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Science, Technology and Economic Growth: Exploring the Linkage in Case of Indian Economy”

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Abstract—*This research paper offers some perspective on the role of Science and Technology in India’s growth story so far. Using Solow Model of Growth Accounting, the paper attempts to reveal the sources of such economic growth that has taken place in the economy over a period of time. The paper also considers opportunities for future prospects of major factors that contribute to economic growth commenting specifically on technological progress. In this paper, a basic familiarity with the general structure and performance of the Indian economy and the economic reform process that has been taking place through the last decade or more, have been clearly mentioned along with their impacts on post-independent India. The paper supports its conclusion by the documentation of critical thoughts of industry experts relating to S&T and economy.*

1. INTRODUCTION

Science and technology creates intellectual assets that should be the common property of all mankind and also contributes to the resolution of various issues. It also contributes to the promotion of industry and economy.

It has been advocated and admitted that science and technology has tremendous potential to accelerate the rate of economic growth of a given economy. Many economic models also establish this linkage. Developing countries such as India have also witnessed sustainable economic growth.

2. OBJECTIVES

- To appreciate the role of scientific developments and technological advancements in economic growth of an economy.
- To explore the link among science, technology and economic growth in case of India in recent times.
- To observe and document critical thoughts of industry experts relating to science, technology and economic growth.

For any successful economy, particularly in today’s quest for knowledge based economies, science, technology and engineering are the basic requisites. If nations do not implement science and technology, then the chances of getting themselves developed becomes minimal and thus could be even rated as an undeveloped nation. Science and Technology is associated in all means with modernity and it is an essential tool for rapid development.

Modernization in every aspect of life is the greatest example of the implementation of science and technology in every nation. With the introduction of modern gadgets in every walk of life, life has become simple and this is possible only because of implementing science and technology together. Without having modern equipment’s in all sectors, be it in medicines, infrastructure, aviation, electricity, information technology or any other field, the advancement and benefitsthat we face today would not have been possible.

An innovation ecosystem is a combination of two distinct but largely separated economies:

a) The knowledge economy (comprised of knowledge producers), which is driven by fundamental research, and b) The commercial economy (comprised of knowledge users), which is driven by the marketplace

Today, countries are classified as developed and developing countries. The major categorization is based on economy and the application of science and technology. If carefully analysed, one gets to understand that countries which have a strong base in science and technology arethe ones that developed faster. A few examples are of countries like Russia, Japan, Brazil, China, India and many more.

India is increasingly becoming a top global innovation player in bio-technology, pharmaceuticals, automotive parts and assembly, information technology (IT), software and IT-enabled services (ITES) and has already become the world’s fourth-largest economy on purchasing power parity (PPP) basis.

However, the present models of research funding in the country do not facilitate thefunding of projects in the private sector, whereas several global models do so. Current fiscal incentives for attraction of investments into R&D by way of tax benefits have led only to marginal results and the linkages between academia-research and industry remain underdeveloped and weak. The challenge is how to create a vibrant landscape of Public-Private Partnership and an enablingframework for attracting investment from the industrial sector into R&D systemand incentivizethe same for linking development with deployment in the innovation and technology sector.

India is in a unique position to mount a strong initiative for affordable innovations for technologies for social and public good by taking advantages of

a) Low expertise costs,
b) Vast talent base and
c) The residual idealism in the society.

While technologies for public, strategic, and social goods would require collaborative excellence, competitive excellence models for private good would come from industrial sector.

3. LITERATURE REVIEW

The systematic study of technological changes by the economists and other social scientists, began largely during the 1950s, emerging out of a concern with improving our quantitative knowledge of the sources of economic growth. The early work was directed at identifying the importance of different factors in generating growth and relied on highly aggregated data.

The intellectual impetus that these studies provided, contributed to an increased appreciation by policymakers of the economic significance of science and technology, and a more intensive investigation of its role in phenomena as diverse as: the slowdown of productivity advance in the West, the extreme variation in rates of growth across the world, and the increased costs of health care.

