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Abstract (Document Summary)

Quantitative modelling seems admirably suited to help managers in their strategic decision making on operations management issues, but in practice models are rarely used for this purpose. Akkermans and Bertrand investigate the reasons why, based on a detailed cross-case analysis of six cases of modelling-supported strategic decision making. In several of these cases, effective strategic decision making was achieved despite unfavourable technical contingencies, such as a lack of quantitative data, or low tangibility of the issue at stake. This suggests that such technical conditions cannot be crucial for effective model-based support. However, no case was found where good overall results were achieved under adverse organizational conditions, such as low quality of communication between stakeholders during the modelling/decision-making process and low ownership with these stakeholders for the resulting model and its implications. This suggests that such organizational contingencies are indeed crucial for effective model-based support. The modelling method described achieved good communication and ownership by operating in a process-oriented consulting mode, where client participation in group model-building sessions played a central role.

Full Text (5222 words)

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final revision.

Introduction

Strategy issues are always highly complex, both from a technical and an organizational perspective. One well-established way of dealing with complexity has been to construct (quantified) models of the issues at stake. In the field of production and operations management (POM), quantitative modelling has long been a normal and well-accepted academic way of dealing with complex issues (cf. Meredith et al., 1989). However, the use of models for strategic issues has been rare in POM. This is certainly true in practice (cf. Simulation Study Group, 1991), but even in academia, when we look at the applications of quantified modelling in the POM area, we see that the vast majority of applications is on operational and tactical issues, such as scheduling or vehicle routeing (Graves et al., 1993; Silver and Peterson, 1985). And when we look at the strategic decision-making literature, we find also only a limited number of references to the use of quantitative models (e.g. Mintzberg and Quinn, 1992).

Nevertheless, it has long been acknowledged that it is technically quite feasible to construct quantified models of strategic POM issues, because it is always possible to construct aggregate relationships that describe, in a simplified but adequate manner, the overall behaviour of an in itself highly complex operations system without modelling this complex subsystem in detail (Akkermans et al., 1991; Bertrand et al., 1990; Forrester, 1961; Towill et al., 1992).

So why are models, and quantitative/computer models in particular, not used more often to assist management in dealing with complex POM strategy issues? Often-heard technical explanations in practice are that, although it is theoretically feasible to construct models for strategic issues, it is often not practical or desirable to do so, because of:

low data availability: the required data tend to be unavailable and the judgements required are highly subjective;

high data intangibility: the issues covered are too "soft", and do not lend themselves to quantification.

However, the available literature shows us that these arguments cannot stand a critical review, because already in the early days of operations and systems science research, successful efforts have been made to model the more strategic aspects of managerial decision making and the long-term effects of organizational structures on organizational performance. Pioneers of our field, such as Ackoff (Sengupta and Ackoff, 1965) and Forrester (1961), achieved breakthroughs in this area in the early 1960s, especially in the field of strategic POM issues. Since then, system dynamics, especially Forrester's approach, has been imitated, copied or extended by many researchers of business processes (see Greenblatt and Hung, 1978; Mass, 1978; Mittroff et al., 1973; Morecroft 1983, 1984). So it has been well established that strategic decision making on POM issues can be effectively supported by modelling, despite lack of data or low tangibility of issues.

Moreover, to a considerable extent, problems at the operational and tactical level in POM also suffer from these same drawbacks, and it is at this level that we see an abundancy of successful modelling applications. Research into empirical modelling of real world decision making at the more detailed levels, such as production planning, scheduling and sequencing, shows that, in developing support for this type of decision making, soft factors such as motivation, training and education of people have to be taken into account, and that it is also necessary at this level to work around incomplete and missing data and make subjective judgements (see Bertrand and Wortmann, 1981).

Does this mean that there are no differences in complexity between operational and tactical issues in POM? No, but the complexity is not so much technical as organizational. A key difference between operational and strategic decision making is that, in the latter, input and commitment are required from all the different functional areas from the firm, i.e. not just from production or engineering, but also from marketing, purchasing, development, human resource management, finance, etc. It is the managing of the complications around this group decision-making process that makes strategic decision making more complex. This complexity then can be observed in two stages of the strategic decision-making process:

- (1) During the process, in the challenge of achieving effective and open communication between all these different stakeholders with their different backgrounds, jargons and interests.

- (2) At the end of the process, when a strong and cross-functional commitment is required from the stakeholders involved to implement the resulting recommendations.

