SWP 11/97 **CONTEXT ANALYSIS - A TECHNIQUE FOR ANALYSING RESEARCH IN A FIELD, APPLIED TO LITERATURE ON THE MANAGEMENT OF R&D AT THE SECTION LEVEL**

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ABSTRACT

Context Analysis is a new method for surveying a body of publications as a whole. The process consists of creating a database of information about the publications in a field of study and then looking for interesting relationships in the data. This paper presents our findings about one particular research field, Management of R&D at the Section Level. We investigated how the research activity is related to practitioner needs in this field and found evidence to support the views that the literature in this field provides a forum for debate rather than for the reporting of formal research, and that the publications generally conform to a different assumption about the nature of the R&D process than that held by practising R&D managers. We obtained confirmation of our allocation of facts and judgements about papers by sending a questionnaire to the authors of the papers. The paper discusses practical aspects of how to apply the method in other fields, and suggests that the method might be useful in informing the strategies of researchers and funders of research.

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I. INTRODUCTION

The literature review phase of research has fewer established methodology tools than most parts of the research process. Context analysis provides an additional method for helping to appraise existing literature in a field and for helping with the strategic appraisal of projected new work. Context analysis enables quantifiable statements to be made about the whole body of research activity in a particular field: for example, what types of people are doing the research, what methods are used, what paradigms are being followed, and what types of output arise.

Context analysis extends the already known methods of bibliometric analysis [ref 1, ref. 2]. In bibliometric analysis features of papers in a body of literature, such as numbers of references or author nationalities, are studied. These features are completely external to the subject matter of the papers and could be assigned by an observer without specific knowledge of the field in question. To carry out a context analysis it is necessary to understand the subject matter of the papers and be familiar with the field of research. For example if the research methods used in the field are being studied, the types of method used must first be identified by reading a sample of the papers, and definitions developed. Then the balance of the papers in the field must be read, and a research method is assigned to each paper. Typically five methods might be identified, named and defined. Information about all the papers is entered into a database, and the occurrence of the different research methods can then be related to other factors.

We developed context analysis in the process of examining publications in one field of research, namely **the management of R&D at the section level.** (R&D stands for Research and Development, and we are concerned only with industrial R&D.)

Most of this paper consists of a report of the analysis we made of this literature field. We then give advice based on our practical experience of how other researchers could analyse other fields of research, and finally we discuss the value of the work to us and its potential value to other people.

Below in this Introduction section we firstly give an example of the method in use. Following sections explain how our database of literature was constructed, and present the overview of the literature in our field which was obtained by our analysis. We then go beyond simply describing the literature and use the method to test a hypothesis about the field of study. Finally we explain how we validated our findings by seeking the same information from the authors of the papers.

It has been our policy to explore the method broadly, and we are aware that our findings leave many unanswered questions requiring further study.

A. The field of research we analysed

We originally set out to study strategy for R&D at the section level, a topic of great practical interest to one of us. We found that nearly all R&D strategy research concentrates upon corporate level concerns, but in a modern organisation responsibility tends to be

devolved. The current tendency is for activities such as R&D to be set up as independent cost centres and treated as optional facilities whose services may alternatively be purchased externally. In effect the survival of the R&D unit depends upon its performance in a marketplace. As a result sections and small units in R&D can feel a need for strategic management independent of the larger organisation of which they are a part. No publications specifically addressing the topic of **strategy for R&D at the section level** were found, but a large number were found which addressed various more general R&D management concerns at the section level, or which concerned R&D strategy at the corporate level, or which were really about something else, but had some relevance to our topic. It was decided to review papers on a topic which we defined as **management concerns of the R&D section.**

It was also, incidentally, decided to create a special database and record reference details for all of the reviewed publications in it. This proved to be unexpectedly fruitful, and led to the development of Context Analysis.

B. An example - Author Type and Output Type

It was noticed during compilation of the database of references in our field that first authors might be placed into the following categories of **author type**:

- **academics**: authors who have a university address   [ref. 3]
- **journalists**: authors who appear to be full time journal employees [ref. 4]
- **consultants**: individuals or employees of consultancy organisations [ref. 5]
- **practitioners**: authors who practise or directly supervise R&D   [ref. 6]
- **corporate management**: managers above practitioner level [ref. 7]

We have given one reference to exemplify each category. During classification all of the papers were read, and it came to our attention that the type of author appeared to be significant in predicting the type of output of a paper. To test this hypothesis it was decided to create new columns in the database for recording the **author type** and **output type** of each paper. The **output types** defined by us are shown in table 1.

