Management and Management Science in 15 Years: A Vision of the Future under the Influence of New Information Technologies

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Summary

Informatics will become an integral component of all branches of the applied sciences, and it will have a similarly fundamental impact on them as mathematics had in the past. With the forthcoming age of knowledge processing computers, knowledge will cease to be only an attribute of man, instead it will develop to an attribute of man-machine tandems. This includes management science. Its databases, models, techniques and methodology will be much more easily accessible through knowledge processing and will become the every day's tools of managers. But computer literacy is a prerequisite and will – besides leadership skills – become a basic qualification for managers. To guide such processes of tremendous societal change is a major challenge for today's management scientists.

Informatics and the Efficiency of Science

It is precisely 200 years ago that the German philosopher Immanuel Kant (1724–1804) stated:

> *"I, however, declare that each particular discipline contains only as much science as it contains mathematics."* (Kant: Metaphysische Anfangsgründe der Naturwissenschaft, Vorrede. Riga 1786, p. VIII)

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Some will agree with this statement, some not. But what remains if mathematics were completely removed from physics, chemistry, mineralogy, economics or management science etc., respectively? Very little! It is the *internal content of mathematics* (in the sense of logical reasoning and argumentative precision) that makes a science a science.

Informatics (computer science) will provide a brother to Kant's statement:

> *"Any branch of applied science will become only as efficient as it contains informatics".*

The efficiency of an applied science will be determined by its internal content of informatics. Why? It is the increasing amount of knowledge which can to a lesser and lesser extent be controlled by and utilized through the human brain and traditional administration of information. In the future the one and only chance to administer knowledge appropriately lies in the adequate utilization of informatics.

Knowledge can be divided into *epistemic* knowledge and *heuristic* knowledge. *Epistemic* knowledge refers to facts, to substance matter, to ontological information. In contrary, *heuristic* knowledge covers methods, techniques, any tools of information manipulation, including logic, mathematics, statistics, and theory of science. Each branch of science has accumulated both, epistemic and heuristic knowledge, connected in intimate interdependence. The heuristic knowledge serves the purpose of processing the epistemic knowledge in purposeful ways. None, neither the epistemic nor the heuristic knowledge is of great value without one another.

The quantity of *epistemic* knowledge has in any branch of science by far exceeded the capacity not only of the human brain, but also of the traditional information access systems, consisting of books, journals and other written material, bibliographies included. Even if theoretically one had access to any information, only a small portion would practically be accessible to him and could really be utilized – due to the fatique of information retrieval. From this it follows that there would be a great demand for information systems that make a bigger amount of epistemic knowledge more easily accessible to investigators.

Also the quantity of *heuristic* knowledge in any branch of science is so vast that nobody can utilize it all. In the traditional system, the applica-

tion of certain heuristic knowledge (e.g. mathematical techniques) requires more or less that one has to have a *procedural* understanding of its details. Again, the limited capacity of the human brain prevents us from working with more than a narrowly limited number of techniques, tools etc. *Functional* instead of *procedural* understanding (see below) would be sufficient for the application of heuristic knowledge if the procedural rules could be left with the information processing device.

In order to make more efficient use of the whole body of knowledge, comprehensive knowledge processing systems will become more and more necessary in any branch of science. They should not only *store* and *administer* the epistemic knowledge, but should also *guide* the user and *lead* him to those facts which are relevant to him. They should not only be a *collection* of heuristic knowledge, but should also *advise* the user regarding his choices of appropriate methods, tools, and techniques.

We will have such knowledge processing systems in the future.

Two prerequisites have to be fulfilled, though:

(i) The whole body of both, epistemic and heuristic, knowledge of the corresponding branch of science has to be available in a *systematic order* which allows for their deposit in *data bases.* Such a systematic order exists in any branch of science, at least rudimentarily, although not fully satisfactorily. Stafford Beer somewhere defined science as systematizing the knowledge of the world. This process has – in any branch of science – to be continued and extended with particular respect to data base logic.

(ii) Secondly, advanced computing technology is necessary. Much can be expected from the forthcoming generation of the *"knowledge* processing" instead of merely *"information* processing" machinery, which the Japanese call the "5th generation". It is ante portas!

The customers of the forthcoming knowledge processing systems will be a much broader community than today's investigators of scientific literature. At present, only the academics can afford to spend time for an exhaustive evaluation of relevant literature. In many areas of industrial research, investigations in the scientific literature are quite sporadic and superficial. This will change with the more easy access to the sources through adequate knowledge processing systems.

The Interdisciplinarity of Information Systems

With the further progress of knowledge processing it is to expect that after a period of *monodisciplinary* information systems and an increasing number of intersystem links *interdisciplinary* information systems will eventually become reality. Like a general purpose lexicon, they will cover knowledge from any branch of science, technology and social studies and thus support interdisciplinary investigations with respect to any kind of problem. They will reach far beyond any traditional lexicon, firstly in that they cover a much higher dimension of information quantity and secondly in that they guide the user and support him with knowledge processing methodology (heuristic knowledge).

Thus, knowledge and data from such disciplines like physics, chemistry, the technologies, economics, sociology, management science etc. can be analysed by a comprehensive collection of methodology at the same time.

Interdisciplinarity, the ideal of Operational Research since five decades, may become reality through knowledge processing systems.

The Knowledge Tandem

With the generation of knowledge processing systems, the efficient *use of human intelligence* has to be *re-considered.*

So far, the human brain was responsible for storing knowledge, searching for and taking access to additional knowledge (mostly from written material), processing the knowledge and steering the whole process including the decisions where to start and where to stop. The human brain received very little support from any kind of machinery, save for computation aids, particularly since the ascent of the information processing technology. But the computer clearly retained a servant's role with respect to knowledge processing. It had to do what his master told him to do.

