

Report on

Policy Study

on the Integrative Development of Innovation and Technology

in the Guangdong-Hong Kong-Macao Greater Bay Area

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Hong Kong Academy of Engineering Sciences
香港工程科學院



中國工程院
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香港科技大學
THE HONG KONG UNIVERSITY OF
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IPP INSTITUTE FOR
PUBLIC POLICY
公共政策研究院
Innovation for Global Leaders

CAE-HKAES Report on the Integrative Development of Innovation and Technology in the Guangdong-Hong Kong-Macao Greater Bay Area

by

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HKAES and CAE Spotlights



Panel discussion at the CAE-HKAES Forum (24 May 2017)

▲ Group photo with Mr. Paul M P Chan, Financial Secretary, HKSARG at the CAE-HKAES Forum (24 May 2017)





▲ HKAES visit to CAS in Beijing (24-26 April 2016)

Prof W S Wong,
Vice President of HKAES
being interviewed by
Shenzhen TV after a
CAE-HKAES meeting to
exchange views on
integrative development in
the Greater Bay Area
(28 September 2017)



▼ Group photo with Mr John Tsang, then Financial Secretary of HKSARG at the CAE-HKAES joint Summit (13-14 April 2015)



Panel discussion ▶
during the CAE-HKAES
Joint Summit
(13-14 April 2015)



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FOREWORD by

Dr. Andrew K.C. Chan
President, Hong Kong Academy of Engineering Sciences

In this new era of economic development, innovation and technology (I&T) are the game-changers that can propel the advancement of society and tackle global challenges. This joint-Academy policy study, consisting of collaborative efforts by the Chinese Academy of Engineering (CAE) and the Hong Kong Academy of Engineering Sciences (HKAES), was prompted by the belief that a vibrant innovation and technology industry is vital to the economic future of Hong Kong, and that synergy must be created with the metropolises in the Greater Bay Area in order to be a leading force in the economic development of the Region.

The CAE is the national academy of China, consisting of the most distinguished academicians across the whole spectrum of engineering and technology disciplines. The HKAES is Hong Kong's own Academy founded in 1994 by eminent leaders in the field, with strong support of the government and the Hong Kong Institution of Engineers. It is an organization of Hong Kong's most distinguished engineers elected for their outstanding achievements in engineering sciences, practices, business and public service. Many of them are also fellows of other national academies.

This study is a deep collaboration of the two Academies, building on the shared vision arising from the CAE-HKAES Joint Summit on Innovation and Technology Industry in Hong Kong and the Pearl River Delta (PRD) held in Hong Kong in April 2015. The Summit, attended by policy makers from the Mainland, Hong Kong, Taiwan and overseas, provided a useful platform for exploring directions for the future development of industry in Hong Kong and the Pearl River Delta employing the combined strengths and expertise on both sides of the border.

As the first independent cross-border collaborative study, this project provides an objective analysis of the I&T strengths of Hong Kong and suggestions for the way forward for transforming Hong Kong into a knowledge-based economy. I hope that Hong Kong's stakeholders will derive some insights from this joint-Academy study as they reflect on the scientific and technological strengths of our dynamic city and ponder new strategies to strengthen its long-cherished global competitiveness.

The Academy wishes to acknowledge the sponsorship of the Central Policy Unit in sponsoring the Discussion Forum held on 24 May 2017. The strong support of the Hong Kong University of Science and Technology and the contributions of Professor Joseph H W Lee in leading the Study are gratefully acknowledged.

Dr. Andrew K.C. CHAN PhD (Cantab), BBS, JP, FHKEng, FREng
President
Hong Kong Academic of Engineering Sciences
(2015-2017)

FOREWORD by

Professor Yong Gan
Former Senior Vice-President, Chinese Academy of Engineering

The prosperity and stability of Hong Kong is critical to the successful implementations of the “One Country, Two Systems” principle. It is of utmost importance in China’s momentous national development and its revival and transformation into a rising global power.

The Pearl River Delta (PRD), the Beijing-Tianjin-Hebei region, and the Yangtze River Delta are collectively referred to as China’s three dominant economic circles, and they play a decisive role in the economic and social development of the nation. Among them, the PRD region has the highest GDP per capita. Founded on the “One Country, Two Systems” principle, the cooperation between Hong Kong and the Pearl River Delta region involves the interfacing and integration of a major international financial center and service economy with its neighboring cities that are part of an increasingly competitive regional economic powerhouse. This unique regional cooperation cannot be limited only to cross-border exchanges; it must be elevated to the national strategic level to enhance China’s engagement with and competitiveness in the global community.

In 2015, Hong Kong’s service sector accounted for 93% of its GDP, whereas its manufacturing industry accounted for only 1.2%. This structural imbalance of the economy and the high youth unemployment rate are serious social problems awaiting solutions. It is therefore obvious that there is an urgent need for Hong Kong to enter a new era of economic development through innovation. Steps should be taken to: integrate the science and technology resources and international status of Hong Kong with the well-established industrial base of the Pearl River Delta region; facilitate the incorporation of Hong Kong’s innovation capabilities into the national innovation system; strengthen regional cooperation; deepen the cooperation in research and innovation between the Mainland and Hong Kong; make all levels of national schemes for human resource development fully accessible to Hong Kong; make concerted effort to remove institutional barriers; enhance exchanges in science, technology and culture; and boost innovation and entrepreneurship among the young generation of Hong Kong. These measures are essential for achieving robust long-term development of both the Mainland and Hong Kong, and for enhancing our national competitive advantage on the international stage.

In June 2016, the Chinese Academy of Engineering and the Hong Kong Academy of Engineering Sciences embarked on a collaborative project entitled “A Study on the Integrative Development of Innovation and Technology in the Guangdong-Hong Kong-Macao Greater Bay Area”. It is a great pleasure to see that the report on the findings of this study is finally in print. This study is the first in-depth collaboration project between the two engineering academies. I hope that this endeavor can serve as a valuable experiment in the area of innovation and technology policy research, and has laid a solid foundation for further and deeper collaborations in the future.

Professor Yong GAN
Former Senior Vice-President, Chinese Academy of Engineering
Convener of CAE-HKAES Policy Study

PREFACE

In light of the rapid advancements in innovation and technology today, governments and industries in every corner of the world are compelled to reshape their thinking and strategies in order to rise up to the challenges of globalization, economic growth and other critical issues. It has been 20 years since the return of Hong Kong to its motherland. At this important juncture, it is timely for our city to cast a fresh eye on the progress that it has made on innovation and technology, and to contemplate the paths that it should take to further enhance its world competitiveness.

This is the first high level cross-border collaborative project on innovation and technology policy for the integration of Hong Kong and the hinterland. This study is both timely and necessary in view of the convergence of accelerating disruptive technologies, the positioning of innovation as a driver of economic growth in the national 13th five-year plan, and the urgency for a new model for the economic development of Hong Kong.

This year-long study, which was kicked off in July 2016, embodies an analysis of the strengths and weaknesses of the I&T ecosystem in Hong Kong, and a synthesis of views and insights of leaders across industry, academia and government. It began with a review of the progress in I&T in Hong Kong since the setting of the original vision by the Commission on Innovation and Technology in 1998, and in the context of the recommendations made in the 1997 “Made by Hong Kong” study by MIT. An objective analysis of research strengths of Hong Kong universities in broad S&T areas and knowledge transfer performance indicators was conducted by CAE-HKAES. Existing collaborative links between Hong Kong and the Mainland R&D partners were reviewed. The views of society leaders, prominent scholars and heads of knowledge transfer offices of Hong Kong universities were sought in a series of in-depth interviews. A list of 38 selected “success stories” from Hong Kong universities and industry have been collated to document exemplary local research innovation with commercial relevance. HKAES Fellows also held extensive discussions on the findings and insights gathered – in particular the missing links in the commercialization of applied R&D from the universities. A Forum held in May 2017 to share and discuss the initial findings was attended by members of HKAES, a delegation from CAE and Shenzhen, and key stakeholders including government officials.

The HKAES Fellows (project leadership team) who devoted time to this study hold a strong affinity for Hong Kong. They have grown with the development of I&T in Hong Kong; many of them also serve on the Government’s advisory committees. Their deeply-felt affection towards Hong Kong is one of the motivations that drives this collective effort to find answers on how to move Hong Kong forward in a dynamic and fiercely competitive environment. Some of the comments stated in this study may come across as frank and critical – which only reflect the Fellows’ collective sense of the imminent need for the transformation of Hong Kong to stay vibrant and competitive.

Although some of the findings and recommendations may have also appeared in other studies, this project represents a detailed, hands-on review and analysis by a group of practitioners in innovation and technology from both sides of the border, offering new insights and perspectives into the issues. As this study spans over the course of a year, a number of events have occurred in the meantime that may have already helped steer Hong Kong in the direction that this study has aspired. It is gratifying to see that progress is being made. To build on this momentum, it is our sincere hope that the findings of this study may be of some value to our all-society effort to catapult Hong Kong into a new phase of knowledge-based development for a sustainable future.

We wish to acknowledge the contributions of all the interviewees and in particular to the Project Working Group and the research support team. The support of Prof. JM Ko, Prof. OC Lin, Prof. N Sharif, Prof. WS Wong, Prof. X Wu, and Dr. Ying Ying are deeply appreciated. The recommendations draw heavily on the many discussions of the leadership team. Special thanks go to Prof. Tony F Chan and Prof. Wei Shyy, respectively President and Executive Vice-President and Provost of HKUST for their staunch support of the study and their firm vision to contribute to the development of I&T policy in Hong Kong.

Professor Joseph Hun-Wei LEE FREng, FHKEng
Elman Family Professor of Engineering and Public Policy
The Hong Kong University of Science and Technology
Convener of CAE-HKAES Policy Study

Executive Summary

“ Never before has there been a more critical need to invest serious efforts in transforming Hong Kong into an innovation-led knowledge-based economy.

“ I&T cuts across all sectors of the economy and a concerted effort must be made to upgrade the traditional industries of today and create high valued-added industries of tomorrow.

EXECUTIVE SUMMARY

This report by the Hong Kong Academy of Engineering Sciences (HKAES) and the Chinese Academy of Engineering (CAE) is the first in-depth collaboration between the two engineering organizations. In July 2016 the two Academies embarked on the first ever independent cross-border collaborative project on innovation and technology (I&T) policy for the integration of Hong Kong and the Guangdong-Hong Kong-Macao Greater Bay Area. The study endeavors to find answers to two key questions: *What does it take for Hong Kong to transform to another level of performance in innovation and technology and how best to collaborate with Mainland partners in the Greater Bay Area?*

The Purpose of the Study

As recommended by the study team in MIT who published the book “Made by Hong Kong” in 1997, Hong Kong would need to transform itself through technology and innovation and closer integration with the Mainland in order to maintain the competitiveness of its industries and its overall economy. Although the Government has since made different efforts on various fronts to boost R&D, the approach was cautious and the outcomes were mixed. One of the reasons was that Hong Kong’s stakeholders were lukewarm towards the new concepts of reinvention in the past and many opportunities were missed as a result. Nevertheless, in recent years there has been a gradual change in attitude towards I&T and the related role that the government should play. Now that the Innovation and Technology Bureau (ITB) is in place, a much needed strategic realignment of I&T development for Hong Kong must be addressed. The study aims to offer recommendations for policy-level strategies in harnessing the special strengths of the I&T sectors in Hong Kong and the Greater Bay Area so that the competitiveness of both economies can be enhanced.

The Uniqueness of the Study

Besides being the first deep collaboration between the HKAES and the CAE, this study is a very timely initiative against the backdrop of the national 13th five-year plan, in which technological innovation was high on the agenda. It is also a relevant study to help the Government shape the future direction of I&T development with the aid of the Innovation and Technology Bureau. In this study, HKAES and CAE conducted independently an objective analysis of research strengths of Hong Kong universities in broad S&T areas and knowledge transfer performance indicators. Against rigorous international benchmarks, a list of 38 selected “success stories” from universities and industry in Hong Kong has been identified to reflect exemplary local research innovation with commercial relevance. The study also reviewed the existing collaborative links between Hong Kong and Mainland R&D partners. During October 2016 to April 2017 a series of in-depth interviews was conducted with 37 distinguished leaders across academia, industry and government (including international leaders familiar with I&T in Hong Kong) to obtain their views on the missing gaps and barriers to the development of innovation and technology. HKAES (the Project Leadership Team) also met with CAE on 19 May 2017 to deliberate on the preliminary findings of the Study.

CAE-HKAES Policy Discussion

During the course of the project, the Project Leadership Team participated in the interviews and deliberated extensively on various I&T issues, upon which the study recommendations are based. The Team met on 22 November 2016, 23 and 25 January, and 18 and 22 May of 2017. An interview cum discussion session was also held with leaders of the Hong Kong Federation of Industries (FHKI) on 6 December 2016. On 1 April 2017, the HKAES views on the “Hong Kong/Shenzhen Innovation and Technology Park at the Lok Ma Chau Loop” were also presented by Dr. Andrew Chan (President of HKAES) in a brainstorming session organized by the Academy of Sciences of Hong Kong (ASHK). On 24 May 2017, a policy study forum co-organized by HKAES and the Institute for Public Policy

of the Hong Kong University of Science and Technology and supported by the Hong Kong government's Central Policy Unit was held to share the outcomes of the one-year study. The Project Leaders (Prof. Joseph H W Lee of HKAES and Prof. Yong Gan of CAE) presented the initial findings on the strengths and weaknesses of the innovation and technology ecosystem in Hong Kong. Policy recommendations for developing I&T as an engine for economic growth were put forward. This was followed by a panel discussion. This report has incorporated the collective views and policy suggestions put forward at the forum.

The Findings of the Study

- *Hong Kong is rapidly losing its competitive edge.* Hong Kong is at risk of losing its competitiveness to cities in the Greater Bay Area, in particular Shenzhen which has grown rapidly in recent years, thanks to its I&T reinventions. It has been generally recognized that I&T is an all-society effort. Hence, a coherent I&T policy and a proactive commitment on the part of the government are important to lead the transformation.
- *Innovate or die.* I&T must be fully embraced to sustain economic growth. I&T cuts across all sectors of the economy and a concerted effort must be made to upgrade the traditional industries of today and create high valued-added industries of tomorrow. The financial industry is also in need of rapid development in financial technologies (Fintech) in view of the changing financial landscape.
- *Hong Kong possesses unique strengths.* The research strengths of Hong Kong universities constitute a powerful factor in helping to solve the I&T equation for the city. Through an analysis conducted by the Project Leadership Team, it was found that Hong Kong has the greatest number of universities (5) in the top 100 spot in the QS World University Rankings, reflecting the international esteem bestowed on the research capabilities of these universities. Such strengths will need to be coordinated to enable synergistic development of I&T in collaboration with Mainland partners.
- *Laissez Faire or Positive Non-Interventionism does not work for Hong Kong.* The laissez faire policy is out-of-date. The government must take a lead role with regards to R&D investment, training and policy development to encourage and foster I&T for SMEs and R&D enterprises.
- *The current research funding model needs to be improved.* There should be long-term support for I&T development for R&D centers and thematic areas of demonstrated success. Many stakeholders also felt that a more efficient structure for setting agenda and vetting proposals is necessary for the current I&T funding mechanism.

Recommendations

- *Government leadership at the highest level necessary to rejuvenate I&T development.* It is evident that Mainland cities like Shenzhen and Shanghai have the backing of their respective governments in successfully adopting I&T to facilitate businesses, industries and ordinary citizens. Successful cases of government-backed I&T are also numerous at the international level. The governments of Singapore, South Korea and the US, for example, offer proactive support in facilitating and funding innovation and entrepreneurship. It is the recommendation that the Hong Kong SAR Government take proactive action in giving its support and providing the necessary leadership for building a sustainable innovation system for Hong Kong.

- *Professional and technical expertise necessary in government decision making.* Setting up a cross-department mechanism to encourage and support the development of I&T in all pillars of infrastructure and industry would be helpful. It is recommended that the Chief Executive appoint a high-level I&T advisory group to assist in the development of an I&T strategy and policy roadmap for the future, in consultation with independent key stakeholders such as HKAES, the Academy of Sciences of Hong Kong (ASHK) and the Federation of Hong Kong Industries (FHKI). The introduction of more technical expertise into the administration of innovation and technology related units is also recommended. For example, the Government could consider building up its technical capacity by migrating from a voluntary ‘committee service’ to a fully committed professional managerial operation overseen by personnel with R&D training.
- *Support for local technology innovation.* Some companies do not have the incentive to innovate because of financial concerns or other practical considerations. It is recommended that the Government step in and provide a more proactive and efficient funding and technology platform to encourage industry R&D such as supporting pilot test of new technologies, making the best use of procurement policies within legal limits, providing tax exemptions and more liberal sharing of intellectual property developed from government projects.
- *Enhancement of recognition for I&T contribution.* The Government is encouraged to work with the universities to develop a mechanism to foster the engagement in I&T, and to ensure that the pursuit of applied research or knowledge transfer is accepted as part of university’s societal mission. Reforms should be considered for the reward mechanism of universities to recognize the importance of I&T, such as giving academics the option to devote part of their time to engage in applied research and entrepreneurship activities.
- *Nurture of human resources and talents in I&T.* It is recommended that the Government develop policies that will be able to attract and retain Hong Kong trained talents in science and technology. It is also recommended that universities partner with secondary schools to promote research and innovation at an early stage. In addition, it would be beneficial if the existing Research Postgraduate (RPG) scholarship/fellowship schemes could be significantly enhanced to support enrolment of Hong Kong students in top universities overseas.
- *The identification of strategic areas for collaboration in Hong Kong and the Greater Bay Area.* Based on the collaborative study by the Hong Kong Academy of Engineering Sciences (HKAES) and the Chinese Academy of Engineering (CAE), the two organizations jointly recommended strengthening collaborations in strategic areas such as advanced manufacturing, big data science and e-commerce, environmental and urban governance, energy conservation and new energy, medical and health care, and new materials.
- *Development of integrative collaboration of Hong Kong-Mainland I&T.* The development of the Hong Kong/Shenzhen Innovation and Technology Park in the Lok Ma Chau Loop has presented a significant opportunity for deeper collaboration between Hong Kong and the Mainland on I&T development, and for university, industry and government to have a fresh approach to collaboration. It is recommended that a Special Office with cross-bureau authority be appointed to lead the venture and a more flexible cross-border flow of resources be established for effective operations in the Loop.

In conclusion, the Project Leadership Team would like to emphasize that to preserve and to enhance Hong Kong’s world competitiveness, it is strongly recommended that the Government formulate its

I&T strategies with creative ideas and fresh policies building upon the strong foundations that Hong Kong possesses. Never before has there been a more critical need to invest serious efforts in transforming Hong Kong into an innovation-led knowledge-based economy. And the time to act is NOW.

Developments after the May 2017 Forum

Following the Forum, key recommendations of the study (signed by 24 CAE-HKAES Fellows) were submitted in a policy proposal to the State Council in Beijing through the Chinese Academy of Engineering on 22 June 2017. At the invitation of the Academicians Sodality of Guangdong, eleven HKAES Fellows met with a group of CAE/CAS Academicians resident in Guangdong and Shenzhen Government officials to exchange views on the integrative I&T development in the Guangdong-Hong Kong-Macao Greater Bay Area on 28 September 2017. The Chief Executive's Policy Address released on 11 October 2017 outlined a renewed vision of Innovation and Technology with bold policy measures that resonate with several key recommendations of this study including: a high level I&T advisory group led by the Chief Executive; proactive support to technological innovation through tax concession and government procurement; building human resources and talents; and doubling of R&D funding from 0.74 to 1.5% in five years.

报告摘要

本报告是香港工程科学院与中国工程院首次深度合作的研究成果。2016年7月两院分别组织开展针对粤港澳大湾区创新及科技政策的研究，主要致力于回答两个关键问题：一是，香港的创新及科技发展如何能够实现跨越式发展；二是，在大湾区框架下，香港如何能更好与大陆合作。

研究目的

正如麻省理工学院研究团队曾在1997年出版著作 —《香港制造》一书中指出：香港必须依靠科技和创新发展，同时与大陆开展更加紧密的合作，才能确保自身产业和经济发展的竞争优势。尽管香港政府已经通过多种方式促进研发投入，但是，收效并不显著。其中一个原因在于，之前各持份者对重塑香港并不热衷，导致错过了许多发展契机。然而，近年来，各界对科技和创新的态度以及政府对自身应该扮演的角色的认识逐渐发生了变化。创新及科技局（ITB）设立后，香港亟需调整科技发展战略。本研究旨在从政策层面对香港和大湾区如何发挥自身独特优势从而提升双方的竞争力提出可行性建议。

研究的独特性

本研究不仅是香港工程科学院和中国工程院的首次深度合作，而且，是出现在科技创新首次被提升到国家战略高度的“十三五”规划的大背景下，这就更具开创性了。同时，也希望能够协助政府通过创新及科技局明确香港未来的科技和创新发展方向。在联合研究过程中，香港工程科学院和中国工程院分别独立开展了针对香港高校研究优势和成果转化表现指标的研究。基于严格的国际比较基准，本研究从香港高校和产业界遴选了38个典型成功案例，以其客观表现去反映香港本土科研成果转移和商业化的情况。此外，还全面梳理了香港和大陆的研发合作现状。2016年10月至2017年4月，课题组成员对37位来自高校、科研机构、企业以及政府部门的杰出领导者（其中包括对香港科技和创新情况比较了解的国际人士）进行了深入的访谈，主要目的是了解他们对香港科技创新发展所面对的鸿沟和障碍的意见。2017年5月19日，香港工程科学院（项目领导组成员）还会同中国工程院团队审议了本研究的主要发现和基本结论。

政策讨论

课题研究过程中，项目领导组针对各种创新及科技相关议题组织了多次研讨和审议，这些活动是本研究政策建议的重要基础。五次会议具体时间分别是：2016年11月22日、2017年1月23日和25日以及5月18日和22日。2016年12月6日，项目领导组对香港工业总会主要领导人员进行了访谈和研讨。2017年4月1日，香港工程科学院陈嘉正院长代表课题组在由港科院组织的集思会上发表了该院对“落马洲河套地区港深创新及科技园”的观点及意见。

2017年5月24日，香港工程科学院与香港科技大学公共政策研究院联合举办了政策研究论坛，本次活动得到了香港政府中央政策组的大力支持。论坛主要目的是同与会各界人士分享本项目一年来的阶段性研究成果。在论坛上，课题代表李行伟教授和干勇教授首次发布了有关香港创新及科技生态系统优势和不足的研究结果，并针对将创新及科技作为经济发展新引擎提出了政策建议。期间，并和与会人士进行深入座谈讨论。本报告也充分吸收了论坛的主要观点和政策建议。

研究发现

- **香港竞争优势正在迅速消失。**香港在大湾区城市群中的竞争优势正面临消失的风险，尤其是深圳依靠创新及科技大幅提升自身竞争力的背景下，这种风险更加凸显。创新及科技要通过全社会共同努力才能实现的观点正在逐步得到认可。因此，一套连贯的科技创新政策和一个有积极担当的政府至关重要。
- **创新还是灭亡。**知识型经济的发展有赖创新及科技被社会认同。创新及科技贯穿经济发展的各个行业，因此，为了实现传统产业升级并在未来创造高附加值的新兴产业，必须集中力量发展创新及科技。在金融产业不断变化的背景下，金融业也需要快速发展金融科技实现产业升级。
- **香港拥有独特优势。**香港高校的基础研究优势是解决城市创新及科技发展的关键因素。项目领导组的分析表明，在QS世界大学排名前100位的大学中，香港高校数量最多（占据5席），这反映了国际上对这些高校研究能力的认可。但是，香港在创新方面的优势也需要与大陆科技和创新优势相结合才能实现协同发展。
- **放任或积极的不干预政策不再适用香港。**放任政策已是过时。在鼓励中小企业和研发企业加大投入、培训和政策制定中政府必须承担起相应的责任。
- **研发投入模式有待改进。**对有成功经验的研发中心和主要领域的创新及科技发展投入要具有持续性。许多持份者也表示在现有创新及科技投入模式下，需检讨有关议程设定和计划审查的效率。

政策建议

- **创新及科技发展必需政府最高層的支持。**很明显，像深圳和上海这样的大陆城市，政府部门成功地通过科技和创新促进商业、产业和公民日常生活的进步。政府支持的成功案例在国际上也多不胜数。例如，新加坡、韩国和美国的政府为促进和资助创新和创业提供了积极的支持。因此，本研究建议，特区政府应该采取积极行动支持和领导构建香港的可持续创新体系。
- **政府决策部门需要补充专业和技术专家。**建立跨部门机制将对鼓励和支持所有基础设施和工业部门的科技和创新发展非常有益。本研究建议，由特首任命高层次的创新及科技咨询委员会协助制定科技战略和发展路线。咨询委员会成员可考虑从香港工程科学院、香港科学院和香港工业总会等遴选。同时，还建议将更多具有技术专业背景的专家引入到创新和科技部门的管理层面。例如，政府可以考虑从目前的志愿“委员会服务”模式转换到由具科研背景人员监督的全面专业管理模式，从而提升相关政府部门的技术水平和能力。
- **鼓励和支持本地技术创新。**有些公司由于财务问题或其他实际考虑而没有创新的动力。建议政府介入并提供更积极的、更有效的资金和技术平台，鼓励企业研发，例如，支持新技术的试验、在法律允许范围内充分利用政府采购政策、提供税收减免和更自由的共享政府项目产生的知识产权。

- **加强对科技和创新的认识。**鼓励政府与各大学合作构建促进创新和科技发展的机制，这样才能确保应用研究或成果转化作为大学使命能被广泛认同。考虑通过改革大学的奖励机制加强对创新和科技重要性的认可，例如，允许从事学术研究的人员选择部分时间用于应用研究和创业活动。
- **为创新及科技发展培育人力资源和人才。**建议政府制定政策，能够吸引和留在香港受到科学和技术培训的人才。建议大学与中学合作，在早期阶段促进研究和创新。此外，在现有研究生（RPG）奖学金/学术基金方案中加强支持香港学生去海外一流大学学习。
- **甄选香港和大湾区合作的战略领域。**香港工程科学院和中国工程院院士的合作研究表明，可以考虑在如下领域加强合作：先进制造、大数据、电子商务、城市环境治理、节能减排、新能源、医疗保健、新材料等。
- **推进香港-大陆科技和创新协同发展。**落马洲河套地区的港深创新及科技园发展，为香港和大陆深化创新及科技合作提供了重要的机会，为官、产、学、研合作开创了全新的方式。建议任命跨部门的特别办事处来领导，并构建更灵活的跨境资源流动模式，实现落马洲地区的高效率运作和快速发展。

总之，项目领导组强烈建议，为了保持和提高香港的国际竞争力，政府应在现有坚实基础上开创性地制定科技和创新发展战略。现在，就是现在！香港亟待付出全部努力实现转向创新引导的知识型经济发展模式。

2017年5月论坛后的研究进展

根据论坛的主要研究结果和建议，于2017年6月22日，通过中国工程院向国务院提交了由中国工程院和香港工程科学院24位院士联名的政策建议报告。2017年9月28日，应广东院士联谊会邀请，11位香港工程科学院院士与在广东的中国工程院、中科院院士和深圳政府官员，就大湾区科技和创新协同发展问题交换了意见。2017年10月11日，特首施政报告中发布了有承担及有前瞻性的创新及科技发展最新政策，其中的主要政策措施与本报告中的几点关键建议不谋而合，如：设立由特首领导的高层次科技顾问委员会；通过税收优惠和政府采购积极支持技术创新；培养人力资源和人才；研发支出占GDP的比重将在五年内实现从0.74到1.5%翻倍的目标。

CHAPTER 1

Introduction

“ *There is no time to lose – either Hong Kong innovate or be left behind.*

“ In July 2016 the Chinese Academy of Engineering (CAE) and the Hong Kong Academy of Engineering Sciences (HKAES) embarked on the first ever independent cross-border collaborative project on innovation and technology (I&T) policy for the integration of Hong Kong and the hinterland.

