OUR HONG KONG FOUNDATION
團結香港基金

Unleash the Potential in Science and Technology Innovation: Develop Hong Kong into an International R&D Powerhouse

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Executive Summary

Introduction

Although Hong Kong is one of the world's most competitive economies, it has a significant shortcoming, as it lacks a strong capability to innovate, especially in comparison with some other small open economies which have prioritised innovation as a driver for economic growth. In future, innovation has great potential to be a growth engine for Hong Kong, as long as the city raises its innovation capability through science and technology innovation. In fact, when it comes to science and technology innovation, Hong Kong already has a competitive advantage in basic research, making it well-positioned to develop into an international research and development (R&D) powerhouse.

As scientific developments and challenges become more complex and multi-faceted, interdisciplinary and cross-institutional collaboration must be strengthened to enable Hong Kong to become an international R&D powerhouse. There are two preconditions necessary for fostering an effective collaborative research environment: (i) an efficient and strategic funding system; and (ii) a sustainable talent pipeline. This report puts forward seven recommendations to address the seven identified challenges across three sections: (i) funding, (ii) talent, and (iii) collaboration.

Section 1: Providing Higher-level Strategies and Aligning the R&D Funding System

Challenge 1: Fragmented R&D Funding Sources in Hong Kong

The fragmented R&D funding sources in Hong Kong cause inconsistencies and redundancies, posing a significant challenge to Hong Kong's development into an R&D powerhouse. Such fragmentation also leads to the absence of an overarching strategy to guide funding allocation.

Recommendation 1: Establish an Overarching Research and Development Foundation (RDF)

This report recommends that the Steering Committee on Innovation and Technology (SCIT), chaired by the Chief Executive since 2017, should consider establishing a Research and Development Foundation (RDF) to create better alignment of all R&D funding from various Government agencies. The RDF takes references from Singapore and the United Kingdom, as they have established similar overarching entities for such purpose. Specifically, the RDF would (i) formulate vision, provide higher-level strategies, and advise prioritised areas to guide R&D funding allocations; (ii) coordinate all R&D funding bodies and standardise administrative procedures; (iii) foster collaboration among local and international R&D players, and (iv) strengthen and share the expert network for the peer review process across all funding bodies.

Challenge 2: Inefficient Funding Mechanism for R&D Centres

The operational efficiency of the Innovation and Technology Commission (ITC)'s funding for R&D centre projects is suboptimal. The long processing time taken by the R&D centres and the ITC not only sets limitations on the research efficiency of R&D centres, but also prevents them from engaging in holistic planning.

Recommendation 2: Improve Funding Efficiency for R&D Centres

This report recommends that the ITC should provide R&D centres with more funding flexibility in order to strengthen the overall development of science and technology innovation in Hong Kong. The ITC could take reference from other public organisations in Hong Kong and aim to increase the funding autonomy of the R&D centres in the long run. For instance, the UGC funding for universities allocates a significant part in the Research-portion (R-portion) at the universities' disposal.

Section 2: Building the R&D Talent Pipeline

Challenge 3: Lack of Locally-trained Research Talents

In comparison with other economies, Hong Kong has a smaller pool of research talents relative to its population. One crucial track to enlarge the research talent pool is to train more talents locally. However, Hong Kong has an insufficient number of research postgraduate (RPg) students. While the RPg-to-professor ratio in Hong Kong is 2.4:1, it is 4.1:1 in the United Kingdom.

Recommendation 3: Increase the Number of Research Postgraduate (RPg) Students

To address the shortage of research postgraduate students, this report recommends that the Government increases the ratio of RPg-to-professor in Hong Kong to 4:1 by gradually expanding the number of RPg students from 11,700 to 19,600. An estimated annual funding of HK$1.1 billion would be required to support such an increase, and the Government should encourage the private sector to contribute a portion of the fund.

Challenge 4: Deficiency in the Technology Talent Admission Scheme (TechTAS)

Another crucial and more immediate track to increase Hong Kong's R&D personnel is to attract global talents. In this regard, Hong Kong's Technology Talent Admission Scheme (TechTAS) has been under-utilised so far as a result of its overly strict requirements.

Recommendation 4: Relax Eligibility Requirements for the Technology Talent Admission Scheme (TechTAS)

This report recommends that the Government should relax the eligibility requirements for TechTAS. Firstly, the matching requirement could be a burden for start-ups and SMEs as they need to recruit extra local employees. It is important for the Government to adjust the matching requirement for a better balance between safeguarding job opportunities for locals and supporting start-ups and SMEs. Secondly, TechTAS should include professionals from a range of technology-related fields, such as intellectual property protection and data management, in order to fully release Hong Kong's R&D potential.

Section 3: Fostering Interdisciplinary and Cross-institutional Collaboration

Challenge 5: Performance Evaluation Criteria Insufficiently Conducive to Research Collaboration

Interdisciplinary and cross-institutional collaborations have been lagging among researchers. A significant hindrance is that the performance evaluation criteria at both the individual and institutional levels discourage collaboration, and instead, incentivise competition.

Recommendation 5: Revise Individual and Institutional KPIs to Incentivise Collaborative Research

This report recommends revising individual and institutional Key Performance Indicators (KPIs) to nurture a more collaborative research culture. In particular, at the individual level, co-authors' contribution to joint research outputs should be fairly evaluated when considering their promotion and tenure. At the institutional level, the Research Assessment Exercise (RAE)—a performance-based evaluation system that assesses the research quality of University Grant Committee-funded universities—should explicitly state the importance of collaboration and give it greater significance during the evaluation of research outputs.

Challenge 6: Lack of Infrastructure for Upstream and Long-term Research

An additional limitation is the lack of large-scale institutional infrastructure, which is important for supporting collaboration. Such infrastructure would serve to attract and retain more top talents and in turn raise the overall calibre of Hong Kong's researchers to compete with the world's best. At present, Hong Kong lags behind the global trend by not building enough such institutional infrastructure.

Recommendation 6: Establish Mega Research Institutes

To complement the Government's new InnoHK initiative, under which research funding can now only be committed for four to five years, this report recommends the establishment of mega research institutes to create more stable research opportunities and to strengthen medium to long-term and large-scale research collaborations. These mega research institutes would also serve to raise the overall calibre of research talents in Hong Kong by providing promising career paths to attract top global talents and emerging local talents. For a start, Hong Kong should establish a mega research institute for biomedical science as a pilot programme, since it already has a competitive advantage in the field. Taking reference of the federal funding received by the Broad Institute in the United States, this report suggests that the Hong Kong Government should earmark a recurrent funding of HK$1 billion per year for setting up the mega institute.

Challenge 7: Insufficient Cooperation in the Innovation System

Beyond the academic realm, collaboration among the Government, industries, universities, and R&D centres within the R&D ecosystem has been insufficient. Specifically, the R&D centres have not fully realised their potentials in bridging the innovation gap between academia and industries and in forging tripartite cooperation.

Recommendation 7: Establish Branch Offices in the GBA by R&D Centres

Given that many cities in the Greater Bay Area (GBA) specialise in high technology and related areas, the GBA not only offers unique opportunities for R&D centres to foster greater synergies with industries, but also enables GBA industries to leverage the excellent basic research by Hong Kong universities. R&D centres in Hong Kong should take reference to the practice by Germany's Fraunhofer Society and have a greater physical presence in the GBA, such as through setting up branch offices, to facilitate communication and cooperation. This will be conducive to the R&D centres' stable and long-term partnership with the industries.

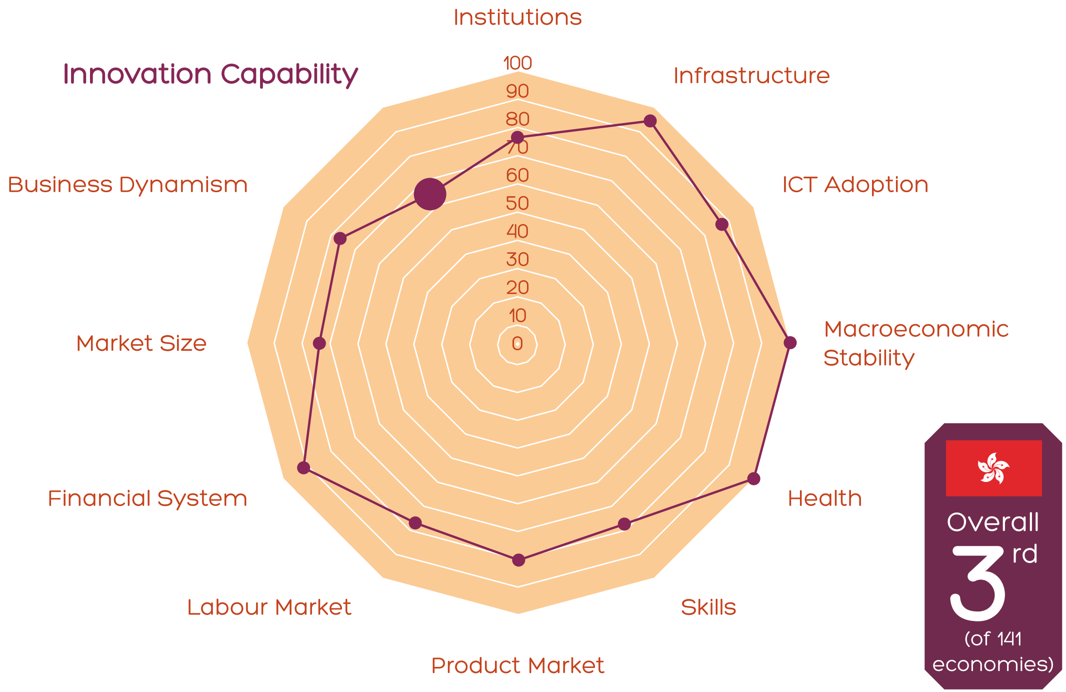
Conclusion

This report proposes seven recommendations, under three sections, for developing Hong Kong into an international R&D powerhouse. Particularly worth highlighting is the establishment of mega research institutes **(Recommendation 6)**. Development in this direction fits well with the Government's R&D expenditure target, raises the quantity and quality of talents, and enhances interdisciplinary and cross-institutional collaborations, thereby addressing the challenges mentioned in all three sections. We believe the recommendations in this report will contribute to a holistic and dynamic R&D ecosystem, and which in turn will enable Hong Kong to unleash its innovative power for significant and sustainable economic growth.

1. Introduction

Hong Kong has long prided itself on being one of the world's most competitive economies. Nevertheless, one of Hong Kong's significant shortcomings is its innovation capability. For example, according to the *2019 Global Competitiveness Report*[1] published by the World Economic Forum (WEF), Hong Kong ranks 3rd overall among 141 economies, but only comes 26th in the pillar of innovation capability. The report indicates that Hong Kong has attained the perfect score of 100 in overall performance in both "macroeconomic stability" and "health", whereas it scores the lowest in "innovation capability" among the 12 pillars with only 63.4 points **(Figure 1)**. The report also states that Hong Kong's "biggest weakness is undoubtedly its limited capability to innovate".

Figure 1. **Hong Kong's performance overview in the *Global Competitiveness Report* (2019)**



Source: World Economic Forum

[1] The *Global Competitiveness Report* is regarded as one of the most well-known publications on competitiveness and is widely cited. According to the WEF, the report is conducted based on the methodology developed in collaboration with leading experts and practitioners through a three-year consultative process, and is designed to support countries to identify relevant policies and practices.

The capability to innovate is crucial for any economy's transformation towards a knowledge-based economy and drives economic growth. Simply put, there are two ways to achieve economic growth: increasing inputs (e.g. labour, capital) into the economy and increasing productivity of inputs.

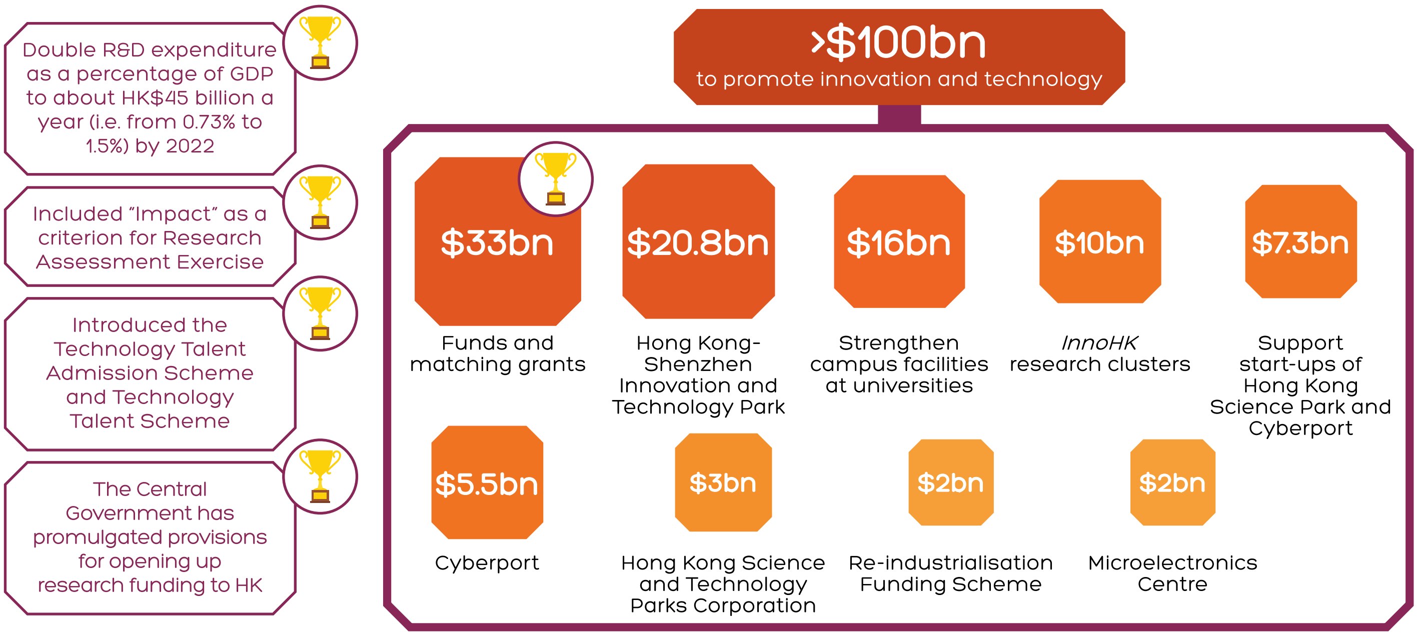
Innovation and technological advancement is an important pathway that can boost productivity. For small open economies like Hong Kong, boosting productivity through innovation would be even more crucial given its limited ability to increase economic inputs. As such, other small open economies have prioritised innovation to drive economic growth and attained much success **(Figure 2)**. Switzerland comes 3rd in the *Global Competitiveness Report* in the "innovation capability" pillar, and the country is a world leader in food and beverage technologies. For example, the Swiss company Nestle is the world's largest private food and nutrition research and development (R&D) organisation. Meanwhile, Sweden and Ireland come 5th and 21st respectively in this pillar, both being renowned for their medical technology. Sweden's Karolinska Institutet and MAX IV Laboratory are two of the world's most advanced medical research institutions, while nine out of the ten largest pharmaceutical companies in the world all set up facilities in Ireland. Closer to home, Singapore ranks 13th in the pillar, reflecting the country's decades of efforts in pouring into R&D. Finally, Israel, known as the "start-up nation", ranks 15th and leads the world in agriculture and defence technologies. Hong Kong should follow the example of other small open economies and strengthen its innovation capability, particularly through science and technology innovation, so as to maintain its economic growth.

Figure 2. **Innovation capability: Hong Kong and other small open economies (2019)**

Note: The bracketed numbers indicate the scores of innovation capability of the respective economies.
Sources: World Economic Forum, Health Europa, Nestle, *The Straits Times*, InnoPharama Education

To this end, the Government of the Hong Kong Special Administrative Region (the Government) has devoted significant efforts and resources in advancing Hong Kong's science and technology innovation in recent years. The Innovation and Technology Bureau was established in 2015 to enhance the Government's ability to formulate and implement policies in support of science and technology innovation. In the 2017 Policy Address, the Chief Executive laid out an eight-pronged strategy, which includes increasing resources, pooling together technology talents, offering investment funding, providing technological research infrastructure, reviewing existing legislation and regulations, opening up Government data, leading changes to procurement arrangements, and popularising science education. According to the 2019 Policy Address, the Government has devoted over HK$100 billion to promote innovation and technology, which includes injecting HK$33 billion into funds and matching grants to encourage R&D and earmarking HK$10 billion to establish the two platforms under InnoHK **(Figure 3)**. It demonstrates the Government's determination to accelerate Hong Kong's science and technology innovation.

