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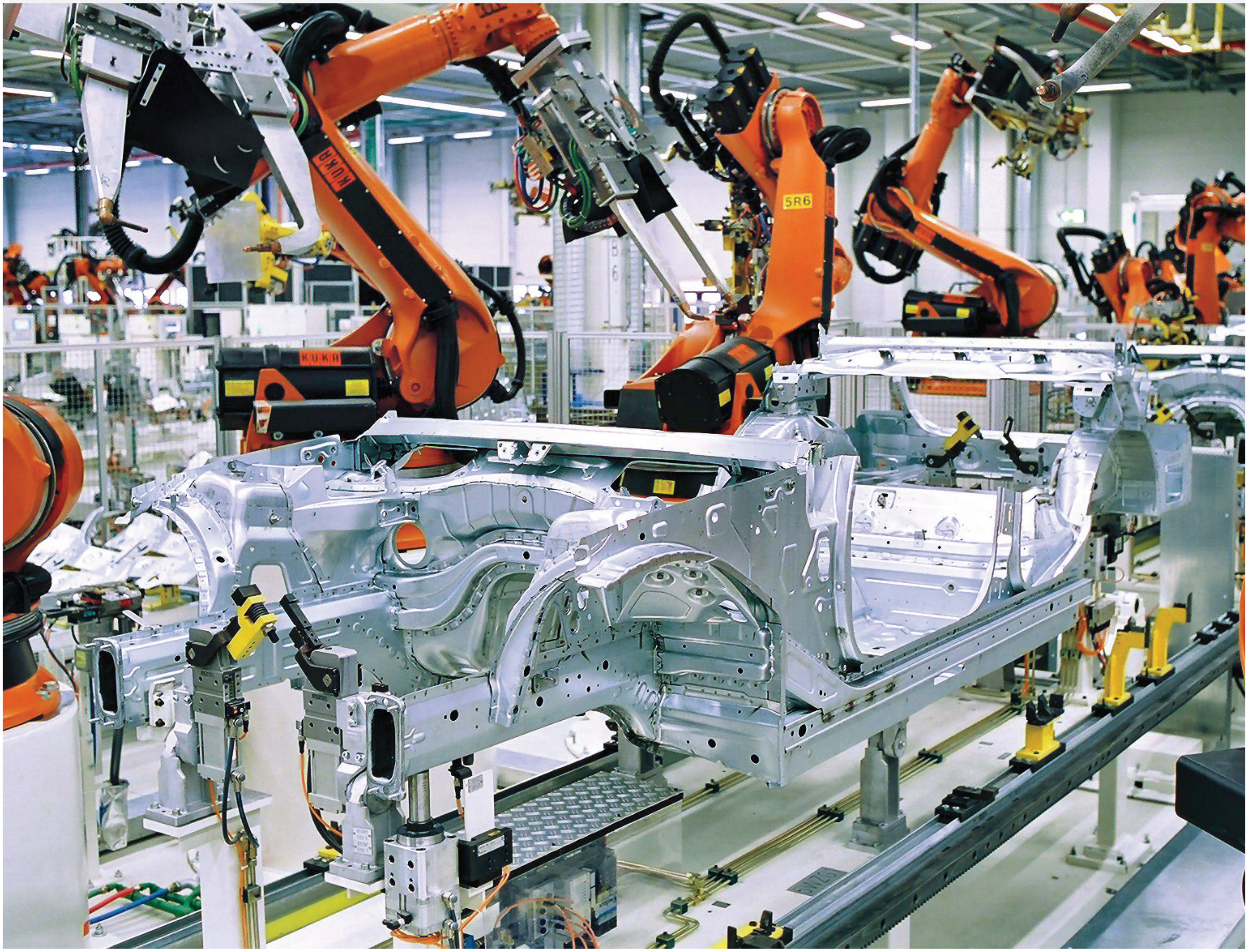

Make in India

How could we be strategic?

VAIBHAV GUPTA, KARTHIK GANESAN, AND ARUNABHA GHOSH

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A report on 'Make in India – How could we be strategic?'.

Editor: Dr Arunabha Ghosh

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About CEEW

The Council on Energy, Environment and Water (http://ceew.in/) is an independent, not-for-profit policy research institution. CEEW addresses pressing global challenges through an integrated and internationally focused approach. It does so through high quality research, partnerships with public and private institutions, and engagement with and outreach to the wider public.

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Vaibhav Gupta is a Junior Research Associate at the Council on Energy, Environment and Water (CEEW). His research interests include mineral resource security; future fossil fuel demand, supply and delivery; and collaborative environmental management. His current research focuses on understanding critical non-fuel mineral resource for India's manufacturing economy. He is also actively involved in energy modeling exercise for India.

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Karthik Ganesan is a Senior Research Associate at the Council on Energy, Environment and Water (CEEW), India. As a member of the team at CEEW his research focus includes the development of long-term energy scenarios for India (based on an in-house cost-optimisation model) and energy efficiency improvements in the industrial sector in India. Linked to his work in industrial efficiency is his role as the principal investigator in an effort to identify critical mineral resources required for India's manufacturing sector. In addition, he supports on-going work in the areas of energy access indicators for rural Indian households and carried out a first-of-a-kind evaluation of the impact of industrial policies on the RE sector in India.

Prior to his association with CEEW he has worked on an array of projects in collaboration with various international institutions, with a focus on low-carbon development and energy security. His published (and under review) works include Rethink India's Energy Strategy (Nature, Comment) the Co-location opportunities for renewable energy and agriculture in North-western India: Trade-offs and Synergies (American Geophysical Union), Valuation of health impact of air pollution from thermal power plants (ADB), Technical feasibility of metropolitan siting of nuclear power plants (NUS), Prospects for Carbon Capture and Storage in SE Asia (ADB). His role as a research assistant at a graduate level focused on the linkages between electricity consumption and sectoral economic growth using a time-series approach.

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Dr Ghosh was invited by the Government of France as a *Personnalité d'Avenir* to advise on the COP21 climate negotiations and has written extensively about the Paris Agreement. His original concept of a "solar club" was championed by the Government of India when it launched the International Solar Alliance in November 2015. Arunabha's essay "Rethink India's energy strategy" in *Nature*, the world's most cited scientific journal, was selected as one of 2015's ten most influential essays. Widely published, he is most recently co-author of *Climate Change: A Risk Assessment* (2015); and *Human Development and Global Institutions* (Routledge, 2016). Two other forthcoming books include: *Palgrave Handbook on the International Political Economy of Energy* (2016); and *Energising India: Towards a Resilient and Equitable Energy System* (SAGE, 2016). He writes a monthly column in the *Business Standard*, contributes regularly to other periodicals, and comments via several international radio and television broadcasters. He has been an author of three UNDP *Human Development Reports*.

Dr Ghosh has advised the Prime Minister's Office, several ministries, state governments and international organisations on a range of subjects. He has presented to heads of state, India's Parliament, the European Parliament, Brazil's Senate, and other legislatures; trained ministers in Central Asia; and hosted a documentary on water set out of Africa. He is a member of Track II dialogues with Bhutan, China, Israel, Pakistan, Singapore, Turkey and the United States, and formulated the Maharashtra-Guangdong Partnership on Sustainability. He is a founding board member of the Clean Energy Access Network (CLEAN) and is board member of the International Centre for Trade & Sustainable Development, Geneva. He also serves on the Executive Committee of the India-U.S. PACEsetter Fund, which invests in promising decentralised energy solutions. He holds a doctorate from the University of Oxford (Clarendon Scholar; Marvin Bower Scholar), an M.A. (First Class) in Philosophy, Politics and Economics (Balliol College, Oxford; Radhakrishnan Scholar); and topped Economics from St. Stephen's College, Delhi.

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1. Introduction: Strategic Importance of Manufacturing and Enabling Technologies

In the last decade, increasing urbanization and rising income levels have accelerated consumer demand for manufactured goods, in India. By 2030, India is expected to become world's fifth largest consumer market.[1] On the other hand, a sluggish manufacturing sector has failed to recognise and capitalise on this rise in demand. The share of industry (a superset that includes manufacturing) in the country's GDP has been languishing in the range of 26%-27% in the post-liberalisation era, and manufacturing has contributed just 14% to 16% to India's GDP.[2] The "Make in India" initiative was announced by the current government as one of its flagship programmes, with the aim to revive the manufacturing sector.

However, while moving forward with 'Make in India', policy makers need to be wary of the socio-economic reality of India and the challenges of pursuing growth in specific manufacturing sectors. India's diversified manufacturing sector is spread across its geography. While this forms a sound base on which India's economy can grow, manufacturing is also under threat from a range of factors. Entrepreneurs find it easier to set up firms in the services sector. Investors, in turn, prefer higher returns on investment over shorter payback periods, which make long-term investments in strategic industries challenging. India's youth prefer the pay scales and glamour of the services sector, even as a start-up culture is beginning to develop in the e-commerce space. There is an urgent need to bring confidence back in the manufacturing sector. India's enterprise and talent must be channelled towards the grand challenge for India's development: growth which is inclusive and sustainable.

