Attitude to Collaboration With Industry: A Latent Class Typology of Academic Scientists in India

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There is a dearth of empirical studies on identifying barriers to initiating collaboration between the academia and the corporate world. This paper attempts to map the attitude of academic scientists towards cooperation with industry in the context of status of the academic scientist, field of specialization, and the type of institution where employed. The data were collected through a sample survey in which about 1100 scientists in twenty universities in India had participated. The population of a university was classified into four categories - periphery, center, semicentre, and semi periphery. Attitude to collaboration was tapped through six items - mission incompatibility, lack of challenge, constraint on academic freedom, lack of response, cultural incompatibility, and ethical incompatibility and measured on a 5-point Likert scale (1-strongly disagree to 5-strongly agree). Latent class analysis was used as a methodology of typological analysis for classifying the respondents into clusters based on similarities of their attitude to collaboration with industry. The distribution of contextual variables in the derived clusters was subsequently probed. The structure of multivariate relationships between the classification categories and the categories of the contextual variables was analyzed through multiple correspondence analysis to provide a synoptic view of the global structure of the data. The fine-grained structure of the relationships of typology categories and the categories of contextual variables was analyzed through a series of simple correspondence analysis. About 33 per cent of respondents constituted a group characterized by a positive orientation towards collaboration with industry and they came from applied science area. Only 13 per cent constituted a group characterized by the ivory tower attitude towards collaboration with industry while a large number of respondents (53 per cent) formed a group which appeared to be neutral to the collaboration with industry. The results have implications for the management of collaborative projects among the universities and industries.

1 Introduction

The literature on sociology of science has extensively discussed the chasm between the academia and the corporate world. First of all, there is a difference between the moral codes of these two types of organizations. The academic community operates under Mertonian norms of science, which may be antithetical to the norms of the corporate world. The specific characteristics of scientific ethos are often viewed as a major barrier to cooperation with industry. Scientific collaboration with industry can undermine the very foundation of ‘communalism’ of science. Communalism implies that the knowledge generated through scientific research is subject not to private, but to public ownership. This is contradictory to the norms of most corporate enterprises. They tend to regard their scientific and technological knowledge as proprietary. This leads to the dilemma between freedom of publication and secrecy of research findings. Secondly, the industrial and academic communities are embedded in different institutional environments, each of which has its own operating characteristics. Institutional norms and procedures inhibiting efficient collaboration may be present both in the academia and the corporate world. Industrial researchers tend to be more prone to the ‘not invented here syndrome’ than the academic researchers. How far these norms are relevant or valid today is an open question. It appears that the barriers between the two cultures of open scholarship and corporate secrecy have broken at least in the industrially advanced nations. The need for cooperation between industry and the academic institutions has been a subject of intense public debate. Studies have attempted to probe into the linkages
between research carried out in the universities and the possible application of such research work in industries leading to technological innovations. Nelson has found university research to be an important source of innovation in some industries, particularly those related to the biological sciences. Other empirical studies have shown that spillovers from university research influence the spatial distribution of research output, measured as patent applications. Though not specifically related to the university set-up, it is worthwhile to mention a study carried out in India by Chaudhury and Dixit who have observed that some of the emerging industries like biotechnology and software, and some of the mature industries like metallurgy and machinery have been deriving their technological competitiveness from useful interactions with R&D institutes.

In India, the need for stimulating cooperation between industry and academic institutions has been a subject of intense public debate. While everyone agrees that there is little collaboration between the academia and the corporate world, hardly any empirical study has been carried out to identify the barriers to collaboration. What are the origins of these barriers? Do they reside in the organizational milieu or in the mindset of the academic community?

The present paper attempts to map the attitude of academic scientists towards cooperation with industry. It also explores the effects of various contextual factors (viz. status of the academic scientist, field of specialization, and type of institution where employed) on this attitude.

