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Global Expert Mission
Bioinformatics in Israel 2018

Contact
Dr Nee-Joo Teh
Head of International and Development
neejoo.teh@ktn-uk.org

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1. Welcome

Innovate UK global missions programme is one of its most important tools to support the UK's Industrial Strategy's ambition for the UK to be the international partner of choice for science and innovation. Global collaborations are crucial in meeting the Industrial Strategy's Grand Challenges and will be further supported by the launch of a new International Research and Innovation Strategy.

Innovate UK's Global Expert Missions, led by Innovate UK's Knowledge Transfer Network, play an important role in building strategic partnerships, providing deep insight into the opportunities for UK innovation and shaping future programmes.

The Bioinformatics Expert Mission travelled to Tel Aviv and Haifa in November 2018 and in this publication we share the information and insights gathered during the delegation's time in Israel.

The mission was comprehensive and engaged a wide range of stakeholders in the bioinformatics sector and also the wider healthcare and innovation sectors in Israel. However, it is acknowledged that the mission also faced limitations e.g. in terms of the time available and not being able to include the Weizmann Institute and organisations based in Jerusalem.

2. Introduction

Israel is a country of 20,000 km^2 with a population of 8.5 million i.e. it is the same size as Wales with a population slightly greater than London[1]. However, Israel is recognised as having a highly entrepreneurial and innovative business environment so that its economy is highly developed with 2017 GDP of US$351 billion (US$40,270 per capita)[2].

2.1 Start-up Nation and Innovation Support

The Israeli Government has for more than 20 years prioritised investment in research and development (R&D) centres, start-up support including incubators and accelerators and public universities to ensure that there is a coordinated innovation ecosystem.

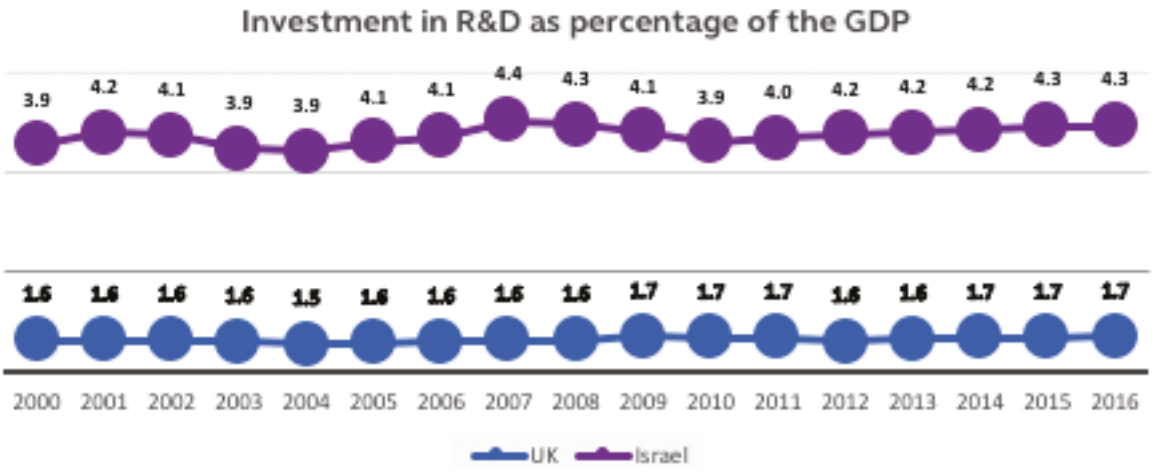
Figure 1: The Israeli innovation ecosystem[3]

The first interventions of the Israeli Government in support of the formation of this innovation ecosystem was the creation of the Yozma venture capital funds in the 1990s. This was just the first step of the extremely successful effort to incentivise investment in start-ups companies. Many countries and regions have attempted to copy the Israeli model with varying degrees of success.

This programme, among other initiatives which leveraged financing from foreign corporations and institutions, has helped Israel to become the country with the highest R&D expenditure in the world (2016 4.3% of GDP, c.f. UK 1.7% of GDP, Figure 2)[4]. This has encouraged an entrepreneurial culture producing new companies, products and services at world-leading rates resulting in the label "Start-up Nation"[5].

[1] mfa.gov.il/MFA/AboutIsrael/Pages/Facts-about-Israel-2018.aspx
[2] data.worldbank.org/country/israel
[3] Presentation by Shir Zilberstein, Taglit Innovation Centre
[4] data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
[5] www.startupnationcentral.org/how-to-benefit-from-the-israeli-innovation

Figure 2: Graph comparing Israel and UK R&D investment as percentage of the Gross Domestic Product (GDP) between 2000-2016



2.2 The Academic Research Base

Israel has a strong academic and research base. The Technion and the Weizmann Institute are internationally recognised for their research impact and excellence. The country has seven research universities: Bar-Ilan University, Ben-Gurion University of the Negev, the University of Haifa, Hebrew University of Jerusalem, the Technion – Israel Institute of Technology, Tel Aviv University and the Weizmann Institute of Science[6]. Israeli universities are ranked among the top 50 academic institutions in the world in a number of scientific disciplines, for example:

- Chemistry – Technion
- Computer science - Weizmann Institute of Science, Technion, Hebrew University and Tel Aviv University
- Natural sciences - Hebrew University and Technion
- Engineering - Technion

The Israeli Centres of Research Excellence (I-CORE) programme has established 16 cross-institutional clusters of top researchers in specific fields and returning young Israeli scientists from abroad[7]. The centres cover a spectrum of research areas, including life sciences, medicine, science and engineering, social sciences, law and humanities. Each centre of excellence has been selected via a peer review process conducted by the Israel Science Foundation.