The importance of good communication and high client ownership has long been established in the literature on strategic decision making in the broad sense (Mintzberg, 1994; Schein, 1969) and in the early 1990s in the area of POM specifically (see Akkermans (1995) and Akkermans and van Aken (1992) for a literature review) and also in the area of strategy modelling (Morecroft and Sterman, 1994; Vennix, 1996).

Of course, achieving good communication and high ownership are challenges that exist for all attempts to support strategic decision making, whether one uses formal models or not. But when one looks at the literature on strategic decision making per se, one finds that there the main transition has been from a so-called "expert mode" of consulting, which neglects the effects of phenomena like group dynamics, organizational politics and jargon differences to a more process-oriented one (Mintzberg, 1994; Schein, 1969; Vennix, 1990). Could it be that modelling efforts at the strategic level tend to be unsuccessful because the modellers themselves act like the experts, who hold all relevant knowledge, rather than facilitators, whose expertise lies in capturing the expertise in the group of stakeholders? It is research questions like these that the authors originally set out to evaluate, on the basis of six cases of model-supported strategic decision making in POM issues.

The theoretical considerations described above can be reformulated into the following three research hypotheses:

H1:Formal models can be used effectively to facilitate a complex strategic decision making process with its group dynamics and jargon problems, provided they are employed from a process facilitation perspective with the client and appropriate group modelling techniques are used.

H2:Even in cases where technical impediments exist, such as low data availability or high problem intangibility, successful model-based support will be possible since these technical impediments are known to exist at all levels of decision making.

H3:It will not be possible to have effective strategic decision-making process contingencies in cases where strong organizational impediments exist, such as low quality of stakeholder communication during the process and low levels of client ownership for the resulting model and its recommendations (even if data are available and the problem is highly tangible!).

Research methodology

The research described here was not a (quasi-) experimental design, but exploratory case-based research. In strategic decision making, one rarely has the liberty to conduct controlled experiments; the essence of strategic decision making requires a real group of real decision-makers, with a past and a future together, a great deal of dispersed knowledge of the issue at stake in their heads, yet considerable ambiguity remaining, and real-world pressures such as profitability or time constraints constantly on their back.

This has at least three major consequences:

- (1) The researcher has to use as well as possible, the case material presented.

- (2) The number of cause-effect relationships will tend to become huge, because there is very little solid theory on which to build a focused research design.

- (3) The research model and the research procedure will need to be developed incrementally, in a number of iterative steps, as neither can be based on textbook theory at the start of the research. Both the research model and the evaluation procedure are therefore shown here in their final form.

Research model

Figure 1 shows the overall research model for the evaluation research as it was developed by the authors (Akkermans, 1995a). This model identifies the various aspects of the effectiveness of strategic decision making and decision implementation for POM issues. It suggests that actual implementation results will depend on both the quality of the model that is being used, as well as on the level of organizational support for that model and its recommendations. It also shows that both will depend critically on the quality of the whole process of meetings, interviews, workshops, analyses, etc. that typically takes place in any strategic decision-making context.

Finally, Figure 1 shows that there are a number of contingencies at play. "Data availability" and "problem tangibility" are examples of technical, problem-related contingencies, "political sensitivity" and "problem ownership" are examples of organizational contingencies. The third category of "contingencies" is one that is within the control of the modeller/consultant/facilitator; this is the specific design of the modelling method used. Aspects of that design include the usage of quantitative simulation, what graphical modelling techniques were employed and the skill level of the process facilitators.

Figure 1 contains a top-level overview of the research model. Below that top level lies a second level, where each of the overall factors is defined by a number of so-called "indicators". Tables I and II provide listings of these indicators.

Most of these labels will be self-evident, but some crucial ones require additional explanation. (How they were measured may be less obvious, but will be discussed in the section on evaluation procedure.) For example, "communication", which was the catch-all for "the quality of the conversational process between the various participants", was actually subdivided into five different aspects, notably:

exchange of ideas/viewpoints;

openness;

common language;

(lack of) verbal dominance; and

freedom.

Also, the objects of the nouns can be semantically ambiguous. For instance, "willingness to co-operate" refers to participants' attitude towards the modelling process, whereas "ownership" points to participants' feelings towards the output of that process, i.e. the model and the recommendations that arise from it.

For a complete description of all the indicators, the reader is referred to Akkermans (1995).