As an emerging power, India's national security also depends on the robustness and sustainability of its economic growth. Among other factors, which include its human capital, its natural and physical capital, and its scientific and technological strengths, Indian industry will also have an important role to play. From a national security perspective, manufacturing matters for four main reasons:

- *Jobs*: A dynamic manufacturing sector is both dependent on labour mobility and also encourages it, as workers gain and transmit skills and technical knowhow across different sub-sectors, if not industries.
- *Innovation*: Around the world, the manufacturing sector is also often the fountainhead of innovation in the economy. But India spends far less on R&D than other leading economies and only a small share is accounted for by the private sector.
- *Trade balance*: In India, a large share of export earnings (nearly half) is spent on importing crude oil. As a high value-added sector, manufacturing could have a dual role: exports of

manufactured products could serve as the bulwark against rising import costs for raw materials; and reducing dependence on imported fuels by innovating in energy efficiency.

- *Resource security*: As the manufacturing sector grows, it will need more domestic and foreign sources of energy supplies and other critical mineral resources, such as cobalt, lithium, antimony, molybdenum, copper, gallium etc., which have gained prominence in recent years.

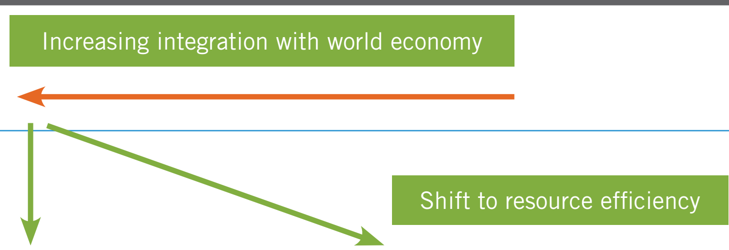
Two important parameters create a direct link between manufacturing and national security: indigenisation and resource efficiency. The case for indigenisation rests on creating jobs at home, developing state-of-the-art technologies, improving the trade balance, and increasing resource security by reducing exposure and vulnerability to resources. Efficiency in the use of resources – the other parameter – is important because it could increase jobs in new sectors, promote innovations, improve the trade balance, and of course improve resource security (Table 1). India's efforts in growing higher value added manufacturing at home (essentially, high-tech indigenisation) would have to be accompanied by better ways to acquire and use resources efficiently (Table 2). The most important national security aspect for India's manufacturing sector is resource efficiency.

Table 1: Factors affecting the manufacturing/national security linkage

	Low/Medium Indigenisation	High Indigenisation
Low Resource Efficiency	Jobs ↔ Innovation ↓ Trade balance ↓ Resource security ↓	Jobs ↑↑ Innovation ↑ Trade balance ↔ or ↓ Resource security ↔ or ↓
High Resource Efficiency	Jobs ↔ Innovation ↑ Trade balance ↑ Resource security ↑	Jobs ↑↑ Innovation ↑↑ Trade balance ↑↑ Resource security ↑↑

Table 2: The need to shift towards resource efficiency

	Low/Medium Indigenisation	High Indigenisation
Low Resource Efficiency		
High Resource Efficiency		



An enormous amount of resources need to be secured to transform India to a manufacturing hub. Undoubtedly, resource efficiency and indigenisation are prerequisites to achieve that. However, to become a global innovation centre, India needs to have a clear vision to translate research from concept to commercial products and services. In the following section we discuss the important transitions that are necessary to realise the manufacturing aspirations of the country.

2. Transition towards a Competitive Manufacturing Economy

If resource efficiency has to be at the heart of India's manufacturing competitiveness, a strategic approach towards 'Make in India' would be needed. This strategic approach would have to support India's transition in three important aspects.

1. from resource vulnerability to securing resources
2. from acquiring technology to developing high technology
3. from education and skills to R&D and innovation

Transition 1: From resource vulnerability to securing resources

Natural resources (fuel, minerals, ecosystem services etc.) are the lifeblood for the manufacturing sector. As the stock of natural resources is finite in, a major source of concern is the vulnerability of industrial clusters to environmental and resource pressures. Indian manufacturing will have to endure several pressures, ranging from low or no availability of domestic resources, increased competition for global supplies, sudden increases in prices due to imposition of export taxes and carbon levies, and the price pressure from having to eventually align domestic prices with international trends. As a remedial measure alternative sources of supply must be considered beyond our immediate periphery. Ports, freight and supporting infrastructure are needed at a commensurate scale. If new supply routes are developed for critical resources, then infrastructure will also have to increase along our coasts and inland.

Elsewhere, leading economies have initiated steps to acquire overseas natural resources, whether through new agencies (Germany), innovative financing (Japan), sovereign funds (China), and long-term plans and supply agreements (Korea). For Indian manufacturing and its national security, the transition towards greater resource security would need the following interventions.

- RECOMMENDATION 1 (SHORT-TERM): In the immediate short-term, i.e. within the next two years, support Micro, Small and Medium Enterprises since their land, water, energy and other resource requirements are more limited than for larger firms. Their share of the GDP is ~ 8%, representing 45% of the total manufacturing output.[3] MSMEs are also more likely to converge around existing manufacturing clusters before necessitating the creation of new National Investment and Manufacturing Zones (NIMZs). Stronger supply chain linkages would further increase the effectiveness of clusters. The government has initiated multiple credit guarantee schemes, such as, the Scheme of Fund for Regeneration of Traditional Industries (SFURTI); Credit Linked Capital Subsidy Schemes (CLCSS); Credit Guarantee Fund Scheme assists MSEs (CGTMSE), etc.in support of MSMEs. However, MSMEs should be supported with access to long-term debt through priority sector lending (under RBI guidelines). Another scheme called 'performance and credit rating scheme' stimulates awareness among the MSMEs about their strengths and weaknesses, while applying for credit. The Bureau of Energy Efficiency should also support efficiency norms and practices in the MSME sector to further reinforce the efficiency improvements. In order to have demonstrable impact, initial efforts should concentrate on clusters in critically polluted areas. There should also be focus on clusters linked to energy, water, machine tools, precision equipment, etc. which generate jobs and promote industrial innovation. The biggest obstruction in implementation of all these reforms is the huge volume of unregistered MSME units (95%),[4] which anyway are outside of the purview public scheme. The Udyog Aadhar Scheme is testimony to this unique phenomenon of Indian enterprises and has been launched to bring them under the ambit of these schemes for formal registered units. Effective implementation of this single initiative will decide the fate of other reforms at large.

- **RECOMMENDATION 2 (SHORT-TERM):** Another immediate priority is to develop a framework for determining critical mineral resources. This list could be continuously updated but there is a need for applying objective criteria to establish criticality. These would include potential import dependence, potential supply vulnerabilities, potential price pressures, and domestic infrastructure bottlenecks. This task should be led by the National Security Council Secretariat or the recently formed 'India Resource Panel', and the results should be discussed and overseen by the Cabinet Committee on Security. The work could be supported by the consortium of sector specific experts, such as Geological Survey of India, Indian School of Mines, non-government agencies, etc. It is also important to get inputs on critical resources from the ministries of defence, finance, external affairs, commerce, petroleum and natural gas, coal, and steel, among others. While the central government will take the lead, resource-rich states should be included in the process.

- **RECOMMENDATION 3 (MEDIUM-TERM):** An Integrated Resources Corporation (IRC), as an autonomous body, is needed to support individual firms with financing and other support for a range of critical resources. The IRC's main role would be to help firms acquire resources via: equity capital; guarantees for debt market financing; liability guarantees; long-term bilateral agreements; and coordination with embassies. It could have representation from the major ministries, industry chambers, civil society organisations, and financial institutions. Over the long-term, it could establish overseas offices in countries that are major sources for resources, eg. Australia, Canada, Indonesia, Qatar, etc.[5]

- **RECOMMENDATION 4 (LONG-TERM):** Monitor critical infrastructure on the state of coastal and inland infrastructure, maintenance and construction requirements, and the adequacy and optimisation of use. This should be a continuous and long-term priority combined with horizon planning for the demands on critical infrastructure. The government should monitor and annually report on the state of coastal and inland infrastructure, maintenance and construction requirements, and the adequacy and optimisation of use. Data should be received from the Ports Authority of India; Ministries of Coal, Petroleum & Natural Gas, etc. The Report could be drafted by a network of think-tanks on behalf of the Integrated Resources Corporation's Board. To begin with, the focus should be on the main points of vulnerability in India's resources supply lines (for e.g., coal ports, oil and gas terminals, etc.).

