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**The Case Study Approach in  
Operations Management Research**

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**Stream: Designing Qualitative Research**

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## Abstract

This paper explores qualitative research in general and the case study approach in particular as used in Operations Management (OM) theory-building research. It discusses the relative strengths and weaknesses of qualitative approaches used in OM research as against their quantitative counterparts while arguing for the specific strengths and suitability of multiple case study approach in investigating contemporary topics and soft issues within the OM field. The paper attempts to position case study approach as a credible alternative to traditional positivist approaches currently used in OM research by addressing some key epistemological and methodological issues that have been overlooked in extant literature. The importance of articulating the philosophical foundation, taking a holistic approach to research design and a clear exposition of the research methodology used in demonstrating the credibility of case study research is emphasised.

## Introduction

The field of Operations Management (OM) has been critical of itself for lack of plausible grand theories of its own, relative to other more mature disciplines like sociology and economics (Amundson, 1998; Meredith, 1993). The limited relevance of OM research to the practitioner is another issue widely cited in literature (Buffa, 1980; Slack, *et. al.*, 2004). Both problems are exacerbated by the positivist methodological tradition that dominates the OM field (Meredith, 1998; Meredith *et. al.*, 1989; Swamidass, 1991). Yet, literature has paid little or no attention to some apparently basic but fundamental issues pertaining to the use of qualitative approaches in OM research. With its roots in such areas as scientific management, operations research and industrial engineering, OM has traditionally been seen as a technique-based specialisation. Furthermore, because OM is viewed as an applied field, researchers have been under pressure to produce knowledge that can be readily used by practitioners. The cumulative response of researchers to these demands, combined with the complexity of research issues confronted, has resulted in a research tradition of quantitative modelling, simulation and statistical analysis at the expense of developing a strong conceptual base (Westbrook, 1995; Meredith, 1993).

Over the last few decades, OM has undergone significant change in composition and identity. The content and scope of the field has enlarged and enriched along a number of dimensions. Apart from the growing services component now present within OM, it has evolved from a strategically-neutral, technique-based specialisation toward a strategically significant, functional field of management (Chase & Prentis, 1987; Neely, 1993; Voss, 2005). Subsequently, corresponding adjustments to OM research priorities have also been witnessed (Pannirselvam *et al.*, 1999; Scudder & Hill, 1998) albeit with a bias toward problem solving, and limited efforts in extending the conceptual base of the discipline (Bertrand & Fransoo, 2002). Nonetheless, the approaches to OM research and the methodologies used still appear to have firmly anchored in the positivist school of thought (Pannirselvam *et al.*, 1999) – one that thrives on quantitative research. This methodological bias may have significant implications for research undertaken in the emerging areas of OM.

Despite those difficulties, there has been an increasing interest in and an exposure of qualitative research in OM including some themed issues of journal publications. For instance, an edition of the *International Journal of Production & Operations Management*, (2002), as well as an edition of the *Journal of Operations Management* (2002). Although these efforts recognise the potential value of qualitative approaches in OM theory-building research, many hurdles need to be cleared to realise their full potential (Stuart *et al.*, 2002). For instance, qualitative studies are often judged by positivist standards and criticised for their lack of generalisability and individual bias (Cassell *et al.*, 2006; Silverman, 2001). Yet there appears to be no consensus among OM researchers on how to address these concerns. Some researchers argue that efforts toward such consensus are futile given that each qualitative research is unique and context-bound and that qualitative research is guided by multiple philosophical positions (Rolfe, 2006). However, editors and reviewers of major scholarly journals appear to have a different view on the matter. Because this situation impedes the progress of the OM field, this paper redresses the balance by arguing for the wider use of qualitative approaches within OM theory-building research.

This paper discusses key methodological issues associated with the use of qualitative approaches in OM theory-building research with particular reference to multiple-case studies. The discussion builds on existing knowledge of the use of quantitative and qualitative research methods in OM, qualitative and/or theory-building research in

management, and work carried out in other related areas such as strategy process research. This paper complements extant literature on the topic (McCutcheon & Meredith, 1993; Meredith, 1998; Stuart, *et. al.* 2002; Voss, *et. al.*, 2002) as it addresses several substantive issues that have been overlooked in the general discussions of methodology and research design of OM projects.

