

# Proceedings of the China-India-US Workshop on Science, Technology and Innovation Policy

## Section II Keynote Presentations

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## Keynote Presentation

### Prof. C N R Rao

My dear friend, Shri Kapil Sibal, Minister of Science and Technology, Dr Neureiter, Dr Kasturirangan, other dignitaries, visitors and dear friends: When I was asked to give a talk, I felt very inadequate because I was not sure I am a good policy man. Whenever I talk of policy, I eventually come to real, workable things. I do not want to talk about major global issues. I am so glad that Prof. Dahlman has given a wonderful picture of all the important issues facing us. With that background, I will stick to one point only – only one item.

The title of this Workshop is Science, Technology and Innovation Policy. As a scientist, I feel that whenever people talk of technology, innovation and development, and so on, the first thing – the first word ‘science’ – is usually forgotten. They even forget that science is the basis of both technology and innovation. I don’t see any country which is advanced in technology which is also not advanced in science. Unfortunately, while talking about global things – the management type of talks and so on – science becomes the first casualty. When I say ‘science’, I include engineering. Without a strong foundation in science and engineering, I do not see any future for either China or India. I want to talk only about this matter.

Well, why am I talking here? It so happens that I am probably one of the older people here. I have been associated with the United States for the past 55 years – I first went to the US about 55 years ago, and I got my PhD 50 years ago in the United States. In fact, just two weeks ago, I got an honorary doctorate from the North-Western University. I am very closely associated with many universities in the US. I am still a professor at the University of California, Santa Barbara, and have just accepted a visiting academic position in Berkeley.

What I want to say is that mixing up China and India with the US is a little unfair. America – whether you like it or not, however much you complain, howl and cry – continues to be the centre of science and innovation. There is no point comparing it – at least to India. The United States knows how to adapt, it knows how to change, it knows how to improve, and it knows how to innovate. America knows the secret of success. It may not all be done by the individuals born in the country. The United States may get and eventually grant citizenship to Indians, Chinese, Vietnamese and so on, but that doesn’t matter. The point is that America knows how to do it. It is the greatest success story in science. People complain, but they succeed in making up whatever the deficiencies the American system may have. I will come back to the deficiencies in a minute.

America produces about 23,000 PhD’s in a year. More interesting to me is that if you take the top one per cent of the research publications in the world, more than 60 percent come from the United States. This is very important – not the total numbers. My experience is that if you really want to go to the Mecca of science, even today it is the United States. There is no question about this – in science *and* engineering. I just came

back last week from the United States. It is really wonderful to see how a little university like Northwestern, which I have known for 50 years, has come up. It was not number one in anything when I knew it long ago. Today, it is easily the top institution in advanced materials – almost as good as MIT. How did it do that? Small universities, which were not great centres and are now great centres? A great thing about the United States is the continuous evolution of institutions which keep on coming up faster than we know.

They say there are three pillars in science – the United States, Europe and Asia. The number of papers from the United States is roughly equal to the number of research papers from Europe and roughly equal to the number of research papers from Asia. In Asia, of course, China is a big contributor, Japan is another contributor and India is a reasonable contributor. But in quality, however, there is no comparison. This is what I said – more than 60 percent coming from the United States form the top one percent. Look at the Nobel prizes. We are yet to get one in free India. Independent India has had no Nobel Prize in science yet. So don't ignore this when talking about global cooperation. Do all your cooperation, but remember that the United States is a giant in science, without question.

I belong to the US National Academy of Sciences and also the other academies there. The Academy has brought out a beautiful document which you all *must* read. It is called *Rising Above the Gathering Storm*. In fact, three or four of the members in the committee that put up the document are close friends of mine, like George Whitesides and Richard Zare.

What is it that it talks about? There are four important items. The most important thing for America to worry about is the K-12 education; producing 10,000 science and maths teachers per year, sowing the seeds for ten million minds; long-term basic research which should be encouraged, and how one should provide 200 young people half-a-million dollar grants. These are some of the recommendations made. There should be a presidential innovation award in the US. The brightest and the best should be involved in higher education, and America should become the most attractive place for higher education. This is a wonderful way of putting it. I would like India also to be like this. When we are talking of cooperation, we want India to be made most attractive – at least equally attractive for higher education.

They say that only 15 percent of the undergraduates are in science and engineering in America, compared to the 50 per cent in China. There is no question that in science and engineering, the numbers in China are much higher than in the United States. Although the NAS report is a good report which everyone should read, it leaves you somewhat depressed and is a bit negative. In fact, I was telling some of my good friends that it is more negative than it should be. Actually, they are talking from a position of strength. Whatever it is that America is struggling with – poor school science education, lack of good teachers, etc., it is still number one – way above other countries. So it is a very interesting situation. I think that it was President Clinton who said that for the future of America, knowledge matters the most. That, I think, is important.