2 Methodology

Data

This study is based on the subset of data collected for the project 'Assessment of Scientific Potential in Academia'. The data were collected through a sample survey in which about 1100 scientists in twenty universities (hereafter called institutions) in India had participated. The population of institutions was classified into four categories according to several criteria reflecting their research potential and prestige. Research potential was operationalized by several indicators like the number of publications and their citation impact, number of Ph.D.s awarded, ratio of the number of Professors to total faculty, etc. These four categories are listed below:

Category 1: Periphery (universities with poor research potential).

Category 2: Semicentre (universities with very good research potential).

Category 3: Centre (universities with outstanding research potential).

Category 4: Semiperiphery (universities with average research potential).

Attitude to collaboration was tapped through the following six items:

(i) Mission incompatibility: It is not the mission of the academic researcher to collaborate with industry.

(ii) Lack of challenge: Corporate sponsored research provides no challenge to the academic researcher.

(iii) Constraint on academic freedom: Collaboration with industry limits the free choice of research themes.

(iv) Lack of response: Industry is not interested in basic research.

(v) Cultural incompatibility: Industry and academia are incompatible in ways that make collaboration exceedingly difficult.

(vi) Ethical incompatibility: The need for secrecy in corporate sponsored research is incompatible with the academic tradition of open scholarly exchange.
All the items were measured on a 5-point Likert scale anchored at: 1-Strongly disagree, 2-Somewhat disagree, 3-Neither agree nor disagree, 4-Somewhat agree, 5-Strongly agree.

Analytical Schema

The following alternatives were considered for analyzing the effects of contextual variable on the attitude to collaboration with industry.

- Partitioning of the dataset into categories defined by the contextual variables and then examining the similarities and differences among the categories.
- A series of logistic regression analyses, one for each attitudinal variable, with contextual variable categories as predictors in the regression equations.
- Typological analysis: Classifying the respondents into clusters based on the similarities of their attitude to collaboration with industry and then looking at the distribution of contextual variables in the derived clusters.

The first approach based on the classification of respondents into categories defined by the contextual variables is no doubt important, but artificial. Moreover, the first and second approaches ignore the fact that underlying assumptions of classical statistical techniques of regression analysis and analysis of variance (ANOVA) are hardly satisfied by sociological data. Hence, the third approach has been adopted which is not constrained by the usual statistical assumptions of these techniques and allows the data to unfold for itself.

Statistical analysis was carried out in two stages:

- Construction of a typology by classifying the respondents on the basis of the similarities of their attitude to collaboration with industry, using Latent Class Analysis.
- Exploration of the relationships between typology groups and contextual variables, using Simple and Multiple Correspondence Analysis.

Broadly speaking, a set of objects can be classified into homogeneous groups through cluster analysis or factor analysis. However, there are several methodological problems in using classical cluster analysis. Firstly, one has to define a measure of similarity or distance among the objects to be classified and also define a measure of cluster distance. Secondly, there is a plethora of clustering algorithms and the choice of a particular algorithm often tends to be arbitrary. Factor analysis and other correlation approaches to data analysis consider only bivariate dependencies and ignore the higher order dependencies in the data. Latent Class Analysis (LCA) has been used for typological analysis, which does not suffer from any of the above-mentioned limitations.

Latent Class Analysis Methodology

LCA searches for (and usually finds) that latent classification which is most likely for the given data. The only clustering criterion is that all objects in a given class have the same probability distributions for all manifest variables. Alternatively, one may think of latent classes as dimensions, which structure the objects (i.e., cases) with respect to a set of categorical variables. When all latent classes are controlled, only random relationships among the variables remain. Thus, LCA divides objects into latent classes, which are conditionally independent, implying that the variables of interest are uncorrelated with any class. The classes are latent not only because they are unobservable directly, but also due to the fact that their identification is based upon a function of a set of manifest indicators.