The paper begins with a brief discussion of the conceptual foundations that guide it followed by a brief introduction to the case study approach. It then provides a background on quantitative and qualitative methods that have traditionally been used in OM research, outlining the circumstances in which each approach is preferred, their strengths and their weaknesses. The paper next discusses the strengths and limitations of the case study approach and argues for its ability to contribute to OM theory-building research. The paper concludes with a call for consensus toward a generic framework for guiding, facilitating, and evaluating qualitative research within the OM field.

## **Understanding Research Frameworks**

The well-known objective of scholarly research (or disciplined inquiry) is to contribute to knowledge and understanding of world phenomena. This is usually achieved by way of answering one or more of the natural language questions of *what, who, when, where, how, why, should, could* and *would* (Wacker, 1998). These questions typically represent various phases of the research process, including description, exploration, explanation and validation (Handfield & Melnyk, 1998; Meredith *et.al.*, 1989). The cumulative knowledge produced by research is best organised in the form of theory, which is an explanatory statement about an object, an event, a phenomenon, a behaviour and so forth, with predictive capacity. Theories themselves are perceived in a number of different ways depending on the level of abstraction or scope and the precision they provide, which include frameworks, models, tautologies, laws, and generalisations (Little, 1992). Besides theory building, there are other functions of research such as fact-finding, classification, and the measurement of existing knowledge (Amundson, 1998; Wacker, 1998). What makes theory different to other forms of scientific activity is its explanatory power and hence the ability to make predictions. Theory development is a dynamic, cumulative, and an iterative process. Without exploration and description it is near impossible to gather the rich information and data required for building theories with explanatory power. Furthermore, theory development is said to be time and context bound. This implies that

the process does not cease once theories have been developed, but will continue to be refined, retested, and refuted as the knowledge and understanding of the phenomena advance. Therefore, explorations, descriptions, explanations, validations and refinements can be placed on a spiral of analytical progression, similar to what Meredith (1993) called the stages of theory development.

Methodology, in its broadest form, refers to a way of thinking about and studying world phenomena (Strauss & Corbin, 1990). It often prescribes the preferred method(s) containing procedures and techniques for collecting, analysing and interpreting data. The key role of methodology is to facilitate the research process by assisting the researcher in transforming observations into empirical generalisations (Handfield & Melnyk, 1998). Historically, alternative research methodologies have been guided by different research paradigms, each of which was supported by a specific philosophy.

Paradigms, or worldviews, have been characterised by their ontological, epistemological and methodological underpinnings (Guba, 1990; Morgan & Smircich, 1980). While some authors argue that this paradigmatic differentiation is difficult to operationalise and sometimes unhelpful (Rolfe, 2006), researchers are still expected to acknowledge their philosophical stand and/or the research paradigm that informed their study (Gephart, 2004; Easterby-Smith, 1991); this is often done explicitly or implicitly. This expectation is based on the argument that a researcher's philosophical position guides the design as well as the choice and use of methodology; therefore, the researcher's position should also be used (in principle) to evaluate the merits (or otherwise) of research outcomes. While it is beyond the scope of this paper to go into detail on alternative research paradigms, they are mentioned briefly to facilitate the discussion on the methodology discussed in the present paper.

Notwithstanding their variations, realism/positivism, interpretivism/constructivism and critical theory/existentialism have been portrayed in research literature as the three key alternative paradigms of broadest scope (Neuman, 2003; Guba, 1990; Meredith, et. al., 1989). Furthermore, they have been interpreted and adapted across disciplines depicting varying levels of abstraction. The three paradigms have been accompanied by the recent popularity of pragmatism, a philosophical stance that has been embraced by a number of applied fields such as education, health sciences and management (Cassell, et. al., 2006; Hope & Waterman, 2003; Johnson & Onwuegbuzie, 2004; Ormerod, 2006).

The epistemologies associated with of the three philosophical positions for research are now discussed. Within the positivist school of thought, the ultimate purpose of research is scientific explanation; that is, to discover and document universal laws of behaviour or phenomena. The reason for adopting this school of thought is to learn about the world so that people can predict and control events. However, for interpretative researchers, who largely engage in social science research, the goal of research is to develop one understanding of the social world and discover how people construct meaning in natural settings, while the purpose of critical theory researchers is to change the world. They conduct research to critique and transform social relations and do this by revealing the underlying sources of social relations and empowering people (Neuman, 2003). According to pragmatism, theories, developed collectively and cumulatively through experience, guide actions and should be judged based on the outcomes of those actions (Ormerod, 2006).

