FRESH IDEAS ABOUT BUSINESS IN EMERGING MARKETS
EMCompass

www.ifc.org/thoughtleadership
NOTE 94 • NOV 2020

Deep Tech Solutions for Emerging Markets

By Anastasia Nedayvoda, Peter Mockel, and Lana Graf

Deep tech companies aim to address the world's biggest challenges. These include providing Internet access to the unconnected, reducing greenhouse gas emissions, significantly increasing productivity gains across industries, and helping to solve many other intractable problems, particularly in emerging market and developing economies. A deep tech company brings transformative technology from the lab to the market, and democratized research infrastructure and increased available funding has led to the rise of deep tech companies globally, including in emerging markets. Yet commercialization is critical to realizing the benefits of deep tech solutions, and deep tech firms often struggle to successfully commercialize their breakthroughs. Strengthening local ecosystems and investing in deep technologies are critical to overcoming this common obstacle. As development finance institutions, institutional investors, and private equity and venture capital investors explore longer-term investment strategies, deep tech commercialization offers not a tech-enabled silver bullet but a holistic approach to investing in technology solutions.

Deep tech companies aim to solve complex societal and environmental challenges. By providing Internet connectivity to remote and rural areas via a satellite constellation or reducing the carbon footprint by pulling carbon dioxide out of the atmosphere with specially formulated chemicals, these companies attempt to commercialize scientific or engineering discoveries to benefit society. Their business strategy is driven by research and applied technology transfers. Deep tech solutions address a global market and work to solve challenges prominent in both developing and developed countries. When a deep tech solution works, it often creates a platform technology that enables disruption across industries, allowing for additional optionality around addressable markets.

Research-intensive startups drive deep tech commercialization. These startups' production cycles are rooted in the multi-stakeholder process of transitioning technology from a research lab to the market, differentiating them from software-based companies. Research institutions have always played an important role in technology commercialization. As new commercialization models emerge, research institutions are reinventing their approaches to technology transfer and existing processes, creating new entry points for other investors.

Why is Deep Tech Gaining Prominence Now?

According to the 2019 Tough Tech Landscape report, investments in deep tech grew from 500 deals totaling

About the Authors

Anastasia Nedayvoda, Investment Analyst, Telecom, Media, and Technology Upstream – Global Infrastructure, IFC. Her email is anedayvoda@ifc.org.

Peter Mockel, Principal Industry Specialist, Climate Strategy & Business Development, Economics and Private Sector Development, IFC. His email is pmockel@ifc.org.

Lana Graf, Principal Industry Specialist, Disruptive Technologies and Funds, IFC. Her email is lgraf@ifc.org.

$2.9 billion in 2012 to over 1,600 deals for $35.7 billion in 2018.[1] These figures are not due to outlier quarters. In 2018 alone, there were 101 startup exits (when early investors sell their stakes in the market) globally for companies working in deep tech.

Several factors contribute to this trend:

- Advances in digital infrastructure provide a reliable backbone for scientists and engineers. Cloud computing allows for increased energy efficiency and decreased upfront computing costs for data-intensive scientific experiments.
- Advances in basic research have opened up more areas for applied research.
- The cost of inputs, including hardware and materials, is falling, making scientific experimentation more widely available.
- It is now possible for many researchers to access digital and research infrastructure that was previously too expensive or scarce to use.

Moreover, COVID-19 has forced many companies to pivot and look for new ways to create value. Deep tech companies are well-positioned to support communities during the pandemic. They have helped produce and distribute personal protection equipment using 3D printing, increased availability of testing options, and created new disinfecting solutions.[2]

The COVID-19-related research and engineering pivots that have led to increased multidisciplinary collaboration can serve as a trampoline for many deep tech commercial innovations across a range of sectors for years to come.

Box 1: What is Deep Tech?

Deep tech is a term for technologies that are based on scientific or engineering breakthroughs and have the potential to be commercialized. These technologies include artificial intelligence (AI) and machine learning (ML), materials, advanced manufacturing, biotechnology and nanotechnology, drones and robotics, photonics and electronics, cleantech, spacetech, and life sciences.* Deep tech companies are research and development (R&D) intensive and multidisciplinary. Source: IFC.

