# Determinants of Productivity in Indian Science

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By

A. V. S. Kamesh

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*Dedicated to My Family*

The good that is there in this, belongs to them by right.

—Graham Greene

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> "A teacher affects eternity; he can never tell where his influence stops."
> —Henry Adams

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—A. V. S. Kamesh

# CHAPTER ONE

# INTRODUCTION

## 1.1 General Introduction

Sociology of science is concerned with how and in what ways social factors influence the process of generating knowledge and the product. Over time science has moved from an amateur, self financing activity (as the 18th and 19th centuries) to professional, funded/sponsored, (by public and private sources) activity carried out in big laboratories. In today's world most of the scientific knowledge is produced in organizational settings. Social, cultural, technological and administrative variables related to organizations exercise influence on the process of knowledge production, sometimes, the content of the knowledge is influenced by situational contingencies. So there is a need to understand organizations, which have emerged as the dominant loci of scientific knowledge.

Modern organizations are groups of people coming together for a specific purpose, characterized by own context, socialization, technology and interdependent practices like interactive behavior and co-operation within and with rest of those outside the organization from the point of view of their goals, needs which distinguish them from one another. Organizations with an aim of production recruit people and train them to suit the needs. People join the organizations to achieve their personal needs. The former process called the 'socializing process', and the latter, 'personalizing process' is programmed to blend in such a way that both the entities benefit within a prescribed context, behavior pattern typically known as the organizational culture. Technology comprises an essential component as that of the human resource in an organization. The organizations acquire different tools that aid in production and communication. Different media facilitates the flow of information within and across organizations. Computer mediated communication technology is a new paradigm in which information technology seems to be emerging as an important mode of communication and co-operation in a given social context and across cultures and organizations. The career structures of people recruited in modern organizations are designed in accordance with their productivity, a measure of their performance according to recognized standards. Thus, generally personnel in the organizations are rewarded according to their output.

Various theories have been offered so far to explain the different forms of organizations, the most accepted, though with its lacunae, being the bureaucratic model of Max Weber (1947). Of late, in the field of organizational structure, attention has been turned towards the emergence of ‘post-bureaucratic’ organizational forms (Drucker, 1988). These new forms are viewed as closely related to the developments in computer-based technologies, in specific Information and Communication Technologies (ICTs). This work appraises the relationships between these new information and communication technologies and its potential implications for productivity among scientists working in different organizational settings in India.

In this work I focus on determinants of knowledge production in Indian science. This work explores implications of socialization into research focusing on the doctoral and post-doctoral training, during which a budding scientist is exposed to knowledge, practices related to community of researchers in a cognitive domain regarding acquisition, exchange and production of knowledge; interaction within research groups and between research groups; information technology as an enabling tool of communication for scientists’ productivity and the size of the research work group.

This work examines the influence of information technology on the communication pattern among organic chemists in India. Collaboration is one of the outcomes of communication in science, which in turn influences as patterns and levels of productivity. I try to elucidate the pattern of collaboration among organic chemists by enumerating the factors responsible for collaboration and examine the impact of communication through information technology on the pattern and extent of collaboration.

Keeping in view the fact that productivity is the major parameter of measuring performance in scientific organizations, the focus is on the conditions that facilitate/hinder productivity in the Indian context. Conditions of productivity include opportunities to do research adequate research infrastructure, communication facilities and organizational culture in the Indian context. Sources of ideas for producing knowledge include journals (libraries are repositories of journals), conferences and the recent World Wide Web (www) through which access to journals, the vehicles of communication in science, is made cheaper and faster. Recently e-journals have become an important medium. One of the important facilitating conditions in today's context is the computer-mediated communication. Through computers one can access information available worldwide. Hence, one of the prerequisites is availability of or access to computers. In different organizational settings, the degree of access to computers may vary, especially in developing countries like India. This in turn would influence the extent to which they can gain access to information.

I hypothesize a typical life cycle of scientist in which he starts as a doctoral student, passes through post-doctoral training and is recruited in an organization to start the professional career. Stage-I of dependence with the doctoral supervisor and department, for acquiring knowledge to produce scientific knowledge with the aid of technology related to the process of production, communicating with the peers and networking and being inducted into a regular/permanent job.

