Scientists in laboratories: a comparative study on the organisation of science and goal orientations of scientists in CSIRO (Australia) and CSIR (India) institutions

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CHAPTER 5: METHODOLOGY

5.1 Introduction:

This thesis has been designed as a theoretical and empirical exploration of the organisation of science and the way in which the action of scientists and their research activity are structured in the two laboratories - namely the CFTRI/CSIR and the FRL/CSIRO. The two case studies on these laboratories in Chapters 6 and 7, and the empirical research on the action of scientists in Chapter 8, which follow, have been developed as a way of empirically "grounding" the theoretical framework developed in the preceding Chapters. Although the overall strategy of exploration in this thesis is somewhat akin to what a "scientist" might do (i.e., drawing assumptions from the existing theory and individual perceptions about the "reality" - construction of concepts and a theoretical framework - drawing hypotheses - conducting experiments - drawing conclusions to substantiate the theoretical framework....), a great deal of the research material contained in this thesis deals with interpretations of meaning rather than singular, external, objective and evidential imposition of meaning, as is reflected in the classical "scientist" process outlined above. In Mannheim's terms, my interest in the exploration of the social reality of scientists in laboratories has been pursued not only from the point of "objective" level of meaning, but also from the "expressive" or "subjective" and "evidential" levels of the meaning context of scientist's action. That is, in following Weber and Schutz the "interpretive" understanding of the scientist's action in terms of the "subjective" meaning is held to be important as much as the sociological reconstructions and constructions derived from the historical analysis and external observation. What is also constitutive of this consideration is an important methodological implication which suggests that any exploration of a social reality should take into account the social context within which the action is enacted.
Such an attempt to explore the social reality of scientific research by looking the actors in their social context is an approach that, in varying methodological forms, has characterised much of the post-Mertonian tradition in the sociology of science - including the recent approaches to "laboratory studies" that have conducted over the last decade.

As pointed out earlier, particularly from Mannheim, not one, but several levels of meaning are involved in the constitution of social action and its context dependency. To be able to tap objective, evidential and expressive meanings, therefore structures both methodology and theory construction - for the two must align in an analysis of the meanings context for action: that is, meanings cannot be imposed by the investigator - as has tended to be the case in studies that assume "normative" behaviour; instead, meanings must be derived from both the scientist's own experience, objective and evidential constructions that relate to their own location of action in social context; and, the scientist's own constructions need to be balanced against the investigator's evidential constructions, derived not only from external empirical test, but also from participation with scientists in the mode of Weber's verstehen or interpretive understanding.

The basic implication for the construction of theory, and of proposition to be tested in research, has been followed through in that initial hypotheses were taken as tentative, to be refashioned and focused as a wider range of evidence emerged; the hypotheses were themselves tested against interpretation of social context and meaning of action by the scientists (interview), but the expressive meanings attributed by scientists both to themselves and social context were tested against objective measures (factor analysis of underlying orientations; actual productivity indicators, etc.), and against evidential interpretation of ranges of evidence about social context (for example, derived from detailed analysis of historic evidence and direct laboratory observation). Thus, whilst the general theoretical frame for this thesis was developed
prior to the commencement of field research (from theory, previous research experience and preliminary analysis of data), what was also developed was a methodology that would not test hypotheses as fixed, but allow specific hypotheses to emerge during the course of the study. The final (relative to the present Ph.D project) specific hypotheses are presented in Section 7.6 (Table 7.7); the methodological frame, which I have formed "method of multiple feedback", is described later in this chapter.

The literature was only a partial guide to developing such an iterative, interpretive methodology that also integrated an analysis of history and cultural influences into an assessment of social context. When the field research for this thesis commenced in February 1983, the empirical and methodological approaches that were current in the literature directed my research interests towards a more cognitively oriented sociology of science. The main concern of the "laboratory studies" presented in recent years was basically the cognitive content of scientific "fact" construction and de-construction. Although the main agenda of a cognitively oriented sociology of science (in recent years this area is in fact distinguished as sociology of scientific knowledge) in many ways has emerged as a response to the "normative" perspectives in the sociology of science (neo-Mertonian and neo-Kuhnian), it had its own limitations. This concerns the relative absence of any practical guidelines for a cross-cultural and historically based study of scientists and their research activity in laboratories. For example, the rejection of the internal/external, social/cognitive dichotomy (by the micro level laboratory studies) in the analysis of science as a reaction to the "internalistic" traditions in the sociology of science did not result in any fruitful suggestions for the micro-macro interface in the context of laboratory based studies. Knorr's [1981] work may be regarded as a possible exception to this. However, there was no great deal of methodological literature to locate the scientist's action and their research activity between the laboratory's structures (organisational)
and the scientific community, laboratory's historical context, national policies and socio-cultural systems. Whereas Whitley's [1972], Law [1974] and Law and French [1974] formed an initial basis for the "interpretive" perspective, Hill's [1974] detailed study on Thai Research Institutes demonstrated the way in which the "interpretive" perspective can be combined with an historical analysis.

