Australia's deep tech opportunity

Insights from the Cicada Innovations journey

August 2020

Prepared for Cicada Innovations by

αlphaβeta Australia part of Accenture

Cicada Innovations commissioned this report as part of celebrations of its first twenty years. Founded in 2000, Cicada Innovations is Australia's leading deep tech incubator. It is located at the National Innovation Centre at the Australian Technology Park in Eveleigh, New South Wales; photo above. For more information, visit https://www.cicadainnovations.com.

The report has been prepared by AlphaBeta Australia, a data-driven consulting firm with offices in Sydney, Canberra and Melbourne. It specialises in integrating economics, data and strategy to help its clients understand the forces shaping their industries. AlphaBeta Australia is part of Accenture. For more information, visit www.alphabeta.com.

Accenture is a leading global professional services company, providing a broad range of services and solutions in strategy, consulting, digital, technology and operations. Combining unmatched experience and specialised skills across more than 40 industries and all business functions — underpinned by the world's largest delivery network — Accenture works at the intersection of business and technology to help clients improve their performance and create sustainable value for their stakeholders. For more information, visit www.accenture.com.

For further information on this report contact sydney@alphabeta.com.

Contents

Foreword

This report celebrates Australia's deep tech successes and explores the value of deep tech for Australia. I am excited to share it with you.

The report draws on Cicada Innovations's first 20 years. Founded in 2000 with the visionary support of the University of New South Wales, the University of Technology Sydney, and the University of Sydney, with the Australian National University joining soon after, we have grown into Australia's leading incubator of deep tech, and we have learned a lot along the way.

If the fires, floods, droughts and worldwide pandemic of 2020 have taught us anything, it is that creativity and collaboration are even more vital than we knew. We have had to galvanise together - government, industry, community, research and education institutions, and entrepreneurs - to build solutions and get them into the field fast and at scale.

Every day at Cicada Innovations, I have the privilege of supporting precisely that kind of collaboration. If the world seems to have come to a halt during lockdown, our most pressing problems in food, energy, health and the environment have not. Neither have Cicada Innovations' deep tech firms; some have pivoted impressively fast to respond to the pandemic. SpeeDx quickly developed a respiratory testing kit for COVID-19. Calumino launched its Rapid Thermo Scanner, capable of detecting fever with extraordinary accuracy, and of being mass-deployed to make airports, schools, nursing homes, and office buildings safer.

The rest of the Cicada Innovations community has not missed a beat during the pandemic – in fact, we have never been busier. Clarity Pharmaceuticals commenced a revolutionary paediatric oncology trial in a leading cancer hospital in the US. Sustinent continues its work to turn green farm waste into animal fodder. Invertigro is trialling its fully integrated modular farming solution in the Mars Simulation project. Flurosat has been training Agronomists globally to improve on farm outcomes through data, analytics and AI. Neuromersiv was awarded a $1 million investment from the BioMedTech Horizons program to continue developing their VR device for brain injury rehabilitation. We've had new residents Telemattica and Presien join us and continue their work on smart IOT solutions for heavy industries and infrastructure. They and the many other companies residing at Cicada Innovations remain hard at work bringing disruptive scientific innovations into the hands of those who need them the most.

Australia has a long history of innovation success. Australia's First Peoples built complex systems to manage environment, health and food challenges that remain relevant today. David Unaipon's gamut of inventions a century ago ranged from a new shearing device to a centrifugal motor, a multi-radial wheel and a mechanical propulsion device. More recent Australian inventions have been adopted worldwide, including cochlear implants, the flight recorder or blackbox, Resmed's CPAP device and WiFi. Few of us can name more than a few of Australia's deep tech successes, yet they underpin much of what we take for granted today.

As this report shows, Australia's deep tech investments have created equally deep social and economic value. Just a sample of Cicada Innovations' resident and graduate firms have created hundreds of millions of dollars of social and economic value already. Looking more broadly, Australia's Cochlear, ResMed, and CSL Limited alone have transformed millions of lives. They are now valued at $12 billion, $35 billion, and $127 billion respectively.

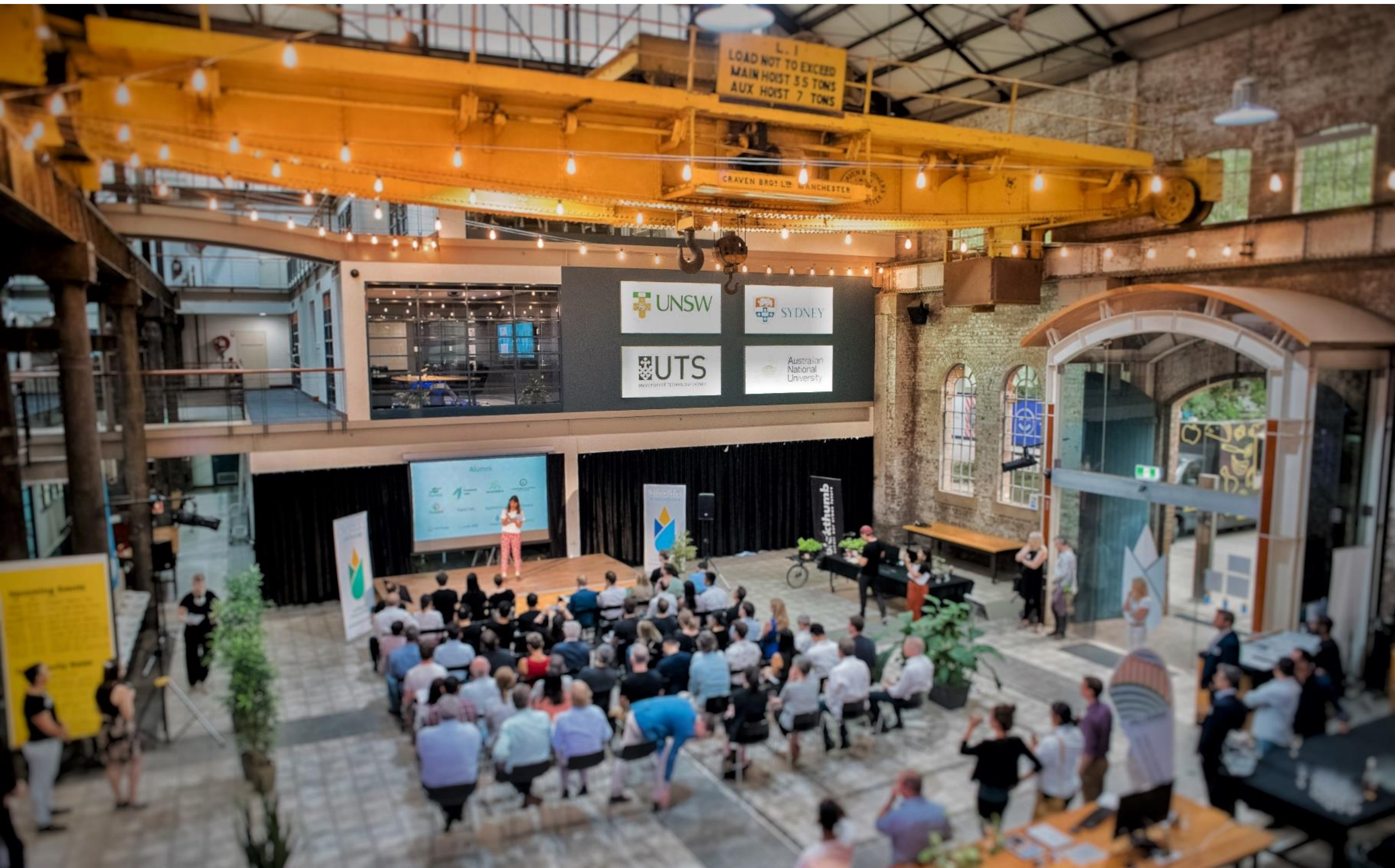
Success does, however, take time. The Australian deep tech giants are "thirty-year overnight successes". Many companies at Cicada Innovations have been on their journey for over a decade. While deep tech's long timeframes can be daunting, they yield the technologies that can help us hear, cure cancers, connect us across oceans, and feed us.

As we seek to recover and transform the economy post COVID-19, we can draw from Australia's deep tech strengths and successes to build a healthy society, high quality jobs, and a robust and sustainable economy.

Looking out further, we must ask how government, industry, community, research and education institutions and entrepreneurs can best work together to make the most of our deep tech strengths, and how we can align policy and practice to strengthen the pipeline of deep tech companies we need to fuel our future.

All of us at Cicada Innovations hope that these insights from our journey will inspire you to join us in transforming Australia into the deep tech economy we know is possible. Deep tech must be in our conversation and on each of our agendas, so these stories can inspire the coming generation of innovators.

Sally-Ann Williams
CEO, Cicada Innovations



Key findings

Deep tech is key to solving today's pressing challenges

Australia and the world face **pressing challenges**, from climate and poverty to privacy and health care

Deep technologies – innovations based on scientific research – can help address the world's most pressing challenges

Australia needs to invest to lead in deep tech

Deep tech takes time
Breakthroughs can take over a decade of investment

Deep tech drives benefits
Australian deep tech can strengthen economic performance

Australia is **a world leader** in technical and scientific publications

But just **12 Australian firms** are represented in the world's top **2,500 R&D leaders**

Australian deep tech startups are...

Improving farming yields to feed the world

Building **drone delivery systems**

Creating better ways to make **targeted cancer treatments**

Developing safer and cheaper **rechargeable batteries**

Startups incubated at Cicada Innovations have ...

Created **$370m+** in value for business, consumers and society *(6 leading start-ups)*

Generated **$625m+** in value via IPOs & trade sales *(4 leading start-ups)*

Reinvested in research, new ventures, and mentoring

Australia can help deep tech flourish by ...

Building a bridge through the crisis

Developing a **shared vision**

Nurturing deep tech **culture**

Investing for the **long term**

Executive summary

Deep technologies – significant innovations based on scientific research – will be a key part of the answer to many of today's global challenges. Globalisation, urbanisation and digitisation have driven the world economy in recent decades, but they have put pressure on our environment and generated new forms of insecurity. Despite global growth, many people remain in poverty. The COVID-19 pandemic underscores just how critical breakthroughs in medical technology are; and many other diseases are still wanting for effective treatments. For Australia, an ageing population is beginning to strain the health care system. Managing the energy transition requires new approaches. Solving these challenges requires clever policymaking, leadership, and healthy institutions, but it also demands that we develop breakthrough technologies.

Deep tech is also key to economic performance, but Australia is at risk of falling behind. Technology is the only driver of sustained economic growth, and innovating countries perform better. But while Australia is a world leader in deep technology research, relatively few Australian corporates are global R&D leaders. Of the leading 2,500 global firms who are recognised as R&D leaders, just 12 of them are Australian. The economies of South Korea and Canada are similar in size to the Australian economy, but they have 60 and 28 firms, respectively, in the top 2,500 R&D leaders.

Startups are key to Australia's deep tech evolution. Australian deep tech startups are already building intelligent robots and scaled drone delivery to reduce the environmental costs of transport; cutting the cost of cancer drugs so that lifespans can be prolonged and suffering ameliorated; and developing new farming tools that improve agricultural yields and help feed the world.

Because deep tech is expensive and development takes a long time, developing the right commercialisation pathway is crucial. Incubators are increasingly demonstrating their efficacy at successfully commercialising deep tech startups. Incubators provide startups with crucial inputs: access to finance, a business network, skilled workers, and specialised equipment and facilities.

The experience of Cicada Innovations, Australia's oldest and largest deep tech incubator, shows that substantial value can be generated via this route. A selection of just successful six startups that have incubated at Cicada Innovations have generated over $370m in value for business, consumers and society; four leading Cicada Innovations startups have returned in excess of $625m in business exits and reinvested in research, new ventures and mentoring. More broadly, Cicada Innovations startups have generated new Australian jobs and -manufacturing capability.

Australian policymakers, business leaders, and investors should pursue four priorities to realise our deep tech potential. First, we need to build a bridge through the pandemic crisis, and ensure that our existing investments are protected. Second, we should develop our shared vision of the deep tech capacity we want. Third, we need to nurture an innovative culture in our organisations. And fourth, we should commit to invest in deep tech for the long term.

This report shows how critical deep tech is in addressing our biggest challenges, and how it is already creating value for Australia in a multitude of ways. It documents how deep dech incubators serve the unique needs of deep tech startups. It demonstrates how Cicada Innovations, Australia's oldest deep tech incubator, has generated significant value over the last 20 years. Finally, it sets out a vision for Australia to realise its deep tech potential.

1. Deep tech matters now more than ever

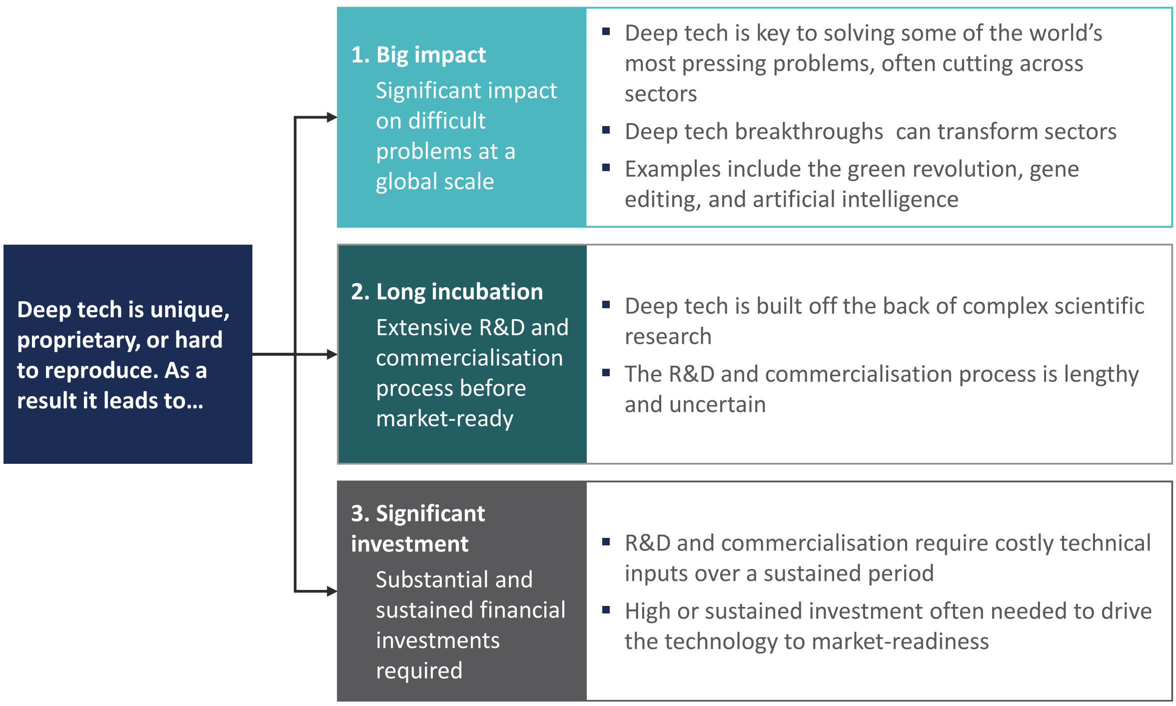
Solving the global challenges of this century – and driving local economic success – depends on the prompt and effective commercialisation of new technologies.