The Stage-II of independence starts with the recruitment into a scientific organization, and acquiring the technology in terms of infra-structure for research as well as for communication and building one's own scientific group.

The stage-III describes the interdependence among the hitherto independent scientists for want of information, knowledge and resources in terms of infrastructure for being more productive to achieve organizational mandate or personal goals.

## 1.2 Review of Literature

Science is a social activity. Its contents-description, explanations and techniques have been created by human beings and shared among groups of human beings engaged in scientific activity. As a social activity, science is clearly a product of history, which takes place in time and place. Science as an act of knowing involves the application of rational, empirical methods and underlying belief in a material reality.

In all modern societies of the contemporary world, science is recognized as a legitimate social activity and various levels of public support are extended to it due to its perceived role in socio-economic and cultural transformation. Comparative analysis of science in different societies would illuminate specific features of the structure and organization of science, values and norms guiding the cognitive activities of the communities of scientists and interaction among themselves at individual and institutional levels and between science on the one hand and economic, political and social power structures on the other. (Haribabu: 1991)

### 1.2.1 Theoretical Orientations

In the sociological study of science, several theoretical orientations emerged over the years. The first approach is concerned with investigating the interrelationship between science and other social institutions and the influence of these institutions on science and vice versa. The second approach is concerned with the study of science as a social system. Science is treated not as a body of knowledge or as a set of methods and techniques but as: -

> ...the organized social activity of men and women who are concerned with extending man's body of empirical knowledge through the uses of techniques. The relationships among these people, guided by a set of shared norms, constitute the social characteristics of science.
> (Storer 1966:3)

The term scientific community has gained importance in sociology of science. Generally scientific community is defined in a way that a community is defined. Merton (1973) who looked at science as an institution tends to view scientific community as one, whose activities are governed by set of norms. However, Merton makes a distinction between technical norms- logic and evidence- that are employed in evaluating knowledge claims are pre-given and impersonal and hence beyond sociological scrutiny. What a sociologist therefore, can do is to examine as to what extent a scientist's behavior conforms to the social/moral ethos of science. The norms defined by Merton are:

Universalism- openness to scientific knowledge irrespective of nationality, caste, class, gender etc.,
Communalism-sharing scientific knowledge through full open communication,
Disinterestedness-no vested interest on scientific knowledge,
Organized Skepticism- making of a final judgement through methods, not by dogmatism,
Originality-fabricating for the first time and
Humility-learning new things.

A scientist's conformity to norms would be rewarded in the form of recognition and any deviation would attract sanctions/punishments. Further Merton's analysis showed an increasing tendency for the work of the more productive and eminent scientists to receive more and more attention. This latter process, which Merton termed as the 'Mathew Effect' leads to the distribution recognition, reward and communication system to highly recognized/reputed scientists. Merton’s functionalist paradigm of the sociology of science has been criticized on the conceptual and methodological grounds, where Mathew Effect within this perspective is unsatisfactory due to its location of “class structure” which places accessing of sources. (Mulkay 1979, 80).

## Kuhn’s Work

Thomas Kuhn defines scientific community in a more historically more constitutive sense. It is a scientific community shaped by a paradigm, which evolves norms both technical and social. What is technical is socially, historically arrived at. He emphasized on the revolutionary character of scientific progress, where a revolution involves the abandonment of one theoretical structure and its replacement by another, incompatible. He suggested the sociological characteristics of scientific communities.

In *The Structure of Scientific Revolution* (1962), Kuhn says that science never grows by linear growth but by discontinuous revolutionary shift of *paradigms*--a major break through which gives a new research tradition, a whole way of thinking and acting within scientific community. This is because the paradigm represents the totality of the background information, the laws and theories which the members of a particular scientific community adopt for their application.

