Research Office
Legislative Council Secretariat

Information Note

Measures to promote government-industry-academia/research institute collaboration and their outcomes in selected places

IN05/2022

1. Introduction

1.1 Developed economies around the world have been positioning innovation and technology ("I&T") as a key driver of economic growth. They have specifically promoted the tripartite collaboration between government, the industry, and academia/research institutes in the I&T development process, as "cross-sector collaboration" has been considered conducive to ensuring relevance of related research and development ("R&D") efforts and enabling translation of R&D outcomes into viable business opportunities.

1.2 In Hong Kong, the Government has stepped up the support for local I&T development in recent years, particularly the establishment of the Innovation and Technology Bureau ("ITB") in 2015 as the dedicated authority to formulate holistic I&T policies for the industry. ITB was retitled as the Innovation, Technology and Industry Bureau on 1 July this year. Nevertheless, some stakeholders have reflected that there are still rooms for enhancing the competitiveness of Hong Kong in applied research through cross-sector collaboration to facilitate the adoption of I&T in industry development.

1.3 Overseas places such as **Singapore** and **Israel** are among the leading economies in driving I&T development to foster sustainable economic growth and build up long-term competitiveness. R&D investment in Singapore and Israel, as measured by the ratio of the gross domestic expenditure on R&D ("GERD") to Gross Domestic Product ("GDP"), stood at 1.89% in 2019 and 5.40% in 2020 respectively, higher than that of 0.99% in Hong Kong in 2020.[1] According to the Global Innovation Index 2021 published by the World Intellectual Property Organization,[2] Singapore and Israel also ranked among the top in "innovation pillars"[3] such as

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1 See Census and Statistics Department (2022), Central Bureau of Statistics (2021b), and National Research Foundation and Agency for Science, Technology and Research (2020).

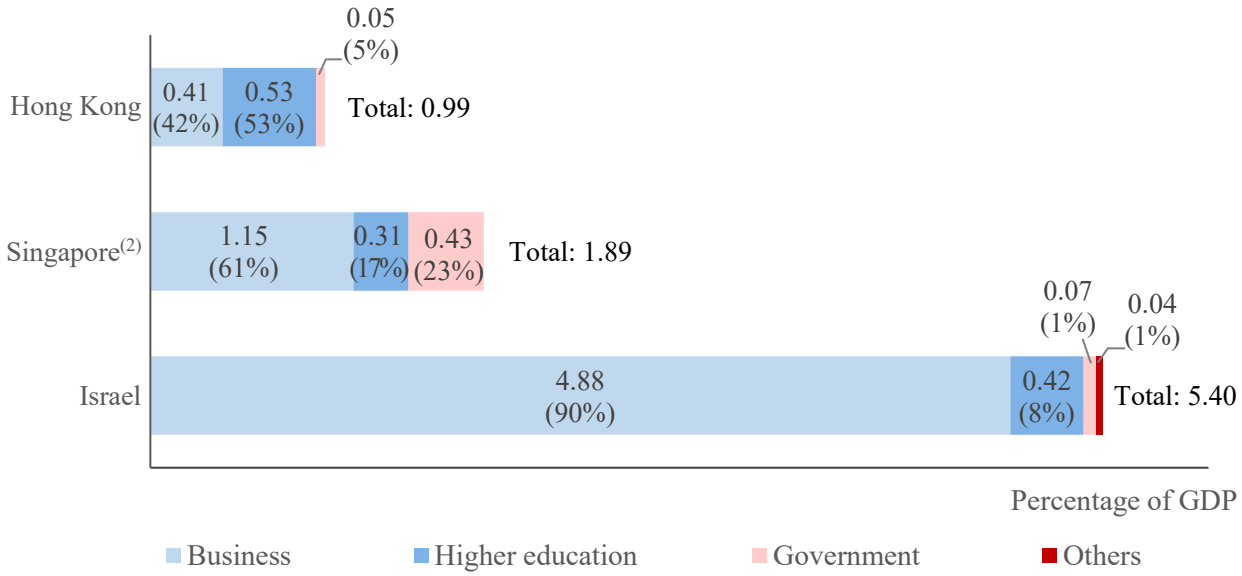
2 The Global Innovation Index 2021 was compiled by the World Intellectual Property Organization in partnership with the Portulans Institute and other corporate and academic network partners. The index is a composite indicator that ranks some 130 worldwide economies in terms of their enabling environment to innovation and their innovation outputs.

3 Innovation pillars are groups of indicators reflecting the enabling environment to innovation and the innovation outputs of a particular jurisdiction.

"human capital and research", "business sophistication" and "knowledge and technology outputs".[4] Indeed, both places have often been viewed as successful cases of making use of proactive measures to foster cross-sector collaboration in I&T development.

1.4 The distribution of R&D activities conducted across the government, business and higher education sectors varies significantly in Hong Kong, Singapore and Israel. In Israel and Singapore, the business sector was the dominant player in conducting R&D activities, contributing to 90% of GERD in 2020 and 61% of GERD in 2019 respectively (**Figure 1**). In contrast, the higher education sector led other sectors in Hong Kong by contributing over half of GERD in 2020, slightly outpacing the business sector (at 42%). According to the latest available figures, Israel and Singapore were ahead of Hong Kong in terms of the number of R&D personnel, at the levels of 8 342 [5] and 8 087 [6] per million population respectively. The corresponding figure in Hong Kong was 4 862 in 2020.

Figure 1 – GERD as a percentage of GDP by performing sectors, 2020(1)



Notes: (1) The figure in bracket refers to the share of total GERD contributed by the respective performing sector.
(2) Figures of Singapore are as at 2019. The government sector figure also includes R&D activities of the public research institutes.

Sources: Census and Statistics Department (2022), Central Bureau of Statistics (2021b) and National Research Foundation and Agency for Science, Technology and Research (2020).

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4 See World Intellectual Property Organization (2021).

5 The latest figure reported in the Global Innovation Index 2020. See Cornell University et al. (2020).

6 The figure was as at 2019. See National Research Foundation and Agency for Science, Technology and Research (2020).

1.5 At the request of Dr Hon CHOW Man-kong, the Research Office has prepared this ***Information Note*** which studies the major measures adopted in selected places for promoting cross-sector collaboration in I&T development, as well as the related outcomes, challenges encountered and recent developments. This Note will first review the case of Hong Kong, then followed by the relevant experience in Singapore and Israel, in terms of the government measures adopted to promote local I&T development, with focus specifically on initiatives targeted at encouraging cross-sector collaboration in R&D activities and translating related outcomes into commercial products and services.

