# TECHNOLOGY POLICY IN A VISION FOR THE FUTURE

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Under the chairmanship of Dr. A. P. J. Abdul Kalam, the Consultative Group of Eminent Senior Scientists has produced a Draft Technology Policy statement (Appendix A). In that statement, the Vision for India's technology has been stated to be:

> *India will compete ably and thrive in the world economy by innovating, manufacturing and trading high quality and high-tech products across international boundaries by (a) training her engineers and technologists to international standards, (b) encouraging them to innovate by rewarding them and their institutions with both real and psychic income (c) integrating technology with cultural, social and economic development processes and (d) maximizing employment through appropriate technologies.*
>
> *India will emerge as a major proprietor of intellectual products.*

With this Vision in view, the following objectives have been advocated in that Draft Policy:

- *To make Indian technology and industry internationally so competitive as to dispense with the need of having to seek any trade protection.*

- *To make India technologically so advanced that it will import, and not export, talented people.*

- *To deploy technology to promote good quality of life, thereby ensuring (a) good health and education (b) quality of air, water and soil, (c) smooth flow of goods and people, and (d) free flow of information and access to knowledge.*

- *To use technology to (a) minimize disparities by reducing poverty and not wealth, (b) maximize employment both by matching skills to the dictates of innovation and by promoting employment multiplication, and (c) make India self-reliant in selective areas of technology, ridding the need of importing it under duress.*

- *To investigate and utilize indigenous techniques (including medicine) and make India a self-reliant advanced nation.*

- *To ensure that S&T Policy is output driven through optimum utilization of public investments in Science and Technology and thereby realize strategic outcomes and competencies identified for various sectors.*

## ISSUES

There is no doubt that both the Vision statement and the targeted objectives set up an attractive challenge for the future development of the country. At the same time, the following issues have to be addressed before this Vision can become a reality:

- While the government's contribution to R&D (around 0.6-0.7 per cent of GNP) is comparable with the best in the world, industry's contribution is barely 0.1 per cent - twenty-thirty times less than that in developed countries.

- As a result, Indian industry is characterised by repetitive imports of technology with next to no absorption of whatever technology had been purchased earlier.

- While the country can be proud of being self reliant in many strategic areas (including space technology and nuclear energy), the quality of even the simplest manufactured products - electrical switches and water taps for instance - is woefully poor.

- Technology development is inherently risky with low probability of success. The country has no culture, or system, of venture capital that can finance and nurture promising ideas. So, Indian laboratories boast of many innovations but few of them ever reach the market.

- Technical education is beyond the means of most families. So, much youthful talent goes waste. Even the few who manage to get such education largely migrate abroad.

- Technical education and careers are mainly reserved on a caste basis. That too denies many talented children an opportunity to shine in the profession.

- On ecological issues, the tendency is either to exaggerate the cost or magnify the benefits of new technology. There is no system in the country for addressing the issue dispassionately and to maximise the ecological-cost to economic-benefit ratio.

- There are well-organised groups that violently reject technology change for various reasons. That has made it very costly to adopt many technology advances in spite of their benefits.
- Most departments in the government have specific rules that discriminate against indigenous technology and instead encourage indiscriminate imports in its place.
- Technology imports have become a major source of political and bureaucratic corruption.
- There is an incorrect view that India has a large manpower base in science and technology. Table 1 shows how poor India really is in this respect.

**Table 1. A Comparison of S&T Manpower in India and Other Countries**

| Country | Scientists and Technicians per 1000 of population | R&D Scientists per 10,000 of population |
|---|---|---|
| **China** | 4 | -- |
| **Germany** | 86 | 47 |
| **Israel** | 76 | 59 |
| **Japan** | 110 | 60 |
| **Korea** | 61 | 22 |
| **USA** | 55 | -- |
| **India** | 1.2 | 2.5 |

## IMPORTANCE OF TECHNOLOGY

In this day and age, it may be considered superfluous to stress the vital importance of technology in economic development. Yet, that is necessary because there is a strong conviction that it is capital that drives the economy more than any other factor.

Annual budgets, Five-year Plans, company reports make a great play about capital investment. While money is critical, it is not the most important contributor to a nation's growth. Denison has calculated (Table 2) the factors that contributed to the growth of the United States between 1929 and 1982. He found that as much as 64 per cent of that growth was attributable to advances in knowledge (that is, to R&D). Education came next with 30 per cent whereas the direct contribution of finance and capital was barely ten per cent. Management and economies of scale too contributed more than capital did. Similar conclusions were arrived at by Solow too.

**Table 2. Components of GNP Growth in United States: 1929-82**

| Type | Share |
|---|---|
| Labour input except education | - 23 |
| Education per worker | 30 |
| Capital | 10 |
| Advances in knowledge (R&D) | 64 |
| Better resource allocation (management) | 19 |
| Economies of scale | 20 |
| Land | - 4 |
| Other determinants | - 20 |

Unfortunately, Indian businessmen, and planners too, have an ineradicable conviction that money is all. They and the labour leadership too have a morbid fear of technology change. For instance, as late as 1985, the Government of Kerala banned outright the use of computers in any of its establishments.

Indian businessmen feel that they are too poor to support education and R&D. It is more than likely that they are poor only because they do NOT support education and R&D. Incidentally, according to Denison, economies of scale accounted for 20 per cent of American growth. It appears possible that India's ideological support to small-scale industries and the government's aversion to economies of scale have impeded the country's development substantially.

**Box. 1. Limitations of the East Asian Model**

Long before the East Asian meltdown, Paul Krugman correctly predicted that the East Asians were merely paper tigers. Writing in 1994 in the journal *Foreign Affairs,* he said:

Consider in particular the case of Singapore. Between 1966 and 1980, the Singaporean economy grew a remarkable 8.5 per cent per annum, three times as fast as the United States; per capita income grew at a 6.6 per cent, roughly doubling every decade. This achievement appears to be a kind of economic miracle. But the miracle turns out to have been based on perspiration than inspiration: Singapore grew through a mobilisation of resources that would have done Stalin proud. The employed share of the population grew from 27 per cent to 51 per cent. The educational standards of that workforce were dramatically upgraded: while in 1966, half the workers had no formal education at all, by 1990, two-thirds had completed secondary education. Above all, the country had made an awesome investment in physical capital: investment as a share of output rose from 11 to more than 40 per cent.

. . . these numbers should make it obvious that Singapore's growth has been based largely on one-time changes in behaviour that cannot be repeated. Over the past generation, the percentage of people employed has almost doubled; it cannot double again. A half-educated workforce has been replaced by one in which the bulk of workers have high school diplomas; it is unlikely that a generation from now most Singaporeans will have Ph.D.s. And an investment share of 40 per cent is high by any standard; a share of 70 per cent will be ridiculous. So, one can immediately conclude that Singapore is unlikely to achieve future growth rates comparable to those of the past.