Normal scientists will articulate and develop the paradigm in response to account for and accommodate the behavior of the some relevant aspects of the real world which revealed through experimentation. In doing so, they will inevitably experience difficulties and encounter falsifications. If difficulties of that kind get out of hand, a crisis state develops. A crisis is resolved when an entirely new paradigm emerges and attracts the allegiance of more and more scientists until eventually the original, problem-ridden paradigms are abandoned. This discontinuous change constitutes *Scientific Revolution* .So, the notion of universality and objectivity is paradigm-bound (Haribabu, 1999).

Post-Kuhnian sociology of science has been attempting not only to understand the organization of science but also the content of science-descriptions, explanations, theories and models in relation to the context (Haribabu, 1999) . Cetina’s *The Manufacture of Knowledge* (1981) is a post-Kuhnian development where she introduces *social-constructivist* approach to study the production of scientific knowledge among scientists by employing practical, analogical, literary, symbolical and social situated reasoning. Further, she suggested that *lab* is the site of production such as; Reasoning, Tacit Knowledge and local contingencies.

This production of scientific knowledge is based on local and situational contingencies and influences. In the scientific lab, the goal is not to find the truth but to understand how the works are going on and what is going on. Cetina shows how science draws cultural inputs, resources (physical, cultural) from the wider society. Growth of scientific knowledge is no longer epistemic (working in a particular paradigm) but it works as a transepistemic network for resource mobilization. So, scientists in lab as entrepreneurs who does-investment, returns, and optimization

In recent years, social system perspective of science has gained importance. The changing global context, especially, after the WTO came into existence the norms of WTO impinge on science. Ziman (1996) provided a view of transition from academic science to post academic science elaborating the features of each of them and examines whether the contemporary science is shifting towards a new mode of interactive institutional science. The Mertonian norms of academic science, viz., communalism, universality, disinterestedness, originality and skepticism are institutionalized in a setting where public and private patronage is the principal support of scientific research.

This work employs the notion of scientific community to understand Organic chemists in India. I examine whether there is any stage evolving especially in India, which is characterized by the reshaping of scientific community in the wake of the changing global context, emergence of new, faster, and sophisticated modes of enabling communication technologies and that of network oriented sub-culture of collaboration and their consequences are examined for the productivity, career, and reward structure in a society wherein research is pursued in organizational settings with different levels of resource endowments.

### 1.2.2 Mode- 2 Production of Knowledge

The norms of post-academic science according to (Gibbons et.al1994) shaped in a post-industrial context in contrast to those of academic science, include,

1. Proprietary knowledge,
2. Local problem solving
3. Authoritarian setting of research agenda
4. Commissioned market-driven support and

5. Expertise oriented around problem solving that is accountable to quality control.

Ziman, Gibbons, Limoges, Nowotny et.al.(1994). While arguing that scientific enterprise is changing propose a theoretical framework to investigate five pervasive charectestics of research. They are:

1. Application
2. Interdisciplinary
3. Networking
4. Internationalization and
5. Concentration of resources.

Their results indicate that research is becoming more interdisciplinary and increasingly conducted in networks at international level. Ziman, in "Prometheus Bound, Science in a Dynamic steady state" hypothesizes that the exponential growth in science seen as a norm by scientists motivated all to publish more papers and resulted in a cumulative pressure on resources in science. This conflict over resources with other priorities led to resources attain a steady state and necessitated adjustments in science as a social system that evolved in conditions of exponential growth. Authors of "The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies (1994)", Gibbons et.al. argue that, the internal dynamics of science have generated a new way of producing knowledge. They depict a paradigm shift in performing research in qualitative terms from that of discipline based academic activity to a new research mode called "Mode2" due to the post II World war expansion of the research and education system and entrepreneurial fund raising. They conclude that:

> Internal dynamics are bringing about a transition to different type of science system and throw light upon science as an evolving system of interacting institutions.

### 1.2.3 Science, Scientists and Developing Countries

Literature on Science in developing countries is scattered through numerous journals, seminar reports and proceedings. But there are only a few empirical studies. Moravcsik (1985) shares the same idea that research on science in developing countries is an unexplored and fruitful area.