2. Hong Kong

2.1 After Hong Kong's economy fell into recession consequential to the outbreak of the Asian financial crisis in 1997, the Government put I&T development to the fore as a new engine to achieve more diversified economic growth. In 1998, the then Chief Executive Mr TUNG Chee-hwa mapped out an I&T blueprint in his Policy Address with measures to support R&D activities and their applications.[7] To formulate and implement policies and measures to promote I&T, as well as promote cross-sector collaboration, the Innovation and Technology Commission ("ITC") was set up within the then Commerce and Industry Bureau in 2000, and was subsequently placed under ITB in 2015 when the dedicated bureau was established and put in charge of the holistic I&T policies through a high-level leadership.

2.2 Added to this, the Government has since 2017 stepped up I&T development in eight major areas[8] to drive economic diversification, create quality employment opportunities and improve citizens' quality of life. The Steering Committee on Innovation and Technology, chaired by the then Chief Executive Mrs Carrie Lam, was also established in December 2017 to steer collaboration across bureaux and departments in driving I&T development in Hong Kong. The current Chief Executive Mr John Lee has in his election manifesto also stressed a commitment to developing Hong Kong as an I&T centre to facilitate the city's economic transformation. In July 2022, ITB was retitled as the Innovation, Technology and Industry Bureau.

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7 Major initiatives under the blueprint included establishing an Innovation and Technology Fund to support R&D projects and setting up the Hong Kong Applied Science and Technology Research Institute to enhance local I&T development.

8 These comprise: (a) increasing resources of R&D; (b) pooling together technology talent; (c) providing investment funding; (d) providing technological research infrastructure; (e) reviewing existing legislation and regulations; (f) opening up government data; (g) leading changes to Government's procurement arrangements; and (h) strengthening popular science education.

Innovation and technology ecosystem in Hong Kong

2.3 As mentioned in section 1 of this Note, the higher education sector has been the key player in Hong Kong in conducting basic research, and the associated expenditure on its R&D activities accounted for 53% of GERD in 2020. Their research expenditures were mainly financed by grants from the University Grants Committee ("UGC") and its advisory body, the Research Grants Council ("RGC"),[9] as well as from other public institutions. Meanwhile, the commercialization of academic research results is usually managed by a technology transfer office ("TTO") associated with its respective university.

2.4 The business sector accounted for another 42% of GERD in Hong Kong. Yet only some 4 100 business establishments (or around 1% of businesses in Hong Kong) had undertaken in-house R&D activities in 2020, and just some 14% (around 600) of these business establishments had collaboration arrangements on R&D activities with other organizations such as higher education institutions, public research institutes or affiliates of the establishments concerned.

2.5 Notwithstanding the relatively smaller share (5%) of GERD as a performing sector, the Government has over the years assumed the roles of **facilitator** and **major funding source** in I&T development, providing research facilities, infrastructure, and financial incentives and support to the business and higher education sectors to develop and apply I&T. Reflecting this, R&D expenditure financed by the Government amounted to 51% of GERD in 2020.[10] In addition, promoting cross-sector collaboration and nurturing talent are among other key objectives of the Government's I&T policy.

Measures for promoting cross-sector collaboration in I&T development

2.6 As cross-sector collaboration is crucial to bringing synergy to R&D and commercialization activities, the Government has over the years (a) established relevant institutions and infrastructure; and (b) implemented a range of financial

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[9] UGC allocates recurrent grants to the universities in the form of a block grant of which the "research portion" accounts for about 23% of the grant. To promote research excellence, UGC has been allocating some 50% of the "research portion" to its funded universities on a more competitive basis according to their success in obtaining peer reviewed RGC Earmarked Research Grants. The other half is allocated with regard to the universities' performance in the Research Assessment Exercise.

[10] For the R&D activities in the higher education sector specifically, apart from providing funding via UGC and RGC to support such activities, the Government has provided extra funding to TTOs of seven designated universities since 2013-2014 to enhance their technology transfer capabilities.

support programmes to promote the collaboration. The specifics of the relevant measures are summarized in the paragraphs below.

Establishment of relevant institutions and infrastructure

2.7 The Government set up the Hong Kong Science and Technology Parks Corporation ("HKSTPC") in 2001, the Cyberport in 2003, and five R&D Centres in 2006[11] to provide the infrastructure and platforms for stakeholders to connect and catalyse their innovations into business solutions. The Hong Kong Science Park managed by HKSTPC is set up to provide R&D office and laboratories for innovation and entrepreneurship, while Cyberport is established as a hub for digital technology, whereas the R&D Centres are tasked to drive and coordinate applied R&D as well as promote commercialization of R&D results and technology transfer in their respective focus areas. In addition to these R&D and I&T platforms emerged over the past two decades or so, the Hong Kong Productivity Council, which was established in 1967 to support local enterprises in improving their productivity and competitiveness, has in recent years expanded its mandate to cover I&T development, including facilitating local enterprises to implement re-industrialization through adoption of new technologies.

2.8 More recently, two research clusters were set up at the Hong Kong Science Park, namely (a) the "*Health@InnoHK*" focusing on healthcare technologies; and (b) the "*AIR@InnoHK*" focusing on artificial intelligence and robotics, with a view to pooling together talent from around the world and developing Hong Kong as the hub for global research collaboration. Under the two research clusters, 28 research laboratories that were set up by local universities in collaboration with world-renowned universities and research institutes have already commenced operation as at June 2022.

2.9 The central government has also provided solid support to Hong Kong's development into an international I&T hub as well as taking forward closer integration among cities in the Greater Bay Area ("GBA"). A flagship project on this front is the construction of the **Hong Kong-Shenzhen Innovation and Technology Park** ("HSITP") in the Lok Ma Chau Loop in 2017 to provide the platform for I&T enterprises, R&D institutions and academia from around the world to

[11] The Government in 2006 set up four R&D Centres, namely: (a) Automotive Platforms and Application Systems R&D Centre; (b) Hong Kong Research Institute of Textiles and Apparel; (c) Logistics and Supply Chain MultiTech R&D Centre; and (d) Nano and Advanced Materials Institute. These R&D centres are funded by ITC. Also in 2006, the Hong Kong Applied Science and Technology Research Institute, which was established in 2000 and financed by the Government's annual recurrent subvention, was designated as the R&D Centre for Information and Communications Technologies.

collaborate on R&D and commercialization activities. HSITP also positions itself as a major cooperation platform for GBA,[12] together with the potentially synergistical development of areas around Lok Ma Chau/San Tin to form the San Tin Technopole.