Expenditure on research and development (R&D) is typically considered to be the best single measure of the commitment of resources to inventive activity on the improvement of technology. According to a paper by Adam Jaffe, which provided an overview of trends and patterns in R&D activity since the early 1950s, as well as some international comparisons. He discussed how federal spending on R&D is roughly the same today in real terms as it was in the late 1960s, but that expenditures by industry have nearly tripled over that period—raising its share of all funding for R&D from roughly 40% to 60%. Basic research has fared relatively well and increased its share of the total funds for R&D, with universities being the primary beneficiary of the marked shift of federal spending in this direction.

4. EARLY DECADES AFTER INDIAN INDEPENDENCE

The origins of the current science and technology system in India can be traced to the establishment of the first scientific agencies that the British found necessary to manage and expand their Indian empire in the 18th and 19th centuries. The Survey of India goes back to 1767, and the India Meteorological Department to 1875. Several of these agencies grew under some outstanding British leaders who (working with Indian assistants) left enduring imprints on their disciplines and on the organizations they headed (e.g. Sir Gilbert Walker in meteorology, Sir Ronald Ross in health). The establishment of institutes for carrying out more general scientific research or technology development in modern terms was more difficult. The landmarks here were usually due to Indian enterprise rather than British patronage. For example the Indian Association for the Cultivation of Science was established in Calcutta in 1876 by a remarkable doctor, Mahendra Lal Sircar. The Indian Institute of Science at Bangalore, whose establishment was resisted by British commercial interests for many years, finally started operating around 1909 as a result of a unique three-party agreement between the commercial house of Tatas, the Maharaja of Mysore and the British Viceroy's government. Beginning in the 1930s, the Indian National Congress, under the leadership of Jawaharlal Nehru and Subhash Chandra Bose, started planning for science and industry, almost as if in anticipation of the times when they would be able to make and execute national policy under their own government. British policy during and between the two world wars faced the difficult problem of striking a balance between responding to the demands of prosecuting war in distant colonies cut-off from Britain and ensuring that no commercially or militarily sensitive technology became available to the 'natives'.

Meanwhile many Indian scientists, most notably C V Raman, S Ramanujan, M N Saha and J C and S N Bose, made international reputations from their strikingly original scientific work. Basic science, rather than technology or economics, was in fact a major cultural force that changed the country's perception of itself and its people's abilities. It is against this background that one can understand how the advent of self-rule saw an immediate and dramatic increase in the attention devoted to science and technology.

In 1946, the highly regarded Indian political leader C. Rajagopalachari was already presiding over the governing body of CSIR (Council of Scientific and Industrial Research), which had been set up in 1942, incidentally under pressure and even with offers of support from technology-starved Indian business interests. CR (as he was known) joked with the scientists, hoping that they 'will look upon us [politicians] as one of those many natural forces you have got to cope with'. On 23 August, barely a week after he had taken over as Prime Minister of an independent India that was burning in the fires of a disastrous partition, Nehru called for an inter-ministerial meeting on science.

Nehru had taken the tripos in natural science at Cambridge, and used to speak nostalgically of the days when he haunted its laboratories. He looked upon science, and a 'scientific temper', as the solution to the problems 'of a rich country inhabited by starving people'. He declared that it would have been better for him to be 'the Director of this [the National Physical] Laboratory, if I had the competence, than to be the Prime Minister'. The agnostic pandit reserved his sacred rituals for a new god: he liked 'to burn incense at the altar of science', and saw dams and factories as modern temples. He considered scientists and engineers more important than administrators and lawyers, and dismissed businessmen as unlikely to play a part in national development 'because of their limited outlook'. In 1958 he had Parliament pass a scientific policy resolution, which said in part that 'it was an inherent obligation of a great country like India with its tradition, scholarship and original thinking and its great cultural heritage to participate fully in modern science, which is probably mankind's greatest enterprise today'. Science and technology, therefore, were tools with which Nehru was going to transform a civilization in distress.

For about thirty years the public science and technology system that Nehru and his scientist collaborators like the nuclear physicist Homi Bhabha and the chemist S S Bhatnagar built seemed like a model for the developing world. The Atomic Energy Commission was established in 1948, and the civilian CSIR and the Defence Research and Development Organization grew dramatically in the 1950s and 60s. In education the IIT system was established, and the Indian Institute of Science and the Tata Institute of Fundamental Research grew substantially.

