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INVENTIONS AND INNOVATIONS - KEY ELEMENTS IN THE STRIVE FOR COMPETITIVE ADVANTAGE

- MIND TO MARKET -
THE CATALYTIC ROLE OF EDUCATIONAL AND RESEARCH AND DEVELOPMENT (R&D) INSTITUTIONS

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ABSTRACT

This paper examines the changing face of research and development (R&D) and the associated innovation processes. The demands of society have changed and these have in turn influenced the functioning of academic and R&D institutions. Those institutions have had to adapt to the newly emerging needs of society in order to remain relevant in context. The pressure is therefore on the educational institutions to develop human resources with core competencies such as leadership, communication and innovation integrated with the ability to manage, and to engage in intra and inter-organizational teamwork to allow opportunities to be sustainably exploited. It is in this context that dynamic "knowledge-networking," and the protection of value-added knowledge assets as a means of reaping optimum benefits from innovations via the various legal frameworks of intellectual property rights (IPRs), take center stage in the crafting of a vibrant global economy. On the one hand this has led to a blurring of the boundaries between disciplines and on the other it has demanded formalized frameworks for "ownership" of the developed knowledge and "benefit sharing" between partners. Such symbiotic relationships pave the way to enhancement of networks and collaboration, enrichment of educational programs with sustained knowledge renewal and the transformation of all that into tangible productive forces aiding in the creation of well-prepared human resources of an innovative culture. A fair amount of the human resources and wealth generated in the developing/least developed countries gets siphoned into developed countries with practically no "feedback" across the border. In addition to other professional expertise, institutions especially in developed and developing countries will have to master 21st-century techniques in knowledge engineering, information metering and generating, valuing and managing IPRs to face industry and society with a sense of confidence and positive responsiveness. It will essentially involve managing the intellectual property of institutions in terms of maintaining a targeted and strategic IPR portfolio, enforcing rights when necessary, transferring intellectual property rights appropriately and at the optimum value, and making collaborative linkages in tandem with the institutional business and research strategies. These will help to establish the groundwork for the much-needed "feedback" into developing and the least developed countries.

I. INTRODUCTION

1. The progress of science throughout generations has been driven by the powerful motivation to uncover and unveil the truth hidden in the realms of nature and to create multiple forms in which science is manifested in applications and technologies for the benefit of society. Innovations capitalize on intellect and experience. The aggregated steps of observation and analysis, and the linking of those steps to previous ones is a continuous process, as it helps to suggest or establish new links in the boundless search for the ultimate truth. This cumulative human experience, when overlaid with the varied shades of individual creativity, paves the way to innovations by individuals or groups of individuals which in turn forms the basis of competitiveness. The infinite ingenuity and capability of a human mind can add value through innovations with the potential for wealth creation in society.

2. The 20th century has seen explosive activity in science and technology, with the human knowledge base growning non-linearly and in several instances discontinuously in step jumps that bear fruit in the coalescence of seemingly unrelated fields, giving birth to biotechnology, information technology, smart materials, etc. These intensely knowledge-driven activities, and the enhanced competition between groups and nations, inevitably demand newer ways of thinking and organizational management of creativity, science and technology to meet the new and exciting opportunities in the arena of international trade and business. As society progresses and rapid developments take place, the intersection of science and technology with public policy becomes significant. Such dynamic relationships which stimulate, foster and monitor the “mind to market” process result in innovative differentiation and distinctiveness, which are benchmarks of a healthy society. It is acknowledged that new economic opportunities and improved social and environmental situations depend on the quality of our education and research effort. Our educational and R&D institutions have the pivotal role of creating and nurturing fertile minds that will continually contribute to the enhancement of our social and economic well-being through a process that drives innovation by capitalizing on intellect and experience. Accelerating and enhancing these activities in diverse ways especially with supportive innovation incentive policies remains a top social priority. There is an urgent need for the institutions to adapt to survive in the changing world.

II. THE CHANGING FACE OF RESEARCH AND DEVELOPMENT (R&D)

3. The shortening of product life cycles calls for continual and rapid delivery of quality innovative products, processes and services to the marketplace. Industrial development requires innovative approaches to technology creation and transfer, production, marketing and investment. Universities offer education, training, research and advisory services. The pressure is therefore on the educational institutions to develop human resources with core competencies such as leadership, communication and innovation integrated with the ability to manage, and engage in intra and interorganizational teamwork to allow opportunities to be sustainably exploited. It is in this context that dynamic knowledge-networking and protection of value-added knowledge assets, as a means of reaping optimum benefits from innovations via the various legal frameworks of intellectual property rights (IPRs), take center stage in crafting a vibrant global economy. Innovation and the effective management of technology have become a top priority for nations as well as companies, to stimulate economic development and strengthen their competitiveness. New economic opportunities and an improved social and environmental situation both depend on the quality of our education and research effort.