Deep tech drives human progress

New technology is central to the story of human progress. Translating knowledge into commercial technology has lengthened and improved human lives. Radical advances in technology – for example, genetic engineering that allows more resilient crops to be produced, doing much to ameliorate world hunger – are rare but valuable. Such technology is now known as ‘deep tech’, and is defined by three characteristics: first, it has an enormous impact on the world; second, it requires a long period of development before it is market-ready; third, it can demand sustained financial investment (Exhibit 1).

Exhibit 1 – What is deep tech?

Definition of deep tech



Note: Box 1 below shows that Australian technologies are often commercialised over long periods
Source: Cicada Innovations, Startup Genome

Deep tech innovations such as the silicon microprocessor, genetic engineering and Wi-Fi have proved transformative, helping to solve problems beyond the capacity of previous technologies and building the foundations for new industries. Today, Australia and the world face a slew of such pressing problems. The universal challenges of humanity today are commonly understood through the United Nations’ Sustainable Development Goals (SDGs). Deep tech has the potential to play central roles in achieving each of these 17 goals (Exhibit 2), often cutting across several at once.

Globalisation and automation have changed the occupation mix in many Western economies, with many jobs from the old economy having been displaced. Such displacement has been concentrated in a few occupations. Jobs involving repetitive, manual tasks have been automated or outsourced to other countries where wages are lower.[1] This trend is likely to continue, as business processes are automated in the much larger services sector. Deep tech is key to Australia's ability to create the new products and services that will support employment and incomes in future. Deep tech itself directly creates high quality jobs, and deep tech products and services help the industries that use them adapt and thrive.

Another critical challenge is responding to climate change. Cutting emissions requires a global response, particularly achieving affordable and low emissions energy. In addition, Australia confronts a set of impacts unique to this continent. Climate change is expected to threaten biodiversity and increase the severity of droughts, cyclones, and other extreme weather events which in turn have substantial economic consequences. For example, the drought in NSW has decimated the agricultural sector and degraded the natural landscape, which in turn has weakened regional NSW's economy. Deep tech innovations can also help mitigate the effects of drought and water shortages, in addition to reducing carbon emissions.

Australia and other developed countries also face a demographic challenge: an older population places demands on health care and social services. Older Australians rightly rely on quality health care and are well-placed to benefit from advances in medicine, but this can be expensive. Higher health care utilisation, higher unit costs and new health services are expected to more than double total federal government health spending per person in the next four decades.[2] Deep tech can help improve health care while driving down its cost.

Australian deep tech startups are addressing these local and global challenges. Box 1 shows how four of them are working to solve big problems. All four are current or recent residents at Australia's leading deep tech incubator, Cicada Innovations. The startups apply and combine a range of technologies to applications as diverse as boosting agricultural yields, cutting the cost of last-mile deliveries, storing energy, and improving health and wellbeing for wheelchair users. Chapter Three sets out the estimated value that other Cicada Innovations deep tech innovations have delivered.

[1] AlphaBeta (2017), The Automation Advantage.

[2] Australian Government (2015), 2015 Intergenerational Report: Australia in 2055. While older people do disproportionately drive health care costs, expected net ageing is not a major contributor of per person health care costs. Ageing is projected to boost federal health care expenditure by about 10 per cent per person in coming four decades, over and above the contribution of non-demographic factors like new health services.

Exhibit 2 – Deep tech can help address critical challenges globally and in Australia

The Sustainable Development Goals – and startups at Cicada that are helping to achieve them

SDG 16: Peace, justice, and strong institutions

- Cybersecurity is a worldwide concern as economies continue to digitise
- *Deep tech example*: **UpGuard** provides robust monitoring of cyber threats for organisations of all sizes, communicated through easy-to-use tools

SDG 2: Zero hunger
SDG 11: Sustainability

- Mitigating the effects of climate change will be a key priority for Australia in the new century
- *Deep tech examples:* **Invertigro** is developing indoor vertical farming technology for resilient urban food supply; **Leaff** is pioneering light filters that improve yields of greenhouse produce

SDG 3: Good health & wellbeing

- The world faces challenges in providing healthcare for all, and in supporting an ageing population
- *Deep tech examples*: **Neuclone** is pioneering approaches to making in-demand biopharma-ceuticals at lower cost; **Calumino** has developed the Rapid Thermo Screener for temperature scans, and Eve Care to monitor aged care residents’ wellbeing and detect falls using IoT and AI

SDG 9: Industry, innovation, and infrastructure

- New digital technology can make infrastructure and industry more innovative and sustainable
- *Deep tech example*: **LX** is developing a highly adaptable internet-of-things (IoT) platform for sensors detecting temperature, pressure, moisture, light, and humidity that can all operate remotely and connect online

SDG 8: Decent work and economic growth

- Job opportunities for all Australians will be important in the face of globalisation and automation
- *Deep tech example*: **Flirtey** is developing drone delivery, creating opportunities for businesses in suburban and regional areas

SDG 7: Affordable and clean energy

- Access to cheap renewable energy will be key for Australia’s future economic growth
- *Deep tech example*: **Gelion** is producing cheaper, safer and more sustainable alternatives to expensive lithium ion batteries. Battery technology is crucial for the storage of electricity generated from renewable sources

Source: UN, Company websites, Cicada Innovations

Box 1: Deep tech startups incubated at Cicada Innovations address valuable opportunities

Cicada Innovations currently hosts 46 deep tech startups, including those seeking to tackle some of Australia's largest problems. Below are four examples of deep tech startups residing at Cicada Innovations or recently graduated, each aimed at tackling a valuable opportunity (Exhibit 3).

FluroSat and Gelion are providing solutions to a changing climate in Australia. FluroSat is seeking to boost farming efficiency using data analytics, which will be crucial as droughts become more frequent in Australia. Gelion is bringing a new generation of batteries to market, which helps scale renewable energy generation by providing a low-cost storage solution. Loop+ helps wheelchair users cut the risk of pressure injuries by tracking their activity.

Exhibit 3 – Challenges currently addressed by Cicada Innovations incubated startups

Challenge	Startup tackling it	What it does	Value of the challenge in Australia[1] ($ bn)
Lost agricultural output and sustainability	FluroSat	Precision farming has the potential to increase crop yields and decrease water and fertiliser use. **FluroSat has developed software that enables precision farming at scale.**	7.6
Cost of last-mile delivery	Flirtey	The last mile is the costliest mile, accounting for 15-20% of total purchase value. **Drone delivery is a cost-effective solution for delivering small items.**	2.8
Safe and cheap alternative to lithium-ion batteries	GELION	Lithium-ion battery systems are non-recyclable, flammable, and rely on a critical raw material. **Gelion has developed a new battery system, based on zinc-bromine which is safe, and uses widely available low-cost inputs.**	2.2 (Growth expected due to uptake of renewables)
Pressure sore hospital admission	loop+	25% of wheelchair users develop pressure injuries, reducing their quality of life and leading to avoidable costs for the health care system. **Loop+ has developed a sensor pad, app and data platform that lets users monitor their activity, manage their health, and share data with clinicians**	2.0

Notes: 1. The value of the challenge is calculated on annualised basis for Australia. Challenges that each firm is addressing are global in nature and are much larger when measured globally. Flirtey currently operates in the United States; exhibit presents the value of the challenge for drone delivery in Australia. 2. The value of some challenges, such as for energy storage, are expected to grow substantially in the next 10 years.
Source: Company websites, ABS 4618, ABS 4627, ABS 8501, Bloomberg, AlphaBeta analysis

Commercialising deep tech is key to economic success

Deep tech typically demands a long and expensive commercialisation process. However, economies that have built the capability to nurture and invest in deep tech over the long run can reap the extraordinary benefits that flow over time from deep tech initiatives.

New technology is the mainspring of global economic growth.[3] No other input can drive improvements in living standards indefinitely. Infrastructure and equipment are critical, but the net returns from additional capital eventually turn negative. Education is also critical, but education per person also runs into diminishing returns. Natural resources, too, are limited. By contrast, a flow of new ideas embodied in technologies and adopted across the economy can support a steady stream of new and improved products and services. Technology has been the main driver of global economic growth for centuries, and it remains so today.

Corporates and startups also can also profit from innovating, and in turn create wealth and boost incomes. Much of the economic payoff to deep tech commercialisation accrues locally, not globally. While technologies created abroad can be purchased or copied, at least a third of the benefits from innovation come from local R&D. Deep tech commercialisation drives productivity and incomes in the region or country hosting the research, commercialisation and production of new technologies.[4]

Reflecting the importance of deep tech in driving innovation, the proportion of entrepreneurs who are championing deep tech is growing (Exhibit 4). Deep tech startups made up just 29 per cent of all startups launched globally in 2010-11 but grew to 44 per cent in 2017-18. Investment trends have followed suit, with a growing proportion of startup funding heading to deep tech startups over other startups. Between 2011-12 and 2016-17, the proportion of overall startup funding directed towards deep tech grew by 14 percentage points, from 50 per cent to 64 per cent.

Even so, innovation is almost certainly under-provided by the market. Competition and copying mean that innovators do not capture all the benefits of their innovations, reducing the effort and investment that is worthwhile for them. The total economic return to R&D may be two to three times the return captured by the innovating firms.[5] The multiple is larger still for R&D conducted by startups that are financed by venture capital.[6] As a result, policies that help researchers and companies commercialise technologies are needed to unlock the full local economic benefits of deep tech.

---

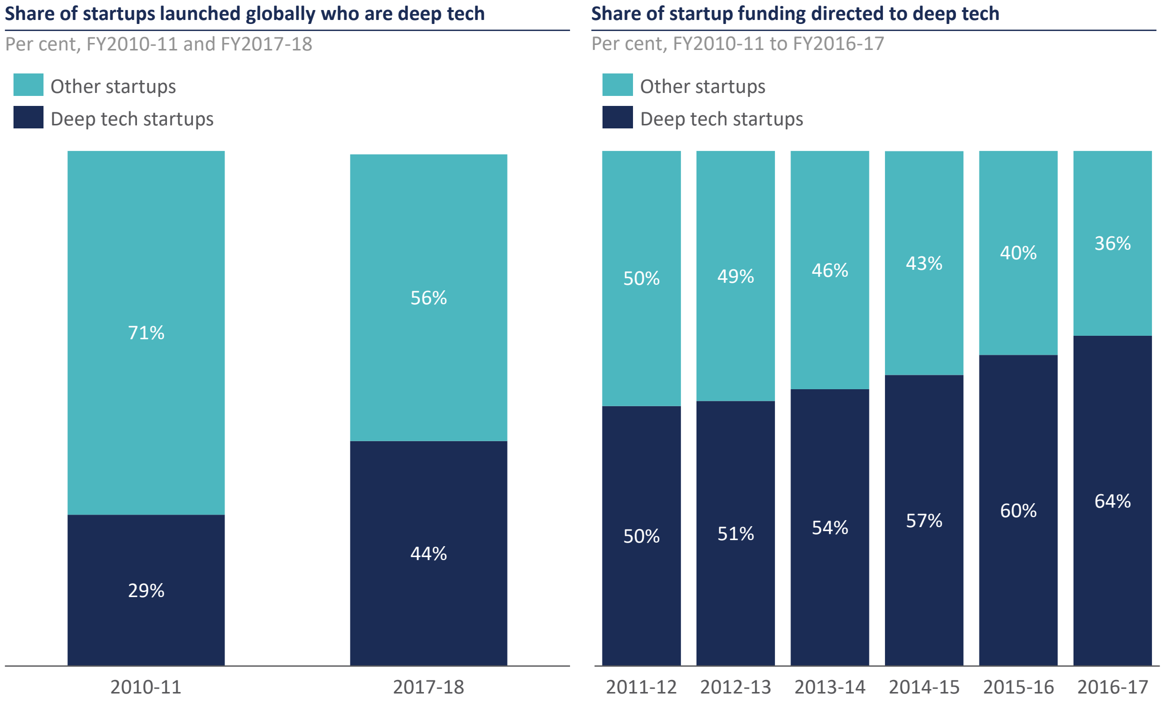
[3] Solow, R.M. (1957), "Technical Change and the Aggregate Production Function" Review of Economics and Statistics, 39; Romer, Paul M. (1990), "Endogenous Technological Change," Journal of Political Economy, University of Chicago Press, vol. 98(5); Jones, Charles (2005), 'Growth and Ideas', *Handbook of Economic Growth*, Volume 1B. Ed. Philippe Aghion and Steven N. Durlauf

[4] Jonathan Eaton & Samuel Kortum (1999), "International Technology Diffusion: Theory and Measurement" International Economic Review, Volume 40, Issue 3; Lychagin, Sergey, Joris Pinkse, Margaret Slade, and John Van Reenen, "Spillovers in Space: Does Geography Matter?" (2016), Journal of Industrial Economics, Volume 64, Issue 2.