Figure 3. **The Government's efforts devoted to science and technology innovation**



Note: [1] The trophy icon represents similar policies that Our Hong Kong Foundation (OHKF) recommended in *The Ecosystem of Innovation and Technology in Hong Kong*.
[2] Including funding pending Legislative Council Finance Committee's approval.
[3] The Government has also allocated HK$500 million to promote the use of technology by the Government, HK$500 million to organise the City I&T Grand Challenge, HK$ 500 million to implement the IT Innovation Lab in Secondary Schools Programme, and HK$500 million to launch the Technology Talent Scheme.
Sources: 2017 Policy Address, 2018 Policy Address, 2019 Policy Address, 2018-19 Budget, 2019-20 Budget

Hong Kong's competitive advantage in science and technology innovation lies in its basic research, which enables the city to realise its vision to become an international R&D powerhouse. This is evident by the fact that five Hong Kong universities made it to the top 100 in the world **(Table 1)**, with three of them rank among the top 50 according to the QS World University Rankings 2020, making Hong Kong the city with the densest concentration of world-class institutions, coming only second to London[2].

Table 1. **Hong Kong universities among the top 100 in the world (2020)**

University	Rank
The University of Hong Kong (HKU)	25
The Hong Kong University of Science and Technology (HKUST)	32
The Chinese University of Hong Kong (CUHK)	46
City University of Hong Kong (CityU)	52
The Hong Kong Polytechnic University (PolyU)	91

Source: QS World University Rankings 2020

Narrowing down to STEM (Science, Technology, Engineering, and Mathematics) subjects, Hong Kong's universities continue to stand out in the world **(Table 2)**. For example, the University of Hong Kong (HKU) ranks 4th in Dentistry, while the Hong Kong Polytechnic University (PolyU) ranks 15th in Civil and Structural Engineering. By capitalising on its research excellence, Hong Kong will be well-positioned to become a leading, innovation-based economy.

[2] London has four top 50 universities while Hong Kong has three, according to the QS World University Rankings 2020.

Table 2. **Hong Kong universities among the top 100 by STEM subjects (2019)**

Subject	University (Rank)
Biological Sciences	HKU (48), CUHK (51-100), HKUST (51-100)
Chemical Engineering	HKUST (34), HKU (51-100)
Chemistry	HKUST (22), HKU (34), CUHK (51-100)
Civil & Structural Engineering	PolyU (15), HKUST (17), HKU (17), CityU (51-100)
Computer Science & Information Systems	HKUST (26), HKU (33), CUHK (36), CityU (51-100), PolyU (51-100)
Dentistry	HKU (4)
Electrical & Electronic Engineering	HKUST (22), HKU (30), CityU (51-100), CUHK (51-100), PolyU (51-100)
Materials Science	HKUST (23), CityU (51-100), CUHK (51-100), HKU (51-100)
Mathematics	CUHK (28), HKUST (36), HKU (45), CityU (51-100), PolyU (51-100)
Mechanical Engineering	HKUST (29), HKU (40), CityU (51-100), PolyU (51-100)
Medicine	HKU (29), CUHK (45)
Nursing	CUHK (26), PolyU (31), HKU (43)
Pharmacy & Pharmacology	CUHK (49), HKU (51-100)

Source: QS World University Rankings by Subject 2019

To transform Hong Kong into an international R&D powerhouse, collaboration among the four players within the R&D ecosystem: the Government, universities, R&D centres[3], and industries, must be strengthened.

[3] "R&D centres" refer to the five R&D centres (Automotive Platforms and Application Systems R&D Centre, Hong Kong Applied Science and Technology Research Institute, Logistics and Supply Chain Multitech R&D Centre, Nano and Advanced Materials Institute, and Hong Kong Research Institute of Textiles and Apparel), which primarily drive applied R&D in selected focus areas.

Although this report will further explore the topic of collaboration in Section 4, the importance of collaboration should be highlighted at this point. As scientific challenges become more complex over time, overcoming these challenges often demands collaboration across different disciplines and institutions. For example, the Novel Surgical Robotic System (NSRS), jointly developed by HKU Medicine and PolyU Engineering teams, would allow surgeons to operate through a single-incision or a natural orifice to perform surgical operations. It paves the way for minimally invasive surgery in the future and enhances the well-being of patients.

When collaboration goes beyond the higher education sector, it can result in greater impact. The invention of MP3 is a good example, for it was developed through the collaboration between Fraunhofer, Europe's largest R&D organisation, Friedrich-Alexander University Erlangen-Nuremberg, and companies including Apple. With improved compression capacity, MP3 became a global success in the past two decades, making it much more convenient for people to carry music wherever they go.

Another example is the Human Genome Project, which amplified the benefits of collaboration to an even greater extent by pulling together the best talents from the world and pooling international resources together. Formed of a consortium of over 20 institutions across six countries, the project succeeded in its ambitious task to decode the entire DNA sequence of a human being for the first time. Not only are genetic diseases such as Alzheimer's disease now better understood, but the sequencing method used in the project was also applied to decode the SARS virus, which helped doctors diagnose patients. The enormous and long-lasting impact brought by the Human Genome Project was only made possible through the collaborative efforts on an unprecedented scale **(Table 3)**.

Table 3. **Examples of R&D collaboration**

Project	Institutions	Disciplines	Impact
Novel surgical robotic system (NSRS)	The University of Hong Kong, The Hong Kong Polytechnic University	Medicine, Engineering	NSRS is the first robotic system in the world with arms having in-vivo motors that are both small enough and strong enough to perform various surgical operations inside the human body, paving the way for future non-invasive surgery.
MP3	Friedrich-Alexander University Erlangen-Nuremberg, Fraunhofer, Apple, and other companies	Electrical Engineering, Mathematics	MP3 requires much less storage space than its original format while retaining the music quality. As a result, music fans can fit their entire collection onto a device no bigger than a matchbox.
Human Genome Project	Over 20 institutions across six countries, including United States, United Kingdom, Japan, France, Germany, and mainland China	Biology, Chemistry, Physics, Mathematics, Computer Science	For the first time, scientists are able to decode the entire DNA sequence of a human being. The result increased scientists' understanding of genetic diseases, such as Alzheimer's disease. In addition, the sequencing technique invented during the project was applied to decode the SARS virus, which helped doctors diagnosing patients.

Sources: The Hong Kong Polytechnic University, The University of Hong Kong, National Institutes of Health (United States), Fraunhofer (Germany)

Nevertheless, to foster a collaborative environment, two preconditions must be met. Firstly, Hong Kong requires a more efficient and strategic funding system. Secondly, it needs to build a sustainable talent pipeline **(Figure 4)**. Therefore, this report will be structured around the three key topics: funding, talents, and collaboration.

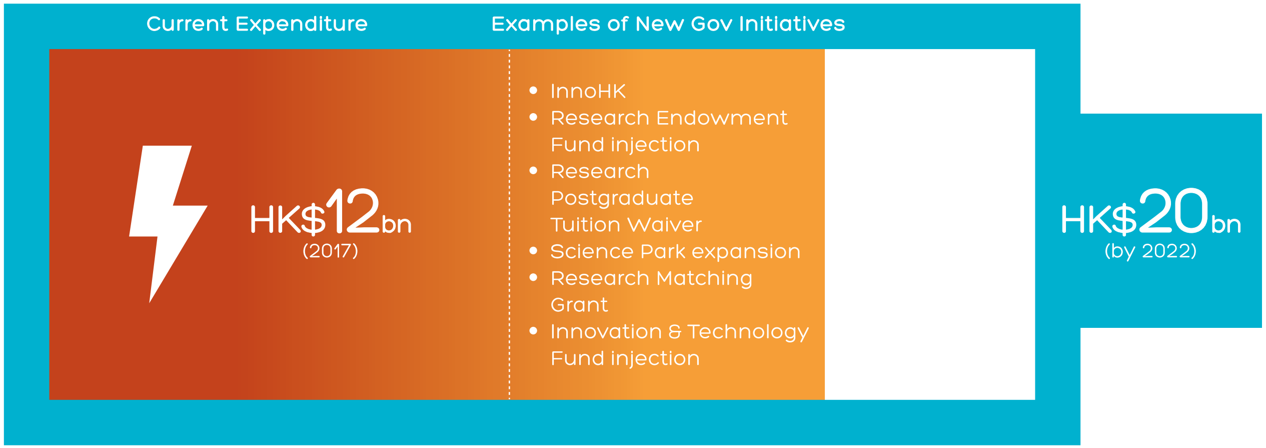
Figure 4. **R&D ecosystem in Hong Kong**

2. Providing Higher-level Strategies and Aligning the R&D Funding System

For a long time, Hong Kong has trailed behind our competitors in terms of R&D expenditure as a percentage of annual Gross Domestic Product (GDP), spending only 0.8% of its GDP in 2017, as compared to the OECD average of 2.4%. Furthermore, unlike in other advanced economies, the public sector in Hong Kong accounts for the majority of R&D expenditure. In 2017, the R&D expenditure of the higher education and government sectors combined amounted to HK$11.9 billion, representing approximately 55.8% of total R&D expenditure. Meanwhile, the business sector spent HK$9.4 billion, or 44.2% of total R&D expenditure. On the other hand, public and private R&D expenditure in the United States as a percentage of total expenditure were 28.1% and 71.9% respectively in 2015.

Aware of the aforementioned problems, the Government has set a target in the 2017 Policy Address to double total R&D expenditure to approximately HK$45 billion, or from 0.73% of GDP to 1.50%, by 2022. Besides, the Government aims to reverse the proportion of public to private R&D expenditure in the same period (i.e. HK$20 billion will come from the public sector and HK$25 billion from the private sector). In achieving this target, the Government has announced a series of initiatives, including spending HK$10 billion over five years to establish two research clusters at the Science Park, namely Health@InnoHK and AIR@InnoHK, HK$3 billion over three years to introduce the Research Matching Grant, HK$3 billion annually to waive the tuition fee for local research postgraduate students, and injecting a one-off amount of HK$20 billion and HK$10 billion into the Research Endowment Fund and the Innovation and Technology Fund respectively. Nevertheless, there remains a gap before the Government's target is met **(Figure 5)**.

Figure 5. **The Government's efforts in terms of boosting public R&D expenditure**

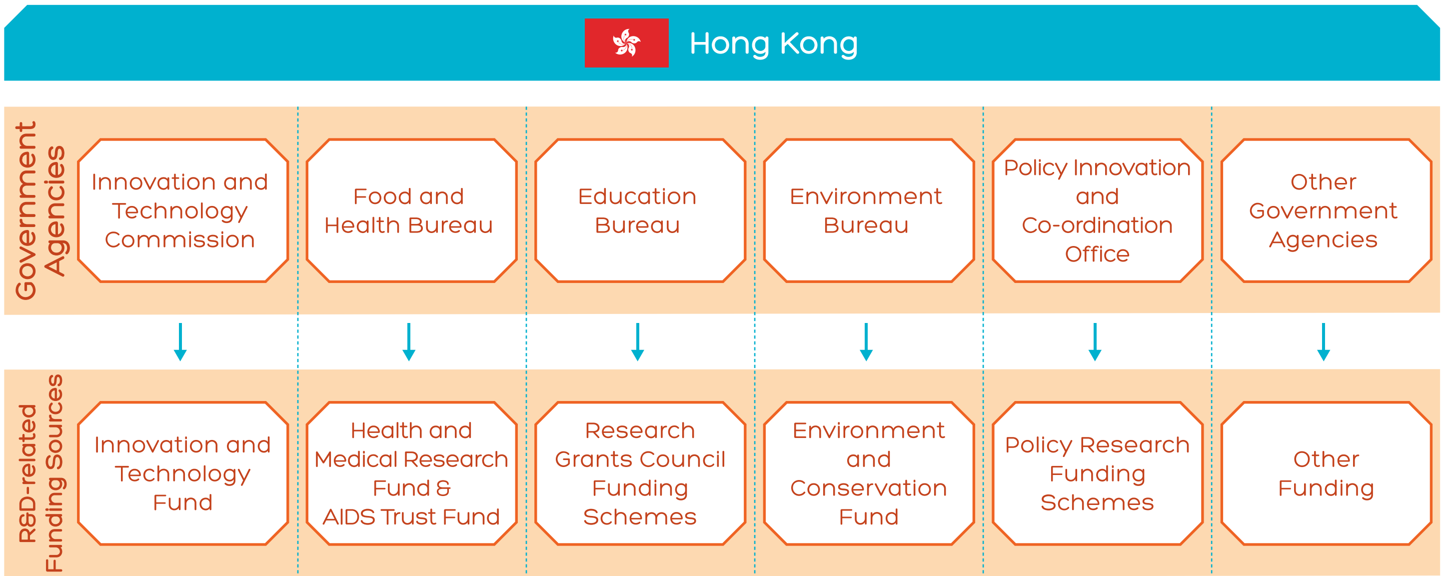


Sources: Census and Statistics Department, 2017 Policy Address, 2018 Policy Address, 2018-19 Budget, 2019-20 Budget

Challenge 1. Fragmented R&D Funding Sources in Hong Kong

Although having sufficient funding is vital to strengthening Hong Kong's R&D, it is equally important that the funds are allocated in an efficient and strategic manner. However, the R&D funding system is currently fragmented and poorly coordinated. According to the Task Force on Review of Research Policy and Funding's report, there are five agencies that provide R&D funding within the Government. Firstly, under the Innovation and Technology Commission (ITC), the Innovation and Technology Fund provides financial support primarily for applied R&D activities. Secondly, the Food and Health Bureau oversees the Health and Medical Research Fund (HMRF) and the AIDS Trust Fund, both of which support research projects related to public health. Thirdly, the Research Grants Council (RGC) under the University Grants Council (UGC) provides competitive research funding for UGC-funded universities and self-financing degree-awarding institutions. Fourthly, the Environment Bureau manages the Environment and Conservation Fund, which provides support for environmental research. Finally, the Policy Innovation and Coordination Office (PICO) administers two Policy Research Funding Schemes to finance public policy research. Beyond these five agencies, other Government bodies also provide research funding in specialised areas **(Figure 6)**.

Figure 6. **Hong Kong's fragmented R&D-related funding sources from different Government agencies**



Notes: Under different funding sources, there might be programmes that cover areas other than R&D. In this section, we will focus on the programmes related to R&D only.
Source: Task Force on Review of Research Policy and Funding

The fragmented funding sources create a range of problems for the ecosystem. The foremost problem is the lack of an overarching vision for R&D in Hong Kong, as individual funding bodies allocate funds based on their own visions and objectives. While the Government has identified four areas to prioritise in the 2019 Budget, which are Biotechnology, Smart City, Financial Technology, and Artificial Intelligence, yet other than Smart City[4], it has not formulated a concrete roadmap regarding how to develop the other three areas. Another significant problem arising from a fragmented funding system is the absence of coordination amongst funding schemes. For example, when UGC calculates the recurrent institutional research funding (i.e. R-portion)[5] for each university, it is partially informed only by the university's success in applying for RGC earmarked grants. Other sources of funding are disregarded in this calculating process, leading to undesired incentives. For example, if a researcher already obtained sufficient funding from non-RGC sources, the researcher would still be incentivised to apply for RGC earmarked grants to ensure that his or her home institution would not be disadvantaged when the R-portion is calculated. In this scenario, the researcher would potentially take away limited resources from other researchers in need of funding.

Besides, different funding schemes administered by various funding bodies do not consistently publish all relevant information for researchers. For example, RGC publishes the framework of the peer review process[6], while other funding bodies do not have such a practice. The lack of consistency makes it challenging for researchers when they navigate through the funding system. Furthermore, the fragmentation of the funding sources also means that there are disparate portals to apply for funding, which increases the administrative burden on researchers. Finally, fragmentation leads to resource overlap. For example, both the HMRF and RGC fund research activities are related to public health.