China has decided to spend about 2.5 per cent of its GDP on science and technology. Its leaders have declared in the Party Congress that S&T expenditure will be 2.5 per cent of GDP. It is one of the largest exporters today. In the numbers of engineers – four-year graduates in engineering, science, computer science, etc. – China produced 350,000 graduates in 2004. There were 2,90,000 three-year graduates in one year, compared to 1 40,000 four-year graduates and only 85,000 three-year graduates in the United States. America produces less than half the number of graduates, when compared to China.

I have been a president of the Academy of Sciences for the Developing World for a long time, also called TWAS (Third World Academy of Sciences) – I have had close association with China and the Chinese Academy of Sciences. I must say they have done a tremendous amount of service to Chinese science by opening many institutions. The National Natural Science Foundation of China has done very well. The Chinese have become very good in manufacturing. They also produce 16,000 PhD's now. It is an amazing, extraordinary number. China is now producing 16,000 PhD's, against 23,000 in the United States.

I was recently in Tokyo – a very important meeting on Advanced Materials. You know that advanced materials is a very important area related to development and everything else – all that is involved in every aspect of life. One finds that the highest number of citations today in materials research is for Chinese Academy of Sciences. China is number one – not the United States. China publishes more papers in nano-science and technology than any other country. These are all the good things.

What has happened in China in spite of this large explosion in numbers is that the quality is somewhat indifferent. This is my opinion. The quality of Chinese science is indifferent. Coming to India, it is equally indifferent (or more indifferent). The number of institutions in China is large, the number of papers is large, but the percentage of Chinese papers that make the top one per cent is less than two per cent – something like 1.5 per cent, which is very small. India is even smaller than this figure. China is improving fast. What I expect will happen in China, if I see the Chinese determination in everything else, is that they will improve their quality in the next five years in a very big way. I see their institutions improving, getting better in everything – infrastructure, facilities, and everything else. They are improving so fast that I think in about ten years, in the world's top one per cent, the Chinese will contribute at least ten per cent. This is my prediction.

I want to bring in one element which is not science. It has nothing to do with science, technology or innovation, but something that China has accomplished which we have not, in India. There is a peculiar kind of nationalism in China which I admire in the people. The Chinese I meet – young boys and girls who work in the Chinese academic institutions – they are all very proud to be Chinese. They want to do something for China. I wish that we had people like this in India. The tremendous nationalism in the young Chinese to do something in science and innovation will, I think, help China in a big way.

Let me come to India. Independent India started, in 1947 – I was a young college student at the time, and by 1958 our parliament endorsed a science policy resolution which owed

much of its inspiration to Prime Minister Jawaharlal Nehru. We were the first country to declare publicly the importance of science and technology in the betterment of India. We slowly developed. Institutions were created – Indian Institutes of Technology (IITs). I even belonged to the very first IIT in Kanpur. A lot of such institutions came up. Mission-oriented agencies came up – Space and Atomic Energy. They have done fairly well, in fact, rather well, I would say. But the education system, and science as a whole, has suffered just because of these mission-oriented agencies. They never bothered about others – people like me who do science in small laboratories. Science in the education sector suffered badly in India. That is why our universities have stopped producing in the last 20-30 years, in spite of all the things the government did.

In the early years, we had no money. India was a poor country – don't forget that. The first time I went to an international conference, India could give me \$8 to attend the conference.

I am very proud that in the last 4-6 years, particularly in the last four years, the government has given more support to science and education than at any other time. There is a recognition that we have to do something for science and education. I am so glad that we have our Science Minister here. We have started new Institutes of Science. There is more money for science. Of course, we are short of people, but we will create them.

We have also had an advantage. I am very proud that India is a democracy – I would have it no other way. Democracy to the limit is what we have in India. There is no other country that is more democratic than India. We are a democracy to the extent that progress has become slow because you have to convince everybody. I am not going to dwell on this too much, except to say that democracy, which is a great thing for us – it is the greatest strength of India – has also been a slight deterrent. It has slowed down progress a little.

But what I hope will happen in India in the next few years is that the increased input to institutions in the last 4-5 years will really change the situation. Remember that India has lots of engineering colleges and IITs. We never thought that they were going to serve India. This year – India has admitted 500,000 undergraduates in engineering – the highest in the world. Last year, we admitted 400,000 undergraduates in engineering compared to the total of 75,000 in the United States. These are boys and girls of the small engineering colleges that have served India. I want to thank them. The Space program and the Atomic Energy program have all been served by ordinary engineers from these engineering colleges. Most often, the IIT graduates are not available. They are all serving elsewhere. Ordinary engineering and science graduates have served India. I want to thank them.