3 Analysis and Results

3.1 Latent Class Analysis

Latent class analysis was performed using LACORD. The program computes the frequency of all possible response patterns of the ordinal variables, and also the frequency of response patterns actually observed in the data. The program computes
likelihood ratio test statistics and Akaike Information Coefficient (AIC) for comparing different models. The model with the lowest AIC index is selected for further analysis and interpretation. The assignment of objects to latent classes is not deterministic, but probabilistic. The program computes recruitment probabilities of each object for different classes and then assigns it to the class, which has the highest recruitment probability. Finally, the program provides the expectation values and category probabilities of the manifest variables to all classes. Latent class analysis was performed in two stages. In the first stage, the LCA model was run several times to compute the AIC index for different number of classes ranging from 1 to 8 classes. The values of AIC issued by the program indicate that the model with three latent classes is the most preferable model, since it has the lowest value of AIC (Table 1).

Table 1—Determination of latent classes

<table>
<thead>
<tr>
<th>Number of classes</th>
<th>Akaike Information Coefficient (AIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8282.062</td>
</tr>
<tr>
<td>2</td>
<td>8050.500</td>
</tr>
<tr>
<td>3</td>
<td>7917.458</td>
</tr>
<tr>
<td>4</td>
<td>7991.167</td>
</tr>
<tr>
<td>5</td>
<td>7991.167</td>
</tr>
<tr>
<td>6</td>
<td>8012.843</td>
</tr>
<tr>
<td>7</td>
<td>8282.062</td>
</tr>
<tr>
<td>8</td>
<td>8050.500</td>
</tr>
</tbody>
</table>

In the second stage, the model was run for three latent classes for computing recruitment probabilities and assignment of objects to the latent classes.

Figure 1 shows the expected values of the manifest variables for each latent class as well as for the entire data set, assumed as one latent class. The figure shows the similarities and differences in the attitude of objects in these classes.
A striking feature of the results is the near unanimity of response to the following items:

- Corporate sponsored research provides no challenge to the academic researcher.
- Industry is not interested in basic research
- The need for secrecy in corporate sponsored research is incompatible with the academic tradition of open scholarly exchange.

The expected values of these items are consistently low (=1) for all the latent classes, which means that irrespective of class membership the respondents do not agree with any of the above statements. The academic community does not feel that corporate sponsored research would lack challenge and excitement or the industry would not be interested in scientific cooperating with academic institutions. The academic community also does not seem to be unduly concerned with any constraints on publication of research findings that might be imposed by the industry.

There are, however, important differences in the expected values of the following variables:

- It is not the mission of the academic researcher to collaborate with industry – expected scores vary between 1.355 and 4.170.
- Collaboration with industry limits the free choice of research themes – expected scores vary between 1.601 and 4.372.
- Industry and academia are incompatible in ways that make collaboration exceedingly difficult – expected scores vary between 2.778 and 4.601.

3.2 Structural Analysis

The structure of multivariate relationships between the classification categories and the categories of the contextual variables (viz academic rank, type of institution and field of specialization was analyzed through Multiple Correspondence Analysis, using HOMALS procedure in SPSS.

Correspondence analysis is an exploratory statistical study which displays the rows and columns of a rectangular data matrix as points in a scatterplot, often called a 'map'. It is a powerful graphical tool in many situations involving categorical data. It produces a visual representation of the relationships between the row categories and the column categories in the same space. However, it is by no means a 'new' technique for data analysis. Fielding has provided a review of the relationships between the methodology of correspondence analysis and other techniques such as factor analysis, and principal component analysis of qualitative data and dual scaling. Correspondence analysis is particularly helpful in analyzing cross-tabular data in the form of numerical frequencies, and results in an elegant but simple graphical display permitting more rapid interpretation and understanding of the data. It can be thought of as trying to plot a cloud of data points on a single plane to give a reasonable summary of the relationships and variation within them. Hierarchical cluster analysis is sometimes used for classifying objects into mutually exclusive clusters. Mutual exclusivity is a desirable attribute of classification, but it becomes less important when the classification deals not only with the groups of objects, but also with the structure and relations between objects. Hierarchical cluster analysis has two important limitations. One limitation is that it precludes the possibility of an object to belong to more than one cluster. However, Arabie et al. have developed an algorithm for representing overlapping structure in data, using the additive clustering model. Another limitation is that with this procedure, one can cluster either the row elements or column elements of a data matrix, but not both simultaneously. In this study, the methodology of correspondence analysis, which does not suffer from these limitations, has been used. Furthermore, correspondence analysis allows the representation of column and row elements of the data matrix in low dimensional subspaces. This representation can be used to reveal the structure and pattern hidden in the data. The two-dimensional factorial map reveals the main features.
of the multi-dimensional data set.