In the past decade or so, other economies have moved towards aligning their R&D funding systems and formulating overarching R&D strategies to guide their funding allocations. In Singapore, the National Research Foundation (NRF) was established in 2006 under the direct oversight of the Prime Minister's Office. The NRF sets the national direction for R&D by developing an overarching strategy every five years. While the NRF itself has established various funding schemes that align with its strategy, the strategy also guides other funding bodies under various government ministries, such as the Agency for Science, Technology and Research (A*STAR) and the Academic Research Council, on how they should allocate funds. The most recent five-year plan was released in 2016, titled "Research Innovation Enterprise (RIE) 2020". The plan endeavours to create a knowledge-based, innovation-driven economy and society in Singapore. The NRF has identified four strategic technology domains to prioritise for, such as Health and Biomedical Sciences, with detailed action plans further elaborated in the RIE 2020. Moreover, the plan laid out four strategic thrusts which include allocating more funding towards collaborative and applied research competitively **(Figure 7)**.

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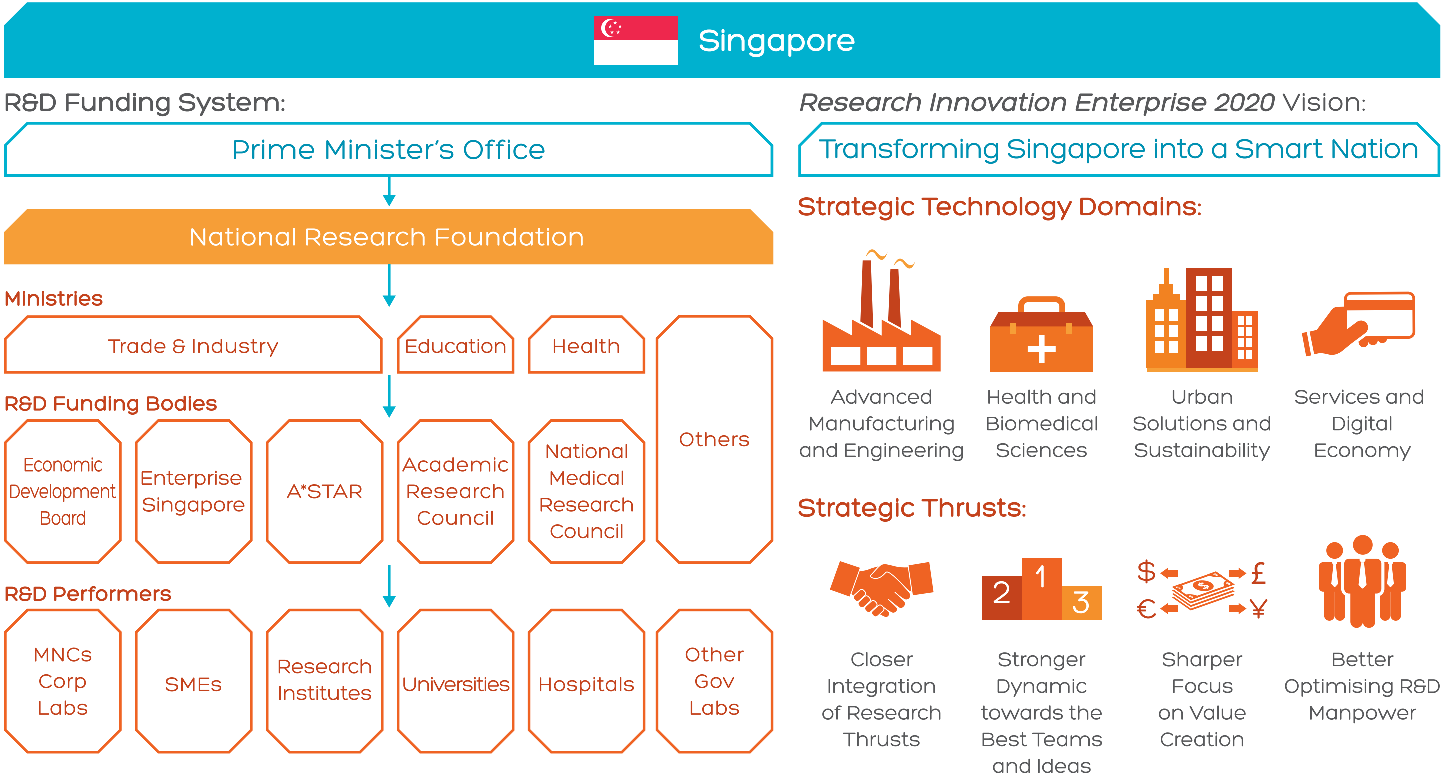
[4] Hong Kong Smart City Blueprint (2017)

[5] Institutional research funding here refers to Research Portion (R-portion) of the block grant, which is a recurrent research funding for UGC-funded universities provided by the Government.

[6] Research Grants Council GRF, ECS and HSSPFS – General Panel Guidelines (2018)

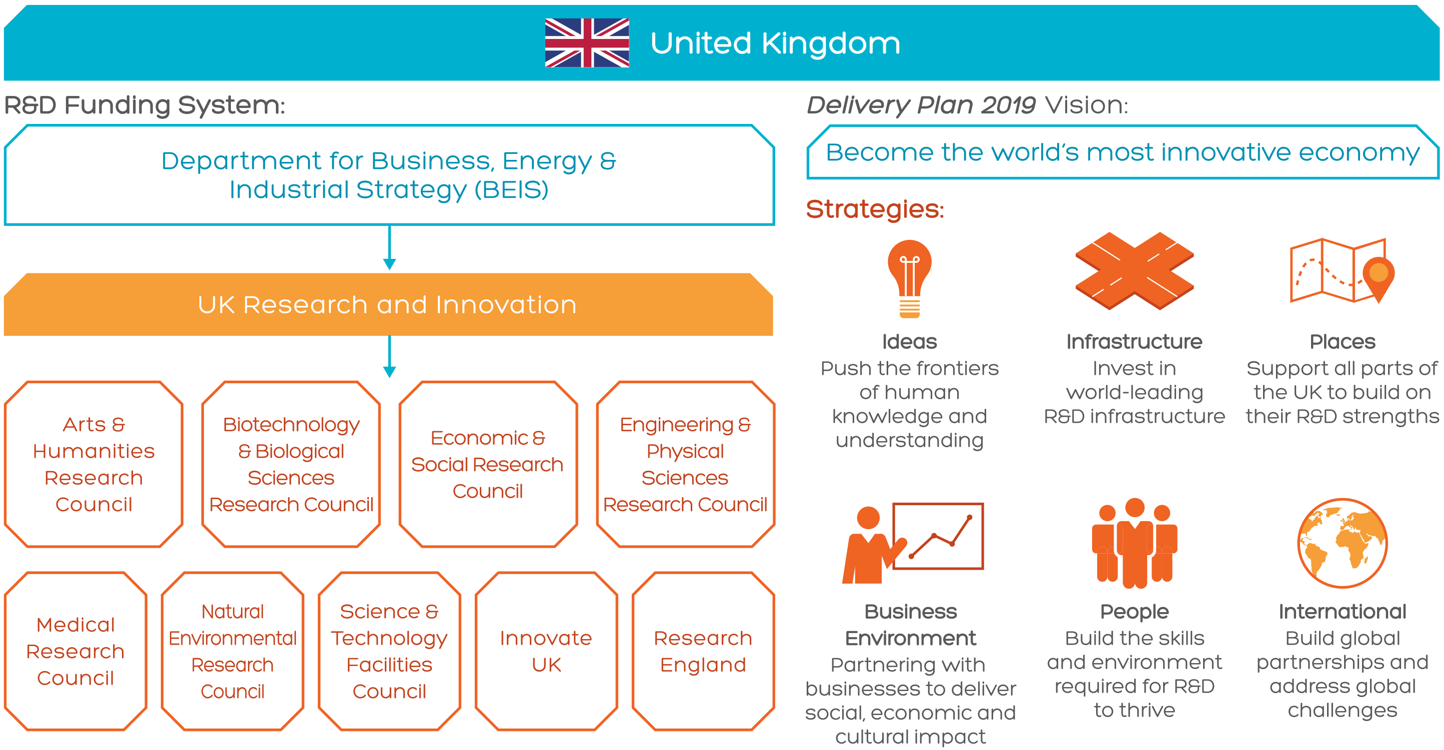
Figure 7. **Case study 1: Singapore**



Source: National Research Foundation (Singapore)

Meanwhile, in the United Kingdom, the UK Research and Innovation (UKRI) was established in April 2018, bringing together the seven Research Councils, Innovate UK, and Research England **(Figure 8)**. The UKRI was set up to provide higher-level research strategy for the United Kingdom, and it has brought together nominated representatives from each of the organisations to coordinate on funding approaches. In 2019, the UKRI released its Delivery Plan[7] to deliver on the goals related to R&D as set out in the UK government's broader Industrial Strategy. The Delivery Plan outlined a six-pronged strategy, which involves Ideas, Infrastructure, Places, Business Environment, People, and International. It is a strategic plan far more detailed and comprehensive than that of Hong Kong.

Figure 8. **Case study 2: United Kingdom**



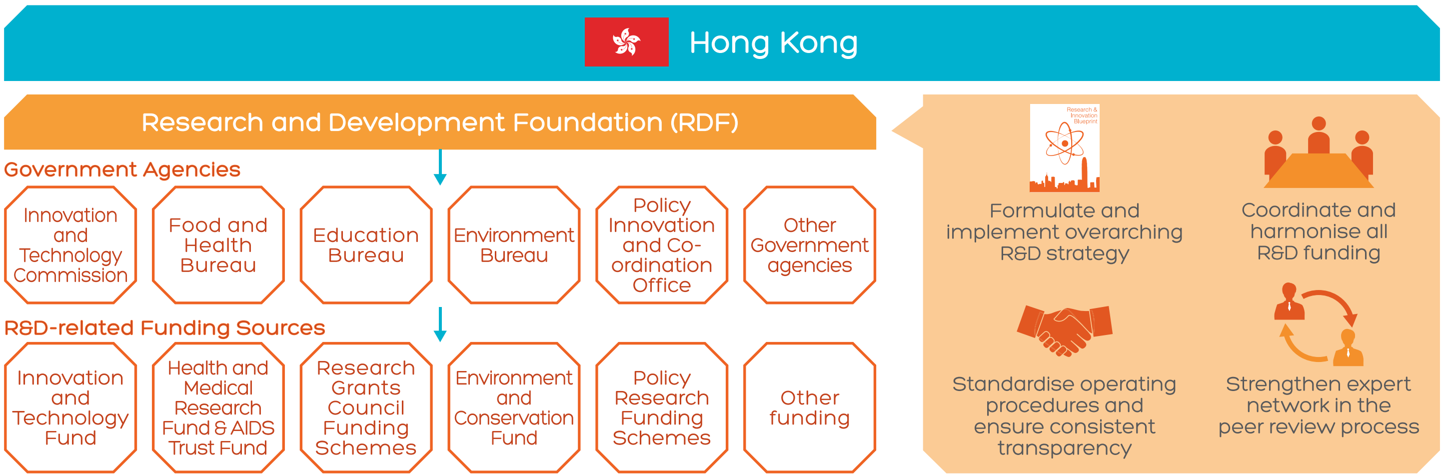
Source: UK Research and Innovation

[7] UKRI's *Delivery Plan 2019*

Recommendation 1: Establish an Overarching Research and Development Foundation

Hong Kong can take reference from Singapore and the United Kingdom and establish a similar overarching entity, which will be named in this report as the "Research and Development Foundation" (RDF) **(Figure 9)**. Although the Government has already set up the Steering Committee on Innovation and Technology (SCIT)[8], chaired by the Chief Executive since 2017, to examine and steer measures that boost innovation and technology development in Hong Kong, it should take a step further. The SCIT should consider establishing the RDF to better align all R&D funding from various Government agencies. The RDF would serve four purposes. Firstly, it should formulate a vision, and provide an overarching R&D strategy for Hong Kong. Such a strategy should provide a concrete roadmap on how Hong Kong will develop its prioritised areas and guide R&D funding allocations. Secondly, the RDF should actively coordinate among all R&D funding bodies and standardise administrative procedures. This includes creating a single funding portal[9] in order to substantially decrease the administrative burdens on researchers, while also ensuring that researchers are aware of all the funding opportunities available. Thirdly, the RDF should foster collaboration among the players within the local and international R&D ecosystems. By acting as a single voice for Hong Kong's R&D community, the RDF would be in a strong position to reach out to international players and negotiate collaborative deals. Finally, the establishment of the RDF would strengthen and share the expert network for the peer review process across all funding bodies.

Figure 9. **Establish an overarching Research and Development Foundation**



Source: Task Force on Review of Research Policy and Funding

[8] According to the Government, the Steering Committee is a high-level, inter-departmental Government internal committee with membership comprising the majority of the Government Secretaries as well as the relevant department heads to steer, coordinate, and take forward the innovation and technology development in Hong Kong in a more expeditious and efficient manner.
[9] The United States, the United Kingdom, and Singapore all have single funding portals despite having various funding bodies.

Challenge 2: Inefficient Funding Mechanism for R&D Centres

While the previous recommendation focuses on the strategic deployment of funding, there is also a need to improve the operational efficiency of various funding bodies. The following recommendation will use ITC's funding for R&D centres as an example.

To drive and coordinate applied R&D in selected areas, the Government established five R&D centres in 2006: Automotive Platforms and Application Systems R&D Centre (APAS), Hong Kong Applied Science and Technology Research Institute (ASTRI), Hong Kong Research Institute of Textiles and Apparel (HKRITA), Logistics and Supply Chain MultiTech R&D Centre (LSCM), and Nano and Advanced Materials Institute (NAMI). These five centres are largely funded by ITC, which provides more than 70% of total project funding on average[10]. However, a lack of holistic planning and long funding approval process are two long-existing challenges in ITC's funding mechanism.

Currently, each R&D centre has a few research themes that define their main R&D competence, with several research projects under each theme. For instance, ASTRI's R&D strategic focus covers five areas: Smart City, Financial Technologies, Intelligent Manufacturing, Health Technologies, and Application-Specific Integrated Circuits. However, the funding for R&D centres is approved by ITC on a project-by-project basis. As a result, R&D centres are prevented from engaging in a more holistic planning on the development of each research theme.

In addition, according to the Audit Commission, the average combined processing time taken by the R&D centres and the ITC[11] was as long as 158 to 222 days[12]. Funding for projects is reviewed by several committees such as audit, finance, and administration individually in both the ITC and the R&D centres, leading to the problem of duplicate reviews. In addition, application paperwork frequently has to go back and forth between the ITC and the R&D centres to obtain supplementary materials. It is therefore difficult for R&D centres to carry out short-cycle research projects for rapidly developing topics. For example, the R&D cycle of integrated circuit usually lasts six months, yet funding applications would take another six months to be processed, not to mention the time R&D centres have to spend on preparing proposals before application.

[10] The total project funding for R&D centres include ITF funding for projects and industry contribution for projects. In 2017–18, the average percentage of ITF funding for projects over total project funding among five centres was more than 70%. For detailed breakdown of funding for each R&D centre, please refer to the Appendix.
[11] The average processing time taken by the R&D centres and ITC represented 64% and 36% of the total processing time respectively.
[12] The Audit Commission (2013), Innovation and Technology Fund: Management of Projects.

Recommendation 2: Improve Funding Efficiency for R&D Centres

To resolve these aforementioned inefficiencies, we suggest that the ITC should provide R&D centres with more funding flexibility to fully unleash their potentials in Hong Kong's R&D ecosystem.

The ITC should provide the R&D centres with more flexibility in its research funding in the long run. In fact, several public organisations in Hong Kong have achieved success with flexible funding mechanisms. For example, the UGC grants a significant part of the R-portion[13] to universities for research without specific requirements on how it is spent[14]. Furthermore, while the funding is allocated for research, there is no requirement for the universities to spend the funding entirely for research purposes, and could even spend it for teaching purposes[15].

Given its application-oriented positioning, the research cycle of R&D centres is usually shorter than that of academic research in universities. Flexible funding is therefore more necessary for R&D centres. To gradually increase the funding autonomy of R&D centres, ITC could take reference of the funding mechanism of universities and other public organisations. This would result in greater efficiency, which would enable R&D centres to adapt to the latest innovation breakthroughs and adjust funding distribution for projects in light of new disruptive technologies or trends. More significantly, it would enable R&D centres to conduct more holistic and long-term strategic planning, encourage their research development, and promote the overall development of key research areas in Hong Kong.