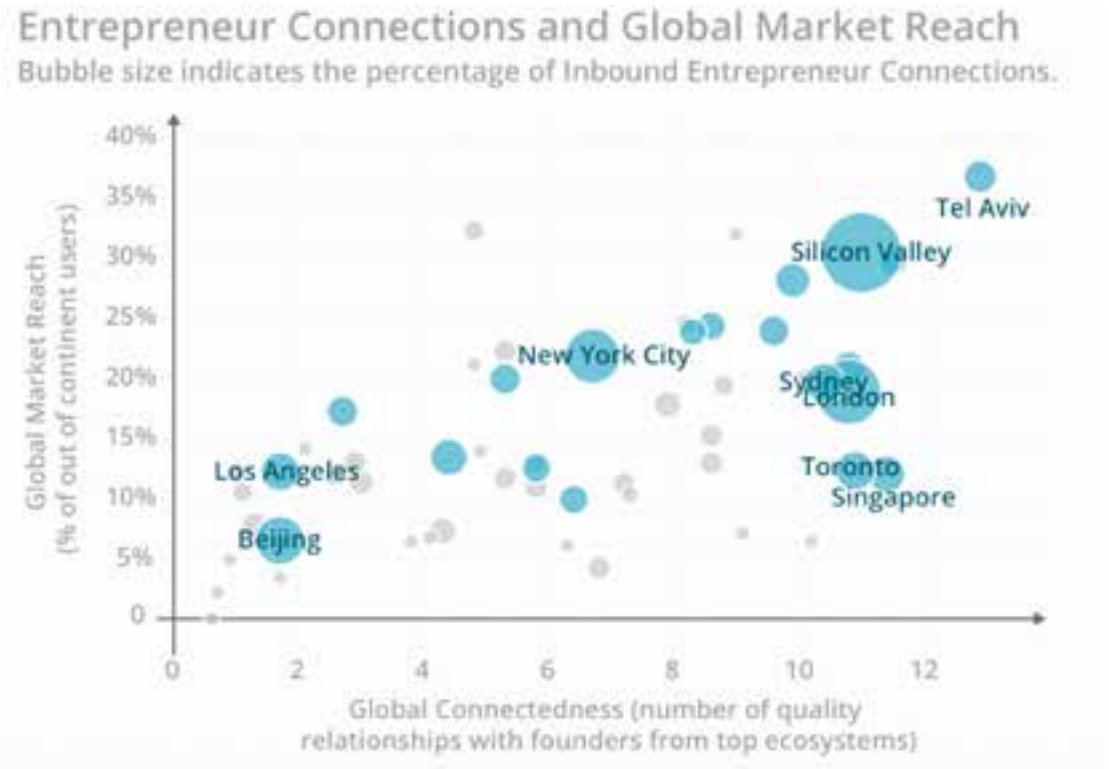
2.3 The Geography of Innovation

With between 2,200 and 2,700 tech start-ups churning out products for global markets, Tel Aviv has one of the highest start-up densities in the world[8]. Israel's start-ups are focused on developing products for global customers (Figure 3).

Figure 3: Product focus of start-ups

[6] www.mastersportal.com/ranking-country/112/israel.html
[7] www.i-core.org.il
[8] Start-up Genome report 2017

Figure 4: Entrepreneur connections and global market reach



A key factor driving the entrepreneurial culture is the relatively small size of the population and the connections fostered by compulsory conscription at the age of 18. Military conscription helps to break down societal barriers as well as instilling a hard-working mentality. Degree training is delayed until individuals are in their early 20s, producing mature graduates who are better prepared to develop start-up companies. In addition, there is a strong culture that embraces failure as part of the learning and innovation process. Thus, Israel exhibits a comparatively small but well connected entrepreneurial population focused on creating products for global markets.

2.4 Start-up Nation or Scale-up Nation?

Israel recognises that it also faces challenges from the success of the "Start-up" nation programme. Although the country has created many successful start-up companies, there has not been the same level of success in growing these companies into mid-size and global multinationals. This is a particular issue in the more developed technology sectors where successful small companies have been bought by larger foreign companies so that the benefits of the Israeli investments are seen to be lost abroad. There is also a concern regarding a "brain-drain" of Israeli talent being targeted by foreign companies to leave Israel. This is compacted by fierce competition for skills and human resources, as a significant number of large corporations have set up R&D sites in the country, increasing salary and turnaround of staff.

The Israeli Government has implemented a number of policies to attempt to mitigate the impact of mergers and acquisitions by foreign companies. In particular, restrictions have been introduced that attempt to retain Israeli intellectual property (IP) in the country by imposing penalties on any company that has received government grant funding (i.e. the majority of Israeli start-ups and small and medium enterprises) for the transfer of the IP and production outside of Israel.

Case study: Desktop Genetics and Twist Bioscience - collaboration or partnership

Twist Bioscience is a US-based company that was established in 2013 and has grown rapidly to establish itself as a market leader in DNA synthesis. Genome Compiler, based in Tel Aviv, was set-up to provide DNA design services and a "market place" for DNA synthesizers, such as Twist Biosciences. The two companies worked closely together to ensure their products and services were aligned and in 2017 Twist Bioscience bought Genome Compiler.

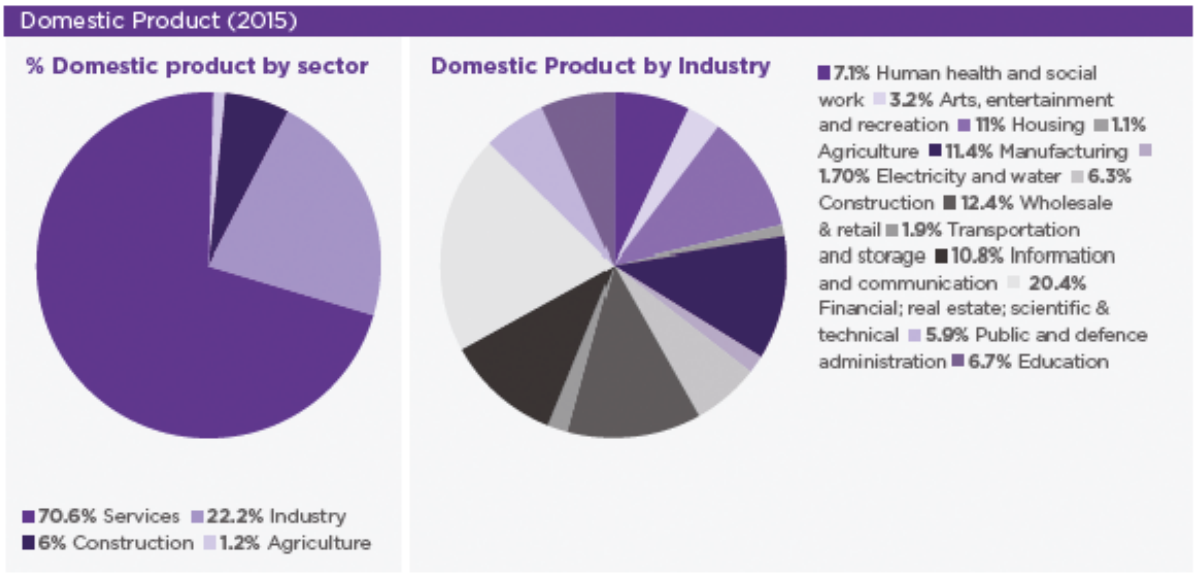
Twist Bioscience also has a similar partnership arrangement with London-based Desktop Genetics to provide integrated experiment design and DNA synthesis tools to expedite gene editing research. Desktop Genetics will provide synthetic guide RNA (sgRNA) CRISPR library design services complemented by Twist Bioscience's highly specific guide libraries for accurate editing of gene targets.