## **The Case Study as a Qualitative Theory-Building Approach**

While the case study approach has been widely used in qualitative research, it has held a prominent place within OM compared to other qualitative traditions such as ethnography and phenomenology. Lenard-Barton (1990) described the case study as an account of a past or current phenomenon, usually drawn from multiple sources of evidence – be they primary or secondary sources. Yin (1994) defined it as an empirical inquiry into a contemporary phenomenon within its real life context, while Creswell (1998) emphasised the notion of case as a bounded system. Other writers concur with these sentiments, recognising the case study to have an exploratory capacity, to be grounded in nature, and to be an intensive, in-depth, phenomena-based naturalistic inquiry (Luck *et. al.*, 2006; Bergen & While, 2000; Meredith, 1998). Collectively, these attributes make the case study approach a serious contender in OM theory-building research against more rational, abstract, restricted and detached approaches such as quantitative modelling, simulations and questionnaires, which are more suited to theory-testing or validation. For example, Meredith (1998) claimed that “the natural emphasis of the case study approach on understanding is clearly most directly focused on theory building” (p. 445). The case study approach can yield even better results when used in hybrid forms such as the grounded theory case, a combination of retrospective multiple-case and single longitudinal case, as

well as a combination of action research and a longitudinal case (Kiridena, 2005; Lenard-Barton, 1990; Rytter *et. al.*, 2005).

However, case studies are not without their limitations. They have been reported in multiple forms and multiple types with multiple levels and methods of data collection and analysis (Eisenhardt, 1989; Yin, 1994). This leaves its opponents with opportunities to challenge the case approach for its limited objectivity. Furthermore, there is little representation of this approach in OM-related academic publications. This is partly attributed to a lack of specificity and detail around the philosophical position adopted, methods of data analysis and the procedures used in the interpretation of findings, which is an important part of the evaluation criteria used by scholarly journals (Cassell, 2006; Gephart, 2004). As noted, criticism has also been based on related aspects of scientific research such as limited generalisability, individual bias and anecdotalism (Silverman, 2001). This paper asserts that if these issues were properly addressed, the case study approach can be one of the best suited methods to examine a number of contemporary socio-technical phenomena within OM, and facilitate the development of plausible theories.

## **The Status of Qualitative and Quantitative Research in OM**

Despite their prominence in the natural sciences, quantitative approaches situated in positivism have not translated well into the social sciences. The OM field has had a strong affiliation to natural and pure sciences such as physics and mathematics (see for example, Bowman, 1963; Hopp and Spearman, 1996). For a long period, OM topics such as aggregate planning, inventory control, material requirement planning, scheduling, and quality control have been examined by quantitative modelling and simulation (Bertrand & Fransoo, 2002; Chase, 1980; Meredith & Amoako-Gyamph, 1990; Meredith *et. al.*, 1989). In fact, the extensive use of these methods has allowed OM researchers to develop expertise and excel in their use (Buffa, 1980).

However, quantitative modelling and simulations may not always be appropriate in OM research. Most models, for instance, rely on a variety of assumptions, including the presence of a closed-loop system, an idealised decision-maker and the use of rational choice in decision making (Swamidass, 1991; Beach *et al.*, 2001). Traditionally, laboratory experiments, in which one variable is manipulated to determine the consequential effects in

other variables, have also earned the respect of positivist scholars within OM. In experiments, the object of study is typically isolated from its context for the purpose of controlling for variables that are not subject to observation; yet, it may not always be possible to control all extraneous variables. However, apart from ethical considerations, the complexities associated with manipulating human factors for controlled experimentation have deterred many OM researchers from using laboratory experiments (Meredith, 1998).

Although experiments under controlled laboratory conditions are rare in OM research, field experiments and other related methods such as participant observations and focus groups can be found in some areas of OM (Meredith, *et. al.*, 1989; Flynn *et. al.*, 1990). The latest addition to the suit of quantitative approaches in OM research is the survey. Over the last decade or so, survey research has been extensively used in the emerging areas of OM, such as strategy, quality management and process design (Forza, 2002; Malhotra & Grover, 1998). Survey research uses data usually gathered through questionnaires or structured interviews to draw statistically generalisable relationships among variables representing a phenomenon. The primary source of data is individuals representing a social unit. Surveys have often been used in confirmatory hypothesis-testing research, though their relevance in exploratory and descriptive research is not excluded (Flynn, *et. al.*, 1990).