“ A re-invention of Hong Kong is urgently needed or it risks a fast erosion of its competitiveness.

Chapter 1

Introduction

1.1 Overview

2017 is a significant year for Hong Kong as it marks the 20th anniversary of its return to Chinese sovereignty. Looking back, Hong Kong has had its fair share of economic and political challenges. Despite all the ups and downs, Hong Kong is still widely acknowledged as a world-class city with a strong competitive edge for business and investment. Nevertheless, this reputation is no cause for any complacency. In fact, a re-invention of Hong Kong is urgently needed or it risks a fast erosion of its competitiveness. In the 2016-17 *Global Competitiveness Index* published by the World Economic Forum (WEF), Hong Kong has slipped two notches to the 9th position, trailing considerably behind Singapore who has coveted the runner-up position for a number of years, behind Switzerland. The WEF cites that “The challenge for Hong Kong is to evolve from one of the world’s foremost financial hubs to become an innovative powerhouse”. What does it take for Hong Kong to transform to another level of performance in innovation and technology, and how best for Hong Kong to leverage the strengths of its Mainland partners to achieve true synergistic collaboration?

In July 2016 the Chinese Academy of Engineering (CAE) and the Hong Kong Academy of Engineering Sciences (HKAES) embarked on the first ever independent cross-border collaborative project on innovation and technology (I&T) policy for the integration of Hong Kong and the hinterland. The objective of the project is to:

- (i) study the synergistic and integrative development of I&T in the Guangdong-Hong Kong-Macao Greater Bay Area;
- (ii) offer policy recommendations to develop I&T as an engine for economic growth; and
- (iii) identify potential areas with critical mass for strategic development (e.g. intelligent living, aging and health care, robotics and autonomous systems, sustainable environment, financial services).

1.2 Why this Study?

Innovation and technology (I&T) are the drivers of economic growth – a proven maxim which few would disagree. Throughout the years, Hong Kong has constantly been reminded of the need to transform itself into a sustainable knowledge-based society through the development of I&T. In the book “Made by Hong Kong” published by MIT in 1997, the study team examined the challenges of Hong Kong's manufacturing industries and suggested alternative ways and directions for these industries to maintain competitiveness using new tools such as new technologies and a closer integration with Mainland China. However, these concepts were not fully or immediately accepted at the time to many of Hong Kong's stakeholders. Although efforts have been undertaken by the Government to boost the adoption of I&T, such as the establishment of the Innovation and Technology Commission (ITC) and its Applied Science and Technology Research Institute (ASTRI) in 2000 and the Hong Kong Science and Technology Park (HKSTP) in 2001, the results were mixed.

However, after nearly twenty years of experience at I&T development and seeing the success of other economies which have diversified, there is a gradual change of attitude towards I&T. Many are also of the opinion that more leadership from the government would be necessary to lead the formulation of strategic I&T policies. The “laissez faire” or “positive non-interventionism” policy is behind the

times. With the establishment of the Innovation and Technology Bureau (ITB) in November 2015, Hong Kong is ready to address this important issue once again in order to chart an effective course of action for I&T advancement. There is no time to lose – either Hong Kong innovate or be left behind.

1.3 What is Unique about this Study?

This study was the first deep collaboration between the two elite engineering organizations to study the synergistic and integrative development of I&T in Hong Kong and the Pearl River Delta region (in this study this is synonymous with the *Guangdong-Hong Kong-Macao Greater Bay Area*). It is also a very timely initiative in response to the national 13th Five-Year Plan which stated that one of the nation's major objectives is innovation-driven development in science and technology. The plan also embodies a clear policy to support the HKSAR in the participation of this national movement.

1.3.1 Review of I&T Status

In conducting the study, the Project Leadership Team reviewed the progress in I&T in Hong Kong since the setting of the original vision by the Commission on Innovation and Technology in 1998, and in the context of the recommendations made in the 1997 “Made by Hong Kong” study by MIT. With regard to the creation of new products and processes and R&D work force, the inputs into the science, technology and innovation system have been strengthened since 1997. Specifically, the amount of funding assigned to R&D (measured as a percentage of GDP) has increased from a gross expenditure on R&D (GERD) figure of 0.38% in 1997 to a corresponding GERD figure of 0.74% in 2014. Over the same period, in absolute terms, the gross expenditure on R&D has increased from just under HK\$6 billion in 1997 to just over HK\$16 billion in 2014. The HKSAR government also attaches weight to the contribution that the creation of intellectual property makes to the economy. Recognizing the importance of intellectual property protection, Hong Kong SAR's mini-constitution—the Basic Law—specifically provides in Articles 139 and 140 that the Hong Kong SAR should on its own develop appropriate policies and afford legal protection for intellectual property rights. Against this background, the HKSAR Government has developed a new body of intellectual property law which aims to reach the highest international standards, and put Hong Kong at the leading edge of intellectual property development and protection. It is set to become a premier IP trading hub in the region.

An independent analysis of research strengths of Hong Kong universities in broad S&T areas was carried out by the HKAES and CAE. Since 1997, the most significant change in Hong Kong is the rapid emergence of internationally recognized universities with basic research capabilities that are respected worldwide. According to the QS world university rankings (with criteria heavily influenced by research performance), five out of the eight universities in Hong Kong are ranked among the world’s top 100 universities in 2017-18. This reflects the scientific strength that has been developed over the past two decades with the support of the Hong Kong Research Grants Council and other funding bodies. The working group had also analyzed the R&D strengths of Hong Kong universities and industry, and was able to identify many successful, high impact cases of research innovation with commercial relevance against rigorous international benchmarks – an indication that Hong Kong possesses outstanding capabilities in I&T (Chapter 2 and Appendix B). Existing collaborative links between Hong Kong and Mainland R&D partners were also reviewed.

1.3.2 Interviews with Society Leaders

A most important highlight of this study is the interview programme. During October 2016 to April 2017 the project working group conducted a series of individual in-depth interviews with a distinguished group of leaders and practitioners across academia, industry and government (including international leaders familiar with I&T in Hong Kong). We engaged their views on the role of innovation and S&T in the development of Hong Kong, issues on the Hong Kong-Mainland collaboration; experience on success and failures of I&T, and suggestions on revamping policy to

bridge the missing gaps and overcome barriers to the development of innovation and technology (Chapter 4 and Appendix C). HKAES Fellows (the “Project Leadership Team”) also deliberated extensively on the initial findings and insights gathered jointly with CAE representatives – in particular the missing links in the commercialization of applied R&D from the universities. The study aims to offer recommendations for policy-level strategies in harnessing the special strengths of the I&T sectors in Hong Kong and the Greater Bay Area so that the competitiveness of both economies can be enhanced.

1.3.3 CAE-HKAES Discussion Meetings

During the course of the study HKAES fellows (the Project Leadership Team) participated in the interviews and deliberated extensively on various I&T issues, upon which the study recommendations are based. The Group met on 22 November 2016, 23 and 25 January, and 18 and 22 May of 2017. In particular, an interview cum discussion session was held with leaders of the Hong Kong Federation of Industries (FHKI) on 6 December 2016. On 1 April 2017, the HKAES views on the “Hong Kong/Shenzhen Innovation and Technology Park at the Lok Ma Chau Loop” were also presented by Dr. Andrew Chan (President of HKAES) in a brainstorming session organized by the Academy of Sciences of Hong Kong (ASHK).

Throughout the study HKAES fellows and study team interacted with CAE representatives on various I&T issues. In particular, the Project Leadership Team met with CAE at a meeting on 19 May 2017 to discuss the preliminary findings of the Study.

1.4 CAE-HKAES Forum on Integrative I&T Development for the Guangdong-Hong Kong-Macao Greater Bay Area – 24 May 2017

On 24 May 2017, initial findings of the study were presented at a CAE-HKAES Forum that took place at the Central Government Offices at Tamar. The Forum was co-organised with the Institute for Public Policy (IPP) of the Hong Kong University of Science and Technology (HKUST) and supported by the Central Policy Unit (CPU) of the Hong Kong government. Key government officials, industry leaders and academics attended the event; the guest of honor was the Financial Secretary Mr Paul Chan who emphasized the government’s commitment to promote the innovation in technology development in Hong Kong. The CAE team was led by Vice-President Professor Gan Yong and included leaders from the Shenzhen and Qianhai Government. The Forum presented the initial findings of the one-year independent CAE-HKAES study on the strengths and weaknesses of the innovation and technology ecosystem in Hong Kong. Policy recommendations for developing I&T as an engine for economic growth were put forward. This was followed by a panel discussion, chaired by HKUST President Prof Tony F Chan.

Key themes of the discussion include:

- (i) University-industry-government collaboration in I&T
- (ii) Future of R&D funding ecosystem in Hong Kong
- (iii) Hong Kong-Mainland-overseas collaboration – including the development of the Lok Ma Chau “River Loop” Innovation Park

This report has incorporated the collective views and policy suggestions put forward at the forum.

1.5 The New Wave of Innovation and Technology Development in the Guangdong-Hong Kong-Macao Greater Bay Area

This study has witnessed a number of exciting related developments in I&T in Hong Kong:

- (i) The birth of the Hong Kong/Shenzhen Innovation and Technology Park at the Lok Ma Chau River Loop (January 2017).
- (ii) Key recommendations of the study (signed by 24 CAE-HKAES Fellows) were submitted in a policy proposal (『中国工程院院士建议：将深港福田-落马洲大河套片区确定为国家战略，创建世界级产业技术创建中心』) to the State Council in Beijing through the Chinese Academy of Engineering on 22 June 2017 (Annex).
- (iii) At the invitation of the Academicians Sodality of Guangdong, eleven HKAES Fellows met with a group of CAE/CAS Academicians resident in Guangdong and Shenzhen Government officials to exchange views on the integrative I&T development in the Guangdong-Hong Kong-Macao Greater Bay Area on 28 September 2017.
- (iv) The Chief Executive's Policy Address released on 11 October 2017 outlined a renewed vision of Innovation and Technology with bold policy measures that resonates with several key recommendations of this study including: a high level I&T Advisory Group led by the Chief Executive; proactive support to technological innovation through tax concession and government procurement; building human resources and talents; and doubling of R&D funding from 0.74 to 1.5% in five years.

CHAPTER 2

Research and Innovation in Hong Kong

“ Regardless of the ranking systems used, Hong Kong universities are among the top 60 in the world in engineering and technology/computer sciences.

“ In the 2017/18 QS Rankings Asia, Hong Kong universities garnered 4 places in the Top 10, outperforming Mainland China, South Korea and Singapore who each secured 3, 1 and 2 places respectively.

“ Hong Kong and Mainland collaboration in selective areas of excellence will help invigorate the innovation ecosystem in the Greater Bay Area – joining hands to bring forth technological breakthroughs and creating a win-win situation for both Hong Kong and the partner cities.

Chapter 2

Research and Innovation in Hong Kong

2.1 Overview

Over the years, the Hong Kong SAR Government has initiated a number of efforts to foster the development of innovation and technology (I&T). The latest accomplishment is the establishment of the Innovation and Technology Bureau (ITB) in 2015 charged with the mandate to formulate comprehensive policies for the development of I&T in Hong Kong. The Innovation and Technology Commission (ITC) under the Bureau provides support in the execution of related plans and policies. The ITC works closely with the Government departments and stakeholders to promote applied R&D in different technologies, to upgrade traditional industries and to provide internship opportunities for science and engineering graduates. The ITC has also set up five R&D centres to develop applied R&D in five strategic areas. A government-funded Innovation and Technology Fund (ITF) in support of I&T projects is also in place to help with the upgrading needs of industries. In 2000, the Hong Kong SAR Government established The Hong Kong Applied Science and Technology Research Institute Company Limited (ASTRI) to conduct high quality applied research to enhance Hong Kong's technology-based industries. In 2001, the Hong Kong SAR Government established the Hong Kong Science and Technology Parks Corporation (HKSTPC) to bolster infrastructure support for technology start-ups and related activities. The Hong Kong Productivity Council provides a range of support and services to enhance the efficiencies and competitiveness of Hong Kong enterprises. In addition, Hong Kong and the Mainland have strengthened collaboration in I&T through the implementation of funding schemes and exchange programs.

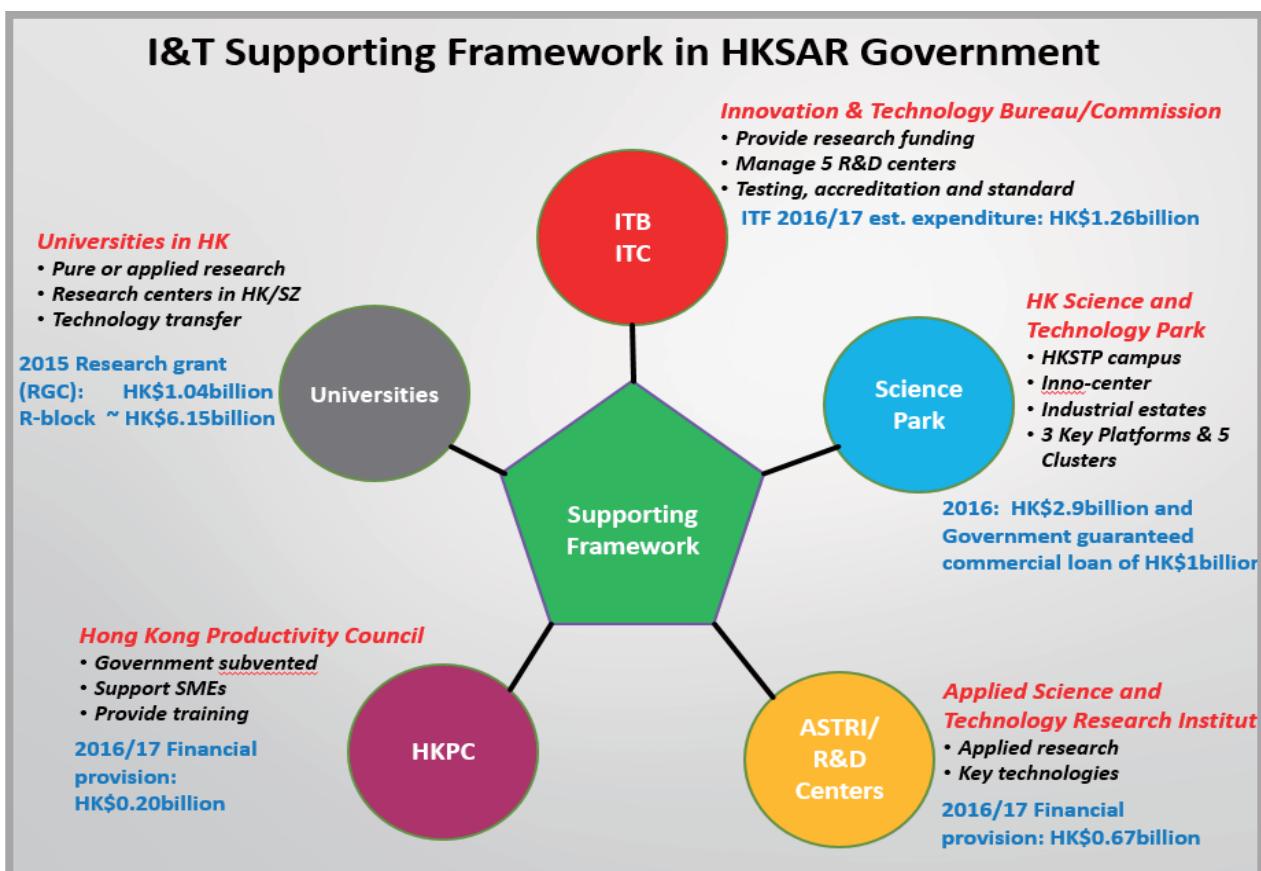


Figure 2.1 Framework for supporting I&T development in the HKSAR Government

2.2 World-Class Strengths of Hong Kong Universities

A very significant component in the I&T support framework deserving important attention is the universities in Hong Kong. The universities have considerable potential in lifting Hong Kong to a higher level of I&T development. In this study, the Project Working Group conducted a review of the strengths of Hong Kong's universities. It is noteworthy that although the Hong Kong SAR Government invested only a relatively small percentage of GDP to support research and development, the investment in a research university and the building up of research capabilities in higher institutions have made positive impacts. The Hong Kong University of Science and Technology (HKUST) was established in 1991 to advance learning and knowledge through teaching and research in science and technology among other areas, and to assist in the social and economic development of Hong Kong. In a relatively short time span, HKUST has established itself as a highly regarded university not only in Asia, but also in the world. In addition, throughout the past several decades, researchers at the University of Hong Kong, the Chinese University, Polytechnic University, City University and Baptist University have built up high standards of basic research and innovative capabilities.

2.2.1 World Academic Rankings of Hong Kong Universities

In view of the growing strengths of the universities in Hong Kong, the Project Working Group conducted an analysis of the QS World University Rankings to understand how the Hong Kong universities fare in global rankings. The university rankings published by various organizations are mechanisms to measure the performance of colleges and universities based on a number of factors, such as research, teaching, funding, internationalization, the number of notable awards received by academic staff, graduate employment and others. Although there are debates about the methodologies and the usefulness of the rankings, they are unequivocally key benchmarks for evaluating the academic standing of higher institutions.

The most established and extensively recognized global rankings are, it is fair to say, those produced by the Times Higher Education (THE) and Quacquarelli Symonds (QS). The QS and the THE rankings were originally a joint effort during the period from 2004 to 2009, and were known as the Times Higher Education-QS World University Rankings. However, in 2010 the two organizations discontinued their collaboration when THE decided to initiate a new ranking methodology in collaboration with Thomson Reuters. As a result of the growing awareness and strong interest by the academic community around the world, the QS Global Academic Survey now stands as the largest survey of its type on the opinions of academics globally. It has a response of over 75,000 for the 2018 edition of the rankings. The indicators used by QS are Academic Reputation from Global Survey (40%), Faculty Student Ratio (20%), Citations per Faculty from Scopus (20%), Employer Reputation Global Survey (10%), Proportion of International Students (5%) and Proportion of International Faculty (5%).

Since 2009, QS has also launched an Asian University Rankings that ranked the top 350 Asian universities. In addition to using the same criteria as the World University Rankings, other indicators such as incoming and outgoing exchange students are also used.

After a careful review and analysis of the rankings, it has been found that the results related to Hong Kong universities are very gratifying. The process followed was:

- a. The study identified the universities that are ranked in the world's top 100 and that are located in major metropolitan areas in the world;

- b. Of the universities identified, the top concentrations are as follows:

	City	Number of Universities in the Top 100 Spots
1	Hong Kong	5
2	London	4
3	Boston	3
4	San Francisco Bay Area	2
4	New York	2
4	Chicago	2
4	Beijing	2
4	Tokyo	2
4	Melbourne	2
4	Paris	2

In addition:

- c. In the 2017-18 QS University Rankings Asia, Hong Kong universities garnered 4 places in the Top 10, outnumbering Mainland China, South Korea and Singapore who each secured 3, 1 and 2 places respectively.
- d. Regardless of the ranking systems used, Hong Kong universities are among the top 60 in the world in engineering and technology/computer sciences;
- e. Against the most rigorous standards, four Hong Kong universities are among the top 10 in Greater China (Mainland, Taiwan, Hong Kong and Macao).

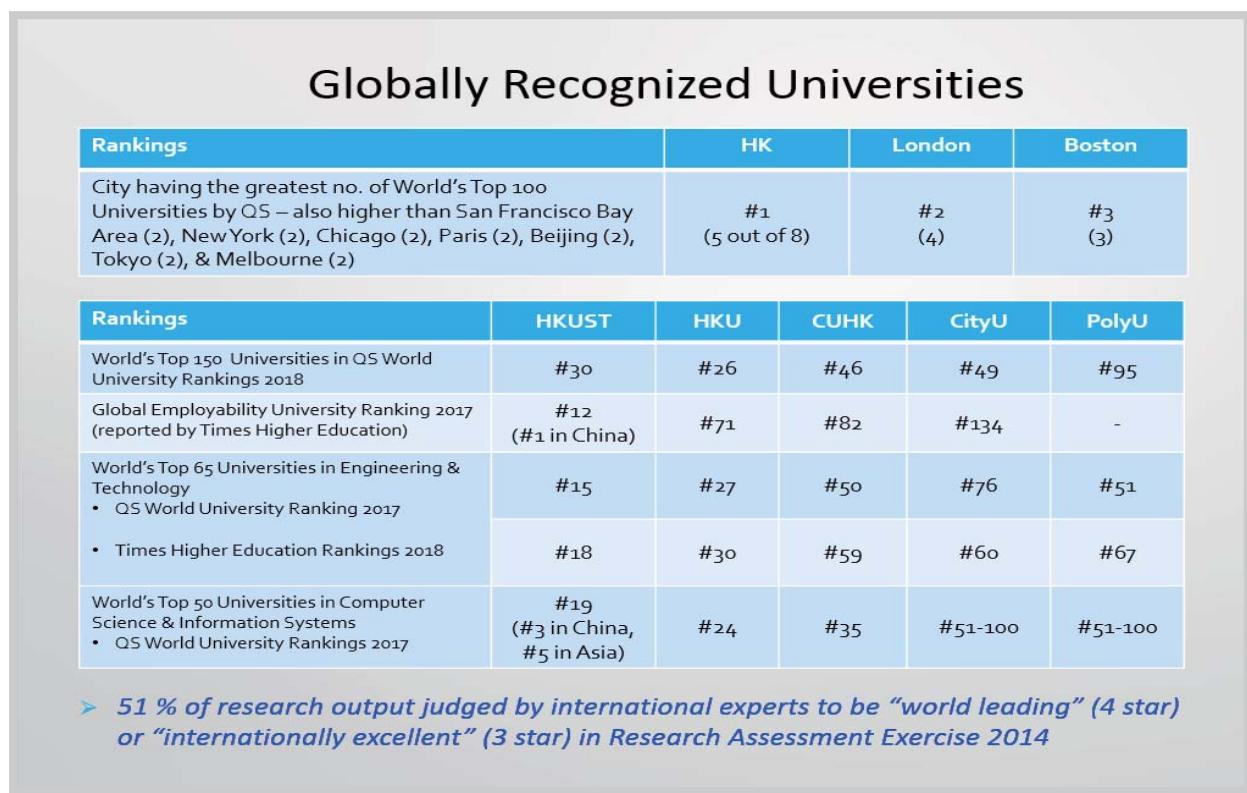
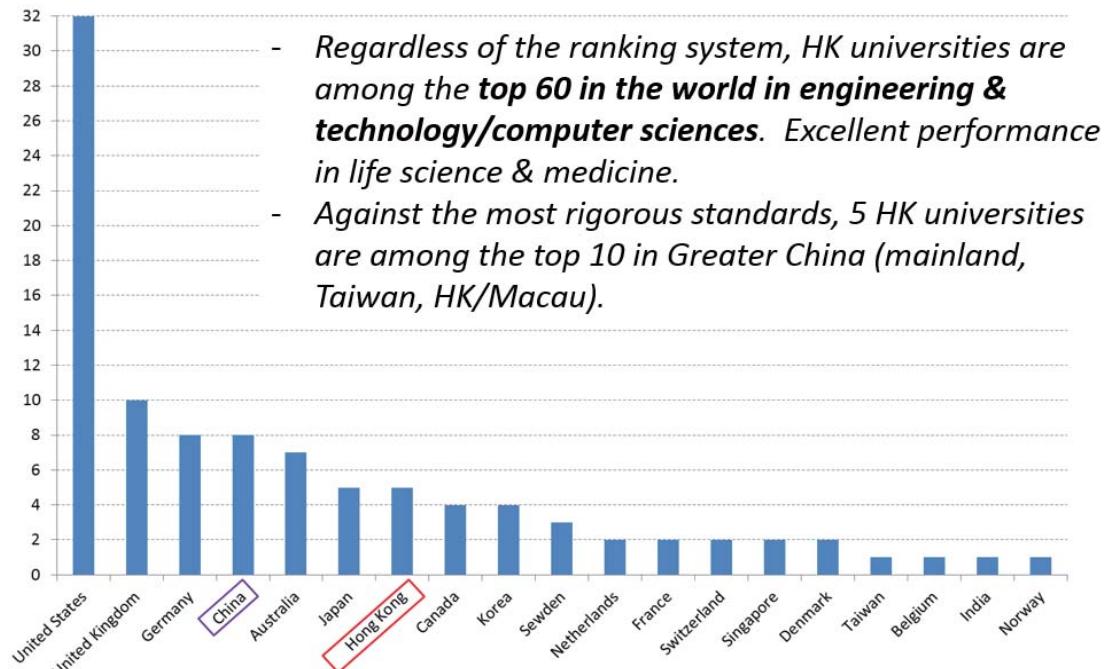


Figure 2.2 Global rankings of Hong Kong universities

Number of University Engineering & Technology Departments Ranked within Top 100, 2017-18, by Country



Source: Times Higher Education World University Rankings

Figure 2.3 Number of university engineering and technology departments (by country) ranked within top 100 in the Times Higher Education (THE) Rankings, 2017-18

Appendix A provides some background information on the widely accepted world ranking methodologies as well as an overall flavor of the world standings of Hong Kong universities.

Moreover, according to the Research Assessment Exercise (RAE) conducted by the University Grants Committee in 2014, 12% of the projects assessed were appraised as world-leading level, 34% have reached international excellence level, and the rest have reached international or regional level.

Despite the international recognition of the intellectual strengths of Hong Kong universities, our World City is still far from “an innovation-led knowledge-based economy” as originally envisioned at the turn of the millennium. Nevertheless, there are still hopeful signs that Hong Kong has the potential to catch up. The statistics of the *IMD World Competitiveness Yearbook 2016* can provide a glimpse into the current I&T situation. To this end, a selection of economies with comparable innovation performance indicators is shown in Fig. 2.4 below. As the data have depicted, Hong Kong’s level of GDP per capita is similar to Taiwan, South Korea, Singapore, Switzerland and Sweden. Hong Kong’s education as a percentage of GDP is on equal footing with Singapore, and is slightly less than the rest of the economies mentioned above. As for R&D as a percentage of GDP, Hong Kong drastically lags behind all of the economies listed. It is therefore not surprising to note that as far as the innovation ranking indicator is concerned, Hong Kong is again lagging behind Taiwan, South Korea, Singapore, Switzerland and Sweden.

Although the input of R&D is very modest, it can be seen that Hong Kong has managed to build up a strong cluster of universities, and five of them are among the world’s top 200 – equal in number to Sweden and more than those of Taiwan and Singapore. The number of scientific talents (in terms of graduates from S&T doctoral and postgraduate programmes) available is also very respectable, similar

to that of Switzerland and Sweden, although still behind Taiwan, South Korea and Singapore. With additional R&D investment, a supportive I&T ecosystem and more proactive policies to facilitate I&T, Hong Kong with its solid basic strengths is well positioned to transform itself into a key I&T player among the competitive economies.