The latter study provided a guide for what became the "method of multiple feedback" as did some elements of the interpretive approach of "repeated feedback" used by Jagtenberg [1983]. The research techniques that were encompassed included quantitative, qualitative methods and historic analysis.

Sources consulted within the historic analysis are presented in Chapters 6 and 7 where the social and historic contexts of the case studies are outlined. In keeping with an interpretive account, histories were constructed from original documents that were external to the two laboratories - Review Committee Reports, Prime Minister speeches, and so on; from original documents that were internal to the laboratory - Annual Reports, publication records, statements of procedures, etc; from secondary interpretive accounts of India and Australia science histories; and from information obtained in interviews within laboratories. In other words, "official" views were tested, and sources that provided objective, evidential, and expressive accounts of history were balanced.

Quantitative and qualitative methods were equally balanced in the development of an interpretive account of scientist - actors within their social context. An overview of these methods is presented shortly, whilst the detail of their application is reserved for presentation along with the findings, in Chapter 8. Before moving on to this overview and also an explication of the way the different tests were combined under the "multiple feedback" method, it is necessary first however to identify how the laboratory studies were framed - in terms of selection of laboratories, the general conduct of the studies, the selection of respondents and research projects
to be studied, the framing of assessment of research productivity and the general structure of interviews.

5.2 The process of selection of the laboratories for case studies

The Ph.D. project commenced in May 1982 with a broad goal of making a comparison between scientists across national and cultural contexts in the CSIRO and CSIR. At this time, a major problem was to identify a laboratory each from these larger science establishments to provide a specific focus for the empirical research of this thesis. Having originated from the same British model of DSIR, although the CSIR and CSIRO shared many similarities in terms of their broad structure, function and management of research providing a context for comparison, the first task was to establish some such similar basis for the selection of case studies. Towards this end, the following selection criteria were applied:

- Laboratories with similar broad mission in scientific and technological research;
- Laboratories working in more or less similar science disciplines and sub-disciplines; and
- Similar structural relation between the laboratory and its larger organisational (CSIR or CSIRO) context.

Applying the above criteria the choice to select laboratories was indeed quite wide because at least ten laboratories in each science agency could meet the above conditions. However, the choice had to be narrowed down to select one each from the CSIR and the CSIRO. The subjective conditions that determined the selection of CFTRI, Mysore, India and the FRL, Sydney, Australia were as follows:
- Firstly, my own academic background with a degree in science, which involved physics and chemistry as the main subjects of study provided the basic ability to understand the biological and physical aspects of food research. (The mission of CFTRI and FRL is to carry out research on food for the primary and the secondary industry and the needs of the community in their respective national contexts).

- Secondly, during 1978 and 1980 I was involved in a project on technology transfer: case studies on food research projects in the CFTRI for two years. [see Qureshi et al, 1984]. Working on this project I gained a working knowledge about food science and technology and a network of contacts with scientists.

- Thirdly, while the CFTRI's location was only accessible through a field trip from the Wollongong University, the FRL at Sydney was within a commutable distance from Wollongong.

- Lastly, the Director, CFTRI and the Chief, FRL readily agreed to the idea of my carrying out field research in these laboratories.

5.3 Specific methodological details concerning the empirical research on two case studies.

The empirical material used in the two case studies was collected over a period of two and a half years starting at the end of 1982. The field research on the FRL/CSIRO involved 18 months and the field research on the CFTRI/CSIR involved 12 months. The Australian case required a larger input in terms of time because it was a "new" experience compared to the Indian case. I had to learn more about the
FRL/CSIRO than the Indian counterpart. The Indian case was quite familiar to me because of my own research experience in the National Institute for Science, Technology and Development Studies, (CSIR), New Delhi, for about 10 years. My involvement in the UNESCO's Indian team on the ICSOPRU study (1977 to 1979) covering CSIR laboratories and my involvements with CFTRI, referred to earlier, provided me with a substantial background to the research activities of CFTRI/CSIR.

During the field research in the FRL, the laboratory provided me with an office (for 6 months) located in the "food technology" building where the Applied Food Science Group was housed. I utilised this period for regular face to face interaction with the FRL scientists and scientific assistants during the administering of and the collection of the interview schedule, personal interview sessions, small technical excursions into the research work being conducted by the scientists etc. All the interviews held with the researchers at the FRL were tape recorded. The strategy to develop initial rapport with the researchers was that the interview schedule was administered to the respondent sample first and the initial confrontation with a respondent put me in personal contact. To enable the researchers to fill in the long questionnaire, I allowed them to "sit" on the questionnaire for 4 to 5 days with a suggestion that I would come back to collect it and explain the doubts, if any, confronted by the respondents in answering the questionnaire. More often than not the doubts emerged and my "in between" encounters with respondents, before the collection of questionnaire, provided an additional opportunity to develop a rapport and make a request for an interview date and time. This method worked out well. After spending a couple of months in the laboratory my face became quite familiar to the researchers. During the lunch and tea sessions in the canteen some scientists expressed their "Aussie" humour commenting "when do I have a 'date' with you" or "I suppose my 'dating' is over".