Qualitative research is diverse, and often incorporates a variety of data collection and analysis methods. The traditional definition of qualitative research is based on the distinction between non-numerical versus numerical data collection and analysis techniques. However, contemporary interpretations refer to a deeper, sophisticated and more encompassing family of methodologies. Citing a number of publications, Cassell and colleagues (2006) attributed the difficulties in defining qualitative research to four key issues – the range of approaches that are classified under the title of qualitative research, the multiplicity of epistemological positions adopted by qualitative researchers, the diversity of disciplines that use qualitative research, and the variety of forms and uses that can be seen across different geographical regions.

However, in addition to the type of data used and reporting methods, many scholars in the field agree that the genre of qualitative research shares a number of distinctive characteristics; namely, it's methodological tradition (a multi-method focus and preference towards multiple sources of data), naturalistic inquiry, its mainly inductive and interpretive character in understanding the meanings of socially constructed phenomena and the active role and/or involvement of the researcher in the research process (Neuman, 2003;

Creswell, 1998; Strauss & Corbin, 1990). These features clearly set apart qualitative research from its quantitative counterpart, though the two are not mutually exclusive. Either approach may be superior to the other in handling a particular research issue depending on the circumstances and the aim of the study.

Of the many qualitative approaches, those reported in published OM research include case and field studies, grounded theory and action research (Flynn et al., 1990). The most popular data collection/research instruments used with these approaches are observations, interviews and archive analysis, all of which can be undertaken in a variety of formats.

The contribution of qualitative research toward generating hypotheses and building plausible theories grounded in empirical data has been hailed by many authors (Meredith & Samson, 2002; Voss *et. al.*, 2002; Flynn *et al.*, 1990). Though challenging and less efficient than quantitative approaches, qualitative research is extremely effective when investigating new or emerging topics (Yin, 1994; Eisenhardt, 1989) where newly formed (deduced) hypotheses barely resemble reality.

The qualitative research process is not as straightforward as the simple application of a set of tools and techniques, and is therefore difficult to summarise. Qualitative research requires skill, dedication and time. However, the rich insights gained through the extensive and comprehensive collection of data, as well as the inductive, iterative and simultaneous data collection and analysis that involve triangulation, constant comparison and reflexivity are the key dividends of such deliberations. These explorations and insights invariably lead to the construction of associative, and in some cases, causal relationships among various aspects of a phenomenon that form the basis of theory building. Moreover, the understandings or meanings of phenomena in qualitative inquiry are developed in their natural settings, an aspect that upholds their plausibility.

However, a misconception shared by the proponents of positivism is that valid theories can only come through a deductive route. As a consequence, the OM community too has tended to view qualitative research as less esteemed than quantitative research (Flynn *et. al.*, 1990). While the inductive and deductive approaches have a long history as the foundation of scientific inquiry (Wallace, 1971), the somewhat artificial divide between the two appears to have affected the progress of the OM field.

Despite their widespread use, the suit of quantitative approaches used in OM research displays three major weaknesses. The first is the validity of assumptions upon which the

design and findings are based, given the complex and multivariate nature of issues investigated. The second is their narrow focus that has implications on the generalisability of findings. The third is what is known as context-stripping where a phenomenon is studied in isolation of its context; this raises questions about the assumed causal relationships among variables. These issues are particularly relevant when the focus is theory building. They are also important when investigating managerial decision-making and people-related issues, as these phenomena cannot be meaningfully studied in isolation of the organisational and social settings in which they occur.

While qualitative traditions attend to some of these concerns, they also suffer from a barrage of difficulties associated with credibility. Furthermore, they operate within the constraints of data access, researcher skills, time and other resources. Additionally, there are a number of factors that indirectly inhibit the progress of qualitative research, particularly when qualitative methods are used in disciplines where positivism has traditionally ruled. These include the limitations imposed by editorial requirements, the evaluation criteria used in the review of manuscripts and the disposition of reviewers towards particular methodological paradigms. While none of these problems are fatal, overcoming them would certainly help researchers realise the full potential of qualitative approaches. Furthermore, these challenges can be more productively met through concerted and collective efforts toward developing a generic framework for guiding, conducting and evaluating qualitative research in OM.