	China	Shanghai	Shenzhen	Taiwan	HK	South Korea	Singapore	Switzerland	Sweden
Land (1000 km²)	9,600	6	2	36	1	100	0.7	41	447
Population (M)	1,375	24.2	11.9	23.5	7.31	50.6	5.54	8.24	9.83
GDP, (\$Billions)	10,866.47	414	284	523.73	309.93	1,377.87	292.73	664.74	492.62
GDP per Capita, \$	14,107	25,365	26,838	46,783	56,743	36,520	85,253	58,551	48,142
Education, %GDP	3.6			4.0	3.3	4.9	3.1	6.0	6.6
R&D, %GDP	2.09	3.73	2.85	3.00	0.74	4.23	2.20	2.97	3.28
Innovation ranking (WEF)	34			16	23	22	11	1	7
High-Tech Exports, %	25.75			38.62	10.71	26.84	49.28	26.84	14.26
University in World's Top 200 (2016-17)	6			3	5	7	2	7	5
Total R&D Personnel (FTE thousands)	3,758.9			245.9	27.4	442.0	42.5	75.5	84.5
S&T doctoral/RPG* graduates	32,331			2,478	1,627*	4,945	4,338*	1,787	1,716

Main source: IMD World Competitiveness Yearbook 2016
 WEF – World Economic Forum
 *FTE – Full time equivalent

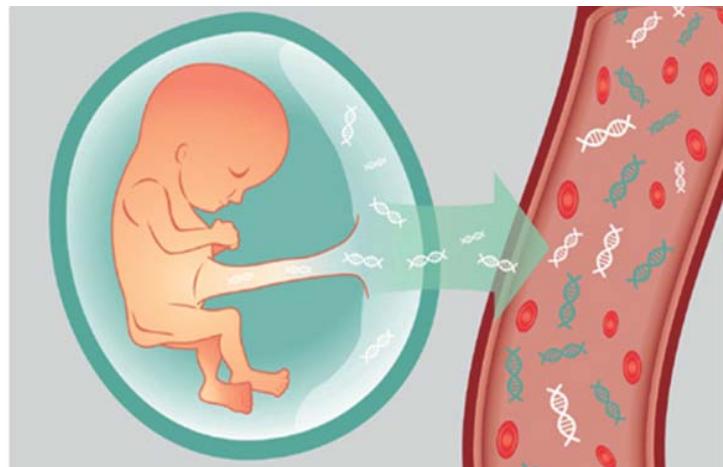
Figure 2.4 Comparison of innovation performance indicators in selected economies; data from IMD World Competitiveness Yearbook 2016

2.2.2 Innovative Potentials of Hong Kong Universities

Apart from globally recognized research competence, the local universities are also very successful in their innovative ventures. One can trace such success to two decades ago. In 1993, an internet service project in the Department of Computer Science of the Hong Kong University of Science and Technology became a trailblazer and evolved into a hugely successful company called Hong Kong SuperNet Limited. It was the first licensed commercial internet service provider in Hong Kong when it was sold in 1996. The sale had generated proceeds of about 23 times its initial investment over a period of three years, and the proceeds had benefited further research and technology start-ups at the University.

There is no doubt that the innovative spirit is very much alive and well in universities in Hong Kong. The Project Working Group has examined the innovative and entrepreneurial efforts of the six universities who have a research focus, and has identified a number of successful examples (Appendix B) that can truly put Hong Kong in the world map of innovative success. Some highlights are illustrated below:

- A breakthrough development in non-invasive prenatal testing (NIPT) at the Chinese University of Hong Kong has allowed millions of pregnant women in over 90 countries in testing the DNA of fetus. Previously, such testing would entail taking an invasive sample from the uterus or the placenta, incurring a 0.5% risk of harming or even killing the fetus. The technology has created a very valuable patent portfolio that has been licensed internationally. This patent portfolio represents one of the most valuable originating from Hong Kong. Based on this promising success, research work has commenced to extend plasma DNA testing for cancer detection and monitoring.



- An oral formulation of arsenic trioxide developed by medical researchers at the University of Hong Kong, and manufactured under the name Arsenol® in the treatment of acute promyelocytic leukemia (APL). Treatment with oral arsenic-trioxide has demonstrated clinical efficacy and fewer side effects compared to intravenous administration. To date, hundreds of APL patients have been treated with oral arsenic trioxide, a majority of whom went into complete remission.

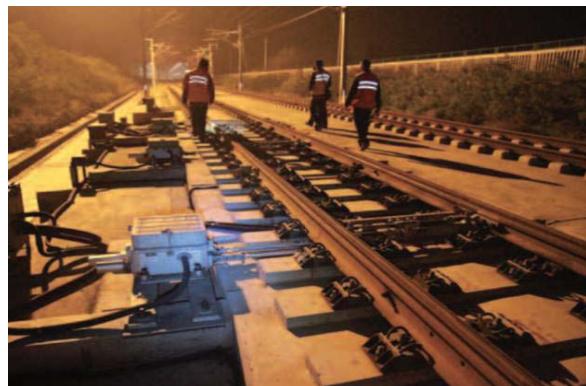


- An MPhil student under his mentor at The Hong Kong University of Science and Technology developed the first generation of consumer-friendly unmanned aerial vehicles (UAVs) in 2006, and the then start-up company, DJI, has now become the dominant player in the drone industry. The technology has made radical impact on capturing images by innovations in control technologies for low-altitude flying. Not so long ago, visuals were mainly in 2D images and video; a comprehensive three-dimensional (3D) view could only be captured from a ride in a helicopter or through professional drones that are difficult to control. The technology is now a mainstream in business and consumer sectors. In 2014 and 2015, TIME magazine selected DJI's drones as one of the top 10 gadgets, and in 2014, Forbes recognized the founder of DJI as one of the top 10 innovators from China. DJI now collaborates with HKUST in the form of a Joint Innovation Lab to develop more advanced technologies and funds scholarships for HKUST graduate students to pursue robotics research, several of whom have now taken up key positions in technology companies.

dji THE FUTURE OF POSSIBLE
 Mr Frank Wang - selected as Top 10
 most innovative persons in China in 2014,
 the youngest innovator on the list.



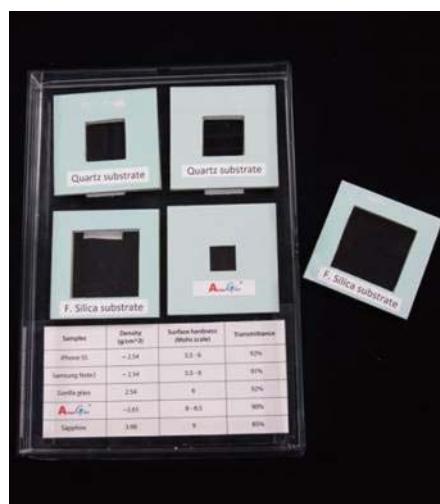
- The Hong Kong Polytechnic University pioneered the development of a sensing system (FBG sensing system) which can automatically find defects in railway tracks and trains, and provide alert of abnormalities affecting train service, travel time and safety. The system can span over a hundred kilometer, realizing long-distance, real-time and multifunctional sensing. In addition, the FBG sensor system is also cost effective, compact and weatherproof, among other attributes. It has been implemented throughout Hong Kong's railway networks to enhance reliability and efficiency. The technology has made prominent contributions to the advancement of railway networks worldwide.



- Vitargent, a biotechnology company founded by two alumni of the City University of Hong Kong, employs patented technology developed by a faculty member in the Department of Biomedical Sciences and her research team. The technology improves the safety of water, food, medicine, cosmetics, plastics and daily necessities by rapidly testing for toxins with results available in 48 to 72 hours. The company's technology is widely used by government departments, research institutions, cosmetics groups and food companies in Hong Kong, Mainland China and Europe. It also worked with Hong Kong property developers to conduct thorough tests of the drinking water supplied in their properties. In April 2015, it won the Grand Prix at the 43rd Geneva International Exhibition of Inventions of Geneva – the world's most renowned invention show. In 2016, the Company successfully raised series B financing led by a Hong Kong real estate conglomerate, hoping to push the company to become Hong Kong's first home grown biotechnology start up attaining unicorn valuation status exceeding USD 10 billion.



- Cathay Photonics Limited (CPL), a start-up in Hong Kong Baptist University funded by the Innovation Technology Fund as well as venture capital investment, has demonstrated how to bring excellent research to the business and industrial sectors. CPL has developed a few patent-pending technologies for ultra-hard and anti-scratch sapphire thin-film coating, which is a turnkey solution for the cover screens for smartphones. Sapphire is the second hardest natural material known and is difficult to cut and polish. Growing a single crystal sapphire is extremely time-consuming and it is technically challenging to grow large-size substrates. The production cost is therefore high and not feasible for large-scale commercial production. CPL's technology is now able to provide a solution to these issues with a sapphire thin-film that is lightweight, durable, anti-scratch and cost effective. Its manufacturing cost is approximately half that of sapphire covered glass. The invention has received many esteemed awards internationally.



The above findings reflected the impressive strengths of the research capabilities of Hong Kong universities, and it would be crucial to direct these capabilities coherently and effectively to support the transformation of Hong Kong into a knowledge-based society.

2.3 Hong Kong Areas of Excellence for Synergistic Development in the Greater Bay Area

To further analyse the strengths of Hong Kong's innovation and technological capabilities, and to understand how these strengths can be leveraged for local, regional and national development by creating synergistic partnerships, the Project Working Group also took to the task of identifying Hong Kong's areas of excellence and the potentials for collaboration with the I&T community in the Greater Bay Area.

The Greater Bay Area has been an important base for the manufacturing and export industries. In recent years the region has seen tremendous growth in terms of Gross National Product (GDP) per capita. In 2014, GDP per capita of the region exceeded 100,000 yuan for the first time. In 2015, the high rate of growth continued and the GDP per capital reached 100,600 yuan. There is rapid development in the advanced manufacturing and high tech industries. However, these industries are still very much in need of innovative technologies in order to be elevated to the next phase of growth. As part of this study the Chinese Academy of Engineering (CAE) conducted an analysis of potential areas of synergistic collaboration between Hong Kong and the Mainland (see also Chapter 3). Working with HKAES, CAE researchers analysed objective performance data and met extensively with stakeholders from engineering sciences, higher institutions, science and technology organizations, enterprises and students to identify the research strengths of Hong Kong and market needs of the Greater Bay Area. The aim was to identify common grounds and opportunities whereby synergies could be created through effective collaborations, aligning talents and expertise with the needs of

emerging industry needs and national developmental priorities. The broad research areas and representative examples of centres of excellence in Hong Kong universities are listed in Tables 2.1 and 2.2. Viewed against the key areas of strategic emerging industries (Table 2.3), the basic research strengths of Hong Kong match well with the innovation and developmental needs of industries in the Greater Bay Area. Basic research strengths in broad areas of computer science and information and communication technologies, electronic engineering, chemistry and new materials, biomedical sciences, robotics and autonomous systems, new energy, infrastructural and environmental engineering exist across many Hong Kong universities. Applied R&D excellence at an internationally competitive level has also been developed in a number of prestigious partner State Key Laboratories and Branches of National Engineering Research Centres – including brain and cognitive science, infectious diseases, automatic engineering, molecular neuroscience, advanced displays and optoelectronics, tissue restoration and reconstruction, marine environment, and smart cities. As presented in the CAE recommendations to the Central Government in June 2017, Hong Kong and Mainland collaboration in selective areas of excellence will help invigorate the innovation ecosystem in the Greater Bay Area – joining hands to bring forth technological breakthroughs and creating a win-win situation for both Hong Kong and the partner cities.

Table 2.1 Key Research Areas of Hong Kong Universities

Name of Institution	Key Areas
University of Hong Kong	Biomedicine; Neuroscience; Chemistry; New Energy; Smart Grid; New Materials; Computation and Information; Drug; Genomics; Integrative Biology; Food Safety and Quality.
The Hong Kong University of Science and Technology	Nanotechnology; Neuroscience; Biotechnology; Electronics; Wireless Communication; Information Technology; Artificial Intelligence; Big Data; Robotics and Automation Technology; New Energy; Fuel Cell; Civil Engineering and Environmental hydraulics; Smart City; Environment and Sustainable Development.
The Chinese University of Hong Kong	Chemistry; Biomedicine; Electronics and ICT; Robotics and Automation Technology; Smart City; Environment and Sustainable Development.
The City University of Hong Kong	Wireless Communications Technology; Marine Environment; Materials Science; Biomedical Sciences
The Hong Kong Polytechnic University	Civil Engineering; Architecture; Structural and Environmental Engineering; Sustainable urban Development; Textile; Rehabilitation Sciences; Advanced Manufacturing Technology; Rail transit.
Hong Kong Baptist University	Environmental and Biological Analysis; Chinese Medicine; Chemistry; Information Technology; New Materials.

Table 2.2 Centers of Excellence and Applied R&D Institutes and Incubators in Hong Kong

Name of Institution	Key Areas
Partner State Key Laboratories	Brain and Cognitive sciences; Emerging Infectious Diseases; Liver Research; Synthetic chemistry; Pharmaceutical Biology; Agrobiotechnology; Digestive Disease; Oncology in South China; Phytochemistry and Plant Resources in West China; Marine Pollution; Millimeter Waves; Molecular Neuroscience; Advanced Displays and Optoelectronic Technologies; Environmental and Biological Analysis; Chirosciences; Ultra-precision Machining Technology.
Hong Kong Branches of Chinese National Engineering Research Centers	Application-specific Integrated Circuit System; Tissue Restoration and Reconstruction; Control and Treatment of Heavy Metal Pollution; Precious Metals Material; Rail Transit Electrification and Automation Engineering Technology; Steel construction.
Hong Kong Applied Science and Technology Research Institute	Financial technologies; Intelligent Manufacturing; Health Technologies; Next Generation Network, Smart City.
Hong Kong Innovation and Technology Commission R&D Centres	Automotive Parts and Accessory Systems; Information and Communication Technologies; Logistics and Supply Chain Management Enabling Technologies; Nano and Advanced Materials; Textiles and Apparel.
Hong Kong Science and Technology Parks Corporation	Electronics; Information Technology; Green technology; Biotechnology; Precision Engineering.
Hong Kong Cyberport	Information and Communication Technology

Table 2.3 Key Areas of the Strategic Emerging Industries in Pearl River Delta Region

Industry	Key Areas
High-end information electronics	New Display, Next Generation Mobile Communication, Internet of Things, Cloud Computing, Triple Play Network, Next Generation Internet, Geospatial Information Systems, Software and Integrated Circuit Design, Digital Home
Biomedicine	Biomedical Sciences, Biological Breeding, Diagnostic Reagents, Innovative Drugs, Modernization of Traditional Chinese Medicine, Medical Devices, Life and Health
New Energy	Nuclear Power, Solar Energy, Wind Power
New Materials	Advanced Metals, New Inorganic Non-metallic Materials, High-performance Organic Polymers and Composite Materials, Special Fine Chemicals, New Rare Earth Functional Materials, Cutting-edge New Materials
New Energy Vehicles	Entire Vehicle, Key Components, Ancillary Facilities, Environmental Management
Semiconductor Lighting (LED)	Key Technologies and Industrialization
Energy Saving and Environmental Protection	Energy-Saving Technologies and Products

The Project Leadership Team, in reviewing the strategic needs of I&T in the region, suggests that collaboration be strengthened in areas such as advanced manufacturing, big data science and e-commerce, environmental and urban governance, energy conservation and new energy, health care and new materials. Some of the specific areas have been identified in Table 2.4.

Table 2.4 Areas of Hong Kong – Mainland Collaboration to be Strengthened

Area	Sub-Area
Advanced Manufacturing	Robot; Industrial Integrated Systems; New Energy Vehicle; Intelligent Automobile; Advanced Energy Storage battery; High-End Marine Equipment; Avionics; Wearable Devices.
Big Data Science and E-Commerce	Big Financial Data; Cloud Computing, Social Networking, Data Mining; Smart City; Electronic Commerce; Pattern Recognition; Information Security Technology; Sensor Technology.
Biotechnology	Pharmaceuticals; Targeted Drugs; Chiral Drugs, etc.
Environment and Urban Governance	Water Pollution Control; Smart City; Marine Pollution Control; Environmental Monitoring Technology, Haze Governance Technology.
Energy Saving and New Energy	Renewable Energy such as Solar Energy, Wind Energy, Wave Energy, Biological Energy, High-Efficiency Thin-film Photovoltaic Cells, etc.
Medical Health	Medical health and aging areas: Disease treatment such as cancer, hepatitis B, diabetes mellitus, etc.
New materials	Nanometer Material; New Biomimetic Materials.

CHAPTER 3

Scientific and Technological Collaboration Between Hong Kong and the Greater Bay Area

“ Since 2006, more than 475 Hong Kong researchers (including 28 Principal Investigators of projects) have been involved in 162 research studies of the National Science and Technology Plan. In addition, 16 Partner State Key Laboratories, 6 Hong Kong Branches of China National Engineering Research Center and 3 Hong Kong National High-Tech Industrialisation (Partner) Bases have been established.

“ However, bottlenecks to taking the collaboration to a higher level remain: policies need to be introduced to ease the flow of human talents and research resources including grant money across the border, and to facilitate the formal training of postgraduate students in the Industry-Education-Research bases (IERs) of Hong Kong universities.

Chapter 3

Scientific and Technological Collaboration between Hong Kong and the Greater Bay Area

3.1 Introduction

There is a long history of cooperation between Hong Kong and major cities in the Greater Bay Area in building up traditional industries. Since the “Open Door” policy of 1978, the relocation of the production bases of Hong Kong manufacturing industries to the Pearl River Delta under the “Front Shops, Back Factories” model has brought prosperity to both Hong Kong and the Pearl River Delta region. Over the past two decades, prompted by the increasing need to develop high end, innovation-led industries, substantial R&D collaborations between Hong Kong and Mainland entities have steadily mushroomed. This includes initiatives from the private and non-governmental sectors, as well as more recent government led projects to drive “collaborative innovation” between Hong Kong academics and local industry. As of 2016, six Hong Kong universities have established research and educational institutes in Guangdong to capture research funding and collaborative opportunities. The positioning of innovation as a driver of the economy in both the 12th and 13th National Five Year Plan and the establishment of “new areas” (special economic zones) of Nansha, Hengqin and Qianhai to spearhead Hong Kong-Mainland collaboration also provided positive stimulus for collaborative developments in research and innovation. This chapter provides an overview of the status of scientific and technological collaboration between Hong Kong and the Mainland, with particular emphasis on the Greater Bay Area.

3.2 Basic Cooperation Framework between Hong Kong and the Greater Bay Area

Since returning to China in 1997, Hong Kong has been developing closer relationships with the Mainland on all fronts. The cooperation between Hong Kong and the Greater Bay Area are carried out under three major frameworks - the Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA), the Framework Agreement on Hong Kong-Guangdong Cooperation, and the Mainland/Hong Kong Science and Technology Co-operation Committee Agreement.

3.2.1 National Level Institutions

(i) The Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA)

In order to strengthen the trade and investment cooperation between the Mainland and Hong Kong and to promote the prosperity and economic development of both regions, the Central Government and the HKSAR Government signed the Mainland and Hong Kong Closer Economic Partnership (CEPA) on 29 June 2003 to pave the way ahead. To enable further enhancements, the two sides sign a new supplemental agreement every year, and the preferential terms in trade, finance, tourism, culture, architecture, law and other 28 industry sectors in Hong Kong have continuously been expanding.

CEPA has been in effect for more than a decade, and has facilitated economic and trade exchanges between Mainland and Hong Kong considerably. It has also created huge market and business opportunities for both sides resulting in the prosperity and development of Mainland and Hong Kong's economy.

(ii) Mainland and Hong Kong Science and Technology Co-operation Committee Agreement

To promote exchanges and cooperation between the Mainland and Hong Kong in the fields of science and technology, the Ministry of Science and Technology (MOST) and the Hong Kong Commerce and Economic Development Bureau (CEDB), formerly the Commerce, Industry and Technology Bureau, signed an agreement on 17 May 2004 to establish the “Mainland/Hong Kong Science and Technology Co-operation Committee of Mainland and Hong Kong”. The purpose of this agreement is to strengthen

cooperation in science and technology including electronic and information technology, biotechnology, new materials technology, advanced manufacturing and other fields. In 2013, the MOST and CEDB further signed an agreement to strengthen the co-ordination of scientific and technological cooperation between the two sides. The above agreements serve as the main vehicle or mechanism for Hong Kong–Mainland scientific and technological cooperation. Each year, the two sides convene a committee meeting to summarize the work of the previous year and to discuss the work plan and priorities for the next year. This collaborative framework has achieved fruitful results to date - including the alignment of Hong Kong with national planning on science and technology, the establishment of Hong Kong scientific research platforms and bases, the participation of Hong Kong scientists and technical personnel in the National Science and Technology Programs, the encouragement of innovation and entrepreneurship and the support for regional cooperation in science and technology.

Since 2006, more than 475 Hong Kong researchers (including 28 Principal Investigators of projects) have been involved in 162 research studies of the National Science and Technology Plan. In addition, 16 Partner State Key Laboratories, 6 Hong Kong Branches of China National Engineering Research Center and 3 Hong Kong National High-Tech Industrialisation (Partner) Bases have been established.

3.2.2 Regional Level Establishments

(i) Hong Kong-Guangdong Cooperation Framework Agreement

To strengthen communication and coordination between Guangdong and Hong Kong and to coordinate mutual comprehensive development after Hong Kong's return to China, the Guangdong Provincial Government and the Hong Kong Special Administrative Region Government jointly established the Joint Conference System and held its first meeting in 1998. The two governments agreed to meet once annually, alternately in Guangzhou and Hong Kong. This arrangement has become an important platform for promoting deeper and higher level of cooperation.

The expert groups under the joint conference are responsible for the research, follow-up and implementation of the thematic cooperation projects and the promotion of the existing cooperation projects. The Hong Kong/Guangdong Expert Group on Cooperation in Innovation and Technology is responsible for promoting the cooperation of science, technology and innovation. A meeting is held annually to supervise scientific and technological cooperation. The Group is co-chaired by the Director of the Department of Science and Technology of Guangdong Province and the Permanent Secretary for Commerce and Economic Development of HKSAR Government.

In view of increasingly fierce regional competition and a fast-changing global environment, Guangdong and Hong Kong have re-examined their strategic partnership in order to promote mutual development. In April 2010, the two governments signed the "Hong Kong-Guangdong Cooperation Framework Agreement" in Beijing (hereinafter referred to as the "Framework Agreement"). The Framework Agreement affirmed full cooperation between Guangdong and Hong Kong. The Agreement systemized the Joint Conference System (which began in 1998 with annual meeting alternately held in Guangzhou and Hong Kong), and set up 18 expert groups under this system as communication and coordination mechanisms.

The Framework Agreement had determined nine areas of cooperation, such as basic infrastructure and introduction of joint-R&D funding schemes. An expert group on "Co-operation in innovation and technology" is tasked to promote scientific and technological innovations related to the development of strategic emerging industries, to support the collaboration between Guangdong's S&T organizations and Hong Kong's R&D centers under the Innovation and Technology Commission (in automotive parts, information and communication, logistics and supply chain management, nanotechnology and advance materials, textile and apparel), to support the establishment of incubation facilities in Guangdong for

the commercialization of Hong Kong research results, the cooperation of science parks in the two jurisdictions, the facilitation of access to research resources, and the planning of the "Shenzhen-Hong Kong Innovation Circle" and other initiatives.

(ii) Pearl River Delta Technology Organization Exchanges and Cooperation Memorandum

Parallel to the government-level collaborations, community-based contributions have also been made. To improve the overall science and technology competitiveness and innovation capacity of the Greater Bay Area, the science and technology associations of nine cities in the Greater Bay Area and S&T organizations in Hong Kong and Macao ("the S&T associations") signed the "Pearl River Delta Technology Organization Exchanges and Cooperation Memorandum" in August 2009, to enable resource sharing and the attainment of complementary advantages. The Memorandum requires that annual regional S&T community forums be held in the Greater Bay Area, and a regional S&T organizations cooperation advisory committee be set up. In addition, the "S&T associations" have joined hands in developing and introducing popular science demonstration and teaching facilities. The rotation system of mounting popular science exhibitions has also been established. Members will also jointly organize popular science forums, exhibitions and other related activities.

3.3 Existing Research and Innovation Collaborative Platforms

In recent years, in line with the need to develop high end, innovative and knowledge intensive industries, many research collaborations between Hong Kong and Mainland entities have steadily mushroomed. First, Hong Kong universities have set up Industry-Education-Research (IER) platforms in Shenzhen to capture collaborative opportunities. Second, at a grass root level, many joint research and development centers have been established. Hong Kong academics are also allowed to directly apply for national basic research funding from the National Natural Science Foundation of China (NSFC) through their respective IER platforms. Third, the strategic importance of innovation in the national plan and the establishment of "new areas" in the Greater Bay Area have further stimulated Hong Kong-Mainland collaboration.

3.3.1 Hong Kong Branches of Education and Research Institutions (IER) in Guangdong

The universities of Hong Kong have a long history of collaboration with Mainland institutions to share knowledge and to contribute to the economic and social development of both Hong Kong and the Mainland. After the return of Hong Kong to China in 1997, many Hong Kong universities began to establish bases in the Mainland to foster closer collaborations in education, research and other areas.

As early as 1998, the Shenzhen Municipal Government, Peking University and HKUST jointly established the PKU-HKUST Shenzhen-Hong Kong Institution. After this joint venture, with the support of the Shenzhen Municipal Government, the universities of Hong Kong have obtained approval to establish their respective industry, education and research bases (IER) within the Shenzhen Virtual University Park starting from 2006. To date, six Hong Kong universities (CityU, CUHK, HKBU, HKU, HKUST, PolyU) have established IER bases in Shenzhen. The IERs are legal entities managed by the respective parent universities in Hong Kong. At each IER, a mix of research centers, educational programs, and start-up companies to commercialize university research have been established with the support of local and national research funding – with impressive achievements (Table 3.1). The basic S&T research strengths of Hong Kong universities have been combined with the industrial demands of the Greater Bay Area to promote technology transfer to the industries. A flavor of the variety of activities can be gleaned from a detailed description of activities at the HKUST Shenzhen Research Institute (see case study).

In 1999, a tripartite agreement among the Hong Kong University of Science and Technology (HKUST), the Fok Ying Tung Foundation and the Guangzhou Government have led to the establishment of the Nansha Information and Technology Park (NITP) in Nansha, Guangzhou. Further in 2005, the Fok Ying Tung Foundation made a substantial donation to HKUST for the establishment of a research institute in Nansha, which led to the establishment of the HKUST Fok Ying Tung Research Institute in Nansha in 2007 (see later section).

3.3.2 Technological Innovation Platforms

In addition to the IERs, various collaboration platforms for research and innovation have been established over the years by government, higher institutions, S&T organizations and the community in both Hong Kong and the Greater Bay Area in a combined effort to promote technological advancement and innovations (Table 3.2). Strong emphasis has also been placed on the nurturing of human resources. An example is the HKUST LED-FPD Technology R&D Center in Foshan set up with funding from the Nanhai District Government and the injection of research expertise from HKUST to provide R&D, testing and technical training services for Guangdong. The over-riding aim is to promote development of innovative technology with self-owned intellectual property. Some of these collaborative entities have provided the seed for national 973 projects or partner State Key Laboratories.

3.3.3 The Guangdong-Hong Kong Technology Co-operation Funding Scheme (TCFS)

The TCFS funding scheme, established in 2004 by the Hong Kong/Guangdong Expert Group on Co-operation in Innovation and Technology, aims to enhance collaboration among universities, research institutions and industries in both areas, and to elevate the technological level of industry in the Greater Bay Area. The Shenzhen Municipal Government joined the scheme in 2005. Projects funded by the TCFS will have to demonstrate an element of Guangdong/Hong Kong cooperation (e.g. collaboration among research institutes and enterprises in Guangdong, Shenzhen and Hong Kong). As at December 2016, the Hong Kong Innovation and Technology Fund (“ITF”) and relevant government authorities of Shenzhen have jointly funded over 60 projects.¹ Since the inception of the TCFS in 2004 until January 2017, more than 240 projects have been approved under the Scheme.² Of these projects, over 30 percent are co-funded by relevant government authorities in Guangdong Province or Shenzhen and the Innovation and Technology Fund.³

3.3.4 Research Projects Awarded by the National Natural Science Foundation of China (NSFC) to IER Platforms of Hong Kong’s University bases in Shenzhen

The National Natural Science Foundation of China (NSFC) is an organization under the aegis of the State Council responsible for managing the funding in support of basic research and scientific talents in China in line with national strategic aims. Since 2012, Hong Kong universities may apply for research funding from NSFC through its respective bases in the Mainland. Over the years, the universities from Hong Kong have actively participated in the NSFC research programs. In 2016 Hong Kong academics have submitted a total of 268 research proposals to NSFC under the general programme (including 78 for the young scholars), with an average success rate of around 30% (Table 3.3a). The total NSFC funding of RMB 36.3 million (Table 3.3b) accounts for less than 10 percent of the typical annual funding of around HKD500 million under the General Research Fund of the Hong Kong Research Grants Council.