Clearly other possible outputs could be thought of, but the definitions above were derived from reading the papers and all of the papers clearly fell within one of them. One might for example expect papers which present data plus reasoning following from the data, but none were found. In the category **measurement method,** all papers were on measuring the efficiency of R&D, and none were on how to measure other aspects of R&D, such as effectiveness.

Author type was gleaned from the authors' biographical notes or addresses, and was deducible in all but one of the papers. **Output type** was assigned by the reviewer, and this proved practicable for 100% of papers. Table 2 presents a crosstabulation of this data. χ^2 tests showed that the different pattern of output type for each type of author is statistically significant at better than 99% in each case.

Table 1. Definitions of **output types**. The references are papers which form examples.

Recipe	Rules, normally empirical, claimed to be generally applicable. E.g. Top management support promotes new product success. [ref. 8]
Strategy	An argument leading to things to do in general situations to place the whole organisation in a good position [ref. 9]
Tactics	An argument leading to things to do in particular situations to place a project or department in a good position [ref. 10]
Model of R&D	A statement of how the whole R&D management process is thought to work [ref. 11]
Theory of an aspect	An explanation of how an aspect of R&D management is thought to work [ref. 12]
Comment only	A statement with no apparent support within the paper, or a comment giving rise to no recommendation [ref. 13]
Data	The simple presentation of data with no interpretation [ref. 14]
Measurement method	A technique for measuring the effectiveness of R&D [ref. 15]

Table 2. **Author type** and **output type** of papers on **management concerns of the R&D section.**

Output Type	Journalist	Academic	Consultant	Corporate	Practitioner	TOTALS
Rules	3	82	23	26	6	140
Strategy	18	68	13	69	11	179
Tactics	22	61	25	21	29	158
Model	0	63	4	12	5	84
Theory of an aspect	0	19	2	6	2	29
Comment only	9	0	8	7	3	27
Data	0	18	0	3	0	21
Measurement method	0	11	2	4	0	17
TOTALS	52	322	77	148	56	655

It can be seen that the idea that **author type** to some extent determines **output type** is supported by this data. Corporate and Practitioner authors concentrated on strategy and tactics respectively, which was not surprising to us. Academics concentrated somewhat on rules. Why this should be so was not at all clear, but we advance a theory about this later in this paper. The dominance by academics is not surprising, but the significant contribution made by journalists was not expected by us. We were very surprised at how

few of the papers presented data or theory, since we would have expected these to be the main outputs of research.

It was felt that the above results are interesting, and so it was decided to conduct further work along the same lines to investigate and develop this approach.

C. Discussion and Definition of Context Analysis

We define the **context** of a paper as an assembly of factors concerning the paper which are external to its research content, such as the nationality of the author, the topic the paper discusses, or the type of output of the paper. Some such factors could accurately be described as attributes, others as features and others perhaps as characteristics, but we group them all together as **context factors**. By contrast, the internal content of a paper might be certain data measured, or a certain theory proposed or proved. These internal factors do not concern us here.

Thus *"The output of the paper is a theory"* is a context statement, which concerns us, while *"The output of the paper is the theory that R&D managers should be over 35"* is a content statement, and does not concern us.

Note that in the example above **author type** could be considered to be a bibliometric factor, assignable quickly by a librarian for example, whereas **output type** is a context analysis variable: to assign this it is necessary to read and understand the papers and to have the insight of a researcher. We can define four levels of factor:

1. Elementary (e.g. number of references): can be assigned by a clerk
2. Bibliometric: (e.g. author type) might be assigned by a librarian
3. General context: (e.g. quality of writing) could probably be assigned by any researcher who has read the papers
4. Specific context: (e.g. school of thought) can only be assigned by a researcher familiar with the particular field who has understands this new term (explained below)

The following sections describe the technique that arose, and present some more results.

II. CONSTRUCTION OF A DATABASE OF PAPERS

A. Selection of context factors

The database was expanded to record the following **context factors** for each paper in addition to **title** and **first author**. (In order to make the data manageable all factors concerning the author refer to the first listed author only.)

1. Author type (as in the example above)
2. Output type (as above)
3. Reference, broken up into journal, issue and year
4. The degree of relevance to **management concerns of the R&D section**
5. A grading of our opinion of how well written the paper was
6. A grading of our opinion of the importance of the paper in its own field
7. Nationality of author
8. Affiliation of author

9. How formal the work was, in a range from formal study to expression of views
10. The research methodology used
11. The School of Thought underlying the work. (This concept will be explained later).
12. The relationship of the paper to theory: whether it describes or tests a theory
13. Some other factors not reported on in this paper

This list of context factors was partly thought up by us, partly arose from reading of the papers, and partly arose out of a separate piece of research which we were carrying out: a practitioner case study. This case study will be the subject of a separate publication.