## **The Case Study as a Credible Research Approach**

Natural sciences involve the study of physical and material aspects of the world and has traditionally been based on positivism. Social sciences however, focus on the study of human aspects of the world, their behaviours, norms, interactions, institutions and cultures (Neuman, 2003), and has found value in qualitative research (Flynn et al, 1990). OM manifests as a *mongrel* mix (Schmenner & Swink, 1998) of physical and human aspects pertaining to the socio-technical systems used in the delivery of goods and services (Drejer *et. al.*, 2000).

Investigating contemporary topics in OM, like service operations, innovation and logistics management, and operations strategy and technology, demands innovative approaches that challenge the methodological traditions inherited from the positivist school. For instance, Leong *et. al.*, (1990) emphasised that manufacturing strategy researchers must be willing

to invest in finding and learning new methods of analysis. This is also because of the level of detail required in the analysis and the complexities involved in researching such phenomena. Further to this, theory-building research in these areas requires in-depth analysis of data from real world situations because the knowledge-base has not sufficiently developed to allow for deductive approaches. For example, the technological and organisational variables in OM systems cannot be meaningfully studied using only quantitative approaches. To capture the critical characteristics of complex, multivariate and context-dependent problems, it is imperative that researchers explore wider methodological options (Chase, 1980; Trim & Lee, 2004).

Given the advancement of OM and the emergence of different topics (Samson & Whybark, 1998), researchers cannot continue to abate qualitative approaches. Yet they need to conduct credible qualitative research that can, at least, overcome the hurdles of getting published. Therefore, there is a clear need for demonstrating the quality of qualitative studies. This paper contributes to that effect by way of exploring some of the less talked about but substantive methodological issues relating to a popular qualitative research approach in OM namely, the multiple-case study approach.

## **Philosophical Foundations**

The terms “case study” and “case” are interchangeably used in a variety of forms and contexts; there is the instructional case used in the classroom, the case used in the investigation of crime, the case in law, medicine and psychiatry, as well as the case study in research. Although it is not difficult to discern case study research from its other uses, this has bred some confusion among part of the OM scholarly community (Eisenhardt, 1989). For example, in the editorial of a recent issue of the *International Journal of Production & Operations Management*, Webster and Taylor (2005) commented that “too few authors understand the difference between a case study written for teaching purposes and a research-based case that makes an original and novel contribution” (p.1163).

Secondly, there seems to be a mishmash of approaches to case study research. Although qualitative research in social science is usually informed by the constructivist/interpretivist school of thought, OM researchers often adopt a positivist stance in their analysis and interpretation of data within case study approach. While some authors appreciate the synergies gained through this approach (Fitzgerald, 2001), others strongly object to the use

of quantitative data in case study research (Eisenhardt, 1989; Luck, *et al.*, 2005; Yin, 1994).

Thirdly, there is much variation in the reasons for using quantitative and/or qualitative approaches. These reasons include the aim of the research – more specifically, whether it is theory-building or theory-validating; the level of understanding of the phenomenon being studied; and the researcher's allegiance to a particular research paradigm. However, seldom are these acknowledged in OM research.

The issues surrounding the philosophical foundations have primarily stemmed from the distinction between positivism and the qualitative approaches. The dominance of the former has had considerable influence on the latter. In fact, qualitative designs within OM is often marked by quests for objectivity; demonstrations of theoretical sampling; analytical induction; replication logic; the use of *a-priori* definitions of research questions; and specification of constructs. This influence is further suggested by Yin (2003) who asserted, “our approach has been to place case study research within the framework of the scientific method-to develop hypothesis, collect empirical data, and develop conclusions based on such data. The result is not claimed to be science but the emulation of the scientific method.” (p. 163).

Given the rivalry between positivism and the qualitative approaches, pragmatism has been portrayed as a viable alternative philosophical stand. It is said to reconcile those apparently contradicting ontological assumptions and epistemological positions (Hope and Waterman, 2003, Johnson & Onwuegbuzie, 2004; Onwuegbuzie, 2002).

However, to date, pragmatism has not appealed to OM researchers. In light of this, pragmatism warrants greater attention and exploration within OM. This is particular because it supports the dual goals of rigour and relevance in research.