But it is only when one actually does the quantitative accounting that the astonishing result emerges: all of Singapore's growth can be explained by increases in measured inputs. There is no sign at all of increased efficiency. . . . .once one allows for their rapid growth of inputs, the productivity performance of the "Tigers" falls from "the heights of Olympus to the plains of Thessaly"

At the rate India is progressing, it will take 100 years to attain the per capita GNP South Korea reached by 1995. Evidently there is something wrong with our economic policies. The mistake is our policy makers worship Lakshmi instead of Saraswati. Both deities do contribute to economic growth but with a difference. Korea has depended more on Saraswati than on Lakshmi and prospered to the envy of most nations; India has done the reverse and has remained poor.

## THE EAST-ASIAN MODEL

East Asian countries are by far the most successful practitioners of capital-led growth. Paul Krugman has explained that the East Asian Model depends on increasing the inputs of labour and capital; the Western one on increasing the efficiency of utilisation of those two inputs – through technology innovation. According to Krugman (Box 1), the East Asian Model is liable to get saturated on the labour front once the entire population is put to work. Similarly on the capital side, saturation will be the result when savings and foreign investment reach their peak. Further, as foreign investment is notoriously fickle, the risk is not merely saturation but instability – as demonstrated already by East Asian countries. In contrast, innovation-led development is relatively autonomous, and hence, more stable. In particular, so long as there is worthwhile innovation, there is little risk of recession. So long as a nation is building better and better mousetraps, there is little risk of shortage of customers! However, it must be said to the credit of East Asian countries that after a foundation of capital-led growth, they are now investing heavily in R&D and in higher education too. In other words, the East Asian economies are receptive to criticism while Indians are more likely to be resentful of criticism. It is also a fact that while the East Asian economies look forward to a future better than the past, Indians have a tendency to look backward with longing to a pre-historic "Golden Age".

There is another reason why India may not succeed in adopting the East Asian model. Small countries - Singapore, or at the most Malaysia - can prosper through capital-driven growth. For a large population like India's, *similar level of per capita* foreign direct investment is next to impossible. Even if such massive foreign investment materialises, that capital may be used only for the kind of goods that have been discarded by developed countries, and hence have low profit margins - television sets, for instance. Further, whatever niche there was for a large country appears to have been captured already by China.

Imported technology is like a banana peel, the fruit from which all value has been extracted, and which can yield only a marginal profit. Small countries can prosper by selling a million TV sets at comparatively low profit margins. Taking that route, India will have to export hundreds of million sets for which a market is just not available. So, being a large country, India can prosper only by exporting products with large profit margins – that means, innovative products that will emerge only from high quality education and innovative R&D.

## CULTURE AS AN IMPEDANCE TO TECHNOLOGY DEVELOPMENT

According to Olson[1], there can only be two reasons why some countries are rich and others are poor: (a) differences in factor endowments (namely, land, labour, capital and technology), or (b) differences in environment. Olson concludes that, of the two, it is the environment that is crucial. Considering the vastly different economic wealth of neighbouring countries with similar endowments, (United States and Mexico, South and North Koreas, or former West and East Germany), wealth and poverty cannot be the result of differences in factor endowments but due to faults in political policies and institutions.

It may be argued that poor countries are poor because their people are unskilled. It sounds reasonable to argue that people in developed countries are more capable, better skilled, better educated, better trained and so on. According to Olson, that argument too is not tenable. He points out that immigrants from poor countries outperform natives of rich countries. So, India has *more talented people than United States has,* but loses them all due to brain drain.

According to Olson, technology is purchasable, capital is available, and the supply of high quality labour is more than the demand. That leaves only one more factor of production, namely, land and mineral wealth. It is true that there is greater pressure on land in India than in the USA. But many other countries like Japan have practically no natural resources and yet support much larger population densities. Land is critical only for an agricultural society and not in a modern one.

***Appropriate Technology:*** True to the Gandhian spirit, many people in the country favour Appropriate technology, more accurately described as traditional craft technology. While it has its uses, it has its limitations too. For instance,

a. A bullock cart: cannot provide the same quantity or quality of service as a motorised vehicle.
b. It does also pollute – relative to the quantity of service provided, its biological pollution is high, overall more polluting than a motor vehicle
c. Relative to quantity of service, its capital/ running costs is high.
d. It cannot generate high incomes

***Social Activism:*** Social activists, like anti-dam groups, are a major force arraigned against technology development. They are right in so far as they alert the community against the dangers of ecological disaster or social injustice. They are likely to be wrong to the extent they over estimate the costs and under value the benefits of change. By the same token, technologists are likely to under estimate the costs and over value the benefits. The contrasting culture of the two groups (Table 3) indicates how the two will affect technological progress.

**Table 3. A comparison of Social Activists with Technologists**

| **Social Activists** | **Engineers and Administrators** |
|---|---|
| Insist on zero-cost solutions | Insist that there is no free lunch |
| Treat single issue as paramount | Accept some costs as inevitable |
| Insensitive to secondary consequences | Down play direct consequences |
| No hesitation to break the law | Constrained to act within the law |
| Offer simplistic solutions | Must make their designs work |
| Opposed to innovation | Experiment with technology |
| Seek to avoid poverty | Try to generate wealth |
| Have high communications skills | Maegre communication skills |

Without in any way belittling the concerns advocated by social activists, it must be stated that social activists do impede rational development. If ecologists had been active at the time Bhakra was being built, and most of Bilaspur town was submerged,

[1] Mancur Olson Jr., *Big bills on the sidewalk: Why some countries are rich and others are poor,* The Journal of Economic Perspectives, 1996.

that dam would never have been built, there would have been no Green Revolution, and millions would have perished of malnutrition if not by outright starvation. It is even debatable whether their methods will bring prosperity to the people whose cause they claim to espouse – they are more likely to perpetuate their present dismal poverty.

***Preference for Imports:*** Except where it is entirely unavoidable, Indian administrators (whether in the public or in the private sector) fear to try local designs. They consider that well-worn imported designs alone are risk free. For instance, it is the official policy in the Department of Telecommunications (and in others too) not to procure any equipment unless it has been used for a minimum of two years. As a result, Indian designs face a Catch-22 situation: They will not be accepted unless they have been in use, and they cannot be in use until they are tried out!

So, except when foreign technology is not available at all (as in defence, atomic energy and space), Indian designs do not get a chance to prove their worth. Private industry too is no different. They want swadeshi *only for manufacturing operations but not for technology*. In the bargain, predatory MNCs often trade on this weakness for imports and attempt to destroy any Indian technology that can prove a threat to their own hegemony. Such predatory tactics are not rare; they are, in fact, quite common[2]. While it would be unfair to tar all foreign firms, it would be unwise not to protect the country from such threats.

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[2] The following three examples illustrate the point.