Transition 2: From acquiring technology to developing high technology

Many leading economies are now focusing their sights on the energy and resources sectors to develop new technologies. These emerging technologies are supported by long-term strategies and funding. The 'Make in India' initiative is primarily directed at increasing the manufacturing base in India. It has less of a focus on innovation but it does have complementary missions in the Skill India and Startup India initiatives. However, with all 25 manufacturing sectors taking centre stage, there is no understanding of special sectors for India. Certain strategic industries, including aerospace, renewable energy, defence equipment, and electronic hardware, will require concerted attention since India's capabilities are underdeveloped; require long-term investments; and will face severe competition. The recommendations for acquiring and developing high technology to breed innovation include:

- **RECOMMENDATION 5 (SHORT-TERM):** Support nascent technology acquisition and development activities (eg. auto, renewable energy, energy efficiency, defence) and encourage efforts to revive established manufacturing bases (eg. machine tools). In order to achieve this goal, it is recommended that India primarily relies on industry (public and private sector) to identify which technologies to invest in. The government's role would be supportive. It would offer support through long-term credit (working capital is crucial for developing transformational technology), risk guarantees, and support from its network of embassies in order to identify technology acquisition opportunities. Most of the activities could occur within firms or at an industry level, so long as the incentives are clear and have a degree of longevity.

- **RECOMMENDATION 6 (SHORT-TERM):** Outline national security implications of strategic industries. This is an immediate priority so that the 'Make in India' programme can be implemented with a strategic focus. For this, it is important to undertake a technology gap analysis, for which industry associations should take the lead. Once the target industries have been selected, it is important to analyse their resource requirements; niche technologies that could be developed; key market potential; and vulnerability to price and demand shocks. One effective strategy would be to leverage associations with greater backward and forward linkages, such as AIMTMA (for machine tools), SIAM & ACMA (automobiles), MAIT (IT hardware), etc. A working group comprising the NSCS, NITI Aayog, TIFAC and the Department of Industrial Policy Promotion (DIPP), among others, could serve as the forum to assess developments and vulnerabilities in strategic industries.

- **RECOMMENDATION 7 (MEDIUM-TERM):** Establish a Strategic Innovation Prize for public-private opportunities and risk sharing in key technologies with payments contingent on technologies being developed. This can be a medium-term goal (over the next four-five years), by when certain new technologies could be demonstrated. The Strategic Innovation Prize would specify clear goals such as increasing efficiency of power plant boilers or reducing weight of batteries in electric vehicles or a new weapons system. It could call for consortium-led proposals, requiring both private and public entities to be part of any consortium as well as co-financing by consortia to promote private R&D investment. R&D would be undertaken by one or more winning consortia. Upfront public funds could leverage interest from capital markets to provide the working capital for R&D. The Prize could be administered via the Department of Science & Technology, but funding could be contributed by relevant ministries (like defence, power, petroleum & natural gas, etc.). It is important to involve large business conglomerates who would benefit from investing in dynamic but innovative small and medium firms. The R&D would occur in a networked manner through government labs, enterprise labs, universities, and independent institutions. In fact, network-based R&D would force consortium partners to raise their productivity because the prize and payment would be contingent on delivery of the new technology.

Transition 3: From education and skills to R&D and innovation

R&D activities in India are not as productive as compared to other large economies. India has not been able to increase the number of PhD's in science and engineering significantly. India lags most major economies in converting its R&D investments into high quality research. In India, more than 25% of investment is directed at basic research, against China's 5% and U.S.'s 17%. A disproportionately low spend in the advanced stages of the research implies that few ideas translate to a commercial success. If patents are considered as an indicator of innovation, then we see that there is a rapid growth since the mid-1990s but filings per person remain low.

The Government of India is targeting the creation of 100 million jobs from the manufacturing sector by 2022 under the Make in India programme. To achieve economic and social goals, more than 75% of all new job opportunities would have to be "skill based". Skilling the workforce for a more integrated R&D ecosystem is a critical input for a competitive manufacturing sector at a later stage. In tandem, India needs reforms at multiple levels of the innovation development chain. This extends from basic and advanced research (in academic institutes) to the proof-of-concept stage (with the active support from public and private financing) and finally as research enters the market at a competitive scale.

However, before India reshapes the innovating ecosystem and prepares for appropriate skills required, we need to understand the importance of key enabling technologies that will impact the economy in the decades ahead. What is a strategic industry for India? What is the rationale for the choice of strategic sectors (or technologies)? An elaborate analysis of the performance of India in key strategic technological sectors is offered in this study. The recommendations for the third transition – building a strategic ecosystem for R&D and innovation – are discussed in section 6 of this report.

Strategic industries; enabling technologies

A strategic industry for India is one that enables the domestic production of high value added goods and services while ensuring that the manufacturing process is efficient in managing the limited inputs available to India.

a. Over the course of the last year, the government has initiated several policy reforms towards improving the ease of doing business, thereby supporting the 'Make in India' initiative in a big way. We have performed well in terms of the following:

b. Government has managed to attract foreign investments in multiple sectors. This is evident from the 48% increase in FDI equity inflows between October 2014 and September 2015.[6]

Several multinational companies have announced plans to set up manufacturing facilities in India while investing in expansion of their current business in India. The electronics sector has specifically attracted much attention.[7]

More recently, the government has launched another key programme called "Startup India". It is a good first step to foster the culture of entrepreneurship in India, by assisting new businesses with financial support, and simplifying the process of administrative and legal compliances for such firms. The Startup India mission also intends to bridge the gap between industry and academia through active collaborations and incubation facilities.[8]

While many steps to promote indigenous industry are underway, there still exists no understanding within the country on exactly what should be considered as a strategic industry and the technologies needed to pursue them. As a result there is no coherent strategy at the national level on how emerging technologies can be brought closer to industrial development and at commercial scale. ***Emerging and enabling technologies have key features: (a) knowledge intensiveness, (b) rapid innovation cycles, (c) multidisciplinary nature in cutting across many areas, and (d) immense disruptive potential. Hence, the activities as part of the current 'Make in India' drive must go beyond the mere promotion of India as an investment destination.***

In this study, we have attempted to identify and understand the emerging technologies that India must focus on. Through an extensive review of various studies on technology trends, we carried out an in depth analysis of five emerging technologies, namely ***biotechnology***, ***nanotechnology, micro and nanoelectronics, photonics, and advanced materials***. These technologies have been identified as growth enabling technologies and disruptive in the global context and for India as well. A distinct feature of such disruptive technologies is their diverse and multidisciplinary application potential, by displacing older technologies, or by enabling whole new classes of products and markets. The five comprehensive knowledge-intensive technology areas are already recognised by major economies based on their potential impact on global economy. For example: In 2009, European Union (EU) directed national agencies to identify enabling technologies for their industrial progress and augmenting innovation capacity. Further, they commissioned a high level expert group to develop a strategy to promote these technologies and deploy with industries in a close manner.[9] Similarly, an independent study for the United States identifies the similar set of technologies as strategic for their economy.[10] From India's perspective, all five technologies have wide-ranging applications – for strategic sectors, to stimulate economic growth, and for social development imperatives (Figure 1).

Figure 1: Enabling technologies potential to address challenges and requirements for India's progress

Indicators	Components	Emerging Technologies				
		BT	NT	PH	MNE	AM
Social development challenges	Water and sanitation	•	•	•		•
	Energy access	•	•	•	•	
	Quality of life	•	•	•	•	•
	Low cost medical needs	•	•	•	•	•
	Improved diagnostics of disease	•	•	•	•	•
Economic growth challenges	Low carbon economy	•	•	•	•	•
	Environmental safeguard	•	•	•	•	•
	Resource efficiency	•	•			•
	High value addition	•	•	•	•	•
Strategic requirements	Manufacturing of defence systems		•	•	•	•
	Resource security	•	•	•		•
	Energy security	•		•		•
	Advanced machines and tools		•	•	•	•

Keywords: BT = Biotechnology; NT = Nanotechnology; P = Photonics; MNE = Micro and Nano electronics; AM = Advanced materials.

Source: CEEW analysis

3. Why Focus on these Enabling Technologies?

From an economic perspective, the selected technologies can prove to be game changers for the Indian economy and can potentially boost India's dwindling industrial growth if developed strategically. India is facing several challenges both on the industrial growth as well as societal front, resource crises at multiple levels, environmental degradation, lack of water supply and sanitation services, food shortages, unmet medical needs etc. These technologies are expected to play a key role in sustained future growth by addressing some of these challenges. The application of these technologies is spans a wide spectrum of products and services. Hence, we estimate the potential sectors that could be influenced by each of the identified technologies and attribute the economic contribution i.e. gross value addition (GVA) by that product group to the overall impact made by the particular technology.