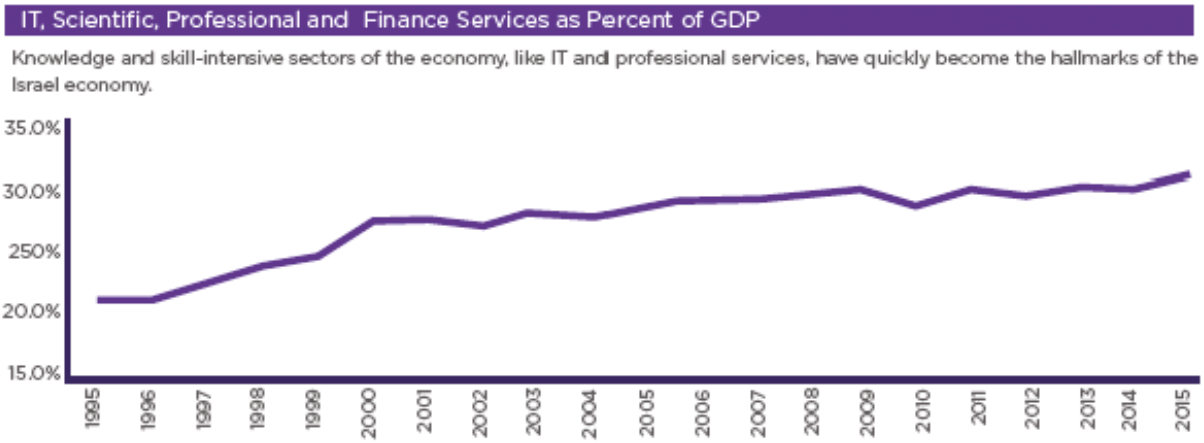
3. Sector Overview

3.1 Life Sciences Sector Overview

The tech sector has provided the basis for economic growth over the past decade, fuelling Israel's reputation as a world leader. The World Economic Forum recognises Israel as an information and communications technology (ICT) "Powerhouse" of innovation, with over 800 companies powering the sector. Israeli ICT exports grew by over 25% in the last four years, to over US$23 billion. ICT services constitute over 60% of its service export.

Figure 5: Importance of ICT to Israeli economy[9]

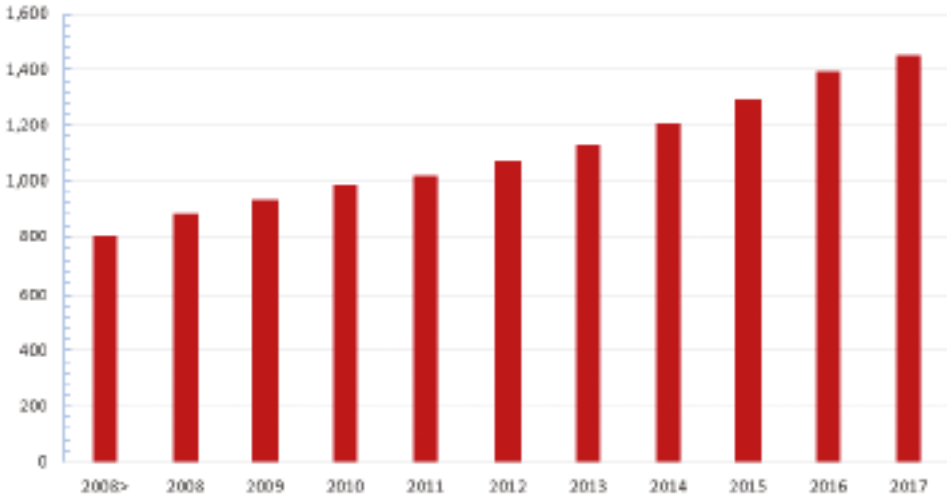




[9] Facts about Israel: The economy mfa.gov.il/MFA/AboutIsrael/Pages/Facts-about-Israel-2018.aspx

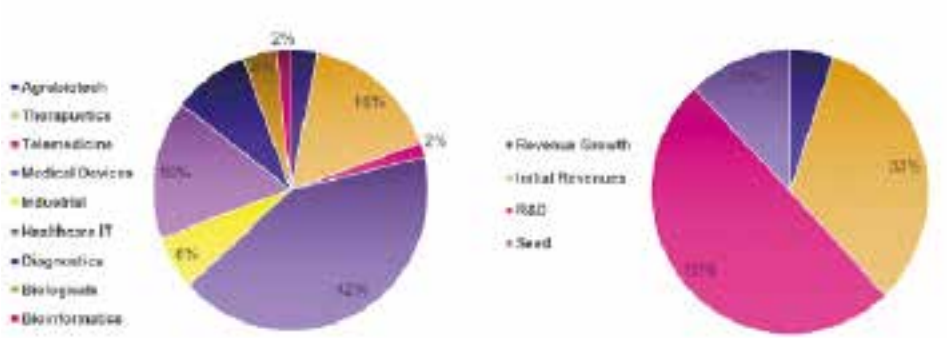
Following in the footsteps of the ICT sector, the life sciences sector has been growing exponentially (Figure 6)[10]. In 2017, this consisted of 1,450 companies with more than 85,000 employees. However, the majority of the companies are small, employ fewer than ten people, and over 40% of them were founded less than ten years ago.

Figure 6: Cumulative number of active life science companies[11]



The Israeli life sciences sector is dominated by three sub-sectors: medical devices (42%), healthcare IT (16%) and therapeutics (16%). In 2017 bioinformatics represented only 2% of the sector. The majority of the companies are small and are still pre-revenue i.e. seed funding and R&D (Figure 7). There is relatively low activity in the biopharma sector, but the government is seeking to promote this.

Figure 7: Israel life sciences snapshot, by sectors and company stage[12]



[10] Israeli Life Sciences Industry CatalogBio International Convention 2018 innovationisrael.org.il/sites/default/files/Bio%20International%20Convention%202018_WEB%202.pdf
[11] Israel's Life Sciences Industry IATI Report 2018
[12] Israeli Life Sciences Industry CatalogBio International Convention 2018 innovationisrael.org.il/sites/default/files/Bio%20International%20Convention%202018_WEB%202.pdf

Tel Aviv and Haifa are the main concentrations of tech- and R&D-focused businesses in Israel. However, Jerusalem also has a significant life sciences sector. The city is home to some 150 life sciences companies that employ more than 3,000 people and accounted for 27-29% of local venture capital investment over the past six years. Nearly half of the biotech and medical research in Israel is conducted in Jerusalem at the Hebrew University of Jerusalem and its affiliate Hadassah Medical Center[13]. It was not possible during the mission to visit companies and research organisations based in Jerusalem.

Figure 8: Israeli life sciences sector – key background

- Over 1,400 life sciences companies. Over 40% already generating revenue
- Produces more scientific papers per capita than any other country (The Luzzatto Group Research, 2017)
- Civilian R&D is the highest as % of GDP among OECD countries
- Pioneers in immune and stem cell research and therapeutics
- Source of numerous blockbuster drugs such as Humira, Enbrel, Rebif and Copaxone, generating about US$20 billion in annual sales
- Extensive international R&D and commercial partnerships
- Unique financing tools and incubator frameworks for start-ups
- Third most innovative nation in the world (WEF Global Competitiveness Report 2016-2017)
- World-renowned academic research institutes such as the Technion and the Weizmann Institute

3.2 Israel's Biomedical Industry

The Israeli biomedical industry (biopharmaceuticals, medical devices and digital health) is one of the fastest growing innovative industries in the country. In 1996, there were 186 companies in this sector, while today there are 1,400 companies with 120 new companies being formed each year. Forty per cent of these companies are already generating revenues for Israel's healthcare providers.

The Israeli health system has been pivotal in the creation of a strong life-science ecosystem. It consists of four not-for-profit health management organisations (HMO) (Clalit, Maccabi, Meuhedet and Leumit) which provide universal healthcare via a compulsory medical insurance plan.

The four HMOs are independent organisations that are funded by the Ministry of Health to provide healthcare services. Although the HMOs are government funded to provide healthcare services via compulsory insurance, they retain a high degree of autonomy regarding the additional services they offer and their organisational and development strategies.