While a few interview sessions with the scientists were carried out after
making some preliminary analysis of the questionnaires, the majority of the interview
sessions took place over a period of 5 months after the collection of data through the
questionnaire. After 6 months of regular full-time visits to the laboratory (3 to 4 days
in a week) the field research required only occasional visits for the rest of the period
because I could get the data by telephone requests and even interact with scientists
through telephone from Wollongong.

In the case of CFTRI, I was housed in Planning Division with an office. As pointed out earlier, CFTRI was not a new experience for me and I had wide personal network of contacts with the researchers. As in the case of FRL, the interview schedule was administered, and then followed by interview sessions. But unlike the FRL researchers, CFTRI scientists and scientific assistants did not agree for a tape recorded interviews. However, notes were maintained about the discussions held with the researchers. The notes of the discussion with scientists were made after the interview because I noticed some inhibitions from the scientists when the points were being noted in the face to face level of interaction. The major part of the interview sessions in the case of FRL were directed towards the research projects because there were no formal project statements or proposals. In the case of CFTRI, all ongoing projects in the sample considered for empirical research had formal proposal statements, ongoing progress reports and concluding remarks (for completed projects only). Thus a major part of the interview sessions were utilised for understanding the laboratory 'culture' and validity checks of the information contained in the project statements. I had access to all the project statements/proposals etc. written by scientists because of my contacts both in the CFTRI and the CSIR Head Quarters, New Delhi. Language was an important link for the continued rapport with CFTRI scientists. Besides English, the south Indian based Tamil, Kannada and Telugu were the languages generally used in the every day interactions between scientists and scientific assistants. Being a South Indian, (CFTRI is located in a
South Indian city - Mysore), I was fairly conversant with all the languages including English, and this played an important part in drawing me closer to my respondents.

As pointed out at the end of the introduction, the empirical research in this thesis (Chapter 8) employed different statistical methods. The basic framework of methodological approaches as they relate to the selection of the population sample, the research projects, measurement of research productivity, and the conduct of interviews, are presented here. The details of statistical techniques of analysis employed in survey analysis is reserved for Chapter 8, where the results are presented.

(i) About the selection of scientists, scientific assistants and the research groups included in the empirical research:

After the selection of laboratories for comparative study was made, the next task was to identify the research groups in both the laboratories for empirical research. CFTRI is a larger laboratory than FRL both in terms of personnel and research groups. Both the laboratories were mainly concerned with all aspects of plant based food research, particularly the post-harvest research. In order to establish some sort of a comparative basis (in terms of broad research groups and scientific disciplines/sub-disciplines) between the CFTRI and the FRL, all research groups or scientific divisions were considered as the universe except those concerned with meat, fish and poultry; infestation control and pesticides and flour milling and baking (see Figure 5.1). In the case of FRL all groups were included in the study. The universe considered for the study included the following research groups and corresponding scientific disciplines/sub-disciplines.
<table>
<thead>
<tr>
<th>CFTRI Research Groups/Division</th>
<th>Disciplines/ Sub-Disciplines</th>
<th>FRL Research Groups/Divisions</th>
<th>Disciplines/ Sub-Disciplines</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Lipid Division</td>
<td>Lipid research organic chemistry food technology</td>
<td>2. Nutritional Quality and Safety of food Group</td>
<td>Biochemistry Microbiology Bacterial spores Molecular biology</td>
</tr>
</tbody>
</table>
7. Protein Res. Div. | Physical chemistry  
| Protein chemistry  
| Biochemistry  
| Food technology  
| Plant biochemistry  
| Oil seed proteins  
| Protein research  

8. Sensory Evaluation Division | Statistics  
| Sensory evaluation  
| Social psychology  

9. Rice and Pulse Division | Applied Botany  
| Agriculture chemistry  
| Rice and Pulse Technol.  
| Plant physiology  

10. Fruit and Vegetable Division | Biochemistry  
| Plant pathology  
| Plant physiology  
| Microbiology
At the time of field research in the FRL there were 42 scientists, 38 experimental officers and 59 technical support staff involved in broad research groups as shown in the Table 5.1. The actual sample drawn for the empirical research (Questionnaire) included scientists (80%), experimental officers (82%) making a total of 85% of the total population. The technical support staff was not considered for the study because most of them were involved in assisting the scientists without any interests in research directions as such.