This will change with the forthcoming computer generation of knowledge processing.

The computer is going to play a much more active role, and advanced knowledge processing will require both, man *and* computers. A

tremendous quantity of knowledge will be administered by the knowledge processing systems, *epistemic* knowledge including billions of statistical data as well as *heuristic* knowledge. In addition, the access to knowledge will be actively supported by the system. It will even suggest search paths and give advice to the user. The system will also suggest procedures (e.g. statistical techniques) to be applied to certain sets of data. And it will fully control the procedural application of techniques, tools and other methodologies. This relieves man from heavy and troublesome burden and makes his mind free for new activities: he has to learn how to use the knowledge processing systems.

They both, man and knowledge processing systems, will form a *knowledge tandem.* Knowledge and knowledge processing will not remain the prerogative of man. It will be split with the computer which will control all those areas of knowledge which can better and more efficiently be controlled by machinery than by man.

An age of split intelligence is ante portas, split between man and machinery. Intelligence will not remain an attribute of man, it will instead become an attribute of man-computer tandems. Leading brains of the future will have to be able to utilize the knowledge processing machinery in the tandem sense. The brains may store less epistemic and less heuristic knowledge according to today's standards. Their epistemic and heuristic knowledge will lie on a meta level and enable them to have immediate access to any kind of particular knowledge they want.

This is frightening? No, this is going to be the future. But it is the free decision of each single individual to say: "This future is frightening and inhumane because it reduces the intellectual functions of man." Or: "This future is challenging and stimulating because it offers new dimensions of freedom for intellectual actuation." Everybody has to decide for himself whether he should mentally flee this future or whether he should actively participate in its design.

It is the responsibility of today's leaders in politics, management of industry and commerce, research and education to take preparatory actions to lead our social systems into this future.

Management Science in the New Age

Denmark's GNP in 1950? The history of SAAB? The turnover of

VOLVO in 1958? The current capacity of the distilleries of Aalborg? Norway's off-shore crude oil production since its beginning? The price of Norsk Data shares on January 2, 1986? How many sources in different libraries would have to be consulted today! All such information will in the future be available from any terminal connected with knowledge processing systems. This is not frightening, is it?
You are interested in Laser technology? You will get any information from the knowledge processing systems: An introduction to Laser physics – with a choice of the depth level, a survey of all the different Laser systems including their details, a survey of Laser applications with all details, addresses and market shares of Laser producers, all the commercial data like production and sales values of single companies, nations and the world. All such information throughout the historical development of Laser technology. Would this be frightening? It would not, would it?
Much has been published about production theory and production functions – at the macro economic and at the micro economic level. Different approaches are being discussed in different countries. Knowledge processing systems of the future will provide us with introductions, surveys and details of this field, including bibliographical data. Who would be frightened by this?
Knowledge processing systems will certainly make all the branches of science and social studies much more efficient. Today, the effort to get access to specific knowledge requires quite a big share of time and cost for the research processes. This would be reduced drastically.

Knowledge Processing and the Efficiency of Management

Knowledge processing systems will not only be available to researchers. Managers, political leaders etc. would have access to it as well. And they would utilize it – in a similar way as management scientists.
How did the sales of certain products develop? What is our company's market share in a certain field? How did certain markets develop? Which companies are competitors in a specific market section? What are the direct labour expenses for certain product groups? What is the

salary and wage distribution within the company? What are the effects of a certain investment policy?
For such information, general purpose knowledge processing systems have to be extended by an individual knowledge and data section of the company. Such knowledge will only be available through computers. Therefore, computer literacy will become an absolutely necessary qualification for managers and other leading figures.

Computer Literacy and Leadership Skills

Management of the past and of the future require two types of activities: On the one hand, managers have to deal with *information* and – based upon information – make decisions and initiate actions. On the other hand, they have to lead, direct, guide, convince and deal with *people* – inside and outside the company. With the knowledge processing systems, the first part will fundamentally change, the second will not, except for the utilization of new communication technology. The first part requires – in addition to today – computer literacy. The second part reqires leadership skills in a similar way as in the past – even if supported by new communication devices.
Can this be combined? Will the manager of the future have both, computer literacy and leadership skills? Or will there be two types of managers, information managers and human resources managers? This split of responsibility would cause a *schism* of management and of management science. It is to be hoped that such a division into *two cultures* will not take place. It belongs to the responsibility of today's educators in management science that the new generation of managers will be trained in both fields, the *utilization of knowledge processing systems* and in *working with people.*

The Immediate Challenge

Knowledge processing systems will be a central characteristic of the future. In order to keep the development under control, society has to be guided into this future. There is no time to wait and see.
This is a challenge for the whole profession of management scientists. Much has to be done, such as:

- The knowledge processing systems have to be designed, not only the

machinery (the task of computer scientists), but the architecture of the relevant knowledge. The whole field of management science and economics has to be re-structured in the light of automatic knowledge processing. A tremendous task!

- Based upon the architecture, the reqirements with respect to the knowledge processing machinery have to be defined.

- The huge amount of actual relevant knowledge and data required for the information system have to be adjusted to the architecture of the information system and – with the beginning of the installation – be fed into the system.

- All the potential users have to be made familiar with knowledge processing systems. Even more ambitiously: they have to be prepared to play a proper role in the "knowledge tandem" discussed above.

The knowledge processing computers *will come* in the near future. There is no doubt. Society has to be prepared to live with these computers and to utilize them.
It is not the machines, it is the effectiveness of the man-machine tandems that keep an enterprise and a country in a state of competitiveness. The people have the choice whether they want to remain competitive or not. It is the responsibility of their leaders to inform them about the possible futures, before they take the choice, and to guide them into the chosen future, accordingly.