- In 1991, several European suppliers demanded around Rs. 1500 million to supply a communication system for the Indian Navy. When the navy approached US manufacturers with whom, for political reasons, India had had no contacts earlier, they quoted a price of Rs. 150 million only. Not expecting the Indian government to go to Americans, apparently, the Europeans had not included the US in their cartel.
- In another instance, India's aircraft carrier, INS Vikrant was in need of a re-fit for a guidance equipment for landing aircraft. The price quoted by a French firm was Rs. 9.5 million. Finally, IIT Delhi developed the same at a cost Rs. one million only.
- Recently, an American firm quoted Rs. 7.5 million for a piece of railway electronic equipment, but when IIT Delhi succeeded in developing a local version, the price was brought down nearly 80 per cent to Rs. 1.7 million.

In two articles entitled "Who Is Us?" and "Who Is Them?"[3] Robert B. Reich, the former US Labour Secretary argues that the labour force is always "Us" but the owners may or, may not be – even if they are citizens. According to Reich, the Corporation is "profoundly less relevant to . . . economic future than the skills, the training and knowledge commanded by . . . workers". He adds that control and ownership of corporations is NOT important. “What is crucial is how much corporations invest in the future capability of the workers, and how far they employ local scientists, engineers and technicians in R&D. A corporation which invests in the training and upgrading of human capital is “Ours” even if it is owned by foreigners; a corporation which does not invest in human capital is not “Ours” even if owned by our own citizens.”

According to Reich, financial capital is fluid; international capital movements are far simpler and easier than international movements of human capital. So, human capital is reliable; financial capital is ephemeral and untrustworthy. Further, as a rule, financial capital chases human capital – that is why so many software firms are coming to India. Or, if we have human capital, we need not worry about financial capital. The converse is not true. That makes skilled work force a more reliable asset than financial capital. Development based on human capital is dependable; that based on financial capital is undependable. As he says:

> *"well-trained workers attract global corporations, which invest and give the workers good jobs; the good jobs, in turn, generate additional training and experience. As skills move upward and skill accumulates, a nation's citizens add more and more value to the world – -and command greater and greater compensation from the world, improving the country's standard of living."*

Then, an Indian owned firm, even if it is a Public Sector Undertaking is NOT one of "ours" if it is wedded to imported technology. In contrast, any foreign firm that brings in new technology, new management, new skills and invests in R and D employing Indian scientists, engineers and technicians, is truly one of "ours"!

***Economies of Scale:*** In his analysis of the growth of the United States, Denison estimates that Economies of Scale contributed towards 19 per cent of the total. That was twice as much as capital did. Evidently, the managerial ability to handle larger

[3] Robert Reich, *Harvard Business Review, 1991.*

and larger system is an important factor in economic growth. That is an area where India is indeed weak. Small scale industries get so many tax incentives and are allowed to evade so many taxes, that it is NOT profitable for them to expand to a globally competitive size. As a corollary, there is no incentive to invest in R&D and keep pace with global advances in technology. That is a double jeopardy – the country loses out both by poor technology and lack of economies of scale.

***Indifference to Time Management:*** In India, there is insufficient awareness that growth has two elements, material increase and the time taken to achieve it. If time of implementation is halved, for the same increase, growth will be doubled. In India, delays and impedances are seen as a source of power, not as a loss of face. Indian officials see both monetary and psychological profit in impedance. So diseconomy of scale prevails. Or, economy of scale will take root in India if the penalties are so imposed that they cause either monetary or psychological injury on those who impede, and act as bottlenecks and not as lubricants and rewards are granted on those who act like lubricants. In India, there is currently so much fascination for impedance that few people are consciously aware of the extent they practice it, or how it erupts in every kind of transactions. That is particularly true in any issue that concerns technology innovation – the most critical factor in economic growth.

## TECHNICAL EDUCATION

According to Denison, the contribution of education and skill building to economic development is next only to that made by technology. In a way, India can boast of having over 800 engineering colleges; many more are being added almost every week. However, most of them are expensive and yet the quality is poor. Table 5 compares some features of IITs with those of the MIT, United States. The main difference between the two lies in endowments – MIT is rich and can afford to subsidise education for needy students. Indian institutions have no such resource, not even IITs. In brief:

a. Technical education is costly and affordable only by the very rich unless heavily subsidised.

b. Such subsidies may not be available from the government, or it may be inadvisable to be dependent on the state.

c. That leaves no option but to depend on business to secure enough endowments to make education widely affordable.

Table 4. University Financing – A Comparison

| Item | MIT, Cambridge, USA | IITs |
|---|---|---|
| Salaries | 5000 perchis | 30,000 perchis |
| R&D Income | 60 % | 10 % |
| Fees Income | 13 % | 20 % |
| Endowments | 23 % | 2 % |
| Fees Rate | 600 perchis | 3000 perchis |

Perchi = national per capita average hourly income

d. Business will offer such endowments only when it sees value in it. Hence, universities should tune the education they proffer to business needs.

Such attunement will benefit universities too because that will ground their theoretical studies to the actual state of the real world.

## SCIENCE AND TECHNOLOGY ENTREPRENEUR PARKS

In the nineteenth century, the United States established a number of universities with large land grants. The produce from that land supported agricultural research and education to such an extent that those universities were largely self-supporting. A similar exercise is needed for engineering institutions too. Then, engineering universities may be established with land granted for Science and Technology Entrepreneur Parks (STEP). If the STEPs are large enough, the commercial rent from the firms located there could meet most of the cost of technical education. That is one way of bringing down student fees to 15 per cent of the total.

**BOX 2. THE RENSSELAER TECHNOLOGY PARK**

The Rensselaer Technology Park (Rensselaer Polytechnic Institute) is the owner/developer/operator of multi-tenant rental space in the Park which extends over 1250 contiguous acres with 450 acres of commercial space, 150 acres for housing, 150 acres of river frontage for parks and conference facilities and remaining 500 acres left as nature reserve. The Park has a road network built to highway specifications and all underground utility services, including: fibre-optic cabling, power from two separate sources internally looped, telephone, natural gas, public water and sanitary and storm sewers. Buildings have been designed as one story, highly flexible/adaptable space to accommodate technology enterprises ranging from the sophisticated needs of computer environments and research labs to the provision of conventional office and manufacturing space. Development of the Park is guided by a Master Plan and regulated by Covenants and Development Standards. The intention is to assure standards of development that are characterised by quality and consistency without imposing cumbersome bureaucracy. The standards address such things as density and open space requirements, building setbacks, parking requirements, drainage, waste disposal, noise, air quality, landscaping, building design and materials specifications, etc. It is the policy of the university that *parcels will only be available on a land lease basis. Land will not be sold.*

The Department of Science and Technology, Government of India has established Science and Technology Entrepreneurship Parks (STEP) in a number of engineering colleges. Funds are provided jointly by the DST and by Financial Institutions (IDBI, ICICI & IFCI) with the aim of (a) nurturing innovation and S&T based entrepreneurship and (b) fostering linkages between academic institutions and industry. The STEPs provide basic services and offer guidance to budding as well as existing entrepreneurs. So far, 13 STEPs have been established in and around academic institutions of excellence spread all over the country. The programme has so far resulted in setting up of more than 600 new enterprises employing a capital of about Rs. 50 crores. These units have a turnover of nearly 88 crores and provide direct employment for about 5000 persons. Further, skill development and other programmes have generated employment for another 6000 persons.