* It is important to note that life science startups are often counted separately from the rest of deep tech companies, as biotech and pharmaceuticals have an established path to commercialization, unlike most other areas of deep tech.

Opportunities Offered by Deep Tech

Deep tech solutions help address the world's most pressing challenges. When a deep tech solution works, it creates a platform technology that can enable disruption across markets and jumpstart new industries. The solutions developed by deep tech startups can elevate traditional industries in low-income countries by creating new types of infrastructure or technologies that can address existing bottlenecks.

For example, biotech company Apeel Sciences has developed a technology that allows avocados, citrus, and other types of fruit to last twice as long as usual. The technology is derived from natural products and reduces food wastage along supply chains. Satellite imagery providers like Planet add value to the development of more sustainable and productive smallholder agriculture by providing solutions around field boundary detection and crop land mapping in conflict-affected geographies. Applied Solar Technologies (AST), an IFC client, has raised the standard of energy management at telecom base stations across India by powering mobile phone antennae with solar energy and battery storage. Similarly, microfinancing in developing countries received a tremendous boost with the arrival of AI for credit scoring. Instant credit decisions are being made by machine learning models instead of an army of credit officers. For example, Twiga Foods, a fast-growing food trading marketplace and distribution network with 4,000 suppliers and 35,000 vendors, uses AI to estimate credit scores for small-scale vendors, providing loans of $30, on average. It allows vendors to increase the size of the orders they handle by 30 percent and has increased profits for retailers by 6 percent.

Deep tech is best suited to solve intractable problems by providing unique and transformative solutions. Deep tech solutions can increase agricultural productivity without damaging the environment and human health, or bring productivity gains to manufacturing and other resource-intensive industries without unsustainable scale-ups of pollutive operations. In the energy sector, deep tech has created the core technologies of renewable energy, including solar and wind power. Going forward, however, more will be needed, especially in terms of renewable baseload power, from technologies like energy storage, hydrogen, new fission nuclear, and eventually nuclear fusion.

Deep tech startup ecosystems create positive spillover effects to boost economic development. Historically, there has been a strong relationship between economic complexity, technical knowledge and skills, and economic growth. Countries that have harnessed new technologies have consequently expanded their economies.[3] And research shows that low-skilled workers gain from high-tech employment growth: for every 10 new high-tech jobs created, six low-skilled workers gain employment.[4] Local deep tech ecosystems can also help attract and retain qualified talent, boosting domestic STEM—science, technology, engineering, and mathematics—reliant industries. And regional economies often benefit from knowledge spillovers from universities that incubate deep tech startups.

Artificial intelligence presents numerous deep tech development opportunities, and its successful commercialization is the subject of several ongoing discussions.[5] Other deep technologies that may offer development opportunities include the Internet of Things (IoT), spacetech, cleantech, and other solutions that aim to improve environmental sustainability.

Commercializing breakthroughs in the Internet of Things can disrupt many sectors. In manufacturing, IoT solutions can help detect corrosion inside a refinery pipe and provide real-time production data, enabling significant productivity gains and consolidating small players by reducing information asymmetries. In smart cities, utility companies use IoT to enable smart grids and meters, optimizing production and distribution to meet real-time demand. In agriculture, low-power sensors optimize crop monitoring and automate irrigation.

Commercialization of IoT breakthroughs can be enabled and accelerated by the deployment of 5G. 5G standards enable a larger number of devices to be connected simultaneously to a network and communicate with minimal delays. Supporting IoT pilots across verticals and addressing regulatory challenges emerging in parallel with the goal of market creation can provide additional support to IoT commercialization.