In the case of CFTRI there were a total of 145 scientists, 219 scientific assistants and 200 technical assistants involved in the broad research division as shown in the Table 5.1 at the time of the study. The total population considered for the study included 110 scientists, 55 scientific assistants and 45 technical assistants. The reasons for the exclusion of other personnel are as follows:

**Scientists:** Out of 35 scientists not included in the study, 23 scientists were involved in the research division not considered for the study for the reasons pointed out earlier. 12 scientists were not included because they were designated as 'scientists' but in actual practice they were not involved in research *per se*.

**Scientific Assistants:** 164 scientific assistants were not included in the study because about 15% were involved in the research groups excluded from the study. The rest 85% were at the bottom end of the scientific assistant hierarchy (4 levels), who were mainly involved in washing test tubes, glasses, beakers and the maintenance of the technical equipment.

**Technical Assistants:** 155 technical assistants were not included in the study for the same reasons as given above, except that few of them were involved in the workshop activities and pilot plant maintenance.
The sample drawn from the total population for the study included scientists (80%), scientific and technical assistants (30%), making a total of 56%. This sample was drawn from the broad research divisions as shown in the Table 5.1.

(ii) About the research projects: At the time of the field research in the FRL and the CFTRI, there were 91 and 69 projects respectively. 75% of the research projects from the FRL and 88% of CFTRI's projects were included in the study. (see Section 8.6 and also the Appendix for the list of projects). These projects were drawn from the respective research groups/divisions as shown in Table 5.1.

(iii) About the research productivity: The empirical research on the goal orientations of scientists towards various types of the research productivity in the CFTRI and the FRL is based on the data obtained from two sources. The first is the attitudinal content of the goal orientations of scientists drawn through the questionnaire responses. The second source is the data on the actual research productivity as contained in the annual reports of the laboratories. The type of research productivity in both the laboratories were measured in terms of paper publications, report, process, product, patent to minor items such as blue-prints, drawings and designs, prototype equipment etc. All these items were included in the analysis. These items are drawn from the total population of scientists, scientific assistants and experimental officers considered for the study and who were involved in the research groups are shown in Table 5.1. The analysis made on the various aspects of research productivity in the CFTRI and the FRL (see Section 8.6.1) does not necessarily correspond to the analysis made on the research projects (see Section 8.6). This is so because most of the projects included in the analysis in the FRL and the CFTRI were ongoing projects or began during the field research or just concluded during the field research. It would have been an 'ideal' analysis to relate the results of productivity of scientists to all of the research
projects worked on by them in the laboratories. However, given the time constraints in a Ph.D. project, I have opted to relate the analysis of research projects to the productivity of scientists in the FRL and the CFTRI in the immediate history (that is, in the three years prior to 1983). It may however, be pointed out that it is difficult to reach the 'ideal' situation in a broad based study such as this thesis, because some of the projects in the FRL were at least 10 to 12 years old.

(iv) About the interviews: The field research at the FRL involved 35 interview sessions (28 with the scientists and 7 with the experimental officers). As pointed out earlier, all the interviews were tape recorded and on an average, each interview session with a scientist lasted for one and a half hours. In the case of CFTRI 42 interview sessions (23 with the scientists and 19 with the scientific and technical assistants) were conducted between January 1984 and July 1984. Unlike the Australian case, most of the interview/discussion material were prepared as notes after the interviews. Due to the perceived threat from the management, the respondents did not agree to give tape recorded interviews. This, of itself, is interesting data on the relative salience of more senior approval for scientist action between the two institutions. Most of the interviews from the CFTRI was possible because of my personal network of contacts with the respondents.

All the interviews conducted in the CFTRI and the FRL were of an open-ended form. Some energy was expended during the interview sessions in both the laboratories to use validity checks on the data collected through the published and documented sources. This approach was directly in keeping with the "multiple feedback" approach, which I proposed earlier, was an appropriate "interpretationist" frame for the thesis methodology. However, the interviews were basically directed to enlarge my understanding about the goals of research projects (particularly in the FRL), the research "cultures" in the laboratories and the way in which the laboratory's
organisational mechanisms mediated the influences routed through professional orientational and social reference groups.

In the case of CFTRI, the laboratory based committee system and the socio-cultural influences from the "neighbourhood" played an important part in the laboratory life of scientists. Thus, much of the discussion in the interviews was directed to an understanding of the significance of these factors. The role of science planning mechanism and the significance of it in the direction of research work was no 'secret' in the laboratory. Information on this score was easily available and therefore this aspect played a low key in the interview discussions.

In the case of FRL, the initial interview sessions conducted with the Applied Food Science Group indicated that the reward system played an important part in the laboratory's mediations on the research work of scientists. Together with the information on the research projects, the nature and impact of laboratory mediations on the research work of scientists was the main aspect in the interview discussions held with the respondents in the FRL.