There is also an Incubator Program designed to help launch new ventures, which will typically "graduate" in two to three years. Rentals progressively increase with duration of occupation to deter lessees from overstaying.

These are impressive results. However, they fade into insignificance compared to experience elsewhere – Tsinghua University in Beijing claims to generates all by itself US$ 200 million a year.

As an alternative to STEP, several electronics parks have come up in recent years. Unlike STEP, which is linked to an academic institution, the Electronics Parks (at times called Hi-Tec Cities) are independent systems and cost a hundred times more. They are also much closer to industry. They emulate international standards of construction, total commercial orientation. They are located in expensive congested cities. So, their costs are high. So far, they have shown little interest in basic research or on education in its true sense.

Box 3 describes the features of the STEP established by the Rensselaer Polytechnic Institute (RPI) in the United States. The RPI lays as much emphasis on the environment as on technological services. It is as much a case of habitat development as one of establishing industrial services. It seeks to attract very small entrepreneurs with fewer than ten employees as zealously as it pursues large multi-nationals. Few STEPs in India can claim to have a Master Plan let alone a vision for an environmentally attractive habitat. The Technology Parks in RPI and other universities are huge; Indian attempts are puny in comparison and are unlikely to be commercially viable.

As the Box item tells, the RPI is highly concerned about a pleasant, garden environment. That may appear an unwarranted luxury for a poor country like India. There are two reasons why that view is wrong. During a visit to Delhi, the Lord Mayor of London was asked by Indian businessmen how the City of London manages to attract investment as well as it does. His reply was that it was because the streets in London are cleaned six times a day! Modern investors are put off by dirt and squalour. When they can enjoy a high Quality of Life elsewhere, investors and technologists see no reason to come to places that are at best untidy and at worst repulsive. So, for a STEP to attract business and particularly foreign investment, it must pay as much attention to aesthetics as to technical services.

***Incubators:*** RPI has made a provision for both STEP and for Technology Incubators. Basically, STEP supports new technology industries that may or may not be based on innovation. STEP is a for-profit commercial venture of the university, but those profits are used only for the advancement of education. Incubators are different. They are meant to support innovations and nurse them till they become commercially viable. An industry established in a STEP may continue indefinitely, but the lease in an Incubator is for short periods only, typically not more than three years, rarely if ever, more than five years. So, there is a planned turnover in Incubators that is absent in STEPs. The Mission statement adopted recently by the Department of Science and technology and the Asia-Pacific Centre for Transfer of Technology (an arm of the UNDP) is given in Box 4.

## MOTIVATING SCIENTISTS

Failure to retain quality scientists and technologists and losing them through brain drain is a glaring failure of technology management in India and arguably the prime reason for the country's poor showing in technology. The tragedy is that most policy makers are not even concerned about it - possibly because, quite often, their own children are part of the brain drain. As Donald Christiansen, the IEEE editor has said[4]:

> *A country that trains its engineers and technologists well, then rewards them with both real and psychic income, should have little trouble competing in a world economy that thrives on trading high quality, high tech products over international boundaries.*

Here is good advice that the Indian government would do well to follow. The operative words here are "psychic income". For scientists, that comes in the form of recognition by world-renowned scholars. In ancient times, a pundit was respected only when his ability was acknowledged by experts in Banaras. These days, researchers and designers need similar recognition by experts gathered in international conferences. Attending such conferences is considered so important that the National Science Foundation is known to return a project proposal if too little had been budgeted for travel. Its philosophy is that a work worth doing is worth disseminating to a gathering of experts. In India, such travel is considered a waste and provided only under humiliating conditions.

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[4] Christiansen, Donald, *Engineering Excellence: Cultural and Organisational Factors,* New York, 1987, IEEE Press.

In particular, teachers' reputations are made by their students. At present, few youngsters are willing to take up research. That has become so serious that even

> **BOX 3. MISSION STATEMENT FOR INCUBATORS**
>
> Establishing Technology Business Incubators either independently or in reputed academic institutions and R&D centres,
>
> Instituting policy frameworks, administrative systems and statutes to promote innovation and knowledge-driven businesses,
>
> Networking knowledge centres, industries and governments, both nationally and internationally, to promote entrepreneurs,
>
> Obtaining appropriate financial support from governments, private investors and from multi-lateral agencies,
>
> Creating awareness of incubation concepts among the community, the state and business organisations,
>
> Sponsoring appropriate programmes for exchange of experiences among experts on Incubators from various countries,
>
> And ensuring equity for all stakeholders as also rapid improvement in the Quality of Life for humanity at large.

those who do not mind low Indian salaries, are deterred from taking up teaching positions even in reputed institutions such as the IITs. That problem will be remedied only when research stipends become as attractive as career jobs in industry.

Administrators, including lowly clerical staff, rule scientists with an iron hand and allow next to no autonomy. Lack of opportunities for social intercourse with reputed researchers the world over, absence of autonomy and poor remuneration are the three major causes of brain drain. For these reasons, the following performance based rewards are suggested to recognise outstanding performance and to separate it from mediocrity.

a. Every time a scientist has a paper accepted in a reputed, refereed international journal, a travel grant will be given as a reward to attend an international conference.

b. R&D project investigators will have the powers of a Head of Department to authorise expenditure out of those project funds without seeking approval from any other authority.

c. Research assistantships should be instituted in large numbers with remuneration competitive with industry but only on contracts for a period of 5-6 years.

**Table 5. A Comparison of Administrators and Technology Managers**

| Government Administrators | Technology Managers |
|---|---|
| Must follow rules/ precedence strictly | Expected to innovate all the time. |
| Hierarchical; authority is determined by the position held | Culture of peer system; professional reputation determines influence |
| Adequate if nationally competitive | Must be globally competitive |
| Command little value abroad | Command a world market for expertise |
| Seniority, experience paramount | Productive mainly in young age |
| Subservient to the organisation | Individualistic; elitist |
| Good administrators are extroverts | Good scientists are often introverts |
| Personality critical for success | Scholarship critical for success |
| Tasks are specific, must be done and persons may be interchanged | Task matched to personal expertise; technology can be exchanged |
| Transfers are routine; deemed useful | Transfers rare deemed harmful |

## MANAGING TECHNOLOGY

Indian technology output is less than its potential in so many different ways that there must indeed be serious flaws in its management. A set of corrective steps have been indicated in Box 4. The issues identified are brain drain, import bias, career insecurity, competitiveness, economic justice, and ecology. The first three require correctives. The others can be expected to materialise when the first three issues are tackled.