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[13] The amount of the R-portion is $4.3 billion per annum for the 2016-19 triennium, which is a "one-line" allocation of resources without prescription attached as to how it should be spent.
[14] Report of the Task Force on the Review of the Research Grants Council (Phase I)
[15] To ensure that there is an appropriate balance between funding efficiency and prudent management of public resources, the Research Assessment Exercise (RAE) assesses the research quality of UGC-funded universities every six years.


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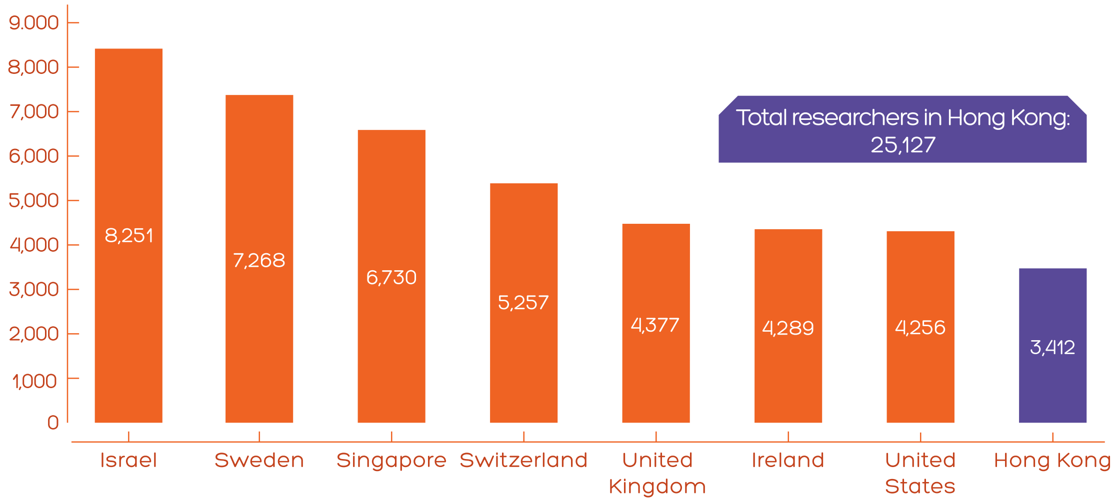
3. Building the R&D Talent Pipeline

To develop Hong Kong into an international R&D powerhouse, research talents is one of the most critical inputs. A continued and sustainable supply of top talents lays the foundation for high-quality research, which has strong implications for the innovative power of a society and sustainable vigour of an economy.

Currently, Hong Kong has a relatively small pool of research talents. According to *The Global Innovation Index 2019*, Hong Kong has approximately 3,400 researchers per million population, a ratio lower than that of other small economies such as Singapore and large countries such as the United States and the United Kingdom **(Figure 10)**. In particular, Singapore's ratio almost doubles that of Hong Kong, exceeding 6,700 researchers per million population.

Figure 10. **Number of full-time equivalent researchers per million population (2017)**

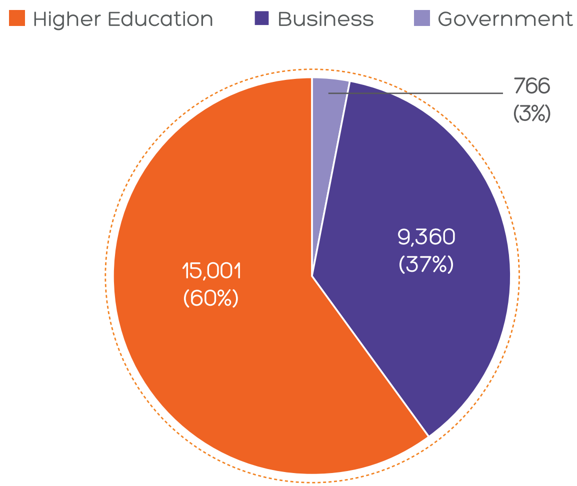


Sources: *The Global Innovation Index 2019*, Census and Statistics Department

On an absolute scale, Hong Kong has approximately 25,000 researchers in full-time equivalent (FTE), with 60% working in the higher education sector, 37% in the business sector, and the rest in the government sector **(Figure 11)**. The number of researchers in the current talent base is far below from a sufficient and sustainable talent pool.

Researchers in the business sector, which make up 37% of total researchers in Hong Kong, are insufficient. In comparison with other small open economies, Hong Kong's 9,360 researchers measured in FTE is almost half the size of the R&D personnel in Switzerland and one-fifth of that in Sweden. The deficiency of technology companies in Hong Kong partly explains such a talent shortage. These companies are reluctant to settle in Hong Kong not only due to high business costs but also because of its inadequate supply of local R&D talents, particularly research postgraduates. Therefore, building a strong local talent base in the higher education sector is of critical importance.

Figure 11. **Number of full-time equivalent researchers in Hong Kong (2017)**

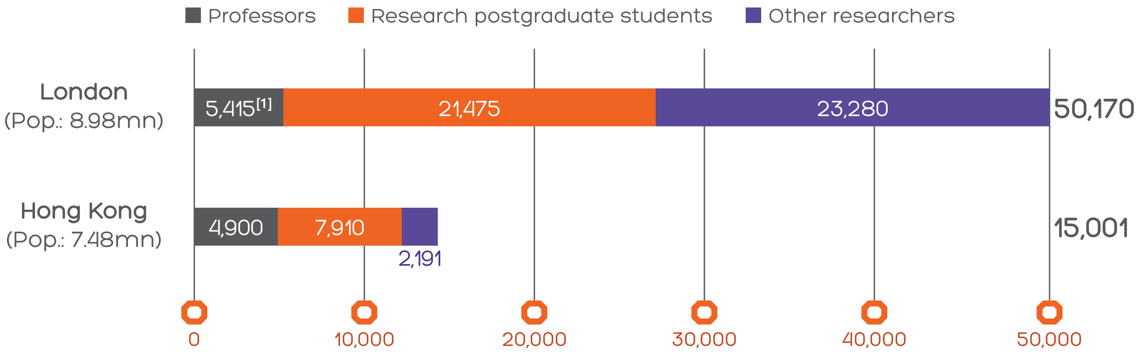


Source: Census and Statistics Department

Unfortunately, even though the 15,001 researchers in the higher education sector already account for the majority of Hong Kong's research talent pool, supply remains insufficient. In comparison, Hong Kong has less than one-third of London's 50,170 researchers, albeit London having a slightly higher population **(Figure 12)**. The researchers in the higher education sector comprise of professors, research postgraduate students, and other research-related staff. In Hong Kong, there is little room to increase the number of professors, for the number of first-year-first-degree places in UGC-funded universities is fixed at 15,000 per year, putting a limit on the universities' recurrent funding from the UGC, including the budget for expanding the professor base.

Nevertheless, the number of professors in Hong Kong is only marginally fewer than that of London, so the gap in the number of total researchers is mainly due to the shortage of research postgraduate students and other research staff instead. In fact, London has more than double the number of research postgraduate students than that of Hong Kong. These students increase professors' capacity and enable professors to take on additional research projects. More importantly, they are potential research professionals who can form a strong local talent base, which is necessary to sustain Hong Kong's R&D in the long run. Other researchers, such as postdoctoral researchers and laboratory scientists in London, exceed those in Hong Kong by almost ten times. These researchers in London work in universities' research centres and various independent research institutes, which Hong Kong severely lacks.

Figure 12. **Researchers in the higher education sector: Hong Kong vs London (2018)**

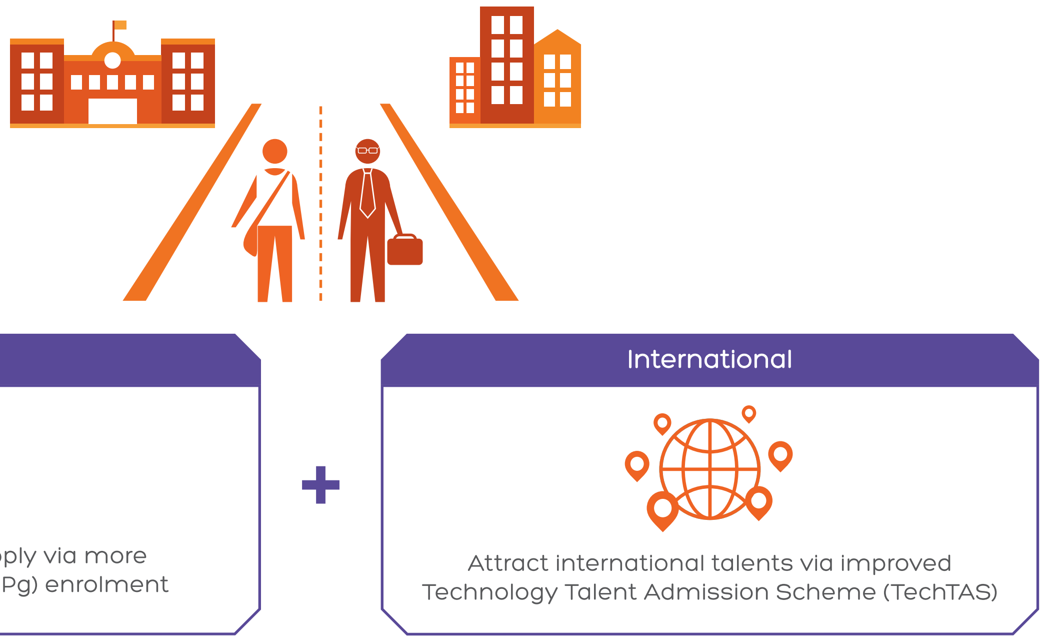


Note: [1] The figure includes senior academic staff in leadership or management positions.
Sources: Higher Education Statistics Agency (United Kingdom), Hong Kong universities' websites, Census and Statistics Department

In view of Hong Kong universities' limited resources in terms of infrastructure and funding to increase on-campus research centres, more large-scale research institutes are desired in order to accommodate the increasing flow of R&D professionals (especially postgraduate students and postdoctoral researchers) and to advance collaboration between institutions. Moreover, top-notch talents around the world would be drawn to such research institutes where they can take on large-scale and long-term projects to tackle global challenges. Section 4 will further discuss the topic of research institutes as well as the quality and research productivity of research professionals.

Given that Hong Kong is currently experiencing a severe shortage in R&D personnel, it should therefore increase research talents through two tracks, i.e. training more local talents and acquiring more overseas talents **(Figure 13)**. Locally-trained talents, who tend to have a stronger attachment to Hong Kong, can form a solid local base and create an energetic local research environment. International talents, on the other hand, not only satisfy relatively pressing talent demands but also reinforce Hong Kong's cultural variety and international inclusiveness. These two talent supply tracks will be elaborated in more detail below in this section, under Challenge 3 and Challenge 4.

Figure 13. **Building a critical mass of talents in Hong Kong**

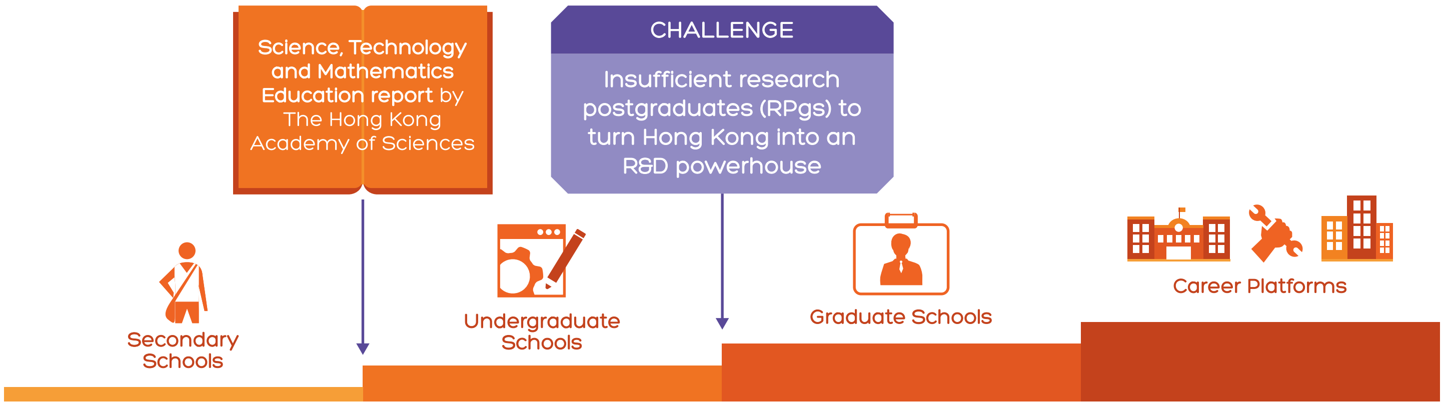


Challenge 3. Lack of Locally-trained Research Talents

The development of locally-trained talents is our first emphasis when addressing the dearth of researchers in Hong Kong. A continuum of talent development should be established and supported to ensure a sustainable talent supply. However, we have observed two major bottlenecks along the researcher development pipeline in Hong Kong **(Figure 14)**. Firstly, there are insufficient high school graduates who pursue STEM subjects at universities. Secondly, further along the pipeline, there is a deficient supply of research postgraduate (RPg) students. As a result, there is a vast researcher gap prevailing in Hong Kong, deterring the advancement in R&D.

In addressing the first bottleneck, The Hong Kong Academy of Sciences published a report in 2017 on STEM education with the vision to raise science and technology expertise and enhance STEM literacy in Hong Kong through its recommendations. Besides, the Government has launched a set of policy initiatives in recent years in an effort to expand Hong Kong's researcher base, such as the Researcher Programme[16], the Postdoctoral Hub[17], and the Tuition Waiver Scheme[18]. Although the Government provides tuition waiver for local research postgraduate students to incentivise local students to pursue RPg degrees, it is too soon to measure its effectiveness. Nevertheless, an insufficient number of research postgraduate students remains the prime hurdle to building up a sustainable pool of local research professionals.

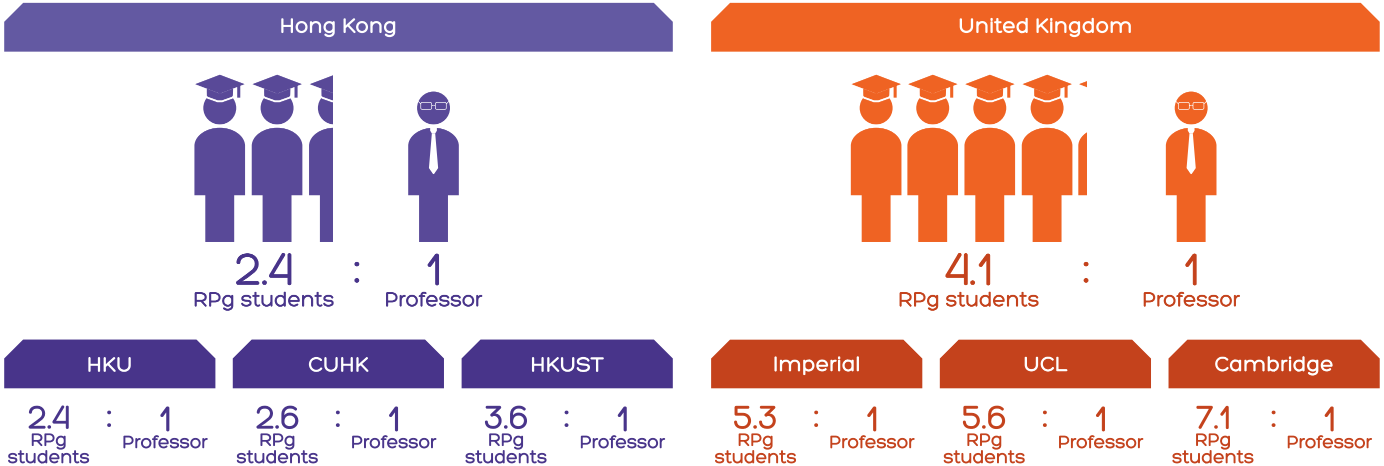
Figure 14. **The pipeline for locally-trained talents**



[16] The Researcher Programme (formerly known as Internship Programme) supports organisations and companies to recruit graduates from local universities as researchers to assist in R&D projects.
[17] The Postdoctoral Hub Programme is launched to subsidise qualified companies in hiring employees with doctoral degrees.
[18] Under the Tuition Waiver Scheme, starting from 2018/19 academic year, the Government would provide tuition waiver for all local students enrolled in UGC-funded RPg programmes.

