INVENTORY MODELS: FROM THEORY TO PRACTICE

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Introduction

The operations research (OR) of inventory fields is quite developed. There are a considerable number of inventory models that - in principle - can be used to improve decision-making in an organization.

The actual use of these models, however, is relatively low especially with respect to their expected potential. This situation has resulted in an "implementation gap" between what is available and what is being used.

The purpose of this paper - primarily in the field of item-level cost minimizing inventory models - is to point out two assumptions of the technical ones causing this gap, the validity of which either does not exist at all or only to a limited extent in practice, and to suggest the use of alternative models which can be put into practice.

The structure of the study is as follows:

In Chapter 1 the components of the implementation gap are briefly discussed. In Chapter 2 the estimation problems of item-level cost parameters are discussed using the results of an application.

Chapter 3 is about the question of the control of the individual item or design of an entire system. The study is closed by a summary of the most promising approaches of bridging the implementation gap.

1. Components of the implementation gap

My approach is illustrated by the following simple figure:
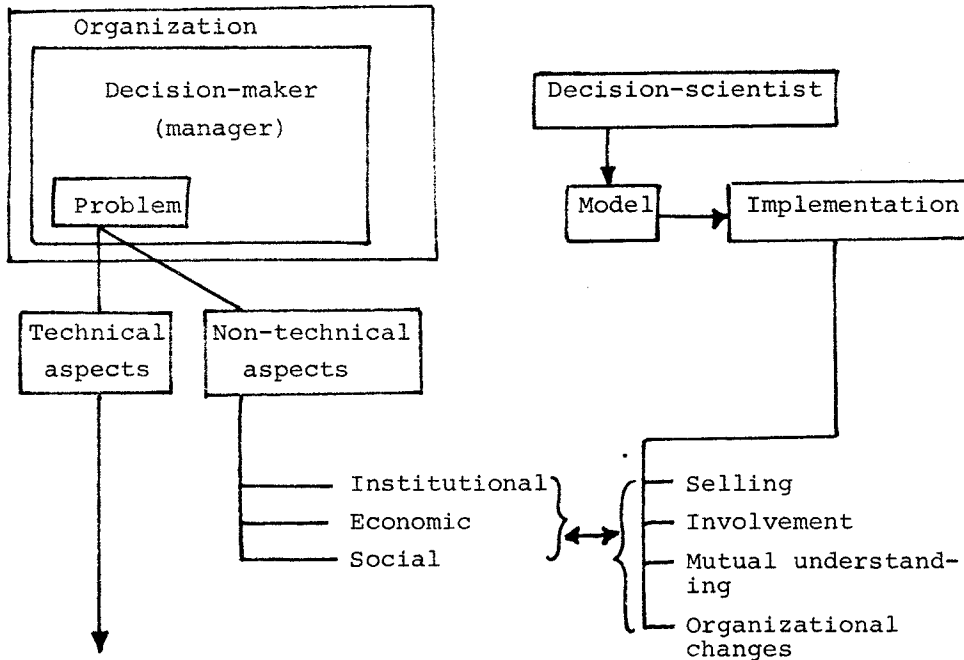
Figure 1 - Components of implementation and their relations

The decision maker in the organization turns to the decision scientist (in this case to an OR practitioner) for help in solving his problem. Generally their cooperation will result in a

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model of the problem and after that the solution of the problem (meaning the implementation of the model) can begin.

In the conventional approach of OR there is a clear distinction between the period of analysis and the period of implementation. The OR practitioner deals mainly with analysis and model-building and it is the manager's task to put the model to practical use. Abolishing the "demarcation line" of different responsibilities and tasks may improve the chances of successful application. According to Eilon (1984) this can be done by the new type of OR workers (by the so-called "change-agents") who consider it their main task to contribute to changes in the organization.

Implementation may be viewed from a variety of aspects including selling, involvement, mutual understanding and organizational change (Schultz-Slevin, 1975).

Selling implies that implementation is a marketing problem and that the product of operations research (e.g. models) must be skillfully made, "packaged" and sold to potential users.

