

# Operational Research in Stock Exchange Quoted Enterprises

An innovation and adaption problem  
for the individual and the organization

---

By Lars Lönnstedt\*)

*A transplanted organ will sometimes be rejected by the body because it constitutes something alien, something that does not fit into the orderly community of body cells. Something similar may happen when introducing and using operational research (OR)<sup>1)</sup>, because the company may lack the necessary properties or because the organization members are not familiar with OR. Exactly as we can prepare the body and alien organ for the transplantation, we can make preparations in order to facilitate the integration and use of OR in an enterprise. A possible way in which to find out what steps are suitable to take in this connection is to study the use of OR in enterprises, and this is what I have done<sup>2)</sup>. As test group for this study has served a number of stock exchange quoted companies<sup>3)</sup>. In an appendix I give an account of the procedures used in the study. (A more detailed presentation of the result may be found in Lönnstedt, 1971).*

---

\*) The Royal College of Forestry, Stockholm.

<sup>1)</sup> Operational research (OR) implies a scientific procedure for solving problems (see e.g. Ackoff, 1962). What has come to characterize OR is, however, the construction and solution of mathematical/statistical models. With this characteristic as starting point I have conceived OR as a common denominator for a class of mathematical/statistical research techniques which have come to be utilized for solving certain problems, liable to arise within organizations. In those OR-techniques I have included linear, non-linear, dynamic and heuristic programming, stock, queueing and game theories, simulation and network planning.

<sup>2)</sup> This study constitutes part of a larger, international study under the leadership of Professor Michael Radnor, Graduate School of Business, Northwestern University, U.S.

<sup>3)</sup> Enterprise means the activity carried on under a common company title.

# Operational Research in Stock Exchange Quoted Enterprises

An innovation and adaption problem  
for the individual and the organization

---

By Lars Lönnstedt\*)

*A transplanted organ will sometimes be rejected by the body because it constitutes something alien, something that does not fit into the orderly community of body cells. Something similar may happen when introducing and using operational research (OR)<sup>1)</sup>, because the company may lack the necessary properties or because the organization members are not familiar with OR. Exactly as we can prepare the body and alien organ for the transplantation, we can make preparations in order to facilitate the integration and use of OR in an enterprise. A possible way in which to find out what steps are suitable to take in this connection is to study the use of OR in enterprises, and this is what I have done<sup>2)</sup>. As test group for this study has served a number of stock exchange quoted companies<sup>3)</sup>. In an appendix I give an account of the procedures used in the study. (A more detailed presentation of the result may be found in Lönnstedt, 1971).*

---

\*) The Royal College of Forestry, Stockholm.

<sup>1)</sup> Operational research (OR) implies a scientific procedure for solving problems (see e.g. Ackoff, 1962). What has come to characterize OR is, however, the construction and solution of mathematical/statistical models. With this characteristic as starting point I have conceived OR as a common denominator for a class of mathematical/statistical research techniques which have come to be utilized for solving certain problems, liable to arise within organizations. In those OR-techniques I have included linear, non-linear, dynamic and heuristic programming, stock, queueing and game theories, simulation and network planning.

<sup>2)</sup> This study constitutes part of a larger, international study under the leadership of Professor Michael Radnor, Graduate School of Business, Northwestern University, U.S.

<sup>3)</sup> Enterprise means the activity carried on under a common company title.

## 1. Characteristics of companies using OR

Studies of innovations have pointed out different variables influencing the decision to introduce a novelty (see e.g. Mansfield, 1969 and Rogers, 1966). My basic hypothesis has been that these variables may be of importance also for the use of OR<sup>4)</sup>. From a survey of 83 stock exchange quoted companies appears that OR is, relatively considered, more commonly used in companies

- a) having more than 2,000 employees<sup>5)</sup>,
  - b) belonging either to the metal working/engineering industry or to the foundry-mining-lumber or pulp industries,
  - c) having a graduate employee density of over 0.5 %,
  - d) having a general manager with a university degree in engineering,
  - e) having had access to computer before 1964<sup>6)</sup>,
- than in companies lacking these properties<sup>7)</sup>.

This result is valid for any year of the period investigated (1955–68). The nonresponse (5 companies) cannot change the result. My *conclusion* is, therefore, that there exists a connection<sup>8)</sup> between these characteristics and the use of OR (see Table 1.1).