In view of the aforementioned challenges, we have conducted a research analysis on Hong Kong's RPg status quo and found that Hong Kong has an RPg student-to-professor ratio of 2.4:1, far below than that of 4.1:1 in the United Kingdom **(Figure 15)**. HKUST, which has the highest RPg student-to-professor ratio among the top three universities in Hong Kong, only has a ratio of 3.6:1. By stark contrast, the University of Cambridge in the United Kingdom has 7.1 RPg students per professor, almost two times higher than that of HKUST.

Figure 15. **Research postgraduate (RPg) student-to-professor ratio: Hong Kong VS United Kingdom**

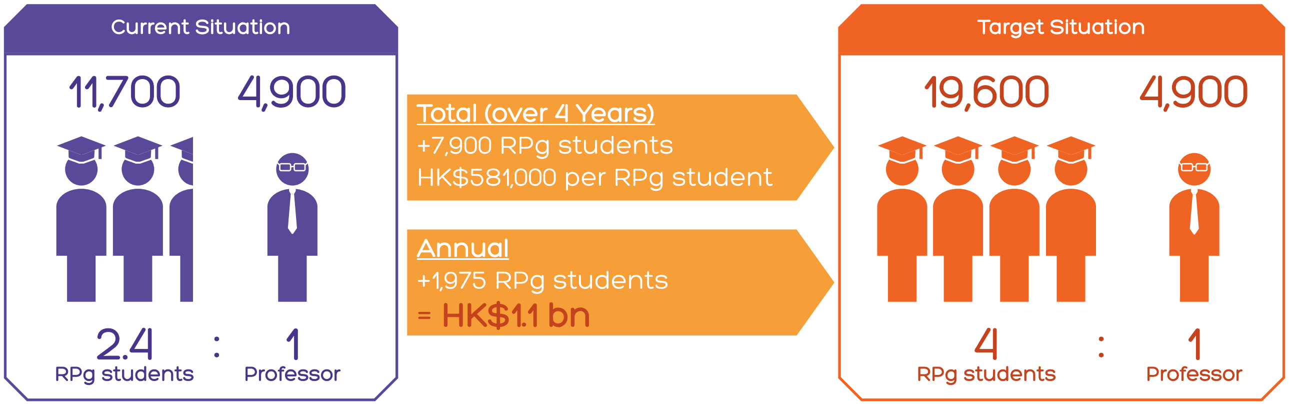


Sources: Higher Education Statistics Agency (United Kingdom), Hong Kong universities' websites

Recommendation 3. Increase the Number of Research Postgraduate (RPg) Students

To meet the growing demand for talents, we recommend that the Government increases the ratio of RPg student-to-professor from the present 2.4:1 to 4:1 **(Figure 16)**. By doing so, the local RPg base will gradually expand from 11,700 to 19,600, thereby creating a more sustainable R&D talent pool in Hong Kong. A total increase of 7,900 RPg students is expected to take place over four years with an annual increment of 1,975. It is expected that annual funding of HK$1.1 billion would be required to support such an increase. As financial support from the private sector has progressively increased in recent years, it is likely that the Government will not need to undertake the full cost but only a major share of it. The Government should also introduce more favourable policies to incentivise donations from the private sector to complement public funding.

Figure 16. **Increasing the number of research postgraduate (RPg) students**



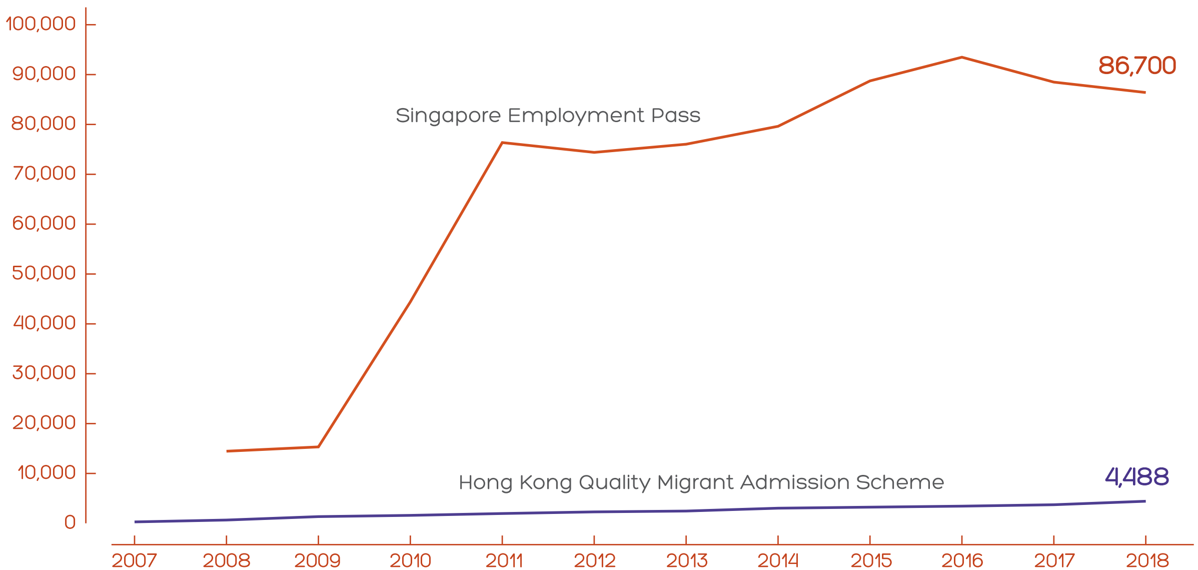
Sources: Hong Kong universities' websites, University Grants Committee

Challenge 4: Deficiency in the Technology Talent Admission Scheme (TechTAS)

While growing the local talent base is indispensable for driving R&D, the process takes a relatively long time. Attracting global talents in parallel to nurturing local ones can provide an immediate supply to fill the talent gap. However, Hong Kong has long lagged in the global talent competition given that its talent schemes are far from effective.

Singapore, for instance, has managed to import more than 80,000 professionals through the Employment Pass scheme in the past decade. By sharp contrast, only 4,000 visas were issued under the Quality Migrant Admission Scheme (QMAS) in Hong Kong during the same period, falling significantly short of its target to attract more highly-skilled talents to settle in Hong Kong **(Figure 17)**. QMAS has been criticised for its long processing time and under-utilisation of quotas. Specifically, QMAS applicants have to wait for an average of approximately nine months, whereas in many other economies, including the United Kingdom, Germany, and Japan, the visa approval process only takes two to four weeks.

Figure 17. **Number of accumulated approved visas for highly-skilled talents: Hong Kong vs Singapore**



Note: Data prior to 2008 is not available for Singapore's Employment Pass. Both newly-issued visas and discontinued ones are factored into the accumulated figures, thus the declining accumulated approved visas reflect the total number of people who currently hold a valid visa.
Sources: Ministry of Manpower (Singapore), Immigration Department

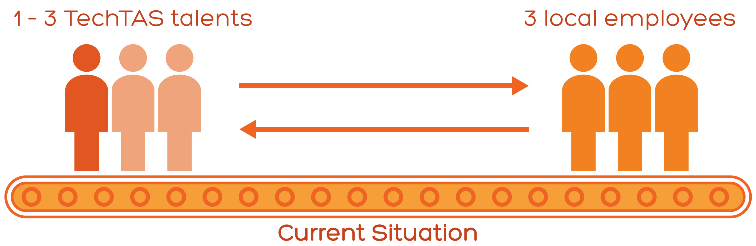
Considering the weaknesses of QMAS and the need to attract more technology talents, the Government rolled out the Technology Talent Admission Scheme (TechTAS) in June 2018. It is a three-year pilot scheme that provides a fast-track arrangement with a two-week review time for eligible technology companies or institutes to admit and employ overseas as well as mainland Chinese technology talents. However, only 291 quotas were approved as of the third quarter of 2019, of which 86 visas were issued. This number is far from enough to meet the talent demand in Hong Kong. The less-than-satisfactory outcome of TechTAS was largely due to its overly strict requirements.

In the newly announced 2019 Policy Address, the Government has moved towards the right direction by easing these restrictions, including to extend the coverage of TechTAS to technology companies outside the Science Park and Cyberport, as well as to extend the quota validity period from 6 months to 12 months. Furthermore, the Government has decided to expand the existing 7 eligible research areas to 13. The six newly covered technology areas are 5G networks, Internet of Things, Microelectronics, IC Design, Digital Entertainment, and Green Technology[19]. Building on the Government's effort to refine the scheme, we believe it is necessary to continue relaxing other restrictions of TechTAS to fully utilise its ability to attract overseas technology talents.

[19] Before the 2019 Policy Address, TechTAS was only open to seven areas, including Biotechnology, Artificial Intelligence, Cybersecurity, Robotics, Data Analytics, Financial Technologies, and Material Science.

1. **Local Talent Matching Requirement**: This requirement concerns the local employee matching ratio. For every three non-local talents hired under TechTAS, the applicant company must also employ three additional people, including one local full-time technology staff and two local interns. In the case where less than three TechTAS talents are hired, the company must also hire three new local staff nonetheless **(Figure 18)**. For start-ups and SMEs, this requirement becomes a great burden as they cannot afford to hire four employees at one time in order to hire one foreign talent. Therefore, we recommend that the Government should adjust the matching requirement to better balance between the needs to support start-up companies in recruiting foreign talents and to safeguard job opportunities for locals.

Figure 18. **Relaxing the local talent matching restriction**



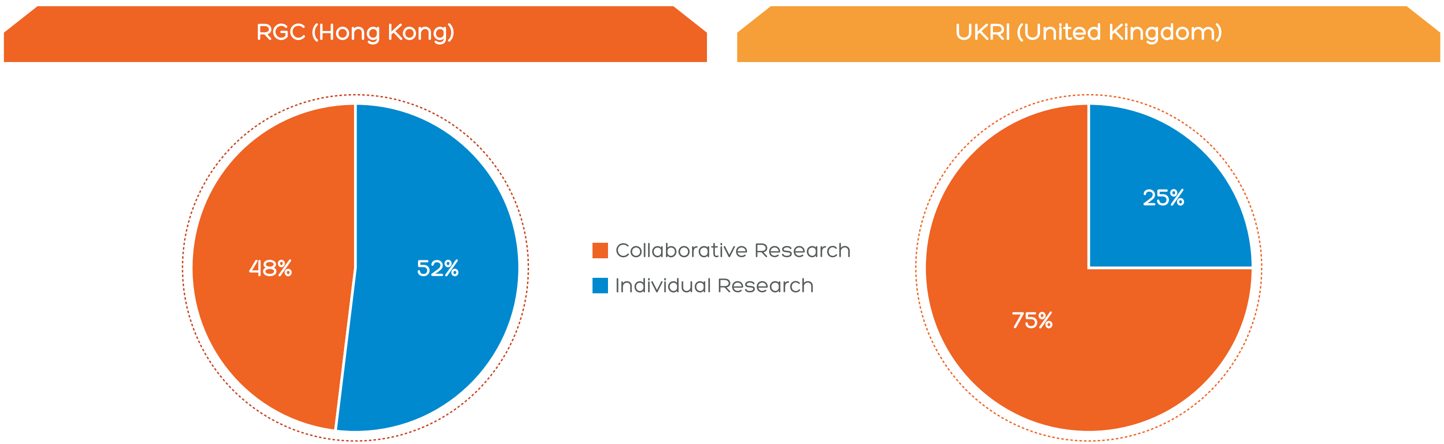
2. **Research Area Requirement**: Although more areas that demonstrate R&D significance and promising growth potentials have been included in the new initiatives announced in the 2019 Policy Address, technology-related areas remain excluded by TechTAS. In addition to frontline researchers who directly conduct scientific research, professionals in technology-related fields, such as intellectual property (IP) protection, technology management, and data quality management, are indispensable for finally bringing R&D outcomes to the market. We therefore recommend that TechTAS should extend eligibility to applicants from technology-related fields to fully release Hong Kong's R&D potentials.

4. Fostering Interdisciplinary and Cross-institutional Collaboration

With an efficient funding system and a sustainable talent pipeline, research collaboration will thrive. Hong Kong would thereby be well-positioned to leverage its competitive advantages in basic research, which is crucial in transforming itself into an R&D powerhouse. Research collaboration, as highlighted in the Introduction section of this report, enables researchers to address multi-faceted challenges that no single individual can tackle alone while amplifying research impact. Against such a backdrop, it is a global trend to break the disciplinary and institutional barriers and to foster collaboration at all levels.

Although Hong Kong is renowned for its basic research, interdisciplinary and cross-institutional collaborations among researchers at universities have been lagging behind. This is evident from comparing research funding allocation by Hong Kong's RGC with the seven Research Councils under the UKRI, which are, respectively, the largest sources of competitive research funding for the higher education sector in Hong Kong and the United Kingdom. While only 48% of RGC's research funding was awarded to collaborative projects, 75% of projects funded by UKRI's Research Councils contained collaborative elements **(Figure 19)**.

Figure 19. **Higher education collaborative research funding: Research Grants Council vs UK Research and Innovation (2018)**



Sources: Research Grants Council, Census and Statistics Department, UK Research and Innovation

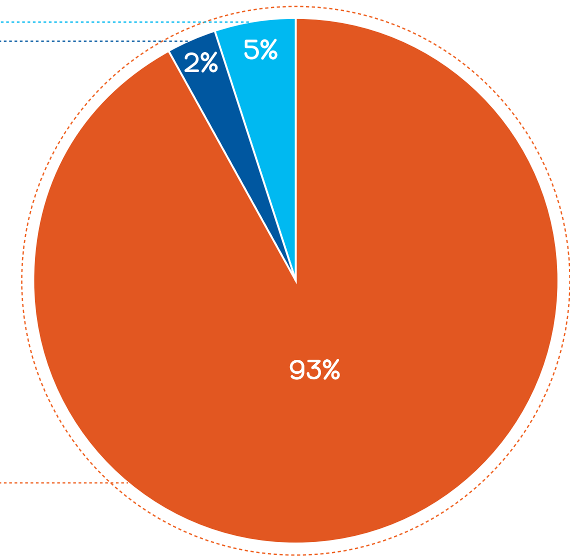
In terms of project number, small grants for individual research projects still predominate in Hong Kong's research landscape under the current funding system, with over 1,000 projects accounting for 93% of total projects funded under RGC's project-based research grant schemes. On the contrary, less than 100 interdisciplinary and cross-institutional collaborative research projects were funded, making up only 7% of total project number **(Figure 20)**.

Figure 20. **RGC project-based research grants by project type (2018/19)**

Collaborative research	
Collaborative Research Fund (CRF)	20
Theme-based Research Scheme (TRS)	5
Research Impact Fund (RIF)	30
Areas of Excellence (AoE)	3
	58

International research	
Joint Research Scheme (JRS)	29

Individual research	
General Research Fund (GRF)	989
Early Career Scheme (ECS)	153
	1,142



Source: Research Grants Council

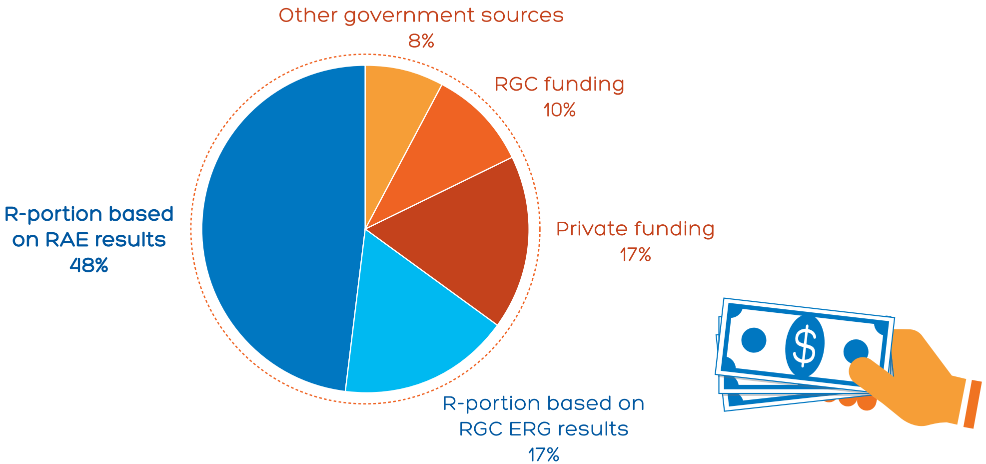
Challenge 5: Performance Evaluation Criteria Insufficiently Conducive to Research Collaboration

Research collaboration in Hong Kong is hindered by insufficiently conducive performance evaluation criteria at the individual and institutional levels. The culture of isolation within and among universities is a striking deterrence to interdisciplinary and cross-institutional collaboration, undermining Hong Kong's R&D capability. Inadequate support for a collaborative research culture both at the individual and institutional levels is the main challenge to fostering a truly collaborative research environment.

