Management statistics

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Jeroen De Mast
Søren Bisgaard
Ronald Does
Irena Ograjensek
Research design

Central question
The central question that the research is to study, is:

“What is the contribution of statistics to management processes in organisations?”

Below, we make this question more specific and give some demarcations of the subject, upon which we propose an approach to answer the basic research question.

Contribution
By the ‘contribution of method A in context B’ we refer to the what and how method A intends to achieve in context B:
1. What is the functionality of the application of method A in context B? Which objective does one pursue by applying method A?
2. What is the approach? How does method A intend to achieve the stated objective?

Statistics
Statistics offers a range of methods for the collection, presentation and analysis of data (Lehmann, 1988). Underlying these methods is the framework of mathematics and mathematical modelling. Typically in statistical methods, a major role is played by the notion of uncertainty and the mathematical solution to deal with it, namely: probability, and – closely linked – the concept of random variation. This uncertainty arises when one realises that an actual data set is just a specimen of a set of possible outcomes that one might have obtained in the given situation just as well. As a consequence, inferences which are made from data should take into consideration not only the data themselves, but also the alternative outcomes that would have been possible. Statistical method does this – and by doing so enables an assessment of the reliability of a certain inference – by regarding observed data as realisations of random variables.

Statistics is an important part of scientific method for empirical inquiry (Good, 1988; Mayo, 1996). Inquiry based on scientific method aims to explain phenomena, and hence to predict and therefore control these phenomena. Scientific method does this by confronting hypothesised theories with empirical evidence and learning from the discrepancies (De Mast, 2002). Statistics provides canonical and standard methods and models to solve inferential problems that an inquirer encounters (Mayo, 1996).

Industrial statistics studies statistical methods which are used especially in business and industry. Examples of statistical tools which are popular in business and industry are statistical experimentation techniques, SPC techniques such as control charts and sampling inspection schemes. Most of these techniques have been placed in coherent strategies (“improvement programmes”) such as Total Quality Management and the Six Sigma Programme.

Statistics in this study is not limited to mathematical statistics, but includes the operational forms that have been proposed for statistical methods (“tools” and “techniques”), and even combinations of tools (“strategies”).

Management processes
Management in an organisation comprises the following processes:
1. Initiation of actions
2. Ratification of initiatives
3. Implementation of actions
4. Monitoring of implementations and actions
Processes 1. and 3. are called decision management, processes 2. and 4. are called decision control (Jensen, 2001).
Dransfield, Fisher and Vogel (1999) discern between three levels of management: strategic, tactical and operational and discuss the application of statistical measurement in each of these levels.

Organisations
We limit the research to organisations that could be described as ‘firms’, for example as defined by Coase (1937). Such an organisation is a player in the market, which means that it is subject to feedback by the price mechanism in the form of profits. Within the firm itself the price mechanism is superseded by management processes. Thus, the subject is demarcated to commercial organisations, excluding governmental and non-profit organisations.

Research design
The central question covers various disciplines, such as statistics, economics, management science, and more. This makes it virtually impossible that a single researcher conducts the study. Instead, we choose to draw from various disciplines and approach the central question from different viewpoints. These viewpoints are:
1. The viewpoint of quality management
2. The viewpoint of economics
3. The empirical viewpoint
4. The historical viewpoint
5. The viewpoint of statistical programmes.
The five viewpoints are described in the succeeding sections and the research question is translated to the context of each viewpoint. The chosen viewpoints are open for discussion.
Our strategy will be to study the central question from the more limited perspectives mentioned above. We shall invite individuals in ENBIS, Pro-ENBIS and beyond to participate in the research programme and write a paper on one of the viewpoints above. The partial answers that each of these studies provide, will be integrated to provide a final answer to the central question.

References
The viewpoint of quality management

Juran (1989) distinguishes quality management activities in organisations in three processes:

1. Quality planning: the determination of the needs of the customers and the development of the products and processes which are required to comply with these needs.
2. Quality control: the reaction to irregularities in the production process.
3. Quality improvement: an organised and systematically pursued change to increase the quality to unprecedented levels (‘breakthrough’).

Quality control is typically an on-line and continuing activity, whereas quality improvement activities are typically conducted in projects. Furthermore, quality control is reactive in nature, whereas quality improvement can be characterised as a proactive search for improvement opportunities. Compare as well Ishikawa (1990, p. 201) and Taguchi’s (1986) distinction between on-line and off-line quality control.

The functionality of quality management is usually sought in two directions:

1. Reduction of costs of poor quality (Dale and Plunkett, 1991), i.e., reduction of costs associated with prevention costs, appraisal costs, costs of external failure and costs of internal failure.
2. Strategic advantages by an increased customer perception of quality, resulting in increased sales, increased market share or increased product prices (Burgess, 1996).

Questions:
What is the contribution of statistics to quality planning, quality control and quality improvement?
What is the functionality of statistical applications in quality management (i.e., which objective is pursued by applying statistics in quality management)?
How does statistics help to achieve that objective, what is the statistical approach to quality management?
In which forms is the contribution of statistics to quality management implemented?
How successful is the contribution of statistics to quality management? To what extent can statistics fulfil its claims? To what extent is the contribution of statistics accepted by quality management?

References


The viewpoint of economics

“The economic problem of society is (...) how to secure the best use of resources known to any of the members of society, for ends whose relative importance only those individuals know. Or (...) it is a problem of the utilization of knowledge which is not given to anyone in its totality” (Hayek, 1945).

