CTIER CENTRE FOR TECHNOLOGY, INNOVATION AND ECONOMIC RESEARCH

R&D in India: Towards the 2% Goal

CTIER-CII Roundtable Discussion

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We look forward to your continued inputs that will inform industry, academia and policymakers in a timely fashion, and help shape India's R&D ecosystem.

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India was one of the earliest investors in R&D. Thirty years ago India spent more on R&D than countries with similar levels of GDP per capita. Over the last 20 years, there has been relative stagnation in the level of spending on R&D (as percent of GDP).

The Central government still accounts for the bulk of R&D spending in India.

Innovation in small firms may not be effectively being captured. A 2013 World Bank cross sectional innovation survey of 3000 SME firms in India found that 70% of the firms claimed to have introduced some kind of product or process innovation.

Many countries that started behind India with respect to their total R&D investment scenario many years ago have since moved ahead of India largely due a dramatic increase in R&D spending by firms - in China more recently, but before that in Korea, Taiwan.
Aspiration is to hit the 2 percent Goal for R&D expenditure as percent of GDP – of which 1 percent is by Industry and 1 percent by the government.

Indian companies are missing from top global R&D sectors by expenditure - sectors such as Technology Hardware & Equipment, Electronic & Electrical Equipment, Aerospace & Defence and Health Care Equipment & Services.

India has the pieces – there needs to be an integrated perspective. If one had to pick a field where India should be allocating a very large share of total national public research spending - it is health. Not only because of the problems India faces, but also because it has an existing industrial base and a world competitive pharma industry.

Section II: What is the nature of R&D in India?

In recent years, technology purchase expenditures for India have increased much faster than R&D expenditures. India is also an important source of R&D services to companies outside.

In the Chemical sector, India appears to have done well in improvising on existing technologies, but has been a laggard in creating any game changing technologies or radical innovations. In the IT sector it was found that part of the spending on innovation was to address existing businesses and a part of it was on platforms that were extensions of existing businesses as well as completely new businesses.

Having an innovation evangelization layer is an interesting practice followed by some of the IT firms. This is a listening function for market needs, customer needs, strategy etc. which binds people in research, development and innovation.

Section III: Industry – University Collaborations

Efforts need to be made to improve the research being done in the public research system in India and connect internationally competitive firms in sectors like IT and pharmaceuticals with the public research system.

A State's investment into the university system produces trained researchers that could go on to do relevant work for industry. The country's research ecosystem benefits as future researchers are being trained alongside the nation's best existing researchers in an apprentice-journeyman system.

Section IV: Benchmarking Competitiveness

The number of commercialized patents is seen as a measure of effectiveness of R&D.

Examples of benchmarking used by Industry include setting a target for how much of the organisation's turnover should come from in-house developed products (for example the target could be 25% to 30%). This could include incremental improvements to existing products tweaked to a customer's requirements.

When ISRO's cryogenic engine was being developed, there were a series of small (and large) enterprises that were involved in its testing, design, building and doing very innovative parts and components. *Should this organisational form (of having an anchor and a cluster around it) be looked at as a mode of R&D efficacy in a country like India where resources are scarce, where the risk associated with investments and its penalties appear to be much higher?*

Section V: Importance of IPR

If large firms encourage or use the patents of smaller firms, then with the right incentives structure one can get a large number of small firms that are prone to doing much more innovative stuff to start patenting.

Patents of start-ups or those generated through a co-innovation network (used by large IT companies) are used mainly for defensive purposes, especially if the work of the start-ups is being integrated into a product of the larger company.

Patenting in India has other challenges like excessive bureaucracy eg. according to the National Biodiversity Act, any patent that requires access to a natural resource should have obtained prior approval from the National Biodiversity Authority.

Awareness among the SMEs needs to be created about other forms of IP like design rights, copyright, trademarks etc. Copyright is a very powerful IP because it is available for a long time.

Section VI: Influence of Macro policies and schemes

The interaction between industrial policy, trade policy, IPR policy etc is complex. It is important to ensure that they are consistently moving in a particular direction that creates some degree of contestability in the market.

There are a number of schemes that the government has floated. There is a general lack of awareness of the various schemes. Companies do not find the schemes necessarily user friendly and have also found issues with the eligibility criteria laid down in these schemes.

Section I: A Snapshot of R&D in India

The India Story so far

Bulk of national R&D spending worldwide happens inside of firms followed by public research institutes and lastly universities. India is an outlier with respect to all three

A specific choice was made by India in the 1950s to locate most of its public research in autonomous institutes rather than the university system.

Industrial R&D is heavily concentrated in India – 100 firms account for over 85% of total industrial R&D spending. Concentrated globally too where 2500 firms account for close to 90% of total global industrial R&D expenditure and around 50% of total global R&D expenditure.