Characteristics, for which I expect to find a connection with the use of OR	This study indicates the existence of a connection	Literature indicating the existence of a connection between characteristics and the introduction of innovations
Company size	Yes	Mansfield, 1968
Company line	Yes	Williamson, 1965
Education of employees Education of general manager	Yes	Rogers, 1966
Date of access to computer	Yes	(Bennis, 1966)

Table 1.1.

*Summary of result with regard to probable connection between different characteristics and the use of OR and also comparison with innovation studies.*

<sup>4)</sup> In common with innovations (from the Latin verb *innovare* = renew) OR constitutes something new to the organization because the problem solving procedure may become changed.

<sup>5)</sup> Engwall (1970) has shown that the correlation between different measures of the size of an enterprise is considerable.

<sup>6)</sup> rented, bought etc.

<sup>7)</sup> The number of enterprises professing to use OR was 43, i.e. 55 % of the 78 replies received.

<sup>8)</sup> Here connection means that two variables are correlated. Cause and effect does not, consequently, appear.

It is possible to establish similarities between this result and that of some innovation studies (see Table 1). This is interesting, considering the fact, that I have studied the innovation of methods, while those scientists have interested themselves in other types of innovations. It should be pointed out, however, that investigations exist which indicate other-type connections. Evan and Black (1957), for instance, found no connection between company size and the introduction of innovations. That result is contradicted by this study and by the conclusions of Mansfield (1968) and Sutherland (1959). The dissimilarities indicate the importance of taking regard also to the type of innovation. Different research methods and definitions might also offer an explanation.

Cross tabulation has shown that companies, having more than 2,000 employees, to a larger extent than other companies are characterized by their direction towards metal working/engineering or the production of raw materials, by their graduate employee density, by the inclination of the general manager's degree (graduate engineer) and by their early access to computers. The connection between the variables may depend on the fact that the natural growth in certain lines of business has made these enterprises big. The size may perhaps also cause a growing need of well educated personnel while the possibilities to satisfy this need simultaneously increase. The same may be valid where access to computer is concerned. If such is the case it is fairly natural that the study indicates the existence of a connection between the variables studied and the use of OR. It has, further, appeared that enterprises with more than 2,000 employees are characterized by certain qualities. These may have been of importance for the company's use of OR but other factors may also have played a role. An example: Big enterprises may, perhaps, receive information on innovations earlier than small companies.

## 2. The use of OR

The material for this paragraph was obtained through interviews at 12 stock exchange quoted companies. In toto, 25 OR-activities were traced<sup>9)</sup>. These had, up till the summer of 1970, worked on 107 projects<sup>10)</sup>. (The result has been summarized in Table 2.1).

From the result appear that 11 of the 25 activities studied are concerned solely with network planning or what I call "*coordination*

---

<sup>9)</sup> The designation *OR-activity* is used as a common denominator for the work performed by an operational researcher or a team of such researchers.

<sup>10)</sup> The word *project* means the work necessary for obtaining a solution. It is to be observed that a problem may initiate several projects, since a solution proposal need cover only part of the problem. A solution proposal is interpreted as a decision basis.

problems" (40 projects). The residual activities are mainly concerned with production and inventory problems (35 % respectively 31 %). The most common *solving techniques* for these 67 projects are simulation (44 %) and linear programming (26 %). The majority of the projects does not, according to the replies received, require more than 4 *working months* (59 %) and does not *cost* more than \$6,000 (51 %). However, information on the extent of all projects could not be obtained. The nonresponse will, probably, influence the result in such a way that the share of more extensive projects will be underestimated.

Other investigations also show that production problems are commonly occurring (see e.g. Holth and Winge, 1969; Bengtsson and Nilsson, 1968). Where solving techniques are concerned the comparison is hampered by the fact that the definition of OR may vary. This concerns, among others, the question whether network planning, regression analysis and variance analysis are to be counted among the OR-techniques. With this reservation in mind it may be established that simulation, linear programming, inventory and queueing theories belong to those techniques most often mentioned in surveys by Eilon, Hough and Betts (Great Britain, 1969), Vatter (U.S., 1966) and Barlow and Grinley (Canada, 1963).