Nehru advocated a socialistic pattern of society, choosing this diluted term presumably to signal that the country's economy (unlike its science) was not going to be completely state-run. The economy remains mixed to this day, although the proportions between private and public have varied over time. Given his opinion of Indian business it was natural that his government set up several modern industries in the public sector. These included machine tools, electronics, heavy electrical machinery, telephones, aircraft, airlines and many others.

Further initiatives were taken in public sector S&T by Nehru's successors (Nehru passed away in 1964), in particular Mrs. Indira Gandhi (who was Prime Minister for two terms, 1966-77, 1980-84). One of these had to do with agriculture. The experience of the mid 60s when India was forced to import large quantities of food grains (and, as the saying went, live from ship to mouth), demonstrated that food security had become a major problem. With the assistance of the US in particular, a green revolution was ushered in, and adequate food stocks were created and maintained to be able to tide over bad monsoon years. The food problem that had plagued India for centuries was solved in about a decade.

The other major development was that several new science departments were set up in the central government. These included the departments of science and technology, biotechnology, non-conventional (now renewable) energy sources, ocean development (now part of earth sciences), scientific and industrial research, and perhaps most significantly, space. As a remarkable indicator of national potential, space deserves some special attention.

5. THE ECONOMIC REFORMS

During the thirty-year socialistic period the 3% growth of the economy was not much higher than that of population, so the country was not getting much more prosperous. Towards the end of the period it was however probably more secure – not only in food. After the Bangladesh war and the 1974 Pokhran nuclear test, and the extensive industrial infrastructure that had been built up, a certain threshold of strategic autonomy had once again been recovered since the 1962 debacle against China and the 1964 Chinese nuclear test. Development, which had followed a low-slow-steady approach (with low investments sustained over long periods), was visible but not spectacular. It had turned out bright young people at the central institutes, but many of them began to go abroad and stayed there, reaping rewards for their contributions that were inconceivable back home.

All these factors combined to provoke the country to re-examine the philosophical roots of its economic policy. Changes in economic policy were accelerated by the advent of a young Prime Minister in Rajiv Gandhi, who (as a former airline pilot) was at home in modern technology. During his short tenure (1984-89) he advocated the wide use of computers and talked about building an India for the 21st century. Although his vision of the future did not gather much immediate support, there can be no doubt that it shook the country up.

In retrospect we can now see that, starting around 1980 an economic liberalization had been initiated without any fanfare, and the rate of growth of GDP went up to nearly 6% and stayed there for another two decades. However in 1991 a balance of payments crisis led to a more explicitly articulated reform regime.

During this period, once again in retrospect, no major initiatives in public S&T, of the kind that had characterized the earlier decades, seem to have been taken. There was however considerable consolidation. Businessmen entered government councils and public sector boardrooms – to the dismay of the socialists. Fundamental questions about the way that the S&T system was run began to be asked. There was a major review of CSIR, and constant questioning about why Indian S&T needs to keep reinventing the wheel. The period did produce some tension, but at the same time brought into open questions that had remained publicly unarticulated for a long time.

In aerospace, that consolidation also saw the initiation of the Light Combat Aircraft (LCA) project and maturing of the Advanced Light Helicopter (ALH). The LCA has not yet entered service and is unlikely to do so for another few years, but there is an order for twenty from the Indian Air Force. And the ALH, now named Dhruv, has been certified in several variants and seems to have established itself as a very useful product of the aircraft industry. Space and atomic energy continued with their programmes, the former with development of the early satellite launch vehicles and the design and manufacture of a series of remote sensing and other satellites, the latter with more nuclear power stations and a second round of nuclear test explosions in 1998.

The most striking development of these decades, however, was the unforeseen and spectacular growth of the IT services industry, which had never figured in the official five-year plans.