So India has reaped benefits in spite of its being poor and in spite of its poor investment in the early days. The IT (information technology) revolution has been caused by these young boys and girls. What I expect is a second revolution now with the new investments of our government – in people, institutions, and scientific research – which have increased by several hundred per cent. The availability of money for scientific research

has increased by a few hundred per cent in the last 3-4 years. For the first time, no one can complain today about money for research in India. The first research grant I had was 3000 rupees per year, when I started research here 50 years ago. In those days, 3000 rupees was not even \$500. I am too old to know what will actually happen, because I don't know whether I will be alive at that time. But in 10-15 years, I think that India will reap the benefits of the major input in terms of big money and on new institutions. We are creating eight new IITs and five new Indian Institutes of Science Education Research, five new pharmaceutical research institutions, and two more science institutions in Trivandrum and Orissa. India's hope is really in these new investments.

I must say that the reason this is important is that it is not only Nobel Prizes that we want for India and China. We would like to have them. Tell me, why should all Nobel Prizes go to America? There is something about the culture, something about their society, plus something about their institutions that make it possible. We should be able to – in China and in India – make our institutions such that ordinary people go there and do extraordinary work. Remember Blackett, a great British physicist and friend of Jawaharlal Nehru when both were students at Cambridge University, was asked to define what a first-rate institution was. A first-rate institution, he said, is one where ordinary people go and do extraordinary work. India needs a large number of such institutions. We are trying to create them. And with this creation, I think that India will fight for its place in the sun, which it cannot now. You may say that we are all equal. We are just not equal in science. We are still the have-nots in science. We have to improve quality. Quality is one of the first things and then comes quantity. So what would I predict for India? In ten years, I hope just like China, India will contribute to about 8-10 per cent to the top one per cent of the world science research.

In all these matters, what are the things that we need to do? Collaboration, of course – it is nice to have collaboration agreements and so on. We should collaborate on real things. Some of the examples were already given in the previous lecture by Prof. Dahlman – things that benefit mankind. In addition, since I am only talking about science, let us really help each other in such a way that countries like China and India can stand on their own feet in doing first-rate science – first-rate science, not second-rate. We want real collaboration – not collaborations which are just signing in books and so on.

If one has to do well in India, one has to be as good as the best in America. It is very tough. And there are very few in India who have done that.

We have always repeated things – repetition versus innovation. We are masters of repetition in India. The Chinese are also pretty good. Now let us take Japan, which is not mentioned today. With all that we talk about Japan it has never been able to come to the top in innovation yet. In science, they have been all right, but never equal to the United States. Japan started way ahead of China and India. In spite of all that Japan has done after the Second World War, it is nowhere near being equal to the United States in fundamental science. It has never been. So I hope that we will learn lessons here in India and China. We have to try very hard to be good, taking the example of Japan. We make good consumer goods, but we don't produce new technologies.

What is required for India and China is tremendous tenacity, perseverance and doggedness. We will not do anything that is second-rate. We will not compromise in quality. Whether India is up to it, I don't know. But I feel that the Chinese may be able to do that.

There is a very nice report by McKenzie – I don't know whether you have read that. It says that people who have invested a lot of money in education – millions of dollars – have not succeeded because they didn't pay enough importance to the teacher. In the value system, the teacher should get more importance – teaching should get more importance. Then America will also improve its K-12 problem. There is not enough importance for the teacher in America. But that recent survey tells me, don't make globalization of education cause damage to India. Let us have inner strength. India needs to have inner strength. China seems to have recognized this very well. We have to be strong because of our institutions in India. A little cooperation is fine.

I would like to close. What will the 21<sup>st</sup> century look like? The population profile says the lower middle class or middle class population between China and India will be 800 million, of which India will be 400 million. We already have 300 million in India. The upper middle class will be 2-3 hundred million at a minimum between the two countries. These are the guys who have three cars and that sort of thing. It is the middle class that is driving your economy. All the TVs and cars being sold in India by the international companies are because of this middle class. Love for India and China should not be because of the products being sold. It should be because we have to uplift India and China in the knowledge business – in science. We don't want more goods – we want more knowledge, because the youth in India is in large numbers. Don't forget that India is the youngest country in the world. 65 per cent of the population of India is below 35. Nearly 50 per cent of India is below 25. So when everyone gets old in the world, India will still be very young.

India will be the knowledge provider for the world. Indians should realize that the real role for India is to provide knowledge to the world because it has and will have more young people than anywhere else. It will provide services because it has more young people. The nurses and teachers will come from India. The scientists and engineers will also come from India. We should produce more PhD's in science and engineering – especially in computer science. We should not be merely service providers in IT.

I hope that India will emerge. I may be too old to see that India, but I somehow feel in my guts that India will come. James Conant, president of Harvard was once asked, "How did you make Harvard such a great institution?" He said, "Oh no, it is nothing. I just got some bright young people and left them alone." India has to do that. Take all these bright young people, particularly in our villages, because 75 per cent of India is in the villages. Many of them have outstanding minds. The city people are spoilt. They are all doing IT. These bright young fellows in villages could be scientists or engineers. We have to save them and use them for a brighter India. China will probably be doing something similar. And we will leave the young alone, without bureaucratic control. I am hoping for that

India, when in science, technology and innovation, India will be an equal participant. It can only be an equal participant when it is as good as anybody else in science.

Thank you.