With regard to the *organizational location* of the OR-activities respectively the users<sup>11)</sup> in the 12 enterprises studied the result shows a difference. The users of the 107 solution proposals are mostly in-lined located (69 %) and functionally dependent (80 %), while the opposite is valid for the 25 OR-activities (14 % respectively 28 %). Also Radno's, Rubenstein's and Bean's (1968) study of 66 American enterprises shows a similar difference in the location of the operational researchers and the users, even if not so marked. According to our result, some network planning activities are to be found in-line or within functions. Most common organizational level (of 5 different) for both OR-activities and users is the 3rd. As a rule, however, the users tend to be located on a higher level while the opposite is true of the OR-activities. Above all where the user's replies are concerned a nonresponse occurs. The distribution of this nonresponse notwithstanding appears that the users mostly are in-line located and dependent of some function. With regard to the location level the nonresponse may have some influence. My experience from the study does not, however, indicate that the nonresponse in any considerable way deviates from the result obtained.

---

<sup>11)</sup> That decision maker or those decision makers for whom the research is made are singly or collectively called user. Any organization member may play the role of user.

Table 2.1.

Research subject	Characteristics of:	
	The OR-activity	
<b>SUBJECT OF ACTIVITY</b>		
Problem area	Coordination and production problems	
Solving technique	Network planning and simulation	
Extent	Work input < 4 working months and cost < \$6,000	
<b>ORGANIZATION</b>	Operational researchers	Users
In-line location	14 %	69 %
Functional location	28 %	80 %
Level	3	3
<b>EDUCATION AND AGE</b>		
Engineering	62 %	69 %
University	67 %	69 %
Younger than 40 years	96 %	45 %

#### *Summary of results.*

According to the study, the majority of network planners (24 in toto) has a college *degree* in engineering. Also among the other operational researchers<sup>12)</sup> (32 in toto) an engineering education seems to be the most common, even if not so common as among the network planners. They are, on the other hand, mostly university graduates. According to the result the user also has, above all, an engineering education at university level. Other studies (see e.g. Eilon, Hough and Betts, 1969; Schumacher and Smith, 1965 and Barlow and Grinlay, 1963) show that an engineering education is not so dominating among the participating operational researchs, as it is according to our investigation. Another commonly occurring group in these studies is the "mathematician/statistician". Also with regard to the graduation level differences are apparent. A university degree is more commonly occurring in the above mentioned surveys than according to our study. *Age-wise* the users are older than the operational researchers. Other studies show the participating operational researchers as being either older than (see e.g. Schumacher and Smith, 1963) or of approximately the same age as their Swedish colleagues studied (see e.g. Slocombe, 1968). Also with regard to these questions it has been difficult to obtain information on all users. In my opinion, nothing seems to indicate that the nonresponse in these studies deviates from those users on which information was obtained.

<sup>12)</sup> The operational researcher is conceived as a person who uses the operational research procedure in order to solve problems. He is an expert to whom the organization members may turn for assistance.

### 3. Characteristics of executed OR-solution

The material for this paragraph was obtained through the above mentioned interviews at 12 stock exchange quoted enterprises. Operational researchers and users reported that 70 (73 %) of the 107 projects studied had been executed<sup>13)</sup>.

A concept of the variables which may influence the execution of OR-solutions I obtained by studying other professional articles (see Table 3.1 and footnote 2 on page 3). The variables obtained in this way were divided into 3 separate classes, the variables being the expression for, respectively, the relationship between users and operational researchers, the problem and the solution result.

Information on the relationship and the results of the use of OR was obtained by telephone interviews with the users. The operational researchers replied at personal interviews to the questions regarding the characteristics of the problems. A summary of the results is shown in Table 3.1.

Table 3.1.

Variable class	Variable for which I expect to find a connection with the execution of OR-solutions	This study indicates the existence of a connection	Other studies indicating that a similar connection may exist
Relation-ship	User's participation	Yes	{ Bennis, 1966 Katz and Kahn, 1966 Radnor, Rubenstein and Tansik, 1970 Colcutt, 1965 Heiman, 1964
	Operational researcher's participation	Yes	
	Contact frequency	?	
	Initiator of project	(Yes)	
Problem	Problem limitation	Yes	{ Ackoff, 1962 Slocombe, 1968 Vatter, 1966
	Quantifiability of variables	Yes	
	Availability of data material	Yes	
Result	Value of solution proposal	Yes	Heiman, 1964 -
	Internal charging	?	

*Summary of results regarding connection obtained between different variables, execution of the solutions and comparison with other studies.*

<sup>13)</sup> A solution is considered executed if it has influenced the decision-making. This means that the decision became different from what it would have been if no solution proposal had been presented.

