Freedom for research, and national development

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This article discusses academic freedom for research with a focus on research in STEM fields. Any freedom is not absolute and is associated with certain responsibilities. Freedom for research has two dimensions: freedom for selecting topics for research and freedom for the conduct of research and this article focuses on the first dimension. The academic freedom available to faculty can be exercised by them to gain recognition based on scientometric indicators (number of articles, citations, journal impact factor, h-index, etc.), or to establish and deepen international collaborations, or to satisfy innate curiosity, but working to link their research to national development agenda is more significant for the country. Managements of higher education institutes should devise reward system to recognize such linkage.

Keywords. Academic freedom for research, linking research to national development, reward system, scientometric indicators.

ACADEMIC freedom is a complex concept and is not amenable to a simple definition. Globally, the debate on academic freedom is dominated by social scientists. This is an aberration as an investment in teaching and research infrastructure for Science, Technology, Engineering, Mathematics, and Medicine (STEM) far exceeds that for social sciences. An insider's perspective can be provided only by individuals engaged in STEM fields. As an individual involved in research and development, policy planning and funding extra-mural research, I was motivated to write this article and will discuss academic freedom for research with a focus on research in STEM fields.

One notes a range of perspectives about the purpose of university education. At one end of the range are those who advocate that the primary purpose of education is the training of students for a work-force to feed the economy and emphasize the utilitarian aspect of research. At the other end are those who – advocate that purpose of a university is to educate concerned citizens for a democratic society, support liberal education, shun utilitarian aspects of education and opine that knowledge has its own intrinsic value. Then there are those who fall in between the two extremes and advocate an integrative approach to education. As research in universities is largely carried out through the medium of doctoral students, we will concentrate on doctoral education rather than university education as a whole. Intensity of debate on the subject of doctoral education can be seen from the remarks by Elkana and Klöpper[1] on the LERU report[2], when they write,

> '…the report[2] is heavily slanted towards the point of views of society's needs in the fields of science and technology. What interests the authors is what graduate can contribute to a knowledge-based economy. While they emphasize basic research and frontiers of knowledge, the fundamental presupposition – even if never spelled out so brutally – is that the purpose of the university is to prepare students for the work force. Accordingly, their definition of the purpose of the doctorate is widely diverging from the one we found in the Carnegie Initiative on the Doctorate.'

Carnegie Initiative on the Doctorate resulted in two reports which present one particular view (that is forming scholar's professional identity in all its dimensions), but within the USA, there is a multiplicity of views as we will see later while discussing the '1945 report' by Vannewar Bush[3]. The opposing views have a bearing on the discussion on academic freedom for research as we will see later in this article.

Academic freedom and associated responsibilities

Academic freedom can be debated from several perspectives: freedom of faculty to teach and research, institutional freedom to manage its affairs, freedom of students in the selection of courses for study and topics for research, freedom of society and the nation to expect

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Table 1. NASA technology readiness level scale

TRL	Definition	Exit criteria
1	Basic principles observed and reported	Peer reviewed publication of research underlying the proposed concept/application
2	Technology concept and/or application formulated	Documented description of the application/concept that addresses feasibility and benefit
3	Analytical and experimental critical function and/or characteristic proof-of-concept	Documented analytical/experimental results validating predictions of key parameters
4	Component and/or breadboard validation in laboratory environment	Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment
5	Component and/or breadboard validation in relevant environment	Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling environment
6	System/sub-system model or prototype demonstration in an operational environment	Documented test performance demonstrating agreement with analytical predictions
7	System prototype demonstration in an operational environment	Documented test performance demonstrating agreement with analytical predictions
8	Actual system completed and flight qualified through test and demonstration	Documented test performance verifying analytical predictions
9	Actual system 'flight proven' through successful mission operations	Documented mission operational results

research to be relevant to needs (economic growth, employability, good health, development of a knowledge-informed policy framework, etc.) and some more perspectives. Academic freedom is not absolute and is associated with certain responsibilities as clearly articulated by professional associations as well as national and international organizations. In many cases, the concept of responsibility is included in the title of a statement on the subject such as in the statement issued by the Association of American Colleges and Universities in 2006, which is titled 'Academic Freedom and Educational Responsibility'.