Six case studies

Over a period of two-and-a-half years, six commercial model-building projects were conducted by the first author; the second author collaborated in the development of the overall approach and directly in the sixth project. Four of these cases were in the field of operations management proper; cases two and four had clear operations management elements, but were also on the broader issue of organizational design in general.

These case studies varied widely in scope, content matter, client type and many other characteristics. They all addressed complex strategy issues and in all six case studies the same modelling approach was used, called participative business modelling or PBM (Akkermans, 1995a). This PBM method blends system dynamics modelling (Forrester, 1961; Morecroft and Sterman, 1994) and other OR techniques with a non-expert mode of process consultation (Akkermans, 1995a; Schein, 1969; Vennix, 1996) to ensure maximum client participation and ownership of results.

Project 1. The first project, still clearly exploratory in nature, was aimed at cycle time and cost reduction in international newspaper distribution operations (Akkermans, 1993). The core of the decision-making process was the development of a simulation model of the distribution process, which led to considerable reduction of cycle time and distribution costs.

Project 2. The second project did not have a clear quantitative orientation. The aim here was to find explanations for the lack of collaboration between independent business units of a company in the service industry (Vennix et al., 1996). In a series of group model-building sessions, a shared visual model was developed that explained why collaboration was not achieved, although this was clearly in the long-term interest of the overall company (but not in the short-term interest of the individual business units). Perhaps the most striking consequence of this project was that the evaluation results showed that the participating managers' attitudes towards collaboration improved as a consequence of their involvement in the project.

Project 3. The third project involved the development of a European logistics strategy for a US-based pharmaceutical company intending to market a new, life-saving drug (Akkermnas, 1995b). The fact that this drug had to be available to hospitals on demand within a few hours throughout Europe placed special constraints on the operation. The project was able to design a strategy and structure that satisfied these and several other business constraints, but implementation never happened because the medicine failed to meet the efficacy criteria set for the clinical trials that it was undergoing. In this case, both a system dynamics and a discrete-event model were developed, the former to evaluate the size and composition of the European distribution network, the latter to assist in business process engineering for the European call centre that the company intended to install to steer its delivery chain.

Project 4. The fourth project had as its goal the development of an implementation plan for the new corporate strategy of an international professional services company (Akkermans and Bosker, 1994). This project failed. Evaluation interview analysis showed this was because participants were unwilling to discuss the problem openly in a group session, in view of the political sensitivity of the issue and the resulting career risks for the participants.

Project 5. The fifth project, in contrast, was very successful. Here the objective was to develop a decision-support system to aid local bank managers in deciding whether or not possible changes in their branch office structures were appropriate (Akkermans, 1995c). A remarkable feature of this project was the large percentage of "soft" issues, such as "level of customer irritation", that the team managed to capture in a quantified model.

Project 6. The final project aimed to improve management insight into strategic supply chain logistics in the semiconductor industry (Akkermans, 1995a). Here the case analysis (i.e. the evaluation interviews) took place half-way through the project, at a time when only a conceptual (i.e. non-quantified) model had been developed which appeared to capture adequately the main supply chain effects involved and was once again well received by the participating managers.

So what do we find? First of all, we see widely different issues being tackled with quite different OR techniques (e.g. discrete event simulation, system dynamics simulation). But we also find that always a similar approach was used in doing so, i.e. a process-oriented one, in which all relevant stakeholders participated in a group model-building process. Finally, we find that in all six cases decisions had to be made on one or more operations strategy issues.

The evaluation procedure

The evaluation procedure for the six case studies was both exploratory and extensive. Exploratory, because very little similar research had been conducted in the past, which also led to a large number of variables to be taken into account, and extensive, because of the broad focus and the huge amount of text material that had to be processed. Figure 2 shows the main steps taken in this evaluation process, or rather, the outputs of each step.

Session notes and tape recordings were the direct output of conducting the cases themselves. The researchers noted observations and memos during the process, and most of the group model-building sessions were taped and these recordings were transcripted afterwards.

An initial theory of what determined strategic decision-making effectiveness in these modelling projects was constructed by the researchers. This theory was based on a survey of standard literature in this area (e.g. Mintzberg (1994) for strategy and Morecroft and Sterman (1994) for strategy modelling, cf. Akkermans (1995a)) and on their experiences and discussions during the cases. This theory was formulated as a causal diagram, in which each relevant concept of strategic decision making was identified and labelled. Figure 1 contains the top level overview of this theory. However, each of the concepts there, such as "process effectiveness", contains up to six second level concepts that all determine this overall concept, e.g. "speed", "focus", "involvement", "communication", and "willingness to co-operate". In this way, there were more than 60 second level concepts in total. Also, a similar number of causal relationships between these second level concepts were identified on the basis of standard literature and interview results, e.g. "willingness to co-operate leads to good communication".