The result of the survey shows that the better the *relations* between user and operational researcher are the larger is the number of solutions executed in the companies studied. As expression for these relations I have conceived the user's participation in the problem definition, the operational researcher's participation in the execution, the contact frequency between them and initiator of the project. The result may be compared to what other researchers have said about the importance of cooperation and participation by changes (see e.g. Bennis, 1966, Katz and Kahn, 1966). With regard to contact frequency and initiator it can be shown, however, that a very biased distribution of the non-response causes that the material does not indicate any connection. The influence of the dependency must also be considered. Conditions in the enterprises and characteristics of the activities may be reflected by the material. An examination shows that projects from some activities deviate from the picture the material as a whole gives of the connection between contact frequency and execution.

Problem limitation<sup>14</sup>), quantifiability of the variables<sup>15</sup>), and the availability of the data material<sup>16</sup>) were by me assumed to reflect different aspects of the *problem*. For all of these variables the result shows a definite connection with the execution. This result agrees with the experiences of other researchers. The nonresponse is small and cannot influence the result, nor does an examination show any influence from the dependence.

The value of the OR-solution which I assumed to be an expression for the *result* was measured as cost savings both in the short-range and long-range perspective and with regard to the value of the solution by decision-making. The result clearly shows a positive connection. Neither nonresponse nor dependence is of any importance. As an expression for the expenditure the user may connect with an OR-solution the occurrence of internal charging was utilized. The result indicates a very slight positive connection. However, a certain distribution of the nonresponse causes the connection to vanish. Also the dependence is of importance. The OR-activities seem to have a clearly pronounced policy with regard to this question: Internal charging either does or does not occur.

In conclusion may be mentioned that I have investigated what influence a) solving techniques used b) timing c) budget of the OR-activities d) the management's initiating the activity and e) the user's

---

<sup>14</sup>) Problem limitation means the assumptions that have to be made with regard to the variables and their relations.

<sup>15</sup>) Quantifiability of the variables refers to the possibility of expressing a quality numerically.

<sup>16</sup>) Availability of the data material refers to the possibility of obtaining information on the values of the variables.



familiarity with OR-projects have on the established connections. I have effected the analysis by classifying the material. Let me exemplify: I have distinguished between network planned projects and other projects. I have then compared the connections in both these groups between the variables and the execution. The result of these analyzes was that the connections became somewhat weaker when the users are familiar with OR-projects or when the activities have been in effect for some years.

#### 4. Conclusion

The survey presented in this article has shown what characterizes stock exchange quoted enterprises using OR. From the result also appears how OR is utilized in these companies. Finally, characteristics of executed OR-projects have been reported on. With this result as a background I will, in conclusion, outline what is, probably, required for making successful use of OR.

One interpretation of the result is that an enterprise *planning* to utilize OR should strive for the same qualities that characterize the "big" enterprises: A certain production inclination, a certain educational level and access to computer. This might, however, not be the whole truth. The variables studied may reflect other qualities of the enterprises. The explanation might be that the "big" enterprises have such complex problems that an OR-procedure is suitable. There exists a need. The size, measured by the number of employees, brings, probably, with it an increased probability that, at least, somebody in the company understands the significance of OR and is prepared to test the method. There exists a consumer side. A possible way for a small company to master these difficulties may be to contact an OR-consultant when necessary. A pre-requisite is, naturally, the existence of consultants.

Another explanation is that the awareness of innovations may arise earlier in big enterprises than in small. Since the big enterprises, as a rule, hire new personnel more often than the small, this carries with it an increased probability that among the newly hired there is, at least, one with a knowledge of OR. Through the larger number of employees the contacts with the world around, probably, also increase. As a total the employees of a big company can meet more people, read more papers, visit more fairs etc. than the employees of a small company. Through increased and intensified information smaller enterprises should be able to handle these problems. As a physician introduces new medicines in order to aid the patient the consultant can also help to spread news to the organizations.