A large storehouse of documents and reports on science and technology policies in the developing countries reveal that official documents mainly contain statements of intent and that the existing knowledge of science and scientists in developing countries is incomplete.

On the basis of national statistics compiled by organizations such as UNESCO and OECD (Organization for Economic Co-operation and Development), shortcomings of the developing countries research systems and shortage of available resources have been observed (Rossi 1973). Other authors compared socio-economic conditions with the level of scientific development these countries (Eres 1982). In some of his writings De Solla Price (De Solla Price & Gursay 1975) prescribed quantitative indicators for the developing countries. Research by Garfield (1983) and his Institute for scientific information (ISI) in Philadelphia points out to the low productivity levels and degrees of dependency (articles of developing countries have greater impact when co-authored with scientists from developed countries). (Quoted in Krishna, 1991).

These studies tend to show that none of the developing countries has a 'genuine' scientific community, including India. India has numerically the world's third largest scientific community (Shiva and Bandopadhyaya 1980). An Indian scientist interviewed by Shiva and Bandopadhyay said:

> There is no scientific community in this country.... I meet my Colleagues only abroad ...........In a well-knit community, where you are exchanging pre-prints, things are happening and there is excitement here. Our excitement comes by mail from outside. It depends on the postal system. This is the worst part; the spirit is dead (Shiva and Bandopadhyaya, 1980. p.587).

Russell and Galina (1998) while elaborating upon the important differences between the way in which science is practiced in the developing world and the developed world point out that science in developing countries suffers from:

- Isolation from the mainstream of scientific activity,
- The need for the development of an indigenous scientific capacity,
- The lack of critical mass of researchers with respect to most fields of knowledge, and
- The urgency of developing better and more efficient communication channels.

Shrum and Campion (2000) who examined whether, the scientists in the developing countries are isolated; contend that, many scientists are isolated in the sense that they are not part of active research fronts. Indeed variation in levels of contact is one of the key features of scientific and technical organization in developed countries. (Shrum and Mullins 1988). In the developing countries, International and domestic networks are inversely related. The present study focuses upon whether the contact aided by the modern means of communication is emerging as a factor responsible for increase in the productivity levels and visibility by initiating the scientists into these networks.

Turnbull (1997) asserts that science is a set of local practices and each set up works as a knowledge system. Rahman (1975), observes, different national and cultural contexts determine the goals set for basic and applied research. Fields of specialization, social outlook, cultural factors, and philosophies of life influence the conduct of research and the goals set by the scientists. Though it is assumed that the research in developing countries is influenced by the cultural and social environments in which they are immersed, Moravsick (1978) questioned the same and argued that,

> Activities in basic and applied research must by nature adhere to certain universal practices regardless of where, why, how, or by whom they are carried out. Science in DCs is therefore not inherently different from science in the industrialized world, rather it is at an earlier stage of development.

Ignatyev (1989) contends that, Knowledge production of developing countries is limited by transnational factors that shape their education, as well as organizational and legal mechanisms of resource production and allocation. This form of dependence is promoted by various human factors institutionalized in social structure and long-term psychological cultural operations. Developing countries are still dependent on industrialized ones regarding what kind of technology they should buy and from whom, and established mechanisms of professional recognition of scientists and researchers.

Since the knowledge formation process in the developing countries is largely influenced and determined by the western world, a considerable part of their scientific output is foreign to where it is produced. Krishna (1990) negates this hypothesis. For him, the growth of science, organized in terms of specialist groups or small communities sharing a set of 'social and cognitive' values to explore and advance systematic knowledge", is recent historic development. Even though science appeared in its institutionalized form from as early as the late 16th and early 17th centuries, the transformative role of science did not come about until the emergence of professionalized communities in 19th century Europe and 20th century North America. The drive towards professionalization and emergence of scientific communities in 19th century Europe shows that these developments have come about in somewhat 'organic' mould catalyzed by the prevailing political structures and other state-supported structures. Further, sites of production of knowledge such as laboratories had begun to be constituted as part of organizational setting such as universities since the later part of the $19^{th}$ century. Though Euro centered, the investigation of Ben-David (1971) and others offers that, the social context of the non-western cultures such as India has relevance to the development of institutional factors. Despite the implantation of the modern science from about 18th century onwards, colonial structures separated institutionalization from professionalization. For countries such as India, colonial experience is important considering the social processes of professionalization of science and the emergence of national scientific communities. Colonial science or scientific works in colonial enterprises had little to do with the emergence of the Indian scientific community in its emergent period (1900-1920) (V.V.Krishna 1990). After the 1870s it becomes sociologically meaningful to speak of three categories of scientific personnel, 'gate-keepers' and 'scientific soldiers', who were part and parcel of the colonial scientific enterprises, and native Indian scientists and their missionary supporters who constituted the third group.