Key facts:

- Clalit[14] is the largest HMO and runs its own network of hospitals in Israel. It operates 14 hospitals, including psychiatric hospitals and a rehabilitation hospital; all are university-affiliated. Clalit runs over 1,300 primary care clinics as well as a network of pharmacies and dental clinics.
- Maccabi[15] is the second largest HMO in Israel, covering about 2 million beneficiaries (25% of market share). Maccabi operates primary care general practitioners, as well as secondary, and healthcare professionals.
- Meuhedet[16] is the third largest healthcare provider in Israel and serves over one million clients.
- Leumit Health[17] Services has over 720,000 members and over 320 medical centres.

3.3 Digital Health, Genomics and Bioinformatics

Digital health, including genomics and bioinformatics, has been identified as a "national growth engine" by the Israeli Government and the Israeli Innovation Agency (IIA). A major driver for this initiative is the fact that all medical data has been stored using an electronic health record (EHR) since the 1990s. The strategy to develop the digital health sector is seen as a long-term programme. IIA estimates that for every US$1 invested in the cyber/tech sector that US$5 of benefit is generated. However, in life sciences, the benefit is currently only 20-30 cents. The IIA recognises the need to diversify the economy and that it will take years or decades to develop the life sciences sector.

[13] Startup Genome report 2018, https://startupgenome.com/reports
[14] www.clalit.co.il
[15] www.maccabi4u.co.il
[16] www.meuhedet.co.il
[17] www.leumit.co.il

3.3.1 Israel Data Sets – Electronic Health Records

The ease of data access in Israel was highlighted throughout the mission. The potential value of the 20-year EHR dataset was recognised in multiple meetings as well as the ability to rapidly access the data to develop new products and interventions (this appeared to be faster and easier than accessing equivalent data in the NHS).

Two digital health record initiatives were highlighted during the mission as supporting the development of the digital health sector:

- OFEK network: since 2005, Clalit Health Services has been using OFEK – an online information system containing computerised medical records that integrates information across hospitals and community settings[18]. A noted limitation of the system is that the data is only held transiently for global querying in this unified state (to protect data security). There also appears to be issues regarding the uptake of the platform within hospitals.
- TIMNA platform: aims to provide big data infrastructure to facilitate research programmes[19]. The aim is to generate a de-identified big data reservoir of clinical data that can be utilised via a dedicated controlled research environment. The data is mainly in Hebrew.

Languages: English and Hebrew

Although English is widely used in the research and business communities, the national language, Hebrew, presents challenges for potential collaborations, especially those potentially utilising clinical and EHR data.

As in many countries, English is widely spoken especially in the scientific community. This facilitates information transfer and provides the basis of collaborations. However, the national language, Hebrew, is not easily understood or translated for business use.

One of the opportunities promoted on the mission was the fact that Israel possesses a single EHR for the population containing 20 years of clinical data. It was also recognised that the value of the data was limited by being in Hebrew and also including scans of hand-written notes (both of these issues may be addressed in the future by initiatives for natural language processing and Hebrew-English translation).

3.3.2 Definition of Digital Health and Bioinformatics

The use and definition of the term "digital health" within the Israeli healthcare system is not consistent and thus, there is potential for misunderstanding and confusion. The Israeli use seems to be directed towards the collection of data from applications within the medtech and diagnostics markets and is rarely associated with omics-based approaches. This may reflect the current status and stage of development of the digital health sector and of the increasing focus of the existing tech sector towards medical and health solutions.

3.4 Israel's Bioinformatics Sector

The mission did not identify a significant commercial bioinformatics sector in Israel. Whereas genomics and bioinformatics have grown rapidly in the UK in the last decade, this has not been matched in Israel. The bioinformatics team at the Technion was small (<5 people) and was service based. Bioinformatics was not viewed as a driver of commercial activity (compared to UK activity), and the sector was perceived by the mission delegates to be at least five years behind the UK. Bioinformatics is provided as a core service in the Technion and the Weizmann Institutes, but companies specialising in bioinformatics were not identified. Some companies were using bioinformatics as part of their wider R&D activities, but this is not a primary research or product focus e.g. Twist Bioscience and NRGene.

There is an active bioinformatics research community in the

[18] www.allscripts.com/File%20Library/Case%20Studies/Clalit-Health-Services.pdf
[19] education.academy.ac.il/SystemFiles/Using%20Data%20Backgroud%20material%20Eng.pdf

academic sector. This is exemplified by Israel's membership of ELIXIR (the European infrastructure for co-ordination of bioinformatics resources)[20]. The lead institute is the Weizmann Institute of Science, and the node partners are Bar-Ilan University, Ben Gurion University of the Negev, Haifa University, I-CORE of the Academy of Science, School of Veterinary Medicine & Faculty of Agriculture (HUJI), Technion - Israel Institute of Technology and Tel Aviv University. The Israel Node facilitates access to biological databases for the active Israeli bioinformatics community.

Some of the companies encountered during the mission appear to have originated from using expertise from the established tech industry and applying skills and technology to create products and services for life sciences e.g. MDClone and NRGene. This may be evidence of a growing shift in the pharma industry from biotech to techbio where drug discovery/development data and the mechanisms by which to analyse it are almost as important as the wet-lab work.

One area of genomics/bioinformatics where Israel was identified as being more advanced than the UK is in prenatal testing i.e. genetic investigation and tests before or during pregnancy[21]. The aim is to screen couples to identify those at risk of bearing children with severe hereditary diseases, such as cystic fibrosis and spinal muscular atrophy. This has created a significant dataset of couples who have been tested. Like many other countries, including the UK, Israel also performs genetic tests for diseases on newborn babies[22].

3.4.1 Israel's Digital Health Ecosystem

The Israeli digital health ecosystem is highly active, and it is dominated by SMEs and start-ups with less than 20 employees. There are estimated to be 500 digital health start-ups, and the majority of the companies are in medtech and clinical digital health sectors (Figure 9).

Figure 9: Israeli digital healthcare landscape[23]

[22] www.elixir-europe.org/about-us/who-we-are/nodes/israel
[21] www.health.gov.il/English/Topics/Genetics/checks/screening-genes/Pages/default.aspx
[22] www.health.gov.il/English/Topics/Genetics/InfantScreening/Pages/default.aspx
[23] medium.com/vertexventures/mapping-israels-digital-health-ecosystem-11044124c03c

3.4.2 Government Programmes

As previously mentioned, the Israeli Government invested NIS922 million (£203 million) in an ambitious digital healthcare programme to improve the healthcare system, but also to provide a boost for Israeli companies developing digital healthcare technologies. In addition, the programme is seeking to enable predictive, preventive and personalised medicines. It will provide incentives for start-ups, by enabling them to collaborate with local and international healthcare providers, and train personnel in this sector. Finally, the programme will invest in setting up a digital infrastructure for medical research and to support collaboration between the healthcare system and digital health start-ups.

There are five main projects:

a) Encouraging R&D and pilot trials in the field of digital health carried out in cooperation with Israeli health organisations.
b) "Technology innovation labs" to promote innovation and strengthen cooperation between multinational corporations and Israeli start-ups.
c) Promoting cooperation agreements with international entities to support R&D of Israeli digital health companies.
d) Supporting the establishment of a Digital Health User Association.
e) Creating a plan for converting personnel into the field of data sciences, with reference to the field of digital health.

