# The Role Of Models In Leveraging Information

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## Abstract

Noting the definition of Knowledge Management (KM) as "the process of identifying, capturing and leveraging knowledge within an organisation and using that information to increase", this paper focuses on the *leverage* aspect. It argues that a powerful tool to achieve leverage is the computer model but reflects that such models have commonly been perceived as free-standing tools and the potential is largely neglected in the context of KM. The paper proposes some general principles for the accommodation of modelling within Knowledge Management systems.

## 1 Introduction

Knowledge Management (KM) has been defined as "the process of identifying, capturing and leveraging knowledge within an organisation and using that information to increase profitability and competitive advantage within the marketplace" (Densford 1996).

There are numerous extant issues regarding those four phases of *identifying, capturing, leveraging, using,* such as corporate memory (Smith 1994, Abecker et al 1997), the relationship of knowledge to added-value (van der Speck and de Hoog, quoted by Macintosh 1998), the underpinning technology (Couldwell 1998), and best practice (Densford 1996). This paper focuses on the issue of obtaining "leverage", that is of securing maximum understanding and insight from the available information.


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Information *leverage* is distinguished here from direct information *interrogation*. To illustrate: the answer to "What were the monthly sales of product X over the last year?" requires interrogation; to address "Forecast next month's sales based on past performance" requires leverage. *Leverage* may be more concerned with strategic aspects of business but not to the exclusion of the operational. Further, it is argued that the overall purpose of an inquiry, directly or indirectly and be it by interrogation or leverage, is to impact upon a course of action - that is, to support a decision. The overall pattern might therefore be portrayed, for a particular issue, as:

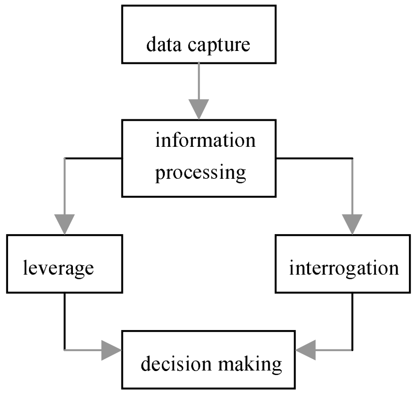


Figure 1: Leverage ~ Interrogation

## 2 Information Systems Context

A logical implication of the portrayal above is the employment of information systems and technology (IS&T); it is an enabler of KM as it is of Business Process Re-engineering (Hammer and Champy 1993).

The wide range and nature of the contribution that IS&T may make within an organisation has been portrayed in a number of ways. Ward & Griffiths (1996), developing from Wiseman (1985), propose three inter-related eras of IS&T evolution in application portfolio and objectives: data processing. management information systems and strategic information systems. Other writers (for example Davis 1984, Baecker 1993, Peppard 1994, Sprague and Watson 1997) broadly support this paradigm of an accumulating contribution to organisations from Information Systems and Technology over time, but add other dimensions in the type of contribution, for example Decision Support and Workgroup computing. Knowledge Management should now be incorporated. Collectively, these perspectives of evolution might be paraphrased as:

Data input, storage, manipulation, reporting
⇩
Data inquiry & analysis (for information)
⇩
Decision support
⇩
Workgroup support
⇩
Knowledge Management

Figure 2: IS&T Evolution

It should be noted, however, that the value-adding profile or potential of IS&T varies by business sector or organisation. McFarlan and McKenney (1983) identified this in their Strategic Importance Matrix.

| Strategic Importance of Planned Systems | | |
|---|---|---|
| | TURNAROUND (competitive advantage) | STRATEGIC (competitive advantage) |
| | SUPPORT (efficiency) | FACTORY (effectiveness) |

Strategic Importance of Current Systems

Figure 3: Strategic Importance Matrix

They argue that commodity industries such as Cement presently use IT only to increase back-room efficiency (*Support*) and are unlikely to (need to) change; whereas for others, such as the Finance industry, IT is already a key competitive (*Strategic*) tool and will continue to be so. Further organisations (McFarlan & McKenney cited Retail) are in a process of change (*Turnaround*) to a greater significance of IT in their competitive actions; and the remainder, for example Steel and other manufacturing industries, use IT as a key business tool in specific areas but are unlikely to develop its contribution as of front-line strategic importance (categorised as *Factory*).