Biotechnology

Biotechnology refers to a group of technologies that could be broadly defined as "using organisms or their products for commercial purposes". Biotechnology is an enabling technology for industries as diverse as pharmaceuticals, diagnostics, textiles, aquaculture, forestry, chemicals, household products, food processing etc. for creating products possessing characteristics such as greater speed, efficiency and flexibility.[11] India has a pool of nearly 380 biotech companies out of which nearly 40% operate in bio-pharma, followed by bio-services (21%), agriculture biotechnology (19%), bioinformatics (14%) and industrial biotechnology (5%) with the smallest share.[12]

The biotechnology sector has a global market valued at USD 216.5 billion, and is expected to reach USD 414.5 billion by 2017.[13] The biotechnology sector in India crossed USD 4.3 billion revenue in 2013 at an impressive annual growth rate of 24% from 2003 onwards.[14] It is expected to reach USD 11.6 billion mark by 2017.[15]

The disruptiveness of industrial biotechnology alone can be seen through bio-refining outputs (fuels, chemicals, power and heat), which are estimated to yield revenue potentials of USD 80 billion for biofuels, USD 10-15 billion for bio-based bulk chemicals and bio plastics alone, and USD 65 billion for power and heat by 2020.[16] Although there is a lot of activity in bio-pharma in India (and to an extent, agriculture biotechnology), industrial biotechnology is still largely untapped in India. **As per our analysis, industrial biotechnology alone has a potential to impact or leverage approximately 14.5% of Gross Value Added (GVA) by manufacturing industries, thus offering extensive opportunities for industrial growth**.

Nanotechnology

Nanotechnology is the study of structures, materials or devices sized between 1 and 100 nanometre (10^{-9} metres). As an enabling technology, it can be applied to realise smaller, quicker and intelligent components of products, with completely new or improved functions in early phases of the value addition chain.[17] At the commercial level, nanotechnology impacts or is likely to impact three major industrial applications: (a) manufacturing and materials, (b) electronics and information technology, (c) healthcare and life sciences.

In 2012, nanotechnology-enabled products contributed nearly USD 1 trillion in a total global industrial value add of USD 22 trillion.[18] This is expected to rise to a whopping figure of USD 4.4 trillion by 2018.[19] **As per our analysis, nanotechnology application sectors as a whole have the potential to impact up to 86% of India's total gross value added (GVA) by industries.**

Micro and nanoelectronics

Micro and nanoelectronics[1] is an expansive technology area, which impacts a range of engineering goods from the simplest components (insulators, resistors, capacitors) to modern materials (disc drives, organic materials, plasmas, semiconductors, quantum effect materials etc.) and systems (integrated circuits, printed circuit boards, multichip modules, sensors, micro-electro-mechanical systems etc.).[20] The "use of micro components for manufacturing electronics products" and is typically associated with integrated circuits (ICs), which essentially are an inter-connected set of electronics components.[21] Nanoelectronics, on the other hand, is defined as "nano-scale (<100 nm) manufacturing of ever-smaller and higher performance of existing semiconductor devices and advances in molecular electronics" and is considered a strategic research and application field.[22]

Products comprising micro and nanoelectronics components and systems represent around USD 1.75 trillion in value, in turn supporting 10% of global GDP.[23] It is recognised as the largest and fastest growing manufacturing industry. The Indian Electronics Systems Design and Manufacturing (ESDM) industry was worth USD 68.31 billion in 2012, as per some estimates the growth rate for the sector is 9.88% till present. However, a matter of concern is the dwindling share of domestic value addition in manufactured goods and the high import dependency (~65%) for manufactured goods. Since 2011, high value added manufacturing is estimated to have declined to 6.7% of total demand of the electronics sector and has resulted in a cumulative opportunity loss of USD 200 billion.[24] Further, it is very likely that in the coming years, the electronics import bill would surpass the oil import bill of India.

While the actual contribution from 'micro and nano electronics' manufacturing (in terms of GVA) currently is a mere 2.7%, as per our analysis, their downstream impact is near universal across the manufacturing sector (direct and indirect). This also shows the immense opportunity that lies with Indian manufacturing industries to increase their production share and boost India's dwindling industrial growth.

1 Referred as "micro and nano-electronics", as it spans from nano-scale transistors to micro-scale systems; integrating multiple functions on a chip

Advanced materials

Advanced materials are entirely new materials or modifications to existing materials to obtain superior performance.[25] Advanced materials can broadly be categorised into the following groups: (a) biomaterials, (b) catalysts, (c) ceramic materials, (d) composites, (e) electronic and optical-photonic material, (f) magnetic materials, (g) metals and alloys, (h) nano materials, (i) synthetic polymers, (j) superconducting materials. These ten groups of products and materials touch our everyday lives in a significant manner.

Advanced materials offer a potential market encompassing numerous cross cutting application areas: energy generation and supply, aerospace, automotive, marine, railways, healthcare, packaging, technical textiles, and construction. It is estimated that global requirement of advanced materials will reach USD 7 trillion by 2030 from the USD 3 trillion demand in 2012.[26]

India has had a focus on composites since 1962. It has seen significant growth over the last decade and is now home to more than 1200 companies involved in the manufacture of composites. Composites find application in the following sectors in India: (a) wind, (b) industrial, (c) railways, (d) automobiles, (e) oil and gas, (f) building and construction, and (g) marine.[27] In the oil and gas sector, there lies a vast potential for composite applications in high-pressure pipes and pipefittings. Even with the high cost of raw materials, scarce availability of many essential materials (thanks to import restrictions) and lack of mechanised processes, composite industries in India are expected to continue on a strong growth trajectory, reaching approximately USD 1.8 billion by 2017.[28] **As per our analysis, advanced materials development has the potential to impact up to 40% of India's total industrial gross value added.**

Photonics

Photonics deals with use of light to detect, transmit, store and process information; to capture and display images; and to generate energy.[29] The photonics industry has a huge potential due to the increasing global demand for industrial laser and optical systems.

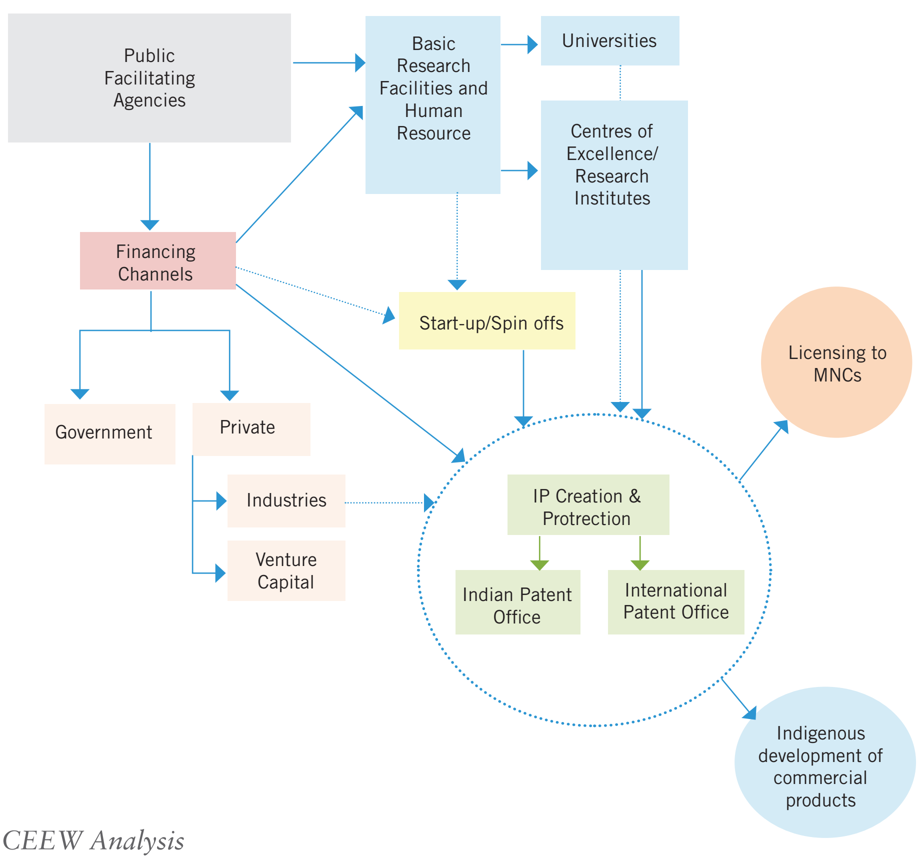
Globally, the total photonics market was approximately USD 400 billion in 2011, and is estimated to increase to around USD 700 billion by 2020.[30] Some of the applications of photonics include: (i) telecommunications; (ii) optical computing and memories; (iii) LED technologies; (iv) display technology; (v) imaging technology; (vi) solar energy; (vii) bio photonics and medical applications; (viii) manufacturing; (ix) sensors.[31]

Photonics influences several manufacturing industries and service sectors through various value added channels: scanning and imaging systems, data transmission, screens and displays, advanced lighting, photonic energy systems, and laser systems. In India, photonics is crucial for the development of several industry sectors, namely electronics, information technology, science, medical, sheet metal diamond, jewellery processing and automotive manufacturing. **As per our analysis, 19% of industrial gross value added in India can benefit by embracing photonics. Similarly, if brought into the fold, photonics could leverage nearly 40% of the total GVA contributed by the entire services sector in India**. The National Optic Fibre Network can also support areas such as education, business, entertainment, environment, health households, and e-governance services.