Implementation of various financial support programmes

2.10 The Government has also promoted cross-sector collaboration with providing **financial support** to stakeholders through various funding schemes under the **Innovation and Technology Fund** ("ITF") administered by ITC.[13] ITF was initially set up in 1999 with an appropriation of HK$5 billion. The fund has received several rounds of capital injection since its inception, amounting to a total of HK$41.2 billion as at April 2022.[14] In 2020-2021, the annual expenditure of ITF, including funding of projects which had elements of promoting cross-sector collaboration, totaled some HK$4.8 billion, up from over HK$700 million in 2013-2014.[15] The Innovation and Technology Support Programme ("ITSP"), which has approved over HK$10 billion so far, is the largest programme under ITF. On top of more general support to R&D activities, ITSP has a mandate to promote platform projects that are industry-oriented and partly-funded by industry players. Meanwhile, programmes such as (a) the R&D Cash Rebate Scheme; (b) Partnership Research Programme; (c) Guangdong-Hong Kong Technology Cooperation Funding Scheme ("TCFS"); (d) Mainland-Hong Kong Joint Funding Scheme; (e) Public Sector Trial Scheme; and (f) Technology Start-up Support Scheme for Universities are more focused on encouraging different modes of cross-sector collaboration.

Observed outcomes and issues of concern

2.11 Under the support of ITF and other related measures, cross-sector collaboration in R&D and commercialization activities has achieved positive progress in the following areas:

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[12] The first batch of eight buildings of HSITP will be completed in phases from end-2024 onwards.

[13] At present, ITF supports 17 funding schemes under five areas, namely (a) supporting R&D; (b) facilitating technology adoption; (c) supporting technology startups; (d) nurturing I&T talent; and (e) fostering an I&T culture. ITF also funds in full or in part the operating expenses of specified R&D entities in Hong Kong. As at April 2022, these R&D entities included: (a) 16 State Key Laboratories in Hong Kong; (b) six Hong Kong Branches of the Chinese National Engineering Research Centres; (c) 28 research laboratories set up under the *InnoHK* Research Clusters; (d) four R&D Centres under ITC; and (e) TTOs of seven UGC-funded universities.

[14] Major funding schemes under ITF that have elements of promoting cross-sector collaboration, together with their key features and the statistics of approved projects, are listed in **Appendix 1**.

[15] See Innovation and Technology Bureau and Innovation and Technology Commission (2022).

(a) according to a recent study commissioned by ITC on examining the impact of selected funding schemes under ITF,[16] it was estimated that 33% of completed or ongoing projects funded under ITSP had generated commericalization income,[17] 31% had patents granted and 15% had resulted in the establishment of startups or spin-off companies. The corresponding figures for projects funded under TCFS were 18%, 56% and 21%;[18]

(b) the number of patents granted to universities whose **TTOs** have been supported under ITF was more than double from 319 in 2014-2015 to 729 in 2020-2021, and the number of patent licensing agreements increased from 333 to 631 during the period;[19] and

(c) the "level of industry income"[20] of the five **R&D Centres** consistently met the target of 30% between 2017-2018 and 2020-2021, and the level of commercialization income amounted to HK$60 million in 2020-2021, up by 22% compared to 2017-2018. According to an independent study commissioned by ITC, the economic contribution brought about by the five R&D Centres reached $4.35 billion in 2019-2020, up by 7% compared to 2017-2018.[21]

2.12 Notwithstanding the above-mentioned progress, there are views that cross-sector collaboration and related I&T developments in Hong Kong are faced with challenges including:[22]

(a) the current performance evaluation criteria of researchers and funding allocation mechanism of research institutions may at times be **incentivizing competition rather than gearing towards**

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16 See Innovation and Technology Bureau and Innovation and Technology Commission (2021a).

17 The cumulative commercialization income generated from projects funded under ITSP was HK$3.7 billion.

18 The cumulative commercialization income generated from projects funded under TCFS was HK$248 million.

19 See Innovation and Technology Bureau and Innovation and Technology Commission (2021a, 2022).

20 The Government has adopted a new indicator on the "level of industry income" from 2017-2018 to assess the performance of R&D Centres in soliciting support of and transferring technologies to the industry. The indicator covers the sponsorship and commercialization income from R&D projects supported by the industry, and the amount of which must account for at least 30% of the approved project expenditure ("the 30% target").

21 See Innovation and Technology Bureau and Innovation and Technology Commission (2019, 2021b).

22 See Our Hong Kong Foundation (2019, 2020).

encouraging interdisciplinary and cross-institutional collaboration, thus failing to foster the development of a collaborative research culture and environment;

(b) the role of the R&D Centres in working with universities/research institutes and the industry in conducting translational R&D work and promoting their connection needs further stepping up;

(c) inadequate adoption of locally developed technologies for public use, hence limiting the effect of promoting commercialization of research outcomes from local academia/research institutes;

(d) inefficient funding mechanism of the funding bodies in terms of prolonged approval process, and potential hurdles to more holistic planning due to the project-based nature of funding approvals;[23] and

(e) the funding sources of R&D is fragmented[24] and the resulting lack of an overarching R&D strategy to guide funding allocation.

Recent developments

2.13 The Government has identified a number of key areas of development including biotechnology, artificial intelligence and robotics, smart city and financial technology, and is committed to promoting positive interaction among the industry, academia and research sectors. Regarding the provision of research infrastructure, the Government has planned to expedite the development of projects that would be conducive to fostering cross-boundary collaboration, including HSITP and the San Tin Technopole envisaged under the Northern Metropolis Development Strategy.

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[23] For example, there are comments that the funding for research projects undertaken by the five R&D Centres are approved on a project-by-project basis and may involve long processing time. As such, the R&D Centres may not be able to make more holistic planning on the development of their respective fields of research.

[24] The R&D funding sources include (a) ITF administered by ITC; (b) research funding schemes managed by other government authorities such as the Health Bureau (e.g. the Health and Medical Research Fund) and the Environment and Ecology Bureau (e.g. the Green Tech Fund); and (c) research funding allocated by RGC for UGC-funded universities and self-financing degree-awarding institutions. The allocation of R&D funding of the respective authorities is based on their individual visions and objectives.

3. Singapore

3.1 Factors such as limited supplies of land and natural resources have prompted Singapore to prioritize the development of science and technology ("S&T") since independence. The establishment of the Science Council in 1967 and the Ministry of Science and Technology in 1968 were fundamental to Singapore's advancement of S&T and restructuring of technology education. In 1991, the National Science and Technology Board ("NSTB") replaced the Science Council, and was put in charge of formulating and implementing the long-term R&D strategies for Singapore. The arrangement of publishing five-year national technology plans was inaugurated in the same year, setting out the overarching visions, strategies and resources committed for R&D for each five-year period.

3.2 The national technology plan was expanded to span Research, Innovation and Enterprise ("RIE") development since the 2010s and include **translation, commercialization and innovation strategies** to tap on the growing pipeline of research outputs and support the enterprises for fostering economic growth in the aftermath of the global financial crisis. For the latest RIE2025 plan, Singapore would expand its reach and support to local enterprises in technology translation and commercialization, thereby accelerating the speed at which companies can translate R&D into market-ready products and solutions.