4. The fundamental role of intellectual property rights is to provide rational legal frameworks within which to create and establish ownership or proprietary domains of knowledge. Such protection would permit the fair sharing of knowledge with due recognition and reasonable benefits for the creator/owner of that knowledge. This form of social governance would encourage the development of innovations and evolve a sense of respect for the developed knowledge, discourage parasitic "knowledge piracy" or "free riding" and profiteering from counterfeits in the market, and help to create symbiotic relationships in society. Reasonable legal frameworks that would discourage the misuse of IPRs, while unfair and anti-social monopolistic practices should complement a strong IPR regime. Only then would society provide an ethical climate that promotes innovation and spurs productivity and investment via fair "knowledge prospecting" thereby contributing to the establishment of a competitive, non-monopolistic, balanced and humane world. Intellectual property is a system that provides for legal protection of the "added knowledge" in the existing knowledge pool, provided certain conditions are met. It does not give protection to any part of the already existing global knowledge base.

5. Over the years, research processes have undergone considerable metamorphosis especially with respect to ownership and the fair sharing of benefits.

6. In the past when research was typically compartmentalized into "upstream" (basic) research in academic institutions, funding was essentially from government sources (see figure 1). Most of the research was directed towards enriching the knowledge base, and the research workers were mainly concerned with peer recognition; benchmarking was done only though disclosure in journals, books, conferences, etc. Ownership of knowledge was not an area of concern. In contrast, innovation processes in commercial organizations were directed to business needs, which may be termed "downstream" or applied research. In such cases the main concern was to meet the business objective with less concern for matters related to enrichment of the global knowledge base. Awareness of IPRs, even within industry was marginal, and survival was due to slow innovation and long product life cycles.

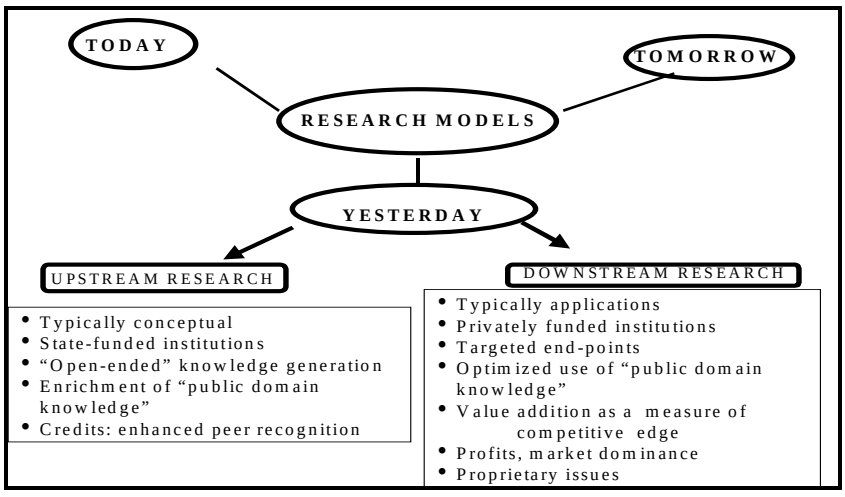

Figure 1: Research Model…YESTERDAY[1]

[1] Intellectual Property Rights…Unleashing the Knowledge Economy, P. Ganguli, (Tata McGraw-Hill, 2001).

7. With the onset of competition in the marketplace, a demand for faster innovation appeared on the horizon which catalysed industry-academic interactive processes, and those interfaces in turn brought about R&D's "midstream" mode.

8. Industry also recognized that upstream (basic) research varied in value, with portions offering the potential for immediate returns, as they were the foundations of innovative products. It was difficult to predict value in terms of quality or quantity. It is now acknowledged that most direct returns result from basic research delivering ground-breaking technology. The underlying potential of basic research rewards was the knocker that rapped on the doors of the academic institutions. The "midstream" mode of working did impart rich dividends to the industrial sector.