¹ Hong Kong SAR Legislative Council Paper No. CB(1)624/16-17(01), 6 March 2017, p.4.

^{2,3} Hong Kong SAR Legislative Council Paper No. CB(1)671/16-17(01), 21 March 2017, p.3.

3.3.5 The New Cooperative Platforms of Nansha, Hengqin and Qianhai

The areas of Guangzhou, Shenzhen, Dongguan, Foshan, Zhuhai and Zhongshan already have many collaborations in industry, academia and other areas. The New Areas (新区) of Nansha, Hengqin and Qianhai are highlighted here to draw attention to their potential for further collaborations and the creation of synergies:

(i) Nansha

Nansha is the geometric center of the Pearl River Delta region with obvious geographical advantages. The State Council officially approved the "Guangzhou Nansha District development plan" in September 2009, making Nansha District an important state-level New Area. In the "Development Plan of the Nansha New Area of Guangzhou" approved by the State Council, it was stated that Nansha should be positioned as a demonstration zone of Guangdong-Hong Kong cooperation. In the National 12th Five Year Plan, it was stated that Nansha should be positioned as a business service center, science and technology innovation center and education and training base connecting Hong Kong and Macao to the Mainland in the provision of services.

Building on the foundation of the Nansha IT Park which is a collaboration between the Hong Kong University of Science and Technology (HKUST), the Fok Ying Tung Foundation and the Guangzhou government, and with a generous donation from the Fok Ying Tung Foundation, HKUST established the Fok Ying Tung Research Institute (FYTRI) in Nansha in 2007. As an important platform of HKUST in the Mainland, FYTRI assists the University in fulfilling its mission of technology innovation and advancement in the Greater Bay Area through research and postgraduate education, and by fostering knowledge transfer and industry collaboration. The Institute focuses its research and education in four areas: Internet of Things, Advanced Engineering Materials, Advanced Manufacturing and Automation, and Environment and Sustainable Development.

FYTRI also serves as a platform through which HKUST faculty and students participate in Mainland research schemes, such as 973, 863 and National Natural Science Foundation of China programs, as well as State Key Laboratory and National Key Projects. It is a Post-doc Workstation in cooperation with the Nansha Information Technology Park and it hosts the South China division of the National Engineering Research Center (Industry Automation).

FYTRI is also a Guangdong and Hong Kong cooperation base. In 2014, the Nansha District Government and the Hong Kong University of Science and Technology established the International Science and Technology Innovation Center - a platform for transforming S&T innovation achievements and for promoting Guangdong-Hong Kong joint S&T innovation and technology transfer. It also collaborates with the Guangdong Provincial Government and the Guangzhou Municipal Government to provide a respective base for the Guangdong, Hong Kong and Macao (International) Youth Entrepreneur Hub and the Guangdong science and technology innovation achievements demonstration center.

Separately, the Guangdong-Hong Kong Science and Technology Park was established in Nansha in cooperation with the Hong Kong Science Park. The Guangzhou HKUST Fok Ying Tung Research Institute, the Hong Kong University of Science and Technology and the University of Wollongong in Australia have set up a China-Australia advanced battery materials cooperation base.

In terms of regional human resources development, Nansha has set up a Creativity and Innovation Valley – Guangdong-Hong Kong-Macao Youth Cultural & Creative Community (创汇谷-港澳青年文创社区), Guangdong-Hong Kong-Macao (International) Youth Innovation Works and other innovative business platforms. It has also built up a research and business consulting tutor group

consisting of HKUST faculty members, national "thousands people's plan" experts and well-known entrepreneurs. Nansha is host to some innovation activities, for example, a technology innovation training camp for students from the cross-straits which provided entrepreneurship training for more than 800 young students from Guangdong, Hong Kong and Macao.

(ii) Hengqin

In August 2009, the State Council officially approved the implementation of the "Hengqin overall development plan", asserting a place for the territory in the national strategies. In April 2015, the Guangdong Free Trade Test Zone Hengqin New Area formally went into operation, meaning that Hengqin is assuming the role of a pilot site for experimenting with reform and innovation.

The National 12th Five-Year Plan has designated Hengqin as a demonstration zone for exploring innovative cooperation among Guangdong, Hong Kong and Macao. It will be a testing ground for deepening reform and facilitating technological innovation, as well as a new platform to promote industrial upgrading in the western bank of the Pearl River Estuary. The 12th Five-Year Plan of Guangdong Province outlined that Hengqin should focus on the development of business services, leisure and tourism, science, education, research and development and high-tech industries. As at November 2016, there are 1129 Hong Kong and Macao enterprises registered in Hengqin, and 445 of them are from Hong Kong.

In general, Hengqin is closer to Macao and therefore it will be more convenient for the two areas to cooperate. However, upon the completion of the Hong Kong-Zhuhai-Macao Bridge in 2018, Hengqin and Hong Kong will have the potential to become closer partners for cooperation.

(iii) Qianhai

Based on the National 12th Five-Year Plan, Qianhai will be an innovation and cooperation demonstration zone of Guangdong-Hong Kong modern service industry. In 2012, the State Council approved the policies for the development and establishment of Qianhai Shenzhen-Hong Kong modern service industry cooperation zone. Its focus is on the development of finance, modern logistics, information services, technology and other services.

Qianhai and Hong Kong have co-founded the Qianhai Shenzhen-Hong Kong Youth Innovation and Entrepreneur Hub (前海深港青年梦工场). It is the first international community of Hong Kong-Shenzhen cooperation in youth innovation and entrepreneurship, and it hopes to attract Hong Kong enterprises to set up a base in the Mainland. Since its establishment in 2014, the Entrepreneur Hub has incubated 172 entrepreneurial teams of which 77 are Hong Kong, Macao and international teams. At present, there are 95 teams in the Hub and 53 of them are Hong Kong, Macao and international teams. The Hub has also provided 1,408 internship positions to Hong Kong University students.

3.4 Summary

A representative snapshot of the current status of Hong Kong–Mainland collaboration in research and innovation in the Greater Bay Area has been provided in the tables that follow this chapter. While the coverage is by no means exhaustive, and the collaboration landscape is rapidly changing, the two sides have certainly built a good foundation and springboard to achieve greater synergies. However, bottlenecks to taking the collaboration to a higher level remain: policies need to be introduced to ease the flow of human talents and research resources including grant money across the border, and to facilitate the formal training of postgraduate students in the IERs of Hong Kong universities.

Table 3.1 Industry-Education-Research bases of Hong Kong Universities in Shenzhen

Institution	Established	Key research project or achievement
HKU Shenzhen Institute of Research and Innovation	2011	One National Key Basic Research Program (973 Program) and seven National Key Basic Research Projects (973 Program); 75 National Natural Science Foundation of China Projects; Seven Shenzhen Basic Research Projects; One Shenzhen Peacock Plan Grant; 30 National and Provincial Matching Fund Projects.
CUHK Shenzhen Research Institute	2007	32 laboratories were set up, including Shenzhen Research Base (or Branch) of 6 State Key Laboratories, 4 Shenzhen Key Laboratories and one Shenzhen Engineering Laboratory
HKUST Shenzhen Research Institute ⁴	2001	In 2012, HKUST Shenzhen Research Institute successfully applied for two 973 projects as principal investigator and was awarded a total of CNY 65 million national research funding. In 2013, it has published more than 150 technical papers and 5 books. In 2013, the number of patent applications was 3, including 2 invention patents. The two patents in 2013 were US patents. In addition, the results of NSFC research projects won many international awards including the American Chemical Society (ACS) Computational Chemistry Prize.
PolyU Shenzhen Research Institute	2000	More than 140 projects and a cumulative total funding over CNY 70 million have been secured. More than 50 commercial cooperation project contracts have been signed totalling CNY 14 million. As of May 2014, the Institute has applied for 21 patents, held 12 patents, and published hundreds of articles. Major research achievements include the world's first palm print identification system, digital city model, InSAR and seismic research, large-scale structural diagnosis and prediction system, high-performance sports apparel, intelligent artificial tendon, temperature sensing fabric and so on.
CityU Shenzhen Research Institute	2001	It has carried out over 100 national, provincial and Hong Kong research projects, such as national 973 and 863 programs, NSFC projects, the Guangdong Provincial Science and Technology key project, and set up Shenzhen Key Laboratory, Shenzhen-Hong Kong Innovation Circle program, The Shenzhen Municipal Science and Technology Program and the Hong Kong Innovation and Technology Program. A number of research and development achievements have received awards from the Hong Kong and Shenzhen governments, including the Hong Kong Science and Technology Industry and Technology Achievement Award, Shenzhen Science and Technology Innovation Award and Shenzhen “Double-hundred” Plan.
HKBU Shenzhen Research Center	2000	Since obtaining the qualification as supporting unit of National Natural Science Foundation in late 2012, it has secured a total of 31 funded projects with a total funding of more than CNY 15 million; it has also secured 7 Shenzhen Municipal Science and Technology Projects. It has published more than 30 academic papers for the NSFC projects.

Note: This information is adapted from *Strategic Research on Collaborative Innovation and Development in Hong Kong and the Pearl River Delta Region* 香港及珠三角地区协同创新发展战略研究報告, 中国工程院 (Chinese Academy of Engineering), 2017

⁴ A more detailed introduction on the operations and achievements of the HKUST Shenzhen Institute is appended as a case study at the end of this chapter.

Table 3.2 Collaborative technological innovation platforms in Guangdong

	Platform Name	Establishment Units	
1	Guangdong-Hong Kong Science and Technology Parks	Nansha District Government	Hong Kong Science and Technology Parks Corporation
2	Shenzhen-Hong Kong Science and Technology major health industry alliance	Shenzhen Hepalink Pharmaceutical	Hong Kong eHealth Consortium
3	Songshan Lake Xbot Park	Dongguan City Government	Hong Kong University of Science and Technology
4	Shenzhen-Hong Kong Youth Innovation Entrepreneurship Base	Shenzhen Science and Technology Innovation Commission	Hong Kong Innovation and Technology Commission
5	Demonstration Center of GD&HK S&T Achievements & Technology Transfer	Nansha District Government	Hong Kong University of Science and Technology
6	TGN Shenzhen Workhub	Shekou Network Valley	Tus-Holdings Co., Ltd.
7	Qianhai Shenzhen-Hong Kong Youth Innovation and Entrepreneur Hub	Qianhai Authority, Shenzhen Youth Federation	Hong Kong Federation of Youth Groups
8	Guangdong-Hong Kong Joint Research Center of Automation Science and Engineering	South China University of Technology	Chinese University of Hong Kong
9	MOE Key Laboratory of Regenerative Medicine	Jinan University	Chinese University of Hong Kong
10	Joint Platform between Guangdong and Hong Kong for Energy-efficient and Environment-friendly Transportation	Dongguan Research Institute of Sun Yat-Sen University	The Hong Kong Automotive Parts and Accessory Systems (APAS) R&D Centre
11	Cross-boundary Trade Declaration Platform	Guangdong Certificate Authority Center Co. Ltd., Foshan Electron Port Limited	E-Mice Solutions (HK) Limited, BRIO Electronic Commerce Limited
12	Co-founded Laboratory for the Study of Atmospheric Environment in the Pearl River Delta	South China University of Technology	Hong Kong University of Science and Technology
13	Guangdong-Hong Kong Joint Laboratory of Infectious Disease Surveillance	Sun Yat-sen University	University of Hong Kong
14	Joint Laboratory for Urology Tumor Research	Sun Yat-sen University	Chinese University of Hong Kong
15	Centre for Protein Research	Sun Yat-sen University	Chinese University of Hong Kong
16	Joint Laboratory of Brain Function and Health	Jinan University	University of Hong Kong
17	JNU-HKUST Joint Laboratory for Neuroscience Innovative Drug Research	Jinan University	Hong Kong University of Science and Technology
18	Joint Research Laboratory for Fiber Optics	Jinan University	Hong Kong Polytechnic University
19	Shenzhen Industry, Education and Research (IER) Base	Shenzhen Municipal Government, Peking University	Hong Kong University of Science and Technology
20	HKUST LED-FPD Technology R&D Center at Foshan	Nanhai District Government of Foshan City	Hong Kong University of Science and Technology
21	Guangdong-Hong Kong Science and Technology Innovation Service Platform	Guangzhou Productivity Promotion Center	Value Creation Center Co. Ltd.
22	LED Interactive Test Service Platform	Guangzhou Research Institute of O-M-E Technology	Hong Kong Science and Technology Parks Corporation
23	Shenzhen PKU-HKUST Medical Center	Shenzhen Municipal Government, Peking University	Hong Kong University of Science and Technology

Note: This information is adapted from *Strategic Research on Collaborative Innovation and Development in Hong Kong and the Pearl River Delta Region* 香港及珠三角地区协同创新发展战略研究報告, 中国工程院 (Chinese Academy of Engineering), 2017

Table 3.3 a) Number of funded National Natural Science Foundation of China Projects from 2012 to 2017 (Number of Young Scholars Projects are in bracket) awarded to the Hong Kong Universities. The averaged success rate is 31.4% (38.8%)

	2017	2016	2015	2014	2013	2012
CityU Shenzhen Research Institute	22 (3)	22 (6)	25 (10)	19 (8)	29 (14)	22 (7)
CUHK Shenzhen Research Institute	8 (1)	6 (2)	9 (2)	22 (3)	39 (18)	29 (7)
Guangzhou HKUST Fok Ying Tung Research Institute	5 (2)		3 (2)	1 (0)	4 (3)	2 (1)
HKBU Shenzhen Research Center	19 (16)	15 (5)	16 (9)	13 (7)	10 (7)	
HKU Shenzhen Institute of Research and Innovation	19 (10)	11 (4)	20 (6)	22 (10)	23 (13)	45 (20)
HKUST Shenzhen Research Institute	9 (2)	5 (2)	8 (2)	6 (2)	9 (2)	1 (0)
PolyU Shenzhen Research Institute	24 (10)	20 (6)	11 (5)	24 (14)	32 (10)	25 (6)
The Chinese University of Hong Kong, Shenzhen	5 (4)	1 (0)	2 (0)			
The University of Hong Kong-Shenzhen Hospital	2 (2)	1 (0)				
Total	113 (50)	81 (25)	94 (36)	107 (44)	146 (67)	124 (41)

(Source: 国家自然科学基金资助项目统计资料 <http://www.nsfc.gov.cn/nsfc/cen/xmtj/>)

Table 3.3 b) Total research grant awards to Hong Kong universities by the National Natural Science Foundation of China Projects (CNY million)

	2017	2016	2015	2013
CityU Shenzhen Research Institute	11.59	10.05	11.50	15.58
CUHK Shenzhen Research Institute	4.01	3.19	5.53	20.61
Guangzhou HKUST Fok Ying Tung Research Institute	2.36			1.49
HKBU Shenzhen Research Center	5.26	6.78	6.20	3.93
HKU Shenzhen Institute of Research and Innovation	7.63	4.60	8.60	14.47
HKUST Shenzhen Research Institute	4.89	2.26	4.20	6.05
PolyU Shenzhen Research Institute	10.22	9.42	4.20	25.64
The Chinese University of Hong Kong, Shenzhen	1.40			
The University of Hong Kong-Shenzhen Hospital	0.40			
Total	47.76	36.30	40.23	87.77

Case Study

HKUST Shenzhen Platform — Shenzhen Research Institute (SRI) and HKUST R and D Corporation (Shenzhen) Limited

The HKUST Shenzhen Research Institute (SRI, established in 2001), and the “HKUST R and D Corporation (Shenzhen) Limited” (RDCSZ, established in 2007) are the main vehicles which facilitate HKUST members in securing Mainland R&D projects and in implementing knowledge transfer and commercialization. It is also an effective platform for HKUST students and alumni to establish start-ups in Mainland China and a gateway between Hong Kong and the Mainland for these start-ups. It has taken on the role as a leading training hub in Shenzhen to foster talents for innovation and entrepreneurship.

In December 2006, the Shenzhen Municipal Government admitted HKUST to the Shenzhen Virtual University National University Science and Technology Park. HKUST was authorized to build the Shenzhen IER Building in the Park as its own base for industry, education and research. The HKUST Shenzhen IER Building, officially opened in September 2011, has a total area of 15,000 square meters and is regarded as a milestone in HKUST’s collaboration endeavors in building close relationships with industries and entrepreneurship in Shenzhen.

Since 2011, SRI has been approved as the supporting organization of the National Natural Science Foundation of China (NSFC) and has developed extensive cooperation with research institutions and enterprises in Mainland China. Six respective centers and laboratories in molecular neuroscience, aggregation-induced emissive material, traditional Chinese medicine, automation and UAV, marine environment and livelihood domain have also been established in SRI. The Biopharmaceutical Research Center in SRI is a Guangdong provincial key laboratory which has undertaken many national key research projects. Moreover, SRI together with industry and alumni with entrepreneurial projects have hosted 5 collaborative laboratories.

Undertaking government research projects is a highlight of SRI in technology transfer accomplishments. As of June 2017, SRI was granted 144 projects (99 from the Government) with a total amount of RMB 213 million, among which 18 projects has received more than RMB 1 million each. Two 973 projects and one Shenzhen Peacock Team project have also been secured through SRI, and each project received more than RMB 30 million in grant funding.



2017 Autumn Alumni Gala co-organized by SRI and MBA Association Guangdong Chapter; senior officers from HKUST and nearly 150 alumni joined this event.



Competitor made presentation at the final round of 2017 HKUST One Million Dollar Entrepreneurship Shenzhen Regional Competition.

SRI serves as a vital communication platform for alumni in the Mainland and a significant link between the alumni and the University. Since 2015, SRI has taken the initiative in organizing activities so as to maintain close ties with alumni. The EMBA Alumni Investment Club was also established in Shenzhen in August 2016 to facilitate the matching of HKUST start-ups with EMBA investors.

As of November 2017, there are 26 start-up companies established by HKUST faculty members or alumni in the HKUST IER Building. The hugely successful DJI Ltd. was home-grown in SRI and still has its after-sales office in the SRI building. Googol Tech, co-founded by 3 faculty members from HKUST, is now the leading company in motion control industry. EasyHin Technology, the first mobile medical start-up in Mainland China, secured venture capital funding of RMB 100 million in 2016.

In 2016 the HKUST One Million Dollar Entrepreneurship Competition (started in 2011) has expanded from Hong Kong to Macao and several cities in Mainland China, and the competition has been gaining reputation and popularity. SRI was host to the Shenzhen Regional Competition and received nearly 300 registrations in 2016 and 2017.

The Innovation & Entrepreneurship Center operated by RDCSZ aims to provide one-step service and working space at very low cost to the HKUST community - faculty, staff, students and alumni – during the initial phase of their project start-ups. To date, 27 programs are based in the Center. In late 2016, RDCSZ set up the Blue Bay Incubator in the IER Building. Blue Bay provides a full range of entrepreneurship services to the HKUST community for fostering innovation and entrepreneurship. In June 2017, Blue Bay became a member of the Shenzhen Qianhai E-Hub, and has opened its door to all startups, especially to Hong Kong businesses. More and more positive impact is expected to be made in the future. At present, there are 10 start-ups being incubated in the Blue Bay Incubator.



*Plaque Unveiling
Ceremony of Blue
Bay Incubator in
Qianhai E-hub*

CHAPTER 4

In-depth Interviews with Leaders in Industry, Academia and Government

“ Hong Kong can play a substantial role as a springboard for marketing and globalization of new Chinese technologies.

“ The role of government should be connecting, facilitating and inspiring.

“ *Innovation is about culture, cluster and cash.*

“ *Hong Kong must take part in world class research and innovation, especially if it hopes to capture the next cycle of knowledge-based, high value-added opportunities for business and industry.*

“ *Encouraging the younger generation to be more interested in innovation and technology requires the participation of the entire society.*

“ *In advancing innovation and technology, investment in training science and engineering talents is key to success.*

“ *We have to succeed in spite of the government.*

Chapter 4

In-Depth Interviews with Leaders in Industry, Academia and Government

4.1 Overview

One of the features of this study is a series of in-depth interviews conducted with a cross-section of leading figures in industry, academia, and officials from the Hong Kong SAR Government and the Mainland. The aim is to collect their candid views on the significance of innovation and technology (I&T) to the development of Hong Kong.

The Project Working Group interviewed 37 leaders and practitioners. The industrialists and entrepreneurs interviewed are seasoned leaders and practitioners who have weathered many storms in building foundations and bringing successes to their companies and organizations. University leaders of Hong Kong and innovation and technology experts from the Massachusetts Institute of Technology (MIT) were also interviewed. One of the MIT technology leaders interviewed is the main author of the “Made by Hong Kong” study published in 1997. Leaders from the financial sector, Mainland organizations and Hong Kong government-related R&D organizations also shared their insights.

In addition, the Project Working Group also arranged a group meeting with the directors of technology transfer offices in Hong Kong universities to understand their challenges of bringing technology to the marketplace.

The interviews focused on engaging the views of the leaders on:

- The position statement - “Given that HKSAR does not have a defense industry, or other significant industries – which is traditionally a driver for science and technology – we must collaborate effectively with Mainland partners to develop our innovation and technology effectively”;
- The significance of Hong Kong in the national development of innovation and technology;
- The role of innovation and S&T in the development of Hong Kong in the long and short term;
- The key factors of success of Hong Kong industry and the key hurdles to future development and “Re-industrialization of Hong Kong”;
- Hong Kong's relationship with the Mainland, especially in the Greater Bay Area in the process of S&T development and the possible areas for fruitful collaboration between Hong Kong and the Greater Bay Area;
- The role of government in the promotion of innovation and technology in Hong Kong. A more engaging government policy, such as having a top official to coordinate and oversee the various I&T efforts carried out by different departments, taking a more proactive role in using procurement to encourage demand of innovative products to support local R&D, and providing profit tax reduction incentives to encourage hiring of R&D talents;
- FINTECH, a niche area for Hong Kong's innovation and technology development, given Hong Kong's strength as an international Finance Centre, and the low barriers.

The list of leaders interviewed is stated below in Table 4.1.

Table 4.1 List of leaders interviewed

Organization	Name
Industry / private sector	
ARUP	Dr. Andrew Chan Dr. Ricky Tsui
Hong Kong Stock Exchanges and Clearing Ltd.	Sir CK Chow
STL Electronics	Mr. George Chung
Fung Holdings (1937) Ltd.	Dr. Victor Fung
CASH Group	Mr. Bankee Kwan
OTC Clearing HK Ltd / HKU	Prof. Lam Kin
Solomon Systech	Dr. Humphrey Leung
ATAL	Dr. Otto Poon
DJI	Mr. Frank Wang
VTECH	Dr. Allan Wong
HKMA	Mr. Arthur Yuen
Federation of HK Industries	Prof. Daniel Cheng Dr. Jimmy Kwok Dr. Daniel Yip Dr. Jack Yeung Mr. Arthur Ho Dr. Samson Tam
University academic leaders	
HKUST	Prof. Tony Chan Prof. Chia-Wei Woo
HK PolyU	Prof. Tim Tong
CUHK(SZ)	Prof. Xu Yangsheng Prof. Vincent Chan
MIT	Prof. Richard Lester Prof. Charlie Sodini
Mainland perspectives	
Former SZ Vice-Mayor	Prof. Liu Ying Li
China Liaison Office	Mr. Liu Zhi Ming
Government-related R&D organizations and universities tech transfer centres	
Science Park	Mrs. Fanny Law
ASTRI	Dr. Frank Tong
LSCM	Mr. Simon Wong
NAMI	Mr. Daniel Yu
Directors of Technology Transfer Office	Prof. Paul Cheung (HKU) Prof. Walter Ho (CUHK) Dr. Alwin Wong (HK Poly U) Dr. Simon Law (HKUST) Dr. Alfred Tan (Baptist U) Dr. David Ai (CityU)

4.2 A General View on Drivers for Science and Technology

Traditionally, there is a perceived lack of drivers for innovation and technology in Hong Kong as it has no defense industry or significant industries. Hong Kong also has the disadvantages of space shortage and a small market for technological products. It is the view that Hong Kong's economy has historically thrived on flexibility and adaptability, with exemplary business entrepreneurship largely focusing on practical solutions and short-term returns. There is also the cultural mindset of intolerance for failures, when the latter is one of the characteristics of the process of innovation. A seasoned industrialist opined that Hong Kong will always remain a user of technology, with innovation happening largely in the building of business models and cutting-edge R&D in isolated niche areas of excellence. Technology, in the opinion of some, is not the decisive factor for success.

Some are of the view that having no significant industries does not preclude Hong Kong from developing something innovative on its own, in light of its unique advantages such as strategic location, free flow of information, international character and sound legal system. Switzerland and Singapore are two comparable economies with no large-scale defense industry that are regarded as front runners in research and innovation. In addition, as one interviewee from the financial sector commented, technology is a means to make the financial industry more efficient; therefore, from this standpoint, technology can be the driver to promote the development of industry. It is the general opinion that to preserve its competitive status, Hong Kong must take part in world class research and innovation, especially if it hopes to capture the next cycle of knowledge-based, high value-added opportunities for business and industry.

4.3 Views from Industry

From a broad perspective, the table below depicted an industrialist's perception of the process of innovation and technology in the four key areas of the value creation chain from R&D to business and market:

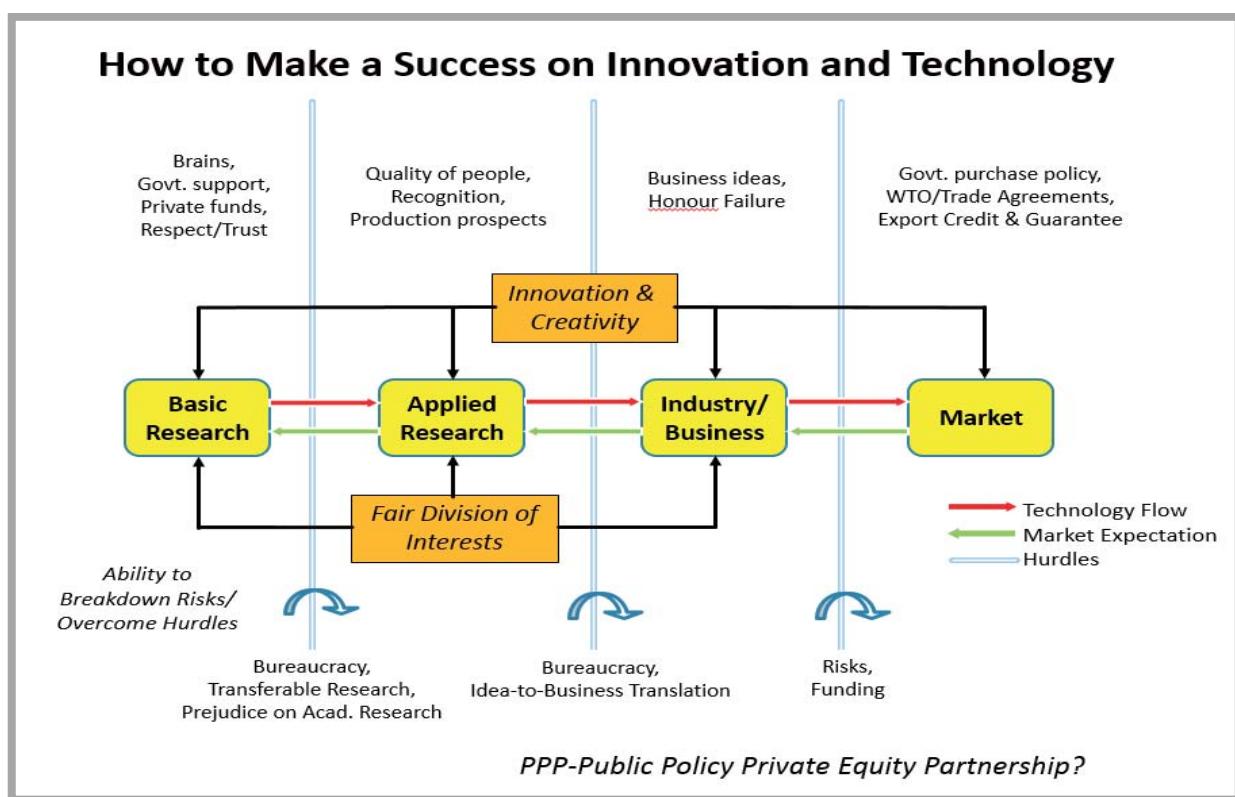


Figure 4.1 The ecosystem for innovation and technology from an industrialist's perspective

4.3.1 Acknowledgement of the Need for Innovation and Technology by Industry

There are different viewpoints and perspectives from the industrialists interviewed. In the past decades, Hong Kong held a dominant position in industries which require a relatively low level of technology. However, with the changing global economy and the transformation of the Greater Bay Area where Mainland cities are catching up rapidly or even surpassing Hong Kong in terms of economic growth, Hong Kong stakeholders have now acknowledged the need to innovate in addition to upgrading the traditional industries. It is generally agreed that innovation and technology are the drivers for economic growth in every economy of the world. In order to stay ahead in world competitiveness, Hong Kong must focus on the development of innovative products or services that can provide a leading edge in the global market.