Innovation and technology ecosystem in Singapore

3.3 The business sector features more predominantly in I&T development in Singapore, accounting for 61% of GERD in 2019. The success in attracting global companies (including 80 of the world's top 100 technology companies) to establish a presence in Singapore provides further impetus in the ecosystem by creating vibrant clusters and enabling knowledge transfer to local enterprises.

3.4 The Singaporean government has played a **proactive and leading role** in spearheading local I&T development, with dedicated **high-level authorities** established over the years to ensure the relevancy of the R&D outcomes to the economy. Of particular relevance was the establishment of the **Agency for Science, Technology and Research** ("A*STAR") in 2002 to replace NSTB as a statutory board formed under the Ministry of Trade and Industry. A*STAR has played an important role in driving mission-oriented research and promoting cross-sector collaboration in R&D and commercialization activities. In addition to A*STAR, Singapore also established the **Research Innovation Enterprise Council** ("RIEC") in 2006 as a high-level council chaired by the Prime Minister to provide the strategic

direction for national R&D development.[25] To support RIEC, the **National Research Foundation** ("NRF") was formed in the same year under the Prime Minister's Office to plan, coordinate and monitor the execution of the strategies as laid down in the series of five-year national technology plans. Altogether, R&D activities of the government and public research institutes accounted for 23% of Singapore's GERD in 2019.

3.5 R&D activities of the higher education sector took up the remaining (17%) GERD in 2019. To support cross-sector collaboration, NRF has teamed up with the Ministry of Education to promote research excellence of the local universities by establishing **Research Centres of Excellence** in designated universities.[26] **TTOs** have been formed in the major universities under the support of the Ministry of Education to facilitate engagement with the industry.

Measures for promoting cross-sector collaboration in RIE development

3.6 The Singaporean government has proactively promoted cross-sector collaboration in RIE development through the implementation of a wide range of facilitation measures as set out in the series of five-year national technology plans. These measures include: (a) establishing relevant **institutions and infrastructure**; (b) forming **designated platforms** to promote collaborative efforts at different R&D stages; and (c) launching **financial support programmes** to enable collaborative RIE activities.

Establishment of relevant institutions and infrastructure

3.7 Under A*STAR, two research councils were set up to oversee 17 research institutes, three research programmes and five resource centres/research platforms which have different areas of research focus. Besides, its commercialization division is tasked with promoting synergies between A*STAR and other stakeholders in collaboration, licensing and spin-off efforts.

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[25] RIEC comprises cabinet ministers and distinguished local and overseas members from the business, science and technology sectors. The Council advises the Cabinet on national RIE strategies and leads the efforts on strengthening enterprise innovation capabilities and accelerating technology translation.

[26] Five Research Centres of Excellence were established between 2007 and 2011 in the two largest universities in Singapore, namely the National University of Singapore and the Nanyang Technological University to attract world-class academic investigators, train high-quality research talent and create new knowledge in specific areas.

3.8 In addition, Singapore established eight **Centres of Innovation** ("COIs")[27] in 2006 to assist small-to-medium enterprises ("SMEs") in upgrading their technological and innovation capabilities. These COIs are administered by the Enterprise Singapore[28] in partnership with selected polytechnics and research institutes to provide ready resources such as laboratory facilities, training courses, testing services and technology consulting to SMEs in specific industries.

3.9 As for R&D infrastructure, the Singaporean government invested in the development of the **Singapore Science Park** ("SSP")[29] in the 1980s and the **one-north project**[30] in the 2000s, with a view to providing a conducive environment for R&D activities and attracting foreign investment in such activities. Furthermore, NRF established the **Campus for Research Excellence and Technological Enterprise** ("CREATE")[31] in 2012 to attract global universities and research institutes to collaborate with Singaporean researchers in interdisciplinary research.

Formation of designated platforms

3.10 To support the implementation of the RIE plans, the relevant authorities have set up the following designated platforms to promote cross-sector collaboration:

(a) **technology consortia** – NRF has since 2014 worked with institutes of higher learning to set up 11 technology consortia in collaboration with industry partners in specific technology areas to facilitate knowledge sharing and technology transfer. The technology consortia promote academia-industry interaction through activities such as technology seminars and joint research projects which are conducive to development of industry-relevant technologies and commercialization of research outcomes;

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[27] The eight COIs cover the following industries: (a) aquaculture; (b) energy; (c) electronics; (d) supply chain management; (e) environment and water; (f) food; (g) complementary health products; and (h) precision engineering.

[28] The Enterprise Singapore, established in 2018, is a statutory board under the Ministry of Trade and Industry entrusted with, among others, assisting enterprises to build their capabilities and develop their overseas market.

[29] SSP is a research, development and technologies hub home to over 350 multinationals, global leading technology companies, and laboratories.

[30] One-north is a 200-hectare development project combining educational institutes, residences and recreational amenities with research facilities to create a "work-live-play-learn" environment.

[31] CREATE is an international research campus and innovation hub, which hosts NRF and other research centres, startups and laboratories.

(b) **Innovation and Enterprise** ("**I&E") platforms** – NRF has also supported the formation of various I&E platforms, to be overseen by A*STAR, in an effort to bring together stakeholders across the R&D community, industry, government agencies and regulators to share knowledge, expertise and technology, and to support industry to **accelerate the translation of R&D results** into market-ready products and solutions. Prominent examples are the **Diagnostics Development Hub** which was set up in 2014 to support the development and regulatory approval of novel diagnostic solutions for global market adoption and the **National Additive Manufacturing Innovation Cluster**, which was established in 2015 to accelerate additive manufacturing [32] applications in industry sectors such as aerospace, maritime and logistics; and

(c) **Open Innovation Network** ("OIN") – The Enterprise Singapore and the Infocomm Media Development Authority set up OIN in 2019 to provide a platform for businesses or government agencies to share their challenges, and for innovators, startups or enterprises to respond with innovative solutions and seek co-development and test-bedding opportunities. The **National Innovation Challenges** initiative launched in 2020 rides on OIN to invite research performers, SMEs and Startups to fast track solutions for overcoming industry-wide or nation-wide challenges faced by the public and private sectors in the post-pandemic world.[33]

Implementation of various financial support programmes

3.11 Furthermore, the Singaporean government has launched a range of **funding schemes** under NRF, A*STAR, and the Enterprise Singapore to support cross-sector collaboration in RIE activities.[34] A list of the major funding programmes administered by the relevant government agencies to promote cross-sector collaboration in RIE development are summarized in **Appendix 2**.