India was one of the earliest investors in R&D. Thirty years ago India spent more on R&D than countries with similar levels of GDP per capita. Over the last 20 years, there has been relative stagnation in the level of spending on R&D (as percent of GDP).

Between 1990 and now, total GDP has been growing more rapidly than between 1970 and 1990. The absolute numbers with respect to R&D are growing, although the change taking place is quite modest. Countries like South Korea and Taiwan that spend much more today on R&D as a percent of GDP were very similar to India 40 years ago in terms of total R&D spending.

When India was spending 0.6% of GDP on R&D 30 years back, it was overwhelmingly public funded research. The research was largely done through autonomous institutes that were quite isolated from the rest of the country - with little connection to firms or the production of researchers.

The Central government still accounts for the bulk of spending in the country. If one goes back 30 years, the share of public sector firms in total industrial R&D was higher than it is today. This share has fallen as a result of private sector firms having begun to invest more in R&D. However, it is worth noting that what companies like GM and Bosch spend on R&D would likely be more than India's total industrial R&D spending.

The Pharma industry is an example of a sector that is science and technology intensive – where India was able to establish a strong industrial base first and subsequently started to invest more and more in R&D – first in R&D for biosimilars and later on R&D for drug discovery.

Although India has a diverse industrial base, there has been no drastic restructuring that has taken place. Some of the large global R&D sectors (in terms of expenditure) include electronics, semiconductors, aerospace and electricals which are largely missing as industrial sectors in India and certainly as R&D intensive sectors – one of the reasons why industrial R&D spending is low.

The SME Story in India: A need to capture what many small firms are doing very innovatively

Small firms are meant to be innovative. Innovation in small firms may not be effectively being captured. In some cases, whatever they are doing might just be R&D.

Often SME innovation or the research being done by SMEs is to enable them to keep up with competition rather than to try and get ahead of it. Especially so, in the case of exporters.

A 2013 World Bank innovation survey of 3000 SME firms in India found that 70% of the firms claimed to have introduced some kind of product or process innovation. Although just a cross sectional survey, the 70% number is significant when compared to other BRICS countries.

In the National Innovation Survey (2014) it was found that 70% of firms have bought new machines and 35% said they have developed or adopted new products. *Further investigation, however, is required to find out whether these products are new to the firm or new to the market.*

Korea's industrialization story

The industry share in R&D spending for India and Korea were similar in 1970. Between 1970 and 1990, two things happened in Korea – a massive restructuring in its industrial structure and deepening within those sectors of the economy.

What makes Korea's industrial share of R&D so dramatic was that it was a rapidly rising share of a rapidly rising share of a rapidly rising GDP. The industrial share of total R&D increased from 15% of total national R&D spending to 85%, at a time when R&D increased from less than 1% to over 2.5% of GDP, and in the same period when Korea was growing at 8% a year for that 20-year period.

Korea's economic take off started in 1960. There was a move from lower value added products like garments to higher value added products like electronics, followed by a move up the value chain within electronics and electronics manufacturing – by 1990 into semiconductors. Massive growth was later seen in automobiles, automobile production, and automobile R&D.

Table 1: Korea's restructuring and deepening within sectors story

Year	Economic restructuring and deepening within a sector
1960s	Korea's economic takeoff starts
1970s	Significant large manufacturer of consumer products - see textiles, toys, simple electronics in large numbers.
1980s	Moves out of textiles and into electronics and electronics assembly
mid-1990s	Becomes largest manufacturer of microwave ovens

Industrial R&D as a share of total Korean R&D took off with the new sectors that Korea got into. This increase in industrial R&D spending was driven both by policy as well as commercial considerations.

There were policies to push larger chaebols and larger firms to invest in new fields often with protection for a certain period of time. For example, there were policies to get Korean firms to invest in the car industry by protecting the market for a period of time, followed by a push later to get the car industry to start exporting.

In Taiwan, there was a similar focus on investing in the car industry. The message from the authorities was that firms needed to invest in R&D, needed to become competitive and needed to export. Taiwanese firms found they were unable to compete once the protection period was over and the industry was allowed to fail. It sent out a very powerful message to other sectors about the need to become competitive and that any protection period would be temporary.

Lessons from Korea, China and other major industrial R&D spenders

Many countries - Japan in 50s, Korea in the 70s, and China in the 2000s – had a similar share of R&D spending by industry, public research institutes, and universities like India. Change has taken place over the last 40 years in Korea and Japan, and the last 20 years in China.

R&D gained in importance especially in industry in these countries, which saw massive increases in spending on R&D by firms. Many countries that started behind India with respect to their total R&D investment scenario many years ago have since moved ahead of India largely due to this very reason. R&D spend by firms has risen very dramatically in all of these other countries - in China more recently, but before that in Korea, Taiwan and Singapore.

