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CASE RESEARCH
Case research in operations management

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Abstract *This paper reviews the use of case study research in operations management for theory development and testing. It draws on the literature on case research in a number of disciplines and uses examples drawn from operations management research. It provides guidelines and a roadmap for operations management researchers wishing to design, develop and conduct case-based research.*

Introduction

Case research has consistently been one of the most powerful research methods in operations management, particularly in the development of new theory. This is particularly true in today's environment. To cope with the growing frequency and magnitude of changes in technology and managerial methods, operations management researchers have been calling for greater employment of field-based research methods (Lewis, 1998). Pure case research, that is research based on analysis of a limited number of cases to which, at best, only limited statistical analysis can be applied, is widely used in Europe but is less common in North American operations management (Drejer *et al.*, 1998). Pannirselvan *et al.* (1999) reported case study and field study research accounted for 4.94 per cent and 3.80 per cent respectively of published papers. However, there are an increasing number of case research based papers appearing.

There are several challenges in conducting case research: it is time consuming, it needs skilled interviewers, care is needed in drawing generalisable conclusions from a limited set of cases and in ensuring rigorous research. Despite this, the results of case research can have very high impact. Unconstrained by the rigid limits of questionnaires and models, it can lead to new and creative insights, development of new theory, and have high validity with practitioners – the ultimate user of research. Through triangulation with multiple means of data collection, the validity can be increased further. Many of the breakthrough concepts and theories in operations management, from lean production to manufacturing strategy, have been developed through field case research. Finally, case research enriches not only theory, but also the researchers themselves. Through conducting research in the field and being exposed to real problems, the creative insights of people at all levels of organisations, and the varied contexts of cases, the individual researcher will personally benefit from the process of conducting the research. Increasingly new ideas are being developed, not by distant academics, but by those working in close contact with multiple case studies – management consultants! It is

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important that case research is conducted and published because it is not only good at investigating how and why questions, but also it is particularly suitable for developing new theory and ideas and can also be used for theory testing and refinement. It is also important that case research is conducted well, so that the results are both rigorous and relevant. Case research is not an excuse for "industrial tourism" – visiting lots of organisations without any pre-conceived ideas as to what is being researched.

As Drejer *et al.* (1998) point out, operations management differs from most other areas of management research, in that it addresses both the physical and human elements of the organisation, e.g. Hayes and Wheelwright's (1984) structural and infrastructural elements of manufacturing strategy. In addition to the "hard" elements of the area, many researchers focus on the human elements of the productive system and the arrangements of the physical elements to support this. Drejer *et al.* (1998) indicate that there is a particular tradition of this kind of research in Scandinavia, where case research is widely used in such research. Case research is widely used in other management disciplines, notably organisational behaviour and strategy. Yin (1994) has described in detail case research design, and Glaser and Strauss (1967) described the grounded theory method. Case research has its roots in the broader field of social sciences, in particular ethnographic studies and anthropology. In this paper, we will draw on the experience of these disciplines as well as that of researchers in operations and technology management. In particular, we will draw on the work of Eisenhardt (1989), who brought together much of the previous work on building theory from case research. Our intention is to provide a roadmap for designing, developing and conducting case-based research and also to describe some recent examples of case-based research in the field of operations and technology management.

Most of the research conducted in the field of operations management is based on rationalist[1] research methods, primarily statistical survey analysis and mathematical modelling. However, since "... the explanation of quantitative findings and the construction of theory based on those findings will ultimately have to be based on qualitative understanding" (Meredith, 1998), case research is very important for our field.

The rest of the paper is structured as follows: first, we discuss when to use case research. Then, we describe how to develop the research framework, followed by a discussion on how to select cases (ideal number, retrospective or longitudinal, sampling and sample controls). Third, we describe how to conduct field research (who to contact, field data collection, and how to conduct interviews), followed by a discussion of reliability and validity in case research. Finally, we discuss the issues of data documentation and coding, analysis and hypothesis development and testing. The steps described above are summarized as:

(1) When to use case research.

(2) Developing the research framework, constructs and questions.

(3) Choosing cases.

(4) Developing research instruments and protocols.

(5) Conducting the field research.

(6) Data documentation and coding.

(7) Data analysis, hypothesis development and testing.

When to use case research

> A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence. It can include data from direct observation and systematic interviewing as well as from public and private archives. In fact, any fact relevant to the stream of events describing the phenomenon is a potential datum in a case study, since context is important (Leonard-Barton, 1990).

A case study is a unit of analysis in case research. It is possible to use different cases from the same firm to study different issues, or to research the same issue in a variety of contexts in the same firm. Case research is the method that uses cases studies as its basis. Meredith (1998) cites three outstanding strengths of case research put forward by Bebensat *et al.* (1987):

(1) The phenomenon can be studied in its natural setting and meaningful, relevant theory generated from the understanding gained through observing actual practice.

(2) The case method allows the questions of why, what and how, to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon.

(3) The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood.

There are many methods available for the operations management researcher, for example Wacker (1998) contrasts the case method with analytical conceptual methods: "... the key difference ... is that the empirical case study method uses data to form the theory, and the analytical conceptual method uses deduction to form theories". Case studies can be used for different types of research purposes such as exploration, theory building, theory testing and theory extension/refinement (see Table I).

Exploration

In the early stages of many research programmes, exploration is needed to develop research ideas and questions. Many doctoral theses begin with one or more case studies in order to generate a list of research questions that are worth pursuing further (e.g. Frohlich, 1998).

Theory building

A particular area where cases are strong is theory building. "Nothing is so practical as a good theory" (Van De Ven, 1989). Theory can be considered as being made up of four components: definitions of terms or variables, a domain – the exact setting in which the theory can be applied, a set of relationships and specific predictions (Wacker, 1998).