At the individual level, contribution from individual researchers in multi-investigators' projects is not entirely evaluated in a balanced and fair manner. According to the feedback from the stakeholders we interviewed, co-authored research outputs are often assessed with reduced credit if the co-authors contribute as co-investigators or collaborators—a phenomenon that discourages collaboration, and instead intensifies competition for becoming the Principal Investigator. For example, IPs are usually stored and managed at the Principal Investigator's host institution even if other investigators dedicate a significant amount of resources into developing them, thus deterring researchers from collaborating.

At the institutional level, UGC's funding allocation mechanism inherently discourages collaboration. 48% of universities' total research funding is allocated from the R-portion based on their research performance in the Research Assessment Exercise (RAE). This makes the RAE the most important determinant in universities' research funding **(Figure 21)**.

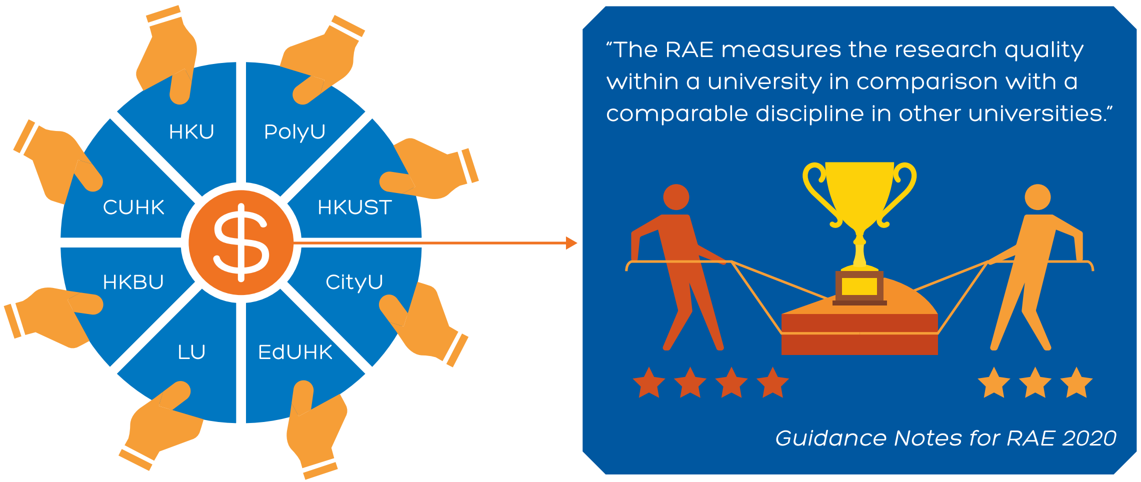
Figure 21. **University research funding by funding source**



Sources: Task Force on Review of Research Policy and Funding, Census and Statistics Department

The RAE is a performance-based evaluation system that adopts a star rating scale to assess the research quality of UGC-funded universities by disciplines[20]. Given that the R-portion funding for all UGC-funded universities is limited, universities are therefore engaged in a zero-sum game to compete for a larger share of the pie, making them reluctant to collaborate **(Figure 22)**.

Figure 22. **Institutional-based funding mechanism discourages collaboration**



Source: University Grants Committee

[20] For further details of RAE, please refer to the Appendix.

Recommendation 5: Revise Individual and Institutional KPIs to Incentivise Collaborative Research

In view of the above challenge, we recommend that relevant parties should revise the Key Performance Indicators (KPI) in the evaluation regime of both faculties and universities to foster a more collaborative research culture.

At the individual level, co-authors should be evaluated in a way that fairly reflects and rightly balances their contributions in joint research outputs when their promotion and tenure are being considered. Although independent publication of world-class papers is still upheld as the key assessment criterion in the academic realm, collaborative research is on the rise globally to advance research excellence as well as to nurture the next generation of researchers. Any amount of inputs or resources contributed by co-investigators as well as collaborators in a multi-investigator project should be rewarded and fairly recognised to incentivise collaborative research.

At the institutional level, interdisciplinary and cross-institutional collaborations, collaborations with R&D centres, and university-industry collaborations should all be recognised and given sufficient weighting in the RAE. Although it is encouraging to see the RAE 2020 has taken the right step to stimulate collaboration by adding the Research Impact and Research Environment components[21], more explicit acknowledgement and greater significance should be given to collaborative efforts. Therefore, it is recommended that both Research Impact and Research Environment should not only credit collaboration in an elaborate manner, but also increase weighting for collaboration in order to fully capitalise on the universities' research strengths for the enhancement of Hong Kong's R&D capability.

[21] The RAE 2020 has three elements of assessments, which are Research Output, Research Impact and Research Environment. Their respective weightings are 70%, 15%, and 15%.

Challenge 6: Lack of Infrastructure for Upstream and Long-term Research

While Recommendation 5 aims to overcome the cultural barriers to collaboration by increasing recognition and incentives for collaborative work, the Government should also adopt a multi-faceted approach in dealing with structural barriers. To develop Hong Kong into an international R&D powerhouse, large-scale infrastructure is essential in facilitating research collaborations. Such infrastructure would also serve to attract global talents and retain local talents by providing them with promising career paths.

Although Hong Kong is well known for the high calibre of its researchers, especially when compared with other economies in Asia, there is still room for improvement in order to compete with the best in the world. According to the list of Highly Cited Researchers 2018[22] conducted by Web of Science Group, Hong Kong universities fell behind UK and US universities in the number of highly-cited researchers **(Table 4)**, who are defined as "researchers that have produced multiple highly-cited papers that rank in the top 1% by citations for field and year". The insufficiency of top research talents hinders Hong Kong's R&D capability.

[22] Highly Cited Researchers is an annual list that recognises influential researchers in the sciences and social sciences from around the world. For the 2018 Highly Cited Researchers analysis, the papers surveyed were published and cited during 2006-2016 and then ranked in the top 1% by citations for their Essential Science Indicators field and year.

Table 4. **Highly-cited researchers: Hong Kong, United States, and United Kingdom (2018)**

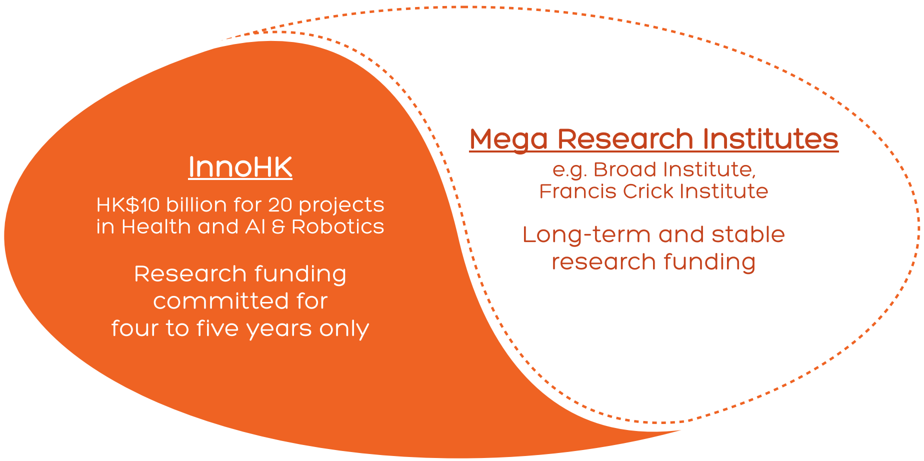
University (QS Ranking 2020)	Number of Highly-cited Professors[1]
Hong Kong	
HKU (25th)	15
HKUST (32nd)	7
CUHK (46th)	9
CityU(52nd)	9
PolyU(91st)	10
United States	
MIT (1st)	44
Stanford (2nd)	64
Harvard (3rd)	186
CalTech(5th)	25
Chicago (10th)	23
United Kingdom	
Oxford (4th)	59
Cambridge (7th)	53
UCL (8th)	43
Imperial (9th)	29
Edinburgh (22nd)	35

Note: [1] Defined by the production of multiple highly-cited papers that rank among the top 1% by citations for field
Sources: Web of Science Group, QS World University Rankings 2020

Recognising the importance of converging high-calibre academics and researchers to conduct collaborative research, the Government established two world-class research clusters at the Science Park, namely Health@InnoHK and AIR@InnoHK. According to ITC, Health@InnoHK focuses on all types of healthcare-related technologies, including Drug Discovery, Molecular Diagnostics, Bioengineering, etc. Meanwhile, AIR@InnoHK focuses on the development of Artificial Intelligence and Robotics applicable in areas such as Financial Services, Smart City, and Advanced Manufacturing. Under the InnoHK initiative, research laboratories or programmes must involve the collaboration between local institutions and the top echelon of foreign institutions.

InnoHK is a significant initiative that provides researchers with unprecedented resources to conduct collaborative research. The annual research funding per project under InnoHK would be approximately HK$100 million on average—ten times more than the funding for a project under the RGC Collaboration Schemes. However, since the research funding can only be committed for four to five years, with technological adoption being one of the assessment criteria according to the *Guidance Notes for Admission to Health@InnoHK & AIR@InnoHK*, it is logically possible that applications might tend to focus primarily on short-to-medium term and application-driven research projects in order to meet the five-year timeframe. Although many researchers appreciate the initiative as it is a pioneering move that demonstrates the Government's determination to develop Hong Kong into a hub for global research, there is still a gap to fill in order to provide adequate opportunities and incentives for global researchers from different institutions and disciplines to collaborate on long-term and large scale research projects. In particular, long-term and stable funding is essential to basic research in order to create fundamental scientific and technological breakthroughs. By comparison, other economies have already established mega institutes to address their research needs **(Figure 23)**.

Figure 23. **Lack of mega research institutes for long-term research projects**

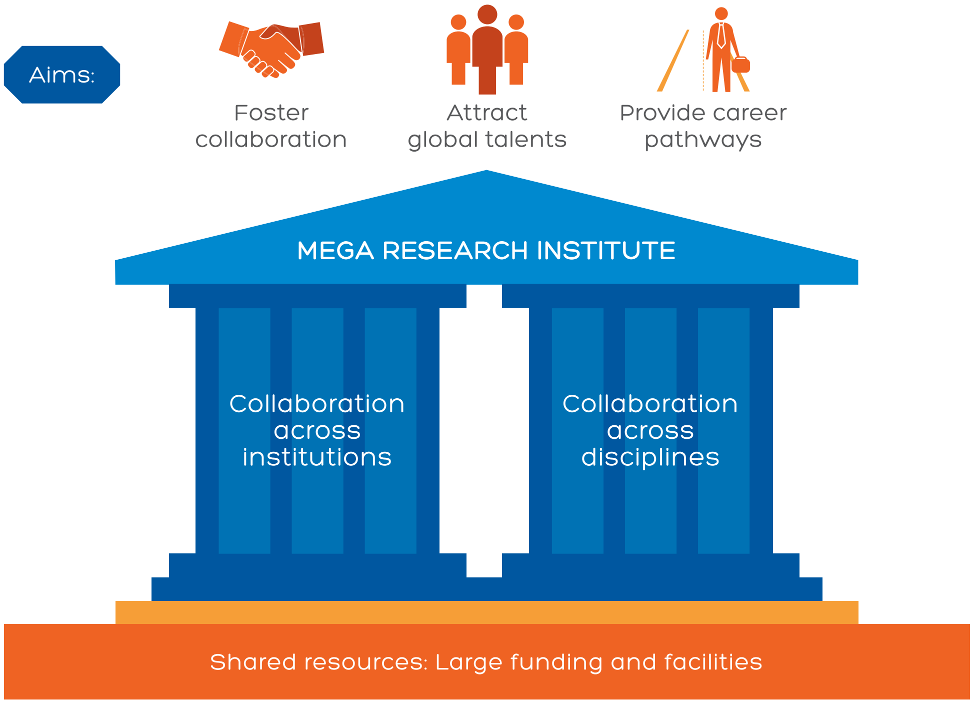


Source: Innovation and Technology Commission

Recommendation 6: Establish Mega Research Institutes

To fill this void, Hong Kong should establish mega research institutes which would create more stable research opportunities and allow more long-term and large-scale research collaborations across disciplines and institutions to take place. On one hand, the new collaborative research institutes will provide researchers with extensive resources, shared facilities, and a collaborative environment to solve large-scale and complex problems together. On the other hand, they serve as a 'magnet', not only to attract local and overseas talents, but also to retain emerging scientists by providing them with promising career pathways **(Figure 24)**.

Figure 24. **Establishing mega research institutes**



Hong Kong should start with establishing a mega research institute as a pilot programme for biomedical science, which has been identified by the Government as one of the key areas where the city has competitive advantages in. As a matter of fact, Hong Kong has two top-level medical schools in Clinical Medicine according to the ISI Essential Science Indicators. Renowned for their biomedical research, Hong Kong universities are estimated to produce about 250 biomedical publications of high impact factor every year. Furthermore, Hong Kong acts as a major clinical trial centre as its clinical trial data is simultaneously recognised for drug registration purposed by the U.S. Food and Drug Administration, the EU's European Medicines Agency, and China National Medical Products Administration.

While the path to research collaboration varies in structure and scope, leading scientific economies such as the US and the UK have been moving towards establishing cross-institutional research institutes. In the US, the Broad Institute is designed to foster collaboration in a deeply collaborative spirit across disciplines, organisations, and regional borders to solve complex biomedical problems of our times. Collaborative research projects involving over six disciplines and more than 40 countries have taken place at the Broad Institute, signifying the rise of a new type of research organisation that breaks cultural and organisational silos. In the UK, the Francis Crick Institute aims to provide comprehensive support for biomedical research endeavours throughout the country and to expand the pool of talents by attracting global scientists from top-notch leaders to junior researchers. Under its unique investigator programmes, the Francis Crick Institute recruits scientists through open international competition with a view to have about one-third of its group leaders employed from around the world in the long term **(Table 5)**.

Table 5. **Case study: Broad Institute and Francis Crick Institute**

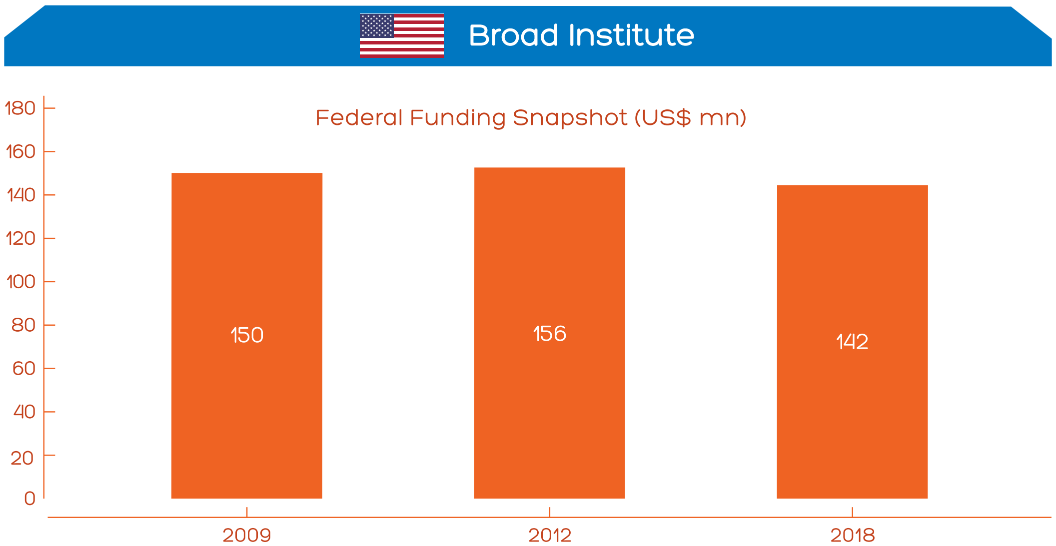
	Broad Institute (US)	Francis Crick Institute (UK)
Year of establishment	2004	2016
Collaborating partners	Harvard University, MIT, Harvard-affiliated hospitals	Medical Research Council, Cancer Research UK, Wellcome Trust, University of College London, Imperial College London, King's College London
Institute at a glance	The Broad Institute was founded with the aim to improve human health by using genomics to advance the treatment of human disease.	The Francis Crick Institute is dedicated to understand the fundamental biology underlying health and disease.
Highlights	**Foster collaboration with deeply collaborative spirit across disciplines, organisations and regional borders:** 1) **Interdisciplinary:** over six disciplines including Medicine, Biology, Chemistry, Computation, Engineering, Mathematics and Statistics; 2) **Interinstitutional:** collaborate with over 100 institutions; 3) **International:** more than 100 projects across more than 40 countries.	**Attract global talents via two unique Investigator programmes:** 1) Crick **Senior Investigators** will be distinguished scientists and clinician scientists who are international leaders in their field. They will be recruited in open international competition and in the longer term will make up about one third of the group leaders; 2) Crick **Assistant / Associate Investigator** is recruited on a 12-year basis to support talented early career researchers. These junior researchers will acquire experience in teaching and university-based research through our three university founders, broadening their professional experience and career development and facilitating a possible move to the university sector when they leave the Crick.