Getting the sequence right with respect to industrialization and industrial R&D is important. In countries like Korea, growth of the industry in terms of establishing a footprint on the ground came first followed by growth in R&D.

First one saw a position of industrial leadership being established, then becoming a mass manufacturer of a product, followed by deepening within that sector or moving out of that sector if it was a relatively unfruitful sector.

In Korea and China, initial industrial development and industrial growth happened without significant investments in R&D for many years – many years were spent just playing catch up.

The number one source for technical capability in Korean firms was feedback from buyers internationally. Buyer feedback on features, level of sophistication of the product and quality was the trigger for building technical capability rather than a deliberate R&D effort which came later.

In Japan and Korea, the process of industrialization was planned and implemented by two extremely powerful bodies – the Ministry for Economy, Trade and Investment (METI) in Japan and the Economic Planning Board in Korea.

Total R&D spending by US has varied between 2.5% to 3.0% of GDP over the past 30 years. In the US there is a big difference however between who funds research and who does research (for example federal government funds a lot of research that is done in the University system).

CSIR was started largely on a British model. Britain moved away from their CSIR model and closed it down in the 1970s. South Africa too has undertaken a restructuring of their CSIR model.

Looking at the average education level of the Korean workforce from 1960 to 1990, the average number of years of schooling in 1960 was very small. By 1970 the average number of years of schooling was dramatically higher and by 1990 there were largely college graduates. What this suggests regarding the development and investment in human capability in Korea is that initially human capabilities were very basic and not connected with research until the 1990s, at which point it started to become a larger part of Korea's industrialisation story.

It is worth highlighting counter examples of countries that struggled to make the transition or get out of the middle income trap. Thailand, Malaysia, Indonesia started to grow rapidly from the 70s onwards and were expected to do what Korea and Taiwan did 10 years later – but the deepening of technical capability and investment did not take place. Similarly, in Brazil there was a lot of industrialization in the 60s, 70s and a bit in the 90s (not so much in the 80s), but one did not see the share of R&D changing. In Mexico, there was very little technological capability developing over the same period with one exception – auto components.

Building India's R&D Ecosystem

The aspiration is to hit the 2 percent Goal for R&D expenditure as percent of GDP – of which 1 percent is by Industry and 1 percent by the government. The end goal should be to have a much more competitive economy overall with technical capability that is materially different from what it is currently.

What is required is an overall framework that links the policy on economic growth, the policy on manpower and human development growth, the policy on investment in technology and the policy on export – almost all the successful countries like Korea appear to have had a plan.

There is a need for an industry restructuring and deepening story that needs to then reflect in the investment in R&D. One could see it in South Korea in the 60s, 70s, 80s and the story that is emerging in China today where the country has moved from a wide industrial base of relatively lower value added goods that put millions of people to work, to investment in newer structures and industries like automobiles, pharmaceuticals and finally growth in new fields that India is not significantly in, like electronic assembly and components where some amount of R&D is done.

The sequence is important – a decade or two of strong industrialization, an industrial base gets built, R&D starts happening in firms, and finally it starts drawing on public research being done in the universities.

It is equally important to design policies keeping in context the broader construct of the Indian system and culture. In India, there is great diversity of views and aspirations and it is important to keep that complexity and diversity in mind.

Various schemes have been launched by the Department of Science and Technology as well as schemes like the Ramalingaswami fellowships by the Department of Biotechnology to bring researchers back to India. Returnees typically end up in CSIR labs as that is where research is being done. There have been issues with respect to the take up of these schemes and there is a need to better connect these schemes with everything else going on in the country.

There is a need to encourage many individual private initiatives – eg. the use of soft power to attract talent back to the country by connecting through alumni networks. Many countries may not have recourse to networks like an IIT alumni network. Initiatives like the SAP's Hanahaus in Palo Alto, a café with conference rooms etc, can provide a meeting ground for innovative entrepreneurs to connect.

If India had to pick a field where it should be allocating a very large share of its total national public research spending - it is health. Not only because of the problems that India faces, but also because it has an existing industrial base and a world competitive pharma industry. The whole area of health accounts for a very small share of national R&D expenditure in India (even after combing R&D expenditure by DBT and ICMR). In the US it accounts for 6% of national R&D expenditure.

There are some real opportunities if India is to achieve much more in the area of connect between industry, industrial R&D spending and the draw on public research. With more companies increasing their R&D expenditure within the pharma sector, there is a readymade draw for public research if there was enough public research happening, and especially happening in the university system instead of separate labs.