[5] Bloom, N, M Schankerman, and J Van Reenen (2013), "Identifying technology spillovers and product market rivalry", Econometrica 81(4): 1347-1393; Charles Jones and John Williams, "Measuring the Social Return to R&D" Quarterly Journal of Economics, November 1998, Vol. 113

[6] Schnitzer, M, and M Watzinger (2017), "Measuring the spillovers of venture capital." CEPR Discussion Paper 12236

Exhibit 4 – Startups and venture capital have shifted towards deep tech



Note: Definitions: Deep tech startups: AI, Blockchain, Life Sciences, Advanced Manufacturing & Robotics, Agtech & New Food, and Cleantech; Other startups: Fintech, Cybersecurity, Edtech, Gaming, Adtech, and Digital Media.
Source: Global Startup Ecosystem Report 2019, Startup Genome

Sustained commitment is required to commercialise deep tech

Deep tech can help Australia confront its pressing challenges and offers an attractive economic prize. But Australian policymakers need to be realistic about our starting position and the timeframes involved.

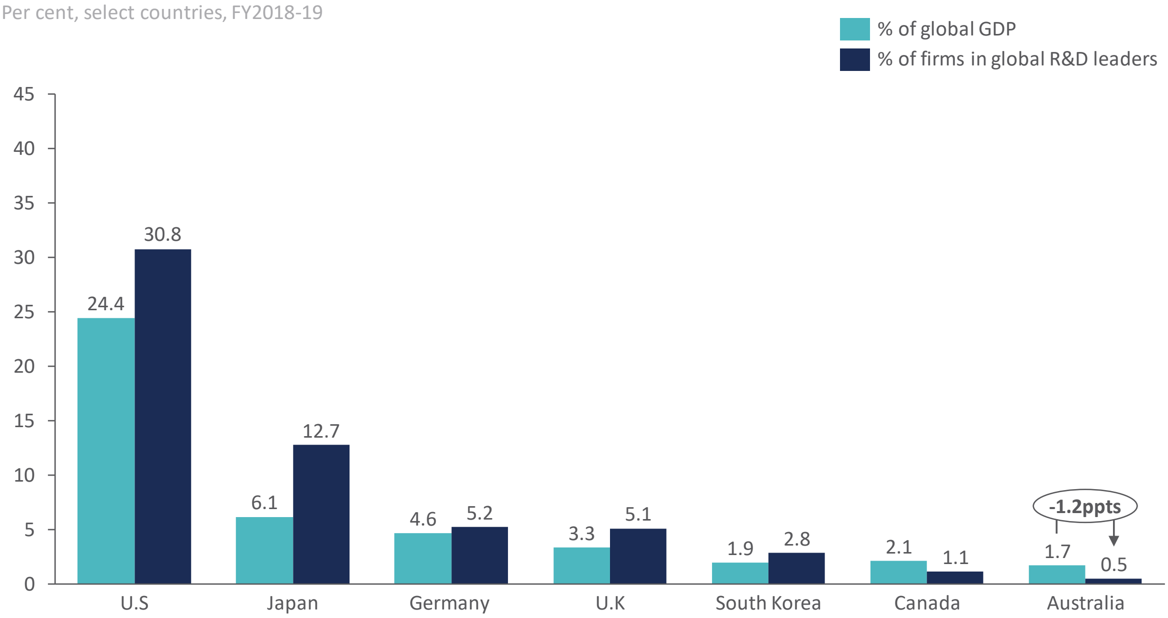
While Australia does have significant research and innovation strengths, even today relatively few large Australian corporates are global R&D leaders (Exhibit 5).[7] Just 12 Australian firms can be counted among the world's top firms by R&D investment. South Korea and Canada, with economies similar in size to Australia's, have many more global R&D leaders. South Korea alone has 60 such firms. If Australian corporate leaders invested in R&D with the same intensity as the top five leading countries, Australia would host five times as many R&D leaders as it does today. Australia faces a long road to achieve its deep tech potential.

[7] Chapter Four provides details on some Australian deep tech research and innovation strengths.

Exhibit 5 – Australia has few corporate R&D leaders at global scale

Major economies: share of global GDP and share of top-2500 firms by R&D investment

Per cent, select countries, FY2018-19



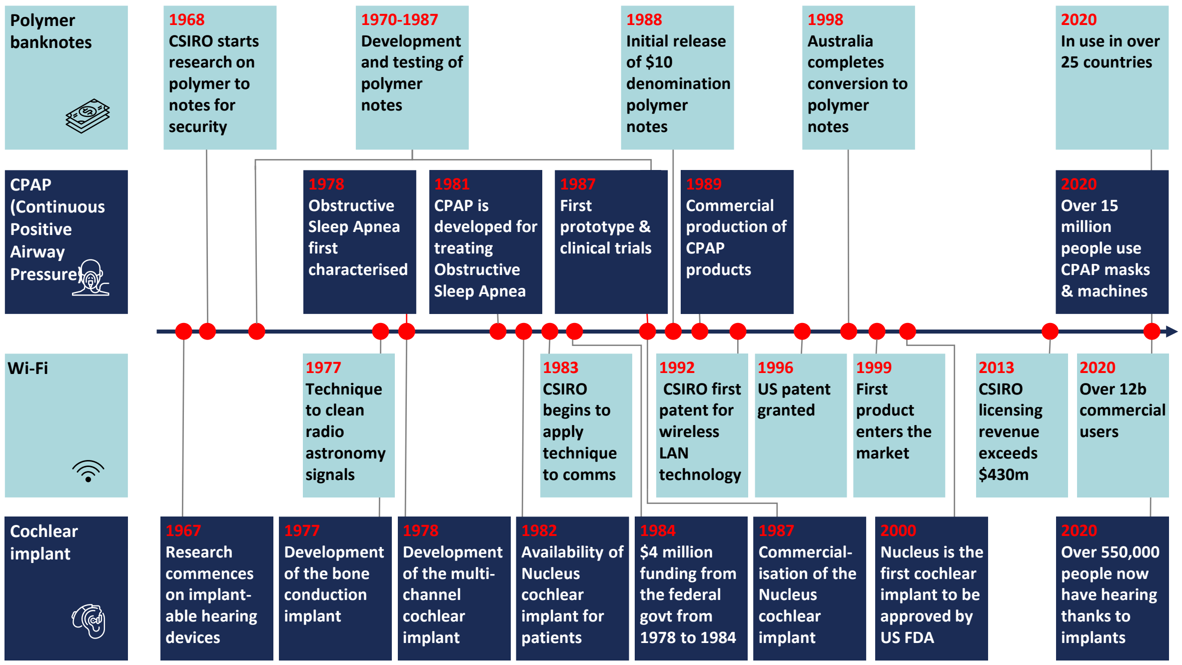
Notes: Australian top public R&D firms by sector are: Pharmaceuticals & Biotechnology: CSL, Mesoblast; Technology Hardware & Equipment: Telstra; Software & Computer Services: Technology One, Computershare; Other: Banks: National Australia Bank, Commonwealth Bank of Australia; Travel & Leisure: Aristocrat Leisure; Life Insurance: AMP; Health Care Equipment & Services: Cochlear; Chemicals: Nufarm; General Industries: AMCOR.
Source: European Commission (2019), The 2019 EU Industrial R&D Investment Scoreboard

Prominent Australian deep tech innovations illustrate the long incubation period required to transform our innovation outcomes (Exhibit 6). The development of polymer banknotes, which are much more difficult to counterfeit than paper banknotes, began in 1968 by the CSIRO. It was not until 1988 that the first batch of polymer banknotes were released for public use. The CSIRO also pioneered Wi-Fi, a process which began in 1983 when researchers began trying to understand how techniques used to process radio astronomy signals could be repurposed for more regular, terrestrial telecommunications. The research and development process took 16 years, with the first Wi-Fi product entering the market in 1999.

In medical technology, both cochlear implants and continuous positive airway pressure (CPAP) machines (used to treat sleep apnea), were important breakthroughs that required extensive research and development over the course of about a decade. Research on hearing implants began in 1967 and the first implant was commercialised in 1982; development of CPAP machines began in 1981 and the technology was taken to market in 1989.

These examples show that deep tech successes can require over a decade to reach market and further sustained effort to develop and mature. The 20-year history of Cicada to date is shorter than the development cycle of many of the deep tech successes that are widely recognised today. It is likely that the prominent Australian deep technology successes of the 2020s and 2030s are already under development at incubators like Cicada.

Exhibit 6 – Timelines for selected Australian deep tech innovations



Source: Polymer banknotes: CSIRO 2011; CPAP: ResMed 2020 and Stanford Medicine News 2019; Wifi: CSIRO 2019 and EPO 2012; Cochlear implants: Cochlear 2017.

2. Incubators are key to commercialising deep tech

Incubators create an ideal environment for the commercialisation of deep tech and have a long history of success.

Incubators help deep tech startups access vital inputs

Deep tech innovations are borne of complex scientific research followed by an intensive engineering and commercialisation process to convert the original idea into a viable product. There are several indispensable inputs for success in taking a complex new technology to market:

- **Access to sources of capital**, and the expertise that venture capital firms can bring from previous experience in related domains;
- **A network of advisers, peers, and mentors** who can guide founders through the multifaceted challenges of commercialisation – from legal matters to cybersecurity;
- **Specialised and secure technical facilities** such as labs and clean rooms, and equipment to engineer and refine the product;
- A **route to market**, to access customers who stand to benefit from applying the technology.

There are three main ways to commercialise a new technology (Exhibit 7). First, a startup can seek out each of these required inputs individually. Startup founders operating independently would have to find and connect to the right deep tech investors and gain their confidence. They would also need to find and tap into a strong network of business partners in many fields outside their area of expertise in order to succeed, such as IP, marketing, and commercial strategy. This demands capabilities that extend beyond the niche expertise of founders, which is usually in their technological discipline. Ultimately, going it alone typically suits innovations that are less technically demanding.

A second way in which a deep tech innovation can be commercialised is within an existing large corporate entity, which can provide ready access to internal business capabilities, facilities, and an ability to commercialise a product if it fits the company's existing channels. Large companies can also provide access to commercial expertise and can support the growth of the team responsible for taking the technology forward. Whilst developing deep tech within large corporate organisations can provide a secure environment, such organisations can struggle to align the needs of deep tech development except where directly adjacent to their core business. In its infancy, deep tech may not add immediate value to corporations. This can be a test of patience and focus for a company's equity investors, some of whom may perceive R&D to be a costly diversion. Corporates do, of course, commercialise technologies. But they tend to do best focusing on incremental innovations that extend the company's core technologies or complement an existing product line.

Exhibit 7 – Relative strengths of three commercialisation pathways

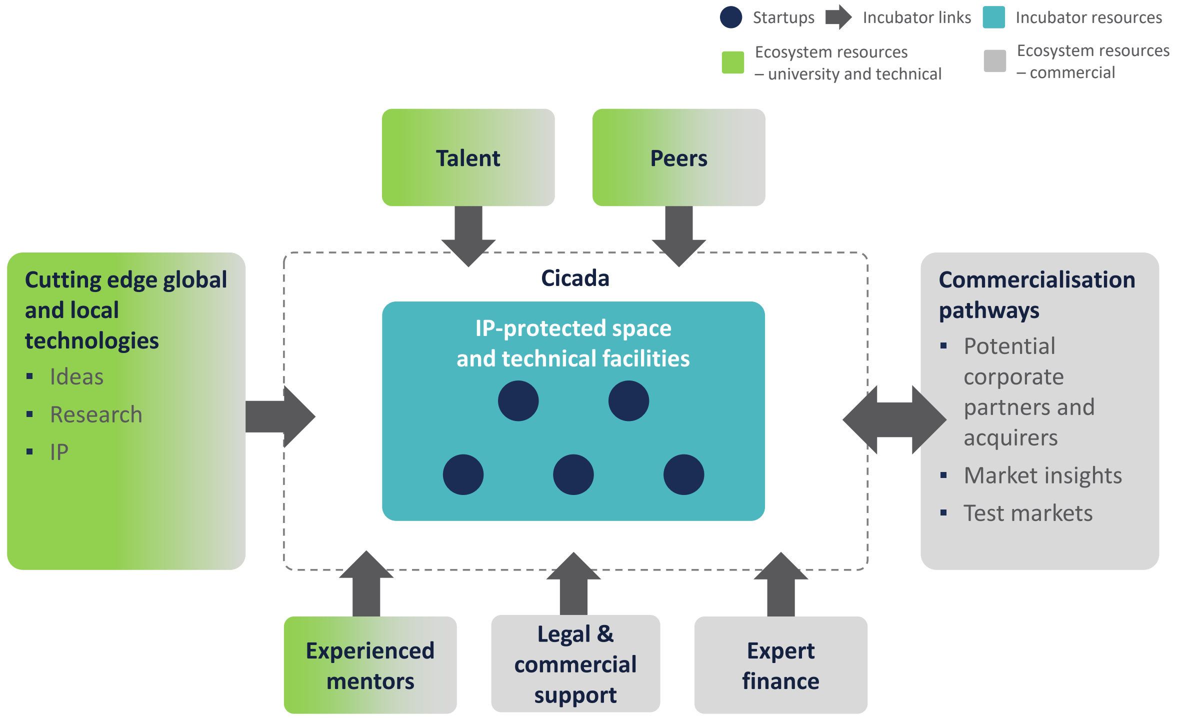
Commercial-isation model	Access to key inputs for deep tech commercialisation: Sophisticated finance	Business services, mentors, peers and talent	Technical facilities	Route to market	Relative advantage
1 Standalone deep-tech startup	Must search for financiers with the right technical background	Limited access to business and technical mentors	Challenging to find technical facilities on a 'pay-per-use' or shared basis	Costly search for partners and channels	Innovations that are **less technically demanding** or are already **far advanced to market**
2 Deep tech innovation within a corporate	Capital markets may penalise R&D that is not accretive to existing business	Only larger corporate R&D specialists will have capabilities and facilities at scale in-house		Corporates are advantaged for innovations that align to existing business	Incremental innovations that **extend that corporation's core** technical capabilities; may also complement existing product line
3 Incubated deep-tech startup	Incubator can reduce costs of connecting to specialist investors	IP, regulatory and business services. On-site community of peers; network of mentors	Flexible access to shared labs, prototyping tools, and other technical inputs	Incubator brand and connections can reduce cost to find the right partners	Innovations that require access to **sophisticated finance, regulatory and IP advice, mentors and peers, and technical facilities**

Source: Industry interviews

Incubation offers a third option that can suit deep tech well. Incubators – organisations geared to nurturing and developing startups – offer entrepreneurs structural advantages over alternatives of going at it alone or innovating within an existing corporate. They help entrepreneurs access the resources and expertise required for their technology to flourish, and grant them the patience and long development time needed to bring a complex innovation to market. For example, a university researcher who has developed a promising technology can take it all the way to market with the support of an incubator.