Involvement suggests that implementation requires decision-makers and managers to play an active role in the research process, to become involved as participants in model-building.

Mutual understanding refers to a state where the researcher and the manager both understand the other's role in the project: there is no communication problem between them.

Organizational change describes a way of implementation that focuses on behavioural changes in the process of the acceptance of the models. If a model is implemented then the final state of the organization is a revised set of the decision processes incorporating that model, that is, the solution of the problem.

All of these perspectives - although from other points of view - are discussed in the relevant literature on the "gap between decision scientists and decision-makers" (Ackoff (1979a), Ackoff (1979b), McArthur (1980), Zanakis et. al. (1980)).

Analysing the question of implementation in respect of the problem arising in the organization, we can distinguish technical and non-technical aspects of a problem (Roberts, 1981). The ultimate purpose of the modeling process is to solve a problem within an organization and it is highly probable that any

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solution the OR practitioner devises will require some changes in the way the organization conducts its business and perhaps even require some changes in its structure. It is resistance within the organization to these types of changes that gives rise to the non-technical aspects of the problem.

The mathematic-technical dimensions represent the mathematical model of the problem, and stand at the focus of most related operations research activity. It is necessary that the proposed technical solution be both theoretically sound and appropriate to the scale and complexity of the problem.

The institutional dimension can be divided into two categories.

The institutional-political conflicts may arise if a technical solution requires either major changes in organizational structure or in the reassignment of responsibilities among key individuals in the structure. Institutional-operational conflicts may arise if a technical solution requires changes in long-standing operational procedures which key people regard as a prerequisite for their continuing control of the organization. Another form of this type of conflict may emerge if a technical solution, which is otherwise sound, is in fact beyond the capacilities of the organization to implement.

The economic consideration is linked to the institutional-operational one. For the OR practitioner, the technical solution will be economically acceptable if it is expected to produce either significant decreases in costs or increses in profits. For the manager, the technical solution may be considered economically acceptable if it promises to produce some institutionally desirable outcome at an acceptable cost level.

The social dimensions rarely come into play until implementation is put into effect. It is connected to technical solutions, which change the work patterns of a group of people and so these new methods proposed by the technical solution are also attempting to change the social system of the work environment.

In the relevant literature on the problems of implementation, the various perspectives of implementation are generally discussed in connection with the non-technical dimension of a

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problem and there is little emphasis on the problems attached
to the technical one, to the validity of the mathematical model.

In the field of inventory theory the typical model is
designed to minimize the sum of "marginal" holding, shortage
and ordering costs for each item. According to a research on
inventory models - Chikán (1983), Barancsi et. al. (1983) -
82% of the sampled 336 models collected and studied were single-
item ones and some 62% were conducted on the basis of the above
mentioned item-level marginal cost parameters.

In my paper two topics are considered: the estimation
problems of the item-level cost parameters and the character
of the inventory planning decisions which deal with the control
of individual items or with the design of an entire system
specified by top management. These topics are closely related
to the concepts of model validation or acceptance, that is:

1. Face validity: Is the model credible to decision makers
   who know the system being modeled?

2. Parameter validity: What is the relation between the model's
   parameters and their assumed counterparts in the real world?
   How are outputs affected as data change?
   This latter question leads to sensitivity analysis.

3. Hypothesis validity: Do modeled relationships describe
   real-life relationships?

2. The estimation of the item-level marginal cost parameters

   The assumption that relevant cost information can some-
how be obtained from the firm's accounting system is almost
generally accepted in the literature, but there are little
if any details of how to do it. In the Hungarian literature,
Sárai (1976), Chikán-Fábri-Nagy (1978) and a practical applica-
tion by Vastag (1983) dealt with that question. From a more.
general point of view, Gardner (1980) discussed this topic and
there are some details in Peterson-Silver (1979).

There are three basic difficulties of estimating the cost
parameters:

(a) We need to estimate future cost parameters on the basis

of previous data, although the use of the actual parameters may disorient the decision, because the structure of the actual parameters is likely to differ from the cost structure in the future. In these inflationary times this can be a very acute problem because not only the costs but also the proportions of the costs are changing.

