Prof. Dr. H. van der Zouwen (Methodology & Social Science, Free University Amsterdam), Dr. V. Dimotrov (Mathematics & Social Science, Sydney University), Dr. J. Franklin (Statistics, Sydney University), Prof. Dr. J. de Leeuw (Statistics, University of California), Prof. Dr. J. Pearl (Computer Science, University of California), Prof. Dr. Ted Porter (History of Science, University of California).

The first two parts will result in a dissertation by a Ph.D. Promotor is: Prof. Dr. R. Meester (Mathematics Free University), Co-promotor: Dr. C. van Dijkum (Methodology & Statistics Utrecht University). This phase of the research will consist of a study of historical documents as is indicated in the description of the topic and the approach. Apart from a dissertation in the fourth year of the study, two papers will be presented on international conferences in the second and third year. Two articles (eventually functioning as chapters in the dissertation) will be written and submitted for international peer-reviewed journals in the field of history of sciences and/or statistics, in the third and fourth year. A short study visit abroad of the Ph.D student to visit and consult colleagues is also planned.

The third part will be realised by Dr. C. van Dijkum and Prof. Dr. R. Meester, assisted by a postdoc (0,6 fte) in a period of three years. This part starts in the second year of the project with an exploration and analysis of methodological and statistical handbooks, and of relevant publications in statistical and methodological journals. Examination, testing of software and application in empirical settings will be a important part in the second, third year and fourth year of the study. Two articles in international peer-reviewed journals of methodology and philosophy will be written and submitted, as well as three papers for presentations in international congresses in the second and third year. A manuscript for a handbook for social scientists in using statistics will be presented on an international (invited) seminar for our colleagues, in the fourth year of the study, and hopefully be published at the end of the study.

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Cost estimates

Staff costs

(per year, in fte, tenured/fixed term, see explanatory notes)

in: (euro)*1000

	Year 1	Year 2	Year 3	Year 4	Total
Project Supervisors (0,1HL+0,3UD)	26	26	26	26	104
1 Phd-student (1 fte)	25	27	29	33	114
1 Postdoc (0.6 fte)		27	27	27	81
Totaal	51	80	82	86	289

Non-staff costs

(per year, see explanatory notes)

in: (euro)*1000

	Year 1	Year 2	Year 3	Year 4	Total
For: - traveling - publications - hard- & software - etc.	5	10	10	15	40