Sources: Broad Institute (United States), Francis Crick Institute (United Kingdom)

With reference to the aforementioned institutes, Hong Kong should set up similar mega research institutes that encourage close collaboration among researchers from different disciplines and institutes across the world to conduct cutting-edge research. Besides, Hong Kong should follow the example of the Francis Crick Institute in setting up talent schemes to attract top-notch scientists and to groom prospective researchers. Hong Kong should learn from the experiences of the US and the UK, and establish mega research institutes that cover upstream, midstream and downstream research projects. Furthermore, the establishment of mega research institutes can lift up the quality of talents in Hong Kong by recruiting overseas research leaders and by providing attractive options for promising research postgraduates to continue their research careers in Hong Kong.

To sustain the mega research institutes in the long run, strong government commitment in the early stage is crucial. Take the Broad Institute as an example: around US$150 million of federal funding is allocated annually to support its research **(Figure 25)**. In view of the importance of a steady annual budget to ensure the future development of the mega research institutes, we suggest that a recurrent funding of HK$1 billion per year should be earmarked for this purpose, while sustainable funding from other public and private funding agencies should be made available as well.

Figure 25. **Federal funding for the Broad Institute**

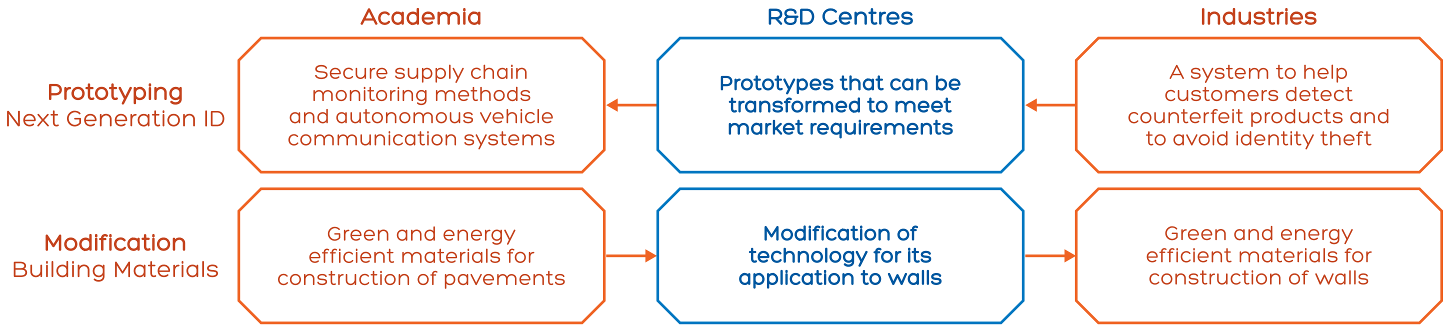


Source: Broad Institute (United States)

Challenge 7: Insufficient Cooperation in the Innovation System

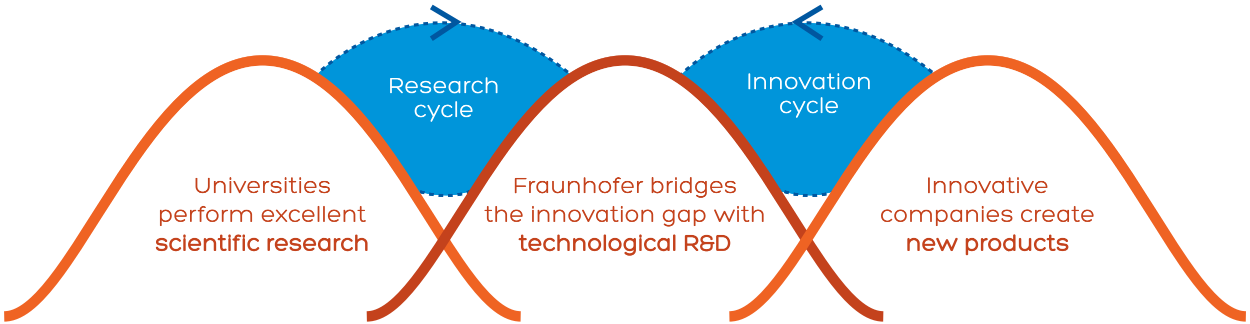
Apart from strengthening cooperation with each other, universities should not ignore collaboration with other players in the innovation ecosystem, particularly R&D centres and industries. R&D centres are valuable partners, given the research and administrative resources they are able to provide for both universities and industries. For example, R&D centres could help relieve manpower shortage in universities by providing research and administrative staffing support for collaborative projects with academia. R&D centres is also one of the key players in aligning universities and industries, as they could fill the innovation gap between academia and industries in different scenarios **(Figure 26)**. The first example of such scenarios is prototyping, where R&D centres build prototypes based on academic research findings to meet market requirements. The second example is modification, where R&D centres adjust scientific techniques in order to cater to industry demands. Next generation ID and green building materials are good demonstrations of tripartite cooperation. Through these cooperation projects, the three players in the R&D ecosystem can develop greater synergies.

Figure 26. **R&D centres filling the innovation gap: two examples**



Looking at overseas experience, Germany offers a prime example in forging tripartite cooperation among universities, R&D centres, and industries. For instance, Fraunhofer, Europe's largest application-oriented research organisation, has defined its role in bridging the innovation gap between the university's research cycle and industry's innovation cycle, which is driven by market demands[23] **(Figure 27)**. Positioning itself between academia and industry, Fraunhofer has leveraged on universities' excellent scientific research while keeping a close eye on the latest industry trends to facilitate the whole innovation system in Germany and even in Europe. Through 72 institutes and research units in different locations, Fraunhofer has maintained long-term and close cooperation with local and international universities. At the same time, 85% of Fraunhofer's €2.6 billion annual research budget is generated through contract research, indicating its deep engagement with industries.

Figure 27. **The Fraunhofer model: current situation in Germany**



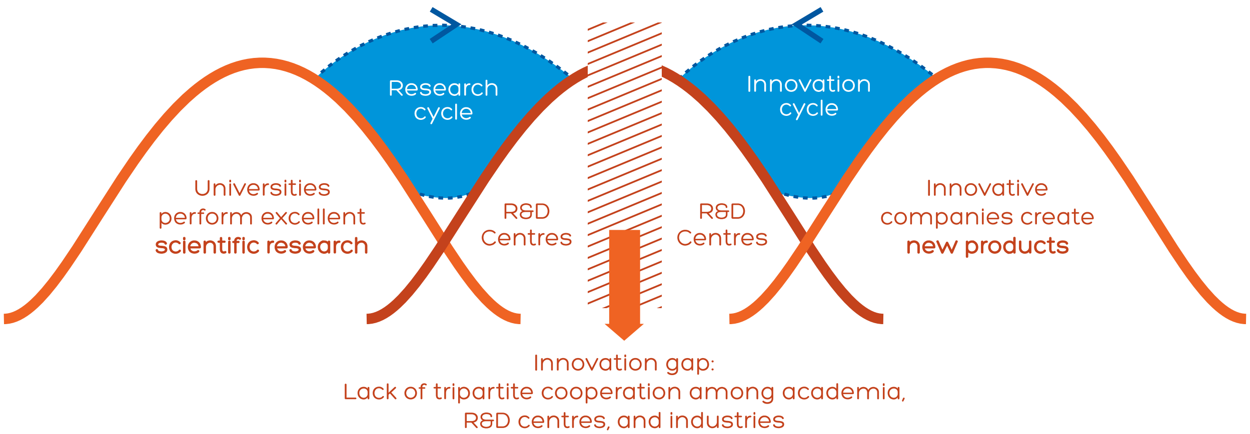
Source: Fraunhofer (Germany)

[23] The Fraunhofer Model - Technology Transfer from Universities to Industry (2018)

Meanwhile, in Hong Kong, R&D centres have also joined hands with universities. For example, HKRITA is hosted by PolyU, from where it can draw on research expertise. ASTRI has joint research laboratories with different universities such as HKU and HKUST. At the same time, R&D centres' cooperation with industry has produced encouraging outcomes. For instance, the "RFID-enabled Parcel Locker System", a joint effort by LSCM and Hong Kong Post, has won the gold medal at the Geneva International Exhibition of Inventions (2017). In addition, the joint laboratory by ASTRI and Hong Kong Telecom has been contributing to the development of Smart City in Hong Kong.

Unfortunately, tripartite cooperation among R&D centres, universities, and industries is rarely seen in Hong Kong, indicating room for improvement in mid-stream research **(Figure 28)**. Although R&D centres are not necessary to foster collaboration between universities and industries, they have a unique role in connecting both sides as mentioned previously. In this aspect, R&D centres could draw lessons from Fraunhofer's successful experience and improve its ability in lining up academia and industry.

Figure 28. **Current situation in Hong Kong**

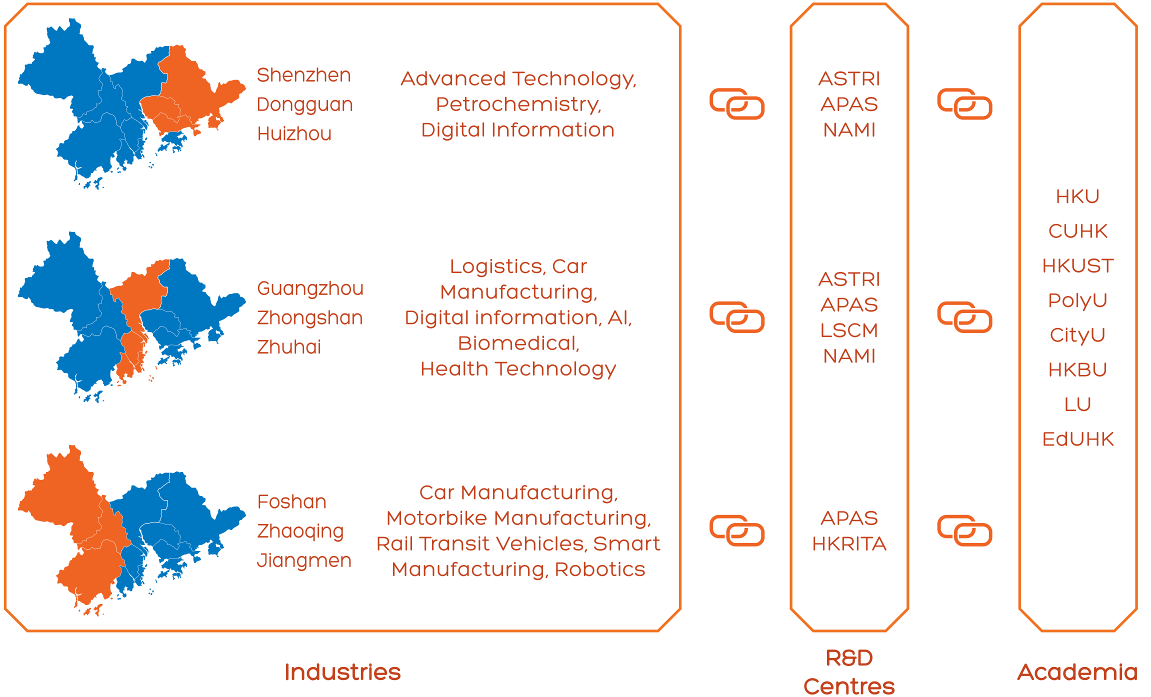


Learning from Fraunhofer's bridging model, R&D centres in Hong Kong should strengthen its connection with both ends for a comprehensive and coordinated innovation ecosystem. At the university's end, an improved KPI framework would help incentivise academia to step up cooperation with R&D centres as detailed in our Recommendation 5. At the industry's end, Hong Kong's R&D centres should turn to the opportunities in the Greater Bay Area (GBA).

Home to numerous established and growing industries, GBA cities specialise in high-technology and related areas, making them compatible partners with top universities in Hong Kong. R&D centres should take advantage of Hong Kong's proximity to other GBA cities to foster greater synergy with industries and facilitate GBA industries in leveraging Hong Kong universities' excellent basic research.

Each GBA city has its own advantages. For example, the eastern GBA cities including Shenzhen, Dongguan, and Huizhou have competitive edges in high-technology, digital information, and petrochemistry, which overlap with the research areas of ASTRI, NAMI, and APAS. Therefore, a long-term partnership between eastern GBA cities and these three R&D centres would undoubtedly produce synergy. Similar potentials can also be observed between other GBA cities and R&D centres for forming systematic and strategic collaborations within the GBA **(Figure 29)**. In addition to directly working with industries, R&D centres should also initiate tripartite cooperation with academia if they deem that industries would benefit from Hong Kong universities' basic research support.

Figure 29. **R&D centres' cooperation opportunities with GBA industries**



Recommendation 7: Establish Branch Offices in the GBA by R&D Centres

A Fraunhofer's practice that we should take note of is the creation of the Corporate Business Development and Marketing Department, positioned to bring together industrial and potential academic partners **(Figure 30)**. The R&D centres in Hong Kong should set up a similar department to advance its industry-related business.

Figure 30. **Function of Fraunhofer's Corporate Business Development and Marketing Department**

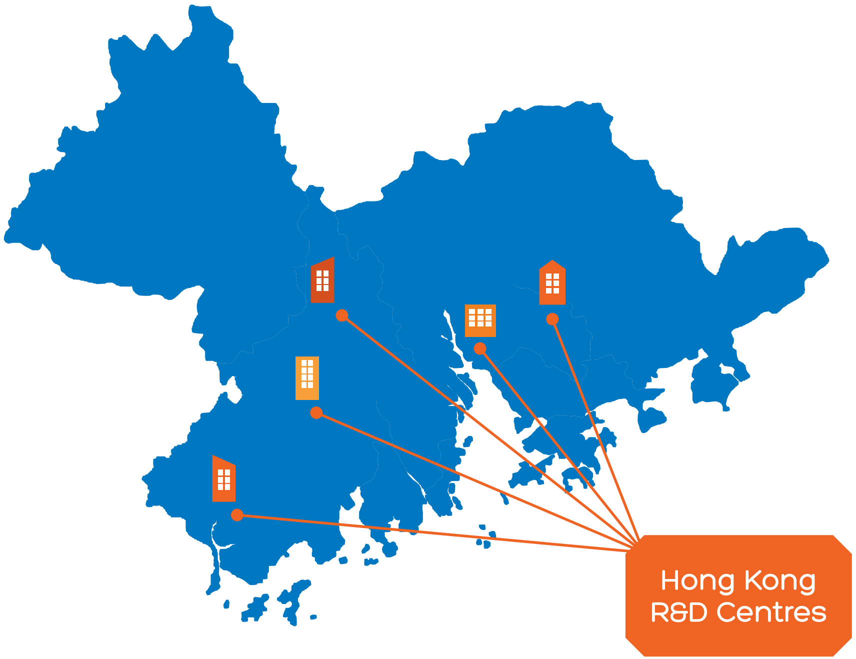
Fraunhofer Institute
Corporate Business Development & Marketing Department

Consist of industry experts	Initiate cross-institute projects	Provide tailored support for companies
Help determine the R&D needs of companies	Line up cooperation opportunities with industries, and decide if academia's research support is needed	Provide research support if needed
		Assist in brainstorming sessions, feasibility studies, product and process development, and offer training to support the implementation of new technologies and procedures

Source: Fraunhofer (Germany)

Taking the idea of establishing a Corporate Business Department further, R&D centres should consider setting up branch offices in the GBA **(Figure 31)**. Setting up offices near companies would help facilitate communication and cooperation, which is conducive to R&D centres' stable and long-term partnership with industries. Currently, ASTRI is the only R&D centre in Hong Kong that has a branch in GBA cities. Other R&D centres should also be encouraged to open a branch office in the GBA to seize potential opportunities. An office located at the heart of the market could help them monitor and evaluate current technological trends in society. Furthermore, a cross-border branch office would help the centres understand mainland China's legal system and better manage IP-related issues for cross-border collaborative projects.