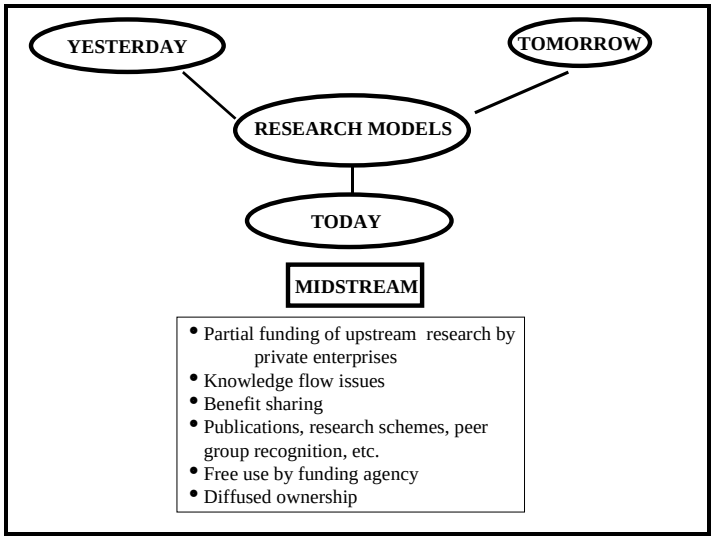

Figure 2: Research Model….TODAY[2]

9. The last decade has been an explosive period of "convergent technologies" which has loosened the boundaries between traditional science and technology areas, causing "new hybrid technologies" to evolve. It has also seen the collapse of the time scales between the "technology generation," "technology application" and "technology-trading" phases. Accelerating and enhancing the product completion process remains a top priority, and R&D processes are evolving as a complex set of operations involving optimized use of global knowledge that draw on intra-enterprise and extra-enterprise resources, including knowledge bases and expertise. Most firms are unable to meet such requirements with their limited human and knowledge resources.

[2] P. Ganguli, *op. cit.*

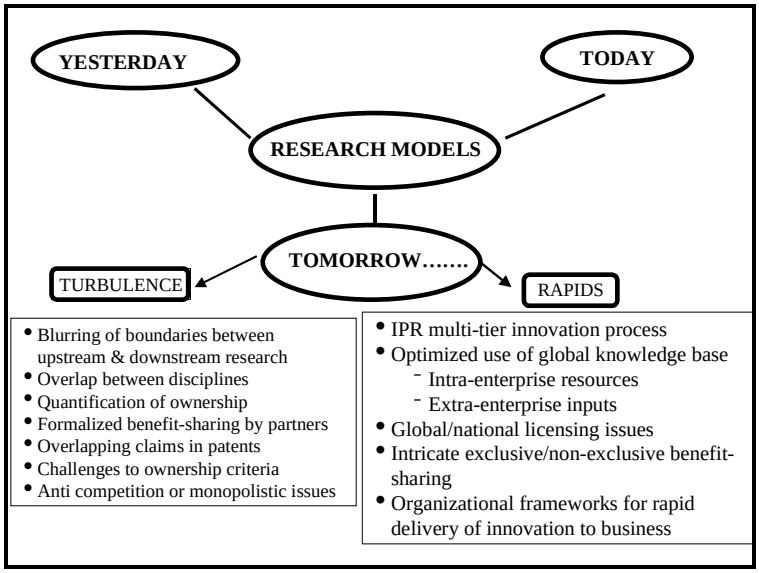

Figure 3: Research Model…TOMORROW[3]

10. Academic and industry researchers are now encouraged to work in small, multifunctional and multidisciplinary teams, with the main goal of exploring new concepts, validating them and developing products for rapid and efficient delivery to the marketplace. The global trend now is to devise cooperative research programs with incentives for business houses to develop research partnerships with academic research groups engaged in fundamental and applied research. Conventional mindsets will have to give way to operational methods in "turbulence" (complex interdisciplinary teams contributing in parts) and "rapids" (many teams contributing in parallel) modes, involving globally networked teams working in tandem. Organizational structures are now being re-engineered to function in these new ways for the rapid delivery of innovations to the market. A clearly structured "Memorandum of Understanding (MOU)" in which IPRs will play a decisive role will preside over relationships between participating teams.