Deep tech incubators provide access to the full suite of inputs a startup needs as it builds a deep technology innovation and takes it to market. They provide business services and technical facilities on site, with secure offices and labs to protect valuable IP (Exhibit 8). They provide tailored advice on regulatory and IP matters. They also bring in high value connections. For example, incubators link startups to specialist investors who understand the costs, risks, and applications for in the startup's field. Deep tech incubation combines startup agility with scale, depth and sophistication, and is ideally suited to the complex and radical innovations that fall outside the core interests of established large companies.

Exhibit 8 – Services and links incubators like Cicada Innovations provide to deep tech startups



Source: Industry interviews

Incubators help high-potential deep tech startups succeed

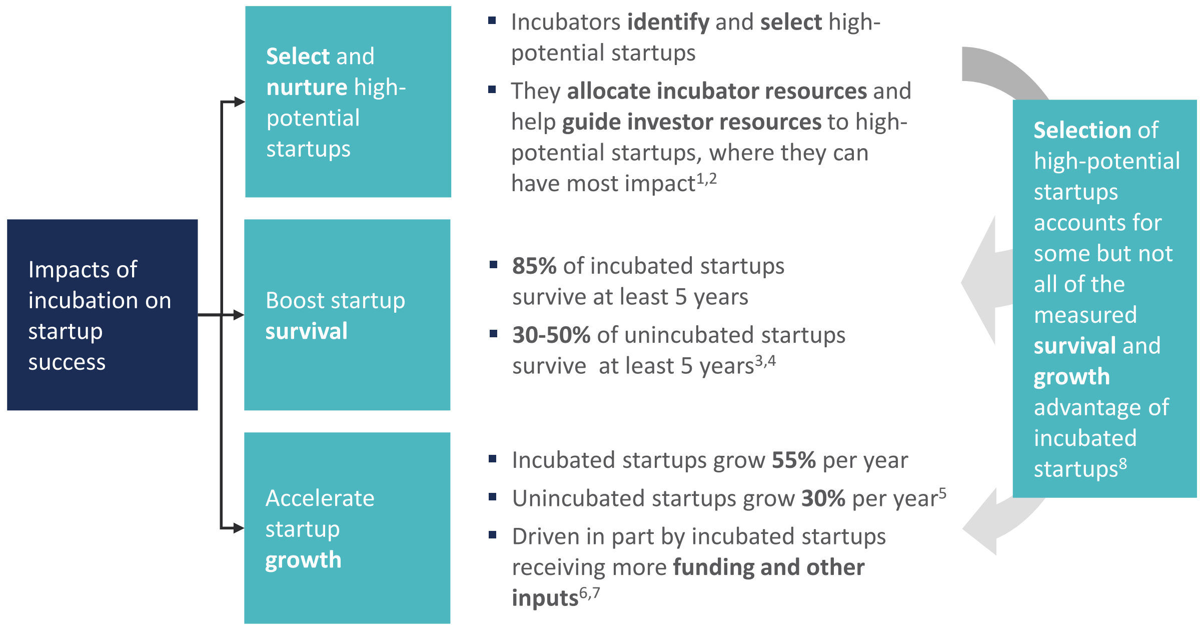
As a result of this combination of services, incubators help startups perform better than they could alone (Exhibit 9). One study found that startups that are incubated have an 85 per cent survival rate over a five-year period, compared to a survival rate of 30-50 per cent of standalone startups over the same period.[8] Incubated startups also grow more quickly. A study of 241 startups found that the average annual growth of incubated startups was 55 per cent per year compared to 30 per cent for standalone for standalone startups.[9]

Incubators also select candidate firms judiciously, which is likely a factor in their increased rates of survival and growth. Choosing only high-potential startups to incubate means that incubators can help guide capital and other resources to where they can be most impactful.[10] Selection does boost

[8] European Commission Enterprise Directorate General (2002), Benchmarking of Business Incubators, Resource document. Centre for Strategy and Evaluation Services
[9] Colombo, Massimo G. and Delmastro, Marco (2002), How Effective are Technology Incubators? Evidence from Italy (September 2002). Research Policy, Vol. 31, No. 7
[10] Aerts, Kris & Matthyssens, Paul & Vandenbempt, Koen (2005), Critical role and screening practices of European business incubators. Technovation. 27. 254-267; Ayatse, F.A., Kwahar, N. & Iyortsuun, A. (2017), Business incubation process and firm performance: an empirical review. J Glob Entrepr Res 7, 2.

the measured performance increment of incubated startups over others. In addition, the services incubators provide also account for much of the performance increment of incubated startups.[11]

Exhibit 9 – Incubators can identify high potential deep tech startups and help them succeed



Sources: 1. Aerts et al. (2005), Critical Role and Screening Practices of European Business Incubators, Technovation; 2. Ayatse et al. (2017), Business incubation process and firm performance: an empirical review, Journal of Global Entrepreneurship Research; 3. European Commission Enterprise Directorate General (2002), Benchmarking of business incubators, Resource document, Centre for Strategy and Evaluation Services; 4. Schwartz (2013), A control group study of incubators' impact to promote firm survival, The Journal of Technology Transfer; 5. Colombo et al. (2002), How Effective are Technology Incubators? Evidence from Italy, Research Policy. 6. Sehitoglu et al. (2013), The impact of business incubation on firm performance during post graduation period, British Journal of Arts and Social Sciences; 7. Xia et al. (2017), The graduation performance of technology business incubators in China's three tier cities: the role of incubator funding, technical support, and entrepreneurial mentoring, The Journal of Technology Transfer. 8. Jonathan Bone, Juanita Gonzalez-Uribe, Christopher Haley and Henry Lahr (2019), The Impact of Business Accelerators and Incubators in the UK BEIS Research Paper Number 2019/009

Deep tech incubators play a key role in global innovation

The first business incubator was launched in the late 1950s.[12] Since then, many governments and universities around the world have supported the commercialisation of deep tech through incubators (Exhibit 10). Incubators, often located in tech-focused precincts around universities, are in turn playing an important role in the development of deep tech ecosystems. Incubators play a role in deep tech development in many North American tech hubs, including:

- **Philadelphia**: The University City Science Center, founded in 1963, is a prominent research and development precinct that has supported deep tech innovation. 31 research institutions in Pennsylvania, New Jersey and Delaware now participate in the precinct. Over 400 startups

[11] N.J. Dee, F. Livesey, D. Gill, T. Minshall (2011), Incubation for growth: A review of the impact of business incubation on new ventures with high growth potential NESTA, London; Jonathan Bone, Juanita Gonzalez-Uribe, Christopher Haley and Henry Lahr (2019), The Impact of Business Accelerators and Incubators in the UK BEIS Research Paper Number 2019/009

[12] How a 1950s Egg Farm Hatched the Modern Startup Incubator Wired, June 28 2017.

have been incubated in the Center since inception, with over $290m raised by resident companies since 2006 in government grants and private funding. Resident and graduate companies across a range of industries from biotech and pharmaceuticals to engineering and artificial intelligence support over 40,000 jobs in the Greater Philadelphia region.

- **Toronto**: MaRS, an innovation hub in downtown Toronto, was founded in 2000 and is now sponsored by a range of universities, hospitals, foundations, pharmaceutical and other companies, the Governments of Canada and Ontario, and the City of Toronto. MaRS has incubated many health, cleantech, fintech and enterprise software startups. DMZ, another downtown Toronto accelerator and incubator founded in 2010 by Ryerson University, has incubated leading startups in artificial intelligence and communications.
- **Greater Boston** has long cultivated a strong science and technology ecosystem based around the exceptional set of universities and research institutions in Boston proper and in nearby Cambridge. It has developed into a global biotech leader, home to over 1000 biotech enterprises from early-stage startups to billion-dollar pharmaceutical companies. MIT, building on its long history of transformative technologies, launched an incubator called The Engine in 2016. It has incubated startups in the health, clean technology, artificial intelligence and biotechnology.
- **California**: The University of California system has played a critical role in developing deep tech innovation in this major epicenter of innovation, technology, and high growth startups. UC Berkeley founded the CITRIS Foundry deep tech innovation hub in 2013. The hub's Innovation Incubator has developed startups in the health, clean technology, medical technology, robotics sectors and pharmaceuticals.

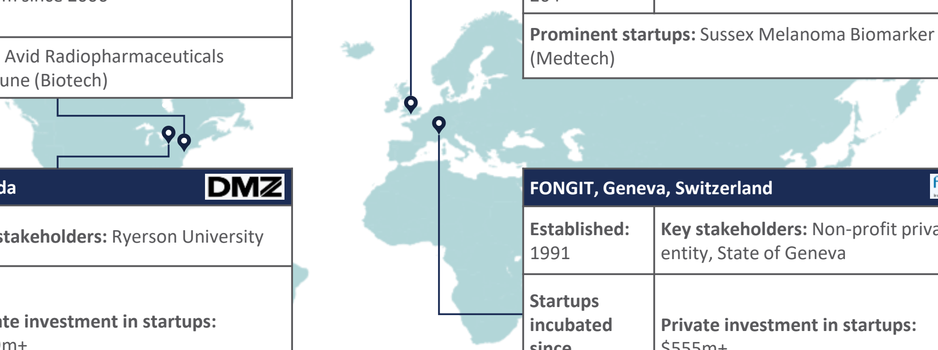
Europe, too, has developed a thriving deep tech ecosystem, with a range of incubators, technology hubs and innovation precincts. Examples of precincts and incubators include some of long standing, and others more recently founded or increasingly focused on deep tech:

- In the **UK**, the area around Cambridge university has developed into a sophisticated electronics, software and biotechnology hub. Located there is one of the UK's leading bioscience incubators, the Babraham Research Campus. Here, world class research and business collaborate to create viable businesses from cutting edge research. Other UK incubators include St John's Innovation Centre, also in Cambridge, and the Sussex Innovation Centre, founded in 1996 by the University of Sussex.
- Around the **Nordic** region there is a number of innovation hubs and incubators. For example, Futurebox, an accelerator and incubator at the Denmark Technical University science park north of Copenhagen, was founded in 2018. Futurebox is already incubating over 40 startups in robotics, artificial intelligence, pharmaceuticals and health technology. Sting, an accelerator and incubator in Stockholm, was founded in 2002. Sting, which has incubated some leading startups in health, space technology, electronics and communications, has been named the best accelerator in the Nordics, and the main runway for startups in Stockholm in 2018.
- **Switzerland**: FONGIT, an incubator based in Geneva, founded in 1991 with support from the State of Geneva with a mission to 'transform technological innovation into social and economic value in the Geneva region.' FONGIT is Switzerland's premier innovation incubator supporting innovative tech ventures in Geneva, providing offices and labs.

Exhibit 10 – North American and European governments and universities have invested in incubating deep tech startups for many years

Selected government and university-backed incubators and science parks that focus on deep tech

Investment in $A



University City Science Center, Philadelphia, USA	
Established: 1963	**Key stakeholders:** 31 top academic and research institutions in Pennsylvania, New Jersey and Delaware
Startups incubated since inception: 442	**Private and public investment in startups:** $290m since 2006
Prominent startups: Avid Radiopharmaceuticals (Pharma), Adaptimmune (Biotech)	

Sussex Innovation Centre, Brighton, UK	
Established: 1996	**Key stakeholders:** University of Sussex
Startups incubated since inception: 264	**Private investment in startups:** $372m
Prominent startups: Sussex Melanoma Biomarker (Medtech)	

DMZ, Toronto, Canada	
Established: 2010	**Key stakeholders:** Ryerson University
Startups incubated since inception: 451	**Private investment in startups:** $859m+
Prominent startups: FleetOps (AI), Kepler (satellite communications)	

FONGIT, Geneva, Switzerland	
Established: 1991	**Key stakeholders:** Non-profit private entity, State of Geneva
Startups incubated since inception: 70	**Private investment in startups:** $555m+
Prominent startups: DyAnsys (Medtech), Roboteq (Engineering), Selexis (Biotech)	

Note: funding is in Australian dollars, converted at 5-year average exchange rate.
Source: University City Science Center; DMZ; Sussex Innovation Center; Fongit

Universities and governments around the Asia-Pacific are also increasingly focusing on deep tech incubation. **Cicada Innovations** (see Box 2), based in Sydney and launched in 2000, is the first deep tech incubator to operate at scale in the Asia-Pacific region. Over its 20-year history, it has incubated 103 startups (of which 46 are still in residence) and assisted hundreds more through its accelerator programs. Prominent startups to emerge from Cicada Innovations include Elastagen, SpeedX, and Propeller Aero. Startups operating from Cicada Innovations have raised more than $450 million of funding. Chapter Three sets out the value created by a sample of firms that have been resident at Cicada Innovations.

The rest of the Asia-Pacific is catching up: it was not until the late 2000s that deep tech startup incubation became a priority (Exhibit 11). Examples of more recent deep tech incubation around the region include the following:

- Since 2008, **Legend Star**, a VC firm with links to the Chinese Academy of Sciences that offers incubator services, has hosted a range of promising pharmaceutical and artificial intelligence startups.
- New Zealand's government innovation agency, **Callaghan Innovation**, launched in 2014. In six years, it has supported incubators that in turn have hosted 45 new startups that have won $56m million in private sector investment. It currently supports four incubators and is expanding. Public funding was $38m in 2019 alone.