Constraints on knowledge have a profound impact on economical planning and are a major theme in the Austrian school of economics. These constraints have two forms:

1. The dispersion of knowledge: the data necessary for economic planning are not given to a single mind, but dispersed among numerous individuals. In order for this knowledge to be used for planning it should either be transferred to the planners, or planning should be decentralised to the individuals who have the data. Some of this knowledge can be easily transferred, but for part of it, this transfer is costly (Jensen, 2001, ch. 4, speaks of specific knowledge in this context). Hayek mentions specifically “knowledge of particular circumstances of time and place.” Once the dispersion of knowledge is introduced, economical planning passes from the manipulation of a known and predictable system into an entirely different realm of investigation in which adaptation, innovative capability, and unintended consequences take on decisive importance. This changes economic planning from an optimization problem into a problem of empirical learning, and statistics takes over from mathematics and operations research.

2. Tacit knowledge (Polanyi, 1966): efficient economic planning should exploit the unconscious knowledge that is embedded in uncodified form in the “know how” of people (Hayek, 1952).

The fact that knowledge required for economic planning is dispersed and in part tacit is the background of the contribution of statistics to economical planning. Three examples:
- Statistics develops measurements and monitoring systems which summarize dispersed knowledge into a format in which it can be transferred (e.g., in the form of Key Performance Indicators) to planners. See Dransfield, Fisher and Vogel (1999).
- Statistics plays an important part in the creation of new knowledge or specification of tacit knowledge. See Box (1997) and Jensen (2001, ch. 11).
- Statistical improvement programmes such as TQM and Six Sigma provide an organisational structure in which economical planning is decentralised to individuals who have specific knowledge of problems (see Jensen, 2001, ch. 11).

Questions
What is the contribution of statistics to economical planning? How can statistics solve the problems of dispersed and tacit knowledge?
What is the functionality of statistical applications in economical planning (i.e., which objective is pursued by applying statistics in economical planning)?
How does statistics help to achieve that objective, what is the statistical approach to economical planning?
How successful is the contribution of statistics to economical planning? To what extent can statistics fulfil its claims?
References


The empirical viewpoint

The two viewpoints above approach the subject from a theoretical perspective. It is also important to evaluate the contribution of statistics to management processes in practice – an empirical viewpoint.

1. Empirical data demonstrating how widespread statistics is in management
   - How widespread is knowledge of statistical techniques in organisations?
   - How widespread are statistical programmes as TQM, Six Sigma, SPC, et cetera?
   - How many organisations apply them?
   - How many and which individuals in an organisation work with statistical techniques?

   Examples of the type of surveys that is meant:
   - Jugulum and Dichter (2001): study the impact of Taguchi’s method in American universities and corporations.
   - Dale, Boaden, Wilcox and McQuarter (1999): study the application of TQM.

2. Empirical data demonstrating the results of applications of statistics
   - What are the results (in terms of money / benefits) of the application of statistical tools, statistical programmes, et cetera? An example of the type of surveys that is meant:

References


The historical viewpoint
Statistical methods made their entry in business and industry in the context of quality control. Leaving aside some pioneering work by, for example, Gosset (“Student”), the field of Statistical Quality Control emerged with the work of Shewhart in the 1920s and 1930s. The quality control methods, as well as the acceptance sampling procedures developed by Dodge and Romig and others, were used extensively during World War II. Statistical design and analysis of experiments began to be used in industry from the 1940s and evolved into different types of application, such as response surface methodology, evolutionary operations and mixture experiments.

One step further than the application of statistical methods for the sake of quality control and improvement, was the notion that it is important that statistical tools are generally mastered by employees in organisations. This notion gave rise to the concepts of Total Quality Management and Company Wide Quality Improvement. From this movement arose the idea that mastering statistical tools is one thing, but that statistical thinking is the essence of what should be taught in industry.

In the 1980s and 1990s approaches to quality control and improvement were institutionalised in the form of certified quality management systems such as the ISO 9000 series. Numerous studies indicate that within the movement of certified quality management systems, professional statisticians stood aside and watched the quality movement overemphasize the qualitative aspects of quality management (Ograjenšek, 2003).

An initiative that found a broad acceptance in the 1990s is the Six Sigma programme. The programme places statistical methods in a business context.

Questions
The historical overview above, which is mainly based on Snee (1988) and Ograjenšek (2003), suggests that the introduction and dispersion of statistical contributions in organisations went hand in hand with the quality movement.
- Historically speaking, how and for what reasons were statistical methods introduced in quality control and improvement?
- Were there other contexts in which statistical methods were introduced?
- How did the objectives with which statistical methods are applied evolve over the years?
- How did the appreciation for statistics in organisations evolve over the years?

References

The viewpoint of statistical programmes

In order to introduce statistical methods in a coherent and operational form in business and industry, numerous statistical programmes have been proposed, such as Total Quality Management (TQM), Statistical Process Control (SPC), Six Sigma, Taguchi’s method, the Shainin System. These programmes have in common that:
- Statistical methods play an important part.
- These statistical methods are supplemented with extra-statistical methods and tools to form a complete methodology to achieve a certain objective. Typical supplements are Quality Function Deployment (QFD), brainstorming techniques and Failure Mode and Effects Analysis (FMEA).
- Typically, the tools and techniques are organised in a stepwise strategy, which places them in a logical order. Compare, for instance, Six Sigma’s Breakthrough Cookbook and the flow of the Shainin System.
- The programme offers a paradigm for the application context of the programme. Such a paradigm consists of a conceptual model of the application context, a vocabulary, plus a philosophy or vision that underpins the programme’s approach. The business model of the Six Sigma programme, with its Sigma metric and its philosophy of aggressive defect reduction, serves as an example.

Questions
Which objectives do these programmes intend to pursue?
What is the role of statistics in this pursuit?
How widespread is the application of these programmes?
How successful are these programmes?
Integration of the various viewpoints and directions for research

The work on the limited perspectives discussed above should be integrated to give a comprehensive image of the contributions of statistics to management processes in organisations. This will inspire directions for further research.