Purpose	Research question	Research structure
Exploration		
Uncover areas for research and theory development	Is there something interesting enough to justify research?	In-depth case studies Unfocused, longitudinal field study
Theory building		
Identify/describe key variables Identify linkages between variables Identify "why" these relationships exist	What are the key variables? What are the patterns or linkages between variables? Why should these relationships exist?	Few focused case studies In-depth field studies Multi-site case studies Best-in-class case studies
Theory testing		
Test the theories developed in the previous stages Predict future outcomes	Are the theories we have generated able to survive the test of empirical data? Did we get the behaviour that was predicted by the theory or did we observe another unanticipated behaviour?	Experiment Quasi-experiment Multiple case studies Large-scale sample of population
Theory extension/refinement		
To better structure the theories in light of the observed results	How generalisable is the theory? Where does the theory apply?	Experiment Quasi-experiment Case studies Large-scale sample of population

Source: The above table is a modification of original work by Handfield and Melnyk (1998)

Table I.
Matching research purpose with methodology

A theory may be viewed as a system of constructs and variables in which constructs are related to each other by propositions and the variables are related to each other by hypotheses (Baccarach, 1989). Without theory, it is impossible to make meaningful sense of empirically-generated data, it is not possible to distinguish positive from negative results, and empirical research merely becomes "data-dredging" (Handfield and Melnyk, 1998). If we are to ground theory on data, then a large and rich amount of primary data is needed, and case studies are a prime source of this (McCutcheon and Meredith, 1993). Cases are particularly useful when there is uncertainty in the definition of constructs (Mukherjee *et al.*, 2000).

Theory testing

Despite its limited use for theory testing, case study research has been used in the operations management field in order to test complicated issues such as strategy implementation (e.g. Pagell and Krause, 1999; Boyer and McDermott, 1999; McLachlin, 1997). When case study research is used for theory testing, it

is typically used in conjunction with survey-based research in order to achieve triangulation. This is the use and combination of different methods to study the same phenomenon, so as to avoid sharing the same weaknesses (Cook and Campbell, 1979; Campbell and Fiske, 1959; Jick, 1979).

Theory extension/refinement

Case studies can also be used as a follow-up to survey based research in an attempt to examine more deeply and validate previous empirical results. For example, Meredith and Vineyard (1993) and Hyer and Brown (1999), conducted case studies, which resulted in extending the fields of AMT and cell system design, respectively.

Overall, operations management is a very dynamic field in which new practices are continually emerging. Case research provides an excellent means of studying emergent practices, an example being a study of product, customer involvement and quality information by Finch (1999). Case research both builds on theory and is an excellent means for development of theory in operations management (McCutcheon and Meredith, 1993). Table II summarises some recent articles in the field of operations management using case studies. These illustrate the different uses of case research.

The research framework, constructs and questions

> No matter how small our sample, or what our interest, we have always tried to go into organisations with a well defined focus (Mintzberg, 1979).

The starting point for case research is the research framework and questions. Case study research has been recognised as being particularly good for examining the how and why questions (Yin, 1994). Such questions can lead both to theory testing, but more importantly to theory development. In theory building research, no matter how inductive the approach, we need to have a prior view of the general constructs or categories we intend to study, and their relationships. Miles and Huberman (1994) suggest doing this through construction of a conceptual framework that underlies the research. Such a framework explains, either graphically or in narrative form, the main things that are to be studied – the key factors, constructs or variables – and the presumed relationships amongst them. Building a conceptual framework will force the researcher to think carefully and selectively about the constructs and variables to be included in the study.

The next vital step in designing case research is the initial research question behind the proposed study. This may precede, or follow directly from the conceptual framework. Even if at this stage the question(s) are tentative, it is important to have as well defined a focus as possible at the start, to guide the collection of data. There is a range of question types, many of which postulate some form of causal relationship (Miles and Huberman, 1994). Examples of these can be found in Table III.

For example, Tyre and Orlikowski (1994), in a study of process technology adaptation, defined two research questions:

Study	Research questions	No. of cases	Other methods	Purpose
Narasimhan and Jayaram (1998)	What are the unique aspects of service operations that lead to differences in the way a reengineering project should be carried out in a service context?	1		Theory building
Lamming *et al.* (2000)	How are different types of supply networks created and operated?	16	Survey	Theory building
Pagell and Krause (1999)	1. Is there a relationship between the firm's external environment and its internal level of operational flexibility? 2. Do firms that align their level of operational flexibility with the level of uncertainty in the external environment exhibit superior performance compared to firms that do not have alignment?	30	Survey	Theory testing
Boyer and McDermott (1999)	Is there strategic consensus in operations strategy across different organisational levels?	7	Survey	Theory testing
McLachlin (1997)	Which management initiatives are necessary for JIT implementation?	6	Survey, interviews, direct observation	Theory testing
Meredith and Vineyard (1993)	How can we better understand the role of manufacturing technology in the firm's business strategy?	3		Theory refinement
Hyer *et al.* (1999)	1. What are the significant elements in a comprehensive cell design process and how are they related? 2. How will the application of STS principles influence and enhance a cell system design? 3. Of the elements in the comprehensive cell system design, which ones appear to be the most significant determinants of sustainable success?	1		Theory refinement
Åhlström *et al.* (1998)	Why is diagnostic benchmarking used? How is diagnostic benchmarking used or not used by companies to improve manufacturing performance?	15	Longitudinal study. Two case visits 18 months apart Survey	Theory extension

Table II.
Recent examples of case-based research in operations management

- What is the pattern of technology adaptations in organisations?
- What organisational forces help explain the patterns of adaptation over time?

A further set of examples of research questions in studies using cased-based research is shown in Table III. In case research, the amount of data that can potentially be collected is vast; therefore the stronger the research focus, the easier it is both to identify potential cases and to design research protocols.

Underlying the research question is likely to be one or more constructs, for example technology adaptation in the example given above. Eisenhardt (1989) argues that *a priori* specification of constructs is valuable because "It permits researchers to measure constructs more accurately. If these constructs prove important, then researchers have a firmer empirical grounding for the emergent theory".

When conducting case-based research it is not uncommon for the research question to evolve over time and for the constructs to be modified, developed or abandoned during the course of the research. This can be a strength, as it can allow the development of more knowledge than if there were just a fixed research question. Again, over time the research may shift from theory building to theory testing. This should be recognised on the one hand, but not used as an excuse for inadequate specification of research questions or constructs. Case research otherwise risks degenerating into a "fishing expedition", where the observer is hoping to catch valuable insights that in turn will lead to research questions.