- CSIRO launched a **Collaboration Hub** at its Lindfield site in Sydney in 2015, supported by the NSW Government's Department of Industry. The Hub offers a co-working space to tenant startups and provides them with access to CSIRO's facilities and equipment, including digital and analogue electronics, prototyping and laboratory equipment. A prominent success is the LiDAR developer Baraja.
- In Singapore, the incubator **SGInnovate** was launched in 2016. It has been supported with $50m of public funding to date. As of 2020, it has incubated (or is still incubating) 70 startups that have attracted $558 million of private investment so far. SGInnovate already has several prominent graduates, including Web-Biotech and Atomionics.

Exhibit 11 – Asia-Pacific governments and universities are also increasingly investing in deep tech startup incubation

Selected government and university-backed incubators and initiatives with significant deep tech focus

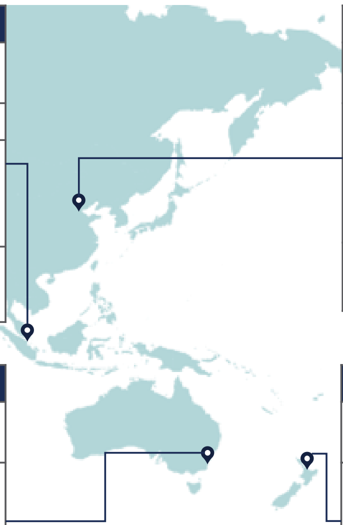
Investment in $A

SGInnovate, Singapore

Year Estd: 2016	**Key stakeholders:** Singapore Government
Startups incubated since inception: 70	**Public investment:** $50m **Private investment in startups:** $558m
Prominent startups: Web-Biotech (Medtech), Atomionics (Quantum Tech)	

Legend Star, Beijing, China

Year Estd: 2008	**Key stakeholders:** Lenovo, Chinese Academy of Sciences
Startups incubated since inception: 39	**Private investment in startups:** $45m
Prominent startups: Face++ (AI), iflytech (AI), PegBio (Pharma)	



Cicada Innovations, Sydney, Australia

Year Estd: 2000	**Key stakeholders:** ANU, UNSW, USYD, UTS
Startups incubated since inception: 103	**Private and public investment in startups:** $450m+ since 2006
Prominent startups: Elastagen (Med tch), Propeller (Engineering), SpeedX (Medtech)	

Callaghan Innovation, Auckland NZ

Year Estd: 2013	**Key stakeholders:** New Zealand Government
Startups incubated since inception: 45	**Public investment:** $38m (2019) **Private investment in startups:** $56m
Prominent startups: BioLumic (Agritech), Aroa Biosurgery (Medtech), Avertana (Cleantech)	

Note: funding is in Australian dollars, converted at 5-year average exchange rate
Source: SGInnovate, Cicada Innovations, Callaghan Innovation, Legend Star

Box 2: Cicada Innovations: Australia's leading deep tech incubator

Cicada Innovations was established in 2000 under the name ATP Innovations as a collaboration between the University of New South Wales, the University of Technology Sydney, and the University of Sydney, with the Australian National University joining in 2003. The four universities are equal shareholders in Cicada Innovations and are represented on the board alongside independent industry experts. Many of Cicada Innovations' resident companies have origins in, or collaborate with one or more of the four university shareholders' research. Nearly all resident companies have had and continue to have active research collaborations with universities in Australia and globally.

Cicada Innovations is based at the National Innovation Centre in the historic locomotive workshop area of South Eveleigh. It offers labs, clean rooms and rapid prototyping facilities and enables R&D and manufacturing on-site. Cicada Innovations began as a traditional tech incubator with the focus on making its space available to startups. In 2006, it also began exchanging below-cost rent and business services for equity in some of its resident startups. In 2011, Cicada Innovations started housing accelerators, beginning with Startmate, a newly formed tech accelerator and piloted its own accelerator program, The Ignition Labs, and assisted in setting up Griffin, an accelerator program that is part of the Canberra Innovation Network.

In 2014, Cicada Innovations partnered with NSW Health to deliver the Medical Device Commercialisation Training Program (MDCTP). The ongoing program accelerates commercialisation of medical technologies in NSW. It has been immensely successful in helping patients, hospitals and governments around the world get access to lifesaving health care innovations. As of May 2020, the flagship MDCTP CORE program has produced 80 graduates who have launched 15 companies and have raised over $53 million in grants and private investment. Hundreds more startups have participated in Cicada's broader set of programs, including accelerators and business coaching.

2016 was a landmark year in Cicada Innovations' history. ATP Innovations was rebranded as Cicada Innovations and it shifted its business model to offering the full set of services and programs early-stage deep companies need through the entire deep tech commercialisation journey – from innovative ideas to the scaleup phase.

In 2017-18, Cicada Innovations launched two industry-specific accelerator programs. GrowLab, launched in 2017, specialises in agrifood and has launched 18 companies to date, raising over $25 million and employing over 90 people. MedLab, launched in 2018, focuses on medical devices, and has launched 6 companies that have raised over $6 million in funding and employed over 15 people. The launch of these two programs allowed Cicada Innovations to nurture and screen startups for its incubator program. In 2018, Cicada Innovations was named the 'Top Incubator in the World' for the second time by the International Business Incubator Association (InBIA), the peak global industry body for accelerators, incubators and entrepreneurship support programs.

2020 is another landmark year for Cicada Innovations – its 20th. To date, Cicada Innovations has incubated over 100 startups, and helped more than 300 companies raise over $450 million in venture capital and government grants, create hundreds of jobs, build local manufacturing capability, file more than 500 patents and trademarks and launch more than 700 deep tech innovations globally. These impressive numbers speak volumes about the contribution of Cicada Innovations to the Australian and global deep tech landscape.

3. Deep tech businesses are creating value for Australia

Australian deep tech startups launched in recent years are solving real-world problems and adding value for founders and employees, business customers and consumers, and for society more broadly.

Deep tech generates economic value in four ways

Deep tech innovations have a critical role to play in addressing many important challenges locally and globally, but they also generate substantial economic value. There four ways that deep tech startups create value in the Australian economy – value flows to the deep tech startup, businesses, consumers, and society at large:

- First, there are benefits which accrue to the **startup** producing the deep tech innovation. They receive revenue by selling their product or service.
- Second, there are benefits to **business customers** of the startup. While they usually pay for the deep tech product or service, the value it generates for their business typically exceeds the price. The benefits are the difference between the price and the value gained.
- Third, customers who are **individual consumers** also benefit. They can benefit directly if they are purchasing the deep tech innovation from the startup and what they gain is either in the improved quality or in the lower price of the new product compared to existing offerings. They can also benefit indirectly if they are customers of a business that has bought that innovation and used it to increase the quality or reduce the price of what they sell to individual consumers.
- Fourth, there are benefits which are **societal** in scale. These are also known as 'spillover' benefits and include benefits that are not captured in the prices of goods and services. For example, reduced pollution or lower public expenditures on health care are typical societal-level benefits that many deep tech innovations generate.

Startups incubated at Cicada Innovations have created substantial value

Studying a sample of deep tech startups over time can help illustrate how they produce economic value and how much of this value spins off to businesses, consumers, and wider society. We undertook detailed economic analysis of the value generated by a sample of six of Cicada Innovations' successful deep tech startups.[13]

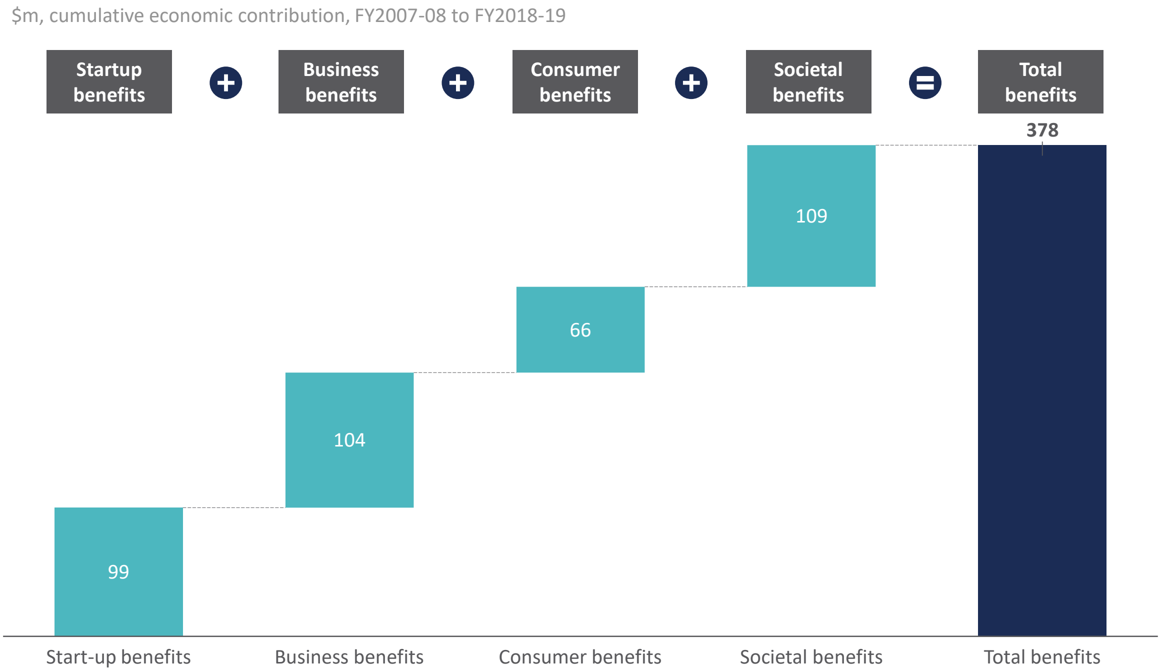
- **Taggle**: automated internet-of-things smart meters and sensors, specialising in water systems monitoring. Used by infrastructure managers, government, agriculture, and property managers.
- **SpeeDx**: precise diagnostics of infectious diseases using cutting-edge genetic methods
- **UpGuard**: tools enabling users to monitor and manage their cyber risk

[13] The described startups are among those that have occupied space at Cicada Innovations and have already reached commercialisation, and have not raised capital through an Initial Public Offering (IPO) or exited via a trade sale.

- **Bugcrowd**: finding security vulnerabilities in clients' software by crowd sourcing researchers
- **Prospection**: health care data analytics for pharmaceutical and biotechnology companies
- **Propeller**: granular mapping of worksites in mining, waste, and construction using drones

Modelling of the four ways deep tech creates value for these six deep tech startups finds $378 million of cumulative economic contribution between 2008 and 2019 (Exhibit 12). This is a substantial contribution from only six startups, and the total value produced by all of Cicada Innovation's startups is much higher – having incubated 103 startups since 2000.

Exhibit 12 – Cumulative economic contribution of six successful deep tech startups incubated at Cicada Innovations

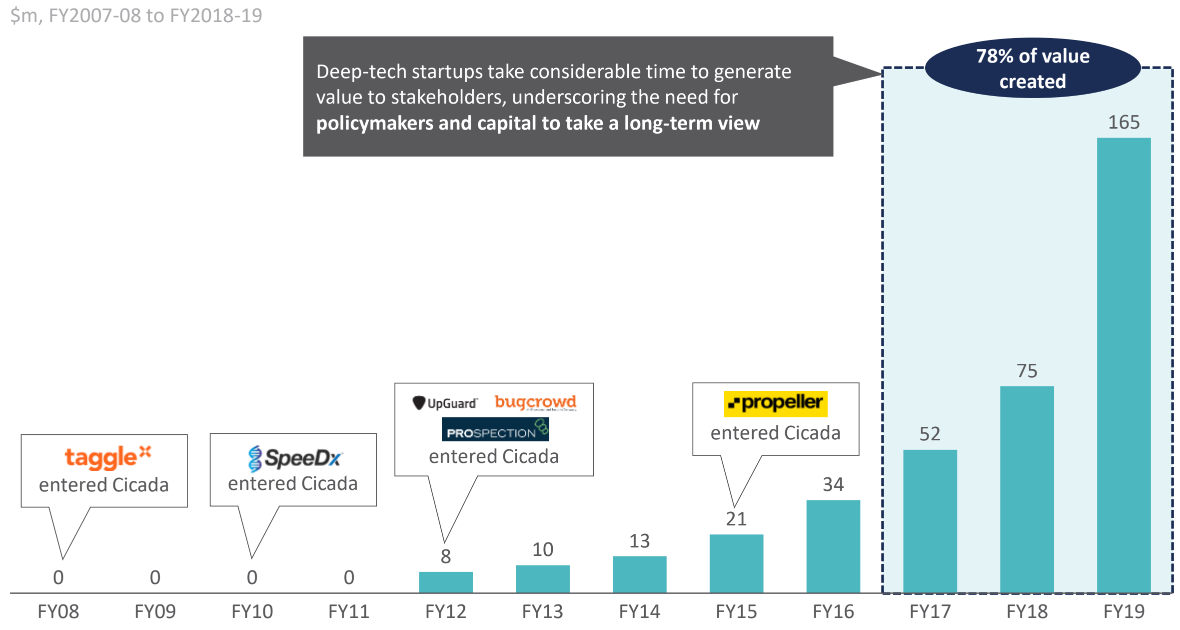


Source: ACIL-Allen, ABS 8501, ABS Census 2016, Bloomberg, Federal Reserve Bank of Atlanta data, Hunter Water data, IBIS World, IPART data, PayScale, Pharmaceutical Benefits Scheme (PBS) data, Mckinsey, Stakeholder interviews, Sydney Water data, U.S Bureau of Labor Statistics data, AlphaBeta analysis

Strikingly, **about three-quarters of the value generated** has accrued not to the startups themselves, but to their **customers, consumers and as wider benefits to society**. In fact, the largest type of benefits are societal benefits, worth $109 million across the six startups modelled. Benefits to business customers are also larger than benefits to the startups themselves, at $104 million and $99 million respectively.