B. The publications included

By April 1996, 655 papers on the subject of **management concerns of the R&D section**, published since 1975, had been entered. Most were refereed journal papers, the most important exception being that papers in *Research Technology Management* are "reviewed by the Board of Editors". The papers were found by the usual methods of keyword computer searching of databases, manual scanning of identified key journals for relevant papers, and some citation searching. Databases searched were ABI/Inform, BIDS, Compendex, INSPEC, NTIS, and PsycLit. The list of papers is thought to be more or less comprehensive for the restricted field in question. We estimate that these papers relevant to **management concerns of the R&D section** comprise roughly 20% of papers on all R&D Management topics. The conscious decision was made not to do searches for key authors as this would perhaps bias the database towards those who feature a number of times, and lead to the neglect of rarer authors.

C. Categorising the papers

All papers included were read by one of us (LTF), and were categorised according to his opinion. The list of possible categories for a factor was modified and extended slightly in the light of experience with the papers. The development of the categories was performed early on in the study, and after this was done there was no particular difficulty in categorising all the papers.

III. RESULTS FROM THE DATABASE

A. Which journals feature - a league table

The 655 publications on the topic were distributed among 114 journals and were distributed as shown in Table 3.

It can be seen that the top journal yielded one third of the papers, the first six journals yielded just over half the papers, and nearly half the papers were distributed among 108 other journals. This shows that publications relevant to our field are highly dispersed.

The comment may be made that **management concerns of the R&D section** is a clear enough concern to the section level R&D manager, but it has not been a recognised field of study, with its own journals or sections in journals. Therefore it is not surprising that papers having some relevance have to be searched for widely. The question arises as to whether a new topic subdivision could be created for this subject within the existing known categories, or whether some topics of practical interest will necessarily be found cutting across subdivisions made by journals.

Table 3. League table of publications in our field.

Publication	Papers
Research Technology Management	140
IEEE Engineering Management Rev.	61
R&D Management	56
Research Management	53
IEEE Trans. Engineering Management	40
Jour. Product Innovation Management	21
Management Science	20
Technology Management	20
Engineering Management Journal	19
Management Today	17
Project Management Journal	12
Harvard Business Review	11
Professional Engineering	7
Engineering Management	7
Sloan Management Review	6
Long Range Planning	5
Ann. Reliability & Maintainability Symp.	5
California Management Review	5
Journal of Marketing	5
Proceedings of the I.Mech.E.	5
Industrial Marketing Management	4
World Class Design to Manufacture	4
Technology Analysis and Science	4
Interfaces	4
IEEE Spectrum	4
Organisational Dynamics	4
Technovation	3
Int. Jour. Technology Management	3
Technology Analysis & Strategic Mgt.	3
Research Policy	3
Business Horizons	3
European Journal of Marketing	3
12 journals	2
70 journals	1
TOTAL	655

B. Writing quality, relevance and importance of the papers
One paper judged by us to be very useful was found as a one-off, on its own in *Irish Marketing Review* [ref. 16]. This raised the question of whether some journals publish the best papers, or whether one needs to read all the journals to capture all the good papers. To explore this, new columns were created in the database to record our ratings of **how well written** each paper was, its **relevance** to our topic, and it's **importance** as a paper in its own right. Each of these was rated on a scale of 1 to 5, with 5 as high.

Table 4 shows the results for these three factors for the journals at the top and bottom of table 3. A **relevance** rating of 1 means that the paper has some relevance to but is not aimed primarily at our special topic. It could be a good paper on R&D management at the corporate level or on general management at the section level. A rating of 5 means that the prime concern of the paper is indeed **management concerns of the R&D section**.

Importance is our view of the significance of the paper in its own intended field. It might for example be a very important paper on business strategy, which has a relevance rating of only 1 or 2 to our special topic.

How well written was our judgement of the writing quality, based simply on an opinion of whether it was easy to read and easy to understand.

Table 4. Rating of papers in a selection of journals for relevance to our topic, writing quality and significance in their own fields. 1 is low, 5 is high.