Space technologies are core to the strategic drive toward global universal connectivity, and solutions based on them aim to eliminate the digital divide. Satellite connectivity can expand broadband access in remote and isolated regions where terrain, population density, or a lack of enabling infrastructure hinders traditional markets. Satellite-enabled connectivity can help develop e-commerce, smart infrastructure, agriculture, and transportation. Earth observation imagery companies bring innovative solutions

Box 2: Deep Tech and the "Valley of Death": The Evolution of Technology Commercialization

The Valley of Death phenomenon refers to the fact that the majority of R&D intensive startups fail to bring their inventions to market, with the majority failing to scale a piloted solution. Deep tech companies usually enter the Valley of Death twice: first, when they look for a technologically strong concept based on their research; and second, when they have successfully piloted the technology and need to move it to deployment and then diffusion.

One way to survive the Valley of Death is to cross it faster. A phase-gate model of technology commercialization seems to prevail with innovations that come from research institutions. Recently, a lean technology commercialization model reliant on digitalization has emerged. The new model allows for parallel implementation of activities that were traditionally performed in sequence.*

Simultaneous implementation is a new form of the commercialization process, and advanced open-source tools are paving the way for leaner processes that can further shrink the commercialization timeline for deep tech companies. This includes software tools (e.g., deep learning frameworks and algorithms) and vast databases of labeled data to provide insights. The databases range from those that include data on face, gesture, pose, and activity recognition, to databases of molecules for material science and pharma. Instead of building an algorithm, a chemical solution, or another core technology from scratch, new companies use the existing tools and insights as building blocks to fast-track the overall commercialization cycle.

For example, MIT-based Kebotix significantly reduces the development time of new molecules for pharma and clean energy by combining deep learning with databases of materials and known test results, and with the robotic automation of experiments. And a Boston-based deep tech company called Cellarity applies open-source deep learning to its proprietary database of digitalized molecular information in cells, an approach that allows for a dramatic increase in the probability of success of new medicines to treat patients, which reduces the time and cost of commercialization.

Source: IFC.

* Saheed A. Gbadegeshin. 2019. "The Effect of Digitalization on the Commercialization Process of High-Technology Companies in the Life Sciences Industry." *Technology Innovation Management Review*, January 2019.

to agriculture, resource management, and infrastructure management, among other sectors.

Technological advancements such as new and more cost-efficient launchers, miniaturized satellites called CubeSats, and last-mile in-space delivery services are disrupting the sector, making new spacetech solutions more feasible. Commercializing space technologies has become easier as the space ecosystem matures, bringing private capital and new public-private partnerships into the sector.

Climate technologies to reduce greenhouse gas (GHG) emissions show potential. Renewable energy and other carbon reduction technologies can enhance energy efficiency and carbon capture and use. They can reduce inputs for agriculture and optimize logistics. The current generation of climate technologies does not require the subsidies used in the early days of wind and solar, and the business cases work without the support of carbon pricing. Instead, these technologies work on cost savings alone, with carbon reduction as an additional benefit.

Commercializing climate technology requires multiple breakthroughs in different disciplines, from cheaper hydrogen generation to low-carbon fertilizers, and a longer investment time horizon. For example, new battery types require about five years to move from a laboratory demonstration to a working product prototype, and another three to five years to achieve mass production. This is longer than the common seven-year investment horizon for current venture capital investments.

Challenges to Deep Tech Commercialization

The challenges associated with deep tech stem from the complexities of the technology commercialization process and can be placed into three broad categories: prolonged timeline, limited availability of social and physical infrastructure, and lack of capital.

It used to take a long time for deep tech companies to reach a market-ready level. While the timeframe for each stage of the tech commercialization process differs by sector, on average it used to take up to several decades (five to 10 years for spacetech, 10 to 15 years for energy, and seven to 10 years for biopharma) to bring a deep tech innovation to market. However, the research from IFC portfolio funds suggests that this timeframe is rapidly shrinking.

Deep tech companies need access to specialized facilities and resources. Research universities offer a unique environment in which scientists can be a part of a research community and have access to the university's facilities and public funding. However, traditional technology transfer offices (TTOs) often pose challenges when deep tech founders move from research to commercialization, as siloed departments may slow down interdisciplinary work and tech transfer agreements may create disincentives for follow-on investors.[6]

Financing options for deep tech companies are limited and the available financial options lack depth and flexibility. Deep tech poses higher credit risk, as its assets are intangible (e.g., patented/not patented intellectual property) and difficult to value (especially pre-revenue). And investors often have limited understanding of the technical and economic feasibility of many deep tech innovations.[7] However, deep tech has been receiving more attention recently from capital investors whose investment horizons are longer than traditional venture capitalists.