For an enterprise that has *decided* to utilize OR it may be profitable to distinguish between long-range and short-range decisions in order to understand the difficulties that may arise by the use of OR. The long-range decisions concern the procurement of resources, while the short-range ones have to do with the use of these resources. As examples of long-range decisions may serve the incorporation into the company of the OR-activity and its organizational location, the training of operational researchers and the assembly of the project portfolio. Short-range decisions may, for instance, concern the method of approach in the solving of a problem. Both these types of decisions may have influence on the use of OR in the enterprise. The difficulties in the execution of a solution proposal may arise from the decision made in connection with the problem solution. These difficulties may, however, become hard to handle if the organizational gap between operational researcher and user is too wide or if the operational researcher lacks knowledge of the conflicts that may arise in his dealings with the organization members and/or does not know how to handle such conflicts.

Since the use of OR, as a rule, entails a division of labor between operational researchers and users it is necessary to look upon the *execution* as a process. The preparations for the execution begin already at the generation of the problem. It is important that the user recognizes that a problem exists. The responsibility for the project should, later, rest with the user, since it is he who has to assess the solution proposal. The user is, of course, dependent upon that the problem is solved in a favorable manner. It is, therefore, the user who ought to define the problem. This may, of course, be done with the assistance of the operational researcher. A cooperation should also occur by the identification of variables and the specification of the connections between functions. The user should also know about the limitations made, the assumption on which the model is built. For the construction and solving of the model the operational researcher is best suited. The user should, however, be kept informed.

Above and beyond the fact that this cooperation gives the user a better chance to appraise the solution he will, probably, become more interested and willing to assist with the research. Even after the user has decided to tackle the problem in accordance with the operational researcher's proposal it is important that the cooperation continues. The operational researcher may, for instance, come up with elucidations and explanations in planning the execution. It then rests with the user to see to it, possibly with assistance, that the plan is followed. It is, consequently, important that somebody or some officials on the user side are trained in handling the model themselves if it is to be used at more than one decision-making occasion. The checking is also im-

portant. Do the intentions of the decision conform to what has been executed? In my opinion the process of execution is terminated by establishing conformity.

Even if this procedure is used difficulties may arise in the execution. OR is a mathematical method. Since it may be difficult to quantify variables or express relations through equations the operational researcher may be forced to limitations in the model construction. The consequence may be that the solution becomes less relevant. Difficulties may also arise because the organization members do not feel that OR justifies its cost.

## 5. Appendix

As population for a study of characteristic features in enterprises using OR were selected 83 companies which in May, 1969 were quoted on the Stockholm Stock Exchange (banks and holding companies were excluded with regard to their special position). One reason for the selection of this population was that it included enterprises applying OR. (A study of the membership list of the OR-association showed this.) Another reason was that there existed a directory.

To find out in which of these enterprises OR was applied a questionnaire was sent to the general manager. An advantage with this method is that it is inexpensive and does not require any large manpower input. Information on the different variables I obtained by studying various statistical summaries. Limited economic and manpower resources made a collection of data on my own impossible. An extension of the questionnaire I considered unrealistic with regard to the possibility that the different subjects of the questions might increase the nonresponse. By an empirical study of this kind the result may be impaired by a number of errors. The application of OR need not be known to the person filling in the questionnaire. Another possibility is that a research job is classed as operational research although it is not according to the definition given. In order as far as possible to prevent these errors OR was defined from different aspects. One definition was verbal<sup>17</sup>). Examples of various application areas were given (production and bottleneck problems, coordination problems, transportation problems, inventory problems etc.). An operational definition was obtained by listing a number of OR-techniques (compare p. 3). A comparison between the replies received and the results from two case studies (Bark-Holst and Welinder, 1969 and Ljung, 1969) indicates good reliability for the material.

---

<sup>17</sup>) OR constitutes a scientific analysis of a system, process or similar with the purpose of giving a quantitative basis for a decision aiming at an increase of the efficiency of the system, process etc.