There is a sincerely held belief in the country that it is money, and not technology, that is the prime Driving Force of economic development. As a consequence, administrators, concentrate negatively on financial control rather than positively on technology development. As shown in Table 4, management of technology and the administration of a government department call for entirely different, at times, contradictory cultures. So, technology cannot be managed the same way general administration is.

**Box 4. Vision Objectives of Technology Development**

*Brain Drain:* India will generate such attractive career opportunities that the country will import, not export, talented engineers.

*Import Bias:* Self-reliance will be realised not by rejecting foreign technology but by trading technologies, acquiring them through exchange with indigenous ones and not by outright purchase.

*Career Insecurity:* The natural displacement of labour by technology will be remedied not by reducing productivity but by stimulating employment multiplication.

*Competitiveness:* Indian technology will be so competitive internationally that there will be no need to protect Indian goods and services.

*Economic Justice:* The threat of increasing income disparities will be met by minimising poverty, not by reducing wealth.

*Ecology:* In all cases, technology will be developed or acquired in keeping with the requirements of good ecology

**Table 6. A Comparison Between Two Kinds of Technocrats**

| Technology Checker | Technology Promoter |
|---|---|

| | |
|---|---|
| Authorised to procure only that which is currently the best. | Will procure what will ultimately be the best. |
| Buys off the shelf products; does not support technology development. | Tries out new designs; offers feedback to improve product performance. |
| Has to live with it even if it proves unsatisfactory. | Gets products on trial; returns them cost free if unsatisfactory. |
| Pays full price up-front. | Pays only after the product is proved satisfactory. |
| Career in jeopardy if product proves unsatisfactory. | Career in jeopardy if an opportunity to induct a novel product is overlooked. |
| Cautious. Will take no risks and buy only proven products even if the technology is old. | Adventurous. Will experiment with new technology. |
| Will resist change | Will welcome change. |

Errors of perception concerning technology committed by generalist administrators are probably less serious than those committed by the technocrats. Quite a few technocrats concentrate on checking that each and every innovation is error-free rather than discover what its future potential could be. Their attitude is best illustrated by the following fable.

> A sailor shipwrecked on an uninhabited island prays to his guardian angel to let him have at least a baby for a companion. Much impressed at that unusual thought, the angel leaves a baby by his side in a sack while he was asleep. The sailor wakes up; sees something wriggling in the sack, ***suspicious of anything new***, and as a matter of abundant caution, he drives a knife into the sack before opening it.

The country has plenty of these "cautious" people. They place impossible hurdles in the path of new ideas. As no innovation is error free in its initial stages, these technocrats end up effectively committing technology infanticide. In their place, the country needs technology promoters - those who accept that new ideas will not be perfect and nurture them to maturity. Table 5 compares the characteristics of the two types of technocrats.

As Marcus Olson has explained the problem with technology development in India is one of cultural inhibitions and not lack of resources - material, human, financial - not even technological ones. Once the country nurtures and retains its abundant talent, and does so by encouraging innovation and enterprise, it will become a technological world power.

## Appendix A
## TECHNOLOGY POLICY STATEMENT 2001

### Preamble

- The Consultative Group of Eminent Senior Scientists, directed by the Government of India to make a draft of the Technology Policy Statement, acknowledges the widespread core competence and innovation in a number of areas in the country. The Group also recognizes the *inevitability* of globalization and liberalization of the Indian economy.

- This *inevitability* can be exploited to the fullest advantage of the country if it is recognized that technology policy entails a dynamic process, that its operation should have an internal standing mechanism that would not allow such situations to either arise or remain unaddressed by default as are apt to jeopardize India’s legitimate interests. With this in view, this Draft Technology Policy Statement outlines a framework for addressing technology-related issues.

- Technology Policy of our country indeed has to focus a vision for the nation. India is a developing country for more than 50 years. To transform India into a developed country, the important constituents needed are economic strength, national security and the skills of the people. Technology is one of the important tools to achieve the vision. This technology policy hence emphasizes that India has to have a vision to transform the country rapidly into a developed nation.

### 2 Technology Status in Year 2001

- In many respects, India's technology policy of the past several decades has been fairly fruitful. The country has achieved self-reliance in many areas, notably in some strategic ones. It has been able to generate a large number of internationally acclaimed scientists and engineers who have brought considerable wealth and prestige to the country. In some of the advanced fields like IT and pharmaceuticals, Indian industry has been able to create a niche of its own in global market.

- The country has a rich storehouse of traditional knowledge, which has potential for development and application.

- In other respects, however, the country's policy and performance have not been up to the mark. Most Indian industries rely on repetitive imports of know-how and hence, are not internationally competitive. Instead of utilizing high quality specialists that the country produces, enough opportunities have not been created for them. In turn, the overall environment tends to induce most of them to migrate, causing irreparable loss to the country's human resource. While India can boast of the ability to manufacture highly sophisticated systems, the product quality, often even of the household goods, is substandard.

- The investment in R&D by industry is 0.1% which is a minute fraction compared to the practice in developed countries.

- Linkages among Academia, R&D Laboratories and Industry are generally weak and ineffective.

## 3 Objectives for Technology Policy

- To make Indian technology and industry internationally so competitive as to dispense with the need of having to seek any trade protection.

- To make India technologically so advanced that it will import, and not export, talented people.

- To deploy technology to promote good quality of life, thereby ensuring (a) good health and education (b) quality of air, water and soil, (c) smooth flow of goods and people, and (d) free flow of information and access to knowledge.

- To use technology to (a) minimize disparities by reducing poverty and not wealth, (b) maximize employment both by matching skills to the dictates of innovation and by promoting employment multiplication, and (c) make India self-reliant in selective areas of technology, ridding the need of importing it under duress.

- To investigate and utilize indigenous techniques (including medicine) and make India a self-reliant advanced nation.

- To ensure that S&T Policy is output driven through optimum utilization of public investments in Science and Technology and thereby realize strategic outcomes and competencies identified for various sectors.

## 4 Vision for Technology Policy

- India will compete ably and thrive in the world economy by innovating, manufacturing and trading high quality and high-tech products across international boundaries by (a) training her engineers and technologists to international standards, (b) encouraging them to innovate by rewarding them and their institutions with both real and psychic income (c) integrating technology with cultural, social and economic development processes and (d) maximizing employment through appropriate technologies.

- India will emerge as a major proprietor of intellectual products.

- The Vision can be realized by working through its four components: -

    - High Quality Training.
    - Promotion of Innovation.
    - Production of Internationally Competitive High Tech Products and Services.
    - Networking Multiple Technologies for Nation Building.

## 5 Action points for realizing the vision

- In order that academic institutions, national laboratories, scientists and technologists acquire credibility with Industry and Government, they will be empowered with adequate authority, resources and operational freedom.

### 5.1 High Quality Training

- The high quality training can be absorbed only by able minds located in both poorly endowed as well as richly endowed families. High quality training will, therefore, be made universally affordable.