Journal	Papers	Relevance			Quality			Significance		
		Av	Max	Min	Av	Max	Min	Av	Max	Min
Top of table										
Research Technology Management	140	3.2	5	1	2.7	5	1	3.3	5	2
IEEE Engineering Management Review	61	3.3	5	2	2.7	5	2	3.2	4	2
R&D Management	56	3.0	5	1	2.7	5	1	3.2	5	1
Research Management	53	3.5	5	2	2.8	5	2	3.4	5	2
IEEE Transactions on Engineering Management	41	3.2	5	2	2.4	4	2	3.2	5	2
Journal of Product Innovation Management	21	3.3	4	1	2.7	5	2	3.5	5	2
Bottom of Table										
Irish Marketing Review	1	4	4	4	2	2	2	4	4	4
Operations Research	1	4	4	4	2	2	2	3	3	3
Electronic Business	1	3	3	3	4	4	4	3	3	3
Strategic Planning Society	1	3	3	3	3	3	3	4	4	4

We conclude from the information in table 4 that the recognised top journals are high on quantity of papers, but average on quality, with quality ranging from very high to very low. *Research Technology Management* has ratings from 1 to 5 for writing, and 2 to 5 for significance. Its averages are similar to those of journals at the bottom of the league table. Since there are so many journals with one or two papers in our field, we conclude that looking at only the top few journals would lead to missing a lot of highly rated papers.

Table 1 could be considered to be purely bibliometric, whereas table 2 required informed judgements to be made about context factors.

C. Distribution by country in which the work was performed

Table 5 shows the national origins of the papers. The database concerns solely papers written in English, which may explain the predominance of the USA and theUK. A Japanese researcher working in France and publishing in the USA would be classed as French.

Interestingly one author has significantly distorted the results, by elevating Canada to third position almost by himself. Professor R J Cooper of McMaster University and his co-authors have written over 30 papers within the field of study, which comprise the bulk of the Canadian papers.

Table 5. National origins of the papers.

Country	Papers
USA	438
UK	114
Canada	45
Japan	14
Germany	8
Switzerland	6
Holland	5
France	4
Korea	4
Israel	4
India	2
14 countries	1
TOTAL	655

D. Centres of activity in the field

A total of 208 organisations contributed papers selected by us as relevant to our topic. Table 6 shows that with some significant exceptions authors are thinly spread among a very large number of organisations, and even the largest centre provides less than 4% of the total papers. The second centre, IRI, is the publisher of *Research Technology Management*, and its articles are mostly commissioned reviews.

Table 6. Top six contributing research centres, out of 208.

Affiliation	Papers
McMaster University, Canada	26
Industrial Research Institute (IRI)	10
US Government	8
Carleton University	7
Rensellaer Polytechnic Institute (RPI)	7
Management Today	7

There was sometimes difficulty identifying research centres. For example, Manchester has three university institutions doing management research, and it is difficult for an outsider to know which belong together, and which are distinct. Is the University of Pittsburgh the same as Pittsburgh University? For that matter, is Cranfield Institute of Technology different from Cranfield University, and is Cranfield's R&D Management Centre part of Cranfield School of Management? In practice these problems turned out not to greatly affect the outcome, i.e. that research is very widely dispersed among a large number of centres in this field and that the largest single centre is clearly at McMaster University in Canada. This information is of considerable strategic importance for a researcher in the field.

E. Type of Author against Formality of Research

We defined four categories of **research formality** in descending order as follows:

- **Formal study**, which is the reporting of a research project with methodology, data and reasoning explained [ref. 17]
- **Reasoned Argument**, which represents a proposition or analysis based on a self contained chain of reasoning [ref. 18]
- **Declaration**, which is a presentation of beliefs with justification by selected evidence from supporting research [ref. 19]
- **Views**, which are statements which are unsubstantiated in the paper [ref. 20]

Table 7 shows the relationship between **author type** and **research formality**. Our chief comment is how little of the work was categorised as formal study. What we have termed **reasoned argument** was usually a discourse based on premises considered to be self evident, and did not appear to represent an extension of previous work.

Table 7. **Author type** and **formality of research**

Formality of Research	Journalist	Academic	Consultant	Corporate	Practitioner	TOTALS
Formal study	2	65	1	15	6	89
Reasoned argument	6	92	20	38	9	165
Declaration	7	85	17	43	11	163
Views	37	80	39	52	30	238
TOTALS	52	322	77	148	56	655

F. Primary research methodology used

We were interested in what methods of research were employed, and classified the papers as shown in table 8.

Table 8. Methodologies employed in the papers.

Main Methodology	Journalist	Academic	Consultant	Corporate	Practitioner	TOTALS
Case Studies	10	61	16	59	17	163
Theoretical analysis	12	119	38	65	4	238
Questionnaire	0	36	2	5	2	45
Interview	22	31	4	7	1	65
Literature Review	2	33	14	10	2	61
Empirical data	0	17	3	2	0	22
Data Analysis	0	10	0	0	1	11
Experience	6	13	0	0	30	49
Delphi	0	0	0	1	0	1
TOTALS	52	320	77	149	57	655

In table 8 we have used terms which normally stand for well recognised techniques of management research, but in our case these terms must be considered to be modifiable by the formality factor of table 7. Thus an author may claim to base a paper on case studies, and be so classified in table 8, but may not show that the case study was conducted with recognised case study methodology, and so the work would be rated in table 7 as views [ref. 21], declaration [ref. 22] or even reasoned argument [ref. 23], as well as formal study [ref. 24] . Formal techniques taught to management researchers, such as questionnaires [ref. 25], interviews [ref. 26], and data analysis [ref. 27] were clearly only used in the minority of papers, and the Delphi method, which is one of the major recognised techniques, was only used once [ref. 28].