3.4.3 Digital Health Initiatives

As discussed in Section 3.4.2 digital health, including genomics and bioinformatics, has been identified as a "national growth engine". The strategy to develop the digital health sector is seen as a long-term programme. The IIA estimates that, in the cyber/tech sector, for every US$1 invested US$5 of benefit is generated. However, in life sciences, the benefit is currently only 20-30 cents. The IIA recognises the need to diversify the economy and that it will take years or decades to develop the life sciences sector.

A major driver for this initiative is the fact that all medical data has been stored using an electronic health record since the 1990s. In March 2018 a national digital health programme was announced, to be invested mainly in setting up a digital infrastructure and for medical research, and to support collaboration between the healthcare system and digital health start-ups.

The drivers behind digital health being considered as a future growth engine for Israel appear to be the increasing importance of the digital health sector globally, especially considering the world's ageing population. Israel sees digital health as an area where it could transfer its skills from the tech sector to its advantage. It is using the health records to incentivise global companies. As mentioned previously, the records may exist, but how easy it is to access and utilise them remains unclear. Technologies to support the ageing population were also highlighted as the focus for R&D and innovation support. This is also reflected in similar initiatives in the UK e.g. the ageing society is one of the four grand challenges identified by the Industrial Strategy[24].

Although, the Israeli Government is supporting the growth of the digital health sector there does not appear to be any focus on bioinformatics. The priorities appear to be on exploiting technology-ready solutions that can be easily taken to market.

3.4.4 Challenge Tenders

The Challenge Tenders is a Ministry of Health initiative where entrepreneurs and technology companies can apply to deploy novel, digital-based solutions in the Israeli healthcare system[25]. Suitable proposals are granted a fully state-funded pilot which can lead to implementation in the healthcare system. The programme is only open to Israeli companies and is similar to the UK's Small Business Research Initiative (SBRI)[26]. Recent tenders have included:

- Assistance in tackling the challenge of overcrowding at internal medicine and emergency departments.
- Help to cope with obesity.
- Digital solutions to help tackle medical mistakes resulting from patient identification errors.

3.4.5 Genomics Programme

The National Digital Health programme[27], launched in 2018, includes the new Israeli National Genomic-Clinical Initiative, named "Mosaic". The programme aims to sequence and analyse the genomes of 100,000 Israeli volunteers. The genomic sequence data will be combined with clinical information to provide databases to support drug discovery and personalised medicine.

The 100,000 Genome project was initially announced in 2017, but it appears that little progress has been made since then. Although it was raised in a number of meetings (e.g. Technion bioinformatics team and Israeli Ministry of Health) no further information regarding the timings, details of operations, aims and outcomes were provided.

During the mission, it became clear that the National Digital Health Programme is yet to decide key issues for the project,

[24] www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges#ageing-society
[25] www.health.gov.il/English/Services/Tenders/prob_tenders/Pages/prob_tenders.aspx
[26] sbri.innovateuk.org
[27] innovationisrael.org.il/en/news/digital-health-pilot-program

including sequencing technology, how they will recruit participants and what level of genomic testing they will carry out (e.g. panels, exome and whole genome sequencing). Israel plans to make an economic and strategic decision on this when it is closer to initiating the project (but the timeline to this point is not known). The Israeli Government plans to work with "experts" in the genomics field locally to deliver their genomics initiative.

3.4.6 Talent and Resources Issues

The dominant position of the ICT sector is seen as having a potentially negative effect on the availability of skilled staff for other sectors. One issue highlighted during the mission was the loss of talent to multinationals, such as Microsoft and Amazon, which are able to offer staff (located both within Israel and abroad) high salaries which Israeli businesses cannot compete with. At the government level, this has created concerns that the growth of Israeli businesses will be restricted as the most talented individuals are attracted to work elsewhere. This issue was also highlighted at the Technion where the retention of data scientists as trained bioinformaticians was highlighted as an issue due to the higher salaries that are available within the mainstream ICT sector.

There was also a low level of knowledge of the European Bioinformatics Institute (EMBL-EBI) and its role in providing training and regulation of the bioinformatics sector. Although Israel is a member of EMBL-EBI it was not recognised widely with the genomics, genetics and bioinformatics organisations encountered through the mission.

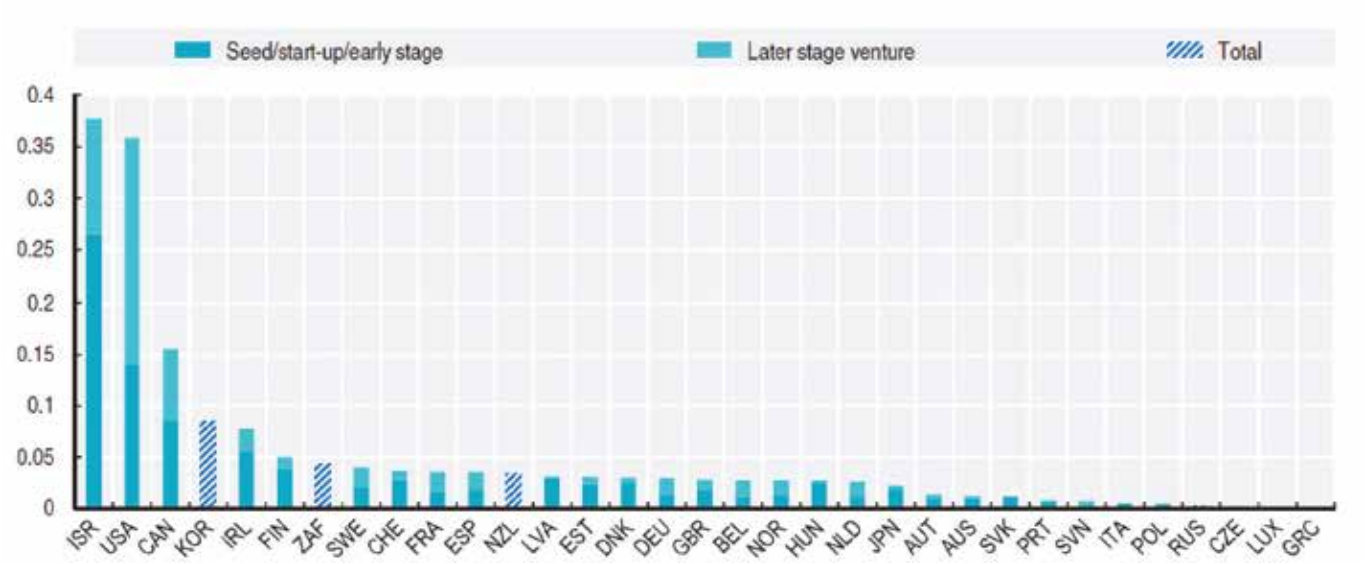
3.5 Support for Research and Innovation

3.5.1 Venture Capital Investment

The Israeli life sciences industry has several sources of funding, including the IIA, venture capital funds (Israeli and foreign), micro-funds, corporate investors, IPOs (mainly the NASDAQ and other foreign stock-exchanges) and angels. The country has a highly active venture capital sector and has, at 0.35% of GDP, the highest level of venture capital investments in the Organisation for Economic Co-operation and Development (OECD) (in most other OECD countries this is less than 0.05%,).