Innovation is about culture, cluster and cash. To be able to thrive effectively, innovation needs an ecosystem with openness to facilitate the exploration of new ideas. It will also be conducive if clusters of companies can be grouped in targeted areas to build synergy and scale. In addition, funds to support R&D and to facilitate venture capital are necessary. A view has also been expressed that innovation and technology is about developing the right technology and bringing the right products to the market at the right time.

4.3.2 Role of Government as Viewed by Industry

As to the role of the government in the development of innovation and technology, one industrialist remarked that “We have to succeed in spite of the government”. In urging stronger commitment from the government, it should be emphasized that the combined efforts of all sectors in society, not just government, are necessary to transform Hong Kong into a knowledge-based society. Government can actively provide conducive measures and initiatives but it also needs the support of industry, academia and the community to make an innovative ecosystem successful.

It is the general view of the interviewees that government should play a more proactive role in encouraging innovation, although not in the sense of enacting strong industrial policies to “pick winners”. It has been suggested that the role of government should be connecting, facilitating and inspiring. While respecting the free market principle, government has to act as a beacon of innovation and technology development in a more visible and committed manner. For example, an industrialist who has served on the Innovation and Technology Fund (ITF) panel observed that there are many technologies with good potentials which are not known to industry. The government can be a facilitator to narrow the gap between university research and product development. It was felt that the existing practice of government support tends to place emphasis on procedural aspects but neglects the need for an adequate level of understanding and appreciation of the subject areas. Having said that, positive comments were made regarding the work and potential of the R&D centres overseen the Innovation and Technology Commission (ITC). In general, it is felt that the government should encourage new ideas and try out innovative products instead of adhering only to proven technology. It is understandable that there are limits and restrictions to government procurement policies; however, it will be desirable if some incentive provisions could be devised for rewarding local innovation. Overall, Hong Kong needs a long-term innovation and technology strategy, bold and streamlined measures to carry out the strategy, and strong commitment at the top government level in order to continue as a competitive player in the world stage

4.3.3 Partnership with Academia

On partnership with universities, collaborating with local academics to develop practical solutions for industries have met with success in some cases. However, it has also been noted that some academics who are less connected with industry do not have a keen sense of the importance of “time to market” (TTM) which is a crucial element to industries. Some are of the opinion that Hong Kong academics

in general are not very eager to connect with industry; they are more driven on spending time and energy on basic research which has significant impact on their academic career. One interviewee has also observed that there are many local academics who does not have Hong Kong roots and therefore may not have a fervent desire to serve the Hong Kong community. In addition, another interviewee also commented that most businesses in Hong Kong are not knowledgeable about the local universities – what they do besides education and what their R&D expertise are.

The Project Working Group has also interviewed the directors of technology transfer offices in Hong Kong universities on the challenges they face in taking research outputs to meet industrial needs. The comments received during the meeting reflected that there is a need to align and manage the expectations of both the researcher and industry, that better funding models would be needed, that there should be more incentives for academics to commercialize their research, that government investment support for startups should be considered, that there should be more flexibility in the funding support system, and that there should be a policy to attract talents outside of Hong Kong to work with local talents in the process of research commercialization. In addressing these issues, the government can play a more active role in bridging the gap between academia and industry for the advancement of innovation and technology.

4.3.4 Collaboration with the Mainland

On collaboration with Mainland partners, the views collected are somewhat mixed. Several of the interviewees expressed skepticism about collaboration pertaining to the commercial sector. They are of the opinion that in a world of competition there is no incentive to share ideas. There are also cultural and perception issues. They feel that joint venture seldom works because both sides will want to hold a dominant position, unless the company possesses a unique knowhow that the other company needs. While they feel that collaboration with the Mainland may not be easy, they are in agreement that integration with the Mainland will be vital. There should be an easing of constraints to allow more free flow of talents.

On the other hand, some interviewees are of the opinion that integration with Mainland in the development of innovation and technology is inevitable. Hong Kong can contribute to the national innovation and technology development but it needs to focus on niche areas. Moreover, partnering with Mainland universities allows access to talent pools. With the right partner, government funding may be tapped more successfully and opportunities captured for Hong Kong talents. In addition, a view was expressed that the collaboration of Hong Kong and Shenzhen, if successful, would lead to the formation of a world-class center for innovation and technology. Hong Kong should show the Greater Bay Area what it can do with innovative technologies to create new business models for the future. It is the general opinion that Hong Kong should develop a policy to attract both Mainland and multinational corporations (MNCs) to establish presence in Hong Kong, thereby creating opportunities for Hong Kong talents.

4.3.5 The Need for Financial Technologies (Fintech)

Financial technologies (Fintech) broadly refers to the application of information and communication technology (ICT) in the field of financial services. A general view has been expressed that Hong Kong must expeditiously catch up on the development of Fintech or its status as a world financial centre would be affected considerably. It is currently trailing behind major world financial centres such as London and those in the U.S. in the use of algorithm trading, although it is still ahead in Asia. Hong Kong has many competitive advantages to develop a strong Fintech ecosystem: an excellent ICT infrastructure, a well-respected legal system, and extensive experience with international and Mainland markets. As an international financial center with free flow of capital and information, there is a unique pool of talents with domain knowledge in finance supported by highly technically trained university

graduates. One interviewee commented that a successful financial centre would depend on innovation and technology, but the important drivers are really the components of a sound infrastructure. The Government can also actively facilitate the development of Fintech, for example, by balancing regulation and innovation; in this regard, a step forward has been made in that the Applied Science and Technology Research Institute (ASTRI), the Hong Kong Monetary Authority (HKMA) and the bank sector have been working actively to develop a financial technology platform (e.g. “regulatory sandbox” arrangement for banking industry to conduct trials on new solutions in financial services under a risk-controlled environment).

It is the opinion of the financial leaders interviewed that nurturing young talent and home-grown Fintech companies is crucial in driving the success of Fintech. To meet this need, HKMA has launched the Fintech Accelerator Scheme internship programme for Hong Kong university students at the end of 2016. Fintech is more about innovation than pure technology; therefore, developing human talents is first and foremost. The Government should also consider funding support for central financial infrastructure which the private sector is not willing or able to bear.

4.4 Views from Academia

4.4.1 Strategic Positioning

Interviews were arranged with the presidents of The Hong Kong University of Science and Technology, the Hong Kong Polytechnic University and the Chinese University of Hong Kong (Shenzhen). Technology leaders from the Massachusetts Institute of Technology were also interviewed. Their views focused more on the strategic levels.

The general view reflected in the interviews is that Hong Kong has unique advantages to develop innovation and technology with its strategic location, free flow of information, rule of law and an international identity. Hong Kong needs to tap the “One Country, Two Systems” advantage. At the strategic level, Hong Kong needs to participate in national research schemes independently with matching funds or contributions to the scheme from the Hong Kong SAR Government. There is an urgent need for Hong Kong industries in the Greater Bay Area to transform themselves to work on more innovation-based products in order to survive.

4.4.2 Strategic Partnerships with Government and the Mainland

As to the role of the government, the interviewees feel that the government should be less conservative and play a bigger role in supporting innovation and technology. It should create a conducive environment that can attract science and technology talents and multinational corporations (MNCs) to set up labs in Hong Kong, and to consider tax incentives for startups. STEM (Science, Technology, Engineering and Math) education in secondary schools should also be encouraged and promoted. Unlike the 1970s and 1980s when STEM subjects were popular among youngsters, it is a common observation today that these subjects are not a favorite choice of the best students in Hong Kong. However, encouraging the younger generation to be more interested in innovation and technology requires the participation of the entire society. There should also be more science and technology expertise injected into government to help set related funding priorities and policies. It is felt that currently, those who have received funding support are required to spend too much time on getting over procedural hurdles, thus compromising the time needed for scientific and innovation endeavors. As innovation and technology cuts across many bureaus and departments, the commitment should be a full-scale, encompassing effort.

It is also the opinion that the Hong Kong SAR Government can consider setting up a Special Development Region (SDR) for developing innovation and technology in the Lok Ma Chau Loop⁵ where there will be free flow of talents from Hong Kong and Shenzhen and favorable conditions provided for entrepreneurial and innovation activities. This confluence of talents and resources in the right environment can be very beneficial to nurturing the younger generation.

Regarding collaboration with the Mainland, it is the observation that Hong Kong has already been collaborating with the Mainland effectively such as partnerships on the research front, and that Hong Kong's traditional industries have a long history of establishment and influence in the Mainland. The question is how to collaborate more effectively given the political and educational landscape to capture the opportunities of the next cycle of knowledge-based, high valued-added manufacturing, and thereby augmenting or contributing to innovation and technology in the Greater Bay Area.

It is also noted that since 1997, Hong Kong has made great strides in building up universities with remarkable strengths that have achieved international recognition. The universities are a technology warehouse and a cradle for nurturing talents poised to meet the innovation and technology demands of tomorrow.

4.5 Views from Government-Related R&D Organizations

Interviews were arranged with leaders from the Hong Kong Science Park Corporation (HKSTP), the Applied Science and Technology Research Institute (ASTRI), the Logistics and Supply Chain Management Institute (LSCMI) and Nanotechnology and Advanced Materials Institute (NAMI). The general view is that in the development of innovation and technology in Hong Kong, fostering genuine collaboration among universities in forming research clusters in areas of strength is important. Industrialists should also be more open-minded in adopting a long-term perspective rather than focusing on short-term gain. There is also the need for high-level administrative officers in the government with a science background capable of appreciating the role of innovation and technology in a knowledge economy. In this regard, a science advisor or an advisory board funded by the government but working outside government bureaucracy and in consultation with the Academy of Sciences of Hong Kong, the Hong Kong Academy of Engineering Sciences and the Science Park may help in steering innovation and technology development. As to favoring innovation in the government procurement process, it will be difficult to introduce preferential use of local R&D innovation in government tenders. However, the idea of selective tax benefits to encourage R&D development and employment of young talents is possible.

It is felt that Hong Kong can play a substantial role as a springboard for marketing and globalization of new Chinese technologies. Hong Kong's international character and advanced legal and financial systems can help market Chinese MNCs globally, especially with the advent of the "One Belt One Road" initiative. Again, the Hong Kong SAR Government departments should devote more effort to keep abreast of the fast developments in the Mainland so as to facilitate closer and deeper collaboration. Suitable personnel with scientific background will be useful in providing the understanding and direction. As innovation and technology are relevant to many government bureaus and departments, they should coordinate closely together to support and champion the innovation success of Hong Kong universities and industry more proactively and visibly. There is a definite need for more R&D talent in Hong Kong. In addition, innovation and technology should embrace all fields of science and technology which is the normal practice in the Mainland and other countries.

⁵ The "Memorandum of Understanding on Jointly Developing the Lok Ma Chau Loop by Hong Kong and Shenzhen" was signed on 3 January 2017 between the Hong Kong Special Administrative Region (HKSAR) Government and the Shenzhen Municipal People's Government.

Again, it is suggested that new government funding models for R&D should be considered and bureaucracy should be streamlined, as overwhelming attention has been placed on having due oversight in spending public money. At the very least, government should encourage the adoption of local new technologies, perhaps by considering profit tax reductions. The partner State Key Laboratories are also a viable channel to help connect to Mainland research units and to obtain a better understanding of Mainland developments.

4.6 Views from Leaders of Mainland Organizations

Interviews were arranged with the former mayor of Shenzhen and the Ministry of Science and Technology representative in Hong Kong.

In the development of Shenzhen as an innovation hub, the emphasis has been placed on technology businesses. The government was focused on building an innovation system in which goals were set for the businesses to enhance its products for the market. To help the businesses, government's resources were directed to enhancing the source of technology and the nurturing of human capital. Hong Kong's role as super connector is diminishing as every major city in the Mainland has established its connection with the world.

The Hong Kong SAR Government should give first priority to science and technology in light of the changing environmental and political landscape. Hong Kong can also make use of its super connector role to attract and facilitate the establishment of Mainland enterprises and MNCs in Hong Kong. In addition, the Hong Kong SAR Government should set up a coordination mechanism across government departments in order to facilitate and accelerate the development of innovation and technology. For example, providing special benefits to certain industry or enterprise at certain appropriate times.

4.7 A Conceted View on the Nurturing of Human Resources

Of all the different views expressed, it has been observed that all interviewees stressed the importance of nurturing young talents in the development of innovation and technology. It is the consensus of these leaders that the Government should make an effort to popularize science and technology education so as to arouse or rekindle young people's interest in science. In advancing innovation and technology, investment in training science and engineering talents is key to success. The Academy of Sciences of Hong Kong (ASHK) has been collaborating with the Hong Kong Academy of Engineering Sciences (HKAES) in promoting S&T among high schools. As an example, the two Academies joined hands to support the annual Innotech Expo events organized by the Our Hong Kong Foundation since 2016. A "Distinguished Master, Accomplished Students" Mentorship Program was also developed in 2017.

CHAPTER 5

Conclusion - Summary of Findings and Recommendations

“ *There is a need to rejuvenate the I&T vision and review the I&T framework laid out in 1999.*

“ Hong Kong cannot afford to remain behind in the starting line when most of its competitors have already advanced considerably in their quest for a knowledge-based society and a sustainable economy.

“ It is crucial for the Government to develop policies that will be able to attract and retain Hong Kong trained talents in science and technology.

“ Innovation is needed not only to create high value-added new industries of tomorrow, but also to upgrade traditional industries.

“ With the growing emphasis on innovation and technology in government policy and the prospects of setting up a large-scale I&T base in the Lok Ma Chau River Loop, Hong Kong must seize the opportunity and adopt a fresh approach in order to preserve and enhance its world competitiveness.

Chapter 5

Conclusion: Major Findings and Recommendations

After a careful review of past innovation and technology (I&T) development in Hong Kong, a comparison of I&T growth with cities in the Greater Bay Area and beyond, an assessment of successful innovations by inventors of Hong Kong origin, and an in-depth analysis of the opinions and insights provided by a cross-section of leaders and practitioners across academia, industry and government, the Project Leadership Team would like to present a summary of findings and recommendations for the way forward.

5.1 Summary of Findings

5.1.1 Is Hong Kong Rapidly Losing its Competitive Edge?

The answer is yes. It is fair to say that until the present time - 20 years after the handover of Hong Kong to China in 1997 - the growth of the I&T sector still has a lot to be desired. Hong Kong cannot afford to remain behind in the starting line when most of its competitors have already advanced considerably in their quest for a knowledge-based society and a sustainable economy. For example, Shenzhen with its laser-sharp focus on steering economic development with I&T, has evolved into a growing hub very much resembling Silicon Valley, and has surpassed Hong Kong as China's most competitive economic center. In view of the rapid development of China as a major world power, Hong Kong is increasingly facing challenges from the Greater Bay Area and other Chinese cities. Shanghai is rapidly rising to become an international financial hub and is already the busiest container port in the world. The city has also been envisioned to become a super cruise hub as many major cruise companies are setting up Asian headquarters there; in addition, Shanghai's plans to transform itself into a global center of innovation in science and technology are already in place. Internationally, Hong Kong is falling behind other major financial centres in the development of financial technologies (Fintech); it must move ahead swiftly in order to preserve its global financial centre status.

Hong Kong is becoming less and less of a “super-connector” and, without a coherent policy and whole-hearted commitment from the Hong Kong SAR Government, it is running the risk of being marginalized and relegated to the rank of a “second-tier” city. It has been noted that currently Hong Kong's investment in R&D is a mere 0.74% of GDP, although this percentage represented an increase from 0.38% since 1997. However, it still pales in comparison to 4.23% in South Korea, 2.2% in Singapore, 3.73% in Shanghai and 2.85% in Shenzhen. The Government should consider enacting concrete measures to pull together academia, industry, government and society to help Hong Kong accomplish the transformation that it urgently needs.

5.1.2 Is Hong Kong Facing an Inevitable Choice - “Innovate or Die”?

After years of mixed reactions from the community, there appears to be a clearer consensus now that innovation and technology are indeed the engines of economic growth and that I&T cut across all disciplines, not just specific sectors. Innovation is needed not only to create high value-added new industries of tomorrow, but also to upgrade traditional industries. In this age of globalization, and with China fast becoming the most important player in the world's economy. Hong Kong needs to sustain its growth by developing niche areas in collaboration with the best Mainland and international partners.

It is true that Hong Kong still has many competitive advantages in terms of having very solid and time-tested infrastructures; to name a few - efficient transportation and logistics systems, first-rate financial services, free trade ports, low tax rates, sound legal system, excellent health services and internationally acclaimed universities. However, to sustain and to enhance the competitiveness of these pillars of economy, there is no doubt that I&T must be embraced in order to fuel the necessary

growth. Otherwise, its competitive advantages will continue to erode as other competitors achieve the same level of openness and efficiencies. This challenge needs to be met with considerable effort, but Hong Kong does not have to do it alone – it can leverage the strength of the Mainland economy and its substantial investment in science and technology.

5.1.3 What Are the Growing Strengths that are Becoming Increasingly Evident in Hong Kong?

Although only a relatively small percentage of GDP has been invested in funding R&D, the investment in a research university over two decades ago and the building up of research capabilities in higher institutions have met with success. The Hong Kong University of Science and Technology (HKUST) was established in 1991 to advance learning and knowledge through teaching and research in science and technology, among other areas, and to assist in the social and economic development of Hong Kong. It is now widely regarded as one of the leading universities in the world. As the 2014 Research Assessment Exercise has also shown, areas of excellence in diverse fields are evident in all research universities in Hong Kong. In addition, as discussed in Chapter Two, an analysis of the world-renowned QS World University Rankings has been conducted to assess the standings of Hong Kong universities. The study has identified that Hong Kong has the greatest number of universities in the world's top 100 in the 2018 Rankings. Moreover, Hong Kong universities are ranked highly in disciplines related to engineering and technology/computer sciences. The universities in Hong Kong have proactively cultivated strong research collaboration with partners in Shenzhen through their established Industry, Education and Research (IER) bases. Their research institutes in Shenzhen have achieved impressive results to date in terms of research funding obtained, R&D centers and enterprises established and the nurturing of talents through academic and internship programs.

The Project Leadership Team has found that the major development since the “Made by Hong Kong” study and the establishment of the Innovation and Technology Commission (1999) is the rise in international esteem of the Hong Kong universities. To illustrate the strengths of these universities, the Team rigorously identified 38 representative success stories in R&D commercialization that have won major international prizes and awards and/or have successfully been commercialized with significant impact to society. It is felt that, as a whole, the R&D innovations of the universities are not viewed as sufficiently appreciated and are under-promoted by government channels.

5.1.4 Does “Positive Non-Interventionism” Work for Hong Kong?

According to the *Index of Economic Freedom* published by the Heritage Foundation, Hong Kong has had the highest degree of economic freedom in the world since the inception of the Index in 1995. It stated that Hong Kong's economy is governed under “positive non-interventionism”, and is highly dependent on international trade and finance.

However, this policy is precisely why I&T in Hong Kong is lagging behind other developed economies. The policy was adopted since colonial times. It has been working well by and large, but is an inadequate match for today's Hong Kong who is facing increasing competition from neighboring economies. The Government must actively seek out opportunities for its businesses and the welfare of its citizens, and provide the necessary support and coordination. It must also align its strategies with the directions of the national government to take advantage of the economic initiatives, such as the “One Belt One Road” initiative. The lack of coordinated preparation and government leadership for technology-based economy, in terms of R&D investment, training and policy development has left Hong Kong far behind other economies.

Hong Kong urgently needs a clear direction to support its integrative development of I&T. There is a need to rejuvenate the I&T vision and review the I&T framework laid out in 1999. Although I&T has been earmarked as crucial to the development of Hong Kong's economy in past policy addresses of

Hong Kong's chief executives, there were roadblocks to driving I&T; for example, the lack of synergy and coordination among government departments and the limits of the current I&T framework.

Policy support has been urged to encourage and foster I&T for SMEs and R&D enterprises – specifically tax breaks for innovation enterprises and more support for pre-commercialization development of promising, cutting-edge technologies emerging from local institutions or start-up companies.

The community expects a visible commitment to I&T from the very top, and the Chief Executive should give priority consideration to this anticipation.

5.1.5 Does the Current Research Funding Model Work?

As mentioned previously, Hong Kong government's current investment in I&T is 0.74% of GDP, as compared with 2 % in Singapore, 3% in Taiwan and 4.23% in South Korea. There is an outcry from industry, academic and think tanks that Hong Kong needs a more steady support for long-term R&D and high value-added technology at all levels. For example, long-term support is much needed for I&T development for R&D centers and thematic areas of demonstrated success.

Many stakeholders also felt that the current I&T funding mechanism is outdated and a more efficient structure for setting agenda and vetting proposals is necessary. In addition, there appears to be a serious shortage of technological expertise and manpower capable of managing the I&T infrastructure and of capturing collaborative R&D opportunities with potential Mainland and international partners.

5.2 Major Recommendations

5.2.1 Rejuvenating and Driving I&T Development at the Highest Level of Government

Hong Kong is increasingly marginalized by neighboring mainland cities and losing its competitive edge. Shenzhen has surpassed Hong Kong as the most competitive city in China. Mainland cities have taken great leaps in adopting I&T to facilitate businesses, industries and the daily needs of ordinary citizens – thanks to the generous support and investments by central and local governments in R&D and the provision of incentives to encourage companies to innovate. Hong Kong, on the other hand, still clings to the traditional industries which did not put innovation as a priority because of funding or risk concerns. The Government should act proactively in giving its support and providing the necessary leadership for building a sustainable innovation ecosystem in Hong Kong.

It is also timely for the government to take steps in forming vigorous I&T policies as the mentality of the Hong Kong industries (in Hong Kong or Mainland) has turned around. The need to “innovate or die” is strongly felt. Hong Kong industries are now convinced that maintaining a status-quo in business operations to minimize commercial risks is not a long-term solution, if it wants to compete with other economies in a future market which will be revolutionized by different waves of innovations. The Hong Kong Government, in consultation with industry and academia, should play a catalytic role in helping industry to transform itself by implementing policies to promote innovation at all levels of the society and government.

It is recommended that an encompassing ecosystem of I&T to facilitate all sectors of society is needed, with more generous investment in mid-stream and applied R&D – to reach 3% of GDP over 5-10 years. Recurrent funding support will be greatly beneficial to existing R&D centers under the Innovation and Technology Commission, as well as helpful to universities for mid-stream research and partnership with prestigious national and international projects. The creation of more R&D centers for areas with critical mass and proven strengths will help elevate research competitiveness in the long run. The Innovation and Technology Bureau (ITB) will be able to carry out its mandate effectively provided

that it has leadership support from the highest level of government committed to mobilizing government departments, industry and academic in an all-society effort to encourage I&T development.

5.2.2 Injecting Professional and Technical Expertise into Government Decision Making

As I&T concerns all government bureaus, a strong coordination of efforts can only be achieved by full commitment from the very top. A cross-department mechanism should be set up to encourage and support the development of I&T in all pillars of infrastructures and industry. It is recommended that the Chief Executive appoint a high level I&T advisory group to assist in the development of an I&T strategy and policy roadmap for the future – in consultation with independent key stakeholders such as the Hong Kong Academy of Engineering Sciences (HKAES), the Academy of Sciences of Hong Kong (ASHK) and the Federation of Hong Kong Industries (FHKI).

It is also recommended that the Government consider developing a mechanism to collaborate with the universities – to strengthen technical expertise in the administration of I&T related units; for example, building up its technical capacity by migrating from a voluntary ‘committee service’ to a fully committed professional managerial operation overseen by personnel with R&D training. It is also desirable to develop a mechanism for secondment and/or rotation of technical or research personnel from universities and industry to the government. In addition, it is important to encourage more I&T policy research to gather new thinking and best international practices to support timely policy formulation and setting.

5.2.3 Supporting Local Technology Innovation Proactively

Understandably, some companies do not have the incentive to innovate because of financial concerns or other practical considerations. For example, some companies are successful at using their existing business models and therefore are reluctant to take risks to experiment with new I&T. Government must be willing to step in and provide some encouragement and support if it is really determined to help in long-term sustainability. Therefore, a more proactive and efficient funding and technology platform to encourage industry R&D is recommended to:

- support pilot test of new technologies
- make use of procurement policy to drive innovation and testing of new products and services (for example, green technology for housing), at the same time giving consideration to the limits of the Agreement on Government Procurement (GPA) which regulates the procurement of goods and services by public authorities who are parties to the agreement.
- provide tax exemption to innovation companies to create jobs and encourage capacity building.
- provide more liberal sharing of intellectual property developed from government projects.
- facilitate the development of financial technologies (Fintech)

5.2.4 Enhancing Recognition of Contribution to I&T

To give more encouragement and incentives for the engagement in I&T, the Government is encouraged to work with the universities to develop an appropriate mechanism to recognize the importance of I&T. It is important to ensure that the pursuit of applied research or knowledge transfer is accepted as part of university's societal mission, and that such involvement should not be penalized or be pre-judged with skepticism. Consideration may be given to offering academics the option to devote part of their time (for example, 3 months in a year) to engage in applied research and entrepreneurship activities and to be paid by income from such activities for the devoted time. Hong Kong academics should also be encouraged to take part in national I&T awards and prize competitions.

5.2.5 Nurturing Human Resources and Talents in I&T

For I&T to be successful, a talented and motivated pool of human resources is critical. This view has been strongly emphasized by the leaders in industry, finance and academia interviewed. It is therefore crucial for the Government to develop policies that will be able to attract and retain Hong Kong trained talents in science and technology.

The younger generation of Hong Kong should be actively encouraged to discover and pursue their interests in science and technology, and be supported by an environment that nurtures an innovative spirit. It is therefore recommended that all Hong Kong universities partner with high schools to promote research and innovation at an early age – for example, new text books written by prominent Hong Kong engineers and scientists, learning methods and internships.

To nurture talents with a world view in their outlook, it is recommended that the existing research postgraduate (RPG) scholarship/fellowship schemes (for example Croucher, Edward Youde) be significantly enhanced to support enrolment of Hong Kong students in top universities overseas – to increase their exposure to world class research and innovations.