The third category of scientists for the first time made organized attempts to undertake basic or fundamental research by the 1920s (Krishna, 1990). Specialist groups, schools, and institutions were constituted in Physics, Chemistry, Mathematics, Biological Sciences and Astronomy by the early decades of this century. By the early 1940s the Indian scientific community made its intellectual presence felt in the international scientific world. There were at least nine fellows of the Royal Society as well as a Nobel laureate in Physics. An Indian scientific community was created which not withstanding its limited spheres of influence, regarded advancing the frontiers of knowledge as a means by which Indian national identity could be established at the international level of science.

Jairath (1984) while discussing the criticisms of the Indian science finds that during the colonial era, science developed in a gradual pace, with minimal state intervention. After independence science developed rapidly with state intervention. This work takes into account the different organizational settings created by the state in which the scientific research is pursued, and attempts to understand the role of acquisition and distribution of enabling technologies coupled with a paradigm shift in terms of media of communication and resultant collaborative strategies on the productivity of scientists.

## 1.3 Scientific Communities and Growth of Knowledge

Habermas (1984) differentiated three primary generic cognitive areas in which human interest generates knowledge. These areas determine categories relevant to what we interpret as knowledge. That is, they are termed ‘knowledge constitutive’- they determine the mode of discovering knowledge and whether knowledge claims can be warranted. These areas define cognitive interests or learning domains, and are grounded in different aspects of social existence-work, interaction and power.

Habermas broadly refers to work as the way one controls and manipulates one’s surrounding environment, which is known as instrumental action- knowledge based upon empirical investigation and governed by technical rules. The criterion of effective control of reality directs what is or not appropriate action. Habermas classified the ‘scientific’ research domains-e.g., Physics, Chemistry and Biology which are empirical-analytic using hypotheco-dedcutive theories. We consider scientific work related to research in this framework and examine the production of knowledge in science. In our study we shall examine how the Organic Chemists in the Indian context utilize the organizational context in which they are located in pursuit of being productive.

(Price (1963) advocates that, in science, the certification of knowledge claims leads to addition to or the growth of a cognitive field through a series of stages such as:

(1) A preliminary period of growth in which the absolute increments are small although the rate of increase is large but steadily decreases

(2) A period of exponential growth when the number of publications in a field doubles at regular intervals as a result of a constant rate of growth that produces increasing amounts of absolute growth.

(3) A period when the rate of growth declines but the annual increments remain approximately constant; and

(4) A final period when both the rate of increase and the absolute increase decline and eventually approach zero.

Price (1963) argued that basic science is currently in the second phase of growth but that, as a result of shortages of resources and manpower, it will eventually enter the third an fourth stages. Price does not offer an explanation for such a growth of knowledge. Diane Crane (1972) offers the thesis that the logistic growth of scientific knowledge is the result of exploitation of intellectual innovations by a particular type of scientific community. Productivity of scientists also depends on what stage of the cognitive development of a research field that a scientist enters. She examines the issue as to how scientific communities affect the growth of knowledge. The author comprehends complex sociological problems as that of understanding the social institutions that produce ideas. In dealing with these types of phenomena, the sociologists face the problem of understanding the ideas that can be highly technical and obtuse. Diana Crane (1972) argues that scientific communities are distinct entities, interconnected with one another in ways that are as yet only vaguely understood.