## 3 Computer-Based Modelling

A "model" is a representation on a computer of those characteristics of some part of the real world relevant to the investigation to be carried out, such that use of the model is a predictor of real world behaviour.

The idea originally emerged as part of Second World War military support analysis (Waddington 1973), but since that time widespread activity in Operations Research groups and others has developed a wide range of modelling tools. For example:

- Linear Programming (Dantzig 1953) permitting the construction of models to solve simultaneous allocation problems;
- Dynamic Programming (Bellman 1957) for sequential allocation problems;
- Simulation (Tocher 1963) for the study of stochastic queuing systems;
- Exponential smoothing methods (such as Trigg and Leach, 1967) for forecasting;
- Genetic Algorithms (Goldberg 1986) providing search procedures for non-linear optimisation;
- Multi-Criteria Decision Methods (Belton 1990) for balancing conflicting objectives;
- Data Envelopment Analysis (Dyson et al 1990) for comparative evaluation.

The common ground is the notion of a structure onto which some view of the real world may be mapped as a valid model, that model then “solved”, and the outcome translated back into real-world terms. Given the demands of constructing and processing such models, Information Technology is again an enabler.

Organisations such as American Airlines have demonstrated the value of modelling tools in a highly competitive business and these have become an intrinsic part of the organisation’s operation (Cook 1998). However, it may reasonably be expected that McFarlan and McKenney's arguments will also hold for modelling and the nature and extent of the contribution of each modelling approach will vary by business sector. Empirical observation of literature and business practice supports this view.

The most frequently used such method (excluding spreadsheets) has commonly been observed to be simulation (for example Cornford and Doukidis 1991). A major review of its use in UK manufacturing industry (Hollocks 1992) revealed a satisfaction rate amongst users of over 92% - a very high rate for application software. Within the remainder of this paper, simulation will be used as an exemplar of modelling where appropriate.

## 4 Modelling and Knowledge Management

The study of simulation in UK manufacturing (Hollocks 1992) identified the following 14 application areas:

| Application Area | % of Respondents |
|---|---|
| plant layout and utilisation | 77 |
| material control rules | 66 |
| manning level requirements | 65 |
| plant loading/scheduling | 60 |
| capital equipment analysis | 52 |
| line balancing | 51 |
| inventory evaluation/control | 49 |
| information flow analysis | 40 |
| process analysis | 35 |
| evaluating alternative technology | 29 |
| tool management | 22 |
| administration/paperwork | 20 |
| maintenance | 17 |

Figure 4: UK Simulation Study - Application Areas

All reflect the notion of leveraging information to provide additional understanding and insight in specific situations. This is further borne out in the 16 simulation case studies summarised by Hollocks (1995) and the accompanying application taxonomy: Facilities, Productivity, Resourcing, Training, and Operations. However, the common paradigm is of computer-based modelling as a free-standing solution to a specific problem. There is no evidence of links (other than managerial or informal) to the wider information or knowledge environment.

Indeed no literature identified to date discusses the role of models within KM, other than the modelling of the KM/BPR processes themselves. This is despite the leading expectation of senior management from KM, as identified in an Ernst & Young survey (Chase 1997), being that it will benefit decision making (89% of respondents).

The same survey does imply that 80% of respondents regarded their company's use of decision support tools as part of KM (with a wide span of success from very-effective to very-ineffective). Unfortunately there is no information on what the executives regarded as "decision support tools".

In the UK simulation study referred to above, 62% of respondents believed that they needed a better understanding of modelling. Thus lack of awareness may be an obstacle to wider exploitation of models.