Israeli high-tech companies raised an all-time annual high of US$5.2 billion in 2017, superseding the prior all-time annual high recorded in 2016 by US$0.4 million, or 9% (Figure 11)[29]. The life sciences sector funding continues to grow, attracting US$1.2 billion in 2017, which represents 25% of the total investments in Israeli high-tech, invested in 135 life science companies.

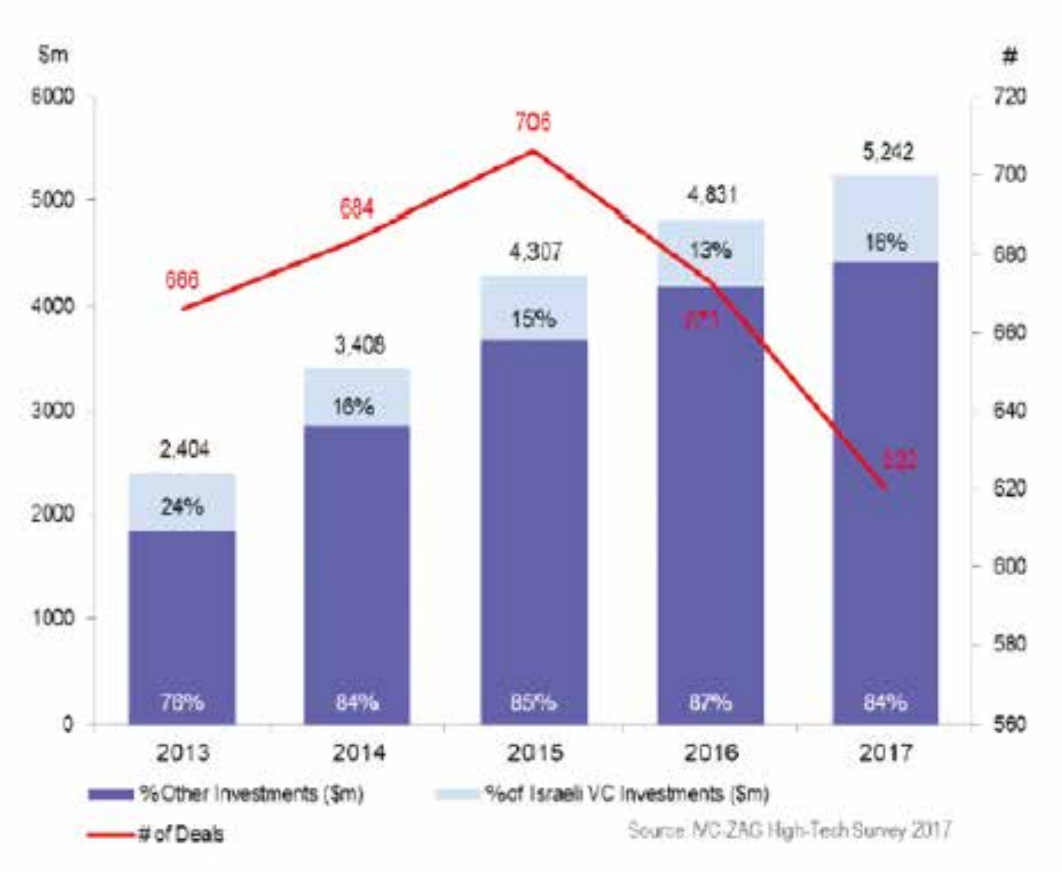
Figure 10: Expenditure by VC as a % of GP (2016 or latest available year)[28]



[28] Israel's Life Sciences Industry IATI Report 2018

[29] www.ivc-online.com/High-Tech-Insights/IVC-Publications/IVC-Surveys/High-Tech-Capital-Raising

Figure 11: Venture capital investment in Israeli high-tech companies[30]