It appeared to us that the popularity of a research method was inversely proportional to the amount of work it entails. Indeed tables 7 and 8 suggest to us that this body of literature provides more of a forum for debate than a medium for reporting research results. This in turn suggested that this body of research is in the pre-paradigm state described by Kuhn [ref. 29], where many competing theoretical bases are being offered. We propose that research on R&D management is in the same state as chemical research was before the atomic theory was developed, and it lacks widely accepted explanatory and predictive powers.

Snow [ref. 30] suggested that in the post-paradigm phase most publications concern firstly the testing and acceptance of a theoretical framework, and then later on its building and application. To test this idea, a new context factor **contribution to theory** was created and the papers were re-analysed, and assigned to one of two categories. 17% of papers were concerned with testing different theories, whereas 83% were concerned with building theories. Of the theory-building papers, 70% were concerned with describing a theory, 25% were concerned with explaining a theory, and only 5% were concerned with making predictions from a theory.

We believe that it would be interesting to apply context analysis to determine the breakdown of methodologies for other fields of publication, to see how different fields compare.

IV. USING CONTEXT ANALYSIS TO TEST AN EXTERNAL HYPOTHESIS

A. Schools of Thought

A case study of strategy in an industrial R&D laboratory was mentioned previously. This was the working environment of one of the authors, and in conducting the study it was noticed that different managers, when apparently faced with the same information, drew quite different conclusions and favoured different courses of action. The hypothesis was formed that these different managers think in different ways or perhaps subscribe, consciously or unconsciously, to different forms of reasoning about R&D management activity. The publications on R&D management also appeared to reveal the presence of these same **schools of thought** underlying the approaches to research on the topic. The schools of thought, as formulated by us were as follows:

1. **Biological** - R&D management must adapt continuously to change. [ref. 31]
2. **Chaotic** - R&D is complex and variable, and there are limits to manageability [ref. 32]
3. **Deterministic** - R&D can be managed by logic and reason [ref. 33]
4. **Empirical** - cookbook rules can be found that apply to R&D most of the time [ref. 34]

It was decided to open a new column in the database and to enter for each paper which school of thought the reviewer thought its content belonged to. It was found quite easy to assign the papers to schools. Very few contained more than one school, and none suggested a new school. It was then possible to find out whether different researcher types favoured different schools of thought, as shown in table 9.

Table 9. **School of thought** and **researcher type**

School of Thought	Journalist	Academic	Consultant	Corporate	Practitioner	TOTALS
Empirical	30	189	55	46	11	331
Deterministic	9	89	11	93	12	214
Chaotic	7	26	8	2	13	56
Biological	5	10	3	7	21	46
None	1	6	0	1	0	8
TOTALS	52	320	77	149	57	655

χ^2 tests showed that the variation of distribution of school of thought for each type of author is significant at better than 99% except in the case of journalists, who are significant at better than 80%.

We interpret these results as follows. The **empirical** approach requires collation of research information drawn from experience, and therefore will be favoured by academics and consultants, who need to base their contributions on some substantial work. The **deterministic** approach requires no substantial amount of work, since only reasoning ability is required. Corporate managers presumably see it as their function to apply reasoning, and therefore favour this approach. It is less clear why journalists might favour

the empirical approach, since presumably they do not undertake the substantial amounts of work that academics and consultants put in. Perhaps journalists report what the others do, and so reflect their approaches. The **chaotic** school appears to leave little to be researched or acted upon, so perhaps that is why it is not favoured by any group.

The most notable finding is that practitioners subscribe much more uniformly to all four schools, but are strongest on the **biological**, which is least favoured by the other author types. This raises a question about the match between the mind sets of those who supply research papers and those who presumably would be expected to benefit from them. Nearly half of the **biological** papers were written by practitioners, which was the most popular school of thought for them, but because very few practitioners wrote papers, the total of biological papers was small.

A further question arises. The large majority of practitioners must be non-publishers. What schools might non-publishing practitioners belong to? Does the literature favour a school of thought which is different from that of R&D practitioners? This is a line of enquiry which we are pursuing as a separate project. The fact that a new unexpected line of enquiry has been opened is an indicator of the value of Context Analysis. A full report is available as a Cranfield Working Paper [ref. 35].