A further perceived obstacle may be requirement to construct, and properly run, models. However, within simulation (and most of the other modelling domains) there are a number of user-friendly commercial software packages available for that purpose, for example WITNESS (Lanner Group), ARENA (Systems Modeling Corporation), MicroSaint (Micro Analysis and Design Inc.). Never the less, a Web search (using InfoSeek) on "model" within "knowledge management" found only one modelling tool, TK-Solver. It may be that software vendors also understate the potential for their products within KM.

It is argued therefore that the place of modelling within KM infrastructures is not, at least overtly, recognised. To promote further discussion, the next section considers some principles relevant to the exploitation of modelling within a KM and IS&T context - in particular the need to facilitate integration.

## 5 Principles for Model Implementation

The notion of integration for KM might be regarded as axiomatic. For example, a recent workshop on Knowledge-based Systems for Knowledge Management in Enterprises (Abecker et al 1997) emphasised the importance of integration in particular in different kinds of information systems, knowledge, and knowledge representation. The following are proposed as the basis of an integration framework.

### 5.1 Components

The approach adopted to integrating models into a KM/IS&T strategy should be independent of the type of modelling technology. Many technologies are available, as observed earlier, with different structures and areas of applicability. A common language is required across dissimilar modelling tools. The first structural notion proposed is that of "components" of a problem area.

In essence, industry is the use of *resources* through a *process* to meet a required *product* (or service) demand. The resources may include materials, plant, manpower, and utilities, as well as time and money. The end product/service may be industrial, for example metals, components, machine tools, maintenance, or recruiting, or be for end consumers. The *process* itself may be complex with alternative process routes with varying consumptions of resources, and also feedback loops into the process (for example re-cycled scrap), or it may be straightforward. There are also conceptual components, for example *capacity* or *constraints* on parameters of the problem. These classes of components can be exploded in a hierarchy of detail and relationships.

### 5.2 System Levels

Integration within an organisation may be helpfully thought of as across five levels, as shown in the diagram below (Hollocks 1990). Access to the database is through the interface level, including data mining and the interfacing between applications. The purpose of the "analysis" level is to evaluate data accessed through the interface level, and hence encompasses modelling. Never-the-less, analysis and modelling is not obligatory; raw data may be interrogated directly.

The components discussed above would be adopted at the operational level, with a mapping to the requirements of the specific modelling approach.

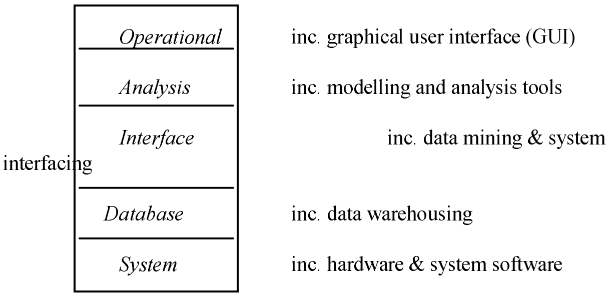


Figure 5: Systems Levels:

Experience has demonstrated the high value of graphics at the front end of modelling and information systems - beyond the use of the conventional GUI/Windows formats. These may present the behaviour of a model, its results, or the contents of a certain sector of the database. The adage that "a picture is worth a thousand words" is, if anything, an understatement. Speed and clarity of understanding of information is important to success.

### 5.3 Construction Principles

Reflecting on industrial practice in modelling and the literature, the following characteristics in the construction of models for integration can be identified.

Models will exist at different levels of abstraction, from detailed models at the individual process level to corporate models which bring together representations of those models below them. This might be regarded as a hierarchy involving "models of models" and a discipline of relationships between the models in that hierarchy is required, including the role of formal meta-models (Friedman 1996).

A distinction should be made between the:

° *physical model* - the representation of the real resources, including specific equipment descriptions (this is the hard constraints of the facilities);
° *logical model* - the description of the logical relationships between the physical items, including process routes (these are the soft constraints);
° *application description* - the specific implementation of the hard and soft constraints currently in use;
° *experiment* - a specific trial using the above.

Hence an investigation (experiment) is carried out by changing information at any one of those logical modelling levels above.