Trends in Addressing Existing Commercialization Challenges

Enabling effective cross-sectoral collaboration helps to ease many challenges and boost opportunities. Corporations, deep tech VC funds, university TTOs, and nonprofits have sought to strike partnerships around open innovation. Startup accelerators and incubators serve as an example of this approach. There is an emergence of accelerator cohorts recruited out of academia. Often, these teams are based out of university-affiliated science parks or similar spaces (e.g., Seraphim Space Camp). The Engine, a deep tech incubator founded by the Massachusetts Institute of Technology (MIT), provides its residents access to all the vast resources of MIT's research labs and state-of-the-art equipment across biotech, nanotech, chip fabrication, and material science. Another trend is recruiting to an acceleration program a cohort of scientists who are not yet sure what scientific discovery they would like to turn into a product (this is typical of AI research). A variation of these models can be effectively implemented in emerging markets.

Many universities are rethinking the role of a TTO by creating more open and dynamic structures that create value for entrepreneurs. In addition, the number of private facilities providing deep tech founders with needed infrastructure (e.g., Newlab) and decentralized and collaborative research platforms (e.g., Just One Giant Lab and OWKIN) has been increasing.

The growing availability of open-source systems and cloud computing resources decreases capital expenditures and lowers international barriers in deep tech commercialization. Deep tech businesses with computationally heavy tasks such as training convolutional neural networks or analyzing properties of proteins rent