In both the laboratories the open-ended interview procedure generated a bulk of interview material. A lot of information was diffused in character, though not unrelated to the main issues under the concern. Abstracts and summaries of interview data are used in the text of the thesis. Because of both the massive volume of interviews transcripts as well as a desire to preserve confidentiality, the raw interview data is not included in this thesis.
5.4 The method of multiple feedback

The empirical research in this thesis was carried out by the generation of knowledge at different levels of generality through the application of more than two methods. To make a comparison between the CFTRI/CSIR and the FRI/CSIRO, the research concerns were rather broad based - investigating, as they, the organisation of science, the scientists' action in their meaning context, the research activity of scientists and the way in which the laboratory's organisational mechanisms mediated the influences emanating from various groups and agencies. The research concerns entailed the use of different methods. The way in which the empirical research analysis progressed was through the application of different methods to exploit the data base at different levels in the laboratory context. In this process, the information generated at one level was useful as a feeder to the analysis at the succeeding level. However, it was also possible to draw out the information to make generalisations about the social phenomenon at a specific level. At the beginning of the field research there were no preconceived notions about the efficiency of such a 'system', because there were no assurances either from the FRL or from the CFTRI sources that it would be feasible to collect the required data on various facets of scientists' activity. The only guiding principle for the empirical research was that it should involve the generation of knowledge at different levels of understanding the scientists' action.

Once the two laboratories were selected for a comparative study in CSIRO and CSIR, initial attention was directed towards understanding the nature and function of scientists in the laboratories, within their socio-historical framework. This formed an important basis to an understanding of the historic traditions in research 'culture' that governed the research activities of scientists, the nature of science and politics in the context of science agencies and the interface between the "neighbourhood" and the research institutions. On the basis of this understanding it
was possible to construct a questionnaire to explore the way in which scientists related themselves to the organisational (laboratory's) context and its formal objectives, the orientations of scientists towards the application of research and the advancement of scientific knowledge etc. (see Appendix 4 for the questionnaire used in the empirical survey). However, the literature on the orientations of scientists in laboratories and science institutions, particularly, the literature on cosmopolitan/local dimensions formed the basis as an additional input into the questionnaire construction. As pointed out earlier, the field research commenced in the FRL/CSIRO.

Being conscious of the narrow base in grounding the study completely on the verbal statements that formed the basis for questionnaire analysis (which in the ultimate analysis reveal the orientations of scientists and their activity underlying the action but not the product of action or its meaning context), it was considered that other evidence needed to be reviewed in order to further validate the questionnaire analysis as well as understand the meaning context of scientist's action. The methodological issue that directed my attention was the discrepancy, if any, between what scientists say they do and what they actually do in the laboratory context. Further, information on this issue was derived from comparing scientist statements to the actual products of their action. what was also important at this stage was an understanding of the negotiation practices of scientists in laboratories. However, these issues did not fully emerge until the preliminary analysis was made of the questionnaire responses and the initial interview sessions conducted with the Applied Food Science Group at the FRL. [The selection of applied food scientists for initial interviews was an accidental product of the fact that I was given an office in the midst of a building where Applied Food Science Group was housed].

The outcome of these initial efforts was a surprise in that the applied food scientists indicated a relatively stronger emphasis on basic research and the achievement of international scientific separation than the questionnaire based
information suggested. The interview discussions revealed that the applied food scientists were negotiating towards the promotion of basic research and were making strong efforts to get their papers published in the specialised science journals. The meaning behind the strong emphasis given to the basic research and science reputation was however not unrelated to the historic traditions of CSIRO 'culture' of promoting scientific excellence in research.

The preliminary field research directed my attention towards generating as much data as possible about the orientations of scientists, negotiation practices extant in the laboratory, goal orientations of research projects and the 'typical' emphasis given on research projects by the core members, and the nature of research productivity. The overall experience gained in the early field research for the collection of data was applied fruitfully in the case of CFTRI.

According to the principle of multiple feedback, the research methodology evolved during the course of the study. The result was that following the initial research phase, the content of interview was both broadened and focused according to what had been learnt; and also, the attention of the investigator was focused on issues that had become significant in the earlier experience. Counter to this however, the questionnaire base remained consistent across the entire study. And, where further questions were raised in subsequent interview experience, they were able to be checked again with groups that formed the initial survey population. The circumstances of initiating research in Australia, and returning after the field trip to India, allowed this level of consistency to be maintained in the comparison, whilst still utilising the interpretative method of multiple feedback to allow the investigator to learn during the course of the research experience. The underpinning of the method of multiple feedback can be represented in the following Figure 5.1.
As we can see from the figure, the generation of empirical knowledge in this thesis is carried out by the method of multiple feedback, where different sources of data base were exploited by the application of different methods - both over time, and at the same time. The method of multiple feedback represents the empirical research conducted at different levels of generality and meaning contexts. For example, the level I represents the historical level of understanding, the level II represents the subjective and objective perceptions held by the scientists, the levels III and IIIa represent the level where the laboratory's organisational 'culture' and negotiation practices are understood, level IV represents the situation where the cumulative impact of the previous levels is observed and the level V is somewhat similar to the IV. It may be pointed out that level V represents only the "objective" meaning of research from "outsider's" point of view (or viewed separately), but is constitutive of different levels of meaning in Mannheim's sense when we relate it to the other levels in the figure. The way in which the method of multiple feedback has been useful in this thesis is threefold:

(a) To establish a basis for empirically exploring the action and meaning constructions of scientists in laboratories through a multi-based data sources and methods for its analysis at different levels of generality.