Freedom for research has two dimensions: freedom for selecting topics for research and freedom for the conduct of research. Researchers on the subject of academic freedom are focused on the second dimension, while the first dimension remains under-explored. The first dimension with regard to STEM fields needs to be explored from the perspective of the utility of research and views about it have evolved with advances in and the relationship between science and technology (S&T)[4]. For the major part of history, technology has developed independent of science and science has benefited a lot from technology, but in recent past the two have become fully intertwined and there is a blurring of distinction between the two in areas where an intuitive approach alone is not enough.

Because of the evolution of the relationship between S&T, problems now facing humanity, and multiple accountabilities for research, I join many others who have called for a relook at the classification of research. Following some other researchers, I endorse a simple classification: Academic Research (AR) and Post-Academic Research (PAR). PAR and AR are fully intertwined or have a large overlap as indicated in Figure 1 (ref. 5). PAR and AR are not antagonistic to each other. PAR embraces and motivates contextual AR. Availability of research funding and quick deployment of results of research motivate researchers to pursue contextual AR. Developments in reactor physics were driven by requirements of the nuclear industry, fluid dynamics by aviation industry, and plasma physics because of an ongoing quest for fusion energy.

Looking at the intertwining of AR and PAR, and knowing that without PAR, new knowledge does not lead to deployment, it is necessary that topics for research are selected by the university faculty based on priorities identified to serve national development agenda. AR that directly leads to the solution of problems faced by industry or society is more challenging as the 'user response' is immediate. One has to first identify a product or a process that needs to be developed, analyse knowledge gaps, formulate research problems and conduct research. This can be done according to the Technology Readiness Level (TRL) framework formulated by NASA in the nineteen seventies and improved subsequently based on experience. This framework has been fine-tuned by many industries to meet their specific requirements. Table 1 gives detail of TRL definitions as given on NASA website. Many research teams and organizations have given alternate TRL definitions to suit requirements of technologies being developed by them (Engel *et al.*[6] for carbon capture and sequestration; Carmack *et al.*[7] for advanced nuclear fuels and materials development); additional levels also have been proposed[8]; levels also have been proposed for the development of systems and interfaces[9]; but essential features remain the same. For example, for advanced nuclear fuel and materials development, Carmack *et al.*[7] propose 'Fuel design parameter and features defined' as TRL4 and 'Fuel safety basis established' as TRL6. (One can develop a TRL framework even to fit in the concept of 'translational research' used by health science fraternity.) The essential point is that a stepwise approach is needed to move from AR to mature technologies, and AR alone is not sufficient. We will return to the 'sufficiency' argument later in this article.

Comparing the terminology of Figure 1 and the TRL framework, TRL1 corresponds to AR, and the rest to PAR. TRL1 could result in several publications from a research group, all aimed at developing a target technology. PAR is a much larger enterprise than AR and is done at national research centres or R&D centres established by industry. One may designate TRL2 to TRL4 as early-stage PAR as university infrastructure is also equipped to carry out such activities.

In situations when AR is aimed at the development of an informed policy framework, or development of codes and guides to streamline design or regulatory processes, or methods for analysing real-life problems, number of levels in the TRL framework will be less and the entire development can be done in universities.

Confining research to TRL1 will give only publications and not contribute to national development until someone else picks it up and carries it forward. To maximize economic benefit from AR, faculty in HEIs should also work on at least early-stage PAR. Else in many cases, it may be superseded by other developments, forgotten and become obsolete. It is worthwhile to recall what was articulated by Richard Courant in the preface to the English edition, published in 1934, of his German text, *Differential and Integral calculus*:

> 'My aim is to exhibit the close connection between analysis and its applications and, without loss of rigour and precision, to give due credit to intuition as the source of mathematical truth. The presentation of analysis as a closed system of truths without reference to their origin and purpose has, it is true, an aesthetic charm and satisfies a deep philosophical need. But the attitude of those who consider analysis solely as an abstractly logical, introverted science is not only highly unsuitable for beginners but endangers the future of the subject; for to pursue mathematical analysis while at the same time turning one's back on its applications and on intuition is to condemn it to hopeless atrophy.'

With this background, let us first examine the landscape in India with regard to policies related to freedom for research.