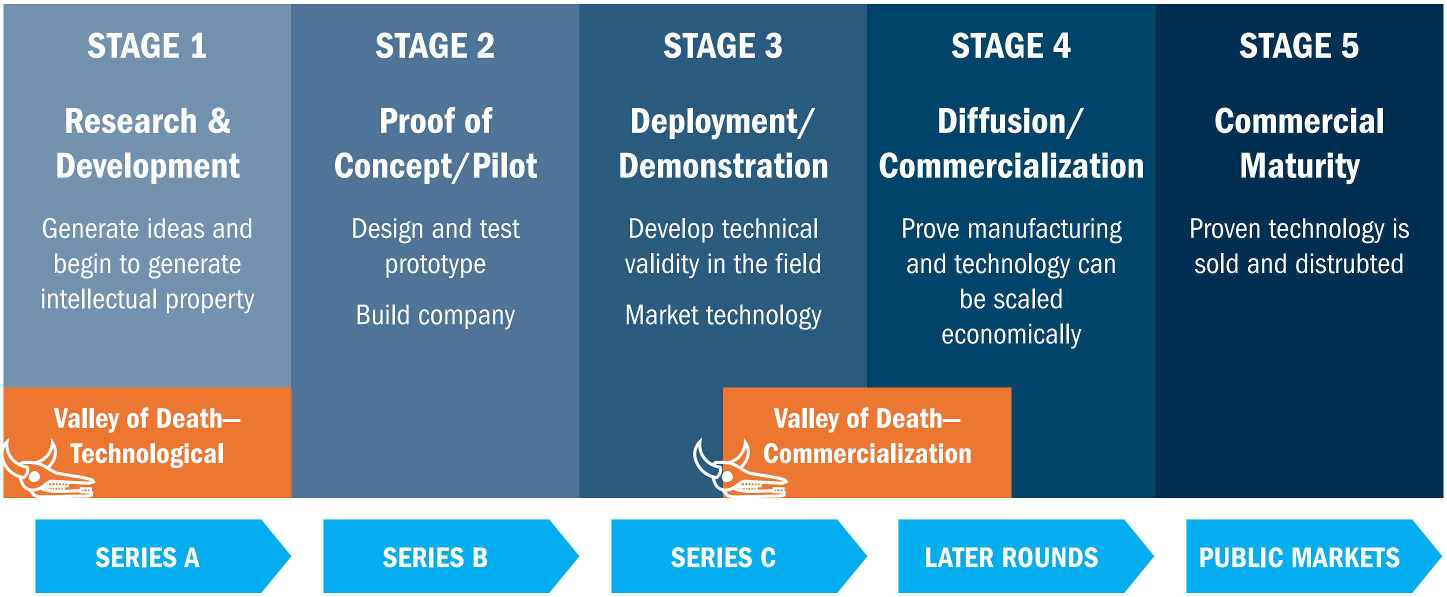

FIGURE 1 The Evolution of the Technology Commercialization Process

Source: Solecki, Mary, Anisa Dougherty, Bob Epstein. 2012. "Advanced Biofuel Market Report 2012." http://www.lexissecuritiesmosaic.com/gateway/FedReg/doc_E2AdvancedBiofuelMarketReport2012.pdf, quoted in Rosen, Chris. 2013. "Business Perspective on Biofuels: Stages of Commercialization." Haas School of Business. http://live-bcgc.pantheon.berkeley.edu/sites/default/files/13-class-20.pdf.

virtual graphics processing units (GPUs) from anywhere in the world via cloud services. Advanced software is increasingly available in the form of free open-source tools. These include general-purpose programming frameworks and services like Ruby on Rails, Node, and Gitlab; open-source databases; and tools providing state-of-the-art machine learning and deep learning capabilities, such as TensorFlow and Keras. As such, the phase gate commercialization model is evolving into a leaner digitalized process for deep tech commercialization (see Box 2) addressing the risks associated with commercialization's time horizon.

In addition, founders are able to iterate their designs with advance simulation techniques using platform technologies like AI and 3D printing, cutting down the initial prototyping stage of a deep tech solution. For example, AgniKul Cosmos, a rocket manufacturer based in Chennai, India, built an engine from an idea stage to a working model in less than two years, utilizing available technological advances.

As this trend grows, it will become easier to ensure that tech startups in emerging markets have access to hard R&D assets, capitalizing on opportunities provided by hardware as a service, such as on-demand access to high performance computing (HPC) or material labs. Amazon Web Services, Google Cloud, and Microsoft Azure lead a fast-growing list of HPC providers hosting both traditional CPU (central processing unit) computing and GPU computing, both optimized for highly-parallel deep learning and scientific computing. Liquid Instruments' Moku:Lab allows for remote deployment of a range of instruments such as waveform generators or laser lock boxes for various experiments that traditionally can be conducted only in a research lab.

More targeted efforts toward streamlined technology commercialization and investing in entrepreneurship have emerged. There is evidence that public R&D expenditure leads to an increase in private sector R&D spending.[8] Recently, the Indian Institute of Technology-Delhi (IIT-D) launched a platform to back startups and researchers interested in building deep tech startups. IIT-D aims to attract startups focusing on connected intelligent systems, mixed reality, advanced materials, drug discovery, and medical research, promising to provide seed funding, workspace, mentoring, and connections to venture capital. The initial funding for IIT tech hubs comes from the Department of Science and Technology; however, the hubs are allowed to raise additional funds from industry for product development and commercialization. And university-affiliated accelerators are starting to invest in the training of potential scientist entrepreneurs. In Israel, leaner approaches to technology transfer and strong partnerships between accelerators and research institutions, coupled with a strong cybersecurity startup ecosystem, are driving deep tech growth.

The Role of the Private Sector in Deep Tech Commercialization in Emerging Markets

Deep tech is becoming global: since 2012, the volume of deep tech financing with cross-border participation has increased six-fold.[9] Higher productivity and knowledge transfer associated with deep tech commercialization can benefit emerging economies.

While private sector involvement in the commercialization of deep tech in emerging markets has been limited so far, there are several examples of successful efforts around private capital mobilization and public-private partnerships between universities and a range of private sector players.

Angel investors and the diaspora are catalyzing the change. Over the past two decades, U.S. tech hubs have seen a dramatic influx of foreign-born tech talent, predominantly from India, China, and some Eastern European countries. Out of the estimated two million residents in Silicon Valley (California), some 730,000 are foreign-born, including almost 40,000 immigrant entrepreneurs. Having worked for large tech companies and empowered by cutting-edge software tools, foreign-born tech talent is becoming agents of change in developing economies. Many companies in the IFC portfolio were founded by first-generation immigrants who worked or studied in the United States and then moved to start a business that addresses problems at home.