5.2.6 Developing Integrative Collaboration of Mainland-Hong Kong I&T

On 1 July 2017, the Framework Agreement on Deepening Guangdong-Hong Kong-Macao Cooperation in the Development of the Bay Area was signed in Hong Kong. In this context, the Hong Kong/Shenzhen Innovation and Technology Park at the Lok Ma Chau River Loop - the development of which was agreed upon by the Hong Kong and Shenzhen governments in early 2017 - has presented a golden opportunity for deeper collaboration between Hong Kong and the Mainland on I&T development.

The Hong Kong/Shenzhen Innovation and Technology Park at the Lok Ma Chau River Loop will be a platform of confluence for academia, industry and enterprises to work on project collaborations. It is recommended that a Special Office with cross-bureau authority be appointed to lead the venture. Both Hong Kong and cities in the Greater Bay Area can make use of each other's strengths and create synergistic collaborations.

The Park should be utilized as a test bed for the implementation of new policies and regulations in order to enable the establishment of a vibrant ecosystem in Hong Kong for I&T industries. A more flexible and accommodating cross-border flow of resources should be established for effective operations in the Loop.

This is an opportunity for university, industry and government to have a fresh approach to collaboration. Suggestions from stakeholders can be solicited immediately and can be developed in the Loop. Some specific recommendations are:

- Set up industry-focused and demand-driven R&D centers that are market-oriented;
- Plan the Loop with consideration to other development plans both in Hong Kong and Shenzhen for better synergy;
- Avoid the double-burden of having to satisfy the regulations of both Hong Kong and Shenzhen for managing the activities in the Loop;
- Target and attract SMEs and nurture start-up, not just high profile tech firms;
- Build up the necessary strengths for the Guangdong-Hong Kong-Macao Greater Bay Area by harnessing the resources and talents from the three areas in an integrative collaboration effort to boost research, innovation and commercialization capable of competing internationally.

The HKSAR Government should also consider establishing additional ITF-funded R&D centers in areas of interest to the I&T industry and find synergy with other existing centers; develop collaborative R&D centers with leading players in the world in relevant areas; providing affordable housing and good schools to attract research talents to Hong Kong; providing visa-free access to all those working in the Loop, their families and other stakeholders, and providing tax and other incentives for companies' investment in R&D work.

The development of research and innovation in the Loop can be facilitated by:

- inviting R&D entities such as ITC R&D centres, Hong Kong partner state key laboratories, Hong Kong Branch National Engineering Research Centres, Areas of Excellence (or proven strength) to establish bases in the Loop, in partnership with Hong Kong industry, for collaboration with Mainland R&D entities;
- creating synergies between the universities' Shenzhen-based research institutes and the envisioned ecosystem of the Loop, with the possibility of relocation of some of the institutes and the establishment of new applied research insitutes in the Loop;
- encouraging academics/researchers with appropriate incentives to devote some of their time for research and innovation work in the Loop.

Furthermore, the Hong Kong Government can work with other Greater Bay Area governments to formulate a joint funding scheme with the Ministry of Science and Technology (MOST) for applied research in the Loop, with free flow of research funds from both sides for use in the Loop.

5.3 Concluding Remarks

At this important juncture of the 20th anniversary of the Handover, there is no better time to rethink the positioning of Hong Kong in a global economy. With the growing emphasis on innovation and technology in government policy and the prospects of setting up a large-scale I&T base in the Lok Ma Chau River Loop, Hong Kong must seize the opportunity and adopt a fresh approach in order to preserve and enhance its world competitiveness. As the saying goes, "nothing ventured, nothing gained". Hong Kong must muster up the courage to take some bold steps and big leaps for the sake of its future generation.

Prof. Tan Tie Niu, Vice-President of the Chinese Academy of Sciences and Deputy Director of the China Liaison Office in Hong Kong, summed up the key elements necessary for forging ahead in innovation and technology at an HKAES function in October 2017:

- *An encouraging science, technology and innovation (STI) ecosystem*
- *A well-defined STI strategy and roadmap*
- *A coordinated action*
- *An emancipated mind*
- *A risk-taking spirit*
- *A proactive attitude*
- *An international perspective*

Together, let us seize the moment and forge ahead to take Hong Kong to the next level of development in sustainability and growth, and to transform this dynamic city into a competitive knowledge-based economy for the long-term benefits of its citizens and of the nation.

References

- Baark, E. and Sharif, N., 2014, "The Hong Kong Experience with Public Procurement for Innovation" in *Public Procurement, Innovation and Policy* (Edited by V. Lember et al.), Springer-Verlag Berlin Heidelberg, pp. 171-190.
- Berger, S., Lester, R.K. and The MIT Made By Hong Kong Study Team, 1997, *Made By Hong Kong*, Oxford University Press, New York.
- Brynjolfsson, E. and McAfee A., 2014, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, W.W. Norton & Company, New York, USA.
- Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2015, *The 13th Five-year Plan for Economic and Social Development of the People's Republic of China 2016–2020*, Central Compilation & Translation Press.
- Chief Executive's Commission on Innovation and Technology, *First Report*, September 1998, HKSAR Government. ([http://www.itc.gov.hk/en/doc/First_report_98_\(eng\).pdf](http://www.itc.gov.hk/en/doc/First_report_98_(eng).pdf)).
- Chief Executive's Commission on Innovation and Technology, *Second and Final Report*, June 1999, HKSAR Government. ([http://www.itc.gov.hk/en/doc/Second_and_Final_reports_99_\(Eng\).pdf](http://www.itc.gov.hk/en/doc/Second_and_Final_reports_99_(Eng).pdf)).
- Department of Statistics, Singapore, *Education and Literacy – Tables*. (<http://www.singstat.gov.sg/statistics/browse-by-theme/education-and-literacy-tables>)
- Dowling, D.A., 2015, *The Dowling Review of Business-University Research Collaborations*, BIS/15/352, Department for Business, Innovation & Skills, UK Government. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440927/bis_15_352_The_dowling_review_of_business-university_rearch_collaborations_2.pdf)
- Financial Services Branch, 2016, *Report of the Steering Group on Financial Technologies*, Financial Services and the Treasury Bureau, HKSAR Government. (https://www.fsb.gov.hk/fsb/ppr/report/doc/Fintech_Report_for%20publication_e.pdf)
- Chin, H., Lau, F., He, W. and Cheung, T., 2015, *The Silk Road Economic Belt and the 21st Century Maritime Silk Road*, Fung Business Intelligence Centre. (<https://www.fbicgroup.com/sites/default/files/The%20Silk%20Road%20Economic%20Belt%20and%2021st%20Century%20Maritime%20Silk%20Road%20MAY%2015.pdf>)
- The Hong Kong Academy of Engineering Sciences, 2011, *Science and Technology Policy for Hong Kong: A Position Paper*, the Science and Technology Forum: Innovation for the Future of Hong Kong and the Pearl River Delta, 1-2 December 2011, Hong Kong.
- The Hong Kong Academy of Engineering Sciences and Chinese Academy of Engineering, 2000, *Proceedings for Symposium on Commercialisation of Innovation & Technology*, .COM IT 2000.
- The Hong Kong Polytechnic University, 2015, *Proceedings of the CAE-HKAES Joint Summit on Innovation and Technology Industry in Hong Kong and the PRD*.
- IMD World Competitiveness Center, 2016, *IMD World Competitiveness Yearbook 2016*, Institute for Management Development, Lausanne, Switzerland.
- Lau, L.J., Shui, K., and Xiong, Y., 2016, *Yes, Hong Kong CAN!*, Our Hong Kong Foundation. (https://www.ourhkfoundation.org.hk/sites/default/files/media/pdf/Yes_Hong_Kong_CAN_eng.pdf)

Lin, O.C.C., 2010, *China on the rise: Competition of Soft Power in the Globalization Era* (中華崛起來？－全球化時代中軟實力的競賽), Hong Kong University Press, Hong Kong.

Lin, O.C.C., 2013, *The Technology Innovation Quartet: Secrets of Successful Entrepreneurship* (科技創新四重奏：成功創業故事解密), Commerce Culture Press, Taipei.

Lin, O.C.C., Wang, K.L. and Chan, K.C., 2002, *A Report - HKUST Forum on the Future Development of Hong Kong*, the Hong Kong University of Science and Technology.

National Science Board, 2016, *Science & Engineering Indicators 2016*, National Science Foundation, USA.

OECD 2015, *OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society*, OECD Publishing, Paris.

Pavese, K.E., Hayter, C. Satinsky, D.M., Levitan, B. and Cooke, C., 2010, *Yaroslavl Roadmap 10-15-20: 10 years to implement, 15 steps to take, 20 pitfalls to avoid*, The New York Academy of Sciences.

Schwab, K. and Sala-i-Martín, X., 2015, *The Global Competitiveness Report 2015–2016: Full Data Edition*, World Economic Forum. Geneva, Switzerland.

Steering Committee on Innovation and Technology, 2012, “Policy Statement and New Initiatives for Promoting Innovation and Technology Development in Hong Kong, and initiatives to dovetail with the National Twelfth Five-Year Plan”, *Paper No. 04/02/12*.

([http://www.itc.gov.hk/en/doc/steering/Discussion_Summary_\(12th_meeting\)_English.pdf](http://www.itc.gov.hk/en/doc/steering/Discussion_Summary_(12th_meeting)_English.pdf))

Stough, R.R., 2016, “Entrepreneurship and Regional Economic Development: Some reflections”, *Investigaciones Regionales – Journal of Regional Research*, Vol. 36, pp. 129-150.

Tsui, L.C., Lun, R. and Cheung, E., 2015, *The Ecosystem of Innovation and Technology in Hong Kong*, Our Hong Kong Foundation.

(https://www.ourhkfoundation.org.hk/sites/default/files/media/pdf/ScTech_full_report_eng.pdf)

University Grants Committee, Hong Kong, Statistics about Our Universities.
(<http://cdcf.ugc.edu.hk/cdcf/statEntry.do?language=EN>).

深圳市科技创新委员会 和 深圳高新区管理委员会, 2014, 深圳虚拟大学园工作汇报.

上海市科学技术委员会, 2016, 上海科技进步报告.

国家自然科学基金委员会, 2012-2017, 国家自然科学基金资助项目统计资料.

Appendix A

Academic Rankings of Hong Kong Universities

1. Introduction

This paper examines the scientific research and technological capabilities of five research universities in Hong Kong as seen from different World University Rankings. Four representative and time-tested authoritative university rankings are selected:

- Quacquarelli Symonds (QS) World University Rankings
- Times Higher Education (THE) World University Rankings
- Shanghai Jiao Tong University Academic Ranking of World Universities (ARWU)
- National Taiwan University Rankings (NTUR)

In addition to the institutional rankings, the relative performance in the “Engineering & Technology” subject area and the corresponding positioning within the Asia or Greater China region are also assessed.

2. Assessment Criteria of Different Ranking Exercises

The Times Higher Education (THE) published their first World University Rankings in 2004. Since then, a number of authoritative university rankings have appeared. In such a ranking exercise, based on publicly available or supplied data, the performance of the universities in teaching, research, reputation, internationalization are evaluated – ending with a composite score according to some weighting criterion. Table A1 lists the general weighting given to aspects of reputation, teaching, research and internationalisation. In general, the QS and Times Higher Education rankings take into account teaching and internationalization elements in addition to research performance normalized by faculty size, while the Shanghai Jiao Tong University (ARWU) and National Taiwan University (NTU) rankings are based exclusively on research productivity (Table A1).

It is widely recognised that university rankings have to be interpreted with due care. On the one hand, the key performance indicators on scholarly output are derived from openly available data (e.g. research publications and citations in Science Citation Index journals) based on clear definition of how the ranking is carried out – there is no manipulation by the evaluators. The non-profit nature of some ranking organizations (e.g. ARWU and NTUR) also adds to the credibility of rankings. On the other hand, many indicators in higher education are not easily quantifiable - “not everything that counts can be counted”. There is also an intrinsic uncertainty or “error bar” surrounding the ranking – in other words a university in the 50th position has probably significant “error bar” overlap with another university in the 60th position. This uncertainty or fuzziness of the relative positioning can be attributed to the selection and definition of indicators by the ranking agencies, and data presentation by the participating institutions. Some rankings also tend to favour larger universities with a longer history of successful graduates, and penalize small elite liberal arts colleges with specific missions. Despite the above shortcomings of simplistic rankings, they have become increasingly important in influencing how the public perceives a university – university rankings certainly have an obvious impact on student enrolment, faculty recruitment, and even to some extent research funding.

The following analysis provides an overview of the scientific strengths of the Hong Kong academic community through a detailed examination of different world university rankings. Innovation and technology must ultimately be based on fundamental research which gives rise to paradigm shifts and breakthroughs that result in disruptive technologies that may lead to new industries and economic

growth. Different ranking systems have different methodologies and criteria; however, research-related indicators play an important role in all these rankings. The ranking is hence a good indicator for the fundamental research capability of a university. The detailed criteria and performance indicators for the four rankings can be found in Table A2 – A5.

Table A1 Weighting distribution of different performance indicators in global university rankings

	<i>QS World</i>	<i>THE World</i>	<i>ARWU</i>	<i>NTU Ranking</i>
Reputation	50%	33%	-	-
Awards	-	-	30%	-
Teaching	20%	15%	-	-
Research	20%	44.5%	70%	100%
Internationalization	10%	7.5%	-	-

Table A2 Details of the performance indicators for *QS World University Rankings*

Category	Indicators	Weighting
Reputation	Academic reputation*	40%
	Employer reputation*	10%
Teaching	Faculty/Student Ratio	20%
Research	Citations per faculty (sourced using Scopus database)	20%
Internationalization	International faculty ratio	5%
	International students ratio	5%

* based on the annual Academic Reputation Survey

Table A3 Details of the performance indicators for *THE World University Rankings*

Category	Indicators	Weighting
Reputation	Reputation survey on teaching	15%
	Reputation survey on research	18%
Teaching	Academic staff-to-student ratio	4.5%
	Doctorates-to-bachelors' ratio	2.25%
	Doctorates-awarded-to-academic staff ratio	6%
	Institutional income	2.25%
	Research income	6%
Research	Industry income	2.5%
	Research papers published per faculty member	6%
	Citations (sourced using Scopus database)	30%
	International-to-domestic-student ratio	2.5%
Internationalization	International-to-domestic-staff ratio	2.5%
	International research collaborations	2.5%

Table A4 Details of the performance indicators for Shanghai Jiao Tong University Academic Ranking of World Universities (ARWU)

Category	Indicators	Weighting	
Awards	Alumni winning Nobel Prizes and Fields Medals	10%	30%
	Staff winning Nobel Prizes and Fields Medals	20%	
Research	Highly cited researchers in 21 broad subject categories	20%	70%
	Papers published in Nature and Science	20%	
	Paper indexed in the Science Citation Index-Expanded and Social Science Citation Index	20%	
	Per capita academic performance	10%	

Table A5 Details of the performance indicators for National Taiwan University Rankings (NTUR)

Category	Indicators	Weighting	
Research	Productivity	Number of articles in the last 11 years	10%
		Number of articles in the current year	15%
	Impact	Number of citations in the last 11 years	15%
		Number of citations in the last 2 years	10%
		Average number of citations in the last 11 years	10%
	Excellence	h-index of the last 2 years	10%
		Number of Highly Cited Papers in Essential Science Indicators (ESI)	15%
		Number of articles in the current year in high-impact journals	15%

3. Performance of Hong Kong Universities in World Rankings

World University Rankings

Table A6 shows the performance of HK universities in the four major World University Rankings during the period 2012-2017. It is striking to note that according to the QS and THES ranking, 4 and 3 (out of 8) Hong Kong universities are ranked among the top 60 in the world respectively; and the performance in the past six years has been consistent and improving. On an institutional basis, the Hong Kong rankings in ARWU and NTU Rankings are less spectacular. ARWU relies heavily on number of Nobel Laureates and Fields Medallists, and number of publications in Science and Nature. NTUR is based on total productivity, while QS and THE use research output normalized by number of faculty as indicators. While the performance of the three traditional research universities (CUHK, HKU, HKUST) is relatively stable, the dramatic improvement in performance of CityU and PolyU should be noted. In general, Hong Kong universities tend to compete well in rankings that are based on performance per staff, rather than total output (which depends on the total number of full time academics).

Asia/Greater China University Rankings

Compared with other universities in Asia, Table A7 shows the performance of the five institutions are outstanding in both QS and THE. In particular, 4 (2) out of the five institutions are ranked within Asia's top 10 universities by QS (THE) in the last three years (2015-2017). Even when benchmarked against most rigorous standards, four Hong Kong universities are among the top 10 universities in Greater China (Mainland, Taiwan, Hong Kong and Macao) according to the ARWU ranking.

Table A8 World university rankings in field/subject-specific areas – Engineering & Technology, Computer Sciences & Information Systems

	QS World University Rankings – Engineering & Technology						THE World University Rankings – Engineering & Technology					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
HKU	45	42	48	43	26	27	43	42	36	34	33	30
HKUST	22	27	19	15	14	15	23	21	21	16	19	18
CUHK	82	84	79	49	41	50	-	-	-	65	74	59
CityU	117	130	101	76	60	76	-	80	89	-	58	60
PolyU	91	90	70	40	44	51	-	89	81	70	74	67
	Shanghai Jiao Tong University ARWU – Engineering/Technology						National Taiwan University Rankings – Computer Sciences					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
HKU	-	111	117	91	95	74	67	55	52	76	58	62
HKUST	36	38	34	39	40	31	46	50	56	45	49	54
CUHK	83	82	75	52	56	72	38	38	38	27	25	35
CityU	42	32	25	24	27	24	12	12	9	8	6	8
PolyU	52	91	90	61	81	51	22	24	15	15	16	14

Appendix B

Success Stories of Hong Kong Research, Innovation and Commercialization

To ascertain and to illustrate the strength of Hong Kong's innovation and commercialization which have achieved international recognition, the Project Working Group has approached industry and academia in search of innovation successes in their respective organizations.

The process used to identify the success stories was systematic and rigorous. The Project Working Group contacted senior management and chief officers in universities and industry to request their recommendations on successful cases for presentation. The criteria for selection include:

- Ground breaking innovations
- international award-winning achievements
- Successful commercialization
- Renowned scientists and engineers in Hong Kong
- Applications of the innovation beneficial to well-being of society and humanity

The success stories presented in this study were not meant to be exhaustive; there are many outstanding and promising innovative projects being undertaken currently in Hong Kong. For the purpose of this study, the Project Working Group has selected a limited number of knowledge transfer cases to be highlighted as representative examples of innovation success.

Appendix B1

Success Stories of Hong Kong Universities

List of Selected Research Innovations from Hong Kong Universities (2017)

Project	University	Principal Investigator	Page
Transgenic Fish Technology for Testing Product Safety		Prof. Shuk Han CHENG	B1-3
Construction and Structural Health Monitoring System for Super-tall Buildings	City University of Hong Kong	Prof. Qiusheng LI	B1-4
Advanced Materials		Prof. Chain Tuan LIU	B1-5
Development of Non-invasive Prenatal Testing (NIPT)		Prof. Dennis LO	B1-6
Intelligent Processing of Chinese (IPOC) ACE Hearing (Automatically Customized Enhancement)		Prof. Kam-Fai WONG	B1-7
Automatic Analysis for Common Chronic Diseases	Chinese University of Hong Kong	Prof Tan LEE	B1-8
Titanium Dioxide (TiO ₂) with Higher Photocatalytic and Antibacterial Activities		Prof. Benny ZEE	B1-9
Setting the Standard for Network Transmission: the BATS code		Prof Jimmy YU	B1-10
Autologous Neural Stem Cell (ANSc) Harvest Technology	Hong Kong Baptist University	Prof Ken Kin-lam YUNG	B1-12
Ultra-hard, Anti-scratch Thin Film		Profr Kok-wai CHEAH	B1-13
Advanced Railway Monitoring System with Fiber Bragg Grating (FBG) Sensors		Prof. Hwa-Yaw TAM and Prof. Siu-Lau HO	B1-14
Anti-erasing Ink	The Hong Kong Polytechnic University	Prof. Pei LI	B1-15
Rational Design of Engineered Arginine Depleting Enzymes as Multi-potent Anti-cancer Agents		Prof. Thomas Yun-Chung LEUNG and Dr Thomas Wai-Hung LO	B1-16
Advanced Displays Technologies		Prof. HS KWOK	B1-17
New Approach to Develop Clinical Therapies to Treat Alzheimer's disease (AD)		Prof Nancy IP	B1-18
Aggregation Induced Imaging Solutions to Control Infectious and Water-borne Diseases	The Hong Kong University of Science and Technology	Prof Benzhong TANG Prof King-Lun YEUNG and Prof Joseph KWAN	B1-19 B1-21
Consumer-friendly Unmanned Aerial Vehicles (UAVs)		Prof Zexiang LI and Mr. Frank WANG	B1-22
Flow-through Hybridization for DNA Hybridization		Dr. Joseph Wing On TAM	B1-23
Oral Formulation of Arsenic Trioxide for Acute Promyelocytic Leukemia (APL)		Prof. Yok-Lam KWONG	B1-24
Growing Cartilage from the Patient's Own Stem Cells		Prof. Barbara Pui CHAN	B1-25
Advanced OLED Material Development for Multimedia and Display Applications	The University of Hong Kong	Prof. Vivian Wing-Wah YAM	B1-26
Computer Forensic and Information Security Technologies		Dr Kam-Pui CHOW	B1-27
A New Generation of Passive LED Drivers for High-Power Lighting Applications		Prof. Ron Shu-Yuen HUI	B1-28

Transgenic Fish Technology for Testing Product Safety (PI: Prof. Shuk Han CHENG, City University of Hong Kong)

Food safety is an important issue that has been given global attention. Vitargent uses the transgenic fish technology for testing product safety in food and cosmetics industry, transforming research excellence into business opportunities and helping to create a safer world with our homegrown technology.

Vitargent, a biotechnology company founded by Mr. Eric Chen Zixiang and Dr Chen Xueping, both alumni of City University of Hong Kong (CityU), employs patented technology developed by Professor Cheng Shuk Han from the Department of Biomedical Sciences at CityU and her research team. The company uses transgenic medaka fish and zebrafish embryos to test for up to 1,000 toxicants. The technology improves the safety of water, food, medicine, cosmetics, plastics and daily necessities by rapidly testing for toxins with results available in 48 to 72 hours.

The company worked with Hong Kong property developers to conduct thorough tests of the drinking water supplied in their properties. Water samples had undergone multiple checking to ensure that the water in all their properties was sparkling clean and safe to drink. In addition, the fish embryos can be used to test and improve existing product lines. It can screen raw materials during product development, ensuring the safety of new ingredients. Vitargent's technology is widely used by government departments, research institutions, cosmetics groups and food companies in Hong Kong, mainland China and Europe.

In April 2015, it won the Grand Prix at the 43rd Geneva International Exhibition of Inventions of Geneva. The Geneva International Exhibition of Inventions is considered as the world's most renowned invention show. In May 2016, Vitargent made great strides in scaling up by successfully raising series B financing led by a Hong Kong real estate conglomerate Nan Fung Group, hoping to push the company to become Hong Kong's first homegrown biotechnology startup attaining unicorn valuation status exceeding USD 10 billion.

Construction and Structural Health Monitoring System for Super-tall Buildings (PI: Prof. Qiusheng LI, City University of Hong Kong)

Professor LI Qiusheng from the Department of Architecture and Civil Engineering at CityU has been awarded the 2016 Jack E. Cermak Medal by the American Society of Civil Engineers. He is the first Chinese scholar in the world to receive this honour, which is the highest in the field of wind engineering and industrial aerodynamics.

By combining and applying field measurement, wind tunnel testing, numerical simulation and theoretical analysis, Professor LI's research team has made significant contributions to enhancing building safety through the systematic study of boundary layer wind characteristics and wind effects on structures. For example:

- The Wind and Structural Health Monitoring Systems developed by the research team were installed in a number of super-tall buildings including Ping An International Finance Centre in Shenzhen (640 metres high), International Finance Centre Two in Hong Kong (420 metres), Citic Plaza in Guangzhou (390 metres), and Guangzhou West Tower (432 metres). The systems can monitor wind action and pressure from typhoons on curtain walls and buildings as well as structural responses, which provide reliable scientific information and guidelines for the wind-resistant design of super-tall buildings.
- Based on long-term measurements from numerous monitoring means, the profiles of wind speed and turbulence parameters within the atmospheric boundary layer over various terrain conditions have been established for the wind-resistant design of super-tall buildings.
- A series of groundbreaking achievements have been made in the field of computational wind engineering, such as a new large-eddy simulation sub-grid model and a turbulent flow field generator; new numerical simulation method of wind-driven rain based on the Eulerian multiphase model and a new method for fluid-structure interaction for turbulent flows with high Reynolds number. A whole set of software for numerical wind tunnel testing was developed for engineering applications based on the new methods.
- Wind tunnel experiments over a much larger range of turbulence scale than previously studied were conducted to explore the effects of turbulence on pressure fluctuations in separated and reattaching flows which enhanced the understanding of the effects of turbulence on bluff body aerodynamics.

Tropical storm is one of the worst natural disasters in the world, regularly hit by typhoons along the southeast coast of China, which caused heavy casualties and economic losses. Professor LI's research results will help to protect people's lives and property safety with great significance.

Advanced Materials

(PI: Prof. Chain Tsuan LIU, City University of Hong Kong)

With the rapid development of modern industry and defense, high-strength steel is becoming more and more important in industries like aerospace, defense, power plants and aviation, etc. Ultra-high strength steel is a kind of specialized high-strength steel with tensile strength ranging from 1400 to 2000 MPa. It has been widely used for making rocket engine casing, aircraft landing gear, bullet-proof steel, etc. In recent years, ultra-high strength steel is turning into more popular in traditional industries such as construction, machinery manufacturing, automotive industry, etc. Many military and even civilian equipment nowadays are made of ultra-high strength steel.

Professor LIU Chain Tsuan, University Distinguished Professor, has discovered an innovative way to manufacture ultra-high strength steel combining nanocluster-strengthening with traditional strengthening methods. This ultra-high strength steel has many advantages over materials made of conventional methods in terms of toughness, weldability, and corrosion resistance.

The technology has been licensed to a high-tech steel machinery manufacturer in Mainland China whose steel products are widely used by more than 70 large and medium sized steel plants in Mainland China. It has also successfully entered into overseas markets like India, Brazil and Saudi Arabia.

More advanced materials are developed. Professor LIU and Professor CHEN Guang from Nanjing University of Science and Technology (NJUST) led the team and developed the new titanium-aluminum nickel-base (TiAl+Nb) single crystal alloy created by the team can be used in turbine engines used on aircraft. Its chief quality is its improved capacity for heat resistance, its high tensile strength and low density. The new material can withstand temperatures up to 900°C and replace the use of Ni-based super-alloys. This new material is better than the nickel-base super alloy developed in the last century because it can reduce the weight of an airplane's engine by 400 pounds, lower energy losses by 15%, and cut noise and gas emissions by 50%. It not only boosts the efficacy of an airplane, but also significantly reduces noise and environmental pollution. The new material can be used for turbine blades and widely applicable in the aerospace manufacturing in the future.

Professor LIU's achievement has attracted a lot of attentions in academic circles and has been published as a cover story in the internationally acclaimed journal *Nature Materials*.

Recently, a research team led by Professor LU Jian, Vice-President (Research and Technology) and Chair Professor of Mechanical Engineering has successfully developing the first-ever supra-nano magnesium alloy.

The new advanced material is ten times stronger than conventional crystalline magnesium alloy and has super-deformation capacity two times higher than that of magnesium-based metallic glass. Also, it can be developed into biodegradable materials that can be implanted in the human body.

It is possible to apply the new alloy in biodegradable implants. For example, magnesium (Mg) alloys are newly developed biodegradable materials. The Mg-based SNDP-GC deposited Mg alloy can be used as a new prototype for biodegradable implants with excellent wear resistance.