Getting technical capability and technical capability deepening right - The difference for countries like Korea and Taiwan really was the technological deepening, the investment in R&D and the broader national innovation system in which this technological deepening and investment in R&D happened.

Additional Comments

There was a study that looked at the effect of size on total R&D spending - the final conclusion was that there was a threshold beyond which one needed to be to invest significantly in R&D, but as long as one was beyond that threshold, there was no correlation between size and investment in R&D. Indian firms are now of a scale and size which is beyond that threshold.

Very rapid growth of the venture capital industry post 1970s, enabled small firms to begin spending much more on R&D. More recent data has shown the above mentioned threshold has come down; the relationship between R&D expenditure and size is non-linear

With respect to whether buyers drive R&D in companies in India - for the Pharma industry besides the buyers it is also the regulatory space that these companies need to operate in – for example to be able to sell in the US, a company would be required to have a certain quality, which in turn would drive innovation.

SMEs may not have the resources to do futuristic R&D. Building capabilities within our University system and encouraging better SME-University relationships may help to fill this gap.

Even with changing policies, India has not been able to create a fertile ground for manufacturing to become a dominant force. Manufacturing needs to come in as a draw for people and research.

Section II: What is the nature of R&D in India?

Background

In recent years, technology purchase expenditures have increased much faster than R&D expenditures.

India is an important source of R&D services. India's earnings from export of R&D testing services to the US has increased dramatically in last 10 years and are more than China's earnings.

Innovation surveys like the National Innovation Survey (NIS) and the World Bank SME survey tell us that India is reasonably innovative, whereas the R&D expenditure data tells us that India is way behind. Looking at the NIS data, one is unable to get a clear picture of how R&D expenditure is leading to innovation.

Understanding the innovation connect

Important to understand as to whether the nature of R&D is changing over time, what the content of the R&D being carried out is and its connection with innovation.

Is there a method that firms use to decide how much they will spend on R&D or on technology purchases? From a policy perspective it is important to understand whether R&D expenditures and/or technology payments result in innovation and capabilities that make India competitive.

In India the firm choices that lead to innovation or build capability revolve around make, buy or copy. One is unable to decipher what gets captured in the data reported as R&D expenditure, for example whether the expenditure is for adaptive purposes or for imitation etc.

With respect to the decision of a firm to purchase technology, whether licensed (disembodied technology) or a new machine (embodied technology) – it would be interesting to know how these decisions get made, how it affects a firm's effort around technology development and whether there are any policies that affect these choices.

Industry Comments

Studies have shown that the cumulative benefits from incremental innovation and its impact on productivity growth are generally higher than from radical innovation. While benefits flow from the incremental innovations, one would need to have radical innovations to grow the incremental off.

The choices made by firms, with respect to incremental and radical innovation has varied across sectors. In the Chemical sector for instance, India appears to have done well in improvising on existing technologies, but has been a laggard in creating any game changing technologies or radical innovations. In the IT sector it was found that part of the spending on innovation was to address existing businesses and a part of it was on platforms that were extensions of existing businesses as well as completely new businesses.

An interesting practice followed by some of the IT firms is an innovation evangelisation layer. This is a listening function for market needs, customer needs, strategy etc. which binds people in research, development and innovation.

In the pharmaceutical industry, given there are long lead times with respect to the products being worked on, the initial intent is to copy existing technology or drugs that are already out there. There is a significant time lag for return on investment when it comes to spending on R&D as compared to purchasing technology.

Additional Comments

It may be more prudent to look at innovation instead of R&D. Innovation leads to productivity improvements. Setting a target for more innovations is likely to result in an increase in R&D intensity. The focus should perhaps be on creating a conducive environment for innovation.

For many companies, given the process of getting something new introduced is a complex and lengthy one, the tendency is to go for 'me too' kind of technology. Any firm before investing in R&D would also need some sort of security, in terms of likelihood of commercial success.

Things a firm does to imitate is a subset of the things it does to innovate.

Unless competition and contagion coexist, it will be difficult to have innovation. Korea and Taiwan were forced to compete at some levels. They also had access to knowledge and so both competition and contagion coexisted.

In India, there is a disconnect between the production system and the technology generation system (which is largely in the public sector). Either there should be a way to better connect these two systems or create a different system altogether that provides a fresh impetus to innovation.

Section III: Industry – University Collaborations

Background

India is an outlier in the proportion of R&D done in the university system

Efforts need to be made to improve the research being done in the public research system in India and at the same time connect internationally competitive firms in sectors like IT and pharmaceuticals with the public research system.

Efforts like the National Research Development Corporation that was set up to connect CSIR with industry only added a layer between labs and industry.

The CSIR Tech Pvt. Ltd. is an organization that tries to connect CSIR with industry.