4. India's Efforts in Translating Innovation into Commercial Products/ Technologies

The research ecosystem in India, as in other countries, has a diverse set of stakeholders who come together to drive the various initiatives. In India, the public sector plays a major role as a bulk of the funding, basic and advanced research infrastructure, universities and research centres are under the ambit of the government or affiliated entities. There also exists a thriving base of start-up companies in key technology areas like biotechnology and nanotechnology. Post liberalisation, with easier capital inflows from overseas and increased interactions with foreign research institutions, novel venture capital firms are expressing greater interest in the opportunities in research-industry linkages. Moreover, the opportunities in an innovation driven economy has the increased focus on intellectual property protection and a strong desire to commercially benefit from indigenous research. The interactions between the key players in the research arena are detailed in Figure 2. The commercialisation of a technology depends on successful translation of its research and development programmes into valuable products.

Figure 2: Key players identified in India interacting for enabling technologies development



Source: CEEW Analysis

India has initiated several programmes at the national and sector specific level to promote scientific temper and the innovations, all such efforts contributes to our performance in translating research into innovation. Research publications are always seen as a metric of a country's performance in science and technology. Although India was ranked 10th (globally) in terms of scientific publications (between 1996-2010), the overall share of publications was very low at 2.46% of the world.[32]

Department of Science & Technology (DST) has commissioned several programmes across the sectors to promote encourage and support young talents towards scientific research. Few of the programmes are; Kishore Vaigyanik Protsahan Yojana (KVPY), IMPacting Research INnovation and Technology (IMPRINT), Innovation in Science Pursuit for Inspired Research Programme (INSPIRE), etc. Few of the key sectors got special attention as well, such as:

a. The 'Nano Mission' was launched in 2007 to develop a strong human resource base at various public funded and private universities.

b. 'R&D in Electronics Group', supported by the department of electronics and information technology (DeitY) undertakes sponsored R&D activities at various laboratories and institutions of higher learning. The main research areas include nanotechnology, medical electronics, microelectronics, industrial electronics etc.

c. DST and Council of Scientific and Industrial Research (CSIR) are the key government organisations promoting R&D in advanced materials and composites.

d. Frontline research institutions in photonics include the International School of Photonics (Cochin University of Science and technology, CUSAT); Tata Institute of Fundamental Research (TIFR); Society of Applied Microwave Electronics and Engineering and Research (SAMEER); Indian Institute of Science (IISc, Bangalore); Defence Research Development Organisation (DRDO); Optical Society of India (OSI); Photonics Society of India (PSI).

To facilitate basic research into advance stages, distinct 'Centre of Excellences (COEs)' were opened up to step up the output. Currently there are 36 COEs under 'Frontier areas of science and technology (FAST) scheme ranging across a wide array of thematic areas. Similarly, there are 30 COEs under the 'technical education quality improvement programme (TEQIP).[33] Recently introduced 'Atal innovation mission (AIM)' under the 'startup India' programme further aims to set up 7 new research parks, establishment of 500 state-of-art laboratories in universities, and 35 incubators to breed entrepreneurship culture among universities.

Innovative products and processes are an outcome of extensive research activities, for which there remains an essential demand for capital investments in a stage-wise manner. Government spending on R&D is a fairly significant indicator of a country's willingness and ability to drive innovations in emerging technologies. Some of the major 'funding support' programmes initiated by India are as follows:

- Fund for Improvement of S&T Infrastructure in Higher Educational Institutions (FIST), It was introduced in 2000-2001 to support infrastructure for basic research as well as modernisation of existing laboratories.

- Technology Development Board (TDB), to provide equity capital/loans to industries for commercial research, and financial assistance to researchers to develop commercial applications and products.

- Industrial R&D Promotion Programme (IRDPP) run by the Department of Scientific and Industrial research (DSIR) to bolster in-house R&D units set up by the industries. It facilitates research by providing tax benefits on R&D expenditures in various forms. The programme supports research largely focused around pharmaceutical and bio-technology sector.

- Technology Development and Demonstration Program (TDDP) by DSIR to hand carry advanced research into prototype development or commercial product. This programme has supported more than 200 projects through partial financial support.

- Technopreneur Promotion Programme (TePP) by DSIR is the financial support towards commercialisation of developed prototype. Depending upon the scale and stage of development, the financial assistance varies from INR 500,000 to INR 4,500,000.

- Fellowships and grants: Various ministries on as and when basis use to announce fellowship and awards in their specific areas to facilitate research.

Overall there is an established mechanism of project funding through public sector/ government through dedicated agencies like Ministry of Human Resource Development (MHRD), DST, Department of Biotechnology (DBT), DSIR, Defence Research and Development Organisation (DRDO), state and central public enterprises – especially to build research capacity within the country. However, the culture of startups assisted through risk capital invested by angel investors and venture capitalists (VCs) is yet not visible in India. The boom of e-commerce market in India has seen few successful investments, but innovative technology products are yet not visible. More recently, Startup India programme has announced to set up a 'fund of funds' with an initial corpus of INR 2500 crore to invest in potential startup ventures.

At the planning level, dedicated agencies such as TIFAC, NST-MIS, etc. are mandated with the task of identifying trending technologies and monitoring outcomes of public funding.

5. Key Challenges in the Development of Strategic Technologies in India

The inability of the existing innovation support system to help translate research efforts (across sectors and technologies) into commercial products is a major stumbling block for India in becoming an innovation hub. The challenges lie at multiple fronts, and are discussed in the subsequent portions of this section

Funding mechanisms exist but limited industry involvement

In India, details on expenditure on R&D projects and programmes carried out by various scientific agencies under ministries/public departments are largely not available in the public domain. A quick analysis of R&D expenditure incurred by DST in 2010-11 shows that **roughly only 10% of the planned R&D expenditure is towards mission-oriented and targeted research programmes, while nearly 70% of the R&D expenditure is diluted among numerous scientific agencies carrying out research classified under non-specific headers.**[2] Moreover, India's progress in raising GERD (Gross expenditure on R&D) up to a level of 2% of GDP from 0.88% is questionable, as a significant portion of the expenditure within the GERD is towards non-plan expenditure, which is not necessarily in support of R&D.

India spends less than 1% of its GDP as GERD, which is much lower than other major technologically advanced economies; Israel spends more than 4%, and France, Germany and the United States each spend more than 2%.[34] Private industry spends more than government in R&D in other major economies, whereas in India public sector spending is two to three times more than that of industry. The **private sector's contribution remains less than one third of the total GERD in India (28.9%), due to associated risks in investment and technology failure.**[35]

Biotechnology

The Department of Biotechnology (DBT), recognised as one of the major public funding agencies had an outlay of only USD 0.22 billion over the period 2005-12, thus averaging approximately USD 31 million per annum.[36] Just to put that into context, the average cost of bringing a new drug to market is USD 1.3 billion.[37] Those Indian companies which have proven strengths in areas of drug discovery often enter into contract research agreements with foreign firms, which ultimately own the patents and a significant share of royalty revenues that will follow.

2 CEEW analysis; specific entities may have mission oriented or focused research programs as an individual, but no centralised information is made available for ease of access

Nanotechnology

India had allocated USD 250 million under its XI FYP (2007-12) to develop a nanotechnology research and innovation ecosystem.[38] Despite this ambitious investment-led plan, India's performance in the sector has been far lower than its competitors when it comes to commercialisation of research led ideas and innovations.

Micro and nanoelectronics

The joint Centres of Excellence in Nanoelectronics at IIT Bombay and IISc Bangalore receive USD 50 million from the government. Further, at IIT Bombay, Applied Materials set up a "Nano-manufacturing laboratory" with USD 10 million as a donation. India approved the "The National Electronics Policy 2012" in October 2012, with aims to strengthen indigenous manufacturing, targets a turnover of about USD 400 billion, USD 100 billion of investment, 28 million jobs and a strong supply chain by 2020.[39]

Advanced materials

Technology Information, Forecasting and Assessment Council (TIFAC) and Small Industries Development Bank of India (SIDBI) have jointly launched the Revolving Technology Innovation Fund (RTIF) of approximately USD 5.5 million (for a period of 10 years) in order to provide assistance to start-ups and small and medium scale enterprises (SMEs) for scaling up product development, demonstration and commercialisation.[40] Further, DST established a Composites Technology Centre in Bangalore with the support of the Karnataka government, estimated to cost around USD 3 million.[41]

Photonics

The "R&D in Electronics" group under DeitY has an Electronic Materials & Components Development (EMCD) division, which includes photonics. However, there is no dedicated funding available at specifically for this technology. Very few companies in India focus their in-house R&D in large scale manufacturing of photonics components. Most of the firms import components and assemble basic products with few jobs in the sector.

Publications but few patents

Data retrieved from patent databases in 26 countries for 2003-13 indicate that Japan and US have a robust performance across all the technology areas. **India has a considerably low percentage of patent applications when compared with other countries** (Figure 3).