11. Through such relationships, the industry gains access to world-class research resources and the best of human resources. Such collaboration imparts to the academic institutions a sense of purpose, exposing them to the demands of the market and suggesting to them the creation of knowledge that can lead to new products and technologies which are further developed by their private sponsors. In turn the faculty and students who participate in such programs are exposed to future technologies, markets, business opportunities and new career options. Such symbiotic relationships pave the way to enhanced networks and collaboration, enrichment of educational programs with sustained knowledge renewal and the transformation of all that into tangible productive forces aiding in the creation of well-prepared human resources of an innovative culture.

12. On the one hand this has led to the blurring of boundaries between disciplines and on the other it has imposed formalized frameworks on "ownership" of the developed knowledge and "benefit-sharing" between partners. The creation of niche domains of knowledge and their effective management are issues that institutions will have to cope with. In such a working relationship the collaborating partners would freely share all knowledge, information and resources. To sustain innovation in such frameworks, organizations need to make it part of their value systems.

[3] P. Ganguli, *op. cit.*

13. The future competitive advantage of knowledge-based activities will be determined primarily by their ability to create, market and manage "value-added" intellectual assets at speed in order to derive "first in the market" advantage in a framework of self-sustained innovation. Contract research, sponsored collaboration, cross-functional teams between competitors, industry-university joint projects and the like are modes of operation that are increasing exponentially. Contract research has gained considerable ground in the last few years, reaching a value of $3.9 billion at a growth rate of 20 to 30 per cent per annum, most of which is contributed by the pharmaceutical industry. Working with high-tech companies also involves developing complex licensing agreements. For example, several small companies with niche technologies have gone into partnership with very large companies to market their products internationally, and the larger company has managed IPR protection in various countries on behalf of the small one. Technology intelligence has to become an integral part of the innovation process, and organizations will be able to identify opportunities rather than have their strategy guided by threats.

14. A new area that has emerged in the last decade is the concept of "Technology Business Incubators" in which researchers, having become entrepreneurs within their academic institutions, are able to start spin offs and to market their work. Globally, such venture-backed companies have produced a disproportionate share of new, particularly well-paid and highly-skilled jobs, and are a key source of R&D spending. Governments are becoming increasingly aware and supportive of venture capital investment. Academic institutions and R&D organizations will have to change their working and administrative cultures to promote such set-ups. A good idea is seldom enough to ensure success in today's competitive market. Delivering value in the marketplace and securing worldwide IPRs are the two key factors of competitiveness. Leading companies are distinguished by their success in managing this innovation process. Meaningful national policies on IPRs can be expected to build up a nation's innovation rate and innovative spirit.

15. In the United States of America, one of the earliest attempts to promote awareness of and enhance the economic utility of academic research was the passage of the Bayh-Dole Act (Public Law 96 - 517). It allows institutions to own the patents that arise out of Federally-sponsored research.[4] Under the Act universities would not develop patented technologies themselves, but would license the patents to industry. A provision of the Act allowed the universities to retain royalties from such licenses, and specified that a fraction of them would be shared with the inventors as personal income. The effect of the Act was that US patents granted to American universities rose from 300 in 1980 to 2,000 in 1995, while the universities granted around 5,396 licenses between 1991 and 1995. More than 250 new companies were formed directly through university licenses in 1996; the total since the advent of the Bayh-Dole Act in 1980 is 1,900.

16. This has brought the academic community to a new way of thinking, but several contradictory issues do still need to be resolved: industries funding research or taking licenses would like to have some sort of exclusivity. The universities, as a part of their academic and peer group recognition, would insist on publishing the results, possibly after filing patent applications; industry may not favor disclosing the details of the findings to the public at such an early stage; strategic trade-offs have to be arrived at; newer ways of group working between academics and industry have to evolve, which would take care of the professional and developmental needs of the academics and the competitive commercial interests of industry. We need to adopt whatever supportive legislation suits our country.

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[4] The Rise of IPR in the American University: L. Nelsen, Science, 279, No. 5356, 1998.

17. All knowledge-related activities such as the work of accessing, creating, generating, trading and applying knowledge are intimately connected to IPRs and their enforcement. All features of IPRs are therefore linked to project management, as they significantly influence decision-making at various stages of project dynamics. Even as projects are conceived and strategies planned, the relevant IPR linked to the subject needs to be mapped so that appropriate technology/product protection "grid-maps" can be constructed. These can be used to arrive at decisions on the trajectory of the project. In the course of the projects decisions will have to be taken on the following stages:

- when applications for IPRs should be initiated;

- when disclosures in terms of publications/announcements, presentations to professional bodies, etc., have to be made; or

- when the possibility of early licensing of the results should be explored, partners sought for joint working alliances and marketing, and so on.