V. CONFIRMATION OF OUR ALLOCATIONS BY AUTHORS' OWN OPINIONS

Much of the above work relies on the opinion of the reviewer in classifying the papers. It would have been a good procedure to check our allocations using the inter-rater method, but this would have entailed a second person reading and categorising a substantial number of papers. It was felt that an alternative equally valid approach would be to ask the authors of the papers to categorise them for us. A questionnaire was developed and posted to the first authors of the 296 most recent papers. This asked for much of the same information as is contained in the database. To date 121 responses have been received, a response rate of 41%. This response is impressive, especially as some papers were over 10 years old, and many questionnaires were returned 'gone away', 'not known' or 'deceased'. Many authors expressed interest in this exercise, and some offered other papers. Some of these were even alert enough to photocopy the questionnaire, and fill it in for these additional papers!

When an author gave exactly the same answer as we did, we called this a primary hit, and for all questions the rate of primary hits was in excess of 75%. For **school of thought** the agreement was 79%. For **researcher type** it was 83%, for **primary research method** it was 76%, and for **contribution to theory** it was 87%. A lot of the misses were grouped into a small number of problem areas that proved to be amenable to improvement with a little further work, such as refinement of definitions, so still higher agreement would be achievable. We conclude that these results sufficiently justify our allocations, and indicate that the context analysis technique can give similar results whether author opinions or researcher opinions are used. The full results of author confirmation have been presented at the 1997 R&D Management conference at Manchester [ref. 36].

Thirty references are given in this paper as examples of various factors or definitions. Twenty six of these allocations were confirmed exactly by the authors in questionnaire returns. In four cases the author did not answer that question or we had no author replies for the category.

A. Confirmation of the Schools of Thought hypothesis

We were pleased to find that authors had no apparent difficulty in answering what might have been the most difficult question, which in effect asked them to classify their paper according to its school of thought. The question asked was: *"Which of the following most closely describes the conceptual framework in which your paper is set?"*, and authors were asked to tick one of the four definitions shown in section IV *A. Schools of Thought* above. About six authors misunderstood one category, which was easily resolved by communicating a fuller definition to them. Apart from this all but one author answered this question without any apparent difficulty. We take this as an indication that the schools of thought hypothesis has validity.

We concluded that Context Analysis can be used to test a theory about a research field.

VI. ADVICE ON USING THE CONTEXT ANALYSIS METHOD

A. Selecting context factors

The **context factors** used would not all have arisen from the literature review alone. It is important to firstly do some work to define the matters of concern in the research field. This work can include findings from outside the literature as well as reading a sample of the papers. The **schools of thought** factor arose from another piece of research[1] whereas **output types** arose from the literature itself.

The initial list of **context factors** we created seemed logical, but several factors proved not to work, in that papers could not be assigned to them. As an example, in table 4 we would have liked to have entered a rating for **quality of research**. This did not prove possible for two reasons. One was that **quality of writing** overlay our desired factor; usually poor writing obscured any underlying research that may have been done. The other reason was that papers simply did not report research in the way we would have expected, i.e. in a way enabling the reader to understand what was done, what results appeared, and the chain of reasoning or analysis that was applied to reach stated conclusions.

As the work progressed we noticed patterns in what was appearing in the literature which gave rise to further questions necessitating creation of new factors. This meant re-reading a large number of papers in order to categorise them according to the new factors. It would presumably be better to identify all of the factors needed at the outset, to pilot the factor list on a sample of the papers, and to check that intended crosstabulations do in fact work out.

B. Definitions of context factors

Carrying out context analysis involves some techniques that are familiar to researchers in the field of social science. [ref. 37, ref. 38]. In social science research a concept such as the the output type **recipe** (table 1) would be called a **construct** and the need to develop a name and definition for a construct is well known, as well as the need to test whether it is a robust construct which would be interpreted the same by all researchers.

Each context factor was given a name which was as accurately descriptive as possible, and also a definition, as exemplified in table 1. It is important to have written definitions of factors for three reasons. One is that the definition list gives the researcher a reference for deciding how to allocate each paper. The second is that the definitions will be required when reporting the work. The third is that we often assign a special meaning to a common

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[1] Our case study of section level R&D management is not yet complete and will be published later.

word, and this needs to be notified. For example, in tables 1 and 2 the factor **theory of an aspect** can be seen from our definition to be used in the somewhat derogatory sense of "that's just a theory, it's not proved".

The definitions adopted described not so much what we were looking for in the literature as what we found, and definitions had to be adapted in the light of findings until it was found that all papers fitted into factor categories. It can be seen that often definitions are an output of our examination of the literature, not an input.