The Indian Patent Office (IPO) has a chronic and ever increasing backlog of unexamined patents and trademark applications. In 2012 there were **123,255 pending patent applications**, which has further increased to **246,495 in patent applications** in addition to 5,32,682 pending trademark applications in 2015.[42] **IPO staff in India experience the highest per capita workload (20 applications a month, as compared with seven in Europe and China, eight in the United States**) at the lowest pay.[43] International patent filing is a very costly affair, and usually research grants provided to universities/individuals do not include this expenditure as part of the budget.

Figure 3: Comparison of total patent applications in the chosen ETs filed by major economies (2003-2013)

Abbreviations: KR (Korea), US (United States), JP (Japan), GB (United Kingdom), CN (China), TW (Taiwan), FR (France), DE (Germany), IN (India), IL (Israel)

Source: CEEW analysis using Total Patents database and Espacenet

India holds 2%-4% share of global publications in *biotechnology* and allied fields.[44] India performs significantly poorer in terms of registering patents; there were only 83 patents in biopharma filed by DBT-sponsored institutes/universities (2004-2010). Only ten out of these were granted and the commercialisation of patents into viable products was even lower. In other sectors of biotechnology, such as agricultural biotechnology and industrial biotechnology, the trend is similar with ten patents granted out of 63 filed during the same period.[45]

For nanotechnology, India was placed sixth in the ranking of countries publishing actively in the field of nanotechnology.[46] While India's global share was very low (6%), the ranking indicates that the research efforts emanating from India have gained visibility. But India had a poor rank (14th position) globally of publications in top 1% cited journals in 2011, with a significant number of papers with citations below the world average.

During 2003-13, more than 500 articles have been published in the field of *nanoelectronics* and more than 20 patents have been filed under the Indian Nanoelectronics User Program (INUP).[47] For *microelectronics*, only 21 patents have been filed by the DeitY, which is far less than the global average.

In *advanced materials*, India is ranked sixth in materials science research with about 12,693 scientific papers published in the most recent five-year period. As of 2007, IITs (3376), IISc (1212) and CSIR (2516) were the top three institutes with maximum publications in the area of materials science.[48]

However, India's share of patents in *photonics* during 2003-2013 is less than 0.1%.

Poor quality and standards of domestically manufactured products and materials

Indian industry, to remain competitive and keep costs lower, must have significant backward integration with domestic suppliers of components and raw materials. However, in many cases the quality of raw materials does not match the international standards in terms of physical and chemical properties. This in turn, adversely impacts the quality of final products.[49] Technology-derived novel products need to be standardised for their quality and safety in terms of their impact on society and environment. A big challenge for India is overcoming the poorly organised quality and product testing system, where voluntary quality improvements against increased manufacturing cost is not favoured by many manufacturing firms.

6. Strategies for Technology Development and Commercialisation

Aiding technology transitions: Outreach and matchmaking

Focus area 1: Technology information portal for R&D funding and activities

A **one-stop technology information portal** could provide a range of information, from the perspective of potential researchers, government funding agencies, entrepreneurs, incubating entities and venture capital investors (Figure 4). By offering a one-stop portal, the database could help identify emerging areas of research, reduce doubling of effort, target limited resources more strategically, and assess the impact of R&D investments especially in facilitating more links between technology developers and industry.

Figure 4: Proposed schematic of a centralised repository for R&D funding and activities

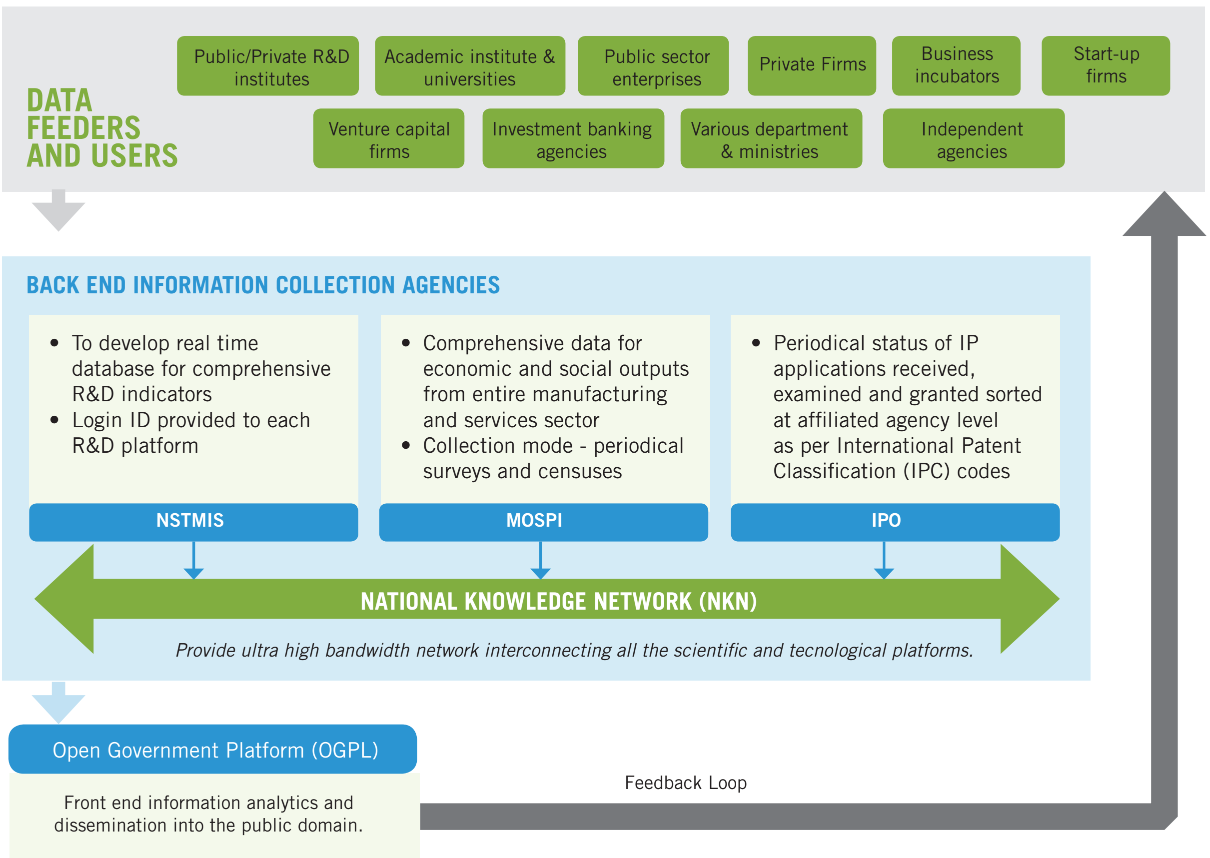
Source: CEEW analysis and design

Skilled graduates (and novice researchers) looking to get a foothold in the research community could get valuable information on which labs and institutes in the country are focusing on areas of their interest. In turn, government funding agencies can avoid duplication of funding by ensuring that there is no excessive investment in some areas while others lie neglected. A more rational distribution (geographic and institutional diversity) of precious public funding is also made easy as it would be easier to visualise current and past recipients and to effectively promote fledgling research institutions. In tandem with the information on output from currently sponsored research (as envisaged earlier), this would also enable high performing labs and institutes to be rewarded with continued support for the high quality of work they produce. Private entities (Venture Capitalists, banks, industries) could also gauge the nature of demand for funding, the areas with potential to deliver high impact research and those commercially viable technologies that have been shelved for want of crucial funding in the final stages of product refinement and roll-out.

Focus area 2: Leverage enabling technologies across sectors and various stakeholders

The **development of such an exhaustive database can be effectively taken up through a collaborative effort among existing agencies.** The entities that are best suited to work jointly on developing this portal are identified in Figure 5.

Figure 5: Key actors proposed to develop integrated technology information portal



Abbreviations: IPO = Indian Patent office; MOSPI = Ministry of Statistics and Programme Implementation; NSTMIS = National Science and Technology Management Information System.

Source: CEEW analysis

The Open Government Platform (OGPL) is identified as the lead agency that is tasked with the responsibility of data analytics and information dissemination to the user community. Agencies such as National Science and Technology Management Information System (NSTMIS), Ministry of Statistics and Programme Implementation (MOSPI) and IPO are identified for gathering information and building the independent databases of indicators pertaining to R&D and financing, industrial output, and patents respectively. The IPO can make its database management system more robust through real time updating the application status classified as per the International Patent Classification system. NSTMIS can adopt a real time data collection mechanism by mandating individual research entities and financing agencies to provide comprehensive data for the proposed repository. The National Knowledge Network (NKN) can efficiently support the proposed system by providing the required ultra-high bandwidth network and enabling a constant updating of information by the various agencies or their representatives.