The methodology of multiple correspondence analysis\textsuperscript{15,16,17,18} could be considered as the common way of generalizing simple correspondence analysis (which displays two categorical variables) to the case of many categorical variables. Other researchers have carried out empirical studies using multiple correspondence analysis\textsuperscript{19,20}.

### 3.2.1 Multiple Correspondence Analysis

Eigenvalues computed by HOMALS measure how much information in the categorical variables is accounted by each dimension. The two-dimensional solution yielded eigenvalues of 0.37 and 0.29 for dimensions 1 and 2, respectively. It is to be noted that the maximum eigenvalue for each dimension is 1.

The two-dimensional configuration of the classification categories and categories of contextual variables depicted in Figure 2 provides an interpretation in terms of the distances. Category points are displayed as centroids of objects sharing the same category. Greater the distance between the points representing the categories of a given variable, greater is the difference in the characteristics of objects (in terms of the incidence of categories of other variables) belonging to those categories and vice versa. For example, the distance between latent class 1 and latent class 2 is greater than that between latent classes 2 and 3. This means that the difference in the character of individuals belonging to classes 2 and 3 in respect of rank, type of institution to which they belong and field of specialization is less than that between individuals belonging to classes 1 and 2. Category points located at the centre of the configuration have average profile. Greater the distance from the centre, greater is the departure from the average profile. Points located at the opposite sides of an axis have opposite profiles.

Discrimination measures computed by the program are plotted in Figure 3, which suggests that the first factorial axis is strongly related to scientific field, type of institution and academic rank. The second factorial axis is strongly related to latent class typology and type of institution. Type of institution is related almost equally with both first and second factorial axes.
Axis $\phi_1$ (Eigenvalue: 0.37)

This axis is constituted by the categories of the scientific field, type of institution and academic rank. It represents the opposition between natural sciences, projected on this axis with negative coordinates and applied sciences projected on this axis with positive coordinates. This implies that the representation of categories of other variables (viz. academic rank and type of institution) of objects whose field of specialization is natural sciences is diametrically opposite to that of objects whose field of specialization is applied sciences.

This axis is also represented by the categories of the type of institution, and academic rank. The category “Professor” is projected on this axis with positive coordinate, whereas the category “Lecturer” is projected on this axis with negative coordinate. This means that the profiles of these two categories are diametrically opposite. The category “Reader” is located close to the origin of the map, implying an average profile.

Axis $\phi_2$ (Eigenvalue: 0.29)

This axis is constituted by the different categories of latent class typology and type of institution. Latent class category 1 is projected on this axis with positive coordinates, whereas categories 2 and 3 are projected on this axis with negative coordinates. This axis is also represented by the categories of type of institution, and academic rank. Type 4 institution is projected opposite to the other types of institutions. Junior academics (Lecturers and Readers) are projected opposite to Professors.

3.2.2 Simple Correspondence Analysis

Multiple correspondence analysis has thus provided us with a synoptic view of the global structure of the data. The fine-grained structure of the relationships of typology categories and the categories of contextual variables was analyzed through a series of correspondence analysis, using the ANACOR procedure of SPSS. The results are summarized below. While interpreting the numerical results of the correspondence analysis, the absolute contribution of the row columns to the composition of each factorial axis is represented by the abbreviation AC and the relative contribution ($\cos^2 \phi$) of each factorial axis to the representation of row and column points in the direction of the factorial axis is represented by the abbreviation RC. All the values of AC and RC are mentioned per thousand.

Relationship between Typology and Type of Institution

The structure of correlations between three typology categories and four types of institutions can be visualized from the two-dimensional factorial map (Figure 4) issued by correspondence analysis.