Another avenue for linkages between universities and industry is through the labor market. There is a disconnect between what the industry demands and what is being supplied by the labor market. This disconnect needs to be addressed to improve linkages between the university and industry through this avenue.

Funding of University Research and the need for improved quality

The bulk of research funding even at universities, that are considered models of industry-university connect (for eg. Stanford University) come from federal funding, through scientific peer reviewed processes. Proportion of total research funded by industry at Stanford University is around 10%.

In India, great bulk of education R&D spending seems to be going to IISc and the IITs. There seems to be enough funding for existing institutes. What needs to be done is to scale the actual research being done within the education sector very dramatically to create demand for much more funding. This will create competition between institutes for funding and also raise the quality of research.

A draft law similar to the Bayh-Dole act (which permits a university, small business, or non-profit institution to pursue ownership of an invention even for federally funded projects), has been lying in parliament for a long time. It has worked in the US as universities compete very vigorously for research funding, which has implications for the quality of research being done. Without good quality research, laws similar to the Bayh-Doyle act would not make any sense in the Indian context.

The need to invest in University research

The argument for locating public research in the university system is two-fold:

1. The teaching benefits graduate education where students gain knowledge of new science and technology alongside people who have current knowledge (those who are doing research)

2. The country's research ecosystem benefits as future researchers are being trained alongside the nation's best existing researchers in an apprentice-journeyman system.

A State's investments into the university system produces trained researchers that could go on to do relevant work for industry. If 'relevance' of research is pushed as a criterion in the university system, it could potentially dilute the quality of research being done there.

The role of science in the innovation process

The role of scientific research in the innovation process is as follows:

Science based industries like biotechnology and semiconductors will likely benefit directly from the output of scientific research.

Once one moves away from what are considered science based industries, the role of science in the innovation process becomes very different. New scientific understanding can show up as something very productive and very powerful many years later.

Science is a wellspring for the kinds of technologies that need to be pursued. While research in science may not provide an immediate output, it does provide a direction for investing in innovation efforts, thus paving the way for subsequent industrialization.

Relevance as a determinant of research

In the private sector, investing in research is often expected to result in something that is marketable and can be commercialized. This 'accountability' is often perceived as the main difference between research done in the private sector in India and in the university system.

A book by Terence Kealey - argued that relevance *should* be a determinant of whether research is undertaken or not. The argument being that when the state invests in public research, it often displaces private investment in public research, and thus ends up being wrong for the economy and social well-being generally.

However, good quality research should be judged on its own basis (through a peer review system) which is more likely to contribute to the material good and to the quality of research, than if one was to chase the goal of relevance. Determinants of quality in the US university system, for example, do not include relevance.

In the US, there have been cases of professors at top tier universities patenting their research, starting up new companies and often selling these companies for a sizeable amount. This suggests that research being done in universities can result in applied science/applied technology even when there is no pressure of relevance – that there is productivity even when there is no relevance.

Derek de-solla Price did some work 50 years ago that looked at some leading innovations and their connection with new scientific understanding. He found there was a lag of 30 years on average between new scientific understanding and when it showed up in something material.

Importance of Basic research

Firms may do basic research so that they have an understanding of what is being done outside their organization. (eg. Public system and other firms in the industry).

Some companies do some basic research to have critical resources in-house. In order to connect with academics, there have to be a critical number of people who can understand that research well – which is why some amount of basic research is allowed in the large companies.

Some companies use it as a talent hook – to stay connected with university research is one way to connect with talented people.

Additional Comments

Story of Korea and China - industrial development came first, industrial R&D came second and public research came third.

The above sequence seems to be working for a number of relatively larger companies in India, but there are a large number of small firms that exist and are very innovative – the question is how do these small firms access the public R&D infrastructure and how do they access the university R&D effort.

Academics are good at asking fundamental questions. Academics want to ask questions of a very different kind and they need that kind of encouragement and support from industry to enable them to ask the good basic questions for industry

Industry and academics need to have right expectations of each other. Academics work to a different schedule. Getting those expectations set right is one of the ways to foster more interactions.

There is also a need for a market maker between industry and academia – for example venture capital is an important layer that can help create that connect between industry and academia.

There are companies that have signed collaborative agreements with the IITs to work on certain thematic areas. By issuing calls for proposals having highlighted the need as well as the problems faced by the company, it generates competition between different researchers as well as raises the quality of proposals being sent in.

To achieve the 2% goal (1% by government and 1% by industry), it may be worth looking into what the optimal split within the government and industrial R&D expenditure could be, where:

1) The 1% by government could be predominantly basic research.
2) The 1% by industry could be largely focused on R&D that will be translational.