Choosing cases

There is a wide set of choices in conducting case research. These include how many cases are to be used, case selection and sampling.

What is the ideal number of cases?

For a given set of available resources, the fewer the case studies, the greater the opportunity for depth of observation. Single, in-depth case studies are often used in longitudinal research. Examples include Narasimhan and Jayaram (1998) who used a longitudinal study of a single case to examine reengineering in service operations, and Karlsson and Åhlström (1995) who studied implementation of just-in-time (JIT) in a single company over a period of time. Another example of a single case study is Schonberger (1982), whose highly influential book on Japanese manufacturing practices was based on an in-depth study of a single Japanese run factory in the USA. There is no clear definition of what is a single case study or unit of analysis. Single cases may sometimes involve the opportunity to study several contexts within the case (Mukherjee *et al.*, 2000). A study of a single firm may involve a number of different cases, the number of cases studied can be different from the number of firms.

Single cases have limitations. The first is the limits to the generalisability of the conclusions, models or theory developed from one case study. When only

Question type	Example of general form
Causal	Does X cause Y?
Non-causal	What is X?
Non-causal – policy	What does "Y" mean?
Non-causal – evaluation	What makes W good?
Non-causal – management	Is X more cost-effective than Z?

Source: Smith (1987)

Table III. Examples of question types

one case is used, there may also be other potential problems (Leonard-Barton, 1990). These include the risks of misjudging of a single event, and of exaggerating easily available data. These risks exist in all case research, but are somewhat mitigated when events and data are compared across cases. Multiple cases may reduce the depth of study when resources are constrained, but can both augment external validity, and help guard against observer bias. The multi-case studies in Table II involve three to 30 cases.

Longitudinal or retrospective cases?

A second choice in case selection is whether to use retrospective or current cases. In many cases this may be an artificial distinction. For example, when researching current case studies it is usually necessary to collect some archival and/or historical data. Retrospective cases allow for more controlled case selection, for example it is possible to identify cases that reflect either success or failure only in retrospect.

Longitudinal case research can be particularly valuable. One of the most difficult but most important things we try to identify in research is the relation between cause and effect. The longer the period over which phenomena are studied, the greater the opportunity to observe at first hand the sequential relationships of events. However, as Leonard-Barton (1990) points out, there are problems with historical data. For example, participants may not recall important events and, even if they do, their recollection may be subject to bias. A particular problem is post-rationalisation, the interpretation of events in a different manner than they would have at the time. For example the respondent may place interpretations on events, or justify decisions with arguments or knowledge that was not available at the time. Similarly, what is described in archive data, such as minutes of meetings, may not reflect the whole truth, difficult or controversial items may not be recorded. Karlsson and Åhlström (1995, 1997) point out that the researcher who wishes to conduct a longitudinal field study of a process faces the problem of access. They see the clinical perspective as one means of overcoming the access problem. This method is characterised by active participation in formulating and observing organisational change. As a result, researchers are able to gain access to rich data denied to other approaches. The main difference from consulting is that the clinical researcher is interested in the results of the interventions and in drawing generalisable conclusions from these results. The consultant is more interested in giving recommendations and implementing them.

The factors governing these choices are summarised in Table IV.

Case selection and sampling

If multiple case studies are to be used for research, then a vital question is the case selection or sampling. Miles and Huberman (1994) state that sampling involves two actions. The first is setting boundaries that define what you can study and connect directly to the research questions. The second step is creating a sample frame to help uncover, confirm, or qualify the basic processes or constructs that underpin the study.

Choice	Advantages	Disadvantages
Single cases	Greater depth	Limits on the generalisability of conclusions drawn. Biases such as misjudging the representativeness of a single event and exaggerating easily available data
Multiple cases	Augment external validity, help guard against observer bias	More resource needed, less depth per case
Retrospective cases	Allow collection of data on historical events	May be difficult to determine cause and effect, participants may not recall important events
Longitudinal cases	Overcome the problems of retrospective cases	Have long elapsed time and thus may be difficult to do

Table IV.
Choice of number and type of cases

The traditional way of sampling is to identify a population, and then to select a random or stratified sample from that population. However, in case research we often build a sample of cases by selecting cases according to different criteria (Eisenhardt, 1989; Yin, 1994). When building theory from case studies, case selection using replication logic rather than sampling logic should be used. Each case should be selected so that it either:

- predicts similar results (a literal replication); or
- produces contrary results but for predictable reasons (a theoretical replication).

Miles and Huberman (1994) suggest three kinds of instances have great pay-off in case research. First, if you can find a typical or representative case – can you find another one? Second, the negative or disconfirming instance and finally, the exceptional or discrepant instance. The third selection criterion is to identify polar types, cases with sharply contrasting characteristics that will highlight the differences being studied. For example, a sample might be constructed of organisations that have high and low performance on certain dimensions, while controlling for performance on others.

An example of theoretical sampling is that of Åhlström *et al.* (1998), who examined the impact of benchmarking interventions on process improvement. They wished to study the impact of starting point on the outcome of benchmarking. The underlying proposition was that the nature of the process would vary from those firms with high levels of "best" practice to those with low levels and from those which had high levels of operational performance and low operational performance. From a potential sample set of over 1,000 cases on which they had data, they pre-selected a convenience sample of cases where access was likely to be easy. Within this sample they then selected cases based on different starting points at the time of benchmarking. On a matrix of high existing practice and high existing operational performance, they chose cases from each quadrant of the matrix, and a fifth set from companies in the middle. This design facilitated examination of how company context impacts

on the effective use of benchmarking. Not all researchers use theoretical or literal sampling in case research. An example in operations management research is Pagell and Krause (1999), who studied manufacturing flexibility. They used a convenience sample of 30 case studies.

Sampling plans are likely to evolve over a research project. Miles and Huberman (1994) suggest a number of tests to apply to a sampling plan:

- Is it relevant to the conceptual frame and research questions?
- Will the phenomena to be studied appear? Can they appear?
- Is it one that enhances generalisability?
- Is it feasible?
- Is it ethical in terms of informed consent, potential benefits and risks and relationships with informants?