(b) The major obstacle in obtaining the cost parameters from the firm's accounting records is that these costs tend to be buried in the other costs of the firm. These costs can be separated only on a subjective basis.

(c) There are some theoretical and practical difficulties in aggregating the costs variously projected (some types of costs are proportionate to the turnover of that item, etc.).

An example

This example concerns the central manufacturing plant of a big Hungarian construction firm. The production capacity of the plant at the time of the analysis was more than 400 million forints per year. We have analyzed the following items: concrete reinforcement bars (15 different types), sheet metals (3 types) and hot rolled sheet metal (1 type). The general processing flow-chart of these items is on the following page - see Figure 2 (the main characteristics of the items were identical). For the items on stock there is a twofold demand: the manufacturing plant requires about 90% of the whole demanded amoːː and the surplus is transported to other building firms who convert these items for final use.

The broken line shows those selections where information flow happens only while the effective processes contain both information and material flow. On the right-hand side of the figure different stages of the process are named.

(i) Holding costs consisted of the following components:
Components proportionate to turnover:
- energy consumption of the cranes and barrows (exact figures from the accounting records);
- administrative costs: telephone, telex, cost of data processing, papers (a subjective estimate from the

① Operations
management of the
construction firm

② Purchasing department

③ Supplier

④ Warehouse

⑤ Manufacturing plant

⑥ Buying orders

⑦ Buildings

- - - - controlling
process
(in.ormation
flow only)

———— effective
process (both
information
and material
flow)

① Registery of
requirement

② Ordering

③

Receiving

④ Warehousing

③ Shipment

Manufactur-
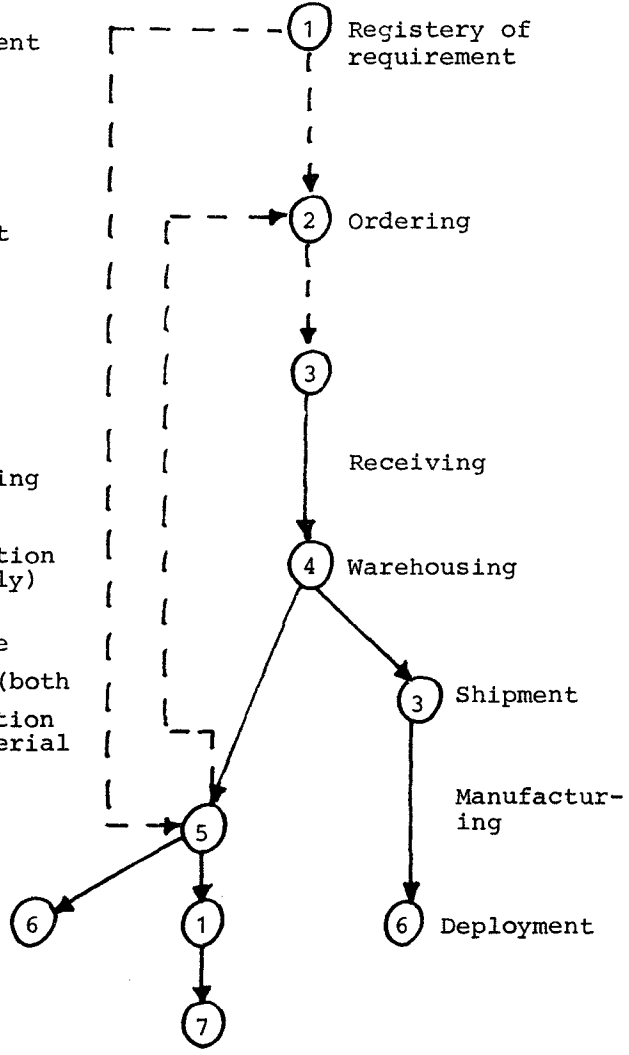ing

⑤

⑥ ①

⑥ Deployment

⑦

Figure 2 - The general processing flow - chart
of the items

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record of general costs);

- wages (the proportion of wages to be allocated to the individual products is subjectively estimated on the basis of physical parameters). We have delt it as proportionate to turnover, but it is rather fixed or semi-fixed.