## 6. References

1. Ackoff, R. L.: *Scientific Method – optimizing applied research decisions*. John Willey & Sons, Inc., 1962.
2. Barlow, K. and Grinlay, A.: *Operational Research in Canadian Business*. *Business Quarterly*, Vol. 28, No. 4, Winter 1963.
3. Bark-Holst, K. and Welinder, H.: *A Study of OR-departments in three Enterprises – case studies*. The Department of Business Administration. Stockholm University, 1969.
4. Bengtsson, M. and Nilsson, H.: *Simulation – An Operational Research Technique in Swedish Enterprises*. The Department of Business Administration. Lund University, 1969.
5. Bennis, W. G.: *Changing Organizations*. New York, 1966.
6. Colclutt, R. H.: *The First Twenty Years Operational Research*. The British Iron and Steel Research Association (BISRA). Operational Research Department, 1965.
7. Eilon, S., Hough, J. and Betts, R. J.: *Profile of Current Members of the Operational Research Society*. *Operational Research Quarterly*. Vol. 20, No. 2, June 1969.
8. Engwall, L.: *Size Distribution of Firms*. Department of Business Administration. Stockholm University, 1970.
9. Evan, W. M. and Black, G.: *Innovation in Business Organizations: Some Factors Associated with Success or Failure of Staff Proposals*. *The Journal of Business*. Vol. 40, No. 4, Oct. 1957.
10. Heiman, D.: *A Procedure for Predicting the Potential Success or Failure of an Operational Research/Management Science Activity*. Department of Industrial Engineering/Management Science. Northwestern University, 1964.
11. Holth, T. and Winge, B.: *Organization of Industrial Engineering in Norwegian Enterprises*. The Department of Industrial Economy and Organization. The Technical High School of Norway, 1969.
12. Katz, D. and Kahn, R. L.: *The Social Psychology of Organizations*. New York, 1966.
13. Ljung, B.: *Some Facts about Departments for Operations Research in Three Swedish Enterprises – A Pilot Study*. The Department of Business Administration. Stockholm University, 1969.
14. Lönnstedt, L.: *Operational Research in Enterprises Quoted on the Stock Exchange Market – an innovation and adaptation problem for the organization*. Stockholm, 1971.
15. Mansfield, E.: *Industrial Research and Technological Innovation*, New York, 1968.
16. Mansfield, E.: *The Economics of Technological Change*. London, 1969.
17. Radnor, M., Rubenstein, A. H. and Bean, A. S.: *Integration and Utilization of Management Science Activities in Organizations*. *Operational Research Quarterly*. Vol. 19, No. 2, June 1968.
18. Radnor, M., Rubenstein, A. H. and Tansik, D. A.: *Implementation in Operations Research and Research and Development in Government and Business Organizations*. *Operations Research*. Vol. 18, No. 6, Nov./Dec. 1970.
19. Rogers, E. M.: *Diffusion of Innovation*. New York, 1966.
20. Schumacher, C. and Smith, B. A.: *A Sample Survey of Industrial Operations Research Activities*. *Operations Research*. Vol. 13, No. 6, Nov./Dec. 1965.
21. Slocombe, D. M.: *Investigations of Some Operational Research Groups*, Imperial College. London University, 1968.
22. Sutherland, A.: *The Diffusion of an Innovation in Cotton Spinning*. *The Journal of Industrial Economics*. Vol. 8, No. 1, 1959.
23. Vatter, W.: *The Use of Operations Research in American Companies*. *Accounting Review*. Vol. 42, No. 4, Oct. 1967.
24. Williamson, O.: *Innovation and Market Structure*. *Journal of Political Economy*. Vol. 73, No. 1, Feb. 1965.

portant. Do the intentions of the decision conform to what has been executed? In my opinion the process of execution is terminated by establishing conformity.

Even if this procedure is used difficulties may arise in the execution. OR is a mathematical method. Since it may be difficult to quantify variables or express relations through equations the operational researcher may be forced to limitations in the model construction. The consequence may be that the solution becomes less relevant. Difficulties may also arise because the organization members do not feel that OR justifies its cost.

## 5. Appendix

As population for a study of characteristic features in enterprises using OR were selected 83 companies which in May, 1969 were quoted on the Stockholm Stock Exchange (banks and holding companies were excluded with regard to their special position). One reason for the selection of this population was that it included enterprises applying OR. (A study of the membership list of the OR-association showed this.) Another reason was that there existed a directory.

To find out in which of these enterprises OR was applied a questionnaire was sent to the general manager. An advantage with this method is that it is inexpensive and does not require any large manpower input. Information on the different variables I obtained by studying various statistical summaries. Limited economic and manpower resources made a collection of data on my own impossible. An extension of the questionnaire I considered unrealistic with regard to the possibility that the different subjects of the questions might increase the nonresponse. By an empirical study of this kind the result may be impaired by a number of errors. The application of OR need not be known to the person filling in the questionnaire. Another possibility is that a research job is classed as operational research although it is not according to the definition given. In order as far as possible to prevent these errors OR was defined from different aspects. One definition was verbal<sup>17</sup>). Examples of various application areas were given (production and bottleneck problems, coordination problems, transportation problems, inventory problems etc.). An operational definition was obtained by listing a number of OR-techniques (compare p. 3). A comparison between the replies received and the results from two case studies (Bark-Holst and Welinder, 1969 and Ljung, 1969) indicates good reliability for the material.