Financing and mitigating risk: More sources, more focus

Focus area 1: Comprehensive and independent evaluation of output from R&D investments

An **unbiased evaluation of the output from research (government sponsored or otherwise) will enhance the efficacy of funding and also prove to be a guiding star in determining the course of future investments in R&D**. This applies at the basic and applied research stages of the technology development chain. It will also enable decision-makers to factor in the constantly evolving end-goals of product development and the demands from consumers, thereby specifying output requirements in a better manner. In addition this will also enable the linking of early stage output from specific research work carried by funded institutes with advanced stage research by other specialised entities, thereby ensuring that research grants are used in a more optimised and efficient manner.

From our analysis so far, we find no specific mechanism that the government or other public agencies adopt to measure "the return" on their investments in R&D. While reputed agencies like CSIR, DBT etc. disclose the impact of their research in terms of publications and in some cases patents, the information on the commercial products being impacted by research is minimal and virtually non-existent. Without linking final impact sectors (manufacturing, services or social sectors) with outputs of research, one cannot ascertain the true value that research has brought about. This precludes informed decision making in the development of national policies, which could encourage potentially rewarding investments in newer technologies.

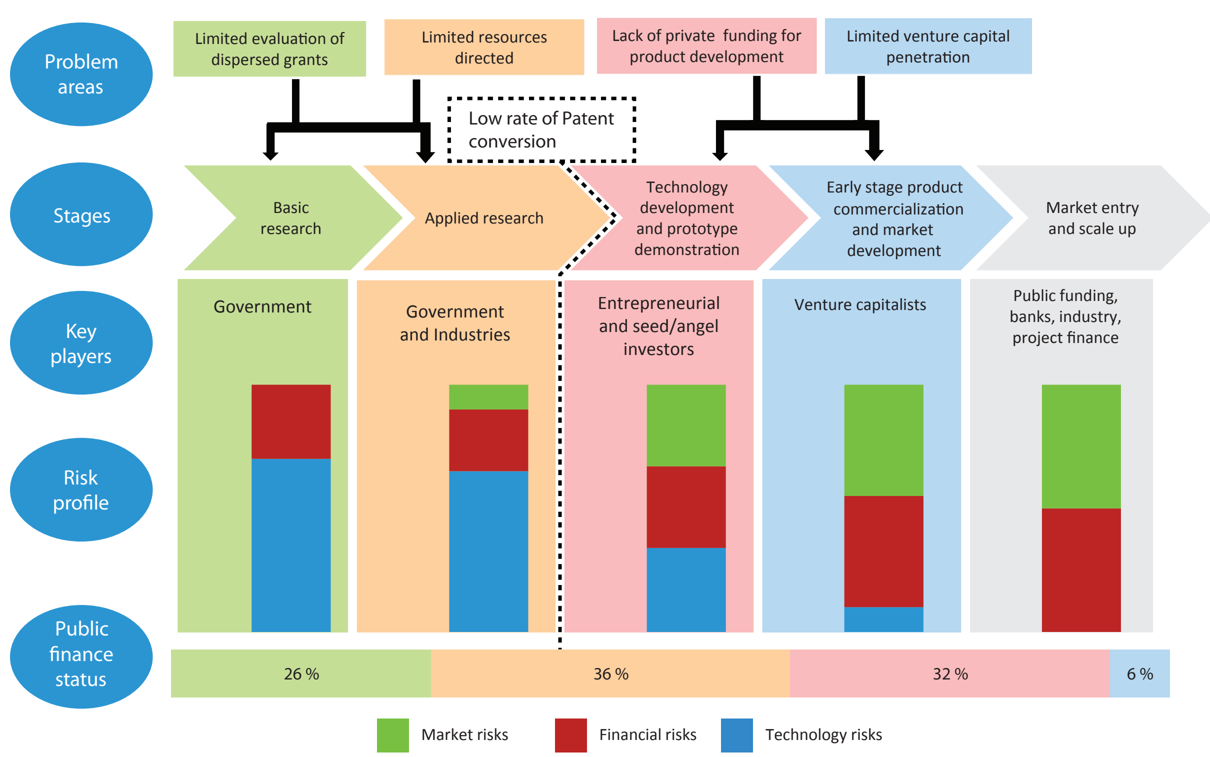
The National Sample Survey Organisation (NSSO) and Central Statistics Organisation (CSO), under MOSPI conduct periodic surveys to solicit data on various growth indicators (e.g. employment, gross value addition, productivity, power consumption etc.) from both manufacturing industries and services classified under the national industries classification (NIC). But we find no specific studies that provide data on technologies in use and the impact of the same. The absence of such information reduces the visibility of various technologies in vogue in industrial manufacturing.

In coordination with agencies like the National Science and Technology Management Information System (NSTMIS), the CSO/NSO must take charge of developing indicative measures of the influence of domestic R&D (both public and private funded) on national productivity and the incremental value add as a result of the adoption of these technologies. The feedback through this process will also enable more targeted investments in future, with a focus on those areas that have shown promise and in some cases ones that desperately need the funding. This would also attract private sector funding with greater likelihood, as it makes a better case for high rates of returns on investments, as evidenced by the surveyed industries.

Focus area 2: Driving R&D towards commercialisation through strategic financing

Academic and research institutes will continue to demand a lion's share of the funding from the government. A breakdown of the public sector investment (Figure 6) shows that much of the funding is in the first three stages of technology development, basic and applied research and technology demonstration. However, there is little concerted action on part of the responsible entities in allocating the scarce resource to strategic sectors.

Figure 6: Technology development chain



Note: The proportion of risks highlighted is only a quantitative representation of observations.

Source: CEEW analysis

We, therefore, propose that **a stage-wise funding mechanism must be adopted by the government, whereby projects identified to reinforce enabling and disruptive technologies can be funded through government-private collaborations.**

Priority for universities and institutes, which are able to collaborate actively with the private sector for conducting research (and obtaining matching funding), will promote competitive grant disbursals for targeted technology development missions. Active collaboration with strong government support will help more start-up companies to emerge from the quality research once they are backed by collaborative efforts.

Further, to promote translation of academic research into visible technology outcomes, **annual appraisal of university professors and researchers must be carried out on the basis of patent outputs on par with research**.

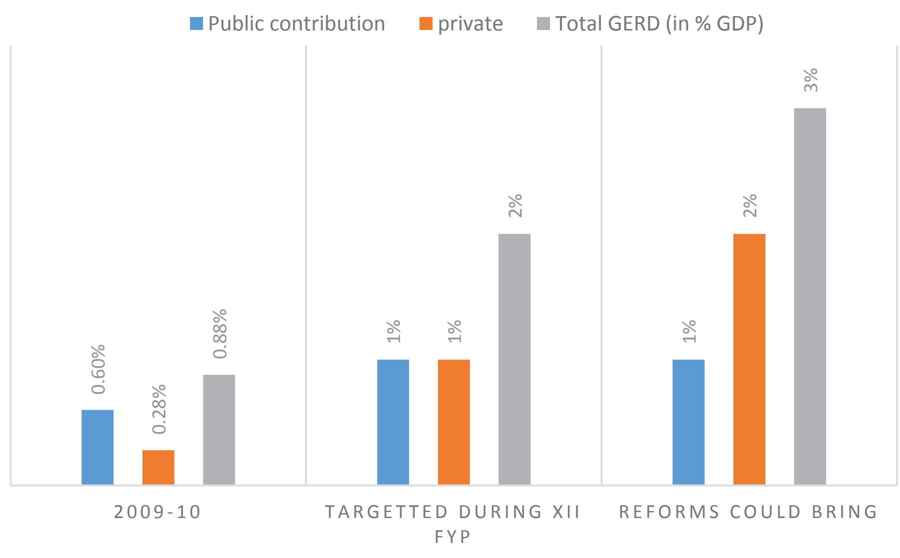
Focus area 3: Promoting private sector participation in technology development and commercialisation

For the private sector, there exist three types of risks associated with R&D, namely (a) high investments, (b) technology success and (c) market acceptance of these new technologies and the products that arise from them.

In order to encourage the start-ups and private industries to increase R&D spending, the government must don the unenviable role of a "risk supporting agency" for their investments. In 2016, the Government of India introduced a bunch of lucrative incentives for young entrepreneurs under 'startup India' programme. This includes tax exemptions; setting up of technology incubators and research parks; credit guarantee fund to encourage banks for debt funding towards startups; and, a corpus of INR 10,000 crore to facilitate private venture capital investments in a ratio of 50:50 for potential startups. While the government is showing a good sign of moving away from the current practice of granting soft loans (in order to support the risks faced by private entities for innovative R&D efforts); in such a model, they should also invite private entities for royalty based cooperative grants, whereby they would be required to share profits (through a royalty) when commercialisation has been achieved. The royalty payment system must be designed to ensure that the payments do not exceed the grant in aid including interest accrued.

This motivated risk support is expected to encourage more R&D collaborations between private and government research labs, and further able to **attract VC funding for the transition from successful demonstration models/prototypes to the market development phase**. It could help to achieve a GERD target of 2% of the GDP without a proportional increase in the contribution from public sources (Figure 7).