- In all developed countries of the world without exception, it is the practice to endow a "critical mass" of highly competitive and pace-setting educational institutions with abundant material and financial resources commensurate to the country's size and human resources. India too will have to reach such a "critical mass" of national institutions commensurate to the country's size and maintain them at international standards.

- Pursuance of the work both of teaching and R & D requires persons of international calibre. Such talented youngsters will be systematically identified, imparted science and technology skills far beyond mediocracy and guaranteed attractive careers.

- Top-level teachers, researchers and designers require the assistance of able technicians with high vocational skills. The industry will be encouraged to spare its master crafts persons for imparting such vocational training.

- Higher education is expensive but offers lucrative careers. It is therefore considered necessary that the beneficiary students meet part of the cost of such education. To facilitate this, loans will be made available to needy students so that no meritorious student is deterred from pursuing higher studies for want of money.

- The lowest to the highest levels of education (particularly in science and technology) offer invaluable rewards for businesses and industries, which too should contribute to that education. Philanthropists and businesspersons will be offered incentives to induce them to support educational institutions.

## 5.2 Promotion of Innovation

- Innovations are of two types: normal and revolutionary; the former requires scholars and the latter, mavericks who may or may not be scholars. The State will institute a search mechanism to discover such talents.

- Innovation is risky and only few attempts succeed. Hence rewards for successes will be made substantial enough to embolden the innovator to take risks.

- In several ways, the culture of the civil service and of the R & D institutions is mutually incongruent. There is much to learn from advanced countries, which constantly devise ways and means to reconcile that incongruence and get the best out of human resources. India too will adopt such methods of management.

- Every ministry and department of the government will have a separately earmarked budget for promoting technology development and technical education and re-education.

- A system of technology watch and patent analysis will be maintained as a public service to provide up-to-date information on technology developments.

- Innovation in the Indian System of medicine will be promoted either as a stand-alone or as adjunct therapy.

- Special schemes will be instituted to encourage and sustain innovation and entrepreneurship amongst youth. National Science & Technology

Entrepreneurship Development Board and other similar mechanisms will be strengthened.

### 5.3 Production of Internationally Competitive High-Tech Products & Services

- The wages paid and the export income are the two primary indicators of global competitiveness. The state will provide due recognition to firms that excel on these two counts.

- A scheme for depreciation of machinery based on the replacement cost, and not on historical costs, will be implemented to ensure that the firms are at all times in a position to afford development of latest technology, indigenously.

- New products and processes take time to establish themselves commercially. The Technology Development Board and other similar mechanisms will be strengthened to enable them to nurture such innovations till they establish themselves in the market.

- A pro-active mechanism will be established to maintain a watch over any dumping of goods by MNCs to the detriment of indigenous manufacturers.

- Unwarranted and repetitive technology imports will be discouraged. All imports will be made transparent and full details thrown open for public view within a year of purchase.

- A comprehensive programme of training and research on trade related issues and intellectual property rights will be promoted in Indian universities. Modern technologies become obsolete rapidly; so, management systems will be constantly reviewed and updated to be one up on obsolescence.

- Deadwood being fatal to technology development, a self-activated mechanism will be instituted for the replacement of sunset industries by sunrise ones.

- Regulations will be so modified as to attract, for instance, highly talented persons to technology development by offering them competitive contractual appointments.

- Manufacturing processes and scientific clinical trials will be standardized, and effective processing, packaging and marketing techniques will be developed to promote drugs including those of the Indian System of Medicine.

- The Government is the biggest consumer of goods and services. In case of large procurements, Government will define its requirement specifications in advance in order to give a fair chance to the Indian industry to compete.

## ▪ 5.4 Networking Multiple Technologies for Nation Building

- Unlike many other countries, India's core strength lies in multitude of crucial areas. For instance, the country has vast human resources – skilled, unskilled and creative, knowledge intensive industries, extensive span of basic services, vast coastline, reservoirs of minerals, biological and biodiversity related natural resources, and ancient knowledge – the wisdom of which, like of Ayurveda or Yoga, is recognized allover the world. Each of these, as also their networking, is amenable for several fold value additions for which appropriate schemes will be evolved for implementation. There will be a standing mechanism to ensure that national resources are exported only as value-added products.

- Worldwide webs and IT systems will be utilized to promote national as well as international linkages.

- Institutions and systems will be developed to integrate and coordinate related technology development activities by academic, R&D, Government and industrial organizations.

- In view of the increasing role of science and technology in the development process, the dysfunctionality of the generalist management is now very clear. Therefore, the importance of S&T professionals in management of developmental and innovative programmes will be recognized. They will be accorded their due importance both in the Government and in the private sector.

- Publicly funded and private R&D institutions will be modernised and restructured to promote relevance, competitiveness, accountability and excellence in achieving targeted outcomes through self-regulating mechanisms.

- Journals in Indian languages will be supported and raised to world standards in order to disseminate technology development widely.

# INDIA'S TECHNOLOGY PROSPECTS FOR YEAR 2025

*Men at sometime are masters of their fates:*
*The fault, dear Brutus, is not in our stars,*
*But in ourselves, that we are underlings*

*– Shakespeare*

## 1. Fundamental Limits to Prediction

Scenarios for the future are built up by extrapolating past data. The extrapolation may be a simple linear one, may include cyclical variations or even employ far more complex schemes. However sophisticated the prediction may be, it will always suffer from a fundamental flaw – it can only extrapolate from past data; it cannot take into account discoveries yet to be made.

Thus, no one in the year 1980 could have foreseen the PC revolution because it had not yet been invented. Even where data are available, their import can rarely be estimated correctly. The technology of the Internet was known in 1980 but without the PC the extent of its popularity could not have been guessed at that time. Even Asimov with his fertile imagination could not dream of computers – he could only visualise a three-dimensional slide rule as a future advance over the prevailing slide rule. (Who remembers the slide rule now though it was the inseparable companion of scientists and engineers not long ago?)

Even great minds have made and make serious errors in prediction. In the 1890s, Lord Kelvin, one of the greatest scientists of the age pronounced that no heavier-than-air object could ever be made to fly. Tom Watson, the head of the IBM no less, estimated that the world market for computers to be no more than three or four. Such serious errors in prognostication are endless. Hence, in any exercise in prediction, both those who predict, and those who try to plan for the future based on such predictions, should bear in mind these inherent limitations of the exercise. Not surprisingly, the greater is the period over which the prediction is attempted, the greater will be the flaws. That is a fundamental problem.

## 2. Expected Economic Scenario in 2025

### a. Physical Consumption

In recent years, India has shown a consistent rate of growth of around 6 per cent. That rate of growth may even increase. Indications are, by the year, 2025 India's economy will be 4-6 times larger than what it is today in real terms.

Then, the bottom 20 per cent of the population is likely to have the same consumption levels as the top twenty per cent do today. That does not necessarily mean everybody will be well to do. Even if they have more to command in absolute terms, the bottom 20 per cent will still be poorer than the remaining 80 per cent and will suffer from want – different kinds of want.