Section IV: Benchmarking Competitiveness

Background

Among the global top 2500 R&D spenders - there are 829 US companies, 360 Japanese companies, 301 Chinese companies, 80 Korean companies and 26 Indian companies

Indian companies are missing from top global R&D sectors by expenditure - sectors such as Technology Hardware & Equipment, Electronic & Electrical Equipment, Aerospace & Defense and Health Care Equipment & Services.

There is a significant gap between the R&D intensity (R&D as percent of sales) of Indian companies and the average R&D intensity of global companies, even in sectors where Indian companies are among the top R&D spenders. For instance, in the pharma sector, the average global R&D intensity is around 18.0%, whereas the average R&D intensity for India is less than half that.

In the Software & Computer Services sector, the average global R&D intensity is significantly higher due to the presence of large number of IT product related firms, whereas in India's case the sector is largely dominated by IT services firms where the intensity is on average close to 1.0%.

Thinking about Benchmarking

The question about efficacy of investment in R&D is something that the government and companies especially are concerned about. When is investment in R&D seen to succeed?

Investment in R&D as a strategy – is it an indicator that would allow a company to survive, create new benchmarks in industry, or create new opportunities for the company in new markets?

Three broad connects with respect to efficacy of investments –

1) What is the translational productivity of an organization in terms of what the company does and what goes out into the market?
2) What is the R&D being done inside a lab, within its ecosystem and with partners, and what ultimately reaches the production entity?
3) How does a company create R&D externalities through a network organisation?

Examples of benchmarks used by participants

By investing in R&D, if a company improves its financial position, its market leadership or benefits society as a whole, the investment is seen as having had a positive impact.

R&D need not only be related to products, it could even be process related that helps to reduce costs - like reducing emissions to minimize damage to the environment.

The number of commercialized patents is seen as a measure of effectiveness of R&D

Setting a target for how much of the organisation's turnover should come from in-house developed products (for example the target could be 25% to 30%). This could include incremental improvements to existing products tweaked to a customer's requirements.

How much of sales is coming from R&D driven products? Innovation surveys also tend to ask the number of new products introduced per rupee of R&D expenditure.

Incremental improvements need to affect the top line and give continuous growth to the organization

A percentage of R&D expenditure is invested in futuristic areas to keep the organization abreast with latest developments, for eg. in areas like nanotechnology, fuel cell developments etc.

Time taken to commercialize one's R&D efforts and the number of new products that a company is able to come out with over a period of time (for eg. adding something new to the business every year)

Innovativeness of a company as reflected in its share price. Valuation of intangible benefits however is a complex story. In the US there are studies linking stock price changes to IP portfolio changes.

Additional Comments

There are rankings of the most innovative companies in publications like Forbes magazine. The criteria for rankings could be used as a starting point for the benchmarking of companies. Some of the criteria include financial outcomes, soft brand, and customer feedback and perceptions.

Have two processes - an innovation process and a development process. Perform a business case study to evaluate an idea (at various stages) and if the idea is found to be moving in the right direction, the idea can then be moved from the innovation phase to the starter/development phase.

Table 2: R&D externalities through network organization – A need to study this in the Indian context

Creating R&D externalities is particularly crucial in many knowledge based sectors where small companies are developing processes and tools that feed into large organizations for the purpose of translation and commercialization. There are many small and medium firms that are linked to larger organizations in the public sector like ISRO and DRDO. Many remain in this ecosystem, while some have managed to transcend and get on to doing global R&D. From a policy perspective, it is important to understand the extent to which this organizational form exists and whether this is an important ecosystem that promotes translation of R&D into commercialization and innovation. If so, what are the policies needed to encourage and promote this? When ISRO's cryogenic engine was being developed, there were a series of small (and large) enterprises that were involved in its testing, design, building and doing very innovative parts and components. Can this organizational form be looked as a mode of R&D efficacy in a country like India where resources are scarce, where the risk associated with investments and its penalties appear to be much higher? One of the reasons why this organizational form worked in the context of DRDO, the Dept. of Space and the Dept. of Atomic energy was that the enterprises could not get technology from abroad, and thus had to develop indigenous solutions by constantly innovating for these big labs and organizations. The R&D expenditure by these small enterprises in such efforts is likely to have been 50-100% of the company's revenue. The R&D expenditure by the smaller firms may not be getting captured anywhere. Difficult to address this by simply looking at the amount spent by organizations like DRDO on these small enterprises (it would only constitute a percentage of DRDO's total R&D expenditure). As seen from the example of the defence related projects, it is important for a cluster to have an anchor. There may be other sectors where a number of smaller enterprises are working together to develop cutting edge stuff. Such efforts, if any, need to be captured.