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[32] Additive manufacturing, also known as three-dimensional ("3D") printing, uses data computer-aided-design software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes.

[33] The government has earmarked S$40 million (HK$225 million) to support the development and adoption of solutions for the challenges raised, with a ceiling of S$2 million (HK$11 million) being allocated for each challenge.

[34] See Agency for Science, Technology and Research (2022a), National Research Foundation (2016, 2022), and Nawaz and Koç (2020).

3.12 Over the years, the allocation of resources under the various funding schemes has been **guided by the strategic goals and key domains for development** laid down in the respective five-year national technology plans. In the past decade, the funding schemes have focused on increasing **industry participation** in RIE activities, and supporting collaborative RIE projects that have high **industry relevance** and **potential economic impacts**. For example, the **Corporate Laboratories in Universities Scheme** launched by NRF in 2013 supports local or foreign companies to collaborate with the local universities on industry-relevant research by funding the establishment of corporate laboratories in the universities. Another example is the **Industry Alignment Fund (Industry Collaboration Projects) Scheme** administered by A*STAR which supports public research institutes to work with the industry in strategic R&D projects. This funding scheme is different from typical academic grants, as proposals will be assessed primarily on their potential economic impact and relevance to building up Singapore's R&D ecosystem.

3.13 Furthermore, A*STAR introduced the **Growing Enterprises through Technology Upgrade ("GET-Up") Programme** almost two decades ago to assist local enterprises to upgrade their technological capabilities through collaborative efforts. The Technology for Enterprise Capability Upgrading Scheme under the Programme provides funding for arranging **secondment of research scientists and engineers ("RSEs") from academia/research institutes to local enterprises** for up to two years to help them improve their production process or develop products.[35] Other supports provided under the GET-Up Programme include providing technical advice to local enterprises on their technology upgrade plan and R&D activities.

Observed outcomes

3.14 Singapore has seen positive progress in some of the initiatives/measures taken to promote cross-sector collaboration in RIE activities over the past decade or so. These include:[36]

(a) support offered to local enterprises by A*STAR – about 2 400 projects had been completed and over 300 A*STAR RSEs were seconded to help local enterprises scale up and innovate between 2016 and 2020;

(b) support provided by COIs – about 980 projects had been completed for over 700 SMEs between 2016 and 2020;

[35] See Appendix 2 for key features of the funding scheme.

[36] See Agency for Science, Technology and Research (2022b), Diagnostics Development Hub (2022), NAMIC Singapore (2022) and National Research Foundation (2021a, 2021b).

(c) work progress of I&E platforms – the National Additive Manufacturing Innovation Cluster has engaged some 1 900 companies and catalysed about 240 projects since 2015, while the Diagnostics Development Hub has supported some 40 startups or spinoffs and catalysed the launch of over 20 products since 2014; and

(d) responses to the National Innovation Challenges – a total of 18 challenge statements were launched since July 2020, with over 900 submissions received and 21 prototypes being selected.

Recent developments

3.15 According to the latest RIE2025 plan, the Singaporean government will commit to sustaining its investment in R&D,[37] putting focus on those key domains that are of strategic importance to the country such as manufacturing, healthcare, urban solutions and sustainability, as well as developing a smart nation and digital economy. In light of the effectiveness of the I&E platforms in supporting industries to translate R&D into new products and services, the government has also planned to support existing platforms to move into adjacent areas with high growth potential, such as from supporting diagnostics development to medical technology, and establish new platforms to tap on R&D strengths in other domains. These platforms will complement other initiatives such as technology consortia and corporate laboratories to further increase the base of enterprises engaging in RIE development and strengthen their innovation capabilities.

4. Israel

4.1 Due partly to geopolitical factors, Israel has put I&T development, especially technology with potential military applications, at the top of the government agenda. In 1969, the Israeli government strengthened efforts to support I&T development by establishing the Office of the Chief Scientist ("OCS") under the then Ministry of Trade and Industry for administering policy measures to boost industrial R&D activities in the private sector. In 1980s, OCS focused on further encouraging local businesses to engage in R&D activities to develop science-based and export-oriented products. The creation of Yozma by the Israeli government in 1993 was a key step in building a robust I&T ecosystem in the country, as this venture capital fund backed by public money helped leverage foreign financing to invest in

[37] The committed budget will reach S$25 billion (HK$141 billion) (around 1% of GDP) between 2021 and 2025, up by 32% compared to that of the previous five-year period.

high-technology startups and consolidate the reputation of Israel as the "Startup Nation".[38]

4.2 Israel's I&T industry continued to benefit from factors such as the influx of science and engineering talent (particularly those from the former Soviet Union in the 1990s), the interest from multinational companies in setting up R&D centres in Israel to take advantage of the government's incentive measures, and the successful commercialization of R&D results driven by the academia. Israel has emerged to be an I&T leader in many fields, including water science, agricultural technology, stem cell research, computer science, artificial intelligence and cyber security.

Innovation and technology ecosystem in Israel

4.3 In Israel, the **business sector** is the dominant player in the I&T ecosystem and their R&D activities accounted for 90% of GERD in 2020. Currently, Israel is the home to over 350 R&D centres set up by multinational corporations, the activities of which account for about half of business sector GERD.

4.4 In addition, the eight research universities of the **higher education sector** have been instrumental in the advancement of scientific knowledge and technology transfer in Israel. They have well-established **technology transfer companies** ("TTCs") as their commercial arm, with the first one coming into place as early as in 1959. At present, TTCs function as profit-making subsidiaries of their respective universities, tasked with bridging the gap between scientific research and translation of the results into marketable products by assessing the commercial potential of the research outputs, filing for patents and other propriety rights, and actively seeking interested commercial partners for launching the products. Meanwhile, the **Israeli government** serves mainly as an **enabler** in promoting I&T development by providing the necessary infrastructure, financial support and regulatory environment to attract local and foreign investment and encourage industry-led and academia-led R&D and I&T activities.

Measures for promoting cross-sector collaboration in I&T development

4.5 The Israeli government has all along adopted a non-intervention approach towards R&D and commercialization activities in the country which have mostly been led by the industry and academia. Nonetheless, as the enabler of innovation, the government has promoted cross-sector collaboration in R&D and

[38] Israel has been known as the "Startup Nation" as it has a very active venture capital market and has the largest number of startups per capita in the world.

commercialization activities through (a) establishment of a dedicated government authority to administer the relevant measures; and (b) introduction of a range of incentive programmes to engage the industry and academia/research institutes in collaborative efforts.