As energy-consumption is closely correlated with GNP, a similar increase in energy consumption too – 4-6 times should be expected. Similarly, per capita income is nearly inversely related to share of agricultural income. Hence, by year 2025, the share of agriculture in the national economy can be expected to shrink to about 10 per cent from the present level of one-third. As a corollary, the share of the agricultural employment, and hence, that of rural population too will dwindle. Unless urban development policies improve drastically, slum population will go up 5-6 times.

Water is a fixed asset and is already in short supply. At the same time, increasing incomes will impose higher demands for water both for domestic consumption and for industrial use. On the other hand, consumption of water for agriculture should decrease both because much water is being wasted at the present time, and because of expected improvements in biotechnology.

Personal transportation will increase faster than GNP, at least tenfold. However, air pollution will not increase in the same proportion because of improved transportation technology. It is possible that vehicles will all be driven either by electricity or by hydrogen.

People will leave in controlled environment almost all 24 hours in airconditioned buildings and travel in airconditioned vehicles. Improved technology of airconditioning will cut down greenhouse gases. So, the ozone hole would probably have been corrected by year 2025.

### b. Social Changes

Life expectation should go up from the present level of 62 to near 80. That will exacerbate problems of old age: hospitals will have more to do with degenerative diseases than with waterborne diseases that are currently the bane of the country – assuming that the four-sixfold improvement in prosperity will be utilised to improve water purification technology. In other words, prevention and treatment of water pollution will be a major industry. Rivers will be restored to their pristine purity.

Conventional literacy will be near 100 per cent and computer usage too will be close to that level – with several hundred million PCs in use. Along with literacy, the consumption of paper is liable to increase – in spite of increased use of computers.

People will have more clothes but fashions may dictate they wear smaller dresses. So, the actual consumption of cloth may not increase as much as one would expect. That will not be the case with shoes – their consumption should increase tenfold.

The trend will be for eating pre-cooked food rather than preparing it from basic materials. Already in New York, dwellings are being built <u>without</u> kitchens. With the breakdown of the family, with single-parent households being on the rise, with the only adult member having to work, there will be no time to cook. That places a big question mark on the future of kitchen gadgets. Incidentally, even now, potato chips cost, weight for weight, more than a Maruti car or a TV set does. So, food processing has already become a high value addition industry inducing entrepreneurs to push the sale of ready made foods more and more. For the same reason, the hotel and restaurant business too will swell.

People will have many more holidays. They will also travel on business much more. At current trends, air travel should increase some 25-30 times. In case, railways wake up and introduce already available technology, a major part of that increase could be diverted to rail traffic. Highways should grow rapidly and probably reach saturation level by year 2025 with a total length of near about 100,000 kilometres.

Urban policy being what it is, housing will be a big question mark. The country will need to have around 10 million housing starts a year. Their need will burgeon also because family size will decrease and the increase prospects of single-parent families as in the West today. Politics may not allow rapid growth in housing because, as rural caste vote banks dwindle, politicians will expand slum vote banks as a substitute.

Education is already a big business and is likely to become bigger. The increasing need for continuing education will raise demand still further. On the other hand, web based education may shrink the size of schools and the demand for teachers. As it has started happening in Kerala, many elementary schools may have to be closed down for want of pupils. However, the requirement of R&D personnel will increase substantially, probably as much as ten times.

Insecurity and crime will be matters of major concern. So, security personnel and security gadgets are bound to grow fast. Terrorist threats will add to the burden because technology will make it easy for few determined persons to harm large populations at will. On the other hand, the threat of conventional wars will probably shrink.

## 2. The Technology Situation

For the past fifty years, we have been hearing doomsday predictions that the world's physical resources will get exhausted. That has not happened so far, but that danger will be greater by year 2025. At the same time, re-cycling techniques are bound to improve and mitigate the risks of exhaustion of resources. Already, much of steel, aluminium, paper and the like are largely re-cycled. There are two exceptions to this rule: energy and cement. Unless something dramatic happens, limestone resources will be nearing exhaustion by year 2025 placing a big question mark on the construction industry. The situation with oil may not be so extreme because advances in technology may make renewable sources of energy competitive.

### a. The Energy Scenario

Unfortunately, solar energy is not available all the time. Two technologies are already available to correct that defect: Ocean Thermal Electric Conversion based on the difference between the surface temperature of the sea (~ 25°C) and water temperature 1000 metres below (4°C ), works day and night, summer and winter. Similarly, a technique called solar chimney uses the temperature difference between large tracts of ground (> one sq.km. area) heated under a glass canopy and that of cold atmospheric air at an altitude 500-1000 metres, can produce relatively constant electrical energy with comparatively little drop in output either at night times or in winter. Both these are as yet experimental but may become viable by year 2025. India has already started work on OTEC plant and is planning a solar chimney too.

Photovoltaic systems are currently five-ten times more expensive than conventional energy systems. They too may become economical. Genetic engineering may increase photosynthetic efficiency of plants and make biomass another possible alternative. Energy conservation too offers much scope.

Coal is, and will be, a major source of energy for India for decades to come. Unfortunately, the quality of Indian coal is poor. The industry is highly criminalized and there is little interest in developing better technologies for the beneficiation of Indian coal. In this field, technology opportunities are immense but interest in technology development is meagre.

Fast Breeder technology in which India is a pioneer increases the amount of energy that may be extracted from nuclear processes fifty times. As a corollary, that also decreases the amount of nuclear wastes left behind fifty times. However, there is a risk because the system operates with weapons' grade Plutonium. The government has already sanctioned the construction of a 500 MW station using Fast Breeder technology. It is more than likely that by year 2025, fast breeders will become the major source of energy in the country.

**b. Water**

It is widely suspected that water will be the cause of future wars. India has already many water disputes with neighbouring countries. That risk may be minimised by treating both water recycling and the cleaning up of rivers as major technology thrust areas. Water conservation too offers much scope. Technology of waterless closets is known already. Drip irrigation has made desert areas bloom. That and other similar techniques may make it possible to grow more with much less water than what we use today. It is also possible that the violent obstruction to the construction of large dams will get exhausted making it politically feasible to harness the country's rivers better than what appears feasible at the present time.

**c. Biotechnology**

Food processing and post-harvest technology are both bound to be major thrust areas. They are both already at the take-off stage. Biotechnology and genetic engineering offer exciting possibilities but it is not clear whether India will be able to occupy a leadership position in these spheres or it will be reduced to a colonial appendage.

India is already a not insignificant player in the field of intermediate drugs. The country has started making important strides in formulations too. It is possible that by year 2025, India will have its due share in the world market in this field.

**d. Manufacturing Industry**

India's textile industry is large and perennially sick. For various reasons, the industry has not been keeping its technology up to date. It makes progress by fits and starts causing much harm to the economy. There is little that technologists can do unless the political and industrial climate improves.