Evaluation interviews were conducted guided by this theory: on the basis of the concepts and hypotheses distinguished by the researchers, interview questions were formulated. Most of the participants in all six cases were interviewed, and their answers were also taped and transcripted.

Coded transcripts were the result of a labour-intensive process of checking all the transcripts of the interviews and sessions (a total of some 70 hours of spoken word) for references to the 60-odd concepts from the initial theory.

Clustered data displays were constructed in an elaborate process of grouping related references in the data sources (e.g. from session A or evaluation interview B), making summaries of these references. An essential step in the analysis here was that each of the assessments made by the respondents on the factors identified in the research model (e.g. the quality of communication, or the level of problem tangibility) was translated into a five-point scale by the researchers ("very low/bad", "low/bad", "normal", "high/good" and "very high/good"). These ratings were then again averaged over the entire population of respondents in that case, and then summarized in a higher-level table, i.e. one for an overall concept such as "organizational platform", as is common in qualitative data analysis (Miles and Huberman, 1984). In summary, such so-called "data displays" were constructed at three levels of aggregation:

all references, clustered per data source, to a particular concept, e.g. consensus, with an overall assessment per data source;

all assessments, clustered per model concept, of the overall aspects of our theory, i.e. four aspects of strategic decision making: process effectiveness; model quality; organizational platform; and implementation results; and three contingency clusters: problem contingencies; organizational contingencies; and aspects of the consulting method. For these also overall assessments were made; and

all assessments, clustered per overall concept, to the four overall aspects of strategic decision making, clustered per overall concept, providing a one-page summary of respondents' assessments of the various aspects of decision making effectiveness, this one page being the result of analysing several hundreds of pages of text.

Causal diagrams per case. A separate stream of analysis was focused not on the values of the concepts themselves, but on the causal relationships between concepts. Data sources were also searched for examples of causal reasoning, e.g. "Process facilitation was very good and this made us communicate effectively". These references were once again collected in tables, but were also presented graphically as causal diagrams.

Member tests per case were conducted after this causal analysis had been finished. Each of the respondents received the relevant causal diagrams of the case in which he or she had been involved, along with a verbal description of the reasoning visualized in the diagram, and was asked to look for missing relationships or wrong assumptions. The feedback from these member checks led to some additional changes in the case assessments.

Cross-case scatter plots were a key element in the cross-case analysis process that started next and also an important visualization element in this article. Here we set out the values assigned to concept A from the initial theory against the values for concept B, to find out if the assumed relationship between them held up across the six cases. Please note that these scatter plots, however inviting it may be to do so, cannot be read as visualization of statistical correlations. Data sets of six pairs are simply far too small for that, especially considering the large number of interrelated causal relations to be considered.

Revised theory. Such scatter plot analyses were conducted for all the 60-odd relationships in the initial theory. Then, in a final inductive effort, those relationships that turned out to hold up across the six cases were grouped into so-called "causal chains" (Miles and Huberman, 1984). One such chain turned out to be: "high willingness to co-operate leads to good client communication, which increases ownership of the final results, which boosts commitment to act on these results". This chain summarizes, in a nutshell, the philosophy behind the PBM method.

Evaluation findings

In general, the authors feel it can be stated that the case data collected from the six case studies were found to be consistent with the three hypotheses formulated in the Introduction.

H1: formal models can help strategic POM decision making

In general, our usage of models to support decision making on strategic POM issues was successful, as becomes apparent from Table III. In fact, where conventional wisdom would assume that the lower the relative reliance on quantified simulation, the more positive the results would be (so PBM as merely some kind of group facilitation technique), Cases 2 and 4, the two cases where no quantified model was developed, happened to be the least successful ones. (Case 6 was not then halfway at the time of the evaluation interviews.)

H2: neither data availability nor problem tangibility are true roadblocks

Although data availability was almost always limited and problem tangibility was usually low, this turned out not to have a dominant effect on overall results. The scatter plots of Figure 3 show what happened in more detail.

So how about H2? Well, we see that there were three cases where high (+) up to very high (++) decision-making effectiveness was achieved despite low (-) up to very low (- -) data availability and problem tangibility:

Case 5, conducted when the method was fully matured, a prime example of such a situation. Few data at all were available on levels of customer irritation or accessibility of branch offices, and the problem as such was pretty intangible too. Nevertheless, very satisfactory results were obtained.