Landscape in India

In India since independence, interventions related to research and education have been made in two distinct ways: one through reports of education commissions or committees, and two through the formulation of 'science and technology' policies. One may consider setting up of Institutes of National Importance (INIs) like Indian Institutes of Technology (IITs), Indian Institutes of Scientific Education and Research (IISERs), Indian Institutes of Management (IIMs) as a part of the first intervention. The first report in the post-colonial period is by the Commission chaired by S. Radhakrishnan, which focuses on education, but also touches upon issues related to research. It describes the interest of the Government of India in scientific research as utilitarian to aid agriculture, industry, medicine, engineering, etc., thus directly linking research in universities to national development[10]. Report of the Commission chaired by D. S. Kothari expresses 'deep conviction that the progress, welfare and security of the nation depend critically on a rapid, planned and sustained growth in the quality and extent of education and research in science and technology'[11]. It emphasizes prioritizing research geared to meet national needs[12]. The Yash Pal Committee makes a recommendation[13] to set up a National Commission on Higher Education and Research (NCHER) and calls for 'Universities to establish live relationship with the real world outside and develop capacities to respond to the challenges faced by rural and urban economies and culture'. The Committee chaired by K. Kasturirangan has submitted its draft report in 2019; it emphasizes an integrative approach to education and proposes setting up of a National Research Foundation[14]. Various reports limit themselves to a discussion on university autonomy in general terms.

Over a span of about a decade beginning from 1951, five IITs were established to encourage engineering education and research and many more have been added in

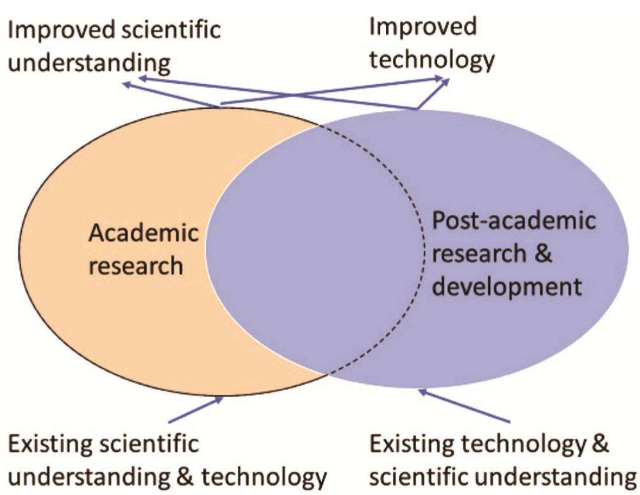

Figure 1. A representation of the relationship between science and technology. Note: The words 'scientific understanding' used in the figure represent understanding in all branches of science including natural sciences, engineering sciences, health (or medical) sciences, agricultural sciences and social sciences.

recent years. They provide excellent education at the under-graduate level and students are well equipped to migrate even to other professions like management or civil services. While talking about IITs, migration of students graduating with a bachelor's degree to other professions or other countries has become a point of discourse in India, but focus in this article is research which is done by doctoral students and faculty.

Four policy statements have been issued by the Government of India since independence and I have given a detailed analysis in an earlier article[5]. The utilitarian aspect of research is underscored by all the four statements. None of the statements discusses academic freedom for research. Also, all statements have steered clear of the debate regarding classification of research as well as the perceived divide between science and technology.

Faculty in India have, by and large, been quiet on the subject of academic freedom due to the preponderance of private colleges, where they do not enjoy permanent contracts[15]. Sundar indirectly links research to national development by writing that IITs were set up in an acknowledgement of the role of professional education in nation-building. IITs and Indian Institute of Science have made a very significant contribution to doctoral research in engineering in the country.

Landscape in the developed world

In none of the documents above, academic freedom figures as forcefully as in documents from Europe and the USA. Magna Charta Universitatum signed by European universities in 1988 says,

> 'The university is an autonomous institution at the heart of societies differently organised because of geography and historical lineage; it produces, examines, appraises and hands down culture by research and training. To meet the needs of the world around it, its research and teaching must be morally and intellectually independent of all political authority and economic power.'

It goes on to say,

> 'Freedom in research and training is the fundamental principle of university life, and governments and universities, each as far as in them lies, must ensure respect for this fundamental requirement.'