Sample controls

When selecting cases it is also important to consider what the parameters or factors are that define the population and are to be held constant across the sample. Controls rely on the selection of the phenomena during the study's experimental design stage for their control. This allows particular factors (e.g. managerial policies, inventory systems) to be, in essence, "held constant" while others (e.g. costs, defect rates) are left free to vary as they would naturally (Meredith, 1998). For example, Sousa (2000) controlled for quality maturity, Voss (1984), in developing a sample of a single application software area, applied tests of independence to ensure that the software had been developed without input from one of the other organisations. Leonard-Barton (1990), in a study of technology transfer, used three dimensions to control for irrelevant sources of variance originating within the firm. First, the technologies selected had all passed some baseline tests of technical feasibility. This provision eliminated from study any cases in which the failure to transfer to users occurred simply because the technology was technically infeasible. Second, all the technologies selected altered the work environment in some obvious way. Third, the transfer stages included in the study were consistently defined across projects.

It is important to apply tests to validate the controls and to ensure that each case meets the sample criteria. The researcher should have the courage to discard cases that do not fit the research design and sample structure.

Developing research instruments and protocols

Typically the prime source of data in case research is structured interviews, often backed up by unstructured interviews and interactions. Other sources of data can include personal observation, informal conversations, attendance at meetings and events, surveys administered within the organisation, collection of objective data and review of archival sources. The reliability[2] and validity of case research data will be enhanced by a well-designed research protocol (Yin 1994). A protocol contains, but is more than, the research instrument(s). It will

also contain the procedures and the general rules that should be used in using the instrument(s), and indicate who or from where different sets of information are to be sought. The core of the protocol is the set of questions to be used in interviews. It outlines the subjects to be covered during an interview, states the questions to be asked, and indicates the specific data required. A commonly used format is the funnel model. This starts with broad and open-ended questions first, and as the interview progresses the questions become more specific and the detailed questions come last. The protocol serves both as a prompt for the interview and a checklist to make sure that all topics have been covered. In addition, it is often useful to send an outline of the protocol in advance, so that the interviewee(s) are properly prepared. A well-designed protocol is particularly important in multi-case research. When developing the research protocol and instruments it is important to address triangulation (McCutcheon and Meredith, 1993). Case research data are not just collected by interview. Frequently questionnaires are also used in collecting data within and across cases.

Case research in operations management differs from case research in the wider social science field in that researchers are interested in analysing the manufacturing and service processes and systems of the plant (Hill *et al*., 1999). Thus research design in operations management should pay attention to what processes and systems are to be studied, the methods for studying them, and the operating data to be collected from them.

As with questionnaires, case research protocols need piloting either in a pilot case or in initial interviews within an organisation.

Single or multiple respondents and viewpoints

In designing case research a key question is what should be the number of respondents? If a set of questions can be reliably answered by one "key informant", then the research process should focus on identifying these and validating that this person(s) is indeed one. However, when there are questions for which no one person has all the required knowledge, or the events being studied may have different interpretations or viewpoints, how and why questions may be subject to different interpretations. In such cases the researcher may consider interviewing multiple respondents, or using a follow-up survey with multiple respondents. In addition, it is also important to recognise that informants are prone to subjectivity and biases. Where this is an issue, the research design should not rely on self-report as the only evidence.

In research design, we must consider the trade-off between efficiency and richness of data. On the one hand, by asking the same question to a number of people, we may enhance the reliability of our data, and by going beyond formal interviews we can collect much valuable data. On the other hand, it can be very time consuming. Leonard-Barton (1990), in reporting on a multiple set of case-based research studies, found that in a longitudinal, in-depth study, she was able to observe many critical events and follow a research thread over a three-year period. She also points out that in this sort of research a large sample size *per se* may not be as important as in survey research. She gives as an example a pilot

study of 25 people followed up with 145 personal interviews. These interviews added bulk, not depth, to the research database. In summary, the researcher should be seeking multiple viewpoints particularly where there is likely to be subjectivity and bias, but be wary of committing too much time and resources.

Conducting the field research

Who to contact

In researching case-based data, it is important to seek out the person(s) who are best informed about the data being researched. This person is often known as the principle informant. However, in gaining access to an organisation, this person may not be known and/or may not be the most appropriate prime contact. An ideal prime contact should be someone senior enough to be able to open doors where necessary, to know who best to interview to gather the data required and to provide senior support for the research being conducted. Gaining access is often a sequential process. The first step is writing to or calling a potential prime contact. As case research requires time and commitment from the organisation, it is important that the value and relevance of the research, and the time and resources required, are outlined at this stage. In many cases, going through an organisation such as an industry or technical association can provide an accelerated way of doing this, as well as providing the opportunity to select a well-structured and controlled sample. Pointing out the mutual benefits to potential participants can be helpful. The organisation may find it useful and interesting to have an issue analysed in a systematic way. Having gained agreement, the next step is to set up the research meetings. For simple research, this can usually be done with a letter outlining the areas that are being investigated, the nature of the people that you would like to interview, and objective and/or archival data that you would like to collect. For more complex case research, set-up visits to the case organisation will probably be necessary. The time required for case research at a site can vary from one or two carefully structured short visits, to a full ethnographic study – in-depth involvement with the organisation over an extended period of time – often years.

Field data collection

An underlying principle in collection of data in case research is that of triangulation, the use and combination of different methods to study the same phenomenon. Such methods can include interviews, questionnaires, direct observations, content analysis of documents, and archival research. Reliability of data will also be increased if multiple sources of data on the same phenomenon are used. Three examples in operations management research illustrate this.

Boyer and McDermott (1999), studied strategic consensus in operations strategy. They performed semi-structured interviews on site in seven plants, with either the plant manager, vice-president of operations or president of each firm. Issues relating to the historical development of the firm, its main competition, main markets, structural (e.g. AMT) and infrastructural (e.g. worker training) investments were explored in these discussions. Interviews

typically ranged from one to two hours in duration. In addition, the survey questions were discussed and elaborated upon, and any questions relating to the content of the survey were answered. Discrepancies between survey responses and interview discussion were noted and clarified. To augment the on-site interviews and surveys, tours of the manufacturing facility were arranged. These tours allowed for a visual check and comparison of each firm's efforts in areas such as AMT adoption, layout, degree of worker empowerment and training, and level of technology relative to others in the industry. In general, these plant tours provided an opportunity for verification and clarification of survey and interview responses, as well as providing the researchers with a feel for the overall work environment and systems.