The first factorial axis accounting for 73.8 per cent of the total inertia (i.e. information) is characterized by the polarity between typology categories 1 (AC=484; RC=871) and 3 (AC=423; RC=997). This axis is also characterized by the polarity between Type 4 (AC=289; RC=662) and Type 1 (AC=586; RC=994) institutions. Typology category 1 and institution Type 4 are projected close together and are therefore correlated. Typology category 3 and institution Type 1 are projected close together and are therefore correlated. Institution Type 3 is located at the centre of the map and is therefore not correlated with any of the typology categories.
The second factorial axis accounting for 26.2 percent of the total inertia does not exhibit a polarity. Typology category 2 (AC=795; RC=752) and institution Type 2 (AC=575; RC=621) are projected close to each other on this axis and therefore are correlated.

Relationship between Typology and Research Field

The structure of correlations between three typology categories and two categories of research field (natural sciences and applied sciences) can be visualized from the one-dimensional factorial representation (Figure 5).

It can be easily seen that the typology category 1 is opposed to typology categories, 2 and 3 which means that the presence of research fields in the typology categories 2 and 3. Typology category 1 is associated with natural sciences whereas typology categories 2 and 3 are associated with applied sciences.

Relationship between Typology and Academic Rank

Figure 6 presents the two-dimensional factorial map which indicates the structure of correlations between typology categories and categories of academic rank.

The first factorial axis accounting for 98.5 percent of the total inertia (i.e. information) is characterized by the opposition between typology categories 1 (AC=585; RC=997) and 3 (AC=396; RC=999) and rank categories 1 (AC=315; RC=985) and 3 (AC=658; RC=999). Typology category 3 and Rank category 3 are projected close together and are therefore correlated. Similarly, Typology category 1 and Rank category 1 are projected close together and are therefore correlated.

The second factorial axis is does not exhibit a polarity. It is represented by Typology category 2 (AC=868; RC=400) and rank category 2 (AC=622; RC=250). However, the association between these
two categories is not strong since the inertia of this is very small.

The results of correspondence analysis are summarized in Table 2.

In Table 2, prominence means that a given category has relatively more than average incidence in the latent class. It does not mean that other categories are not present, but that their presence in the latent class would be below average.

### 3.3 Characterization of the Latent Classes

**Latent Class 1: Skeptic but Positive Orientation to Collaboration with Industry (33.3 per cent of the Sample)**

Respondents in this category tend to disagree with the proposition that collaboration of the industry is not the mission of the academic scientist; it also tends to disagree with the proposition that collaboration with industry would limit their freedom of choosing research themes. They also take a neutral position with regard to the cultural differences between the academic institutions and industry. These results imply that respondents in this category do not subscribe to the ivory tower paradigm but are not sure of the cultural differences between the academia and industry.

| Table 2—Prominence of contextual variables categories in latent classes |
|---|---|---|---|
| Contextual variables | Latent Class 1 | Latent Class 2 | Latent Class 3 |
| **Type of institution** |   |   |   |
| Inst _1 (Periphery) |   |   | x |
| Inst _2 (Semicentre) |   | x |   |
| Inst _3 (Centre) |   |   |   |
| Inst _4 (Semiperiphery) | x |   |   |
| Academic rank |   | x |   |
| Professor |   |   |   |
| Reader |   |   |   |
| Lecturer |   |   |   |
| Research field |   |   |   |
| Natural sciences |   |   |   |
| Applied sciences | x | x | x |

**Prominent Categories:** Institution Type 4, Professors, Applied Sciences.

**Latent Class 2: Ivory tower orientation to collaboration with industry (13.4 per cent of the Sample)**

Respondents in this category unambiguously subscribe to the ivory tower paradigm. They strongly believe that collaboration with industry is not their mission. They also believe that collaboration with
industry would constrain their freedom to choose research themes. Moreover they are highly skeptical about the cultural differences between the academia and industry, which would frustrate any attempt for cooperative relationship with industry.

*Prominent Categories:* Institution Type 2, Natural Sciences.

Latent class 3: Neutral Orientation to Collaboration with Industry (53.3 per cent of the Sample)

Respondents in this category do not exhibit any pro- or anti- ivory tower attitude to collaboration with industry. They are also skeptical about the cultural differences between the academia and industry.