## 6 Examples of Principles in Applications

To illustrate these principles, two specific applications will be briefly described aiming to emphasise the way in which it brings together information from different sources and therefore leveraging their information and exploiting integration. These illustrations do not seek to explore *all* the principles described above. Both examples use simulation as the modelling approach.

### 6.1 Design of Production Plant

#### 6.1.1 Nature of the Problem

A manufacturing process is typically complex, with many interactions between components of the systems at different levels and with many options for the routing of parts and materials through the processes. Individual variations between equipment specifications, limitations on inventory space, dynamic priorities within a varying order load, constraints on resource availability, and many other factors, make the design of enhancements to that plant, or design of a new facility, non-trivial. Appropriate flexibility, including responsiveness and robustness, and the computer control systems which may be used (and which may have an impact upon the plant design itself), must also be considered. Such an enquiry is typically lead by an engineering function or by works management and accommodates specialisms within engineering, the commercial function (for product forecasts), process technologists, and others. All bring information to the subject.

The role of the computer model is to test out the ideas and options in advance of the decisions. Computer simulation is by far the most powerful tool to address this (Hollocks 1989).

#### 6.1.2 The Computer Model

Such a model is operating first of all at the Physical level, considering the production plant, as well as at the Logical level for the plant relationships. Specific Application Descriptions are used related to the products that are to be made. Simulation reflects the dynamic logistics of manufacturing operation and only those areas that are relevant to the decision should be incorporated, that is those to which the decision is sensitive. Therefore, parts of the simulation are effectively representing areas which could be modelled in more detail for other applications, that is they involve models of models.

A modern simulation tool permits an iterative process, no longer a batch tool as in the past, and therefore the team members can collectively construct the simulation model together, a process which shares their information and inputs to the modelling process. The output from a simulation is first in graphical form as a dynamic mimic diagram permitting the participants in the decision team to observe the interactions of the components of the design and their various inputs. Experience demonstrates that this permits misunderstandings to be clarified as well as new ideas and options explored. Final judgements are then on the basis of statistical results from simulation runs - the Experiment.

### 6.2 Production Scheduling

#### 6.2.1 Nature of the Problem

The manufacturing problem, once resolved at the design stage, then has to operate. One specific aspect of this is the day-by-day loading and sequencing of orders onto the shopfloor. The first step in any production scheduling is the decision made when an order is accepted and a delivery date (the due date) quoted and committed. However, day-by-day as production progresses, changes in the world, for example in the order load, plant availability, or manning availability, will necessitate re-planning and reviewing. The lead in this will area will be taken by Production Planning, and other functional groups involved will include Production Management, Commercial Department, Purchasing and Despatch. Again, they all bring their information to the subject.

Part of this process may be modelled in one sense by a company's MRP II (Manufacturing Resource Planning) system in its breakdown of constituent parts of an order and its manufacturing implications. In that sense it is the model of the demand on the works generated by the customer order. However, the production schedules must recognise the finite capacities of the individual items of equipment and other resources making up the manufacturing system. The most practical tool for this task is simulation.

#### 6.2.2 The Model

A model for production scheduling utilises the decision rules which govern the progress of orders through the plant, and executes those rules through simulation time within the finite constraints that apply at that point in time. Such a model is working between the Experimental and Application Description levels with the Physical and Logical levels fixed points. A simulation model is only constructed at the design of a scheduling system, thereafter the model is in routine use. The key interface in this case is typically not the graphics mimic diagram but a bar chart (Gantt chart) display mimicking the ubiquitous planning board already well known to production schedulers. The physical planning board is a strong visual presentation of a situation and the options open but has the burden of slowness and difficulty of updating. Computerising such a presentation provides even stronger physical presentation, with the ability to rapidly update or interact with the plan, as generated through simulation, and so presented.

Such a scheduling tool normally needs to be integrated with other IT systems, in particular MRP II or sales order processing, shopfloor data collection, purchasing and despatch control, or others. The scheduling tool permits the production scheduler to carry out shopfloor order loading whilst bringing in other considerations from the manufacturing management and personnel functions or others who may have their own requirements from operation of the model, for example, in studying manning levels.