However, one notes a nuanced articulation of university freedom in the recommendation 1762 made by EU Parliament in 2006. The Recommendation reaffirms academic freedom and university autonomy in accordance with Magna Charta Universitatum and elaborates it by listing four principles in section 4; the fourth principle being,

> 'high costs and losses, however, could also ensue if universities moved towards the isolation of an "ivory tower" and did not react to the changing needs of societies that they serve and help educate and develop; universities need to be close enough to society to be able to contribute to solving fundamental problems, yet sufficiently detached to maintain a critical distance to take a longer-term view'.

Later in section 10, it says,

> 'Universities should be expected to live up to certain societal and political objectives, even to comply with certain demands of the market and the business world, but they should also be entitled to decide on which means to choose in the pursuit and fulfilment of their short-term and long-term missions in society.'

In these quotes, one can note a clear link with responsibilities towards society and market place, as well as caution against isolation.

According to statements from the USA, academic freedom for research is circumscribed by the accountability of faculty members to their peers and to society for the quality and rigour of their research[16]. Free enquiry in academia is thus predicated on voluntarily assumed forms of un-freedom that are unique to the academy[16].

The statement from AAUP also 'seeks to insulate research and teaching from political pressure'. It emphasizes search for truth without any personal gain:

> 'Institutions of higher education are conducted for the common good and not to further the interest of either the individual teacher or the institution as a whole. The common good depends upon the free search for truth and its free exposition.'[17]

The notion of 'without any personal gain' is under challenge for the past two to three decades as demonstrated by the setting up of offices in universities to deal with issues such as sponsored research, intellectual property rights, technology transfer, technology incubation parks, etc., resulting in the rise of what is being called as 'entrepreneurial university' or 'managerial university' with its role defined by the state to meet national economic priorities and needs[4,18].

With regard to the selection of topics for research, 'Science, The Endless Frontier (STEF)', the report authored by a panel chaired by Vannevar Bush published in 1945 for the US Government has been very influential[3], but the linear model propounded by it has been widely contested[4]. STEF says that essential new knowledge needed for national well-being can be obtained only through basic scientific research or to use the classification advocated by the author that is AR. The logic of STEF's argument is of the 'necessary but not sufficient' sort. It presents academic research as a prerequisite for national well-being, not a guarantee[19]. Sarewitz also opines that if the notion promoted by STEF 'were always true, China's rise would be inexplicable, as it has pursued precisely the course that STEF warned against.'[19]

China has harnessed discoveries made by others to march ahead. This can be compared to the approach followed by Marconi when he invented wireless communication based on discoveries of Maxwell and Hertz. This was highlighted by Flexner while espousing the usefulness of curiosity-driven research[20]. However, Flexner also acknowledges the stimulation provided by industry-driven theoretical inquiries as they open up new vistas 'pregnant with future achievements, practical and theoretical'[20]. He also says that 'even in the pursuit of strictly practical aims an enormous amount of apparently useless activity goes on. Out of this useless activity, there come discoveries which may well prove of infinitely more importance to the human …..'.

When Humboldt proclaimed the unity of education and research, Gross Enrolment Ratio (GER) was perhaps less than 1% (ref. 21). Now it is several times more; it being 26.7% in India[22]. In addition, most of the large countries have national research centres. As a result, science enterprise has become so large that even while looking for practical aims, several curiosity-driven activities are pursued by researchers as a serendipitous extension of their main pursuit. Now the world may be pursuing more curiosity-driven research than what was ever expected by the research community. It is apt to recall the aphorism that – 90 per cent of all the scientists that have ever lived are alive today.

Analysing the above, one notes that while early statements favour curiosity-driven research, recent statements are more nuanced, do not glorify isolation and advocate linking research to the economy and the society. Large resources demanded by researchers have triggered concern of governments with its practical relevance. During the last few decades, one can see an increasing use of words like 'mission-oriented', 'oriented basic research', 'strategic science' and now 'grand challenges' and this 'illustrates the idea that scientists' intrinsic motivation must not be restricted to inner-scientific puzzles but can be channelled towards societal goals'[23]. Positive response of scientists to 'Grand Challenges in Global Health Initiative' demonstrates that this is indeed the case.

To enable national development, topics for research need to be carefully selected and AR has to be followed by PAR, but this aspect is under-explored in the literature related to freedom for research. This is explored in the next section.