Haribabu(1999) provides a sociological review of the production of knowledge including the social origins of knowledge. The author says that, the rationalist-positivist epistemology of science influenced the streams of thought in sociology of science, more prominently the functionalist paradigm of Robert Merton (1973). Through his empirical studies, Merton analyzed that the inequality in science due to skewed distribution of recognition and rewards is functional in the sense that the recognized scientists provide role model for young scientists as significant others.

Mulkay (1979, 80) criticized Merton on theoretical and methodological grounds for a-historical characterization of science.

Kuhn (1970) a historian of science proposed the concept of paradigm that creates conditions for the emergence of a scientific community with shared cognitive beliefs.

Kuhn defines scientific community in more sociological terms. A paradigm guided scientific community, possesses a shared cognitive belief system, standards of research, communication among the members of the scientific community becomes more focused. After the acquisition of paradigm in any given specialty there will be cumulative growth of science, which Kuhn calls the normal science phase. As the paradigm gets extended to more and more areas of research, it is at this stage that the anomalies emerge, which leads to crisis, a new paradigm emerges, as a response to crisis. The productivity of the scientists who enter the cumulative phase of the growth of the paradigm will be high. During the period, when paradigm faces anomaly and crisis, the productivity of scientists declines. This decline of the paradigm is related to exhaustion of paradigm. Thus scientific knowledge grows according to the cognitive consensus among the members of the scientific community insulated from the society.

Post-kuhnian sociology of science challenged the kuhnian notion of scientific community being insulated from the wider context. Approaches like the social-constructivist approach Knorr-cetina (1981) to the study of production of knowledge focused upon the internal and external social context in which science is situated. Knorr et al (1978) begin with the idea that scientists may be affected by organizational settings and structures than is usually recognized in stratification studies. They examined the effect of organizational factors on productivity and concluded that the rate of publication of research findings by the academic scientists increased steadily on average through out the first twenty years of research and then continued at a fairly highly for the remainder of the career. This increase in research productivity occurred despite the fact that less and less time was spent on research and more time on teaching and administration.

The crucial feature explaining scientists' varying rates of productivity was, whether or not they occupied a supervisory position; The significance of supervisory positions was closely associated with the control they have over manpower resources, physical and human and the extent to which they enabled supervisors to extend the range of research projects in which they were involved. Supervisory scientists were able to maintain increasingly high rates of authorship (or co-authorship) by participating in the research project in a rather different manner from their subordinates. Increasingly they confine themselves to defining projects, which were to be carried out in detail by graduate students and other less senior researchers. To quote Knorr-Cetina (1978) "the higher a scientist moves up the hierarchy of the research laboratory, the more he is confronted with a variety of scientific and nonscientific functions in addition to research; the more his research activities change towards goal setting rather than goal executing; and the more he is able to attract project money and consequently become involved in greater number of research projects."

Thus, it seems that structural factors within the organization impinge on the productivity of researchers, to some extent apart from individual differences in ability and motivation. For high levels of formal productivity are closely associated with the position of the supervisor the availability of such position will depend to a considerable degree upon the institutional system within which it is embedded. Related to the ability of scientists to mobilize funds for research is their ability to constitute research groups.

Similarly micro-level ethnographic studies Latour (1979) revealed that in the production of knowledge social and cultural factors shape the social action of the scientists.

In this work I examine how the context of the organization shapes the action of a scientist within and outside the organization in which he/she is located. We considered that it is the organizations that provide the context for productivity of the scientists with human, technological resources like research groups, peer groups.

I considered the impact of the doctoral institution and location and duration of postdoctoral training in a particular organization on the recruitment, career and later productivity levels communication facilities and opportunity to collaborate. We also attempted to study the impact of the relative access of communication technology and collaborative nature of the scientists on their productivity levels.