## 7 Conclusions

The paper has argued that computer models offer a powerful method of leveraging information within knowledge management but remain to be well recognised. The enabling role of IS&T to both KM and modelling has been noted. Some principles have been proposed for the integration of modelling within wider systems.

Given the competitiveness of international business and the need for a value edge, KM incorporating modelling tools offers a competitive opportunity.

## References


Abecker A, Decker S, Hinkelmann K, & Reimer U (Eds) (1997) Knowledge-Based Systems for Knowledge Management in Enterprises. *Workshop held at the 21st Annual German Conf. on AI (KI-97*). Deutsches Forschungszentrum fuer Kuenstliche Intelligenz, Document D-97-03, September.

Bellman R (1957) *Dynamic Programming*, Princeton University Press

Belton V (1990) Multiple Criteria Decision Analysis, *Operational Research Papers*, Operational Research Society, 53-102

Chase R L (1997) The Knowledge-Based Organisation, *Journal of Knowledge Management*, **1**, 1, 38-49

Cook T M (1998) SABRE Soars OR/MS Today, **25**, 3, June, 27-31

Corford T & Doukidis G I (1991) An Investigation of the Use of Computers within Operational Research, *European Journal of Information Systems*, **1**, 2, 131-140

Couldwell C (1998) Fountain of Knowledge, *Computer Weekly*, Dantzig, G B. (1953) Computational Algorithm of the Revised Simplex Method. *Rand Report, RM-1266.*

Davis M W (1984) Anatomy of Decision Support, *Datamation,* 15 June, 201-204

Densford L E (1996) Knowledge management; an underutilized tool that enables companies to know what they know, *Corporate Univesity Review,* December

Dyson R G, Thannassoulis E & Boussofranc A (1990) Data Envelopment Analysis, in *Operational Research Tutorial Papers* (ED. Hendry L C & Eglese R O, Operatioanl Reearch Society, Birmingham, UK

Friedman, L W (1996) *The Simulation Metamodel*, Kluwer Academic Publishers

Goldberg D E (1989) *Genetic Algorithms in Search, Optimisation and Machine Learning*, Addison Wesley, Reading, MA

Hammer M & Champy J (1993) Re-Engineering the Corporation, Harper Collins

Hollocks,B W (1989) Production Modelling is an Integral Part of Decision Making. *Proceedings of the 21st International Symposium on Automotive Technology and Automation, Wiesbaden.*

Hollocks B W (1990) Decision Integration Through Computer Models. *Proceedings of the AutoFact'90 Conference, Detroit,* ref MS90-735, 10.27-10.29

Hollocks, B.W. (1992) A Well Kept Secret? Simulation in Manufacturing Industry Reviewed, *OR Insight*, **5**, 4, 12-17, October

Hollocks, B W. (1995) The Impact of Simulation in Manufacturing Decision Making, *Control Engineering Practice*, **3**, 1, 105-112

Macintosh A (1998) Position Paper on Knowledge Asset Management, http://www.aiai.ed.ac.uk/~alm/kam.html

McFarlan F W & McKenney J L (1983), *Corporate Information Systems Management*, Dow Jones Irwin

Peppard J Ed. (1993) *IT Strategy for Business*, Pitman

Smith J (1994) *Collective Intelligence in Computer-based Collaboration*, Laurence Erlbaum, NJ

Sprague R H & Watson H J (1996) *Decision Support for Management*, Prentice Hall, NJ

Tocher, K D. (1963) *The Art of Simulation.* English Universities Press.

Trigg D W & Leach A G (1967) Exponential Smoothing with an Adaptive Response Rate, *Operational Research Society Quarterly*, **18**, 1, 53-60

Waddington, C H. (1973) *OR in World War 2 - Operational Research Against the U-Boat.* Elek Science.

Ward J & Griffiths P (1996) *Strategic Planning for Information Systems*, Wiley

Wiseman C (1986) *Strategy and Computers*, Dow-Jones Irwin, Homewood, IL