Components proportionate to average costs:
- the cost of financing inventories by the bank (exact figure);
- the opportunity cost of money invested, it is often treated as an exact figure but is in fact a highly subjective measurement.

The major component of the total holding cost was the opportunity cost of money invested, a highly subjective measurement which depends on the risk environment of the firm, and management goals for rates of return on investment.

Grubbström (1980) and Grubbström-Thortenson (1981) suggest the annuity-stream principle for evaluating capital costs. This is an interesting and new research area but at present it is far from real practical application.

(ii) <u>Shortage costs</u> were determined by the following factors:

Components proportionate to the amount of material lacking:

- wages for idle times;
- profit on the lost production;
- extra replenishment charges;
- overtime wages.

(iii) <u>Ordering costs</u> consisted of the following components:

- papers;
- charge for instruments;
- transport costs.

These costs were subjective estimates.

<u>Conlusions:</u>

(1) The estimation methods were highly subjective and because of the above-mentioned general reasons are not exact.

(2) This step-by-step method requires a lot of work and time, thus it is not suitable for regular use.

(3) These costs are average costs and not marginal ones. This leads to a questioning of the validity of the theory and to putting the emphasis on new approaches in model-building.

3. Control of the individual item or design of an entire system?

I think there is a two-fold reason for modeling the behaviour of the individual items. On the one hand, demand is always only for individual items and not for some aggregate of individual items. On the other hand, a more general discussion of this problem is the result of a process called analysis. The logic behind analysis is the following: if we want to understand the behaviour of inventories, which is a complex problem, we must first break the inventories into their component parts and try to understand how these parts (the individual items) behave, and finally synthesize our understanding of the parts into an understanding of the whole problem. I think it may be the key factor in explaining the high proportion of inventory models concerning only individual items. There is a drawback to this approach: we cannot come to an ultimate understanding of the behaviour of the inventories because we cannot get a general management perspective.

From the managers' point of view the inventory management is a problem of coping with large numbers and with a diversity of factors external and internal to the organization. The inventory decision must be seen simultanously from the point of view of the individual item in its relation to other items, the total aggregate inventory investment, the production plan of the firm, the production-distribution system of suppliers and customers and the economy as a whole (See Peterson-Silver, 1979). We cannot concentrate only on individual items without taking account of the effect of the item on other items and on the whole system.

These decisions need synthetic or systems thinking: first, a whole (control of inventories) is conceptualized as a part of one or more larger wholes. In this case the inventories

form a part of the activity of a firm, not as a whole to be taken apart. What is sought is an understanding of the larger containing system. Finally, the system to be understood is explained in terms of its role of function in the containing system.

The technical consequence of the approach of "analysis" is that the models in the literature are ma ly based on this logic that is on the assumption of independent items. The items may be independent or dependent with respect to their

   (i)   demand;

   (ii) purchasing economics.

The success of the Material Requirements Systems in the USA and in Western Europe illustrate the importance of dealing with demand dependency. Jayaraman and Tabucanon (1984) among others emphasize the advantages of coordinated versus independent replenishment. These facts show that dealing with item dependency is of vital importance from the practical applications point of view.

Conclusions

More emphasis must be placed on models of firm-level policy than on models dealing with individual items.

I think future research must be focused on:

(1) The application possibilities of the integrated production-inventory system (MRP, JIT) under various conditions. The question is how to use or is it worth using these systems under such circumstances where not only the demand but the supply is also stochastic.

(2) The theoretical analysis of the extensions of the above mentioned systems means introducing stochastic thinking into MRP.

(3) Elaboration of simple, easy to implement firm-level models, such as, for example, the inventory function (see Uncovsky, 1982).

Summary

In my paper, I have considered two technical problems

in the field of inventory models.

The conclusions, as I have already emphasized, are the following:

- Cost-minimizing models based on item-level cost parameters are not appropriate to real life problems.

- In practice we need models which deal with individual items and at the same time company level considerations. The latter is of vital importance to the success of implementation.

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