Although the IT phenomenon owed little directly to the government, it would be only fair to recognize that it was rendered possible by the vast expansion of S&T education (even if of highly variable quality) in earlier decades, and the popularization of computers by a young Prime Minister. Before the 1980s the major employer of outstanding graduates in S&T was the public sector – research institutes, national laboratories, high-end (public sector) industry etc. The new opportunities unveiled by the computer revolution were often seized by those who learnt some basic skills at one of the roadside computer schools that began mushrooming in cities like Bangalore. It is impossible to resist the temptation to attribute at least part of this phenomenon to a cultural advantage that Indians derived from their own classical science. That the numeral system that is internationally used today can be traced to India is well known. Perhaps not so well known is the fact that the computational power unleashed by the new system led to an extraordinary flowering of numerical mathematics between the third and sixteenth centuries in India. This came to be known in the west only through contacts with the Arabs in the early centuries of the second millennium. The primacy given to number in India, in combination with Indian appreciation of linguistics and grammar as primary sciences, suddenly became relevant to the creation of modern software. (So there was a point to the mention of cultural heritage in the 1958 scientific policy resolution.)

6. THE NEW CENTURY

With the recent spurt in growth rate to the neighbourhood of about 9%, GDP isnow about a trillion dollars, and pictures of India rising or shining have been constantly projected before the world, leading to an unprecedented bullishness about the Indianeconomy. The changes that have occurred in the business scene are indeed striking. Thecountry has a healthy foreign exchange reserve, raising capital has become easier;population growth has slowed down. The economic reforms have been embraced acrossthe political spectrum including the leftist governments in power in a few states. Theemergence of the call-centre and BPO sectors has led to worries about lost US jobs. Although that loss is minute, reports about how US workers are worried about being ‘Bangalored’, as the phrase went, changed the way that both Indians and Americans looked at economic reforms and globalization. Indeed, to this long-time resident of Bangalore, it is clear that the recent prosperity of the city is due to these changes in the economy – although many of us are dismayed at the price that the city has paid in terms of pollution, congestion and a failing infrastructure for what is still largely selective prosperity.

Given the new growth rate, personal income in India should make it a middle income country around the 2020s. Many leaders, and in particular the last President Dr Abdul Kalam, have held up as a viable national target its transformation to a developed nation by 2020. Whether this will happen will in part depend on the definition of ‘development’. If there is no major political, military or financial upheaval, and Europe is not going to be counted as a single unit, the Indian economy will in all likelihood be the third largest in the world before 2020.

Thanks in part to the opening of the telecommunication sector to private enterprise, and to dramatic changes in technology through mobile telephony (with 200M mobiles in the country now) telephones are no longer the possession of a privileged class. Similarly television now reaches more than 90% of the population. Air traffic is growing at 20-25% per annum or more, and sleepy airports of yester years are now milling with passengers.

This recent boom has not been without its problems. Apart from urban chaos, large sections of the population have not benefited significantly from the boom. Without the boom they would probably have been worse off, but that is no consolation. The middle and upper middle classes (now about 25% of the population) have gained a great deal, and some businessmen have become super-rich, but the far-too-slow trickle down the economic ladder has become a serious problem. The government claims that the population below the poverty line has now declined. Although the decline itself cannot be in doubt the numbers quoted are open to question; the official Indian definition of the poverty line is any way so low that there are a lot of poor people even above the line. Certainly the gap between the rich and the poor has widened.

Literacy levels in the country vary widely, from nearly 100% in states like Kerala to only about a third among women in states like Bihar. The national average is just barely more than 60%. Water and public health remain problems across the country.

There is a chronic shortage of energy, and although innumerable analyses of the problem have been made, the country has been unable to meet its needs. Oil prices rise, loss and theft of power in transmission continue, little R&D is done on new technologies (e.g. clean-coal, photo-voltaics), and pricing policies offer free power to farmers with the power generators being left to resort to some cross-subsidy. Economic growth may in coming years be seriously hurt by severe energy shortages.