Case 3, had no data at all (- -) because this was a totally new product with unique characteristics in a new region for a start-up company. Nevertheless, strategic decision making was considered to be good (+), because the team managed, with the aid of several quantified models, to conduct the appropriate analyses and design an effective European logistics strategy and structure.

Case 6 also had fairly low problem tangibility ("achieving more understanding of supply chain management" is a broad goal indeed), yet client assessment of effectiveness was good (+), especially when considering the early stage of the project at the time of the evaluation interviews.

Please note that there was considerable variation in the levels of problem tangibility or data availability; both varied from "- -" to "+", over almost the entire spectrum; so strategic issues are not always very intangible and without sufficient data. More importantly, these variations do not appear to be correlated with the variations in strategic decision making effectiveness, which ranged from - -/- to ++/+. For instance, both cases 4 and 5 had low data availability and low problem tangibility, but the difference in decision-making effectiveness is spectacular: case 4 was a disaster and case 5 a true success. So the explanation for this difference has to be found somewhere else, such as with H3.

H3: communication and ownership are crucial for effective strategic POM decision making

This third hypothesis would be refuted if we could find examples of ineffective communication and low ownership, yet high ratings for overall decision-making effectiveness. If we now take a look at the case data for these variables, once again graphically summarized in two scatter plots, we find that this was never so in the six cases investigated (see Figure 4).

In the majority of cases, good communication and high ownership were achieved. The only real odd one out is case 4 (and to some extent case 2), a very unsuccessful case, as described before. If we recall our comparison of case 4 and case 5 in the preceding paragraph, it becomes clear that these organizational factors offer a plausible explanation for the difference in strategic decision-making effectiveness, rather than low tangibility or data availability.

What these data tell us is that, whenever the modellers/consultants were successful in achieving good communication and ownership, overall strategic decision effectiveness was also high. And in the one case where communication was bad and ownership was very low, overall effectiveness was also low. (It is even possible to distinguish a potential middle ground for case 2, that showed mediocre results for client ownership and similar results for overall effectiveness).

Once again these findings are based on a very limited number of observations, and once again no statistical correlation is implied. In fact, for that purpose one would not only require far more observations, but also a much wider variation among both axes, instead of clusters of data pairs in one area.

Conclusions

In this paper we investigated factors that affect the effectiveness of using quantitative models in this process. The six case situations and the decision-making processes were characterized in a number of terms. Also the results of the decision-making processes were characterized. Next, the results were related to the characteristics of case situation and process. From this analysis, quantitative model-building turned out to be a very effective element of the strategic decision-making process in the majority of the cases investigated.

The research described here was exploratory, but fits in a fairly recent trend towards model-based support of strategic decision making that has shown impressive results throughout (Akkermans, 1995a; Morecroft and Sterman, 1994; Senge, 1990; Vennix, 1996). All this work points in the same direction: strategic issues are soft and difficult to quantify and back up with data, but that does not mean we cannot model them and use the results to aid managerial decision making. What it does mean is that good client participation and high client ownership become truly crucial.

This then becomes a clear design guideline for modellers/consultants who want to support strategic decision making in POM with formal models: check first if the conditions for effective communication and strong client ownership are present, and continue to ensure that these remain in place during the decision-making/modelling process.

Another expansion of the POM modeller's toolkit and skills could be the conceptualization and visualization techniques that are commonly used in the field of system dynamics (cf Akkermans, 1995a; Morecroft and Sterman, 1994; Vennix, 1996). This may prove to be very helpful, since they can be very instrumental in achieving this good communication and ownership during group-model building sessions. However, what will be required even more is a change of attitude, from one where it is the modeller who does the modelling to one where the managers do the modelling and it is the modeller who performs the difficult task of facilitating this modelling process without losing rigour.

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[Illustration]
Caption: Figure 1; The overall research model; Table I; Aspects of strategic decision-making effectiveness; Table II; Contingencies influencing strategic decision-making effectiveness; Figure 2; Main steps in the case evaluation process; Table III; Strategic decision- making effectiveness by case; Figure 3; Cross-case scatter plots for data availability and problem tangibility vs overall strategic decision-making effectiveness; Figure 4; Cross-case scatter plots for data availability and problem tangibility vs overall strategic decision-making effectiveness