A further example is a study by Hyer *et al.* (1999) of cell design:

> Data sources for the study included participant observation, structured and unstructured interviews of key participants, formal debriefing sessions following major design activities, and reviews of a wide array of relevant operational data and other documentation (meeting minutes, status reports, internal white papers, hard copies of electronic messages, and so forth). Although most of the data were qualitative in nature, quantitative data on organisational performance also were collected. This use of multiple measures drawn from different data sources is, as McCutcheon and Meredith (1993) point out, one way of improving both the validity and reliability of case study findings.

A final example is Leonard-Barton (1990), who used unstructured interviews and tapped archival sources. This process generally took two very concentrated days on site plus some follow-up telephone calls. In the second phase of the research, a two-page questionnaire was used to provide standard outcome measures for the cases. When these were received, she telephoned for further discussion and clarification those few informants whose evaluations of outcome in a particular project were widely discrepant from each other.

Conducting interviews

Much, but not all field data will be collected through interviews. The effectiveness of case research will, in part, be dependent on the skills of the interviewer. Leonard-Barton (1990) compares the necessary interviewing skills with those of an investigative reporter. One needs to keep previous interviewee responses in mind while simultaneously probing with the current informant, and be very aware of the significance of what is left unsaid as well as what is said, and so on. Yin (1994) lists a set of skills required by the field researcher:

- To be able to ask good questions and interpret the answers.
- To be a good listener and not be trapped by preconceptions.
- To be adaptable and flexible, to see newly encountered situations as opportunities not threats.
- To have a firm grasp of the issues being studied.
- To be unbiased by pre-conceived notions, and thus receptive and sensitive to contradictory evidence.

There are many ways in which an interview can be conducted and evidence gathered. Interviews can be unstructured, focused with more structure or highly structured resembling a questionnaire. Alternatively, evidence can also be gathered by direct observation of meetings, processes, etc. This could be formal process analysis or casual observation. Another form of evidence collection is participant observation, also described as the clinical method (Schein, 1987). Interviews may be with a single interviewee or with a group. The latter allows debate, but may also be dominated by a, possibly, senior individual.

Single or multiple investigators

Interviews are usually conducted by a single investigator, but as Eisenhardt (1989) points out, the use of multiple investigators can have advantages. They can enhance the creative potential of the teams and convergence of observations increases confidence in the findings. If interviews are done by two people or a team, investigators may either take notes independently or one may take the lead interview role, while the other takes a lead data collection role. In studies involving a large number of sites where multiple single interviewers are used, it is important that early interviews are done in pairs or teams. This increases the probability of a common approach being used in all sites and allows inter-rater reliability to be checked. Inter-rater reliability can be defined in terms of the degree to which raters agree or disagree on the rating or interpretation of the evidence presented to them:

$$\text{Reliability} = \frac{\text{number of agreements}}{\text{total number of agreements} + \text{disagreements}}.$$

For an example of the use of inter-rater reliability in operations management, see Ritzman and Sifizadeh (1999). For a fuller discussion see Demaree and Wolf (1984).

Collecting objective data

The fact that case research is often associated with qualitative data should not deter the researcher from seeking out objective data. Indeed, case research provides the opportunity for researchers to collect such data with greater accuracy and reliability than in survey research, as they can have direct access to the original data sources on performance and operating data.

Administering questionnaires

As discussed earlier, triangulation through the use of different methods of data collection can strengthen the validity of research. It is not uncommon for researchers to administer questionnaires within organisations being studied. This can increase the efficiency of data collection and/or allow for data to be collected from a wider sample of respondents. For example, Leonard-Barton (1990), in the case-based research study mentioned earlier, conducted a telephone survey of 46 unit managers, and sent a series of questionnaires to about 100 sales representatives.

Recording the data

The research protocol should provide a strong foundation for documentation of the evidence gathered in case research. There are very divided views on whether tape-recorders should be used in interviews. They certainly provide an accurate rendition of what has been said. Where exactness of what people have said is important, then taping will be a benefit (Yin, 1986, p. 85). If interviews are more focused on objective data, as is often the case in operations management research, then the benefits of taping are reduced. On the negative side, transcribing tapes is very time consuming, it often takes place some time after the interview, can be seen as a substitute for listening and may inhibit interviewees.

Whatever method is used to transcribe data, it is important there are good and accurate records and minutes of research interviews and meetings. In addition, there should be feedback and checking of the data. This is an important, if slow, activity – "obtaining agreement that the story had been accurately (and completely) presented was the most time consuming part of the studies" (Leonard-Barton, 1990). Feedback and checking typically involves presenting the case description or written up record of the data to the organisation for verification. Keeping additional field notes is an important part of field research. Field notes are a running commentary about what is happening in the research, involving both observation and analysis, preferably separate from one another (Eisenhardt, 1989). Even prior to formal data analysis, it is important that the field researcher is sensitive to the emergence of patterns observed in the field. In case research, there is an overlap between data collection and data analysis. In addition to the formal collection of data, it is often useful to record ideas, impressions, etc. as soon as they occur, and certainly before formal analysis takes place. Many researchers use field notes – writing down impressions when they occur – in order to push their thinking.

Seeking convergence and clarification

In the field there are a number of things that a researcher should be paying attention to. The first is looking for convergence of views and information about events and processes. It is not uncommon to find differing or incomplete views. In such cases, it is important to challenge, to revisit the issue and to seek other sources of data to clarify the information. Inevitably, on reflection and analysis there will be many uncertainties and gaps. In addition, during research in later cases it may become clear that some important areas of questioning may have been missed. There are a number of tactics for dealing with this. One is to revisit earlier cases and to review notes and evidence that may have been forgotten that could address the gaps. Another is to conduct interviews over a period of time, at least on two separate days. Prior to the final day all the data that have been collected can be reviewed to identify gaps and areas needing clarification. These can then be addressed.