Establishment of an independent authority to oversee I&T development

4.6 The Israeli government established the **Israel Innovation Authority** ("IIA") in 2016 to replace OCS as an independent public agency to coordinate and implement government policies for advancing I&T development in Israel. The establishment of IIA stems from the Israeli government's recognition of the need to respond promptly to the changing needs and challenges faced by the stakeholders in the ecosystem. IIA has been empowered to devise a range of supporting tools and incentive programmes to assist the pursuit of R&D and I&T projects at the academia/research institutes and the business sector, and support cross-sector collaboration.

Implementation of various incentive programmes

4.7 The Technological Infrastructure Division of IIA, one of the six divisions of the agency,[39] administers a series of **incentive programmes** to support academia/research institutes and industry collaboration in: (a) forming consortia to develop industry-relevant groundbreaking technology; (b) technology transfer for developing products with commercialization potential; and (c) commercialization of research outputs and technologies.

4.8 In addition, IIA has implemented incentive programmes through its respective divisions to **support collaborative R&D activities of specific business sectors**. Major schemes include: (a) providing **startups** with support of infrastructure and expertise through innovation laboratories operated by the industry's leading corporations with the subsidy of IIA; (b) providing **high-technology companies** with funding and other support such as regulatory assistance and access to testing facilities to collaborate with government entities on R&D or pilot projects of strategic importance; and (c) offering assistance to **manufacturing companies** without R&D experience to access professional consultation and guidance on taking up R&D. The key features of the

[39] The other five divisions are: (a) Startup Division; (b) Growth Division; (c) Advanced Manufacturing Division; (d) International Collaboration Division; and (e) Societal Challenges Division.

above-mentioned incentive programmes for promoting cross-sector collaboration are highlighted in **Appendix 3**.

4.9 In order to **engage participation of the private sector** in I&T development and collaborative activities, IIA offers grants of 20% to 50% of the approved R&D expenditure of eligible companies, and a range of incentive programmes to encourage Israeli and foreign companies to collaborate on technology upgrade and commercialization-focused projects.

Observed outcomes and issues of concern

4.10 IIA's efforts to promote cross-sector collaboration in I&T development have achieved positive progress. In 2021, some 380 applications with elements of supporting cross-sector collaboration had been approved under the major incentive programmes with a total of some ILS 420 million (HK$1.0 billion) grants approved.[40] Reflecting the outcomes of the collaborative efforts of academia/research institutes and industry in recent years,[41] 497 original patent applications were filed by TTCs associated with universities in 2020, up from 457 in 2016. The number of academic articles published in conjunction with at least one industry entity by the eight research universities increased from 1 988 to 2 845 between the periods 2006-2009 and 2016-2019.[42]

4.11 Notwithstanding the above achievements, IIA has noticed the gradual decreasing share of R&D activities undertaken by the academia sector[43] and the tendency for the R&D activities of technology companies to be less original, more conservative and profit-oriented once they went public. These developments, if unaddressed, may undermine the quality of R&D and the competitiveness of the I&T sectors of Israel in the long-run. Besides, IIA has raised concern about the inadequate collaboration of the public and private sectors in developing and adopting technologies for public services that can benefit the general public.

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40 The figures mainly refer to those incentive programmes covered in Appendix 3.

41 According to a study conducted in 2021 on the Magnet Consortiums Program offered by IIA to promote academia/research institutes and industry collaboration, the major outputs of the consortia formed under the programme were academic articles and patents. See Israel Innovation Authority (2022a).

42 See Central Bureau of Statistics (2021a) and Israel Innovation Authority (2022a).

43 R&D activities in the academia sector as a share of GERD dropped from 14% in 2010 to 8% in 2020. See Central Bureau of Statistics (2021b).

Recent developments

4.12 In light of the emerging challenges faced by the I&T sectors as they reach a mature stage of development, IIA's recent strategic directions are to rekindle the attention to R&D activities of the academia sector in general and the collaboration between the academia and local technology companies in particular through implementation of the relevant incentive programmes. Furthermore, IIA has strengthened its mediating and facilitating role in promoting stronger collaboration between the public and private sectors to develop groundbreaking solutions in fields such as autonomous public transportation and modular construction with a view to improving the quality of life of the public in a more discernable manner. The incentive programmes designed for engaging high-technology companies to work with the government on R&D projects will also be a priority area of development.

5. Concluding remarks

5.1 The recent years have seen many developed economies leveraging on the progress in I&T development to drive local economic growth. Hong Kong, Singapore and Israel have all proactively introduced various policy measures to promote I&T development, of which cross-sector collaboration has been employed for turning R&D outputs into business innovations and bringing economic impacts. **Appendix 4** provides a comparison of the major measures adopted by them to promote cross-sector collaboration in I&T development and their related outcomes.

5.2 While **Hong Kong** is considered as having a later start in I&T development, the Government's staunch support to cross-sector collaboration in recent years has expedited growth in the industry. Establishment of relevant institutions and infrastructure, and the provision of funding support through ITF are the main measures adopted by the Government to promote cross-sector collaboration. Nonetheless, there are suggestions for (a) fostering commercialization activities in the higher education sector; (b) addressing some issues in funding mechanism (such as fragmentation, lack of a clearly articulated overarching R&D strategy, and arrangements under some schemes that may encourage competition instead of collaboration); (c) increasing involvement of the public sector in piloting the use of locally developed technologies to promote commercialization of the R&D results; and (d) better leveraging the opportunities arising from cross-boundary collaborations.

5.3 **Singapore** has been developing I&T in a strategic manner with a high involvement of the public sector under the government-led approach. Its five-year RIE plans feature, among other things, the government's consistent efforts to proactively promote cross-sector collaboration as a springboard for translating the

solid foundation of scientific research into business opportunities and generating favourable economic outcomes. Four distinctive features in facilitating cross-sector collaboration are noted: (a) guiding resources allocation and funding support by the overarching strategic goals laid down in the RIE plans; (b) active involvement of authorities and public research institutes in stakeholder engagement and collaborative RIE activities; (c) devising clear targets for funding schemes regarding increasing industry participation in RIE activities and supporting collaborative projects that have high industry relevance and potential economic impact; and (d) setting up designated platforms to connect stakeholders and support collaboration in research, translation and innovation activities.

5.4 Meanwhile, **Israel** is in a league of its own with a very mature yet dynamic I&T ecosystem uniquely characterized by (a) a high involvement of the private sector in both sponsoring and undertaking R&D activities; (b) a number of well-regarded commercialization arms established by research universities; and (c) a flourishing startup environment backed by a thriving venture capital market. The resultant culture in the ecosystem is one of the key factors in fostering close connection among different stakeholders. The Israeli government has played an enabling role to provide the necessary infrastructure and regulatory environment, as well as fund specific incentive programmes to encourage collaboration between industry and academia/research institutes at different stages of the R&D value chain.