---

<sup>17</sup>) OR constitutes a scientific analysis of a system, process or similar with the purpose of giving a quantitative basis for a decision aiming at an increase of the efficiency of the system, process etc.

*OR-projects at 12 of the stock exchange quoted companies* were chosen as *population* for a study of the *use of OR* in organizations and the difficulties accompanying the *execution*. (In order to decide which projects constituted operational research I started from the so called OR-techniques, compare p. 3). The reason for selecting just those enterprises was that I, through a question in the questionnaire, knew that those companies had, at least, one full-time operational researcher employed. This, I expected, would facilitate the collection of data. The number of companies was decided with regard to the resources available to me.

The survey of those 12 enterprises was conducted by first approaching the respective general managers asking permission to make the survey. After having had him identified I then called up the company's operational researcher or researchers on the telephone. A *personal meeting* was arranged in order to give me the opportunity to put my questions. (Particulars of the information received and the motivation behind the choice of questions appear from the result presentation). Personal interviews were chosen with regard to the importance of getting correct information. Explanations might become necessary. The extent of the survey also spoke for interviews. With every operational research project I associated a user. Information as to who was his contact on the user side I obtained from the operational researcher. The contact was approached by *telephone*. This data collecting method was in-expensive and made necessary explanations possible.

The population came to consist of 107 projects which had been terminated before the summer of 1970. Of these 29 were reported not executed by the users. The number of operational research activities traced was 25. The result is, consequently, valid only for these projects. The intimate contacts I have had with the companies concerned probably result in the fact that, at least, more extensive OR-activities have been traced. On the other hand it is difficult to judge to what extent all the projects of the activities have been discovered. Have projects, the solutions of which were not executed, been kept back? In order to reduce this nonresponse I discussed its consequences with my informants. I guaranteed confidential treatment of the material. By the interpretation of this material we must also remember that people may experience situations differently. Our views may change with time. The replies must, therefore, be judged in connection with the category supplying them and with the time they were obtained. A comparison between replies from the operational researchers respectively the users and an examination of the documentation on the projects show that the reliability is good.

portant. Do the intentions of the decision conform to what has been executed? In my opinion the process of execution is terminated by establishing conformity.

Even if this procedure is used difficulties may arise in the execution. OR is a mathematical method. Since it may be difficult to quantify variables or express relations through equations the operational researcher may be forced to limitations in the model construction. The consequence may be that the solution becomes less relevant. Difficulties may also arise because the organization members do not feel that OR justifies its cost.

## 5. Appendix

As population for a study of characteristic features in enterprises using OR were selected 83 companies which in May, 1969 were quoted on the Stockholm Stock Exchange (banks and holding companies were excluded with regard to their special position). One reason for the selection of this population was that it included enterprises applying OR. (A study of the membership list of the OR-association showed this.) Another reason was that there existed a directory.

To find out in which of these enterprises OR was applied a questionnaire was sent to the general manager. An advantage with this method is that it is inexpensive and does not require any large manpower input. Information on the different variables I obtained by studying various statistical summaries. Limited economic and manpower resources made a collection of data on my own impossible. An extension of the questionnaire I considered unrealistic with regard to the possibility that the different subjects of the questions might increase the nonresponse. By an empirical study of this kind the result may be impaired by a number of errors. The application of OR need not be known to the person filling in the questionnaire. Another possibility is that a research job is classed as operational research although it is not according to the definition given. In order as far as possible to prevent these errors OR was defined from different aspects. One definition was verbal<sup>17</sup>). Examples of various application areas were given (production and bottleneck problems, coordination problems, transportation problems, inventory problems etc.). An operational definition was obtained by listing a number of OR-techniques (compare p. 3). A comparison between the replies received and the results from two case studies (Bark-Holst and Welinder, 1969 and Ljung, 1969) indicates good reliability for the material.

---

<sup>17</sup>) OR constitutes a scientific analysis of a system, process or similar with the purpose of giving a quantitative basis for a decision aiming at an increase of the efficiency of the system, process etc.