India is emerging as the next deep tech hub. IFC research suggests that while software-driven startups are dominating the investment landscape in India, the deep tech sector has been gaining some prominence (see Figure 2). According to The National Association of Software and Service Companies (NASSCOM), in 2019 India had 1,600 deep tech startups,[10] excluding companies in life sciences. Deep tech is seeing increased adoption across multiple sectors like industrial, healthcare, automotive, and spacetech. Just as data is critical for AI technologies to thrive, for deep tech companies in the non-digital space, material science (frequently driven by nanotechnology) and process technologies often become the drivers. Innovation happening in India on those fronts drives local startups to address global problems.

The growth of India's spacetech sector illustrates how the private sector can engage and enable deep tech commercialization. Initial public R&D funding for aerospace engineering resulted in a range of spacetech startups incubated at Indian universities. These startups raised initial funding from local angels and the Indian diaspora, often through alumni networks. Pixxel, an Earth Observation startup launched at the Birla Institute of Technology and Science (BITS), aims to launch a constellation of 24 satellites and raised $5 million in seed capital in 2020. Bellatrix Aerospace, an electric propulsion startup incubated at the Indian Institute of Science (IISc), raised $3 million in pre-Series A funding. Astrome, also based out of IISc, has repositioned its millimeter wave wireless technology to build a wireless backhaul solution. AgniKul Cosmos raised $3.5 million to develop a fully 3D printed rocket engine. The Indian Space Research Organization has embraced private-public partnerships by inviting startups to come up with solutions related to a number of space verticals; it recently formed the Indian National Space Promotion and Authorisation Centre (IN-SPACe), an agency focused on including private players in space-related activities.

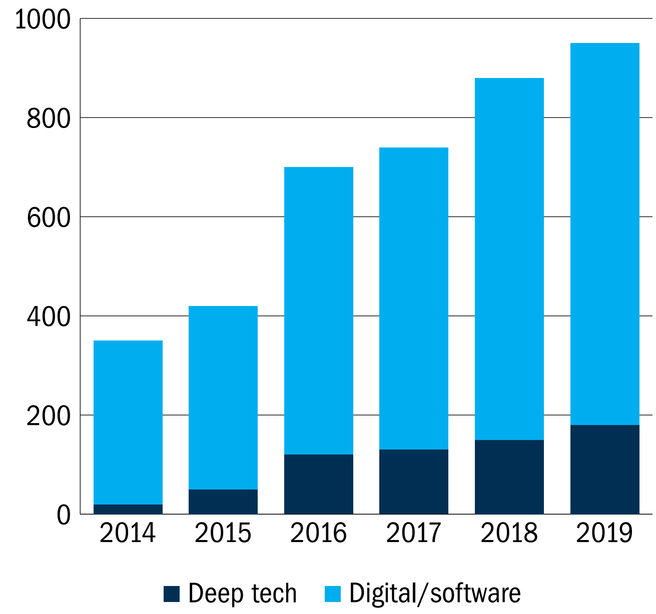

FIGURE 2 **Deep Tech Investments are Rising in India**

Source: IFC Analysis.

Another area of interest that can have a deep impact is the work companies like log9 are doing in the field of battery technology. Their core intellectual property is a nanotechnology-based innovation that allows them to produce graphene for multiple use cases, including battery tech.

Partnerships with corporations and startup accelerators can benefit early-stage deep tech startups. In Israel, universities proactively encourage commercialization through collaborations with international corporations, VC funds, and startup accelerators. According to Israeli

Deep Tech Overview 2020, there are over 150 deep tech companies in Israel, excluding several in life sciences, that have raised a total of $5.52 billion over the 2010–2019 period. Israeli deep tech startups raised a combined $1.8 billion in 2019, almost twice as much as they did in 2018 or 2017.[11]

Business counterparts can benefit from universities' streamlined commercialization processes. Technion, one of Israel's largest public research universities and a pioneer in robotics commercialization, has a track record of effective tech commercialization activities. And Israeli public and private institutions have pioneered a risk-sharing model that supports commercialization. The Israeli model integrates technology transfer, research operations, and funding functions into one business entity, in contrast to the traditional silos these functions often occupy. This reduces bureaucracy and ensures continuity of relationships with internal and external stakeholders across commercialization stages.