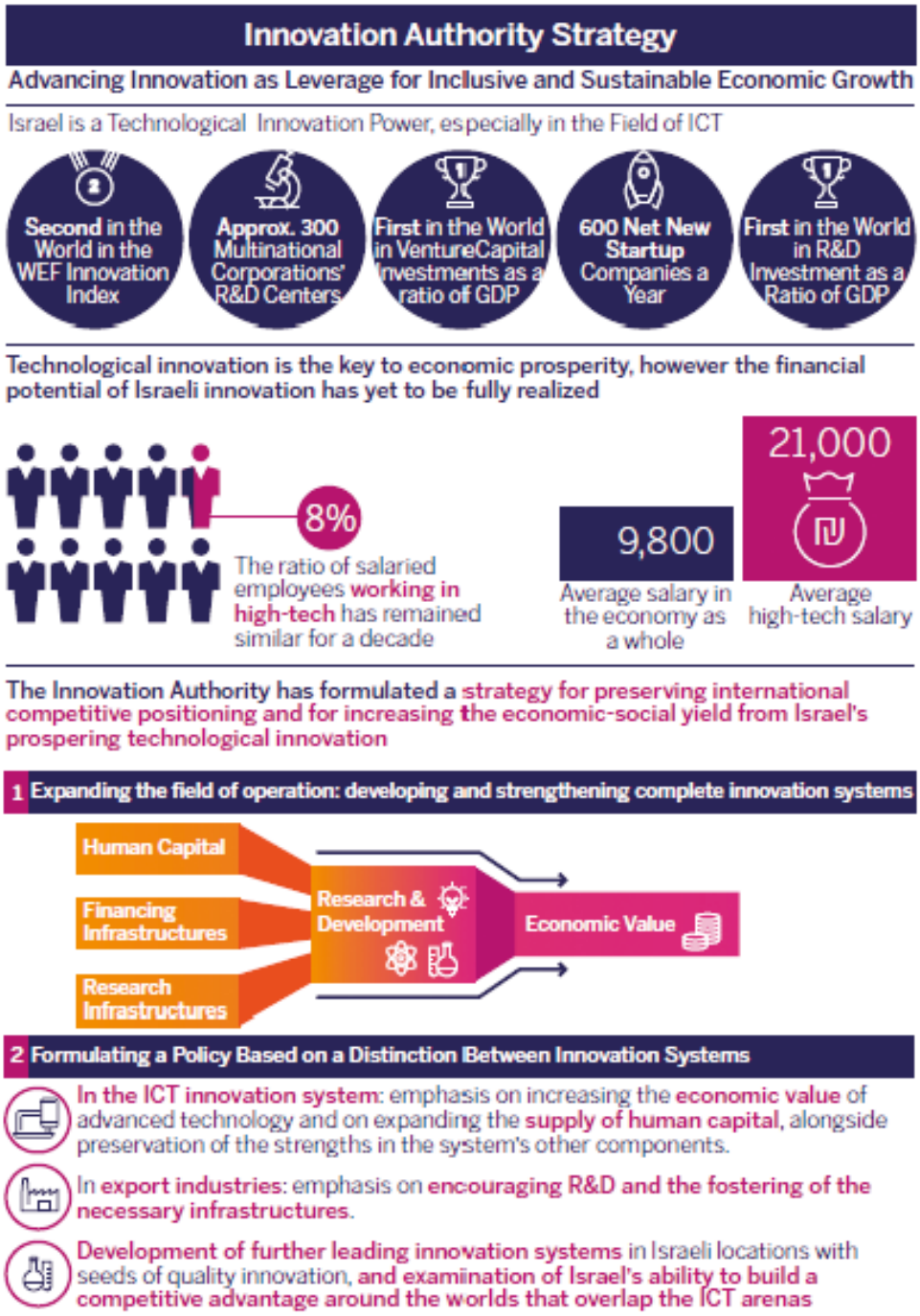


3.5.2 Israel Innovation Authority (IIA)

The IIA[31] is Israel's equivalent of Innovate UK. It is an independent publicly-funded agency and was created to provide a variety of practical tools and funding platforms aimed at effectively addressing the dynamic and changing needs of the local and international innovation ecosystems. The IIA's remit is wider than Innovate UK in that it includes early-stage entrepreneurs, mature companies developing new products or manufacturing processes, academic groups seeking to transfer their ideas to the market, global corporations interested in collaborating with Israeli technology, Israeli companies seeking new markets abroad and traditional factories and plants seeking to incorporate innovative and advanced manufacturing into their businesses (Figure 12). The IIA has a specific focus on promoting and supporting international collaborations and has bi-national R&D/innovation funds with countries including Korea, Canada, USA, India and Singapore[32]. The IIA budget in 2017 was NIS1.6 billion (£338 million).

[30] Israel's Life Sciences Industry IATI Report 2018
[31] innovationisrael.org.il
[32] innovationisrael.org.il/en/page/bi-national-funds

Figure 12: Summary of Israeli Innovation Authority Strategy[33]



In November 2018 the first UK-Israel R&D collaboration fund managed by Innovate UK and the IIA was launched[34]. The £2 million fund is seeking proposals for joint business-led R&D projects, focusing on developing innovative products and applications in any technological and market areas. Applicants are expected to develop ready-to-market solutions or projects which have strong market potential.

[33] Innovation in Israel 2017 innovationisrael.org.il/sites/default/files/Innovation%20in%20Israel%202017_English.pdf

[34] innovationisrael.org.il/en/opencall/uk-israel-1st-call-proposals-rd-projects

3.5.3 Israel Innovation Authority: Incubators Incentive Programme

A key part of the start-up support programme of the IIA is catalysing the creation and operation of new incubators. The "Incubators Incentive Programme"[35] supports a technological incubator as a centre for entrepreneurship that invests in new start-up companies and provides technological, business and administrative support. The incubator offers a supportive framework for the establishment of a company and the development of a concept into a commercial product. The incubators are selected through competitive processes for a license period of eight years and are spread across Israel. There are over 20 government-funded technological incubators[36].

The IIA funds 85% of R&D costs for two years (the amount is capped but varies by incubators and sector) and does not take any equity. The incubator is able to negotiate a 20-50% equity stake in the incubated companies in return for a complementary 15% investment of the R&D costs. The incubators operate on a sector basis and create an environment for start-up companies to share their development and knowledge.

Case study: MindUP Digital Health Incubator

The mission visited MindUP Israel's first digital health incubator, based in Haifa[37]. The initiative is a joint venture of Medtronic, IBM, Pitango Venture Capital, Impact 1st Investments and Rambam Medical Center, in collaboration with the IIA.

In its first year of operation, seven start-ups have been funded from over 350 applications. The start-ups receive a two-year investment and accelerator programme worth US$750K. The IIA provides 85% of the funding as a grant with the incubator investing 15% for equity (20-50%).

The start-ups are not allowed to obtain any additional funding in the two years of the programme and have to prove their product in the market to attract follow-on funding at the end of year two. The start-up teams must attend the incubator every day, and benefit from working with the founding organisations which include multinational medtech and digital health companies, investors and a hospital.

3.6 Initiatives to Support UK-Israel Collaboration

In June 2018, the UK Government signed an agreement with the Israel Innovation Authority (IIA) focused on improvements around artificial intelligence (AI) and ageing, supported by a multi-year £4 million bilateral programme[38]. The programme, receiving £2 million of funding from each country, will be led by Innovate UK and will support developing innovative ideas in a number of areas, including AI. The UK and Israel are both investing in healthcare programmes and bioinformatics, and there is great potential for future mutually beneficial collaborative programmes.

In 2017, the UK Government published its Industry Strategy, which identified 4 Grand Challenges that are focused on global trends to transform the country's future. The AI and Data Grand Challenge is pervasive and has a strong interrelationship with the other three. Under the Industrial Strategy, the government announced an Industry Strategy Challenge Fund (ISCF), which is a core pillar in the commitment to increase funding in research and development, by £4.7 billion over four years to strengthen UK science and business.

One programme under ISCF, the Data to Early Diagnosis and Precision Medicine challenge, has a significant bioinformatics component – the programme will invest a total of up to £210 million in three integrated strands of activity, including the creation of 3–5 Digital Innovation Hubs (DIHs) across the UK and the support of a network of 5–6 centres of excellence in digital pathology, imaging and AI. The DIHs will link routine

[35] Incubators Incentive Programme innovationisrael.org.il/en/program/incubators-incentive-program
[36] Technological Incubators innovationisrael.org.il/en/sites/default/files/Incubators_List_EN_2018.pdf
[37] www.mindup.co.il
[38] www.gov.uk/government/news/uk-israel-strengthen-ties-with-new-innovation-agreements

NHS data with rich data from R&D programmes, providing analytic tools and informatics support for businesses alongside local access to integrated UK-wide data. The programme also has a genomics strand that aims to carry out whole genome sequencing of the 500,000 UK Biobank.

3.6.1 UK Israel Open Collaborative Competition 2018

In November 2018, the UK Israel Open Collaborative Competition 2018 was launched[39]. This £2 million joint funding competition will support collaborative, business-led R&D projects which should result in a new product, industrial process or service.

3.6.2 UK Israel Tech Hub

The UK Israel Tech Hub[40], based in the British Embassy in Israel, connects businesses in each country. It has enabled British companies to access Israel's world-leading innovations, and at the same time has helped Israeli companies go global by partnering with UK firms. To date, the hub has led 175 tech partnerships in deals worth £85 million[41]. Successful collaborations have been generated in a range of technology areas including AI, chatbots, blockchain and Internet of Things and projects such as smart cities and smart industries.

In 2017, the Tech Hub launched the UK Israel Dangoor health initiative[42]. The initiative aims to create a pipeline of up to six technologies per year of the best Israeli healthcare innovations for the UK's healthcare sector. The Dangoor Healthcare Initiative built an accelerator in partnership with Israel's IBM Alpha Zone and DigitalHealth.London, an NHS programme. DigitalHealth.London will provide participating start-ups with key insights on the interests and needs of UK healthcare and will mentor these companies on how to navigate the NHS.