*Prominent Categories:* Institution Type 1, Lecturers, Natural Sciences.

### 4 Discussion

The paper makes an attempt to explore the perception of academic scientists working in universities and institutions of higher learning towards cooperation with industry in relation to various contextual factors like the status of the academic scientist, the field of specialization, and the type of institution where employed. The results have implication for the management of collaborative projects among the universities and industries or even for establishing workable linkages among these sectors. This could prove crucial for generating new and innovating ideas and successful technological innovation efforts.

In this paper, the temptation of analyzing the attitudinal responses of academic scientists under preconceived classifications of rank, field of specialization, or institutional setting.

At a primary level, the latent class analysis shows that there is an unanimity of responses over the following items: ‘corporate sponsored research provides no challenge to the academic researcher’, ‘industry is not interested in basic research’, and ‘the need for secrecy in corporate sponsored research is incompatible with the academic tradition of open scholarly exchange’, with expected values of these items very low for each latent class. These results seem to be very encouraging for the votaries of university-industry collaboration. These results indicate that there is a potential basis for establishing such a collaborative linkage as the academic scientists feel that such a scope exists. There seems to be a greater awareness that corporate research is not incompatible with research carried out in the industries and could, in fact, provide a greater challenge to research scientists in the universities. However, this primary level of analysis has another dimension. It has been found that there are significant differences in perception among the different latent classes in terms of the following items: ‘it is not the mission of the academic researcher to collaborate with industry’, ‘collaboration with industry limits the free choice of research themes’, and ‘industry and academia are incompatible in ways that make collaboration exceedingly difficult’, with expected values of these items ranging from low to high. For example, for the item, ‘collaboration with industry limits the free choice of research themes’, some scientists are of the opinion that the above statement is not valid, and no restriction is imposed on the choice of research themes in collaborative projects while others feel that it is indeed so. Perhaps the later category of scientists feel that collaboration with industry would practically restrict this choice to applied research thrust areas with basic research taking a back seat.

A deeper level of analysis brings to focus the fine grain structure among the different typological categories. Typology 1 (about 33 per cent of the
responses) has a prominence of responses from semi-peripheral universities, of the rank of Professor, and of scientists working in the applied science research field across all universities. This latent class is characterized by scientists who have a positive orientation towards working for establishing some kind of collaboration with industry. Thus, it is not surprising that applied science category persons are more strongly represented in this typology. But these scientists also exhibit a level of skepticism towards the idea of collaboration with industry. This skepticism, which has been mentioned while discussing the various latent class typologies above, permeates across typological class barriers, is symptomatic of cultural differences that exist between the university set-up and the industry. Industry set-ups are supposed to have a greater speed and efficiency of functioning whereas academic set-ups are supposed to be more bueraucratic in nature. To remove this cultural gap and to promote such collaborative ventures, bueraucratic controls in collaborative projects should be minimized, if it is not possible to totally eliminate the same.

Typology 2 (about 13 per cent of the responses) has a prominence of respondents from semi-centric universities, and of respondents with natural science research field across all universities. This latent class is characterized by an ivory tower attitude towards collaboration with industry. The scientists in this class perceive that collaboration with industry is not their mission. These results might seem paradoxical but a deeper analysis reveals that only 40 per cent of the scientists belonging to semi-centric universities fall into this category, and the rest are distributed over the other two typological categories. Moreover, this class has the smallest fraction of all the academic scientists.

Typology 3 (about 53 per cent of the responses) has a prominence of academic scientists from the peripheral universities, of the rank of Lecturer, and of scientists working in the natural sciences research field across all universities. This latent class is characterized by a neutral orientation towards collaboration with industry. These academic scientists are neither very enthusiastic about collaboration with industry nor are they opposed to the idea at the same time. They require to be motivated to take up such endeavours by say, providing them with sabbatical leave for joining an industry or research laboratory for a fixed period of time, so that they get the required exposure and experience of working in and with these organizations. This would go a long way in ultimately establishing workable university-industry collaborative programmes.

References


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