Determining sequence (cause and effect)

One of the main advantages of case research is that it increases the chance of being able to determine the link between cause and effect, something that is

difficult in survey research. It is therefore important to try and determine the sequence of events and the links between them. This is not always an easy task as interviewees often attribute a cause and effect after the event, which may not actually match the actual links. If historical data are being collected, rather than real-time observation, it is important to use multiple sources and cross-check carefully before attributing cause and effect. It can be very helpful to construct a timeline of key events being studied.

Challenges of observer bias

A researcher will enter the field, bringing strong interest in an area and potentially strong biases. It is reported that students of innovation are notoriously prone to a strong "pro-innovation" bias (Leonard-Barton, 1990). Similarly, it is likely that students of manufacturing strategy or JIT will have strong biases towards these areas as well. Personal biases can shape what you see, hear and record. In addition, the researcher may become an advocate, not an observer. There are a number of ways of countering this. One is to use multiple interviewers. Each can then review what is observed by the other. If a structured research protocol is used, then inter-rater reliability can be assessed. It is important that researchers recognise their biases, but also that they do not overreact. The use of tape recording can contribute towards reduction of observer bias, especially if the evidence is presented verbatim rather than summarised.

When to stop

In case research, there is often the temptation to do "just one more case" or "just one more interview" to test some of the emerging theory or to get greater insight into the research questions. Knowing when to stop is an important skill of a case researcher. It may be time to stop when you are in danger of not having enough time to complete the analysis and write up in the time available. It may also be when there are diminishing returns from incremental cases or interviews. Most importantly, the time to stop is when you have enough cases and data to satisfactorily address the research questions.

Summary

Field research with case studies is an iterative approach, which frequently involves multiple methods of data collection, multiple researchers and an evolution of concepts and constructs. This can be illustrated in operations management research in a study of cell design by Hyer and Brown (1999):

> During the past two years, we have visited over 15 firms with the express purpose of exploring what works and what does not work in manufacturing cells. Using a standard set of questions, we asked operations managers to relate stories about cells they have implemented and to highlight the outcomes that have resulted from the changes they made. From this very rich set of stories, we uncovered consistent patterns that ultimately led us to reformulate our thinking about cells. Throughout the process, our definitions and their underpinnings evolved with each new or return plant visit, serving to reinforce or reshape our emerging theory. Our approach was consistent with the prescriptions for case study research of Eisenhardt (1989) in that we intentionally selected theoretically useful cases, used multiple (two) investigators, considered qualitative and quantitative data, and allowed the study to change course as themes emerged.

Reliability and validity in case research

As mentioned previously, it is particularly important to pay attention to reliability and validity in case study research. Reliability and validity have a number of dimensions.

Construct validity is the extent to which we establish correct operational measures for the concepts being studied. If the construct as measured can be differentiated from other constructs, it also possesses *discriminant validity* (Leonard-Barton, 1990). Construct validity can be tested by:

- observing whether predictions made about relationships to other variables are confirmed;
- using multiple sources of evidence, (similar results are evidence of convergent validity);
- seeing if a construct as measured can be differentiated from another, (evidence of discriminant validity);
- seeking triangulation that might strengthen construct validity.

Internal validity is the extent to which we can establish a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships (Yin, 1994, p. 35). *External validity* is knowing whether a study's finding can be generalised beyond the immediate case study. *Reliability* is the extent to which a study's operations can be repeated, with the same results (Yin, 1994, p. 36).

Yin (1994) has outlined how some of these might be addressed (see Table V). In addition, qualitative data often provide a good understanding of the why, a key to establishing internal validity – what is the theoretical relationship and why this happens. Multiple cases have higher external validity than single cases.

Data documentation and coding

Once data are collected they should be documented and coded. A key issue in analysing case research is the volume of data.

Test	Case study tactic	Phase of research in which tactic occurs
Construct validity	Use multiple sources of evidence	Data collection
	Establish chain of evidence	Data collection
	Have key informants review draft case study report	Composition
Internal validity	Do pattern matching or explanation building or time-series analysis	Data analysis
External validity	Use replication logic in multiple case studies	Research design
Reliability	Use case study protocol	Data collection
	Develop case study database	Data collection

Source: Yin (1994, p. 33)

Table V.
Reliability and validity in case research

Documentation

The necessary first step is a detailed write up of each site following the research protocol structure. Where appropriate this will involve transcription of tape recordings. Ideally this should be done as soon as possible after the case visit, both to maximise recall and to facilitate follow-up and filling of gaps in the data.

An example in operations management research is a study of just-in-time manufacturing by McLachlin (1997): "For each site visited, the raw data, originally grouped by informant, was recorded electronically, coded with standard codes, and grouped by construct category. For each construct, summary paragraphs and associated ratings were derived using all available evidence, qualitative and quantitative. The condensed information was placed in a summary display for the particular plant".

Documentation can include typing up of notes and/or transcription of tapes. This produces a case narrative. Other documentation can include gathering together documents and other material collected in the field or through other sources. It should also include documenting ideas and insights that arose during or subsequent to the field visit. Accuracy of the documentation can be increased by letting key informants review draft reports. There are an increasing number of tools available for textual analysis of qualitative data. These allow on-screen coding of documents and exploration of patterns and relationships of words and phrases. These can be particularly useful when tape-recorded interviews are transcribed.

Coding

Central to effective case research is the coding of the observations and data collected in the field. It is important to try to reduce data into categories (Miles and Huberman, 1994; Glaser and Strauss, 1967). The existence of good documentation of observations and multiple sources of evidence allows a chain of evidence to be established. Incidents of phenomena in the data are coded into categories. By comparing each incident with previous incidents in the same category, the researcher develops theoretical properties of categories and the dimensions of these properties (Partington, 2000).