7. THE ROLE OF INDIAN S&T POLICY

How has national S&T policy evolved in response to perceived needs and external factors over the last sixty years? Nehru's scientific policy resolution of 1958 was basically a declaration of faith, and promised to promote science, educate and train scientists and technical personnel, encourage individual initiative and secure for the country the benefits of scientific knowledge. Scientists were promised good service conditions and an honoured place in advisory roles to government. The foundations that the policy laid led to an S&T infrastructure that was remarkable for its times but is now experiencing difficulties. But the slow economic growth that characterized the period began to tell: in 1963 Nehru himself said he wanted a society where it was 'open to every person to lead what may be called the Good Life'. One of Nehru's constant advisers had been the distinguished British physicist and Labour peer Lord Blackett, who in 1967 warned India that 'science is no magic wand to wave over a poor country to make it a rich one'. He emphasized the importance of the whole innovation chain – an idea that has come to be appreciated only forty years after his report.

With the advent of Mrs Gandhi as Prime Minister there was greater concern for national security. In her addresses to the Science Congress she spoke about maintaining independence of judgement and action, and mildly chided the scientific community for being 'unduly influenced by the technological styles of the affluent west'.

Self-reliance and national strength were the goals of her 'pilgrimage' towards science. Twenty five years after her father's scientific policy resolution she announced India's first technology policy statement, whose very first objective was to attain technological competence and self-reliance to reduce vulnerability, particularly in strategic and critical areas, making the maximum use of indigenous resources.

Economic liberalization that started in the 1980s gave more space to private industry. The period coincided with the beginning of the computer revolution in India. This proceeded apace after 1991. Formal recognition of these changes had to wait till 2003, when a new S&T policy was enunciated by the Vajpayee government explicitly recognizing the importance of innovation, of involving the private sector and of protecting intellectual property rights. The economy became now the centre of attention.

Have these policy statements any connection with reality? Certain long-standing issues have always been mentioned, but not resolved to this day: water, literacy, energy, poverty alleviation are examples. Certain other features have always been implemented, irrespective of the party in power: programmes in the strategic sector (the one exception here was the Morarji Desai government of 1977-80), agriculture, special new technologies like ICT and bio-technology. Others reflected adjustment to changes that occurred without explicit domestic policy initiatives, often in response to global forces; e.g. IT, wealth creation, IPR.

8. THE FUTURE

The Indian experience shows how, even within the framework of its political and bureaucratic machinery it is possible to build major technological capabilities that can deliver. However, apart from that part of the strategic sector subject to strict technology denial regimes, it has been difficult to scale up the underlying national dynamic.

Computer and internet technologies have made a great impact because they revealed to Indian engineers a field where their culturally inherited skills matched those in global demand. Coupled with the advantages of living on the other side of the world from the US, enabling work round the clock and globe, IT created a large number of lucrative jobs for an educated middle class that had been starved of opportunities. So, perhaps for the first time in the country's history, knowledge of a certain kind could be converted to wealth with relative ease, provided only that one was willing to work hard.

Indian skills have been chiefly tested and used only in IT services. The hardware industry is weak, and even the software side has found it more profitable to help foreign businesses run better. Industry finds it easier to create wealth by manufacturing to imported designs, and has not found it necessary to undertake much technology development, by itself or in league with R&D and academia. Even those who do not take easily to software development find that the salary sacrifices demanded by public S&T are unacceptably high.

On the whole, the public Indian S&T system has not been directly benefited yet by the economic reforms. The josh, the exuberant and aggressive confidence that characterizes Indian business (who have a regime they are happy with) has not yet touched the scientists. Although one sees innumerable examples of innovation in daily life – from marketing to fixing things to getting things done in a difficult bureaucracy, the overall climate for high-level technological innovation is still lacking. If the country wishes to move away from being a mere blue-collar S&T force and become instead a source of innovative technology, not just a recipient, another shift in the S&T policy regime is necessary. Such a shift has to take into account the new realities of a rapidly growing, globalizing economy. The most important change that is required is the creation of effective networks involving academia, government and business to promote innovation. Perhaps things are changing: the Indian automobile industry is conceiving and developing its first innovative products.

Such a goal might be the emergence of India as a developed nation or a harmonious society or a renewed civilization, with a specific definition of what would constitute that achievement. Many components of such a goal would be social, but those that involve S&T and the economy might include the following:

Making India a middle-income country on a per capita basis (average income of order US $ 3000 per year at current rates), and at least the world's third largest economy in national terms. Literacy rates exceeding 90% across the country, irrespective of caste, religion, gender.