India has a large leather industry. However, Indian prices are barely a tenth of what they are in the West. Poor quality due to poor technology and poor health of slaughtered animals is the reason. The scope is immense. Luckily, the Central Leather Research Institute has been a success and is able to provide considerable technology back up. It is probable that India will command a significant share of the world market in year 2025 – even if synthetics take a large share.

There are genuine fears that India will soon be de-industrialised. Already, in many products, India is unable to compete with the Chinese. Several Indian manufacturers have closed shop in India and transferred their production to China. India's imports of manufactured goods from China have quadrupled in the past five years. The problem is not technological but political. A change in policy on labour entitlements can dramatically alter the scenario.

**e. Materials**

Indian steel is currently the cheapest in the world. However, international politics has choked the export markets. Hopefully, this will be a temporary phenomenon and India will be a large international producer right up to year 2025. Unfortunately, the industry invests little in R&D. The case is similar in aluminium too. So, India makes only low grade materials. Hence, low labour costs are India's only comparative advantage. That is a dwindling advantage. As matters stand, the situation is unlikely to improve in the near future. India is a pioneer nation for ocean exploration of minerals like chromium. However, it is unlikely that the technology of ocean mining will become competitive before year 2025.

The future lies in composites. India's space programme has made significant progress in this field but little has been translated to private industry. Nevertheless, this is one area where India technology may be among world leaders.

**f. Transportation Industry**

At present, India is a minor player in transportation industry mainly because local technology is outdated. However, India's motor vehicle industry is fairly substantial. By year 2025, it may grow to five million vehicles a year to become one of the world's leading players. The country can even become a technology leader.

Indian railways are amongst the most primitive in the world. There are no indications that the situation will change materially in the near future. The country has shown no interest whatever in modernising the railways and bring them up to world standard. It has also been the policy not to encourage indigenous technology development and to rely on imports only. So, technology prospects for Indian railways is very poor.

India;s road construction industry is primitive; even countries like Malaysia know better. Some changes are taking place. The four metropolitan cities are to be interconnected by roads – not of international standards – but close to such norms. It is possible that public pressure will build up, and force public policy to support the modernisation of Indian roads.

Next year, India will produce its first passenger aircraft. It is a small 14-seater plane but it is a beginning. Unless, India expands this industry, at any rate in the supply of aircraft parts, India will not be able to expand its air services. In the defence sector, India has been assembling fighter aircraft for decades. Soon, it will produce LCA, an entirely indigenous fighter of advanced design. The country could become a major player in this field.

### g. Electronics and Telecommunications

Twenty years ago, India established C-DoT and embarked on an ambitious programme of development in telecommunications. C-DoT is dying because current policy prefers imports over indigenous products. In fact, the rule is the Department of Telecommunications cannot buy any equipment unless it has already been in use for two years and in two different countries. As matters stand, unless there is reversal policy, India will soon cease to be self reliant in communication technology. For that reason, India's growth in this field will be less than elsewhere. That will create a bottleneck that will choke progress of software industry.

India's software industry has been growing at 30-40 per cent a year for nearly a decade. That was because the base was tiny. The industry is still operating at low levels of technology. Many international firms are setting up their R&D centres here. Thanks to them, value addition in this industry may grow. There are two clouds on the horizon: One, there is no complementary hardware development in India. Two, telecommunication facilities are, and are likely to remain, primitive.

India is an advanced country in space technology. The country is self-reliant but not internationally competitive as yet. It could become a world leader by year 2025.

### h. Strategic Industries

The technology of nuclear energy is one area in which India has done well. The problems are at the policy level, and with the failure to provide finance as and when needed and at international rates. However, policies are changing. So, the country is likely to be a leader in this field of technology in the decades to come.

In some directions, India's defence technology has made commendable progress. It is likely that the progress in this field will accelerate not decelerate – even if problems with Pakistan are resolved. At the same time, it is doubtful whether political policy will so change that India will become a major exporter of defence materiel.

India is, and is likely to remain, a significant international player in space technology both for remote sensing and for communications.

### i. The Social Sector

Indian medical expertise is among the best in the world. Even now many people come to India to get expert treatment at low cost. There is even a move in countries like UK, to send some of their patients for treatment in India. However, all this is due to low wages. As the country grows rich, this Comparative Advantage will dwindle – unless the country invests in R&D far more than what it does at present.

China has fifty times larger export market for its indigenous medicines than India has. Kerala's massage industry is the only one that is organised to attract international patients. It is possible that the idea will catch on in other parts of the country too.

The IITs and the IIMs are the only internationally famous Brand Equity that India has. Export of highly qualified and trained engineers and doctors is probably the only hi-tech export the country has at the present time. However, this is a short-sighted policy, no different from exporting mineral ore and importing processed machinery. Hopefully, this is one area where India's exports will shrink. The state of development of a nation is determined not by how many talented minds it exports but how many it attracts.

## 3. Two Scenarios

Technology development depends not merely on technical capability but also on sound economic policy and administrative acumen. India's technical capabilities are good but its economic and administrative acumen are poor. Considering the way liberalisation has been opposed tooth and nail both by politicians and by the bureaucracy and virtual non-progress in that direction, indications are that the country will lag farther and farther behind fast developing economies like China and other countries of East Asia. There are few indications that the country will catch up with the West in the foreseeable future. Politicians, bureaucrats, social scientists and educators too are far too obstructive for the country to hope for any significant change. It is also a fact that, politically, the country is obsessed with helping out the handicapped but not to encourage the competent. A strong and far-seeing political leader can change that bleak scenario but narrow interests in Indian polity and society are at present formidable obstacles to rapid change, any change for that matter.

At the present time, India is rated as among the least competitive nations in the world. That is entirely due to political policy. That can change dramatically at one stroke when a progressive government is formed. If by chance that happens, India can expect to be among the technology leaders of the world by year 2025. Otherwise, it will continue to wallow at the bottom as it is doing today.

**a. Worst Case Scenario** (with public policy remaining as it is)

People will live mainly in slums in large congested cities. Half a dozen cities will have a population of more than two crores each and another twenty cities will have a crore of people. Water, energy and housing will be scarce. Roads, schools, hospitals and all other services will be overcrowded. Crime will be rampant. Most talented youth will migrate abroad. India will be a follower, not leader, in technology.

**b. Best Case Scenario** (With rational public policy)

India will be the envy of the world for having solved the habitat problem. Local water harvesting and local waste recycling would have been developed to a fine art to ensure high quality at low cost. Most people will reside in bungalows in optimum sized conurbations dotted all over the countryside. Emphasis will be on conservation and no material will be allowed to go waste. India will be a world leader in IT, energy, telecommunications, biotechnology and the major service provider in education and in medicine.

***Two roads diverged in a wood – and I***
*I took the one less travelled by.*
*That made all the difference.*

*– Robert Frost*