Despite the scale of their contribution so far, these startups are still relatively young by deep tech standards and are likely only beginning to generate value (Exhibit 13). The oldest of these six, Taggle, began incubation in 2008; SpeeDx entered in 2010; UpGuard, Bugcrowd, and Prospection entered in 2012, and the youngest, Propeller, entered just five years ago in 2015. Of the estimated $378 million of value, 78 per cent was generated in the past three years. The trajectory of the deep tech commercial lifecycle is long, underscoring the need for investors and policymakers to take a long-term view to innovation investments.

Exhibit 13 – Annual economic contribution of six successful deep-tech startups incubated at Cicada Innovations



Source: Cicada Innovations, ABS 8501, ABS Census 2016, Bloomberg, Federal Reserve Bank of Atlanta data, Hunter Water data, IBIS World, IPART data, PayScale, Pharmaceutical Benefits Scheme (PBS) data, Mckinsey, Stakeholder interviews, Sydney Water data, U.S Bureau of Labor Statistics data, AlphaBeta analysis

Box 3: Example: How Taggle adds value to its customers and the economy

The Australian startup Taggle provides a great example of how deep tech startups can generate value for the community. Taggle produces smart meters and sensors that can be operated remotely. It is being used by local councils across the country, with over 160,000 meters and sensors installed. Local councils and water corporations are also using Taggle's meters to monitor water levels, pollution, pressure, flow, and temperature throughout their water infrastructure.

Exhibit 14 sets out how we estimate the value Taggle has generated across four categories since it started generating material sales in 2015: its own benefits, additional benefits to its business customers, additional benefits to consumers, and additional societal benefits.

First, Taggle earns revenue from sales to customers. At the time of writing, Taggle had directly created 38 jobs. And second, Taggle helps its business customers by cutting water losses and the costs of running their water networks by much more than the cost of the Taggle service. For example, smart meters help detect leaks at low cost and negate the need for meter readers to visit each meter.

A third additional benefit – about the same size as the business benefit – has flowed to the consumers who use Taggle's technology to quickly identify leaks and use water more efficiently.

A fourth benefit extends beyond the savings to Taggle, its customers and final consumers. The price of water does not fully reflect the environmental and infrastructure costs of capturing, processing, and supplying it. Every litre of water saved results in an additional societal benefit.

Exhibit 14 – Value generated by Taggle

Benefit	How Taggle has generated value
1 Startup benefits	▪ Taggle has developed an end-to-end solution for automated water meter readings
2 Business benefits	▪ Taggle's sensor technology within the water meters detects leakages, saving water for utilities and reducing need for opex and capex ▪ Automated water meters negates the need for staff to manually read meters
3 Consumer benefits	▪ Taggle's meters detect water leakages in homes, reducing the water bill for the consumers
4 Societal benefits	▪ The retail and wholesale price of water does not reflect the environmental costs of capturing, processing and supplying water to consumers ▪ Water savings from utilities and consumers reduces the environmental costs of water supply

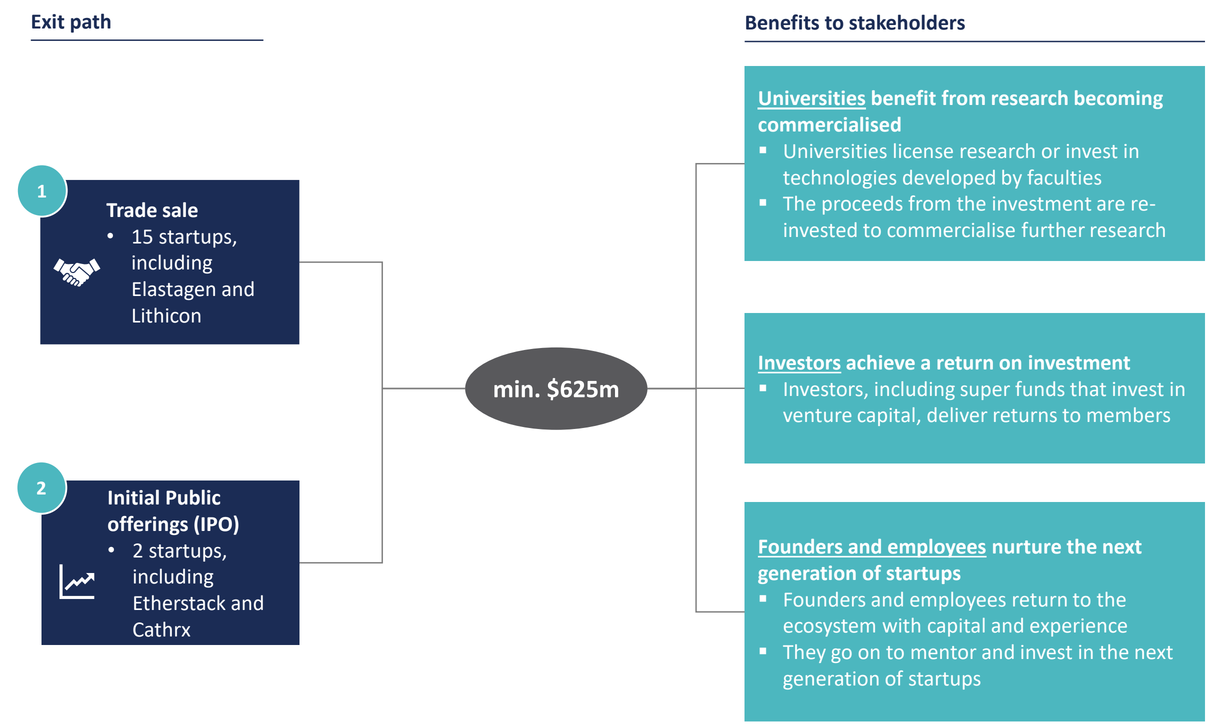
Source: Taggle, AlphaBeta analysis

IPOs and acquisitions return value to the deep tech ecosystem

In addition to the flow of value from operating year-on-year, deep tech startups also deliver economic value when they are acquired or list on a public exchange. Exhibit 15 sets out how the value released in this way can benefit universities, investors, founders and employees, and illustrates it with examples of startups that have been resident at Cicada Innovations. This set of startups does not overlap with the set used in the previous section to illustrate the flow of value created by deep tech startups as they operate.

Of the 15 such startups that have been acquired by larger firms, only two have publicly revealed their terms of sale: Elastagen and Lithicon. Tissue repair company Elastagen was acquired in 2018 by global pharmaceutical company Allergan for a total deal value of $350 million, and Lithicon, an imaging startup, was acquired by FEI for $76 million in 2014. Two other startups incubated by Cicada Innovations – Etherstack, a wireless communications producer, and CathRx, a medical equipment manufacturer, have had IPOs (initial public offerings) and are now listed on the Australian Stock Exchange. These firms raised $200m in initial public offerings.

Exhibit 15 – Value generated by selected Cicada Innovations initial public offerings and trade sales



Notes: 1. Exits can occur either through an IPO or trade-sale. 15 trade-sales have occurred in the past 20 years. Only two trade-sales have publicly disclosed transaction value. Source: Stakeholder interviews, AlphaBeta analysis

These four startups alone have yielded at least $625 million in value from sale or public listing. In turn, the transactions have led to direct benefits to investors, founders and employees and to further rounds of deep tech research, investment and innovation. $11 million of Lithicon's sale value went to the Australian National University, and $4 million to the University of New South Wales, which had helped to fund the startup in its infancy. In addition, founders and employees of startups that have listed or been acquired return to the deep tech ecosystem armed with capital and experience, able to begin again or mentor and invest in the next generation of startups.

SpeeDx: Fast, comprehensive diagnostics helps fight superbugs

SpeeDx founders Elisa Mokany and Alison Todd (centre) with CFO Bhavin Raval (left) and CEO Colin Denver (right)

Inappropriate antibiotic use has made treatments for some infectious diseases less effective in recent years. Biomed startup SpeeDx helps solve that problem. Its diagnostic test uses a technique called quantitative polymerase chain reaction (qPCR) to detect an infectious pathogen and any genetic mutations it may have. This helps clinicians determine which antibiotics the pathogen is resistant to and so identify the most effective treatment.

Founders Alison Todd (an alumna of the University of Sydney) and Elisa Mokany (UNSW) developed the test while working at the now defunct Johnson & Johnson Research (JJR) lab in Sydney. They describe themselves as "accidental entrepreneurs" who founded SpeeDx in 2009 to continue their work after JJR's closure, drawing on Cicada Innovations for advice on business strategy, regulations and grant applications.

SpeeDx's technology has been widely deployed in helping select the best and most effective treatment for individual cases of a range of sexually transmitted diseases that affect about one in 35 people worldwide. It has broader applications in guiding case-specific treatments for other infectious diseases and in oncology. As one example, SpeeDx was able to quickly develop a COVID-19 test, exemplifying how established deep tech companies are able to respond to emerging global priorities.

SpeeDx now has a staff of 81 and offices in Australia, the UK and US. It has more than $5 million in state and federal government grants and US$30 million in venture capital from US-based Northpond Ventures. Its technology is used to fight rapidly evolving superbugs, to identify flu viruses, and to detect genetic mutations in cancer cells — deep tech developments that will have a significant impact on human health and wellbeing.

Source: Interviews

Propeller Aero: 3D drone mapping to revolutionise earthworks

Propeller Aero co-founders Rory San Miguel and Francis Vierbloom. Image: Propeller Aero

Millennial entrepreneurs Francis Vierbloom (a UNSW alumnus) and Rory San Miguel (a UTS alumnus) are pioneers of Australia’s emerging drone industry, founding Propeller Aero in 2014 in a stubborn bid to “make drones a thing”.

Propeller Aero is their second drone startup. Their first, Flirtey, made headlines for performing the world’s first pizza delivery by drone, but eventually moved to the US seeking more drone-friendly regulations.

“I decided it was a great opportunity to take drones in another direction and see what industrial applications they’d be able to tackle,” Vierboom says. “We wanted to figure out the kind of business that would allow drones to make the most impact, that would figure out their real commercial relevance.”

Propeller Aero uses drones to map clients’ industrial work sites in 3D. It is faster, cheaper, safer and far more accurate than traditional surveys. Survey data is stored in the cloud and processed using sophisticated analytics, so clients can plan their projects, track performance and forecast progress. For example, a mining construction company could compare frequent drone surveys with design documents to detect issues that may otherwise cost significant time and money to address.

Propeller Aero is heavily shaped by client feedback, and is a product of its founders’ combined expertise: San Miguel studied mechatronics, robotics and automation at university, while Vierbloom previously worked in enterprise IT. They met through the Australian technology startup community, and continue to benefit from access to venture capital networks and business services through Cicada Innovations. Propeller employs 102 people at the time of writing, and raised $26m in venture capital July 2020.

Source: Interviews

Elastagen: Synthetic skin to change lives after two decades of development

Elastagen founder Tony Weiss and CEO Rob Daniels.

University of Sydney professor Tony Weiss patented his research into medical applications of the protein tropoelastin (TE) in 1997, when he realised its potential in repairing human skin. Over the following decade, Weiss and a broader team developed methods of manufacturing TE and approaches to formulating it for clinical uses. In 2008-2009, the technology was transferred to Elastagen. Rob Daniels and Hamish Hawthorn (previous CEO of Cicada Innovations) raised Series A funding from GBS Venture Partners and Brandon Capital Partners. Elastagen was based at Cicada Innovations, with growing international clinical, manufacturing and regulatory operations.

Led by Rob Daniels, the Elastagen team developed novel injectable TE formulations and developed a pipeline of target indications, including acne scarring, stretchmarks, aesthetics (skin quality) and, with support from NSW Health, burns and chronic wounds. Clinical studies in Australia and Europe demonstrated their safety and efficacy.

After a period of collaboration with the Elastagen team, US biopharmaceutical giant Allergan acquired Elastagen in 2018 for over $350 million in total deal value. Allergan acquired Elastagen primarily for the injectable product portfolio (acne scars/stretch marks aesthetics). The sale is a major step in bringing Elastagen's technologies to patients.

Multiple sources of finance were vital to supporting product development, market research and clinical trials as the company's technology matured, including state and federal government funding and venture capital. At the time of its sale, Elastagen was owned by the University of Sydney and local and international investors including Cicada Innovations, Brandon and GBS.

"This is one of the largest health care sales of this type in Australian history," Weiss says. "A substantial portion of the hundreds of millions of dollars in proceeds will be returned to Australian superannuation funds and the venture capital firms that took the risk of investing in early-stage technology commercialisation. "This will have a multiplier effect, increasing confidence amongst venture capital firms, funds, and venture-capital-backed companies in investing in the next generation of life science technologies."

Source: Interviews

Morse Micro: Wi-Fi inventors go back to the drawing board

Morse Micro co-founders Michael De Nil (second from left) and Andrew Terry (right) and VP Standards Dave Goodall (left) in 2017 with then Assistant Minister for Cities and Digital Transformation Angus Taylor. Image: Angus Taylor MP

Almost everyone has heard of Wi-Fi. It is an indispensable part of our daily lives, keeping us connected at home, at work and in public, and deployed in more than five billion devices worldwide. But few know that this Wireless Local Area Network (WLAN) technology was invented, patented and commercialised in Australia in the mid-1990s.

Fast forward 20 years: entrepreneurs Michael De Nil and Andrew Terry are determined to repeat that success. The former Broadcom engineers founded Morse Micro in 2016, recognising a gap in the market to reinvent Wi-Fi technology for the Internet-of-Things (IoT), allowing us to be even more connected, and improve our productivity, our health and even our safety.

Morse Micro's silicon chip runs on HaLow, a new Wi-Fi standard that offers long distance reach, high energy efficiency, better penetration of obstacles, and a high data rate. It supports features that cannot be supported by other long-range wireless networks, including high definition video, enterprise-grade security and over-the-air firmware updates. Advanced sleep modes allow IP-addressable sensors and trackers to last many years on a coin cell battery. It can connect over 10 times the range, 100 times the area and 1000 times the volume of traditional Wi-Fi.