The innovation was published in top academic journal *Nature* as cover story on 4th May, the first Chinese Scientist's cover story on structural materials.

Development of Non-invasive Prenatal Testing (NIPT) (PI: Prof. Dennis LO, Chinese University of Hong Kong)

Professor Dennis Lo from the Department of Chemical Pathology of The Chinese University of Hong Kong was the first in the world to report the presence of cell-free fetal DNA in the blood plasma of pregnant women. Professor Lo found that such cell-free fetal DNA could be found from the 7th week of pregnancy onwards at a surprisingly high concentration of 5 to 10%. Professor Lo then painstakingly translated this discovery into new prenatal tests for the fetus that can be performed simply by taking a small volume of blood from the mother's arm. This development represents a paradigm shift from previous practice when testing the fetus's DNA would mean taking an invasive sample from the uterus (i.e. amniocentesis) or the placenta (i.e. chorionic villus sampling). Such previous invasive methods are associated with a 0.5% risk of harming or even killing the fetus. Professor Lo's method does not entail such risk and has an accuracy of 99.7% for detecting fetal Down syndrome. Since 2011, Professor Lo's technology has been used by millions of pregnant women in over 90 countries. Professor Lo has also created a very valuable patent portfolio which have been licensed to Illumina and Sequenom, and sublicensed to dozens of international companies. This patent portfolio represents one of the most valuable originating from Hong Kong.

Seeing the similarities between a fetus growing inside a pregnant mother and a tumour growing inside a cancer patients, Professor Lo has also extended plasma DNA testing for cancer detection and monitoring. He is one of the pioneers of the emerging fields of liquid biopsy for cancer. In particular, he has shown that plasma DNA testing is a powerful technology for the detection, monitoring and prognostication of cancer common in China, such as nasopharyngeal cancer and liver cancer. His work is expected to save lives through early detection.

Professor Lo's work has been covered by numerous international media. For examples, see:
<http://edition.cnn.com/2016/03/24/health/dennis-lo-dna-discovery/> and
<http://clinchem.aaccjnl.org/content/58/4/784>.

In recognition of his work, Professor Lo has been elected as a Fellow of the Royal Society, as a Foreign Associate of the US National Academy of Sciences, as a Fellow of The World Academy of Sciences (TWAS) and as a Founding Member of the Academy of Sciences of Hong Kong. Professor Lo has won numerous awards, including the 2014 King Faisal International Prize in Medicine and the 2012 Ernesto Illy Trieste Science Prize from TWAS, presented by President HU Jintao of China.

Intelligent Processing of Chinese (PI: Prof. Kam-Fai WONG, Chinese University of Hong Kong)

In the early 1990s, although there was in-depth research in Chinese linguistic, e.g. in literature, translation, etc. globally, research in computer processing of Chinese language was rare. CUHK was one of the pioneers. The Intelligent Processing Of Chinese (IPOC) research team led by Professor Vincent Lum, Emeritus Professor of Systems Engineering and Engineering Management and Professor Kam-Fai Wong, Director, Centre for Innovation of Technology, proposed the use of phrase structures rather than words for indexing and parallel database techniques for handling large volume of Chinese text. Previous research in the 90s in Chinese processing mainly focused on input methods, character recognition, small-scale parsing, etc. The proliferation of the Internet at the turn of the 21st century and the large Chinese-speaking population worldwide render Chinese NLP a very important research subject, and the focus of many Internet companies, including Google, Microsoft, Baidu, etc.

In 1998, Professor Kam-Fai Wong and members of the IPOC team founded Wisers Information Ltd, the first university spin-off Internet company in Hong Kong partially funded by the Government. This may seem common and straightforward to many of us today, but Wisers was the first of its kind in Hong Kong and China, and long preceded Baidu. The technology platform of Wisers was based on the aforesaid Chinese Natural Language Processing (NLP) and Information Retrieval (IR) technologies developed by the IPOC team. Today, Wisers provides customized news searching and business intelligence services to enterprises and organizations. The team collaborated with the local Chinese news publishers and helped them digitize their newspapers. This was a big step forward for the local news and media industry where publishing was achieved in printed form. Wisers technology was highly recognized internationally and have received the following awards:

- “Wisers Knowledge Management and Content Service System” won the China Computer Federation Innovation Award 2005, December 20 2005, China. (National Science Award Association certificate no. 0131)
- WiseNews won the 2003 World Summit Award (WSA’03), United Nation, Best Practice Product in e-Content and Creativity of Asia

Wisers news retrieval service is widely used by the Hong Kong Government to search for relevant daily news every morning. Also, the service can also be found in public libraries, universities and almost all school libraries. Outside the Government, Wiser’s news service is highly appreciated by reporters, who use it for searching information from news archives, by students who use the service for extracting relevant information for their general education research work, by celebrities, who use it to gauge their popularity, by marketing companies, which use it to detect market trends and customers’ opinions, etc. It is evident that Wiser, founded by CUHK, and her news retrieval services have made life much easier for many people worldwide, who relies on Chinese news information.

Automatically Customized Enhancement (ACE) Hearing (PI: Prof. Tan LEE, Chinese University of Hong Kong)

About 38% of the world's population suffers from some degree of hearing loss. Many people don't seek treatment for hearing loss until the impairment causes breakdown of daily communication. They are put off by the long process of getting a formal hearing test, which typically requires a referral to a specialist plus multiple doctor visits. There are also concerns of high cost and unpleasant stigma. On the other hand, we are all aware that hearing ability deteriorates with age. Many of us choose to live with it and adjust ourselves by, for example, talking loudly and increasing the volume of ear phones. Indeed, each individual has his/her own hearing profile, which is technically specified as hearing threshold, discomfort sound level and dynamic range, etc. Our hearing could be optimized by adjusting input sound according to the personal profiles.

With inter-disciplinary efforts involving ear doctors, audiologists, electronic engineers and software programmers, an innovative and affordable hearing enhancement technology was developed jointly by the Chinese University of Hong Kong (CUHK) and Ximplar Limited, to enable optimized hearing experience for everyone. This patented technology was known as ACE Hearing (Automatically Customized Enhancement). It incorporates the services of hearing professionals into any mobile device. It assesses the user's hearing health with a self-administered hearing test, and then can reshape the device's audio output to provide a fuller listening experience. In clinical trials, test subjects have shown significant preference for ACE Hearing-enhanced speech and music through a smartphone, and also experienced significant improvement in speech recognition in noise without having to increase volume.

The new technology has raised the general public's awareness that they have an unrealized need negatively impacting their quality of life. ACE Hearing won the Bronze Award and Audience Choice Award at The Wall Street Journal Asian Innovation Awards 2011. It was the Top Finalist of 2014 GSMA Best Mobile Health Product/Service Award. In the 2014 Talent Unleashed Awards, whose star-studded judges include Sir Richard Branson and Steve Wozniak (Apple Co-founder), ACE Hearing was one of the Global Grand Winners and the winner of Community Impact Award.

ACE Hearing was initially developed as mobile apps. Recently it has been implemented into a fashionable electronic gadget, named Aumeo Audio. The device can be used with any iOS or Android device for personalized audio enhancement. Aumeo has been made available on market via a crowd-funding project and received overwhelming responses from customers. It has become a reality that a lot of people can hear better with the new technology. In July 2016, Aumeo was recommended by the Executive Editor of IEEE Spectrum magazine in his review article titled "Better High-Definition Audio From Your Smartphone". IEEE spectrum is the flagship magazine in the area of electrical and computer technologies.

The inter-disciplinary team at CUHK also pioneered the research on cochlear implant technology optimized for Chinese tone languages and developed software tools for standardized assessment of speech and language disabilities for Chinese-speaking population.

Automatic Analysis for Common Chronic Diseases (PI: Prof. Benny ZEE, Chinese University of Hong Kong)

Chronic Diseases including Stroke, Diabetic Retinopathy (DR), Coronary heart disease (CHD), Chronic Kidney Disease (CKD), Dementia and Alzheimer's Disease etc, are common in both Hong Kong and the global community. In Hong Kong, more than 700,000 of population are suffering from diabetes. These patients are at the same time at 6-8 times higher risk to develop stroke when compared to normal individuals. While more than 1.2 million of the Hong Kong population is suffering from hypertension, more than half of our population that are at the age of 40 or above require cardiovascular risk assessment. For neurodegeneration diseases, whereas more than 100,000 of the Hong Kong population are suffering from Dementia and Alzheimer's Disease, it is estimated that the risk assessment therefor is required for more than 700 million individuals of the global population.

In attempt to alleviate such heavy burden, Prof. Benny Zee, Assistant Dean (Research) of the Faculty of Medicine / Professor / Head of Division of Biostatistics of the Hong Kong Jockey Club School of Public Health and Primary Care / Director of the Centre for Clinical Research and Biostatistics, has developed a fully automated platform for non-invasive prediction of aforesaid common chronic diseases. By analysing images of retinal vessels - the only directly visible vessels in an individual, estimation of health risks in the community, acquiring of information for early disease management and treatment guide for corresponding therapists / clinicians can be achieved. While retinal imaging has long been used to estimate the risk of DR, the complexity, labor-intensiveness, as well as the bias due to human perception of the process has hindered its further use and application in estimating other diseases such as stroke. In this regard, the platform developed by Prof. Zee that involves the capturing of retinal images from a fundus camera (a type of camera commonly used in optical stores) and the analysis of the uploaded images in a cloud server database can determine the risk of a target disease in as short as five minutes of time. Based on existing clinical data of retina vessels, the team applied pattern recognition skills to devise an algorithm which reads pixel by pixel the retinal images and analyze such pixels to come up with measurements on different vessel patterns that can indicate the risk of diseases as mentioned above.

The revolutionary platform has already won several local and international awards, including the "E Craig Nemec Achievement Challenges - Austin Ventures" in the Venture Lab Investment Competition (VLIC) at Texas Austin, USA on May 2011; the 5th Bank of China "Technology Start-up" Merit Award; Asia-Pacific Region Finalist 2016 at the Talent Unleashed Award 2016 "Best Startup - Social Impact"; Top 50 at the Innovation Forum 2016 – Imagine IF; as well as the Technological Achievement Award at the Hong Kong Award for Industries 2016. Currently, the patented technology invented in 2012 has extended its use by Prof. Zee's start-up firm Health View Bioanalytic Limited that has been initially supported by the Technology Start-up Support Scheme for Universities. The company aims for a wider use in up to 20 branches in an optical chain in the coming two months, saving people's precious time to wait for receiving check-ups in hospitals or clinics.

Titanium Dioxide (TiO₂) with Higher Photocatalytic and Antibacterial Activities (PI: Prof. Jimmy YU, Chinese University of Hong Kong)

Indoor air pollution and urban air quality are listed as two of the world's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. According to the 2014 World Health Organization (WHO) report, air pollution in 2012 caused the deaths of around 7 million people worldwide. To address these, Prof Jimmy Chai Mei YU of the Department of Chemistry and his research team have developed a new technology in the fabrication of Titanium Dioxide (TiO₂).

TiO₂ is a non-toxic, chemically stable material and is a workhorse material for accelerating photoreactions in the presence of catalyst (photocatalysis). Upon the irradiation by sunlight or UV light, powerful oxidative superoxide anion radicals and hydroxyl radicals that can completely degrade pollutants and kill bacteria on contact will be formed. TiO₂ produced using Prof Yu's method has shown to have two times higher antibacterial and photocatalytic activities than conventional TiO₂. Such properties render the various applications of TiO₂ in e.g. environmental remediation and solar fuels, as well as being well established as a platform for dye-sensitized solar cells and heterogeneous catalysis.

The research of Prof Yu and his team has led to 100 publications and has received over HK\$30M of research funding. His research advanced the knowledge of photocatalysis that consequently became an emerging mainstream technology for solving our energy and environmental problems. Such fact is also reflected by the admission of his work to the Chemistry of Materials' 1k Club series owing to the more than 1445 times' citation of his research paper published, as well as the award of Thomson Reuters Highly Cited Researcher to Prof. Yu in 2014 and Chang Jiang Chair Professorship by the Ministry of Education in 2010.

With three corresponding patent filings submitted across five different countries / regions in 2003, the technology was then licensed to a multi-national manufacturer of air purifying systems this year. The company planned to incorporate these patented technology and its know-how into the design of a series of new generation antibacterial air filtration systems for home, hospitals and offices. These new generation air filtration systems will tackle indoor air pollution and improve urban air quality.

The impact of Prof Yu's research has inspired young inventors and children. Two local students, Simon WONG Sum-ming, aged 17, and Michael LI Kin-pong, aged 18, have invented a self-cleaning cylindrical door handle coated with TiO₂ that kills 99.8% of the germs in contact. The pair conceived the idea under the mentorship of Prof. Yu and completed most of the prototype in his lab. The pair went on to win the Intel International Science and Engineering Fair in USA and were also awarded a gold medal at the 44th International Exhibition of Inventions of Geneva 2016.

Setting the Standard for Network Transmission: the BATS code (PI: Prof. Raymond YEUNG, Chinese University of Hong Kong)

Existing network devices such as routers and switches only store and forward the received data packets. The predominant network communication protocol, TCP/IP (Transmission Control Protocol/Internet Protocol), is like the role of a private car in a transportation system in a city. Too many private cars create road congestion. In this regard, network coding serves as a form of “public transport” where passengers share vehicles and may need to change vehicles to reach their destination. The technique provides more flexibility to modify the data packets to be transmitted to benefit the efficiency of network communications. By taking these advantages, Prof. Shenghao Yang and Prof. Raymond Yeung, who is also a co-director of the Institute of Network Coding of CUHK, created what is now known as BATS code (which stands for BATched Sparse code). BATS code is a low-complexity erasure correction code that allows network devices to generate new data packets to compensate network data loss, while at the same time improving the transmission throughput when network data is delivered.

Because BATS code generates and transmits new data packets in the network devices (i.e. the relay nodes) to compensate for data packet loss, the code is a good approach for realising networks that require one or more network devices to connect from the source device to the destination device. A network with two devices and a 20% loss per device, for example, can, when using BATS code, have an increased transmission by 56% and a reduction in the loss rate by 29%. Additional applications of BATS code include 5G/WiFi wireless communications, satellite communications, Internet of Things (IoT), wireless sensor and mesh networks. In a disaster recovery scenario, BATS can also connect multiple wireless communication devices, such as mobile phones and wireless sensors, to deliver information to tens and hundreds miles away without the support of a fixed communication infrastructure.

Such innovative technology has already received from the Hong Kong SAR Government’s University Grants Committee in 2010 a matching grant from CUHK to provide them with funding support of more than HK\$100 million. The team also received an Innovation Technology Fund from the Hong Kong SAR Government of HK\$1 million. In 2016, Prof. Yeung has received the IEEE (Institute of Electrical and Electronics Engineers) Eric E. Sumner Award that recognises outstanding contributions to communications technology.

The team is working closely with both the local and multi-national industrial network in seeking to commercialise the technology.

Autologous Neural Stem Cell (ANSc) Harvest Technology (PI: Prof. Ken Kin-lam YUNG, Hong Kong Baptist University)

Professor Ken Yung Kin-lam from the Department of Biology of Hong Kong Baptist University (HKBU) and his research team has pioneered the harvest of neural stem cells from the adult mammals, manipulate the stem cells and transplant back into the same subject animal. Their technology, Autologous Neural Stem Cell (ANSc) harvest, is the first and the only means in the world for harvesting adult neural stem cells from the brain of live subjects without them having to risk their lives. This historical breakthrough is facilitated by their strategically designed nanoparticles for specifically locating neural stem cells for efficient extraction. As stem cells are regenerative, repeated extraction from the same live subject is possible. The extracted neural stem cells are active and viable. They can differentiate into a variety of neural cells and be re-injected into the brain of the same subjects for replacing their damaged neural cells for recovery.

Traditionally, there is no way to harvest neural stem cells from adult subjects. Researchers usually use embryotic stem cells from embryo. Although there is another technology called Induced Pluripotent Stem Cell Technology or IPS technology, these IPS technologies usually involve genetic engineering. Skin cells will be taken out from the patient/donor and then their genes are modified to turning to be stem cells. One concern about this technology is to make use of “viral” vectors from virus, which is known as “pathogenic”. Even though “pathogenic” causing any disease from virus is not adopted, people still worry if the viruses might have “immutation”.

ANSc harvest is set to bring enormous benefits to medical researches and clinical practices. For the researches relating to neural stem cells, drug discovery or drug development, ANSc Harvest offers neural stem cells from the same cell source/animal to allow the use of same stem cell lines throughout the whole research project, which definitely maintains higher accuracy and consistency. What's more, ANSc Harvest has high potential to be developed as a personalised cell replacement therapy for neurodegenerative diseases. Patients might be able to use their own neural stem cells to replace their degenerated ones in the future.

Led by Professor Yung, his technology start-up OPER Technology Limited (OPER), successively received the three-year Technology Start-up Support Scheme for Universities (TSSSU) grants which is supported by the Innovation and Technology Fund and subsequently licensed the said technologies from HKBU in November 2014. OPER has been named by the Red Herring as one of the Asia's and global top 100 companies. It was awarded a number of prestigious awards including Gold Medal in Surgery Category at the 44th International Exhibition of Inventions of Geneva, Diploma for High Scientific and Technological Invention at the 44th International Exhibition of Inventions of Geneva, HKBU Innovationem Award 2016, SME Youth Entrepreneurship Award 2016, Asia Pacific Entrepreneurial Awards 2016 Hong Kong (Healthcare & Pharmaceutical Industry), Mediazone 2017 Hong Kong Most Valuable Companies and The 5th China Innovation and Entrepreneurship Competition (Hong Kong, Macao and Taiwan) – Second Place (Enterprise Group). In 2015, OPER was the only one start-up in HK coming up to a finalist at GlaxoSmithKline (GSK) Neuro2020 and now, their collaboration is underway. For details, please refer: http://hkbunews.hkbu.edu.hk/?t=ennews_details/344 and <http://opertechnology.com/>.

Ultra-hard, Anti-scratch Thin Film Technology (PI: Prof. Kok-wai CHEAH, Hong Kong Baptist University)

Through the extensive industry engagement over the years, Professor Cheah Kok-wai from the Department of Physics at Hong Kong Baptist University is devoted to solve the technical problems that hinder the advancement of technology and economic growth. Recently, he has led his research team to demonstrate how to bring excellent research to the business and industry sectors, as evidenced by the support of a grant from the Innovation and Technology Fund for his start-up, Cathay Photonics Limited (CPL) and a venture capital investment as well as engagement for prototypes with a few major cover screen manufacturers internationally.

This about two-year-old start-up has won the second round venture capital investment, which valued the company at about HK\$200 million. Bearing the vision of improving the quality of life, CPL is engaged in a business of research and development, commercialisation, marketing, and sale of specialty-coated substrates and ceramics products. The tremendous ascent of CPL has both excited and mystified many.

In October 2014, an Apple sapphire screen supplier filed for Chapter 11 after Apple introduced two new iPhones models, neither of which uses a sapphire screen. Although the CEO of supplier emphasised that it was an unfounded rumour that those Apple smartphones carry sapphire screens, it would be more interesting to look into the background technologies instead of going through the details of the story. Sapphire is the second hardest natural materials known and is difficult to cut and polish. Growing a single crystal sapphire is extremely time-consuming and also technically challenging for large size substrates (i.e. greater than 6 inches). So, the production yield of sapphire is fairly low due to two critical criteria in terms of feasibility and repeatability. Obviously, long fabrication time causes high production cost (i.e. higher than US\$40 per screen), which is unrealistic and impractical for large commercial scale.

However, CPL has developed a few patent pending technologies for ultra-hard and anti-scratch sapphire thin-film coating, which is a turnkey solution for such cover screens. Compared to the existing technology, the merits of CPL's products are lightweight, high hardness, low cost, high optical transmission and less processing time. Importantly, this technology can be adopted by industry without further investment of new equipment or facilities. Furthermore, this non-fragile thin substrate can be applied to screens and providing excellent scratch protection. Its manufacturing cost is approximately half that of sapphire covered glass.

In recognition of the invention, Prof Cheah received the Grand Prix Award, Gold Medal in the Industrial Processes Category and the Special Award from the Romanian Association for Nonconventional Technologies at the 44th International Exhibition of Inventions of Geneva. Besides, CPL won top 10 among 100 contestants among the world at Elevator Pitch World Tour, the HKBU Award 2015 and also the Certificate of Merit from the Federation of Innovative Technologies and Manufacturing Industries (FIMIT).

Advanced Railway Monitoring System with Fiber Bragg Grating (FBG) Sensors Technology (PI: Prof. Hwa-Yaw TAM and Prof. Siu-Lau HO, The Hong Kong Polytechnic University)

With fast growing railway networks, railway operators have been working hard to uphold the safety and reliability of mass transport systems. Developing railway monitoring system for hundreds or even thousands of kilometres of track is a mission-critical challenge, as tiny deviation such as a few millimetres of distortion in the track could seriously compromise the safety of the trains, potentially causing damage and casualties.

To achieve high monitoring and diagnostic robustness for large-scale transport and civil infrastructures, PolyU pioneered the development of FBG sensors for sensing a multitude of different types of physical quantities efficiently. A research team led by Professor Hwa-Yaw Tam and Professor Siu-Lau Ho of Department of Electrical Engineering of PolyU developed a novel photonic-based monitoring technology Fiber Bragg Grating (FBG) sensing system, which can automatically find defects in railway tracks and trains, and provides alert of abnormalities affecting train service, travel times and safety. The optical fibres and FBG sensors were fabricated with state-of-the-art equipment in PolyU's Specialty Optical Fibre Fabrication Laboratory.

The FBG sensing system can transmit information of a wide variety of measurands like temperature, vibration, stress at multiple sensing points with a single optical fiber that can span over a hundred kilometer, realising long-distance, real-time and multifunctional sensing. In addition, the FBG sensor has advantages over conventional electrical sensors, such as cost-effectiveness, compactness, light weight, non-conductivity, fast response, weatherproof, and immunity to electromagnetic and radio frequency interference.

PolyU's expertise and research outputs in FBG sensing technology has made prominent contributions to the advancement of railway networks worldwide. The FBG sensing system has been deployed throughout Hong Kong's railway networks to enhance the railway monitoring reliability and efficiency. With the collaboration with counterparts in Chinese mainland, the technology has also been applied in Chinese railway networks like the Beijing-Shanghai High-Speed Rail Line. Transport Sydney in Australia would like to engage PolyU to install the sensing system in its first driverless trains to provide the feedback signal that is critically important to the safety of its railway system.

The innovative use of FBG sensing technology has received worldwide attention as well as several international prizes and awards, including the Gold Medal of the 37th International Exhibition of Inventions of Geneva in 2009 and the Third Prize of the 2014 Berthold Leibinger Innovationspreis Award, which is one of the highest remunerated international innovation prizes in the field of laser technology. In 2015, PolyU established the Hong Kong Branch of National Rail Transit Electrification and Automation Engineering Technology Research Centre with the approval of State Ministry of Science and Technology (MOST), which manifests PolyU's R&D capability and successful technology transfer experiences in the areas of rail engineering.

Anti-erasing Ink - Nano-based ink Technology against Counterfeiting and Tampering (PI: Prof. Pei LI, The Hong Kong Polytechnic University)

Counterfeit foods and beverages are difficult to detect once they have made their way into stores. How can consumers be better protected?

A new printing ink unveiled at The Hong Kong Polytechnic University would deter counterfeiters. An indelible ink has been successfully developed by Prof. Pei Li and her research team of Department of Applied Biology and Chemical Technology. This new product, namely “Anti-erasing” (ATE) ink, is currently being used to prevent removal of packaging information, thus prohibiting fraudsters to tamper with product labels and packages.

Packages are vulnerable to deliberate tampering because traditional prints can be easily removed by the chemical solution such as solvent or nail remover. Thus unscrupulous distributors and proprietors could alter expiry dates by wiping them off, fooling consumers into buying foods that are out of dates. Even greater health risks are involved when deceptive labels hide the true origins or even dangerous substances.

Using the latest nanotechnology, the team was able to make ink formulations that are impervious to chemical alterations. Products that are essential to public health such as foods, drinks and medicines can now be protected. That will put people’s mind at ease.

The new ATE ink is also able to provide evidence of tampering with double colour tracing marks. Under a conventional ink, there is a layer of tamper-evident substrates which leaves tracing marks when removal of the print is attempted. Tracing marks are irremovable, making it possible to track and trace the fraudulent item throughout the supply chain for anti-counterfeiting investigation.

Another approach to stop tampering, a nano-coating technology (ATE-cTP) has been developed, which can be coated onto a package to form an irremovable coating as an invisible shield against chemical removal, according to the research team, which comprised of specialists in nanotechnology and advanced polymer materials.

The team always wants to bring security printing to wider use and make a true difference. The specialty inks can be applied by most continuous inkjet printers to plastic surface without any changes to the existing manufacturing process. They are ready to fit into any packaging needs and leaves good prints even on rugged surfaces. Moreover, its quick drying formula is suitable for high volume production. Manufacturers can now safeguard their products and their brands with ease.

A number of companies from the dairy, beverage, food processing, electric cable, textile industries in Hong Kong and the Chinese mainland have already expressed their keen interest in using this indelible ink for printing on their products. Meanwhile, one of the largest dairy producers in China, China Mengniu Dairy, is currently using this novel printing technology for a variety of dairy products.

Rational Design of Engineered Arginine Depleting Enzymes as Multi-potent Anti-cancer Agents (PI: Prof. Thomas Yun-Chung LEUNG and Dr Thomas Wai-Hung LO, The Hong Kong Polytechnic University)

Starvation can lead to death. The same theory has been implemented by Prof. Thomas Leung Yun-Chung and Dr Thomas Lo Wai-Hung from the Lo Ka Chung Centre for Natural Anti-Cancer Drug Development of The Hong Kong Polytechnic University, on their cancer therapeutic research. In contrast to traditional cancer therapies, this invention targets to inhibit cancer cell growth by depleting the essential nutrient that is crucial for their survival. The new cancer treatment is based on a natural human enzyme, human arginase I, which has the ability to deplete arginine, an essential amino acid for cancer growth. Although arginine is important to cancer cell survival, certain cancer cells are unable to produce on their own. The arginine can only be uptake from the circulating blood that is synthesized by the normal cells. Arginine deprivation only affect malignant cells while normal cells can produce their own amino acid. According to the above theory, the treatment can be directly designed as arginase injection into the patient body to deplete arginine. However, the short half-life characteristic of arginase in blood makes it a hurdle on the therapeutic application. The arginase can be naturally degraded in blood within a few hours, which is too short to deliver the arginine depletion function. The two Principal Investigators developed the pegylation method, by attaching a polymer, polyethylene glycol (PEG), to the enzyme under a controlled condition. The pegylation can protect the enzyme from the surrounding damages and therefore prolong its half-life in the circulating blood for eliminating the arginine.

Two generations of the pegylated human arginase I were developed. The first generation was jointly developed with a biotech company based in Hong Kong with the support of the Innovation and Technology Commission (ITC) under the University-Industry Collaboration Program (UICP). Thereafter, the company has invested substantially in driving the project to make the drug candidate to be the first US FDA-certified Investigational New Drug (IND) from Hong Kong. Under the collaboration with the local medical practitioners, Phase I and IIa clinical trial have been successfully completed in adult hepatocellular carcinoma. More trials are still conducting on other types of cancer, such as drug resistance hepatocellular carcinoma and other arginine auxotrophic cancer. The second generation had been further engineered to be more homogenous for delivering a stable anti-cancer performance. In order to allow this improved formula to be applied in translational research, it has recently been licensed to a local pharmaceutical company, which undertakes to drive the related clinical trial and commercialization of the medicine, the ultimate goal is to benefit the cancer patients and the society.