An economic liberalization of the S&T system, with an extensive performance linked reward system, and encouragement of faculty setting up their own technology enterprises (subject to appropriate monitoring mechanisms that chiefly demand transparency).

An imaginative and comprehensive plan for creating an S&T ecosystem, and a complete innovation chain including the banking system, with high rewards for successful technologies developed with substantial contributions from within the country; in particular, a special system for helping the end-game in product development. If major initiatives along the above lines cannot be taken, there is every likelihood of India remaining an efficient blue-collar S&T nation that provides R&D services that help more aggressive innovators elsewhere in the world, from one side an outsourcing of services being matched by a corresponding outsourcing of innovation from the other.

And Indian industry is slowly moving up the innovation chain, based on work in India in some cases and on technology acquired from abroad (through corporate mergers and acquisitions even) in others. There are outstanding innovators in India – but their numbers are still too small. Perhaps India is in another time of transition.

9. GROWTH ACCOUNTING THEORY

To produce output in the economy different factors are used and they have different contribution to the output produced.

The growth accounting exercise decomposes the growth of output into components in such a way that one component can be attributed to growth in the inputs and another component which is attributed to growth in technology or residual growth rate that is not attributed to the growth rate of the inputs. And this residual growth rate is called the Solow Residual in the literature of growth economics. It is of high intention because the Neo-Classical growth theories such as the Solow model emphasise that the growth in the economy is an outcome of the growth in the technological progress.

The concept as developed by Abramovitz (1956) and Solow (1957) divides the growth rate in the GDP or the output (Y in the sense of Solow model) into three main heads. One is the contribution of capital made to the GDP or output, another one the contribution of labour made to the output and one key growth rate of the technological progress that has contributed to the output.

Solow began with a production function of the Cobb-Douglas type:

$$Q = A\,K^a\,L^b$$

where **A** is **multifactor productivity** , **a** and **b** are less than one, indicating diminishing returns to a single factor, and **a + b = 1** , indicating constant returns to scale.

Solow noted that any increase in Q could come from one of three sources:

1. **an increase in L** . However, due to diminishing returns to scale, this would imply a **reduction** in **Q / L** or output per worker.
2. **an increase in K** . An increase in the **stock of capital** would increase both output and **Q / L**
3. **an increase in A** or in **multifactor productivity** could also increase **Q / L** or output per worker.

Regarding the production function here we have to make some important assumptions as made in the Solow model also.

1. The form of the production function take place as *labour-augmenting* or *Harrod-neutral* meaning that the technological progress is associated with labour.
2. The production function we use is a *Cobb-Douglas* production function, which in turn is Homogeneous.
3. There exist constant returns to scale.
4. Capital and labour in the production function are paid there marginal products.
5. The elasticity of capital with respect to output is .33 and the elasticity of labour with respect to output is .77. (this is not an easy assumption to make as these values must be estimated and do differ country to country and time to time)

With above assumptions the proportional growth rates in all of the variables, output, capital, labour, and technological progress can be computed as follows.

$$\dot{Y}_t = \frac{\partial Y_t}{\partial K_t}\dot{K}_t + \frac{\partial Y_t}{\partial L_t}\dot{L}_t + \frac{\partial Y_t}{\partial A_t}\dot{A}_t$$

INTERVIEW (1)

Question-(1) What is the currently the state of Science and Technology in our country? Does it require more concern for Indian to be at par with other countries?

Answer- India tryst for scientific endeavour started around Indus-Valley civilisation. But, India missed her spirited focus on scientific fervour due social division on caste and religious fault line.

While the west was ensuing the path of industrial revolution, India fought the onslaught of foreign invaders and foreign rule that brought social and economic poverty and scientific temperament taking the back seat.

However, post-independent India made its attempt to rebuild the basic infrastructure for higher scientific education under the leadership of P.M. Jawaharlal Nehru.