HaLow supports the growing network needs of a wide variety of IOT applications, from industrial process control, building automation, logistics and asset management, retail electronic shelf labels, surveillance systems, agriculture and environmental sensors to smartphones and mobile devices. "Large companies have applied Wi-Fi phone chips to IoT devices, but the mechanics and needs of phone and IoT are completely different," De Nil explains.

Morse Micro's team of 50 includes Wi-Fi inventors John O'Sullivan and Neil Weste. Since completing the Startmate Accelerator program, based at Cicada Innovations, and incubating in the building post-program, the company has grown to become one of the largest in Australia's small semiconductor industry, with some $30 million in funding and offices in Australia, China and the US.

According to De Nil, Morse Micro's biggest challenges are to stay at the forefront of the rapidly evolving technology industry, and to scale the company to support the huge opportunities in the market today and in the future.

Source: Interviews

FluroSat: How an Australian rocket scientist is transforming food production

Anastasia Volkova (centre) with the FluroSat team. Image: Flurosat

FluroSat is an agtech (agricultural technology) company that combines satellite data, sensor technology and advanced analytics to help farmers produce more food with less fertiliser and water.

The company was founded in 2016 by aeronautical engineer Anastasia Volkova (an alumna of the University of Sydney) to reduce the environmental impact of agriculture. The industry relies on fertilisers that contain nitrogen, phosphorus and potassium — minerals that harm aquatic environments when they leak into rivers, lakes and coastal waters.

"One of the main issues behind the problem of agricultural pollution is fertiliser waste," Dr Volkova says. "Back in the day, it didn't make sense to me. The industry that's supposed to sustain and support our environment is in fact hurting it."

FluroSat's 'FluroSense' analytics engine assesses the exact amount of nutrients that each field needs, helping to reduce fertiliser use by up to a quarter, and the water use associated with it. The technology also monitors crop growth, detecting abnormal growth patterns and crop stress caused by disease, pests, water logging and hail or frost damage.

With its technology now monitoring 10.8 million hectares of farmland across 14 countries, FluroSat has drawn on Cicada Innovations for access to advisors, mentors and the talent it needs to grow. The firm has more than 25 staff, and $5 million in funding from Microsoft's M12, Telstra's MURU-D and Main Sequence Ventures, and AirTree, and has premises at Cicada Innovations, at ANU's Centre for Entrepreneurial Agri-Technology, in San Francisco and in Kiev.

Source: Interviews

4. Creating Australia's deep tech future

To realise Australia's deep tech potential, we must build a bridge through the crisis, develop a shared vision, nurture our deep tech culture, and invest for the long term

This report shows that deep tech is one key to realising our aspirations for Australia and the world. First, Australia's deep tech capability is central to sustaining our living standards. When societies can commercialise deep technologies, they can build local industries that sell to the world and support high quality jobs. An innovative economy is also a resilient economy, with a diverse export base and the capacity to retool when conditions change.

Second, we need deep tech to overcome many Australian and global challenges. If we have local deep tech capabilities, we can adapt and develop the best solutions for our unique challenges, as well as adopting technologies developed abroad.

Australia can build the deep tech capability we need. We already have substantial strengths. One testament to the depth of our research capability is the impressive Australian output of top journal publications. Another is that CSIRO and our world-leading biomedical and agricultural research institutes have developed many technologies and partnered with industry to commercialise them. Courageous Australian innovators have taken deep technologies to the world market. Many large Australian companies have adopted, adapted and developed innovations. The Australian startup ecosystem has shifted towards deeper technologies, with a maturing community of deep tech investors, founders and talented teams. And deep tech startups are already creating value for Australian investors, startup founders and teams, and the broader community.

But Australia's deep tech future is not assured. Australia's innovation efforts are unbalanced: we invest heavily in research, but not enough in commercialising deep tech. Australian universities and businesses do not work together as much as they should. Many Australian businesses invest less in R&D than their peers in other advanced economies. Australia counts relatively few R&D powerhouses among our largest companies. Many Australians are sceptical about innovation. The COVID-19 pandemic also threatens to undermine progress.

Australia should pursue a four-part agenda to protect and grow our deep tech capacity (Exhibit 17). First, we need to build a bridge through the pandemic crisis to ensure that our existing investments are protected. Second, we should develop our shared vision of the deep tech capacity we want. Third, we need to nurture an innovative culture in our organisations. And fourth, we should commit to invest in deep tech for the long term.

Exhibit 16 – An agenda for realising Australia's deep tech potential

1 Build a bridge through the crisis	2 Develop a shared vision	3 Nurture deep tech culture	4 Invest for the long term
▪ Protect deep tech momentum ▪ Support university research through the disruption ▪ Provide a lifeline to deep tech startups	▪ Link deep tech vision to broader aspirations for Australia ▪ Develop with broad community input ▪ Set tangible targets for inputs (eg R&D) and outputs (eg quality jobs in new sectors)	▪ 'Build what's next' ▪ Strengthen collaboration between industry and research ▪ Develop international networks	▪ Maintain public sector research investment ▪ Boost research translation investment ▪ Support corporate R&D and deep tech venture capital ▪ Scale and focus deep tech incubation

Source: Stakeholder interviews, AlphaBeta analysis

Build a bridge through the crisis

First, Australia must protect our existing commitment to deep tech research, development and commercialisation through the COVID-19 crisis. The pandemic threatens deep tech through two main channels. First, it has disrupted university teaching revenue, a main source of research funding, and is also affecting the revenue of publicly funded research organisations.[14] Second, it has disrupted tech startups, which face delayed launches and curtailed funding.[15]

While government policy responses to the crisis have provided some support, significant gaps remain. The Jobkeeper employment retention program, for example, offers little respite to universities and pre-revenue startups. Recent changes to Australia's FIRB regime may also make it more difficult for startups to funding.

As governments evolve their response to the crisis, they will need to provide funding continuity for public sector research and preserve momentum in private sector investment. They can learn from programs implemented elsewhere. The UK, for example, has constructed a 'Future Fund' that matches private investments in startups that have previously raised Series A rounds.[16] Other options include bringing forward Research and Development Tax Incentive (RDTI) funding.

[14] Australian Chief Scientist Rapid Research Information Forum Rapid Research Briefs to the National COVID-19 Co-ordination Commission (2020), Impact of COVID-19 pandemic on Australian research workforce and Impact of COVID-19 on women in the STEM workforce.
[15] Allens (2020), The impact of the COVID-19 crisis on the startup ecosystem.
[16] United Kingdom Government (2020), UK Coronavirus Future Fund Guidance.

Develop a shared vision for Australian deep tech

Second, we must develop a shared vision for deep tech in Australia. The vision should connect deep tech to Australians' broader aspirations. Most of us want to live in a prosperous, safe, resilient, sustainable, and inclusive society. More broadly, we want to live in a world that is solving global challenges like food security and health care for all. However, many in the community believe that technology is irrelevant to them. Some believe unchecked technology threatens livelihoods and is a cause, not a potential solution, of global challenges such as pollution and inequality. Finding a path forward together on these issues will be critical to developing support for deep tech in Australia.

The vision must set out what deep tech success looks like, concretely and tangibly. Success can be measured in 'outputs' like good quality jobs and progress against goals such as health care and sustainability.

It should also set out an ambition for Australia's 'inputs' to deep tech innovation. For example, we could seek to lift R&D, venture capital investment, or patent rates. If Australia's private sector R&D doubled, it would be around the level of the US, as a share of GDP. If Australia's venture capital investment doubled, it would be about average in the OECD, as a share of GDP. If Australia's patent application rate quintupled, we would almost match Germany, per person.

Nurture Australia's deep tech culture

Third, we must deepen Australia's culture of deep tech innovation. Innovators build what's next, rather than protecting a legacy from disruption. They are ambitious, but willing to learn from failure. Australia has a long and proud history of innovation, and of technology development. In recent years, Australian startup formation and venture capital has surged, and interest and initiatives from government and corporate leaders have also grown. But a strand remains of risk aversion, low ambition, and even outright resistance to change and innovation.

Australian leadership will be vital in strengthening our culture of innovation. Larger organisations can adopt systematic approaches to foster innovation internally and in collaboration with researchers, suppliers, or customers. The opportunities vary across sectors. Banks and superannuation funds can deepen their skills in innovation investment. Universities can do more to foster collaboration with industry.

We need a culture of deep technology innovation that goes beyond applying existing technologies like apps and marketplaces. Deep tech innovations, as this report has shown, rely on scientific knowledge that is applied to real world opportunities. Leaders who actively search for potential applications of science and technology in their sectors can find a match before competitors do. In doing this, they can draw on technical expertise and look to collaborate with local deep tech innovators, whether corporate, research, corporate, or startups.

We also need to open our culture further to international exchange. Internationally mobile talent is a key factor driving the tech industry in Australia.[17] International collaboration in research is just as important. Australian universities and public sector research institutions only rarely generate

[17] StartupAUS (2020), Crossroads 2020; Innovation and Science Australia (2017), Australia 2030: prosperity through innovation

intellectual property in partnership with non-Australian researchers.[18] For researchers and innovators in Australia, building a culture of global connection is critical to keeping pace with the global leading edge of knowledge.

Invest for the long term

Investments we make now to realise Australia's deep tech potential will pay off over decades. An individual deep tech innovation can take over a decade of development to reach the market, as this report shows. A deep tech ecosystem evolves over an even longer timeframe, and requires a strong supply of long-term capital to flourish.

Australia needs to invest more in deep tech. Our overall investment in R&D is low by international standards.[19] There are few Australian companies among the global leaders in R&D, as shown in Chapter 2. Funding for startups in Australia is strongly geared towards deep tech, but even after the growth of recent years, overall levels of venture capital in Australia are lower than in many leading economies (Exhibit 19).

Australia's policy settings and initiatives such as the R&D Tax Incentive and the Biomedical Translation Fund (BTF) encourage venture capital investment in deep tech. CSIRO's Innovation Fund, also launched in 2016, combines CSIRO, private and government funding to invest in a range of deep tech ventures. Government should continue to progressively expand the arsenal of policy options to encourage investment in deep tech. For example, an innovation fund modelled on the BTF or on NSW's Medical Devices Fund (MDF), but applying more broadly, is likely to attract additional private investment.[20]

Policymakers and others should also invest to deepen the scale and depth of Australia's incubation capacity. Australia's tech sector is maturing and shifting towards deep tech. But the scale of Australian deep tech incubation is relatively small, with the exception of Cicada Innovations. Most Australian incubators are not focused on deep tech, and those that do include some deep tech in their portfolios lack scale. Government investment in incubation may be dispersed across too many subscale incubators.

A funding approach focused on further developing scale and maturity in Australian deep tech incubation is likely to work better than spreading one-off grants thinly across many small incubators. Larger institutions and ecosystems are able to offer deeper networks of advisers, finance, and links to commercialisation.[21]

---

[18] Commonwealth of Australia (2017), Australian Intellectual Property Report 2017
[19] Innovation and Science Australia (2020), Stimulating business investment in innovation.
[20] Science and Technology Australia (2019) *2019-20 Pre-Budget Submission*.
[21] European Investment Bank (2018), Financing the Deep Tech Revolution: How investors assess risks in Key Enabling Technologies (KETs)

Appendix 1: Australian research and innovation investment

Australia produces nearly twice as many scientific and technical journal publications per capita than the OECD average (Exhibit 17). Adjusted for population, Australia has a greater research output than the US, the UK, Germany, and France, and slightly higher output than the Nordic countries.

However, Australia's prolific research output has not translated into a similarly substantial flow of commercial innovation. In stark contrast to its research performance, Australia generates a relatively low rate of patent applications, as Exhibit 17 shows. Per capita, the US has nearly nine times as many patent applications, whilst Germany and France have about four times and twice as many than Australia respectively.

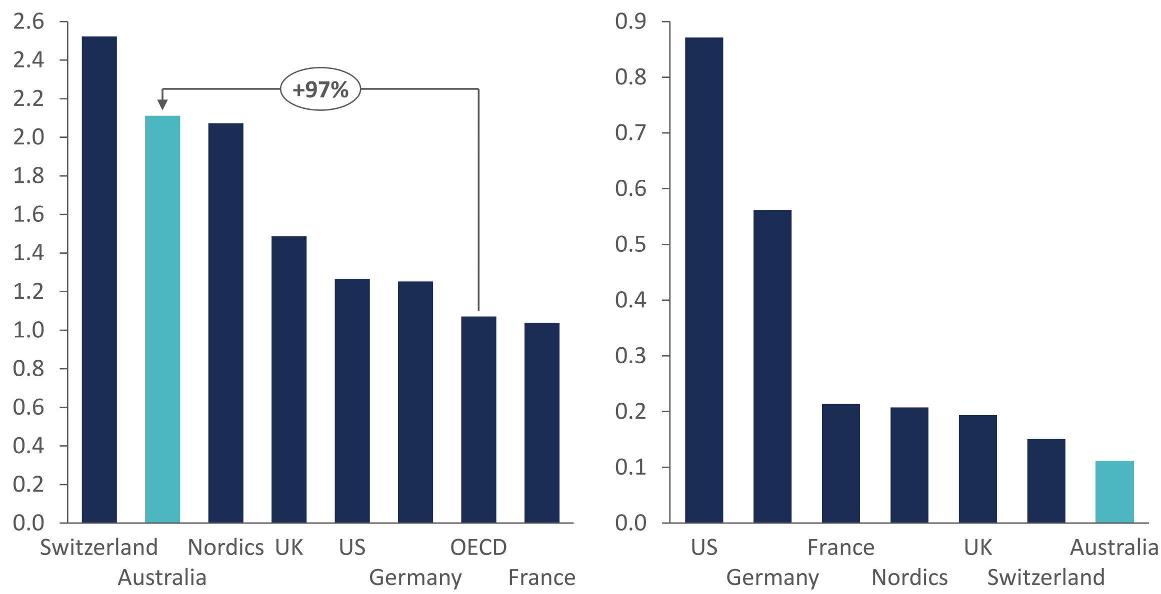
Exhibit 17 – Academic publications and patent applications per capita across OECD countries