(b) Both as an information feeder to the analysis at different levels and as a source of knowledge at a specific level of understanding.

(c) As a validation measurement to the overall analysis and particularly between the level II and the rest of the levels.

The overall empirical research in this thesis, in the light of the method of
multiple feedback is as follows. The two case studies, which follow, on the CFTRI/CSIR and the FRC/CSIRO are based on the sociological constructions from the historical analysis (I in the figure). The questionnaire analysis on the goal orientations of scientists is based on the statistical methods of factor analysis and one-way analysis of variance, (ANOVA, II in the figure), [which implies an appropriate test of orientation, that lie as an ordering principle in consciousness behind the varieties of 'overt' statements]. The interview data, as referred to earlier, is based on the qualitative analysis (III and IIIa in the figure). The analysis of the data on research projects is based on a balancing of qualitative analysis - based on information supplied by the scientists, against published reports (IV in the figure). The analysis on the research productivity (paper publications) is based on the qualitative assessment made by external judges both in India and Australia of the status and intentions of journals in which the scientists published. The analysis of research productivity (Prices/product/patent/reports etc.) is based on the quantitative assessment using appropriate weight measures (V in the figure).

As demonstrated in the principle of multiple feedback on Third level in Figure 5.1, there is room for expansion to any number of additional data bases, as interpretation of findings is based on their synthesis rather than separate tests. However, further extension of the data base was not practicable within the time-frame of the study; and validity confirmation was possible with the range of data reviewed: that is, triangulation across different modes of data (with their implicit separate epistemological assumptions) was possible. As an approach that seeks overall synthesis, the method of multiple feedback allowed the feeding of data both forward and backwards, as the evidential meaning of the whole social context picture was emerging.
5.4.1 The theoretical basis to the method of multiple feedback

The general rationale, within an interpretive research approach, for multiple feedback analysis was presented earlier. It is however worth exploring a little further, the sources of this overall research frame for the thesis.

The method of multiple feedback described in the previous section was based on a recognition that the scientist - actor is relating to their social context according to a range of levels of meaning - as explicated by Mannheim. (see Section 2.4). As pointed out in the introduction to this Chapter the method of multiple feedback was a result of an effort to combine the "interpretive" perspective within an historical analysis as a way of developing an understanding of scientist's action in the laboratories. Whitley [1972]; Mulkay [1979]; Law [1974]; and Law and French [1974] in their own ways have drawn substantial attention to the processes of negotiation in the interaction between the actor and his/her institutional context. But, the most comprehensive treatment of the subject in the context of laboratories is given by Hill [1977]; Law [1974], and Law and French [1974] that formed the basis for the empirical research in the CFTRI/CSIR and the FRL/CSIRO. Law, and Law and French's work opened up a number of practical suggestions and arguments to overcome the 'normative', and 'internalistic' explorations in the analysis of science, particularly, the analysis of scientist's action in its institutional context. Although the specific suggestions on the negotiation practices of scientist's in laboratories was indeed a very useful guide in my own empirical research, Law, and Law and French's work did not make specific suggestions to the way in which the historical traditions of the laboratories and the transactions between the research institutions and its social, political environment influence the action of scientists in the laboratories. In this respect, Hill's [1977] detailed study on the Thai Research Centre (see Section 4.4),
which advanced Law, and Law and French's 'interpretive' perspective in the context of laboratories formed an important basis to the empirical research in this thesis. In brief, Hill's study raised questions such as 'how did the laboratory culture and history surrounding the research institutions influence the various meanings of research activity?' Further, Hill's study also raised questions about the taken-for-granted meanings of research as appear in the formal organisational structures and their relation to what actually goes on 'inside' the research institutions. Together with Hill's work, Anderson's [1975, 1981] research on Indian laboratories (see Section 4.4) formed an important basis at the time of my field research.

Towards the articulation of the method of multiple feedback, I was inspired by Hill's [1970] methodological 'excursion' into "Swimming with Sharks: Techniques of a Multimethod Approach to Concept Validation", and Jagtenberg's [1983] "method of repeated feedback" used in his recent research in the comparison of two Australian research groups. However, there are notable differences between my own method and the methods employed by the above authors. Hill's method - as presented in Hill [1970] was largely based on a 'participant-as-observer' approach, which required the investigator to suspend full notification of his final motives, in order to relate the underlying dimensions of specific behaviour patterns of industrial research groups to their group structure without observation being distorted by subject's non-naivety. The other methods employed by Hill were questionnarie and interview. In the case of Jagtenberg's, "method of repeated feedback", the feedback loop between the questionaire/interview analysis and respondents was continuous until the investigator was satisfied with the mediated synthesis of information.