18. This millennium will see significant progress in industry-university alliances, the evolution of centers of specialized excellence, cross-border collaboration with globally networked teams performing in a value-added chain. Institutions that are unable to adjust to the emerging realities will either be marginalized or cease to exist.

III. NATIONAL DEVELOPMENT IN A GLOBAL CONTEXT

19. Some of the keys to a nation's progress lie in literacy levels, education, information and knowledge proliferation, and the advancement and effective utilization of science and technology (S&T). The knowledge economy has clearly established that countries in possession of superior knowledge and capability in innovative S&T supported by a progressive industrial climate are able to attract high levels of foreign investment and chart a speedy course of technological innovation leading to faster national development.

20. We should examine the processes and the dynamics of the innovation systems in the developing, least developed and industrialized nations if we are to devise recommendations for a meaningful framework for national R&D and innovation policy.

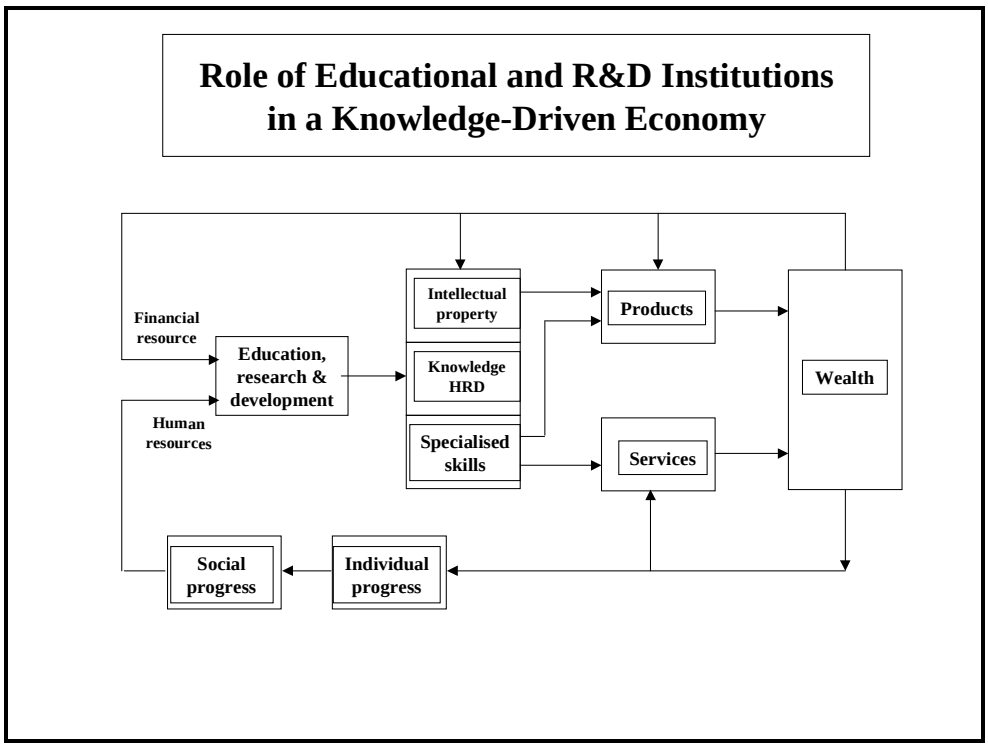

Figure 4: Wealth Generation Model[5]

21. Figure 4 above depicts an innovation model of wealth generation and distribution in a knowledge-driven economy. The model is predicated on the assumption that academic institutions and the social system (including industry) are in a dynamic state with a multi-parameter feedback system that produces individual growth, social progress, and the sustainable development of human and financial resources and infrastructure. Suryanarayan's second innovation model (figure 5) studies the linkages and flow systems in a framework involving developed and developing/least developed countries.

22. As shown in figure 5 (next page), a fair amount of the human resources and wealth generated in developing/least developed countries gets siphoned into developed countries with practically no "feedback" across the border. It will be noted that, in most developing/least developed countries, the innovation system appears able to produce innovations in the "service" sector through the latter's human resources, but are unable to produce any significant, globally competitive and marketable products as compared with developed countries. This anomaly needs to be urgently addressed.