Many researchers have followed the coding scheme suggested by Strauss and Corbin (1990). They propose three steps. The first step is open coding – data are fragmented or taken apart. Concepts are the basic building blocks of theory and open coding is an analytic process by which concepts are identified and are developed in terms of their properties and dimensions. Individual observations, sentences, ideas, events are given names and then regrouped into sub-categories which in turn can be grouped as categories. The next step is axial coding – putting together the data in new ways. The objective of this step is to regroup and link categories into each other in a rational manner. The final step is selective coding – selecting a core category and relating it to other categories.

An example of this in operations management research is a study of black-box engineering by Karlsson *et al.* (1998). One of the drivers of doing good data documentation and coding is to improve reliability. They state:

In order to improve reliability, i.e. demonstrating that the data collection procedures can be repeated with the same results, data from interviews, open discussions, and observations exist in three forms:

- Directly taken field notes (from interviews and observations),
- Expanded typed notes made as soon as possible after the fieldwork. (This includes comments on problems and ideas that arise during each stage of the fieldwork and that will guide further research),
- A running record of analysis and interpretation (open coding and axial coding).

When coding constructs based on case research, it is often prudent to limit the number of categories. "For testing propositions, the magnitude of each construct was either the existence or the non-existence of a condition, based on high, neutral, and low ratings. The purpose of having a neutral range, for which no conclusions would be drawn, was to avoid making mistakes between high and low ratings" (McLachlin, 1997). Miles and Huberman (1994) suggest three concurrent stages to be followed: data reduction, data display and conclusion drawing/verification. Having now addressed data reduction, we can examine the next two stages, which can be seen as the analysis stage.

Analysis

Eisenhardt (1989) suggests two steps in analysis: analysis within case data, and searching for cross-case patterns.

Analysing data – within cases

Having developed detailed case descriptions and coded the data, the first step is to analyse the pattern of data within cases. A very useful and common starting point is to construct an array or display of the data, and with longitudinal cases construct an analysis of the sequence of events. A display is a visual format that presents information systematically so that the user can draw valid conclusions. Displays can be simple arrays, but might also be event listings, critical incident charts, networks, time-ordered matrices, taxonomies, etc. (Miles and Huberman, 1994). The overall idea is to become intimately familiar with each case as a stand-alone entity, and to allow the unique patterns of each case to emerge before you seek to generalise across cases (Eisenhardt, 1989). This in turn gives the researcher the depth of understanding that is needed for cross-case analysis.

Once an array or display has been constructed, then the researcher should begin looking for explanation and causality. Miles and Huberman present a number of ways of analysing case data. One is the case dynamics matrix. This displays a set of forces for change and traces the consequential processes and outcomes. Another form of analysis is making predictions and then using the case data to test them. This might consist of gathering, in tabular form, the evidence supporting and evidence working against a prediction and examining it. A third method is the causal network. A causal network is a "display of the most important independent and dependent variables in a field study and of the relationships among them" (Miles and Huberman, 1994, p. 153). Causal

networks are associated with analytic texts describing the meaning of the connections among factors. This has been used in operations management by Sousa (2000), following Miles and Huberman's (1994) guidelines:

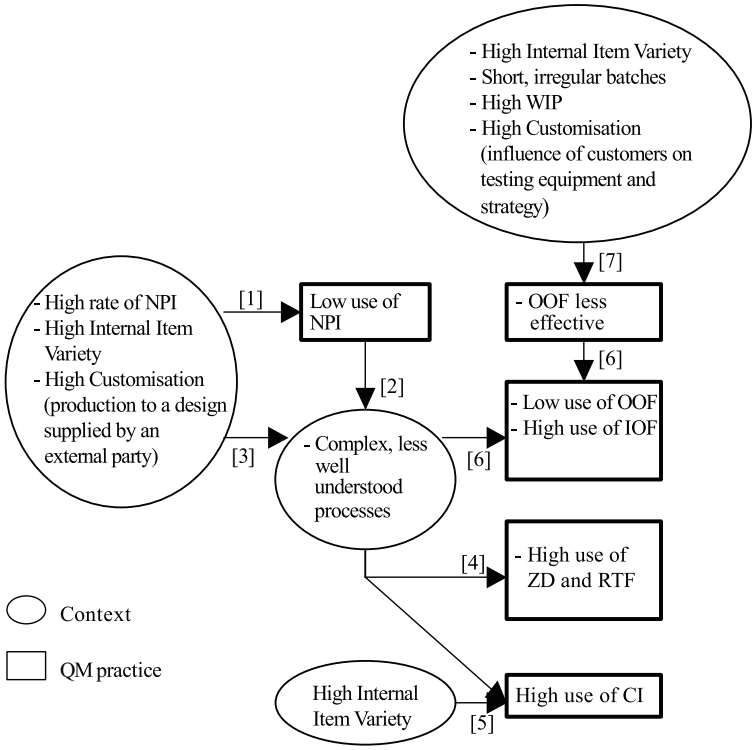
> The working blocks were the codes, researcher comments, interim case summaries and the displays constructed in the data reduction stages. In the whole process, several tactics for generating meaning were used such as noting patterns, seeing plausibility, clustering, counting, making contrasts/comparisons, subsuming particulars into the general, noting relations between variables, finding intervening variables, building a logical chain of evidence and making conceptual coherence (Miles and Huberman, 1994, pp. 245-62). As more knowledge became available during the course of the field work and associated conceptualisation, recurrent patterns of interaction between variables within the orienting research framework started to emerge, both within and across cases. Some variables looked connected, while others looked random or unconnected. These patterns guided guesses about directions of influence among sets of variables. Initial versions of the causal networks were amended and refined as they were successively tested against the data collected in the field. During this process, I actively looked for negative evidence opposing the emerging relationships as well as rival explanations. In addition, I received feedback from informants on the networks' emerging relationships. In order to reduce the effect of the researcher on the behaviour of informants, this was done towards the later stages of the data collection when a certain rapport had already been established with the informants. At these later stages, the relationships to be tested were also clearer. This process led to five individual networks whose relationships received support from the data. In parallel, the five individual case networks were compared with each other in order to identify similarities and differences. These comparisons resulted in the extraction of relationships that were found to replicate across cases, abstracting from the peculiarities of individual cases and generalising them to a broader theory. This resulted in the building of general (cross-case) causal networks embodying generalisable explanations that were empirically grounded in the five individual case networks.