In my own case, the research strategy required taking a middle approach between these two positions. The investigator's status was more that of observer-than-participant then participant-as-observer. [see Gold, 1958]. That is, the intention of the observer was transparent to subjects, but observation of daily practices
was still preserved. The Jagtenberg approach of continuing feedback was impractical given: (a) that the scope of the present study included many more subjects than the micro-level analysis by Jagtenberg's study required; and, (b) the case study approach across the two institutions needed to be broadly similar, and one case study being at a remote location from the investigator's base in Wollongong, that is in India, meant that continuous feedback in the Jagtenberg's mode was impossible for the present study. However, limited direct feedback was possible, while the heuristic development of theory (and its reflection against scientist's own interpretation of meaning) was pursued progressively throughout the research study. With its emphasis on synthesis and triangulation of findings, the method adopted in the present thesis allows considerable confidence to be attributed to the final findings. As in all good research, the methods and methodology epistemologically aligned with the (interpretive) approach of the theory being tested.

Before concluding this methodology chapter, one final task is yet to be achieved, and this is an outline of the basic concepts that underlay the operationalisation of the central quantitative indicators employed in the study. I will turn to this issue now.

Other indicators:

In the empirical research I have used other indicators as operationalisation of sociological concepts such as professional orientational reference groups, social reference groups and neighbourhood-effect. I have described these concepts in the theory Chapter 4 and their use in the data analysis presented in Chapter 8 is related to the meaning context of scientist's action in the CFTRI/CSIR and the FRL/CSIRO.
5.5 Indicators used in the construction of the questionnaire and in the description of the goal orientations of scientists.

The exploration of the goal orientations of scientists and scientific assistants in the CFTRI and the FRL was carried out by a closed-ended questionnaire. At the centre of the research, as the key dependent variable, stands the measurement of goal orientations of scientists. The questionnaire presented a series of statements relevant to goal orientations for graded agreement/disagreement or utmost important/not important at all - response by the scientists (including scientific assistants) surveyed. The statements were derived from a variety of sources (as outlined in Table 5.2) - including the literature, readings on the institution surveyed, and prior research experience of the investigator. What should be particularly noted however is that the development of "orientations to action" did not refer only to what scientists presented in verbal behaviour. The concept of orientation is basically that of a 'structure of relevance', that is, an underlying ordering principle in consciousness. Therefore the mode of analysis employed was not one of frequency counting of separate verbal responses, but one which employed factor analysis to identify the underlying factors (or structures of relevance) that made sense of the way the separate verbal statements held together. This approach was drawn from that used by Hill, Fensham and Howden [1974:64] in their analysis of the underlying orientations of 1000 Australian scientists and Ph.D science students. As a result of applying this approach in the present study, it was possible to derive the collective orientations of a range of separate (and combined) groups of subjects both within and across the two laboratory contexts.
TABLE 5.2

Indicators relevant to the goal orientations of scientists incorporated in the questionnaire

<table>
<thead>
<tr>
<th>Broad indicator or dimension</th>
<th>Variables as sub-indicators</th>
<th>Source from where the items are drawn.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Social, practical and commercial relevance of research</td>
<td>- results of research scaled-up for commercial utilization</td>
<td>Previous experience from CFTRI/CSIR and as a part of UNESCO's ICSOPRU study.</td>
</tr>
<tr>
<td></td>
<td>- work on problems which yield practical results</td>
<td>Adapted from Pelz and Andrews [1966:93].</td>
</tr>
<tr>
<td></td>
<td>- prefer to work on a process/product/patent/report for industry vs. journal publication.</td>
<td>Previous experience from CFTRI/CSIR and as a part of UNESCO's ICSOPRU study.</td>
</tr>
<tr>
<td></td>
<td>- to make proper use of my professional knowledge</td>
<td>Adapted from Pelz and Andrews [1966:93].</td>
</tr>
<tr>
<td></td>
<td>- to see results of my research in laboratory's process/product/report.</td>
<td>Previous experience from CFTRI/CSIR and as a part of UNESCO's ICSOPRU study.</td>
</tr>
<tr>
<td></td>
<td>- to work on problems of social relevance.</td>
<td>CSIRO history as per (I)</td>
</tr>
<tr>
<td>II</td>
<td>- pursuing basic research</td>
<td>CSIRO history, Rivett [1972]</td>
</tr>
<tr>
<td>Professional, scientific orientation</td>
<td>- recognition from scientist colleagues outside the laboratory</td>
<td>Goldberg et al [1965]</td>
</tr>
<tr>
<td></td>
<td>- publishing in specialised science journals.</td>
<td>Box &amp; Cotgrove [1966]</td>
</tr>
<tr>
<td></td>
<td>- present research in seminars/professional meetings.</td>
<td>Hill et al [1974]</td>
</tr>
<tr>
<td></td>
<td>- freedom and autonomy in research from own ideas</td>
<td>Adapted from Pelz and Andrews [Ibid]</td>
</tr>
<tr>
<td></td>
<td>- to make proper use of professional knowledge.</td>
<td>CSIRO history as per (I)</td>
</tr>
<tr>
<td></td>
<td>- to build professional reputation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- freedom on day to day research</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- journal publication vs. process/product/patent.</td>
<td></td>
</tr>
</tbody>
</table>
III Organisational orientation
- to advance career in the organisation
- to seek membership in professional bodies
- to seek membership in journal-editorial committees
- to seek membership in laboratory committees
- to seek membership in industry oriented based committees
- to seek membership in professional-scientific orientation