[5] Presentation by S. Suryanarayan, at the XVI[th] National Convention of Aerospace Engineering, Hyderabad, India, April 5 and 6, 2002.

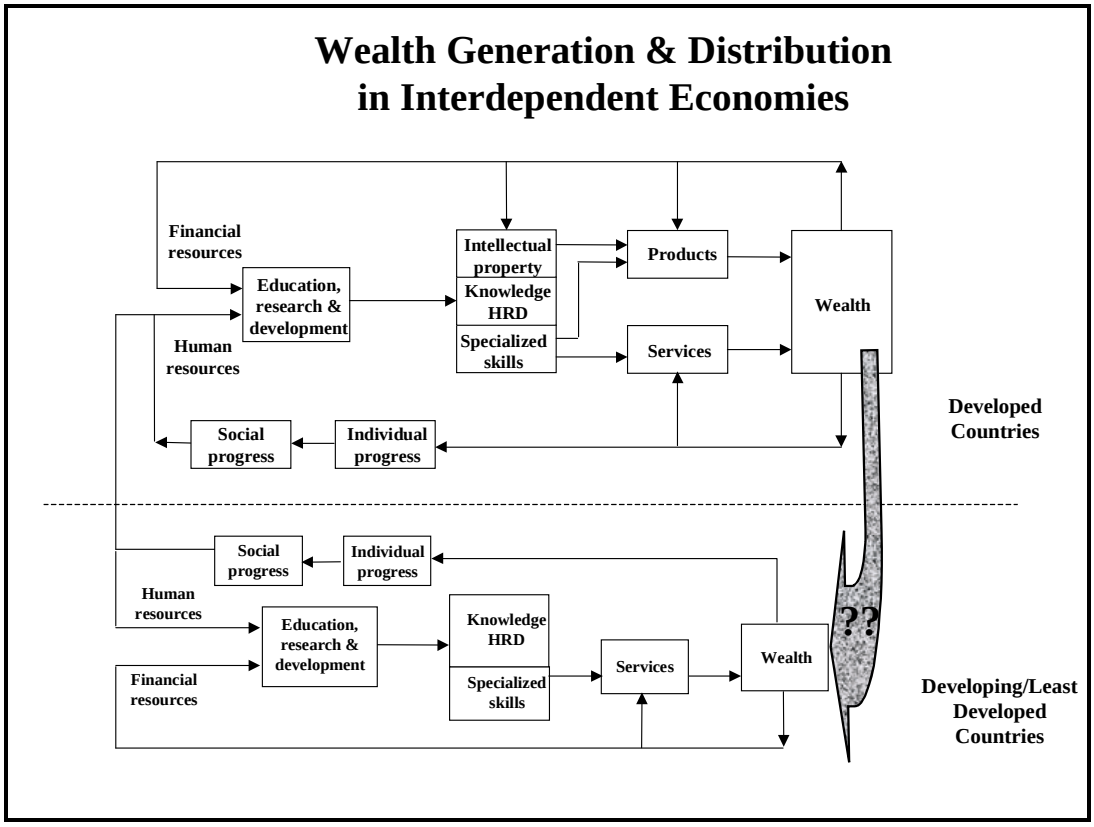

Figure 5: Wealth Generation and Distribution in Interdependent Economies[6]

IV. CONCLUSION

23. Along with other professional expertise, institutions especially in the developed and developing countries will have to acquire 21st-century techniques in knowledge engineering, information metering, and generating, valuing and managing IPRs to face the industry and society with a sense of confidence and positive responsiveness. It will essentially involve managing the intellectual property of the institution in terms of maintaining a targeted and strategic IPR portfolio, enforcing rights when necessary, transferring IPRs appropriately and at the optimum value, and making collaborative linkages in tandem with the institutional business and research strategies. These will help to establish the groundwork for the much-needed "feedback" illustrated in figure 5. Successful management of intellectual assets requires an integrated approach across the major domains of knowledge, which include discoveries and innovations, people and organizational designs, and the linking of innovation management either to the overall national strategy or to sustained growth.

24. We need to make a critical examination of the parameters that would create, promote and activate the feedback with which to establish a symbiotic relationship in the continuous innovation stream which would support the potential reinvigoration of the innovation process in organizations and work for the overall social good. National policies on R&D and technology, industry and commerce and human resource development, coupled with a strong and enforceable IPR regime, would play a major role in such creations.

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6 S. Suryanarayan, *op. cit.*