An example of one of Sousa's causal networks is shown in Figure 1.

Analysing data – searching for cross-case patterns

The systematic search for cross-case patterns is a key step in case research. It is also essential for enhancing the generalisability of conclusions drawn from cases.

There are a wide variety of methods and tools available for this. As with within case analysis, the simplest and often most effective method is to construct an array. When visiting case researchers it is not uncommon to see a wall completely covered with charts that embody a full array of the summarised case data. Typically this involves the construction of very large spreadsheets or charts, and in turn refining these to two-by-two cells. Having constructed an array, a simple but very effective analytical approach is to pick a group or category and to search within for group similarities or differences. A similar approach is to select pairs of cases and to look for similarities and differences, including subtle ones. Miles and Huberman (1994) suggest a number of approaches to facilitate cross-case analysis. The first is partially ordered displays. These are appropriate for first-cut analysis "to see what the general territory looks like". They suggest that further displays can be constructed by organising by concept, by case or by time. Within these, they describe many ways of structuring the data, including constructing and



Note: The research variables are shown in boxes or circles and the relationships among them are shown by arrows. Each arrow (labelled 1 to 7) represents a different connection. The text below the figure describes the meaning of the connections among variables in the network. Constructs are: QM = Quality Management, OOF = Overall process off-line feedback , IOF = In process off-line feedback, NPI = Formalised New Product Introduction Process, ZD = Zero defects process, RTF = Real time feedback, CI = Changeover Inspection.

Source: Adapted from Sousa and Voss (2001)

Figure 1.
Example of causal network analysis

summing indices, two variable matrices, contrast tables that compare extreme cases or exemplars with other, scatterplots and sequence analysis.

With well-coded and quantified case data, continuous measures or data ordered in sequences can be developed. This lends itself to simple analysis such as graphing and more sophisticated statistical tests. There are a number of non-parametric statistical tests that can be used to test and explore patterns, even with relatively small sample sizes. Where large numbers of cases have been used, then the standard analytic procedures of survey research can be used.

Cross-case analysis should also seek to increase the internal validity of the findings. As argued above, the use of multiple data sources or triangulation is important in case research. Deliberately seeking confirmation from multiple data sources leads to more reliable results. As Eisenhardt (1989) points out, we are poor processors of information. We tend to leap to conclusions based on a limited set of data, be overly influenced by individuals such as élite respondents, ignore basic statistical properties and inadvertently drop conflicting evidence. Cross-case analysis is an attempt to counter this.

Hypothesis development and testing

Case research is used for both hypothesis testing and theory development. In most case research there will be some initial hypotheses, which can be directly tested using the case data, in particular with larger case sample sizes. However, in much case research the focus is also on theory development and on shaping and developing new hypotheses from the data as well as testing the initial ones. Wacker (1998) puts forward a four-step general procedure for theory building – definition of variables, limiting the domain, relationship (model building) and finally theory prediction and empirical support. The process of theory testing involves measuring constructs and verifying relationships (Eisenhardt, 1989).

Shaping hypotheses

During the process of case research, overall themes, concepts and possibly relationships between variables will begin to emerge. This is an iterative process, whereby the emergent themes, frameworks or hypotheses are compared with data from each case. This will iterate towards theory that provides a close fit. During this there will be a parallel process of refining the definition of the constructs using evidence that measures the construct in each case. At this stage we are likely to have new or refined hypotheses and constructs that allow us to verify the emergent relationship. This can be done through examining the hypothesis in each case, treating each as part of a series of experiments.

Testing hypotheses

If replication logic has been used in case selection then cases that confirm an emergent relationship enhance confidence in the hypothesis or theory. Cases that disconfirm may at first seem problematical. However, to the researcher seeking to develop and test theory, they provide the opportunity to refine and expand the theory. When the data seem to support hypotheses, case research allows the researcher to go one step further and examine the underlying reasons in each case as to why things are happening. What are the theoretical reasons for the observed relationships?

There are many different approaches. One is to propose alternate theories and use cases to test the fit of each theory. For example, Orlikowski (1992) identified three alternative theoretical models relating technology to the organisation. She conducted depth case studies of five projects at various stages of their life cycles. She then ascertained the fit or lack of fit of each model to the case data. From this she was able to propose a revised theoretical model.

Enfolding literature

In theory development research, it is important to review the emergent theory against the existing literature. This research must be built on existing theory. It is not an excuse to say that "this precise issue has not been studied before". There is always some relevant literature to refer to. Reviewing emergent theory involves asking what is similar, what is different and why (Eisenhardt, 1989). It is very important to address literature that conflicts with the findings. Not to do

so reduces confidence in the findings, and doing it may force you into more creative thinking and deeper insights. Literature discussing similar findings will help tie together underlying similarities. Overall effective enfolding of literature increases both the quality and the validity of the findings.

Conclusion

This paper has set out a step-by-step approach for conducting case research in operations management. Though these have been set out as sequential steps, anyone who has conducted case research will know that they are both parallel and iterative. The research question may be revisited during case analysis, constructs refined and redefined during field research and analysis and so on. It is important to recognise this, and also to have the courage to bring the research to a firm conclusion, and resist the temptation continually and incrementally to improve the findings.

Most of the research conducted in the field of operations management is based on statistical survey analysis and mathematical modelling. However, "... embracing a field investigation technique such as case studies is bound to make the individual researcher, and the field in general richer and better prepared to solve real OM problems" (McCutcheon and Meredith, 1993). We hope that this paper will help operations management researchers conduct case research with the appropriate rigor, which when combined with relevance makes case-based research a very powerful methodology.

Notes

1. The main characteristic of rationalist research is that the phenomenon being studied exists "out there", independent of the research context or beliefs and assumptions of the researcher. Thus the relationships and observations are considered to be independent of the theories used to explain them and can hence be studied, manipulated at will, and controlled as needed by the researcher.
2. Reliability is the degree to which a measure is free from random error components (i.e. what you intended to measure is actually being measured). Validity is the extent to which a measure only reflects the desired construct without contamination from other systematically varying constructs (DeVellis, 1991).

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