## 1.4 Perspectives on Productivity

In all the organizations including the scientific organizations the work output of the members of the organization is perceived as their productivity. Especially in the scientific organizations, scholars have developed various measures of indicating the productivity of the scientists which include number of publications and citations. “The social inequality in science has been explained in terms of differential productivity, rewards, and recognition (Mulkay 1981)”. In this work, we considered productivity as the number of publications by the scientists in refereed journals in a specific time period. In a critical review of the publication productivity of the scientists, Mary Frank Fox (1983) argues that publication is central to research and offers a review of the explanation of productivity levels among scientists through psychological traits, work habits, demographic characteristics and environmental location. Merton (1973) accounts for productivity differentials in terms of only individual talents. Diana Crane (1972) offers the thesis that the productivity of scientists depends on what stage of the cognitive development of a research field that a scientist enters. Long, J. Scott and Robert Mc Ginnis. (1981) describe the impact of the organizational context on the scientific productivity’

Literature shows that,

a) Small proportion of scientists produces the bulk of the research literature.

b) The honorific rewards of science are a monopoly of relatively small intellectual elite. Recognition of scientist’s knowledge is expressed in a great variety of ways, from eponymy and the Nobel Prize, through a multiplicity of other prizes and medals, to membership of national academies.

One prominent feature of social ranking in science is that a very few universities, departments, grand ecoles and research organizations are widely regarded as the main centers of excellence. The attainment of elite status is closely bound up with this phenomenon. These main centers of excellence are endowed with the state of the art technology and recruit the best of the scientists. The most eminent scientists end up at an elite institution and that a large proportion also begin their careers within them. Empirical studies reveal that rates of social interaction within the elite tend to be higher than those between elite and non-elite scientists. Most prestigious universities, and the leading scientists within them, receive a disproportionately large share of research funds. This is very much prevalent in developing countries like India, as the National research communities are themselves stratified in terms of productivity; the receipt of major awards and the resources devoted to research. These communities appear to comprise of haves and have-nots in terms of knowledge, access to technology, especially information and communication technology. We observe:

a) Inequality in rates of productivity
b) In access to research facilities

To begin with the productivity,

1. There is a strong empirical connection between research productivity and scientific rank (Gaston)
2. The production of information tends to precede the receipt of rewards
3. Any complete theory of stratification in science will have to cover productivity and resources, as well as rewards, within a single overall account.
4. The notion of universalism as formulated by Merton involved to main elements
    a) The extent to which performance is accessed by means of impersonal criteria
    b) And the degree to which individuals have equal opportunities to perform
5. The productivity of the members of each generation of research scientist becomes increasingly unequal as their careers unfold.

Gaston (1970) summarized that those scientists who manage to establish a comparatively high rate of productivity at the beginning of their career are able to use the initial advantage to claim more research facilities and thereby to improve their relative position further. Thus, Merton (1973) accounts for productivity differentials in terms of only individual talents.

The literature surveyed showed that productivity differentials are socially produced by factors such as:

- Organizational context
- Stage of Development of a Research Field
- Communication and
- Collaboration

The functional analysis of social stratification in science by Cole and Cole reveal that the stratification system serves three major functions.

1. The self-reinforcing process of cumulative advantage helps to ensure that research resources go disproportionately to those scientists who have the greatest ability.
2. The members of the scientific elite act as models for their colleagues and particularly for the younger men. They display clearly their rewards which accrue to scientific excellence and which need to be visible if they are to operate as effective incentives. The existence of distinct elite encourages other scientists to strive for eminence themselves and in doing so to emulate the behavior of those who most embody the values of science.
3. If they were no elite fewer bright students would receive best available training. As long as the elite exists and is located in a few universities of high repute, the most promising student can choose – or be recruited into those departments where they native abilities will be further nurtured through close contact with the best minds of preceding generations.

Cole and Cole (1973) defined the quality of research papers operationally as the number of citations they receive. They argue that when variations in quality are statistically controlled other sociological variables such as rank of Doctoral department, Gender and Membership of an elite university have very little impact on scientist's receipt of rewards. They note that citations can be used not only as a measure of quality, but also as a measure of recognition.

If they were no differentials in distribution of recognition research resources would be more evenly distributed. Some scientists would surely see this as a positive good. But from the point of view a system it is probably advantageous to have the bulk of research resources go to the men who have been successful in the past and to give them the resources to make additional discoveries. There are three major kinds of inequalities in science.