Six decades down the lane, India has definitely made her mark in various streams of S&T like space and nuclear science, I.T., Bio-technology, automobile engineering, polar science, communication and more noticeably setting of institutions like IITs, ISRO, DRDO, BARC and others.

Yet, India is lagging in comparison to developed countries. As compared to 4651 researchers per million population in China, India has only 140 researchers only. China spends 4 times more than India in her pursuit for S&T, and the USA spends 75 times more than India.

Apart from funds, India's growth in S&T is marred by unethical practices, misuse of power, frivolous publications and patents, psych phony and brain drain.

India needs to focus on growth of S&T to meet the International standards and also to meet the socio-economic imperative of her teeming millions. Following is suggested:

a) Encourage scientific temper build up, by use of social media.
b) Impetus on higher education.
c) Encouragement in R&D, Design engineering, patents and protections etc.
d) Promotion of entrepreneurship.
e) Transfer of technology from labs to field and in particular, agriculture technology.
f) Encourage Private Partnership for defence production.

Question-(2) In your opinion, how far has Science and Technology impacted the Indian Economic growth? (Both negatively and positively)

Answer- India's economy has undergone a structural change since, 1990 as regard to shares of agriculture, manufacturing and services in the GDP build up. While earlier the major share was of agriculture, but today the major share is of manufacturing and services sector. Simultaneously, the share of merchandise trade in GDP has almost doubled up. India's share in world exports has also substantially increased from 0.5% in 1990. S&T has played an important role in bringing about this transformation in Indian economy, which is shifting pre-dominantly from agro-based to manufacturing and services and is now increasingly integrating with the world economy to become globally competitive.

Increase in world exports has helped to evolve innovative and competitive technology to industry. This has resulted in India becoming World's fourth largest economy on Purchasing Power Parity (PPP) basis.

Question-(3) What do you think is the future scope for advancement of Science and Technology to undergo the process of Economic Growth? Are there any other factors which require more focus than S&T?

Answers- India has immense scope for advancement of S&T, India must try to achieve this for the economic growth of millions ravaging under economic backwardness.

Some of the structured suggestions are as follows-

a) Setting up of national level mechanism for evolving policies and providing direction on to basic research.
b) Enlarging the pool of scientific manpower, strengthening the S&T infrastructure and attracting and retaining young people career in science.
c) Implementing selected national flagship projects which have direct bearing on the technological competitiveness of the country in a mission mode.
d) Establishing globally competitive research facilities and centres of excellence.
e) Kindling an innovative spirit around scientist to translate R&D leads into saleable technologies for future human needs.
f) New models of Public Private Partnership (PPP) in higher education, particularly for R&D in universities and high technology area.
g) Identifying ways and means of catalysing industry-academia collaboration.
h) Promoting strong linkages with advanced countries, including participation in mega international science initiatives.

Commander Amod Chaudhary

Joint Director

Engineering Department

Naval Headquarters

10. INTERVIEW (2)

Question-(1) What is the currently the state of Science and Technology in our country? Does it require more concern for Indian to be at par with other countries?

Answer- While India has been doing reasonably well in the domain of science and technology, especially in certain domains such as information technology and space exploration and research and now e-commerce, there are many other domains where there is a lot to do to catch up with the advanced nations. Some such areas are Nano-technology, nuclear energy, aircraft manufacturing, etc.

India needs to be on par with the developed nations if we are to increase our exports and compete with them economically at a global level.

Question-(2) In your opinion, how far has Science and Technology impacted the Indian Economic growth? (Both negatively and positively)

Answer-Science and Technology has played an important role in bringing about a transformation in Indian economy, which is showing a shift from a predominantly agriculture based economy to manufacturing and services based economy and is now increasingly integrating with the world economy to become globally competitive, as demonstrated by its increasing share in world exports. Government S&T departments and agencies have undertaken or promoted research and development to provide innovative and contemporary technologies to industry and India's recent growth has been driven by rapid expansion in export-oriented, skill intensive manufacturing and, especially, skill intensive services. India is increasingly becoming a top global innovation player in bio-technology, pharmaceuticals, automotive parts and assembly, information technology (IT), software and IT-enabled services (ITES) and has already become the world's fourth-largest economy on purchasing power parity (PPP) basis.