Technion's TTO is structured as a wholly owned subsidiary that does hiring independently from the university administration. The autonomous structure allows for faster decision making. The TTO staff with previous experience in the corporate world and entrepreneurship speaks the same language with external partners and shares business experience with university researchers.

Opportunities Ahead

A major advantage of deep tech solutions is their ability to form the basis for future industries that emerging markets need. Development finance institutions and institutional investors are well positioned to lead the way in deep tech, amplifying the amount of patient capital available for deep tech companies that are building solutions for emerging markets. This is particularly the case for growth-stage deep tech companies, when most scientific risks have been removed, and the initial product-market fit has been achieved in developed economies.

Finding the right fit between a scientific or engineering breakthrough and the market takes time and industry expertise. As the solution matures, additional value for deep tech companies comes from having a team that can help identify new adjacent markets to take their core technology to. Recognizing and acting on such opportunities across emerging markets requires specialized knowledge. Building this capability, investing time and resources into scientific and engineering risk evaluation, and understanding deep tech commercialization dynamics will help identify and strengthen the solutions capable of addressing the challenges faced by emerging economies.

Currently, private sector investments in deep tech in emerging markets are limited to a few countries, partly due to the limited opportunities around technology commercialization. Venture capital investments in R&D-intensive startups, as well as investment in specialized funds, can enable the growth of deep tech ecosystems and help bring more sustainable deep tech solutions to the market.

Further investment in innovative research and engineering infrastructure, as well as in emerging models of accelerators and incubators, can support deep tech commercialization. Working to strengthen local tech ecosystems through universities and public-private partnerships provides an entry point for early private sector involvement, which can increase the success of deep tech startups. Universities in emerging markets first invest in undergraduate education, and progress to better postgraduate courses and finally to postgraduate research. Deep tech startups depend on strong postgraduate research, as postgraduates form the core of chief technology officers and technical founders.

Countries with strong academic hubs such as Brazil, Kenya, and several Eastern European countries can set up the systems now to commercialize intellectual property produced by their higher education institutions. These markets are now retaining talent in country, and returnees from the United States and Europe are becoming founders of deep tech startups. The best practices described above form a good starting point for those who wish to develop a sound technology commercialization strategy.

ACKNOWLEDGEMENTS

The authors would like to thank the following colleagues for their review and suggestions: Carlo Rossotto, Principal Investment Officer, Upstream TMT–Global Infrastructure, IFC; Ferdinand van Ingen, Senior Industry Specialist, TMT–Global Infrastructure, IFC; Peter Cook, Senior Investment Officer, Disruptive Technologies and Funds, IFC; Georges Houngbonon, Economist, TMT Disruptive Technologies and Funds, IFC; within Thought Leadership, Economics and Private Sector Development, IFC: Adyasha Mohanty, Research Assistant; and Thomas Rehermann, Senior Economist.

The authors would like to thank Manish Singhal, Founding Partner of pi Ventures, a portfolio fund of IFC Disruptive Technologies and Funds, South Asia, for his contribution; and also thank Georgetown University's McDonough School of Business students for their research contribution: Peian Wang, Mrinal Mahotra, and Siwei Chu.