Figure 7: India's GERD outlay



Source: CEEW analysis

Effective intellectual property regime

In 2014, the Government of India constituted a new think-tank on Intellectual property rights. One important mandate for this think-tank was to come up with the 'National IPR policy'. The said policy draft is still under the consideration by the Cabinet, but it should consider the following focus area actively.

Focus area 1: Capacity expansion of the IPO

In order to speed up patent application examination process, the Intellectual Patent Office (IPO) of India needs to increase its skilled manpower. A readily available pool of certified patent examiners/attorneys will help in customising the selection of technology specific human resources.

- **Outsource "prior art" searches to third party agencies**: As already mentioned earlier, the IPO is faced with an ever increasing official backlog and extensive delays in patent examinations. In order to shorten the pendency period of applications, the Korean Intellectual Property Office (KIPO) outsources its prior art searches to third party vendors. Another successful model is Japan's patent process outsourcing strategy whereby a registered search organisation system was developed solely for the purpose of searching prior art documents. Under this system, Japan plans to significantly expand the number of registered search organisations in various technical fields. During 2009-10, Japan's outsourcing for prior art searches increased by 5.6%.

  In India, the Department of Industrial Policy and Promotion (DIPP) signed a memorandum of understanding with CSIR in order to make it an integral part of the patent application processing system as the latter has the infrastructure, competence and experience in patents search processing. However, this step has generated concerns. Under the Indian Patent Act, 1970 (and its amendments) an examiner or controller is not allowed to file a patent but CSIR is one of the major patents seeking institutions in India.

  In order to increase the efficiency of the patent examination process and deal with pending applications, like Japan Patent Office (JPO) and Korean Intellectual Property Office (KIPO), Indian IPO could also initiate outsourcing of prior art searches to third party vendors, preferably independent registered entities (whether in the private sector or not) to ensure that quality matches the expected standards.

- **Increase in-house capacity**: The IPO could increase its in-house capacity by hiring more trained IP professionals from institutes like the Indian Institute of Patents and Trademarks (IIPTA). The IPO should offer better pay-scale, promotions and compensation through incentive schemes in order to attract more and more IP professionals to work as patent examiners.

Focus area 2: Reorganise and restructure the IPO

Patent examiners must be given the task of examining applications based on their technical expertise and experience for an improved and more efficient evaluation system. There should be dedicated teams to take care of other administrative tasks such as checking some of the procedural formalities, quality checks, keeping track of pendency rates, conducting training sessions, etc.

Focus area 3: Fast-track IP courts for patent infringements

In India, High Courts have the power to deal with cases of patent infringement and invalidity. A separate Intellectual Property Appellate Board (IPAB) was formed in 2007 to ease down the burden of pending cases. However, in cases of patent infringement, only the high court and above remains the competent authority. **Since civil courts in India are already burdened with a backlog of pending cases, patent infringements could be dealt with either under the IPAB or separate fast track courts**. The government has announced fast-tracking of patent applications for new startup firms, along with other rebates and facilitation services. However, this needs to be extended across the academia and institutional research. This would build confidence among innovators and research community for faster redressal of their issues and also reduce the impact of false patent infringement challenges.

Focus area 4: Patent Prosecution Highway (PPH)

India should consider adopting a PPH model under which patent offices of various jurisdictions agree to share patent search and examination results in order to accelerate patent prosecution procedures. Under the US Patent and Trademark Office (USPTO), an applicant receiving a ruling from the Office of First Filing (OFF) that at least one claim in an application filed with the OFF is patentable may request the Office of Second Filing (OSF) to fast track the examination of corresponding claims. Countries operating under PPH programme include USPTO, KIPO, JPO, and EPO. This model could be highly beneficial for the IPO as it would significantly improve the speed of examination of patent applications, reduction in prosecution costs and help increase domestic patent filings.

Focus area 5: Financial reform in the IPO

The government needs to invest more in the development of the IPO. One approach could be to **allow the Intellectual Property Office to retain a fraction of the profits made by it for further development such as training, hiring, administration etc.** It has been estimated that it earns a gross profit margin of 80%-90%, which accrues to the government. The overall surplus generated by the Intellectual Property Office rose from INR 148.06 crores in 2006-07 to INR 213.22 crores during 2010-11, out of which the patent office earned about 79%. Despite the profits earned by the Intellectual Property Office, the patent office fees have been increasing almost every year. More clarity is required on the reason for the hike in patent office fees, and it is necessary for the IPO to publish a roadmap that outlines the proposed reforms and targets to be achieved.

Product manufacturing and quality standards

In India, the Bureau of Indian Standards (BIS) is responsible for establishing quality standards and certifying products. The product certification scheme of BIS aims at providing third party guarantee of quality, safety and reliability of products to the customer, with the ISI mark assuring conformity with specifications. BIS has many laboratories in operation in different parts of the country. The BIS laboratory recognition scheme is in line with ISO/IEC/17025:2005, and laboratories are initially assessed on the basis of the ISO standards. The National Accreditation Board for Testing and Calibration Laboratories (NABL) is the sole accreditation agency, which was established with the objective of providing government and industry with an option for third party assessment of testing & calibration labs. A laboratory wishing to be accredited by NABL has to satisfy the requirement of ISO/IEC/17025:2005 or ISO 15189.

The application of new materials must be justified properly in regard of their impact on human health to create trust among consumers/public. Proactive governance is required to address these issues efficiently by development of material safety data sheets and health specific standards for new materials during their developmental stages.

Focus area 1: Share of accredited laboratories

At present less than 1% of the testing laboratories are approved by NABL in India. As a result, accredited laboratories are also overburdened to deliver timely and efficient services. **NABL should aim to increase the share of laboratories with accreditations to 5% by 2017.** However, the accreditations are valid for only two years with laboratories having to apply for renewals. Many laboratories find this cumbersome, which results in several accreditations expiring or lapsing after two years. Simpler processes and temporary service **tax exemptions and concessions for NABL-accredited laboratories could motivate more non-accredited laboratories to seek accreditation**.

Focus area 2: Mandatory certification for five enabling technologies

In addition to boosting the infrastructure for testing and certification, strong regulations to penalise non-compliance with product quality standards must be introduced and enforced. **ISI certification should be made mandatory for products using any of the five enabling technologies.** Enforcement of penalties to deter the production and sale of inferior quality products, especially in biotechnology and nanotechnology, which have a direct bearing on the health sector, is a key follow up requirement. Continuous monitoring and recording of product quality data will allow the regulators to detect persistent issues and entities which are primarily responsible for the same. Accreditation is the need of the hour. There is an ever increasing need of good quality products from India.

7. Conclusion

Resource efficiency has to be at the heart of India's manufacturing competitiveness and the focus right away must address two critical transitions. The first is moving India from a position of resource vulnerability to one which has secured the resources it needs and the second is from a country that acquires technology from overseas (for domestic use) to one that can develop high technology domestically. Crucial to both these is a related transition that looks at overhauling the R&D value chain in India and driving innovation.

Growth and transformation in manufacturing cannot happen unless India espouses innovation. Too often, however, innovation is conflated with levels of spending. Needed, instead, is a dynamic ecosystem for R&D and innovation with several crucial ingredients: financial investment of course, but also human, physical and natural capital, knowledge acquisition and transmission, laws and regulations, and institutions. The convergence of trends that have been running in parallel so far — demands for energy security, need for materials and resource efficiency, the imperative of environmental sustainability, scientific breakthroughs in the biosciences, and the indispensable role of information technology — now offers both the opportunity for progress in the 21st century and also lays down the challenge for India.

Some of the key suggestions to this end have been discussed in this report. A centralised portal that helps track funding opportunities, and status of funded projects and outcomes that can help to streamline the process of application for funding and identifying areas where there is a dearth of funding. There is an urgent need to identify enabling technologies and the sectors and stakeholders that can drive research in these areas. The study also suggests some enabling technologies (biotechnology, nanotechnology, photonics, micro and nano electronics, and, advanced materials) based on an extensive review of literature and the needs of the country, as envisaged in various national publications.

Diversifying the sources of financing for R&D and bringing in the private sector to be active funders of research is imperative. To increase the confidence of the private sector, a comprehensive and independent evaluation framework for output from R&D investments (so far and henceforth) is needed. Precious public funding must be used in driving (risk guarantee, low cost loans, etc.) R&D commercialisation and overcoming the 'valley of death' in the R&D value chain. Alongside, an effective intellectual property regime that recognises the value of protecting domestic ideas and processes will help trigger investment from those who view the current regime as being unfriendly to innovators. The capacity of the IPO needs to be addressed immediately along with fast-track process for resolving IP infringements issues.

Finally, the quality of domestically manufactured products must match up to standards that are expected (universally). Increasing the share of accredited labs and making certification mandatory in new technology development will boost the image of domestic products and help tap into a large domestic consumer market that is already present.

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