Section V: Importance of IPR

Background

Patents from India filed with the USPTO have been rising. It is estimated that around 60-70 percent of these patents are owned by MNCs. Quite likely that many patents filed in the US are also filed in India.

Some of the top companies like IBM and Samsung file more patents with USPTO than India.

Global data suggests that 85% to 90% of patents never get commercialized. Firms get patents for a variety of purposes not necessarily converting them into innovations by commercializing them.

Large companies in the IT sector may use a co-innovation network to work with startups. Patents of the start-ups or those generated through this network are used mainly for defensive purposes, especially if the work of the start-ups is being integrated into a product of the larger company.

Some small companies sign away their right to patent when they do contract research as they may not be able to go through the patent process.

Patenting in India has other challenges like excessive bureaucracy eg. according to the National Biodiversity Act, any patent that requires access to a natural resource should have obtained prior approval from the National Biodiversity Authority. This is followed by a list of queries from the patent office that need answers and from other government bodies.

Other problems that have also plagued the patent system include a manpower crisis in the Indian patent office. In the National IP policy there is commitment to bring down the examination time to 18 months, and a number of patent examiners have recently been inducted into the Patent office.

Design patents from China have increased significantly compared to India's design patents. The share of design patents in total patents filed with the USPTO from India is relatively small – not necessarily a bad thing.

There were approximately 200,000 trademark registration applications in India in 2013-14

Additional Comments

Citation of a patent could be used as an indicator to measure the effectiveness of the patent

If large firms encourage or use the patents of smaller firms, then with the right incentives structure one can get a large number of small firms that are prone to doing much more innovative stuff to start patenting. This could change the nature and innovativeness of India's R&D ecosystem.

Awareness among the SMEs needs to be created about other forms of IP like design rights, copyright, trademarks etc. Copyright is a very powerful IP because it is available for a long time. Larger companies working with SMEs could create such awareness through their supply chain about the other forms of IP.

There is a need to create an intermediate level patenting mechanism, which is not onerous in terms of time and money and which will allow companies and individuals to get IP quickly.

Certain licensing models may need to be adopted to be better aligned with global systems for transferring technology. This would be needed to obtain technology in the area of IT and telecommunication, which is relevant in light of the recent Digital India campaign.

In the Pharma industry, there are lot of device related patents that cover the design aspects of a drug-device combination product, primary and secondary packaging.

Design patents are important for furniture and crockery – ornamental designs.

Section VI: Influence of Macro policies and schemes

Background

The impact of the 200 percent weighted deduction tax incentive scheme for R&D has been varied. Some companies found it useful in particular to take on more risks and hire more R&D personnel, whereas some large companies did not see it as being a driver of their R&D expenditure (as they were sometimes eligible for MAT in any case).

There are a number of schemes that the government has floated. There is a general lack of awareness of the various schemes. Companies do not find the schemes necessarily user friendly and have also found issues with the eligibility criteria laid down in these schemes.

Grants are often administered through quasi government bodies or universities and require industry to partner with them. Working through the bureaucracy becomes a challenge for industry, which may prevent them from partnering with institutions like CSIR.

The National Biodiversity Act prohibits any company with a foreign shareholder from accessing India's national resources for the purpose of R&D. Some of the larger Indian chemical companies find it easier to obtain resources from abroad – for eg. sourcing microorganisms from the US.

The Prime Minister's Fellowship Scheme is intended for around 100 prospective PhD students in Engineering, Science and Technology. The scholarship is paid for by a combination of funds from industry and government. The number of applicants has tended to be less than 100, and there have been issues with the quality of applicants

Focused schemes that have been recently been launched

The Technology Acquisition Development Fund (TADF) that has been launched to facilitate acquisition of Clean, Green & Energy Efficient Technologies by MSMEs.

A leveraged funding scheme has been launched by the Indian government recently - the Uchhatar Avishkar Yojana (UAY), which shall initially be applicable to projects proposed by the IITs. Appears to be similar to the leveraged funding schemes that have been launched in countries like UK, EU and Canada, where money put into university research by industry is used as leverage for obtaining additional funding from the government. The governments in these countries do not stake claims to the Intellectual Property that may be generated from this process.

The IMPRINT India initiative is a pan-IIT and IISc joint initiative to develop a roadmap for research to solve major engineering and technology challenges in ten technology domains relevant to India.

The INFUSE programme - IIM-A's contribution (funds were obtained from the government) towards a clean energy venture capital fund to support clean energy tech companies, was leveraged by raising additional funds from the private sector. Leveraging was important and the government was prepared to take the first loss. CIIE at IIMA had equity participation in this venture, whereas the government's contribution was seen a grant. The approach taken could potentially be a way of addressing a market gap.

The solar energy research initiative set up by the Department of Science & Technology is a scheme to support R&D of solar related technologies. One of the few cases where the grant was given directly to industry.