Academic publications

Technical & scientific publications per 1000 people, 2016

Patent applications

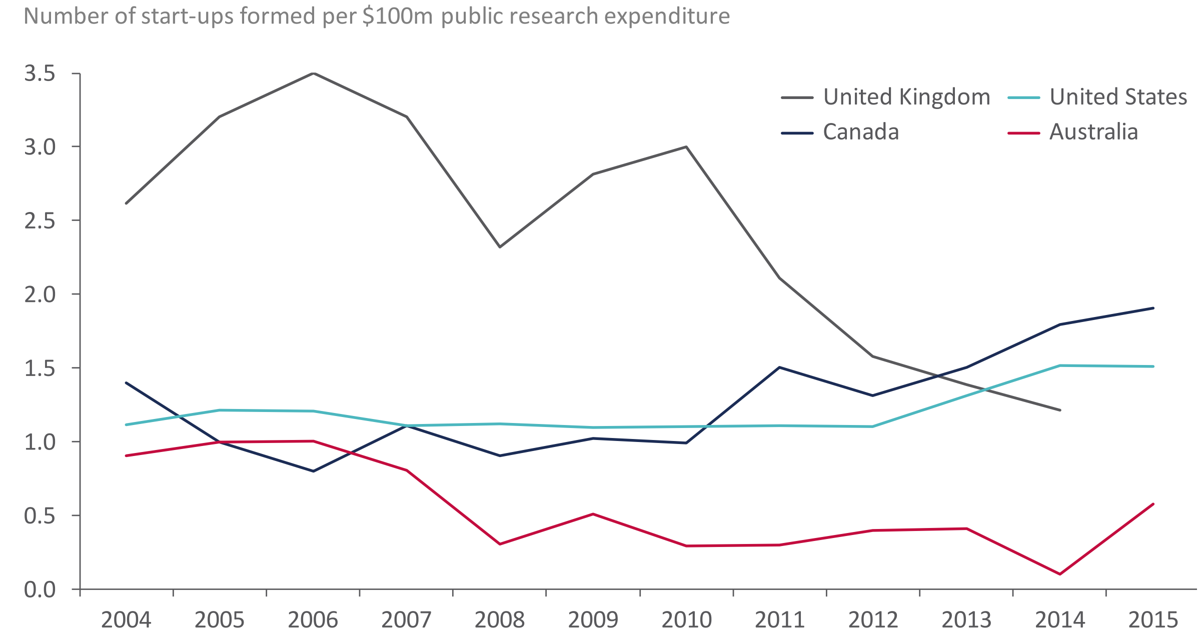
Patent applications per 1000 people, 2016



Notes: Nordic countries include Sweden, Denmark, Finland and Norway.
Sources: World Bank: 'Scientific and technical journal articles', 'population, total', 'patent applications, residents'.

Similarly, Australian universities and public research organisations (such as the CSIRO) spin out far fewer startups per dollar of public research expenditure than do our UK, Canadian and US peers (Exhibit 18). Together, the low level of patenting and startup creation suggest that Australia is not converting its research strengths into commercial products and services at the rate of many other advanced economies.

Exhibit 18 – Startup launches linked to publicly funded research organisations



Source: Australia 2030: Prosperity Through Innovation; Australian Government Department of Industry, Innovation and Science, National Survey of Research Commercialisation, DIIS, Canberra

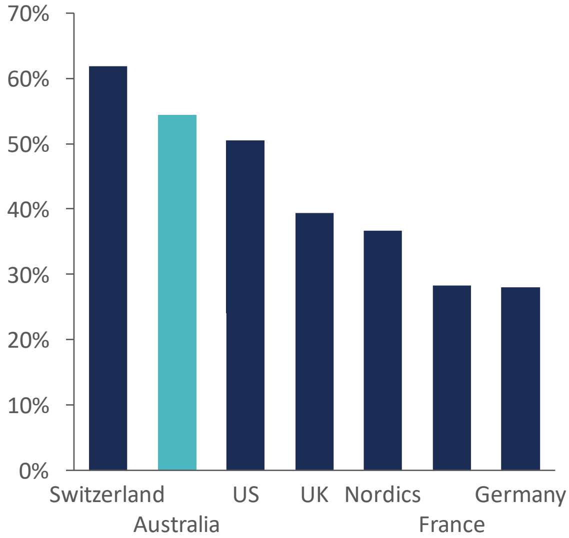
Funding directed towards startups in Australia is strongly geared towards deep tech (Exhibit 19). In 2016, 54 per cent of Australian venture capital was directed towards deep tech enterprises. This is similar to the US (at 50 per cent) and much higher than France and Germany, where less than 30 per cent of venture capital aimed at deep tech.

However, overall levels of venture capital are low in Australia, when compared to our peers abroad. The flow of annual investment in new venture capital made up just 0.03 per cent of GDP in Australia in 2018. This is less than half the OECD average, at 0.08 percent; less than a tenth of Israel, whose where the flow of venture capital investment is almost 0.4 percent of GDP; and 17 times less than the US where it is `almost 0.6 percent of GDP.

Exhibit 19 – While venture capital in Australia is strongly focused on "deep tech rich" sectors, local investment in venture capital is low

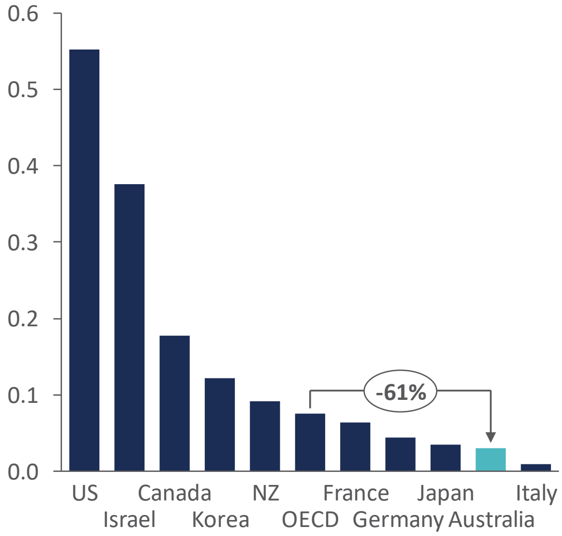
Deep tech, share of venture capital

Deep tech, percent of all venture capital, 2016



Venture capital, share of GDP

Venture capital flows, percent of GDP, 2018 or latest

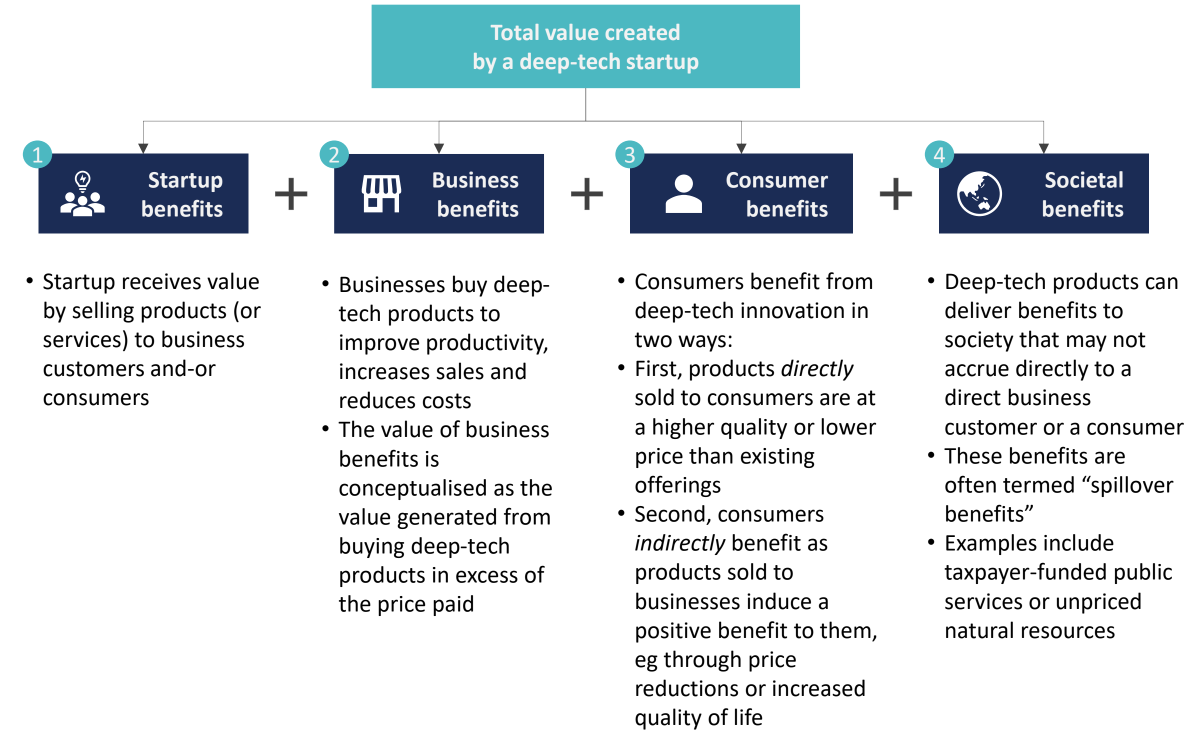


Note: Deep tech is defined here as life sciences, energy and environment, and chemicals and materials. Non-deep-tech comprises consumer goods and services, business products and services, and financial and insurance activities.
Source: World Bank: population, total'; Q4 2019 Pitchbook NVCA Venture Monitor; OECD.Stat 'Venture Capital Investments', OECD Data 'Gross Domestic Product', OECD 'Entrepreneurship at a Glance'; Q4 2019 Pitchbook NVCA Venture Monitor; ABS 56780DO001_201718 Venture Capital and Later Stage Private Equity, Australia, 2017-18; Crunchbase.

Appendix 2: Estimating the value deep tech startups create

The value created for Australia's economy and society by the group of deep-tech startups presented in Chapter Three is estimated by first mapping out the four channels in which value can be created, as set out in Exhibit 20.

Exhibit 20 – Measurement framework for value created by deep tech



Source: Stakeholder interviews, AlphaBeta analysis

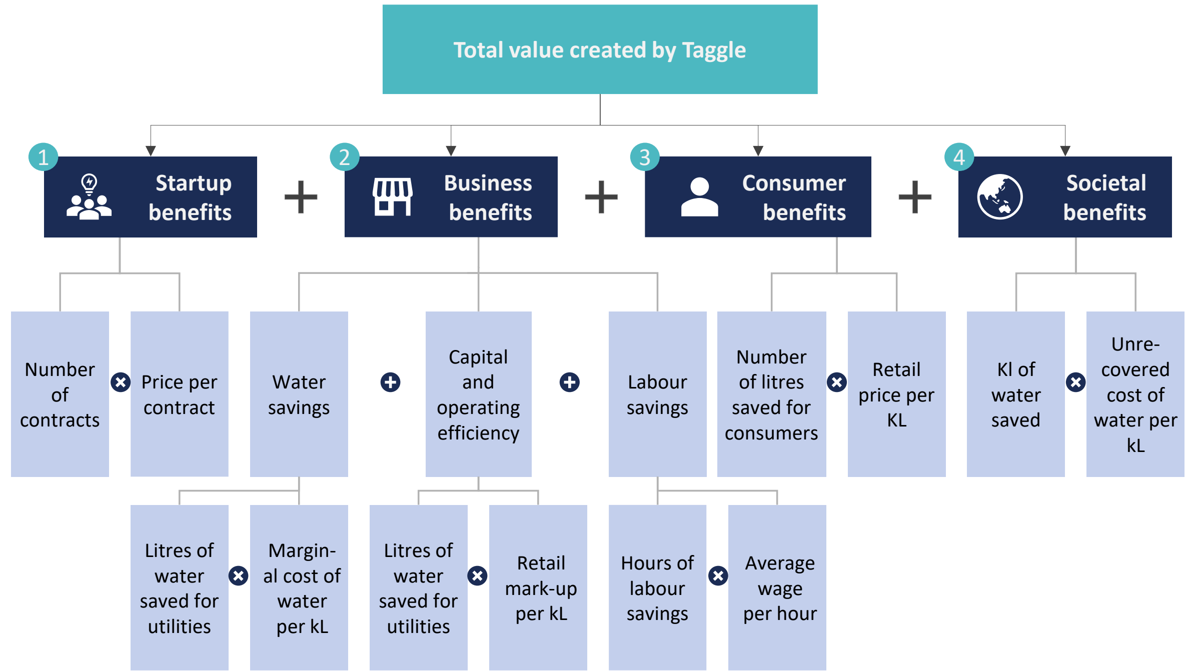
In each channel, value is estimated in the following way, taking care to ensure that each component is calculated in a way that is additive to the others, without double-counting:

- **Startup benefits** are estimated by multiplying the number of products sold by the average price per product.
- **Business benefits** are estimated by measuring the increase in revenue and decrease in costs from businesses buying deep-tech products, based on public and private data relating to each deep startup. Net business benefits are those that remain after the subtracting payments by business customers to purchase deep-tech products and services.
- **Consumer benefits** are identified by undertaking stakeholder interviews to pinpoint each possible benefit that a deep-tech product provides to a consumer and drawing on a range of data sources. The value of the benefit is estimated by multiplying the value of the benefit, at the individual level, by the market size of the product, as measured by the number of individuals buying the product or benefiting from it.

- **Societal benefits** are measured by identifying channels in which a product benefits the broader society and assigning any economic value that is incremental to the prior three benefit categories. For example, innovations in molecular diagnostics have led to more accurate detections of viral and bacterial diseases, resulting in earlier and less invasive treatments which are less costly.

Exhibit 21 illustrates how value is estimated for the remote monitoring and smart meter services provided by Taggle, one of the startups in the group.

Exhibit 21 – Illustration of how a deep tech startup's value creation is calculated



Source: Stakeholder interviews, AlphaBeta analysis


SwagBot

αlphaβeta
Australia
part of **Accenture**