Gradings, for example gradings 1 to 5 of **quality of writing**, also need definitions for the same reasons. Some examples are given in the text associated with table 4.

C. The author questionnaire

The author questionnaire was very successful, but composing a questionnaire is not at all easy. This too is well known to researchers in some fields.

It was not successful to ask the questions that occurred to us in the first instance. Questions only worked if they were based on what had proved successful in the database. That is, if a context factor was formulated so that it was easily assignable by us on reading the papers, then authors appeared to have little difficulty in responding in the same way. We piloted our questionnaire with 8 authors, and modified it as necessary, before piloting again with 12 authors. We were then able to issue the final version to all authors. Considerable effort was given to making the questionnaire appear professional and effortless to complete and return.

D. Limitations of the database software

The database used was Microsoft Access version 2.0. This database does not have a spell checker, and mistakes in spelling author and journal names have the effect of spoiling occurrence counts, so much manual weeding of errors was necessary.

Query writing is vital in using the database but it can take months to learn this skill. There appear to be artificial limitations to what you can and cannot do, which are not logical, but are limitations of the software.

It was not possible to maintain live links with tables embedded in Word documents, so data had to be re-exported to documents whenever it had been updated.

When tables incorporating calculations were moved to be embedded in Word, it proved impossible to control the number of significant figures displayed and the alignment of numbers in tables, except by manual editing of individual numbers.

When writing a report on a context analysis it would be best to work entirely with a version of the database frozen at one point in time, but Access does not enable a copy of a database to be easily made.

E. Finding the papers

It was found to be very difficult to use the standard literature databases to find the relevant papers. We found a lot of papers we did not want, and did not find a lot which we did want. There was no search criterion provided which exactly matched our chosen topic so we had to use several apparently relevant criteria that were available, together with key words. This yielded over 4000 articles which we manually sifted down to 655. Half of these proved to be of low relevance on full examination. The main problems were inaccurate titling, misleading abstracts and too many key words. Some keywords had only slight applicability to a paper. It was necessary to read some papers right through in order to know what was in them.

Once the key journals had been identified it was necessary to go through the actual journals manually. Almost half the papers found this way had not appeared in the database searches. We have seen that even this does not guarantee complete coverage because key journals do not contain all significant papers.

Citation searching was thought to be a potentially valuable technique but unfortunately appears to be set up backwards for our purposes. It gives you the number of citations of a particular paper, but cannot tell you the most cited paper on a particular topic, which is where we would wish to start a citation search from. It is possible once you have the papers to decide which is the most cited, but this is a clumsy approach and will not work unless the most cited paper happens to be already found, of which you cannot be sure. We abandoned the use of this method.

F. Presentation format for results

Although it was easy to extract tables once query writing had been mastered, it was difficult to cast the results in the form required for presentation. Table 2 was originally output from the database in the form shown in table 10, which we call the **database format**.

We felt that it was preferable to present this information in the more compact style of table 2. We call this the **matrix format**, because one factor is spread out horizontally and the other vertically. Unfortunately all the entries had to be transferred more or less by hand from the old to the new framework. Access has facilities to present data in a number of forms of pie chart or graph, but cannot convert output to the matrix format.

Table 10. The form in which the data of table 2 was originally extracted from the database. Only the start of the table is shown.

	RESULT	Count Of RESULT
Academic	Tactics	61
Academic	Strategy	68
Academic	Model	63
Academic	Rules	82
Academic	Theory	19
Academic	Data	18
Academic	Measurement	11
Academic	Comment	5
Consultant	Tactics	25
Consultant	Strategy	13
Consultant	Rules	23
Consultant	Recipe	7
Consultant	Comment	8
Consultant	Model	4
Consultant	Theory	2
Consultant	Measurement	2

G. Too much output to present

The database can be interrogated remarkably rapidly to ask new questions within its scope. such as "How many journals feature" or "Which journals do Canadians publish in?". In Table 4 we put in a column for **how well written** and were then able to give an average writing rating for each journal. It was then trivial on the computer to rank the journals by quality of writing and to produce a league table for this (not shown here). It was almost trivial to go on to produce a table of average quality of writing against **author type**, (also not shown). The number of relationships examinable with a database of this type is very large. If n factor columns are entered, then $n(n-1)/2$ pairs of matrices will be possible. Thus it not practicable to report all crosstabulations in a publication such as this.

Also, a single output table can be too large to publish. As 124 journals feature in our database. then obviously table 4 was originally 124 rows deep, but we included only a sample of this table here. It is easy to browse such a table when it is in a computer, but it is not practical to publish it on paper.

It is thus necessary when using context analysis to be selective about which results are presented.