Additional Comments

The interaction between industrial policy, trade policy, IPR policy etc. is complex. It is important to ensure that they are consistently moving in a particular direction that creates some degree of contestability in the market. Else the incentive to innovate may not be there.

It needs to be investigated whether the various policy instruments are complementing private sector investment or substituting it in India. Previous studies have shown that in many countries such policy instruments end up substituting private investments instead of complementing them.

Where access to some kind of natural resource is required for the purpose of R&D, perhaps the initial research could be undertaken by SMEs, universities or government institutions and later taken over by a larger organization.

A lot of the data collected by Dept. of Science & Technology/ Dept. of Scientific and Industrial Research are not available in the public domain. Need to work with DST/DSIR and CII to access to this data, including data from the innovation surveys. Creating an annual ranking of the top 100 innovative companies may incentivise companies to release information about their R&D activity.

Need to encourage small and medium firms across different sectors to invest in R&D to ensure greater industry participation towards the 2% goal. May help small and medium firms if a policy guaranteed some kind of security that the product they develop would be used in the market.

The ability to mortgage IP, as a way of raising capital, could be a trigger for SMEs to invest in R&D or source technology.

A waiver of the past track record requirement for SMEs could be considered to enable them to access the public procurement system, especially in cases where a SME has developed a new innovative product through the use of indigenous technology sourced from public funded institutions. This could also be a trigger for them to reach out to public institutions for the purpose of sourcing technology.

APPENDIX

List of Participants

	Participants	Designation	Organization
1	Dr. Naushad Forbes	President - CII and Co-chairman, Forbes Marshall, (Chairman of the Board, CTIER)	Forbes Marshall
2	Mr. Farhad Forbes	Co-chairman, Forbes Marshall, (Board Member, CTIER)	Forbes Marshall
3	Mr Anjan Das	Executive Director for Technology - CII, (Research Advisory Council, CTIER)	Confederation of Indian Industry
4	Dr. Pankaj Chandra	Vice Chancellor - Ahmedabad University, (Research Advisory Council, CTIER)	Ahmedabad University
5	Dr. Rakesh Basant	Professor - IIM Ahmedabad (Research Advisory Council, CTIER)	IIM Ahmedabad
6	Dr. Subhash Sasidharan	Associate Professor - IIT Madras, (Affiliated Researcher, CTIER)	IIT Madras
7	Dr. Sreeshap Srinivasa	Sr. Vice President & Head, R&D	Biocon
8	Mr Ashwini K Aggarwal	Director - Government Affairs	Applied Materials
9	Mr. Sunilkumar Vemula	Senior General Manager (Development)	Bosch Ltd.
10	Mr Datta Kuvalekar	Director - Technology	Forbes Marshall
11	Mr. Prashant Sakhamuri	MD – HHV	Hind High Vacuum
12	Mr. Rabindra Srikantan	MD - ASM Tech	ASM Technologies Ltd.
13	Dr. Sridhar Desikan	Vice President and Site Head	Dr Reddy's Laboratories
14	Mr. K Ananth Krishnan	Chief Technology Officer (CTO)	Tata Consultancy Services Ltd
15	Smt Alka Tuteja	GM (CEPD)	Bharat Heavy Electricals Ltd
16	Mr. Puneet Kishore	GM & Head Technical Centre	Oil & Natural Gas Corporation Ltd
17	Dr. Rakesh Vir Jasra	Sr. Vice President, R&D	Reliance Industries Ltd
18	Mr Brian McMurray	Director, Engineering & Operations	General Motors
19	Dr Anil Kumar	Head	Tata Chemicals Innovation Centre, Pune
20	Mr. Sanjoy Sarma	Head - Strategic Engineering Division	Tata Power SED
21	Dr Ashwani Gupta	Scientist	DSIR
22	Dr Praveen Arora	Head (CHORD-NSTMIS), NSTMIS Division	DST
23	Mr. Sanjay Sharma	Technology Leader	E I Dupont India Pvt. Ltd.
24	Prof Pradosh Nath	Director	Centre for Knowledge, Ideas and Development Studies (KnIDS)
25	Mr Raghvendra Saha	Senior Advisor (IPR)	CII
26	Mr G K Moinudeen	Director- Technology	CII
27	Mr. Janak Nabar	Chief Executive Officer	CTIER
28	Mr. Geet Chawla	Research Analyst	CTIER
29	Mr. Ashwin Shankar	Research Analyst	CTIER
30	Mr. Abrarali Saiyed	Assistant Professor	Ahmedabad University
31	Ms Divya Arya	Executive Officer	CII
32	Mr Mayank Rohatgi	Executive Officer	CII