Figure 31. **R&D centres to establish branch offices in the GBA**

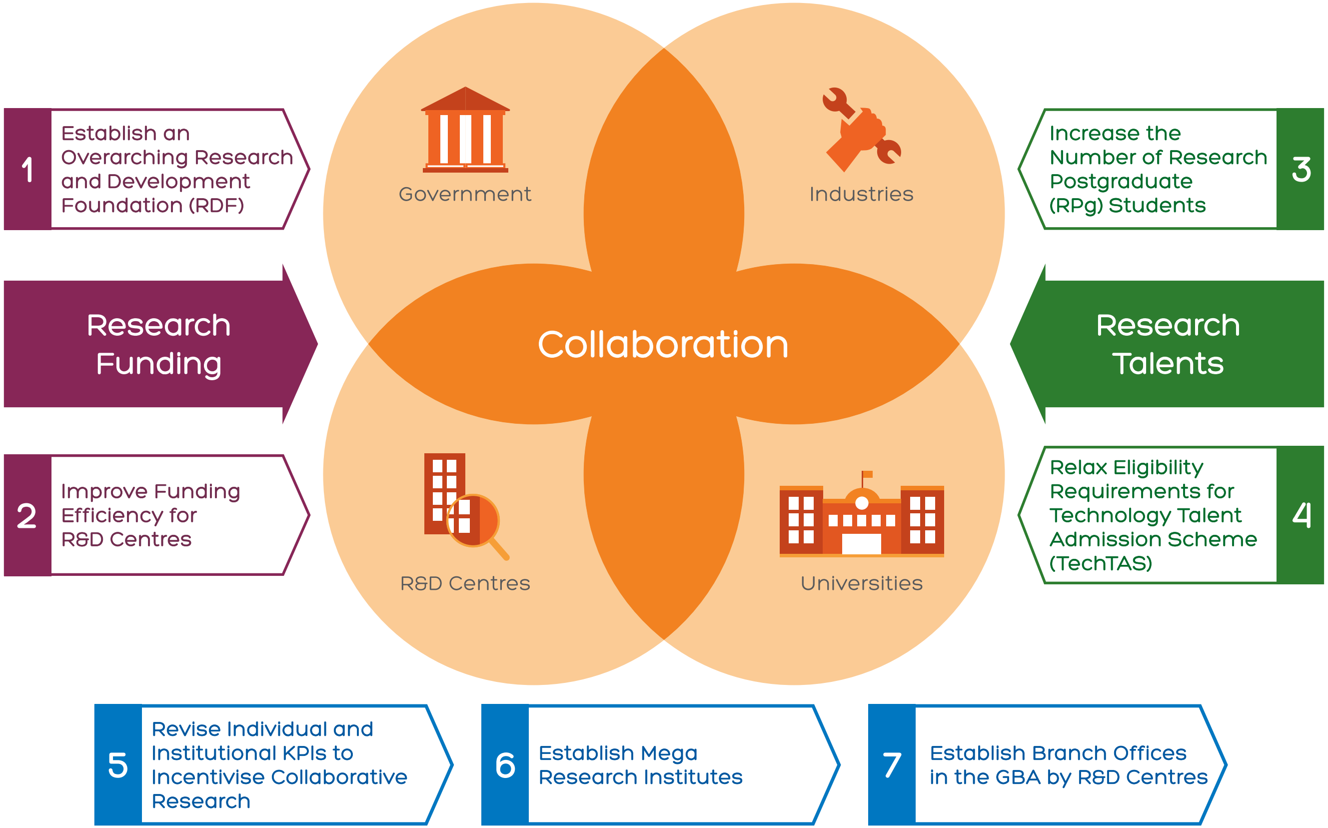


By strengthening R&D centres' links to both ends, Hong Kong would be able to build an organic innovation system in which the academia, R&D centres, and industries work together to drive innovation and technological development.

5. Conclusion

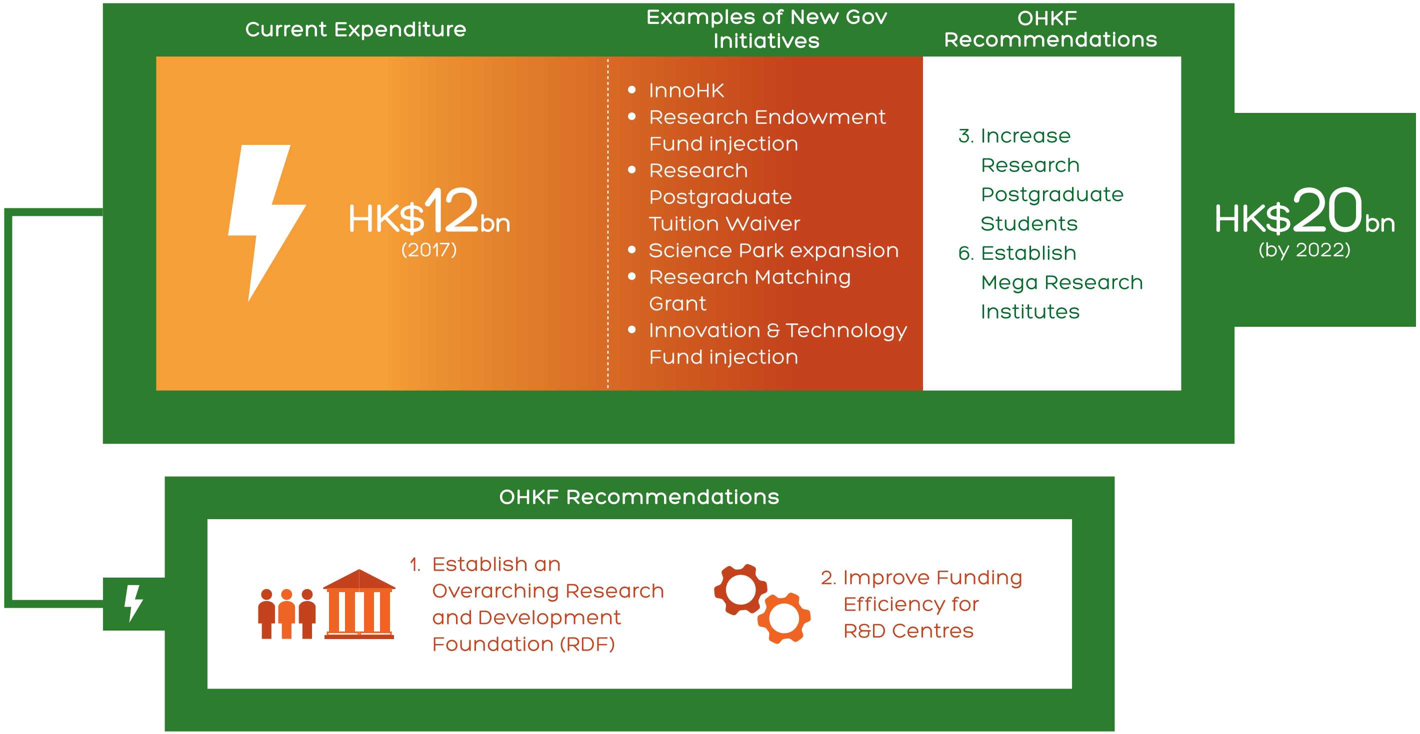
This report has focused on developing Hong Kong into an international R&D powerhouse. As scientific challenges nowadays have become increasingly complicated and thus require greater inputs, cross-institutional and interdisciplinary collaboration is necessary to empower Hong Kong's R&D ecosystem. Nevertheless, this report also concentrates on two essential preconditions for research collaboration to burgeon: a strategic and efficient funding system and a sustainable talent pipeline. Our recommendations are summarised as follows **(Figure 32)**:

Figure 32. **Summary of recommendations**



Among seven recommendations, we would like to highlight Recommendation 6—to establish mega research institutes—as our most significant one in this report. In terms of funding, Recommendation 6, which, along with Recommendation 3, fits well with the Government's R&D expenditure target mentioned in Section 1. Meanwhile, Recommendations 1 and 2 aim to streamline the Government's overall research funding mechanism and enhance its efficiency **(Figure 33)**.

Figure 33. **Recommendations related to the Government's R&D expenditure**



Meanwhile, Recommendation 6 also aims to tackle the issue of talent shortage by providing talents with promising career pathways, along with big-budget, large-scale research opportunities to address grand scientific problems in order to attract and retain top tier talents. In addition, Recommendations 3 and 4 also focus on increasing the quantity of both local and foreign talents **(Figure 34)**.

Figure 34. **Recommendations to increase the quantity and quality of talents**

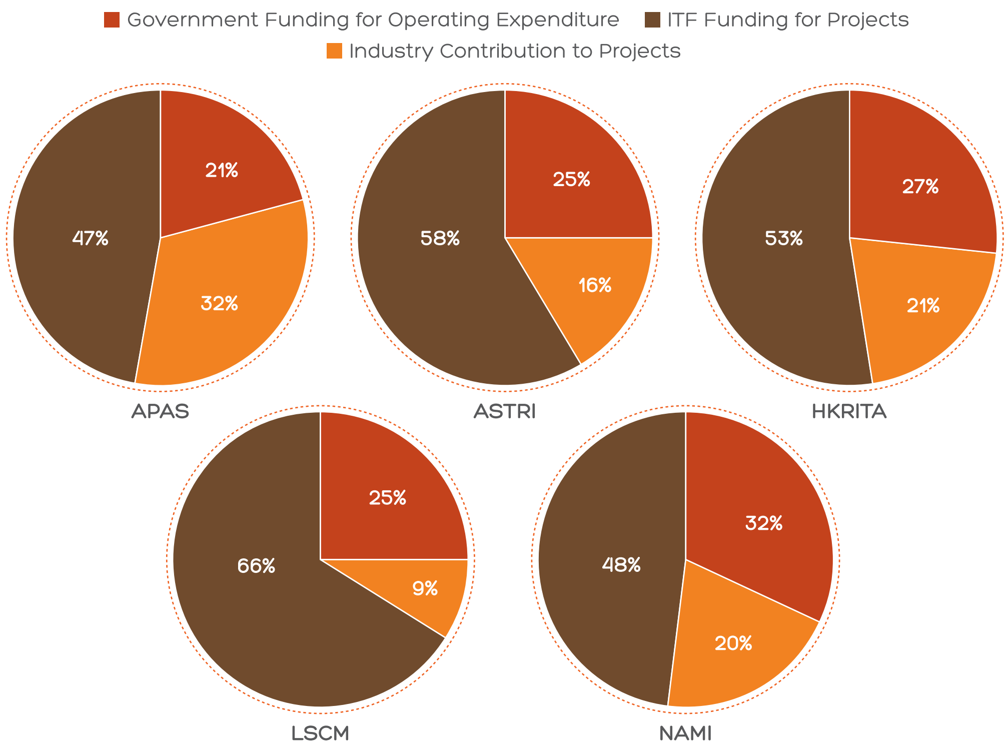
Under the themes of research funding, talents and collaboration, this report has put forward seven recommendations for the Government's consideration. We believe that these recommendations will contribute to a holistic and dynamic R&D ecosystem, and which in turn will enable Hong Kong to unleash its innovative power for significant and sustainable economic growth.

6. Appendix

Appendix 1. R&D Centres Funding Structure

The total funding for the five R&D centres covers three components: (a) Government Funding for Operating Expenditure, (b) Innovation and Technology Fund (ITF) Funding for Projects, and (c) Industry Contribution for Projects **(Annex 1.1)**.

Annex 1.1. R&D centres total funding by component (2017/2018)



Note: [1] Income from licensing/royalty and contract services are not included.
[2] Figures may not add up to 100% due to rounding.
Source: Legislative Council

Components (b) and (c) constitute the total project funding for R&D centres **(Annex 1.2)**. For different types of research projects, the industry contributes different proportions of the total project funding, varying from 0 (seed projects) to 50% (industry collaborative projects) **(Annex 1.3)**.

Annex 1.2. **R&D centres project funding by project type (2017/18)**

Note: [1] Contract research projects are not included.
[2] Since January 2019, the Collaborative Projects were merged into the Partnership Research Programme.
[3] Figures may not add up to 100% due to rounding.
Source: Legislative Council

Annex 1.3. **Different research projects and industry contribution**

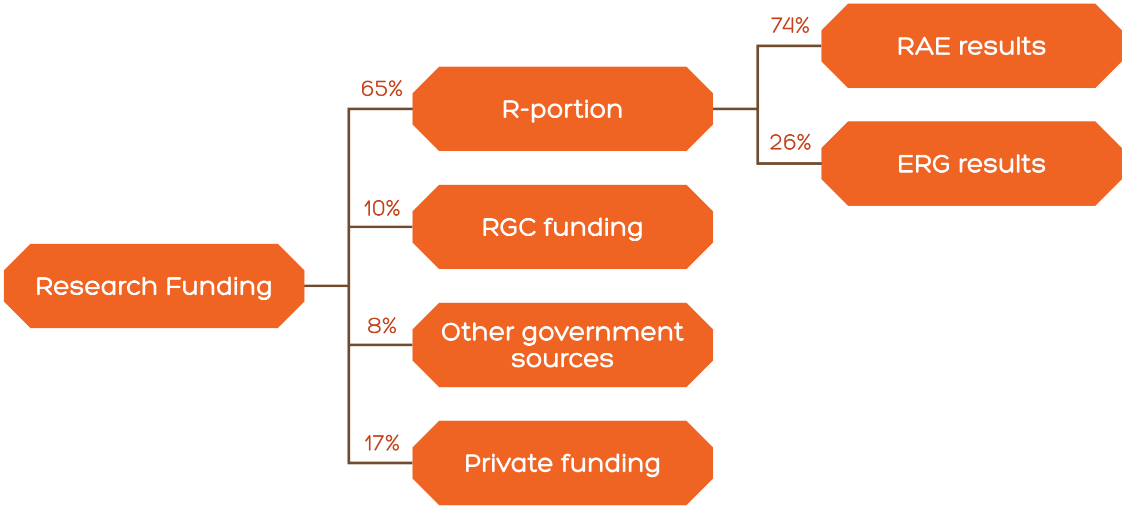
Research Project Type	Industry Contribution (% of Total Project Funding)
Industry collaborative projects	30% - 50%
Platform projects	10%
Seed projects	0

Source: Innovation and Technology Commission

Appendix 2. Research Assessment Exercise (RAE) in R-portion

RAE plays an important role in determining universities' research funding. According to the Task Force on Review of Research Policy and Funding, 65% of universities' total research funding comes from the R-portion of the Block Grant. The allocation of R-portion is determined by two factors: 74% of the R-portion is distributed based on the universities' performance in the RAE, while 26% is apportioned based on the universities' success in applying for RGC's Earmarked Research Grants (ERG). Taking the two figures into account, it can be seen that 48% (65%*74%) of universities' research funding is determined by the RAE **(Annex 2)**.

Annex 2. **How RAE results impact research funding**



Source: Task Force on Review of Research Policy and Funding

The RAE is a performance-based evaluation that assesses the research quality of UGC-funded universities by Units of Assessments. Units of Assessments are organised based on disciplines (e.g. Biology, Health Science, Engineering, etc.). The RAE applies a star grading system for its assessment, with five levels on the rating scale ranging from "unclassified" to "four stars". There are three components in the RAE 2020: Research Output, Research Impact, and Research Environment, which bear a weighting of 70%, 15%, and 15% respectively in the overall assessment result.

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