## **Research Rigour**

Issues around the choice, design and conduct of case study research have direct links to research rigour (or lack of it). The value of case study research is said to be limited because of the reliance on retrospective accounts (internal validity), individual bias (construct validity and reliability), and the idiosyncrasy (external validity) of findings (Eisenhardt, 1989; Leonard-Barton, 1990; Meredith, 1998; Stuart, *et al.*, 2002; Yin, 1994). Silverman (2001) summed up many of these flaws as the problem of *anecdotalism* and argued that

qualitative researchers cannot exempt themselves from the standard requirements that must be met by credible scientific research.

However, there is a growing section of the scholarly community who object to the use of positivist criteria to evaluate qualitative research (Fossey, *et. al.*, 2002; Morgan & Smircich, 1980; Sandberg, 2005).

Two ways to overcome or minimise these limitations are using mixed methodologies and/or a longitudinal approach. For instance, a longitudinal, multiple case study approach has been touted as the most appropriate method for the investigation of strategy process both in strategic management and manufacturing strategy literature (Pettigrew 1992; Barnes, 2001, 2002). Similarly, the combined use of action and longitudinal case study research and the synergistic use of longitudinal single site with replicated multiple site case studies is also deemed advantageous (Leonard-Barton, 1990; Rytter, *et.al.*, 2005).

Mixed methodologies offer opportunity to validate research findings through triangulation or corroboration. This can be operationalised via three routes: data (that is, using both qualitative and quantitative approaches), researcher (that is, involving multiple investigators) and methods (that is, employing a mix of techniques).

A longitudinal single study can be used to establish causal relationships (Leonard-Barton, 1990).

### **Articulating the Research Journey**

Finally, clear and detailed expositions of the adopted methodological approaches are sparse in most publications that have used qualitative research (Cassell, 2006; Gephart, 2004; Eisenhardt, 1989). This is less of an issue in quantitative research because the techniques and instruments used are believed to be self-explanatory. For instance, the issue of credibility in survey research is somewhat mitigated with the mention of statistical techniques; however, for case study research, credibility becomes a serious issue and methodological rigour often needs to be defended.

Few would oppose the importance of articulating the methods of data analysis. However, the qualitative OM literature offers little guidance in terms of how to do this. Even among the most detailed accounts of data interpretation in the published literature, researchers may choose to freely use their qualitative approaches without paying much attention to their philosophical underpinnings.

The crucial part of methodological disposition is clearly articulating the connection between the research questions, the data, and the findings. This is no easy task, particularly in light of the formatting requirements imposed on manuscripts; privileged methodological traditions in certain disciplines; as well as the varying tastes and philosophical allegiances of reviewers.

A simple yet effective way of meeting these challenges is to be as specific as warranted by the context in which the research study is carried out, as well as reporting on all procedures followed. It is also critical to clearly articulate the philosophical foundations that guided the study, which is seriously lacking in many published OM studies.

## **Recommendations**

Based on the above discussion, the following three-fold approach is suggested to help OM researchers deal with the methodological issues, especially in qualitative theory-building research.

- Recognise and appreciate the philosophical underpinnings of research and clearly articulate the philosophical position that informed the study.
- Take a holistic approach to research design (informed by philosophical foundations, research issues and resources, time and other constraints) that may include challenging traditional approaches and stepping out of the comfort zone of the researcher.
- Provide a clear and detailed exposition of the methodological approach used including the tools, procedures and techniques employed that explicates the connection between the research questions, the data and the findings.

## **Conclusion**

This paper has addressed some of the methodological issues faced by OM researchers who embrace alternative approaches to explore research problems from the real world that require in-depth analyses. Whilst qualitative research principles are not unknown in OM circles, research in this discipline suffers from a scientific legacy and positivist approach that thus far has dominated the field. This paper suggests widening the view of researchers to include appropriate research methodologies and tools to facilitate the investigation of emerging issues in OM.

The paper, based on its review and discussion of methodological issues associated with the case study research, suggests that the multiple case study approach, longitudinal case research and data triangulation, supported by the clear articulation of methodology and methods, can demonstrate the quality of qualitative research in OM. Challenging philosophical underpinnings of research paradigms in the OM discipline may provide valid and rigorous solutions to practical problems while pursuing both rigour and relevance.

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