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Major funding schemes under the Innovation and Technology Fund for promoting cross-sector collaboration

Funding schemes	Year of launch	Key features	Number of approved projects since launch[1]	Funds approved (HK$ million)[1]
A. Supporting R&D				
Innovation and Technology Support Programme	• 1999	• Supporting local R&D Centres, universities and other designated public research institutes to conduct applied R&D projects such as (a) seed projects that are exploratory and forward-looking in nature; (b) **platform projects that are industry-oriented with the industry partner contributing at least 10% of the project cost**; and (c) theme-based inter-disciplinary and translational R&D in collaboration with leading research institutes worldwide	• 2 903	• 10,702
Partnership Research Programme	• 2019	• Supporting applied R&D projects undertaken by local R&D Centres, universities or other designated public research institutes **in collaboration with a private company** • Requiring the **industry partner to contribute at least 50% of the total project cost** and allowing it to **own the intellectual property rights of the project outputs**	• 198	• 382
R&D Cash Rebate Scheme	• 2010	• Providing a **cash rebate for a company's contribution to applied R&D projects funded by the Innovation and Technology Fund ("ITF")** or **R&D projects contracted out to local public research institutes and funded entirely by the company** • Increasing the cash rebate level from 10% in 2010 to 30% in 2012 and further to 40% in 2016	• 510[2]	• 720[2]
Enterprise Support Scheme	• 2015	• Providing dollar-to-dollar matching funding of up to HK$10 million per project for local companies to conduct in-house R&D projects • Allowing the company participating in the scheme to own the intellectual property rights of the project outputs	• 182	• 541

Notes: (1) Figures are as at end-March 2022.
(2) The figure only covers partnership projects approved since April 2016.

Major funding schemes under the Innovation and Technology Fund for promoting cross-sector collaboration

Funding schemes	Year of launch	Key features	Number of approved projects since launch[3]	Funds approved (HK$ million)[3]
A. Supporting R&D (cont'd)				
Guangdong-Hong Kong Technology Cooperation Funding Scheme	• 2004	• Supporting R&D **collaboration among universities, research institutes and technology enterprises** in Hong Kong and Guangdong/Shenzhen • Requiring **industry partner to contribute at least 10% of the total project cost for platform projects** and **at least 50% for collaborative projects** • Allowing the industry partner in a collaborative project to **own the intellectual property rights of the project outputs**	• 329	• 959
Mainland-Hong Kong Joint Funding Scheme	• 2019	• Supporting R&D **collaboration among universities, research institutes and technology enterprises** in Hong Kong and the Mainland, with the R&D work conducted in both Hong Kong and the Mainland • Funding contribution requirement and intellectual property rights arrangement are broadly the same as the Guangdong-Hong Kong Technology Cooperation Funding Scheme	• 38	• 73
B. Facilitating technology adoption				
Public Sector Trial Scheme	• 2011	• Providing funding support for production of prototypes/samples of R&D outcomes and/or conducting trials in the public sector to **support commercialization of results of R&D projects funded by ITF**, and those **developed by incubatees or graduate tenants of the Hong Kong Science and Technology Parks Corporation or Cyberport, or by other technology companies**	• 327	• 678

Note: (3) Figures are as at end-March 2022.

Major funding schemes under the Innovation and Technology Fund for promoting cross-sector collaboration

Funding schemes	Year of launch	Key features	Number of approved projects since launch	Funds approved (HK$ million)
C. Nurturing technology startups				
Technology Start-up Support Scheme for Universities	• 2014	• Providing funding support to professors and students of six designated universities[4] to **start technology businesses and commercialize their R&D results** • Providing an annual funding of up to HK$8 million to each of the six designated universities and up to HK$1.5 million in a year for each funded technology startup for no more than three years	• 241 startups were supported[5]	• 191[5]
Innovation and Technology Venture Fund ("ITVF")	• 2017	• With an initial capital injection of HK$2 billion from the Government • **Co-investment of the Government** and selected venture capital funds in local I&T startups at a matching investment ratio of about 1 (for ITVF) to 2 (for the venture capital funds)	• 34 startups were supported[6]	• 198[7]

Notes: (4) It includes (a) the University of Hong Kong; (b) the Chinese University of Hong Kong; (c) City University of Hong Kong; (d) the Hong Kong University of Science and Technology; (e) Hong Kong Baptist University; and (f) the Hong Kong Polytechnic University.
(5) Only startups supported between April 2017 and February 2022 are covered.
(6) The figure is as at March 2022.
(7) The figure refers to the total investment of ITVF as at March 2022.

Sources: Innovation and Technology Bureau and Innovation and Technology Commission (2022) and Innovation and Technology Commission (2022).

Major funding schemes launched by the Singaporean government to promote cross-sector collaboration

Funding schemes	Administration agency	Key features	Progress
A. Supporting collaborative research, innovation and enterprise activities			
Corporate Laboratories in Universities Scheme	• National Research Foundation ("NRF")	• Supporting the **establishment of corporate laboratories by industry in local universities** to encourage academia-industry R&D collaboration • While the participating companies can tap on the technological capabilities of the universities to develop new products and services, the university researchers, who work alongside industry partners, are able to steer their research towards more impactful areas that can create value for the companies	• 16 corporate laboratories have been established since 2013, and the setup cost of each ranged from S$40 million (HK$227 million) to S$110 million (HK$625 million)
Central Gap Fund	• NRF	• Supporting **translation research projects undertaken by public research institutes** that aim to develop early technologies into working prototypes or functional processes that can generate economic and societal benefits, thereby encouraging collaboration across public research institutes and/or industry	• 27 projects have been supported under the scheme
Industry Alignment Fund (Industry Collaboration Projects) Scheme	• Agency for Science, Technology and Research ("A*STAR")	• Supporting **public research institutes to work with the industry** in strategic R&D projects that apply their R&D results to **address industry-relevant challenges** • Assessing the project proposals primarily on their potential economic impact and relevance to building up the R&D ecosystem, such as potential to generate product or process innovations, or bring cost reduction or productivity improvement to the industry players involved	• Information not available

Major funding schemes launched by the Singaporean government to promote cross-sector collaboration

Funding schemes	Administration agency	Key features	Progress
B. Encouraging technology adoption			
Technology for Enterprise Capability Upgrading Scheme under the Growing Enterprises through Technology Upgrade Programme	• A*STAR	• Providing financial support for full-time secondments or part-time attachments of **research scientists and engineers ("RSEs") from academia/research institutes to provide technical expertise and strategic guidance to small-to-medium enterprises** for strengthening their technological capabilities, as well as allowing RSEs to gain industry exposure	• More than 950 RSEs have been seconded to work with over 850 local companies since the scheme was introduced in 2003
C. Co-investing in technology startups			
Early Stage Venture Fund	• NRF	• Providing **co-funding** of S$10 million (HK$57 million) on a matching basis per fund to selected venture capital firms to invest in early-stage technology startups	• NRF awarded funds to 11 venture capital funds and four large local enterprises in three rounds of investment between 2008 and 2016 • In 2020, NRF co-invested with Temasek Holdings to support the commercialization of intellectual property from publicly-funded research

Sources: Agency for Science, Technology and Research (2022a), National Research Foundation (2016, 2022) and The Straits Times (2021).