VII. DISCUSSION

A. Examination of an opinion about a body of knowledge.

We studied a problem which arose out of practitioner interest, but found that it did not exist as a recognised topic in the literature. Table 11 summarises how the body of literature we studied was found to relate to the research concern we started off with. The 655 papers in topic 2 complied with its definition in varying degrees: 6.6% came in the highest category of relevance to topic 2.

Table 11. Hierarchy of research topics.

Description	Topic	Topic definition	Relevant Papers
What we were interested in, defined by work needs	1	*strategy for R&D at the section level*	0
What we studied - a subset of 3. Also of value in work	2	*management concerns of the R&D section*	c650
The recognised field in the literature	3	*management of R&D*	c5000?

We accepted that there were no papers relevant to topic 1 of table 11, but information about the more general topic 2 would have been welcome because one of us (LTF) is a practising R&D manager.

Having read all the papers, he found remarkably little that he considered to be of immediate practical value to him in his work. Many of the papers seemed at first to be internally consistent and convincing, but over time factors became apparent to him which had not been taken into account, and these papers came to seem irrelevant or extremely difficult to apply in practical situations that arose. Context analysis then showed quantitatively that few of the papers are directly relevant to section level R&D management, that very few are written by practitioners, that the backgrounds of the authors influence the type of output of the papers and that the large majority of the papers are written from a completely different viewpoint from that of the majority of practitioners. Thus an opinion about a body of literature has been reinforced by systematically gathered and analysed data.

B. Testing a hypothesis.

As reported above, we obtained good evidence that the **schools of thought** concept which arose from a separate piece of research represents a real phenomenon in R&D management and in research upon it.

C. Ideas for further work on literature and practice in R&D management..

Ball [ref. 39] has recently published survey evidence that most practicing section level R&D managers do not read the journals studied in this paper, and are often not even aware of their existence. We would like to see more work to investigate the relationship of the literature to practice, and also investigations of why authors write their papers. They might write because of an ex officio invitation, as part of PhD requirements, or to achieve research ratings for a university. It would be interesting to analyse journals by the things they appear to value in a paper. Do some journals by virtue of editorial policy or house style influence the apparent direction of published work?

D. Further development of Context Analysis

Methods exist that could be applied to make this work more rigorous from the point of view of formal research methodology [ref. 37, ref. 38]. For example, to identify context factors, the method known as content analysis could be applied to a selection of the papers, or alternatively to interviews with people involved in practical cases, in order to to identify the attributes of interest.

There is the question of whether the context analyst's judgement or the opinions of the paper authors should be used to allocate papers to factor classes and gradings. This may depend on the factor. In the case of authors' affiliations and nationalities, we would tend to rely on the authors but for factors such as **research quality** this is less obviously the correct procedure. It is a useful first step to find out whether authors and reviewers agree on allocations, as we did with our questionnaire.

More information concerning authors and their papers could usefully be published in papers. *IEEE Engineering Management Review* publishes the text of papers from other journals but omits author addresses, which necessitates finding the original paper. In other journals addresses are often incomplete or ambiguous.

If further use of Context Analysis showed that standard context factors applicable to all fields emerged, then it would be possible for publishers to ask for a simple questionnaire about the paper context to be filled in as part of the publishing procedure, and to make the data available with the paper.

Commercial databases of publications are set up to search recognised fields, while our field was nominated from outside the research system. It might be that there is a structural reason why this type of problem will inevitably arise, or that it is a cost of the science free market, but it would interest us to know, and this could be investigated.

E. What Context Analysis could be useful for

Context analysis could be used to inform both funders and researchers of the nature of work in a field, and help to form their strategies. The information gained about the distribution of research publications and centres in a particular subset of R&D Management has been of great value in helping the R&D Management Centre to decide on its policies for research and teaching.

The research community is dispersed and uncontrolled, except in so far as most research requires a funder to be persuaded. This form of overview of a research field might help in the comparison of different research fields competing for funds, and would add to methods such as meta-analysis and foresight, which are already known.

We were surprised how few of the publications reported research results as opposed to opinion and review. This may be a feature of our particular field, and it would be interesting to see what proportions of the literature are given to these two classes of publication in other fields. Similarly, it would be interesting to compare **formality of research** for different fields.

Research funders might find it useful to quantify the degree to which the literature applies to perceived practical problems. In our case the practical problems were defined by the opinion of just one practitioner, and it would be better to define them by a research study aimed at defining factors for context analysis of publications.

Most papers did not seem to us to adequately report the research carried out, and merely gave edited summaries of results with little or no reference to the basis of the information. The great expansion of research over the years is easily quantified in terms of funding and numbers of publications. We suggest that it would also be possible to appraise in some ways the standards of output of a body of research, and assess its state of development as a science.

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