IV Committee orientation (professional-scientific)
- to seek membership in professional bodies
- to work on problems relevant to laboratory objectives.
- to be respected among colleagues in the long run.

V Committee orientation (laboratory and industry)
- to seek membership in important laboratory committees
- to be respected among colleagues in the long run.
- to seek membership in journal-editorial committees
- to work on problems relevant to laboratory objectives.

VI Laboratory based constraints in research
- on research projects
- on publications/presentation of papers in seminars
- on patenting
- on commercial objectives in research/socio/economic objectives.

VII Paternalistic orientation
- institution should have responsibility for housing
- ....... for health care
- ....... for social welfare measures
- senior scientific and technical staff should be respected because of older age.

Adapted from Barth & Vertinsky [1975:121]
Pelz and Andrews [op.cit.]
Box and Cotgrove [op.cit.]

Lincoln et al [1981:99]

Note: sources do not necessarily refer to the individual sub-indicators but to the broad corresponding indicator.
5.6 Summary of the organisation of field research and techniques used

The progression of field research on the basis of the material presented in this chapter may be summarised as follows:

1. Two science agencies namely CSIR, India and CSIRO, Australia were identified for carrying out a comparative study on scientists in laboratories by selecting two laboratories from these larger institutions.

2. The selection of CFTRI (CSIR) and FRL (CSIRO) was made by applying some objective and subjective conditions that ensured the institutions were the most appropriate tests of the theory presented earlier concerning historic and cultural influences on research action and meaning.

3. Once a selection of the laboratories was made, efforts were directed towards understanding the structure and function of these laboratories, as a part of their respective larger institutions, in a social and historical framework.

4. On the basis of the social and historical contexts of the laboratories and in the light of the existing literature, a questionnaire was designed to explore the goal orientations of scientists.

5. The field research in the laboratories commenced first in the FRL with the administration of questionnaire to the scientists (and experimental
officers in the case of FRL, and scientific assistants in the case of CFTRI), and observation of laboratory practice.

6. Some preliminary interviews were held with the scientists at the FRL to examine the questionnaire responses (preliminary analysis).

7. The understanding gained through initial interviews and the questionnaire analysis formed the basis for the detailed exploration and the collection of data on the negotiation practices of scientists in the laboratory; 'typical' emphasis given by researchers on the ongoing research projects; nature of research productivity of scientists; and, the stream lining of the 'structure' in open-ended interviews.

8. The collection of the relevant data was made through the subsequent reformed questionnaires and interviews, from published sources, and from observation.

9. The field research experience gained in the FRL was applied in the research approach used within the CFTRI context for the collection of comparative data.

10. The analysis of the data collected from the CFTRI and the FRL involved the application of quantitative and qualitative techniques as follows:

<table>
<thead>
<tr>
<th>Data on/from</th>
<th>Analysis</th>
</tr>
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<tbody>
<tr>
<td>i) framework on the social and historical background of</td>
<td>historical analysis</td>
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</table>
researchers in the CFTRI/FRL

<p>| | |</p>
<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>ii)</td>
<td>questionnaire</td>
</tr>
<tr>
<td>iii)</td>
<td>interview data</td>
</tr>
<tr>
<td>iv)</td>
<td>research projects</td>
</tr>
<tr>
<td>v)</td>
<td>research productivity</td>
</tr>
</tbody>
</table>

11. The epistemological frame for analysis employed an interpretive approach to data collection, and paid attention to ascertaining the different levels of meaning that reside in any social action context - objective, evidential and expressive - within the form of analysis. The analytic approach which allowed this synthesis was that of "multiple feedback" an approach which permitted validation of conclusions through triangulation of a range of different orders of data.

Having now developed both the theoretical and methodological frame for the thesis - and seen that they are mutually commensurate at an epistemological level, the thesis can now move on to explore the research findings. The first task - as presented in Chapters 6 and 7, is analysis of the historic and social context of the two laboratories studied. The second task - as presented in Chapter 8, is comparative analysis the intra-laboratory findings.