Exploring freedom for research from national development perspective

To contribute to national well-being, research must be followed by development of technologies that is products and processes, or to use the terminology advocated by this author, AR must be followed by PAR. Therefore, topics for research have to be carefully selected to meet this goal and this limits the freedom of the researcher in formulation of a personal research agenda. This issue is critical for all economies, but more so for developing economies as pointed out by the Kothari Commission.

> 'At present, the "centre of gravity" of Indian academic life is largely outside India. That is to say, our scholars and scientists working in fields which are internationally cultivated still tend to look outside India for judgment of their work, for intellectual models of the problems which they study, for the books they read, and for their forum of appreciation and approval… Indian problems are not seen in their concreteness and particularity and as a result, techniques and theories are not adopted to Indian situation.'[24]

Elkana and Klöpper[25] articulate it in a different manner.

> 'The fact that hundreds of new universities in China and India copy the curricula from the United States or Europe, and send many of their doctoral students to study there, results in a serious neglect of their own scholarly traditions as well as local and regional problems. ….. Since working on such problems seldom receives proper recognition, a focus on them usually does not help in building a scholar's reputation nor is it the stepping stone for a successful career. … Hence,… reorienting the system of incentives is the key to real change.'

System of incentives are at present largely based on metrics (number of publications, citations, impact factors of journals, *h*-index, etc.) defined by the interests of large corporations, who have taken over publications of all major journals. Metrics like journal impact factor were not designed for judging scholarship and achievement of scientists[26]. Reliance on citations has several pitfalls: supportive articles receiving quick citations, no differentiation between an 'extensive citation' and a supportive 'me too' citation[27]. Differentiating between 'path-breaking research' and supportive 'me too' research, Chaddah points to journal impact factor tending to reward supportive research[27].

At best, these metrics measure impact only internal to science and not on the development of products and processes, or formulation of policies, etc.[28]. Neff opines that acceptance of publication metrics for performance evaluation of university faculty amounts to scientific community ceding a significant degree of self-governance to publishing companies[28]. This ceding of control is more harmful to developing nations, and Neff illustrates this by giving the example of Mexican Science. The assumption that 'international' is superior to 'national' forces researchers to publish in pay-walled journals, not available easily in institutions in developing countries. In many cases, this steers scientists away from known knowledge needs of their country, and researchers end up in following the agenda of developed nations as also opined by Elkana and Klöpper quoted earlier[25]. By allowing science priorities, assessment of faculty, fellowship of academies and university ranking to be decided by commercial products like citation and impact factors, university faculty have reneged on their freedom of selecting areas for research. In a discipline like physics, where research problems are universal, chasing citation and impact factors pulls researchers to work on topics that may not be a national priority[28].

Many useful results across several disciplines are not made public by the developed world because of strategically drafted national export control regulations, and large corporations because of corporate interests. However, developing countries need results of research in many such areas to feed into their development efforts. University researchers do not find many such topics attractive because of priorities that are shaped by considerations other than national development.

Consideration of a higher publication rate (driven by scientometric considerations), makes researchers avoid field work[28], and post-academic research in general (author's own observation), without which new knowledge cannot feed into technology. This is despite the fact that total number of publications is not an indicator of the *significance* of the research output.

Examining doctoral research in STEM fields in universities in India

According to All India Survey of Higher Education[29], 10,023 scholars completed doctoral studies in natural sciences in the year ending on 30 September 2018 from all Higher Education Institutes (HEIs) that is universities, deemed universities and INIs, and the corresponding number for Engineering and Technology was 7160, and for medical sciences 1606. Number of doctoral graduates in STEM fields has significantly risen during the last few years, particularly in engineering from older IITs. While no data about the place of employment of doctoral graduates from India is available, many of them, particularly engineers, will head to sectors outside academia for employment. According to data from the US, about 24% of doctoral graduates in engineering were employed in academia in the year 2015 (ref. 30). The corresponding percentage for all STEM fields is 43.2%. In the EU, doctoral graduates pursuing a career outside academia is growing. In UK, about 50% of doctoral graduates enter academia[2].

Doctoral graduates are needed by academia to carry forward the process of education and research, and by workplaces to feed the knowledge economy. While it is difficult to say where the optimum lies, higher numbers of doctoral graduates from a discipline migrating for employment to fields outside academia indicates usefulness of the discipline and/or training to industry and society. Therefore, the question to be asked is, are HEIs in India equipping doctoral graduates to work in sectors outside academia? This crucially depends on selection of topics for research, and messaging given to students as a part of hidden curriculum at HEIs. Research topics selected from consideration of national requirements can equip doctoral graduates to work outside academia. The 'messaging' aspect needs to be taken up seriously by all mentors in the education system: valorization of increasingly specialized knowledge, common in universities the world over[31], should not be at the cost of praxis as working in academia is not the only option for doctoral graduates.