3.6.3 BIRAX Regenerative Medicine Initiative

BIRAX (the Britain Israel Research and Academic Exchange Partnership[43]) is a £10 million initiative of the British Council and British Embassy in Israel in collaboration with the Pears Foundation and the United Jewish Israel Appeal (UJIA). BIRAX funds cutting-edge research using stem cell and regenerative medicine therapies to tackle some of the world's most challenging conditions and diseases including cardiovascular and liver disease, diabetes and Parkinson's. Over £7 million has been committed to 15 world-class projects, including eight joint medical research projects announced in February 2015. These included research to use heart cells to restore damaged heart muscle and the use of breath tests for the diagnosis of Parkinson's disease.

3.6.4 BIRAX Ageing Initiative

In 2018 the UK launched a new £5 million fund to promote scientific collaboration and research between Israel and the UK into the ageing process and its effect on human health[44]. The new fund will promote research into ageing-related diseases such as Parkinson's, Alzheimer's, heart disease, multiple sclerosis and diabetes. The initiative also seeks to develop meaningful, sustainable and mutually enriching scientific collaboration between researchers, labs and institutions.

3.6.5 UK-Israel Science Council

The UK-Israel Science Council[45] is a body of 25 leading scientists from the UK and Israel whose core mandate is to improve science collaboration between the two countries. The group was launched in November 2010 and has helped to facilitate collaborative academic-led projects focused on neuroscience, nanomaterials and water science, technology and policy.

[39] UK Israel open collaborative competition 2018 apply-for-innovation-funding.service.gov.uk/competition/274/overview
[40] www.ukisraelhub.com
[41] UK Israel Tech Hub: Impact Report June 2018 www.ukisraelhub.com/2018/06/2018-impact-report
[42] https://digitalhealth.london/our-work/uk-israel-dangoor-health-initiative/.
[43] www.britishcouncil.org.il/en/birax2015
[44] www.britishcouncil.org.il/en/Birax-Ageing-launch
[45] www.britishcouncil.org.il/en/Science-Council

4. Conclusions

Israel is a highly entrepreneurial society with a high rate of start-ups which are focused on creating products using existing technologies, data sets and resources to exploit immediate market opportunities. There is also a trend for applying technologies developed and proven in one sector into new, unrelated sectors. Market analysis of existing products and competitors does not appear to be a major concern, and the focus is on using existing technology and strengths to create good products.

The main focus on Israeli technology-based start-ups is to access export markets, in particular the USA, with Europe and Asia close behind. The UK is a market of interest, but this is predominantly about selling products and services rather than developing innovation collaborations. There is a high awareness of the NHS as a potential customer, although actual knowledge of the NHS and its procurement process is limited.

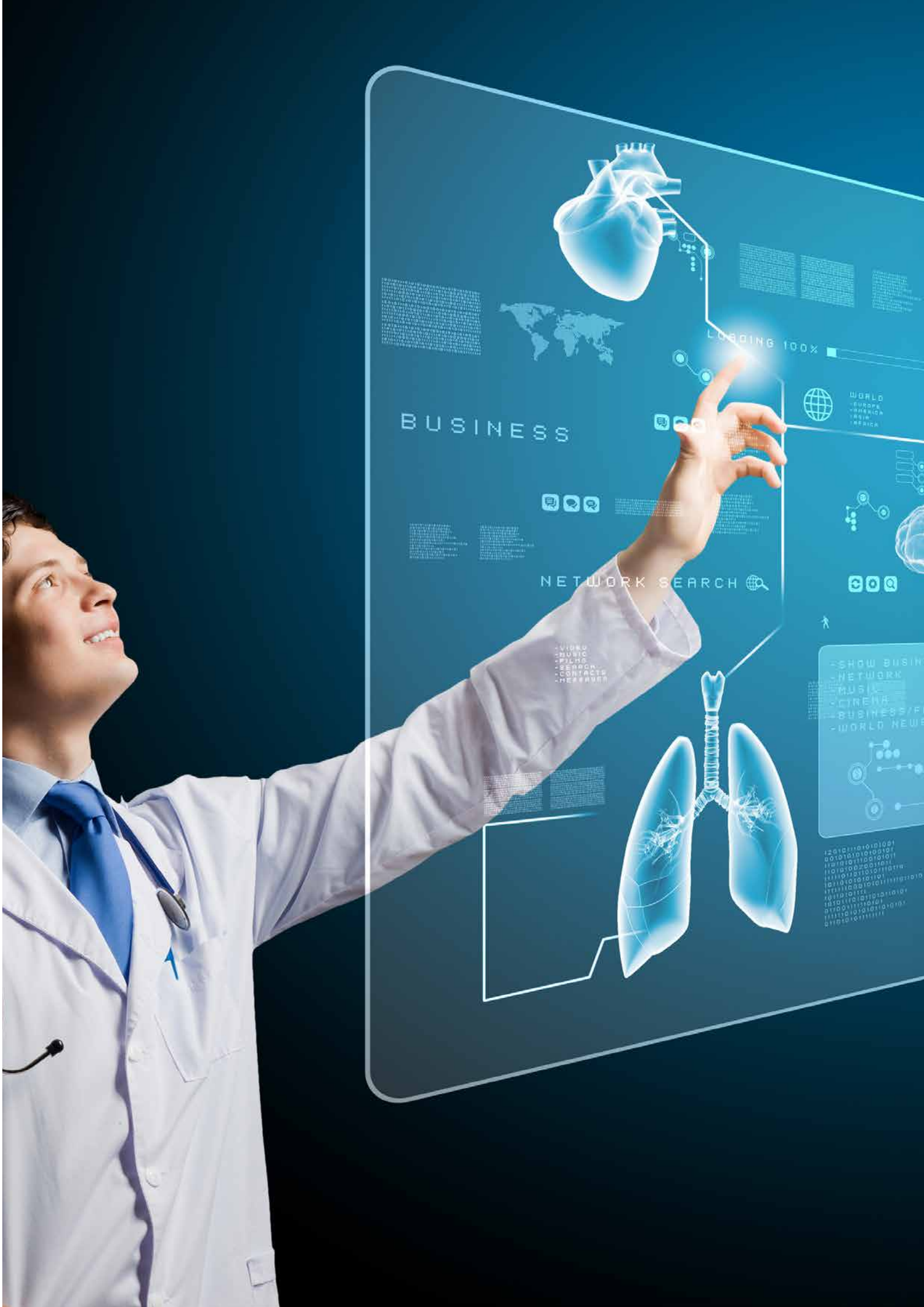
There is a number of existing UK-Israel R&D initiatives, in particular in the academic sector. Israel and the UK share many of the same healthcare challenges and are focusing R&D investment in similar areas, such as the ageing society.

Annex 1:
List of UK Participants

Benevolent AI
Eagle Genomics Ltd
European Bioinformatics Institute (EMBL-EBI)
Genomics England
Innovate UK
KTN
Mendelion
Queen's University Belfast
Repositive

Annex 1:
List of Israel Participants

aMoon venture fund
Applied Genomics
British Embassy Israel
Clalit
Department of International Trade, British Embassy Israel
Digital Innovation Unit, Israel Ministry of Health
Genoox
Health Sector, Israel Innovation Authority
Life Sciences and Engineering Infrastructure Center, Technion
MDClone
MindUP – Health Incubator
NRGene
Project Santera
Taglit Innovation Center
Technion Campus, Visitors Center
Technion Genome Center, Technion
Technion Technology Transfer (T3)
Twist Bioscience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