Question-(3) What do you think is the future scope for advancement of Science and Technology to undergo the process of Economic Growth? Are there any other factors which require more focus than S&T?

Answer-The dominant area that is in a hyper growth stage is the ecommerce domain. With the growing penetration of mobiles into the towns and villages and with affordable telecom plans available to the consumers, ecommerce is increasing in its popularity very rapidly. We have seen multi-billion dollar valuations of companies like flipkart and snapdeal which are competing with giants like Amazon. In addition to S&T, India needs to focus on providing quality education to its youth so that they can contribute meaningfully to the economic progress of our country in this hi-technology era.

Question-(4) Various economists and researchers have predicted that in the near future, our economy would focus more on human capital formation instead of being dependent on technology. What do you think may be the consequences and will it impact our economy positively?

Answer-Development of human capital formation is very important and needs to go hand in hand with development of technology. India needs a well-qualified and technology savvy workforce to leverage the progress that science and technology is making.
Education contributes to economic growth for the country as a whole in the following ways: First, education not only imparts knowledge but also changes people's perceptions and expectations of themselves and the society around them. Education may alter the attitude to work, consumption preferences, saving propensities, economic rationality, adaptability, innovativeness, flexibility, attitude towards family size, and various social attitudes relevant from the economic point of view such as migration within countries and internationally, towards more productive sectors of the economy resulting in rise in GDP and per capita income. Second, education, through investment in human beings, imparts the knowledge to develop abundant complementary resources that may be substitutes for comparatively scarce resources and thus promotes efficient use of existing resources. Lastly, as educational levels increase for women in developing nations, the opportunity cost to stay home and raise families rises. It increases labour force participation. Thus human capital growth will definitely have a positive impact on our economy.

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11. RESULTS

1. Regression from 1952-2014 (Table 1a, 1b)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.999[a]	.998	.998	.04558341	.998	12082.902	2	58	.000	.617

a. Predictors: (Constant), LOGWP, LOGGDCF
b. Dependent Variable: LOGGDP

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.784	.754		1.040	.303	-.726	2.294		
	LOGGDCF	.835	.050	.977	16.586	.000	.735	.936	.012	84.088
	LOGWP	.125	.339	.022	.368	.714	-.553	.803	.012	84.088

a. Dependent Variable: LOGGDP

2. Regression from 1952-1989 (Table 2a, 2b)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.997[a]	.993	.993	.04077909	.993	2561.761	2	34	.000	.370

a. Predictors: (Constant), LOGWP, LOGGDCF
b. Dependent Variable: LOGGDP

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	-4.770	1.746		-2.732	.010	-8.319	-1.221		
1 LOGGDCF	.356	.139	.430	2.554	.015	.073	.639	.007	146.268
LOGWP	2.699	.801	.567	3.370	.002	1.071	4.327	.007	146.268

a. Dependent Variable: LOGGDP

3. Regression from 1990-2014 (Table 3a, 3b)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.997[a]	.995	.994	.02827051	.995	1874.315	2	20	.000	.537

a. Predictors: (Constant), LOGWP, LOGGDCF

b. Dependent Variable: LOGGDP

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	-6.089	1.883		-3.234	.004	-10.017	-2.162		
1 LOGGDCF	.490	.091	.584	5.391	.000	.300	.679	.023	44.195
LOGWP	3.068	.798	.416	3.844	.001	1.403	4.733	.023	44.195

a. Dependent Variable: LOGGDP

12. CONCLUSION

As per the Census 2001, the Indian workforce is over 400 million strong, which constitutes 39.1 % of the total population of the country. The workers comprise 312 million main workers and 88 million marginal workers (i.e., those who did not work for at least 183 days in the preceding 12 months to the census taking).

It is to be noted that the contribution of capital stock to the growth has been more in the overall period from 1952-2014. However, the data reveals a lesser contribution in post and pre liberalisation period. Also as been postulated by the interviews and recent discussions the role of technology is considered not be so vital in producing economic growth. What is more important for developing countries like India is that labour productivity shall be focused. Programmes like skill development are expected to play a major role.

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