Members of faculty in India, in general, do not opt for any industry internship. Industrial training is an integral part of all engineering institutes and hospital internships for medical professionals, but it is not so in case of other disciplines comprising STEM. Both faculty and students of all disciplines need to be encouraged to take up an internship so as to become familiar with real life problems facing India and select them for research. Many HEIs are running external registration programmes for doctoral studies and these programmes need to be expanded and tweaked as necessary to deepen the intensity of collaboration with industry. Kasturirangan's committee has suggested using the agency of the National Research Foundation to establish such linkages[14].

There is a near absence of a culture that encourages employment of post-doctoral fellows (PDFs) in HEIs and research laboratories, but it has been made a requirement for faculty recruitment in several elite institutions. Getting a position of a PDF in a foreign university implies some alignment of the topic of research to what is of interest to universities abroad. Moreover, when a scholar takes up employment in India after return, he continues to work on the research problem taken up by him while abroad with a view to maintain contact with his peers. This is irrespective of the relevance of the work to the country.

A doctoral scholar documents results of four to five man-years of intense research work and if research topics are chosen carefully, this can provide useful inputs for the growth of the knowledge economy of the country in addition to training of manpower. Therefore, research problems to provide inputs to industry and society should be taken up on priority by faculty in HEIs. This is a call for reprioritization of research agenda and not for abandoning curiosity-driven research. As remarked earlier, several curiosity-driven activities are pursued by researchers as a serendipitous extension of their main pursuit. Still a limited number of researchers pursuing curiosity-driven research can be supported, in HEIs that are not a part of mission-oriented departments[5], provided resources required are modest and they are also contributing to solving real life problems as and when their expertise is needed.

Jalote *et al.*[32] have analysed HEIs in India with a view to classify them according to intensity of research using data uploaded by universities for ranking. They conclude that very few HEIs are research-intensive. One of the reasons is the fact that most of HEIs do not have large faculty and so cannot take up problems requiring multi-disciplinary teams. This also prevents them from taking up teaching to meet the requirements of and research on problems facing defence, space and nuclear sector and as a result, these sectors have set up their own HEIs with a focus on their requirements[5]. There is a need to increase the size of our HEIs in terms of spread of disciplines to enable them to play a much larger role in the development of the country. An alternate approach could be a deep networking of institutions using technology, and providing for the mobility of faculty.

Concluding remarks

Metrics like citations, journal impact factor, *h*-index, etc. measure the impact of research only internal to science and not on the development of products and processes, and formulation of policies, etc. Value system in academia, including for institutional ranking, should be reoriented to remove excessive reliance placed on such metrics.

Government should encourage national research laboratories and even think tanks like Niti Aayog to institute post-doctoral fellowship programmes to orient young researchers to work on national problems. While international collaborations are welcome, care needs to be exercised to ensure that they do not drive research away from the developmental needs of the country.

Academic freedom available to faculty should be exercised by them to link their research to national development. Some members of faculty are already doing it and it has to be done by more if not all of them. Management of higher education system should devise reward systems to encourage such linkage. INSA has issued a policy statement on ‘Dissemination and Evaluation of Research Output in India’ which advises moving away from scientometric indicators and stresses on ‘the nature and significance of the contributions’[33]. This has been reiterated by Chakraborty *et al.*[34] by saying that ‘assessment of scientific research output should be based on the quality of research output and NOT merely on bibliometric measures’. It is better to use the word ‘significance’ rather than ‘quality’, but one needs to elaborate as significance could be only internal to science, or national economy, or policies, etc. or a combination thereof.

Government (the policymaker), in consultation with representatives of industry, society in general and academia, should identify areas for national development and prioritize their funding, frame policies that encourage post-academic research and a direct linkage of HEIs with industry and society. It will be challenging to do so as the users of results of research (industry, society) need to be made aware of its significance and that has to be done by faculty together with government bodies. Live relationship of faculty with industry and society is a *sine qua non* for success.

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