Please see the following additional reports and EM Compass Notes about technology and its role in emerging markets: *Artificial Intelligence in Emerging Markets—Opportunities, Trends, and Emerging Business Models* (report, September 2020); *Reinventing Business Through Disruptive Technologies–Sector Trends and Investment Opportunities for Firms in Emerging Markets* (report, March 2019); *Blockchain: Opportunities for Private Enterprises in Emerging Markets* (report, January 2019); *AI Investments Allow Emerging Markets to Develop and Expand Sophisticated Manufacturing Capabilities* (Note 87, July 2020); *Leveraging Big Data to Advance Gender Equality* (Note 86, June 2020); *What COVID-19 Means for Digital Infrastructure in Emerging Markets* (Note 83, May 2020); *Artificial Intelligence in Agribusiness is Growing in Emerging Markets* (Note 82, May 2020); *Artificial Intelligence in the Power Sector* (Note 81, April 2020); *Accelerating Digital Connectivity Through Infrastructure Sharing* (Note 79, February 2020); *Artificial Intelligence and 5G Mobile Technology Can Drive Investment Opportunities in Emerging Markets* (Note 76, December 2019); *The Role of Artificial Intelligence in Supporting Development in Emerging Markets* (Note 69, July 2019).

---

[1] The Engine. 2019. "2019 Tough Tech Landscape Report." https://www.engine.xyz/wp-content/uploads/2019/10/The-Engine_2019_Tough_Tech_Landscape.pdf.

[2] For more examples of deep tech startups addressing the challenges brought by COVID-19 see: Joffe, Benjamin. 2020. "Deep Tech Startups vs Covid-19, with Khosla Ventures, Fifty Years and SOSV." Synbiobeta, June 16, 2020. https://synbiobeta.com/deep-tech-startups-vs-covid-19-with-khosla-ventures-fifty-years-and-sosv/

[3] Manchanda, Sumit, Hassan Kaleem, and Sabine Schlorke. 2020. "AI Investments Allow Emerging Markets to Develop and Expand Sophisticated Manufacturing Capabilities." *EM Compass Note 87*, IFC, July 2020.

[4] Lee, Neil and Stephen Clarke. 2019. "Do Low-Skilled Workers Gain from High-Tech Employment Growth? High-Technology Multipliers, Employment and Wages in Britain." Research Policy, 48(2). https://www.sciencedirect.com/science/article/pii/S0048733319301234?via%3Dihub.

[5] See Makala, Baloko and Tonci Bakovic. 2020. "Artificial Intelligence in the Power Sector." *EM Compass Note 81*, IFC, April 2020; Cook, Peter and Felicity O'Neill. 2020. "Artificial Intelligence in Agribusiness is Growing in Emerging Markets." *EM Compass Note 82*, IFC, May 2020. Biallas, Margarete and Felicity O'Neill. 2020. "Artificial Intelligence Innovation in Financial Services." *EM Compass Note 85*, IFC, June 2020; Manchanda, Sumit, Hassan Kaleem, and Sabine Schlorke. 2020. "AI Investments Allow Emerging Markets to Develop and Expand Sophisticated Manufacturing Capabilities." *EM Compass Note 87*, IFC, July 2020.

[6] Different. 2020. "DeepTech Investing Report 2020." https://differentfunds.com/deeptech-investing/.

[7] Gigler, Soren and Brendan McDonagh. 2018. "Financing the Deep Tech Revolution–How Investors Assess Risks in Key Enabling Technologies (KETs). European Investment Bank, March 2018. https://www.eib.org/attachments/pj/study_on_financing_the_deep_tech_revolution_en.pdf.

[8] Moretti, Enrico, Claudia Steinwender, and John Van Reenen. 2019. "The Intellectual Spoils of War? Defense R&D, Productivity and International Spillovers." NBER, November 2019. https://www.nber.org/papers/w26483.

[9] The Engine. 2019. "2019 Tough Tech Landscape Report." https://www.engine.xyz/wp-content/uploads/2019/10/The-Engine_2019_Tough_Tech_Landscape.pdf.

[10] NASSCOM. 2019. "18% of the Total Start-Ups in 2019 are Now Leveraging Deep Tech – NASSCOM Start-Up Report 2019." The National Association of Software and Service Companies (NASSCOM), November 5, 2019. https://nasscom.in/sites/default/files/media_pdf/pr-indian_start_up%20_ecosystem.pdf

[11] IVC and Grove Ventures. 2020. "Israeli Deep-Tech Overview 2020." https://ivc-online.com/Portals/0/RC/POSTS/Deep-Tech%20Map%20Final.pdf.