Appendix 3

Major incentive programmes implemented by the Israel Innovation Authority to promote cross-sector collaboration

Incentive programmes	Key features	Progress in 2021
A. Supporting collaborative R&D and commercialization activities		
Magnet Consortiums Program	• Supporting **industry and academia/research institutes to form consortia for a period of three years to develop industry-relevant groundbreaking technology**, enabling the sharing of knowledge and cooperation between the consortium partners	• 11 consortia were provided with total grants of ILS 175 million (HK$421 million)
Academic Knowledge Transfer Program	• Encouraging **technology transfer from academia/research institutes to industry** through applied research for developing products with **commercialization** potential, bridging the knowledge gap between academia and industry needs	• 132 out of 205 new applications were approved. Including grants for existing projects, total grants of ILS 107 million were approved (HK$257 million)
Knowledge Commercialization Program	• Promoting cooperation of local or overseas academia/research institutes with an **Israeli industrial company to commercialize their technology** • The programme enables the company to adapt the knowledge developed by the academia/research institutes to its needs for developing groundbreaking products	• 58 out of 85 applications were approved involving total grants of ILS 48 million (HK$115 million)

Major incentive programmes implemented by the Israel Innovation Authority to promote cross-sector collaboration

Incentive programmes	Key features	Progress in 2021
B. Driving collaborative R&D in specific sectors		
Technological Innovation Labs Program	• Supporting **companies to set up innovation laboratories** which provide infrastructure and expertise for startups and facilitate collaboration with other companies in the industry	• 22 out of 28 applications were approved involving total grants of ILS 14 million (HK$34 million)
Joint Government Support Grants for Pilot Programs	• Providing high-technology companies with funding and other support (e.g. regulatory assistance, and access to state-owned testing locations and facilities) to work with government entities on R&D or pilot programmes in selected **fields such as transportation, environmental protection, digital health, space, cyber defence and agriculture**	• 67 out of 157 applications were approved involving total grants of ILS 69 million (HK$166 million)
R&D Preparatory Incentive Program for Manufacturing Companies	• Assisting **manufacturing companies** without prior R&D experience in adopting R&D or those requiring guidance of technical experts with their R&D activities	• 90 applications were approved involving total grants of ILS 6 million (HK$14 million)

Sources: Israel Innovation Authority (2020a, 2022a, 2022b).

Measures to promote cross-sector collaboration in Hong Kong, Singapore and Israel

	Hong Kong	Singapore	Israel
A. Measures to promote cross-sector collaboration			
Overall approach	• The government facilitates cross-sector collaboration by providing relevant infrastructural and financial support	• The government is actively involved in driving cross-sector collaboration by setting the overall development directions, devising a range of policy initiatives to enable collaboration and participating in the collaborative projects	• The government provides funding and other relevant support through a dedicated agency to facilitate tripartite collaboration in R&D activities
Establishment of relevant institutions and/or infrastructure	• Establishment of the Information and Technology Bureau (having been retitled as the Innovation, Technology and Industry Bureau recently) to formulate and implement holistic I&T policies • Investing in infrastructures such as the Hong Kong Science Park, the Cyberport, the Hong Kong-Shenzhen Innovation and Technology Park to nurture technology clusters and enable stakeholders to connect • Setting up five R&D Centres and two *InnoHK* Research Clusters to promote cross-sector collaboration in R&D and commercialization activities	• Establishment of (a) the National Research Foundation as a high-level authority to plan and implement research, innovation and enterprise ("RIE") strategies; (b) the Agency for Science, Technology and Research ("A*STAR") to lead public research efforts and promote cross-sector collaboration; and (c) Centres of Innovation ("COIs") to support RIE activities of small-to-medium enterprises ("SMEs") • Investing in infrastructures such as the Singapore Science Park and the one-north project to nurture research and innovation clusters of different fields • Setting up designated platforms such as technology consortia, Innovation and Enterprise platforms and open innovation network to promote collaborative efforts in various RIE activities	• Establishment of the Israel Innovation Authority ("IIA") to plan and administer relevant support programmes

Measures to promote cross-sector collaboration in Hong Kong, Singapore and Israel

	Hong Kong	Singapore	Israel
A. Measures to promote cross-sector collaboration (cont'd)			
Implementation of financial support programmes	• Providing financial support through relevant funding schemes under the Innovation and Technology Fund ("ITF")	• Introducing funding schemes that specifically aim at increasing industry participation in RIE activities, and supporting collaborative projects that have high industry relevance and potential economic impact • Devising tailored programmes to support local enterprises	• Launching specific incentive programmes to promote academia/research institutes and industry collaboration at different R&D stages, and assisting specific business sectors in collaborative R&D activities • Offering R&D grants and incentives to engage the private sector in collaborative R&D activities

Measures to promote cross-sector collaboration in Hong Kong, Singapore and Israel

	Hong Kong	Singapore	Israel
B. Outcomes			
Indicators reflecting progress of the respective measures	• Number of patents granted to universities whose technology transfer offices were supported under ITF – 729 in 2020-2021, up from 319 in 2014-2015 • Percentages of projects sponsored under the Innovation and Technology Support Programme ("ITSP") and the Guangdong-Hong Kong Technology Cooperation Funding Scheme ("TCFS") that had patents granted – 31% and 56% respectively • Commercialization income of the five R&D Centres – HK$60 million in 2020-2021, up by 22% from 2017-2018 • Percentages of projects sponsored under ITSP and TCFS that had generated commercialization income – 33% and 18% respectively	• Number of collaborative projects between A*STAR and local enterprises between 2016 and 2020 – about 2 400 • Number of collaborative projects between COIs and local SMEs between 2016 and 2020 – about 980 • Number of projects catalysed by the National Additive Manufacturing Innovation Cluster since 2015 – about 240 • Number of products launched under the Diagnostics Development Hub since 2014 – over 20	• Original patent applications filed by technology transfer companies associated with universities – 497 in 2020, up from 457 in 2016 • Number of academic articles published in conjunction with at least one industry entity by the eight research universities – 2 845 in 2016-2019, up from 1 988 in 2006-2009

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Note: ^ Internet resources listed in this section were accessed in July 2022.