The pegylated human arginase I marks an important milestone in Hong Kong's biotechnology and pharmaceutical industry development. It is the first drug to be invented in Hong Kong, proceed to clinical trials and thus US FDA IND granted. The technology has awarded the Prize of the State of Geneva and Gold Award in the 37th International Exhibition of Inventions, New Techniques and Products, Geneva in 2009, as well as the Finalist Award of SEED Competition, China in 2010. The breakthrough has generated a significant interest from around the world. Most importantly, it offers hopes to liver cancer patients and potentially to other cancer types of patients as well.

Advanced Displays Technologies

(PI: Prof. HS KWOK, The Hong Kong University of Science and Technology)

We now live in a display-centric world. Displays are everywhere. There are a lot of technologies behind such modern electronics displays. The State Key Laboratory of Advanced Displays and Optoelectronics at The Hong Kong University of Science and Technology (HKUST), was established to develop such future technologies for the burgeoning display industry in China Mainland. SKL-ADO works on many aspects of display technology, including active matrix thin film transistors, liquid crystal display optics and manufacturing technology, organic light emitting diodes (OLED), microdisplays, energy efficient displays, as well as electronic papers and liquid crystal based smart windows.

Professor HS Kwok is the Director of SKL-ADO and is leading this research and development effort together with industrial partners. One of the technologies he developed was a special photo-alignment materials which can be applied to advanced display manufacturing as well as in the study of advanced optical devices. He was able to achieve very precise control on alignment, which is capable of a resolution of 200nm. In terms of displays, this is equivalent to a 20K resolution. This is much higher than the current high definition (HD) displays, or the 2k4k displays. Such high definition displays can be used in VR/AR situation as well as for projectors. They have a huge market in home and public entertainment, in automobiles, GPS navigation, and more. But one of the most significant contributions would be in the advancement of remote or telesurgery and in laparoscopic surgery; these surgical techniques depend on high definition displays with very high resolution, high contrast and large gray scale, providing surgeons capabilities to discern details like the human eye. In addition, photoalignment has many other applications such as in fabricating unconventional photonic devices as well as in making in-situ polarizers.

Another area that SKL-ADO concentrates on is energy saving displays. By using a color filterless technique, future displays can save up to 80% of the energy used currently. This is enabled by the invention of manufacturable fast response time liquid crystal displays. Fast response time allows the use of RGB LED backlight to produce a full spectrum of colors instead of using color filters.

The thin film transistor team at SKL-ADO has also developed several new TFT technologies that are needed for high definition displays. New device architecture enables cost savings in active matrix manufacturing with enhanced performance. They are also experimenting with different TFT materials and device architectures to provide high performance such as mobility and complementary transistor circuits.

The State Key Laboratory on Advanced Displays and Optoelectronics Technologies awarded to HKUST by the Ministry of Science and Technology of China in 2013. Professor Kwok holds more than 90 patents and is active in technology transfer. For example, Prof. Kwok has solved practical problems of a multicolor LCD without color filter and subsequently licensed the technology to industry; has collaborated with a watch company to develop reflective displays without a rear polarizer; and has developed micro display technology for applications such as Google Glass.

New Approach to Develop Clinical Therapies to Treat Alzheimer's disease (AD) (PI: Prof. Nancy IP, The Hong Kong University of Science and Technology)

Alzheimer's disease (AD) is a progressive, debilitating, and degenerative brain disease, which is currently incurable. Due to increased life expectancies, populations worldwide are aging, and the number of AD patients is increasing rapidly, posing a huge public resource burden in many countries, including China. Globally, AD affects 46.8 million individuals and the number is projected to reach 131.5 million by 2050. There are currently no effective early diagnostic tools or treatments for AD as the pathophysiology of the disease is still unclear, but it is widely believed that beta-amyloid (A β) peptides are one of the main causative agents responsible for the cognitive impairment observed in patients.

Recently, Prof Nancy Ip of the Hong Kong University of Science and Technology (HKUST) made groundbreaking discoveries that have deepened the understanding of this complex, multi-factorial disease, while unveiling exciting new approaches to developing effective treatments. First, she demonstrated the importance of the cell surface receptor protein EphA4 in AD pathology. Toxic A β was found to cause aberrant activation of EphA4 leading to a reduction in the number of neuronal communication points (synapses) as well as degradation of neurotransmitter receptors on brain cells. The resulting reduced neuronal communication may decrease cognitive function. Having identified EphA4 as a key player in AD pathology, its potential as a drug target was explored. Through molecular docking analysis, a small molecule derived from a traditional Chinese medicine herb, gou teng (*Uncaria rhynchophylla*), was identified as an inhibitor of EphA4 and shown to block aberrant EphA4 activity. When this small molecule was administered to transgenic model mice exhibiting AD-like pathologies (AD model mice), it restored impaired neuronal communication to normal, thus confirming EphA4 as a viable drug target for AD.

Prof Ip's studies are also uncovering alternate therapeutic strategies for AD. She discovered that interleukin (IL)-33, an immune protein made by the human body, could be a potential treatment for AD. Her studies first revealed that IL-33 function is significantly compromised in individuals with mild cognitive impairment (those who are at high risk of developing AD). When the protein was injected into AD model mice, the mice rapidly recovered their cognitive functions, and the toxic A β plaques in the mouse brains actually decreased. Prof Ip also discovered that the IL-33 protein mobilized microglia, the immune cells of the brain, to the A β plaques to promote their clearance. The protein also triggered a change in the microglia, which in turn reduced inflammation in the brain. This finding is critical because brain inflammation is believed to contribute to and drive the pathology of the disease.

These significant discoveries were published in the prestigious international journals *Nature Neuroscience* and *Proceedings of the National Academy of Sciences (PNAS)*. To maximize the potential of Prof Ip's groundbreaking research and fully realize the clinical impact of these discoveries, both projects have been licensed to a life science investment company for further preclinical and clinical development towards the development of novel and effective AD therapies. As a further testament to the strength of her research, Prof Ip currently holds 44 patents on various novel discoveries.

Prof Nancy Ip is the Morningside Professor of Life Science at HKUST, Director of the State Key Laboratory of Molecular Neuroscience and currently also serves as the Vice-President for Research and Graduate Studies. Prof Ip's outstanding scientific accomplishments have won her numerous awards and honors including the National Natural Science Awards, the L'OREAL-UNESCO 'For Women in Science' Award, and the honor of Knight of l'Ordre National du Mérite by the French Government. She has been elected to the Chinese Academy of Sciences, the US National Academy of Sciences, the World Academy of Sciences, and most recently, the American Academy of Arts and Sciences. She also plays a leading role in the development of life science in Hong Kong, and has launched prominent collaborations with major biopharmaceutical companies.

Aggregation Induced Imaging Technologies (PI: Prof. Benzhong TANG, The Hong Kong University of Science and Technology)

Prof Benzhong Tang, Chair Professor from the Hong Kong University of Science and Technology (HKUST), was the first to discover molecules that emit light when crowded together, a phenomenon he named “Aggregation-induced Emission” (AIE). Since the 2001 discovery Prof Tang has intensified his research into AIE and developed hundreds of AIE materials (or AIEgens) for a wide-range of applications from biomedicine and healthcare to optoelectronics. Known as the ‘Father of AIE’, these AIEgens are now used in tracking cancer cells inside the human body, assaying antibacterial activity, effective visualization of fingerprints to environmental monitoring. By 2015, AIE was regarded as one of the most influential research in the world by Nature Index, and was evaluated as the second hottest research topic in the field of chemistry and materials by Thomson Reuters. This discovery won Prof Tang the ‘The World’s Most Influential Scientific Minds’ award by Thomson Reuters in 2014 and 2015. This distinction was earned by writing the greatest number of highly cited papers, ranking among the top one percent for the awardees’ subject fields.

Until Prof Tang’s discovery, aggregation of molecules was seen as detrimental to light emission because most light-emitting molecules are flat and stack together, like pancakes, when crowded, extinguishing their luminescence. This phenomenon is known as “aggregation caused quenching” (ACQ). Through experiments, Prof Tang discovered that the light-emission property of molecules could be retained by making the molecules propeller-shaped so that they lock together when crowded and are forced to release their energy as photons. Having understood the structural design and properties, Prof Tang’s team has designed and synthesized hundreds of highly emissive AIEgens.

In 2012, the Ministry of Science and Technology (MOST) of China incorporated AIE into its Basic Research Program (973 Program) and awarded Prof Tang a RMB30M grant for further development of AIE. In 2015, MOST awarded HKUST the establishment of the prestigious Hong Kong Branch of Chinese National Engineering Research Center (CNERC) for Tissue Restoration and Reconstruction. Under the leadership of Prof Tang, the Center will concentrate on the development of new luminescent materials and their hi-tech applications in biomedical sensors and chemical probes, which would benefit many different fields including detection, imaging, quarantine, inspection, diagnosis, environmental protection and homeland security.

The following are two examples of application of AIEgens:

(1) Bioimaging technology - by improving the photophysical property and specificity, while decreasing the cytotoxicity of AIEgen, Prof Tang’s AIEgens can selectively stain organelles such as mitochondria, lysosome, lipid droplet and cell membrane, as well as discriminate cancer cell and tumors, which are extremely beneficial to cancer diagnosis and clinical surgery. Such fluorescence bioimaging techniques track targets via fluorescent signals from AIEgen probe.

(2) Chemosensors – AIEgens can be used as chemosensors to detect chemical traces and is increasingly used in the diagnosis of diseases, food quality control and development of biomaterials. Using the “light-up” property of AIEgens, Prof Tang designed and synthesized many highly specific AIEgens, incorporating the functional groups to identify target species. These AIEgens have the advantages of fast response, high signal to noise ratio, high selectivity and low cost, and can also be used for detection of trace amount of biomass, such as urine protein, cardiolipin, biotin in body fluid, and microorganism, heavy metal, corrupt substances in food.

Prof Tang currently holds 28 patents granted in US, China, Japan and Singapore, with several patents licensed to multinational companies, e.g. Sigma Aldrich. In addition, a company, AIEgen Biotech Co., Ltd., has been established under the Hong Kong Innovation and Technology Commission (ITC)'s start-up support scheme. The company aims to license and manufacture popular AIEgens, and to collaborate with companies to expand the applications of AIEgens. Its first batch of AIEgen products are already available in the market.

Prof Tang's research in AIE has been covered in various international media like *The New York Times* (<http://nyti.ms/1okFbQG>), *CNBC* (<http://video.cnbc.com/gallery/?video=3000491360>) and *Nature* (<http://www.nature.com/news/the-nanolight-revolution-is-coming-1.19482>).

Solutions to Control Infectious and Water-borne Diseases Technologies
(PI: Prof. King-Lun YEUNG and Prof Joseph KWAN, The Hong Kong University of Science and Technology)

Increased mobility in society increases society's exposure to dangerous disease-causing microbes, such as viruses, bacteria, fungi and spores; at the same time, micro-organisms are also increasingly resistant to antibiotics, thus heightening our public health challenge, on a global basis. Microbial contamination of surfaces, in water, and aerosol transmission are common vehicles for the spread of pathogens. Prof King-Lun Yeung and Prof Joseph Kwan and their research teams at the Hong Kong University of Science and Technology (HKUST) have developed solutions to set new standards in curbing the spread of such infections.

(i) World's First Smart Antimicrobial Coating to Control Infectious Diseases

This proprietary smart antimicrobial coating can kill 99.9% of bacteria within one minute, 99% of H1N1 Human Swine Flu virus within three minutes, 99% of bacillus spores within 30 minutes, inhibit mold and fungal growth, and disinfect practically a full (broad) spectrum of microbes found in body fluids, including saliva and blood.

This coating is fast effective, long lasting with lab tests showing sustained efficacy of more than 30 days, compared to conventional disinfectant whose efficacy decreases as it evaporates. US Environmental Protection Agency (USEPA) and US Food and Drug Administration (USFDA) approved that the ingredients of the coating are safe. The coating is also biodegradable, therefore environmentally friendly; is colorless, odorless and easy to apply yet easy to clean off. It may be used indoors and outdoors, on a wide variety of surfaces, including glass, metals, ceramics, wood, concrete, paper and cloth.

The coating comprises a smart polymer that can sense the increase in temperature from the touch of a hand or droplets landing on the coated surface, and automatically releases a larger amount of disinfectant to inactivate disease-causing microbes that may have transferred on to the coated surface from the hand or droplets. This prevents the next person touching the same surface from picking up the germs, becoming infected, causing the further spread of the disease.

(ii) World's First Mini Pulsed Electric Field Device Can Help Control Spread of Water-borne Diseases

This mini pulsed electric field device can kill more than 90% of bacteria that may be present in running tap water within seconds. Only a low-input voltage is required to distort and damage the microbial cell wall of pathogens like Legionella, Pseudomonas, Aeromonas, and Mycobacterium bacteria, and render them non-infective.

The device is powered by batteries, is portable, and can be installed at home or any public tap water to disinfect water flow up to 10 liters/minute and is also effective with seawater. This method is cost effective and environmentally friendly compared to other water disinfection technologies such as chlorination, ozonation, heating and reverse osmosis. The HKUST-developed device has been tested in hospitals for safety, bio-material compatibility and efficacy under practical use conditions.

Use of surface coating or the mini-pulsed electric device + good hygiene practices can effectively stop the route of infection and curb the spread of deadly microorganisms. The HKUST team has filed patents in US, Mainland China and Taiwan. The special polymer coating has been licenced by Greenland Biotech Limited; GermFree7 is available commercially and is widely used in Hong Kong hospitals. Meanwhile the HKUST team continues to apply their technology, extending it to a host of new applications, to benefit public health and society.

Consumer-friendly Unmanned Aerial Vehicles (UAVs)

(PI: Prof. Zexiang LI and Mr. Frank WANG, The Hong Kong University of Science and Technology)

Not so long ago visuals were mainly in 2D images and videos. A comprehensive three-dimensional (3D) view could only be viewed from a ride in a helicopter or through professional drones that are difficult to control. In 2006, the Hong Kong University of Science and Technology (HKUST) made a key breakthrough in control technologies for low-altitude flying that has since radically changed the way we captured images.

Frank Wang, then pursuing his MPhil under his mentor Prof Zexiang Li, developed the first generation of consumer-friendly unmanned aerial vehicles (UAVs). This drone technology was built on motion control applications that HKUST faculty had been developing for machine tools in the manufacturing industry. The quadrotor drones that Frank, Prof Li, and their team built – less than one meter in diameter, sophisticated and easy to operate – brought together important progress in motion control, communication and navigation technologies. The flight controller they developed provided stability for the flying robot, operated in real time and fast enough to handle the dynamics of the platform, maintained hover accuracy, was agile to rapidly change orientation or altitude without becoming unstable, and robust in strong wind conditions to support a range of applications, including photography and movie making. These technology advancements fast-forwarded a global consumer and business sector which has seen exponential growth and potential.

Frank launched his company, DJI, in 2006, and is now the dominant player in the drone industry. In 2014 and 2015, DJI's drones were selected as one of the top 10 gadgets by TIME magazine, and in 2014 Frank was recognized as one of the top 10 innovators from China, by Forbes.

HKUST is now a global leader in UAV technology. Under the auspices of the HKUST Robotics Institute, the UAV team has developed many more autonomous capabilities, the latest one for its perception capabilities algorithms, which equips UAVs with technology to avoid obstacles, such as a mountain, a tree or even an electric wire, in its flight path. The technology frees UAVs from GPS (human) control, so they can autonomously sense and evaluate the environment, and respond independently and intelligently to situations while on their flight missions.

The Institute cooperates closely with DJI under the newly established HKUST-DJI Joint Innovation Laboratory framework, and collaboratively developing a series of key technologies, including highly reliable UAV flight controllers for rapid response to complex 3D environment against destabilization, pan-tilt-zoom (PTZ) camera augmentation and advanced communication technologies allowing captured aerial images to be returned in real time, and autonomous obstacle avoidance capabilities. These technological advancements will open the way for a wide range of innovative civilian applications of UAVs in fields as diverse as aerial photography, close-range inspection of infrastructure, search and rescue, delivery of medicine to disaster sites, and eventually consumer goods deliveries. While quadrotor UAV is what DJI is known for, the Robotics Institute also looks further in developing UAV technology in other configurations, such as vertical take-off and landing technology for fixed-wing UAV and flapping wing designs for smaller vehicles.

A number of other companies that have origins in robots and autonomous system breakthroughs achieved by HKUST students and their academic mentors are both benefiting from and supporting future innovation in HKUST's university-industry model. DJI is the best-known example and model yet; DJI funds scholarships for HKUST graduate students to pursue robotics research, several of whom have gone on to take up leading positions in the Shenzhen-based company.

Flow-through Hybridization for DNA Hybridization (PI: Dr. Joseph Wing On TAM, The University of Hong Kong)

Dr. Joseph Wing On Tam, a former Associate Professor in the Department of Biochemistry at the University of Hong Kong, was involved in research relating to diagnosis of genetic diseases, DNA fingerprinting and applied genomics. Dr. Tam and his team invented a patented technology called “Flow-through hybridization” to address the problems in conventional DNA hybridization techniques.

In conventional hybridization of nucleic acids, DNA samples are dotted or transferred to a membrane by blotting techniques. There is only a small part of the target DNA that is actually located at the surface of the membrane because most molecules are trapped or embedded in the interior part of the membrane. This makes fragments smaller than 300pb undetectable because they are trapped inside the membrane, multiple runs are always needed. A low density medical gene chip working platform, HybriMax, was developed based on the aforementioned patented technology, and was licensed to a company, Hybribio Limited. HybriMax is the core system for future diagnostic kits produced by the same company. HybriMax is an all-in-one integrated PCR, hybridization, and gene chip processing system. It provides rapid, sensitive and highly accurate diagnosis of diseases by analyzing nucleic acid samples.

Other products from Hybribio Ltd. include HPV GenoArray Test Kit, Real-Time PCR HPV Detection Kit, Real-Time PCR HBV Detection Kit, α, β THAL Detection Kit, STD Detection Kits, TB Detection Kit, HCV GenoTyping Detection Kit, and Respiratory syncytial virus Detection Kit. One of the kits used with HybriMax is the next generation “37 HPV GenoArray diagnostic kit”. It is a unique HPV genotyping kit in the world with CFDA and CE IVD licenses, and is able to simultaneously detect 37 HPV genotypes in a single run. The kit, and its old generation, have been extensively used in medical and research laboratories in European and Asian countries such as Spain, Turkey, China, Japan, Thailand, and Philippine. More than 2,000,000 tests have been used with sound feedback. Currently, more than 1,200 hospitals and medical institutes in China have adopted this HPV diagnostic technology and more than 20 countries around the globe have been using its products for clinical and research purposes. Hybribio Limited is going to be listed in ChiNext of Shenzhen Stock Exchange in Q2 2017.

Oral Formulation of Arsenic Trioxide for Acute Promyelocytic Leukemia (APL) (PI: Prof. Yok-Lam KWONG, The University of Hong Kong)

Prof. Yok-Lam Kwong, the Chui Fook Chuen Professor in Molecular Medicine and the chief of the Division of Hematology, Medical Oncology and Bone Marrow Transplantation in the Department of Medicine at the University of Hong Kong, and Prof. Cyrus Rustam Kumana, Emeritus Professor of Medicine and an Honorary Professor in the Department of Medicine at the University of Hong Kong, are leading researchers in developing and using oral arsenic trioxide in the treatment of acute promyelocytic leukemia (APL).

In 1998, Prof. Kwong and Prof. Kumana's team at Queen Mary Hospital, began investigating the use of oral arsenic trioxide in APL patients. In 2000, the team successfully developed an oral formulation of arsenic trioxide that is being manufactured under the name Arsenol®. Treatment with oral arsenic-trioxide has demonstrated clinical efficacy and less side effects compared to intravenous administration; the patients can also take the drug at home, rendering long-term therapy feasible, a better quality of life, and a massive saving in costs. To date, hundreds of APL patients have been treated with oral arsenic trioxide, a majority of whom went into complete remission. Moreover, Arsenol® is the first prescribed drug developed, patented, and registered in Hong Kong.

Having Arsenol® protected by patents in the US, Germany, England, France, Switzerland, and Japan, HKU is now working with some of the largest pharmaceutical manufacturers in China and India, and also with a number of research institutes around the world to produce and investigate the use of Arsenol® in populations of different ethnic origins. In addition, the potential use of Arsenol for other indications, including: other hematological malignancies, solid tumors, and rheumatoid arthritis are also being explored and protected in other patents.

Growing Cartilage from the Patient's Own Stem Cells (PI: Prof. Barbara Pui CHAN, The University of Hong Kong)

Prof. Barbara Pui Chan and her biomedical engineering team in the Department of Mechanical Engineering at the University of Hong Kong (“HKU”), have spent the past eight years in developing a new cartilage regeneration technology to grow a “cartilage-bone tissue plug” mimicking the structural organization of native joint tissues out of cells taken from one’s body. The outcomes of these engineered tissues are comparable to that of autografting (taking tissue from one part of the body and using it to repair another part), which is the gold standard for tissue repair, in animal experiments. This approach does not damage healthy tissue, has no size limit to the dimension of lesion to be repaired and can be applied to other joints besides knees.

Other potential biomedical applications of this technology are being investigated on surgical implants such as artificial periosteum, annulus plug and hernia mesh, and scaffolds for engineered tissues such as a biphasic scaffold for engineered intervertebral disc. In addition, photochemical crosslinking of collagen microspheres has been found to effectively immobilize more protein drugs and alter their release patterns in a controllable manner, thus broadening the application of this technique to controlled release drug delivery.

With the support from the TSSSU program and the 10 patents granted on the four platform technologies, Living Tissues Co. Ltd. was established in 2015 and obtained license from HKU to further develop the core technology to grow new tissues from bone marrow stem cells for cartilage regeneration. The team has now optimized the conditions for equine cells and trials on horses have been started. The ultimate goal of the company is to utilize the technology in human and the upcoming trials are to be commenced in 2017.

Advanced OLED Material Development for Multimedia and Display Applications (PI: Prof. Vivian Wing-Wah YAM, The University of Hong Kong)

Professor Vivian W W Yam, Philip Wong Wilson Wong Professor in Chemistry and Energy at the University of Hong Kong, is active in the R&D of innovative and high performance organic light emitting (“OLED”) materials using gold compounds. She was conferred the *2011 L'Oréal-UNESCO Awards for Women in Science* laureate for her work on OLED materials and innovative ways of capturing solar energy.

Nowadays, LCD/OLED display technologies are widely used in multimedia and display applications. With the unparalleled advantages of OLED over existing LCD technologies, the industry has been scaling up its production capability and broadening its product offerings. For example, it was reported that Apple Inc. was planning for its first release of an OLED iPhone in 2017.

According to some market studies, the global market size of the new display industry will remain at over US\$ 130 billion per year. It is expected to reach US\$ 150 billion by 2020 and US\$ 170 billion by 2025. OLED display is estimated to account for about 15% of the market.

Existing organic light emitting materials in production use for OLED displays are mostly based on Iridium. However, as most of these Iridium-based materials are held by only a few companies with strong patent protection, there is a need to look for new organic light emitting materials which are based on other metals such as Platinum, Palladium and Gold.

Professor Yam has been collaborating with one of the largest multimedia and display technologies companies in Mainland China to develop and commercialize innovative OLED materials for the company’s wide range of products. Together they were supported by a major research grant offered by the Guangdong Government where Professor Yam is appointed the lead researcher in the collaboration. Both parties is also setting up a joint research laboratory at HKU for supporting a number of new R&D projects on advanced OLED technologies.

Computer Forensic and Information Security Technologies (PI: Dr. Kam-Pui CHOW, The University of Hong Kong)

Dr K P Chow and his research team at the Centre of Information Security and Cryptography of the University of Hong Kong have been active in the R&D of innovative and effective computer forensic information security technologies.

They have been collaborating with a number of law enforcement agencies in Hong Kong to fight against cybercrime. For examples, the series of Lineament Monitoring Systems and the SocNet System developed by the team have been deployed by the Hong Kong Custom and Excise Department since 2007 and 2015 respectively to detect and investigate cases relating to online fraud and illegal trading of copyright materials and counterfeit goods. Their latest offering called SHIELD is further capable of protecting small and medium enterprises against cyberattacks and cyber-blackmailing.

With the growing information and cyber security threats in recent years, the business of cyber security expands correspondingly. The Cyber Security Ventures reported that cyberattacks in 2015 have caused an estimated business loss of USD 400 billion to over USD 500 billion a year. It is further estimated by the Atlantic Council and the Zurich Insurance Group that cyberattacks could cost up to USD 90 trillion by 2030 if cyber security fails to advance at a rapid pace. Thus, businesses are more willing to invest more in the domain of information and cyber security than ever before.

Therefore, the team has escalated their effort in the cybersecurity area by establishing a startup company in 2016. Using the technologies developed at the University of Hong Kong, the startup company provides cybersecurity intelligence and security services to government and commercial enterprises in the greater China region. The company was well received by its prospective clients and business partners as it already managed to secure million dollars of business within their first six months of establishment.

A New Generation of Passive LED Drivers for High-Power Lighting Applications (PI: Prof. Ron Shu-Yuen HUI, The University of Hong Kong)

Professor Ron S Y Hui, Philip K H Wong Wilson K L Wong Professorship in Electrical Engineering at the University of Hong Kong, has developed a highly efficient and reliable passive LED driver technology whose lifetime is even longer than the LED chips it drives.

The long-life and high-reliability of LED devices have made them a favorable technology for indoor and outdoor lighting applications such as street lighting in particular. However, existing active LED drivers that are used to drive these LED circuits are prone to failure because the electrolytic capacitors employed by these conventional drivers have a much shorter lifetime than the LED devices themselves. While LED devices typically have a lifetime of 50,000-70,000 hours, electrolytic capacitors could only last for 5,000-10,000 hours. In addition, electrolytic capacitors are vulnerable to the adverse operating conditions like wide-temperature change, thunder lightning and extremely low temperature. These limitations are especially undesirable for outdoor applications like street lighting.

The new passive LED driver technology developed by Professor Hui has an energy efficiency of over 90% and lifetime of over 10 years. It is especially suitable for outdoor street lighting applications for the corresponding circuit topology employs only a few passive electronic components and it requires no electrolytic capacitor (that have short lifetime) nor active power electronic switches like power MOSFETs and IGBTs. The technology is also environmental friendly for over 80% of the components are recyclable.

With over 180 million lamp posts installed in major cities in Mainland China and many more in other countries, the technology offers a much greener solution and it also help reduce the overall cost of public lighting applications. The technology was transferred to a company which is now commercializing the corresponding LED driver product in full speed – the product received its “3C” certification from the Mainland authority followed by the successful deployments of the first two installations in Heshan City, Guangdong in 2016.

Appendix B2

Success Stories of Hong Kong Industry

List of Selected R&D Innovations from Hong Kong Industry

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The Automated Passenger Clearance System (e-Channel)

In 2002, ATAL was awarded a contract to provide turnkey solutions for the Hong Kong Immigration Department with one-stop system design, implementation and installation of the Automated Passenger Clearance System using ATAL's iGate technology, which includes the supply, installation and commissioning of the self-service border control double barrier auto-gate with smart card reader and fingerprint scanner, the design and development of the administration and monitoring system consisting of CCTV/DVRS and integrated custom program.

Since 2004, the Immigration Department has introduced e-Channel in control points for Hong Kong residents to conduct self-service immigration clearance. The e-Channel service has been subsequently extended to enrolled frequent visitors, Macao permanent residents and Mainland residents by phases. e-Channel not only provides effective and speedy self-service immigration clearance for passengers, but also allows the Immigration Department to flexibly deploy the limited resources to the more needy service areas and to improve the overall efficiency as well as to reduce operational costs. e-Channel also showcases how the application of information technology can provide better public services and its benefits to sustain the economic and social development of Hong Kong. The system automatically processes annually hundreds millions of passengers in and out of Hong Kong efficiently and securely. The Hong Kong e-Channel system is the most advanced and largest system of its kind in the world and it has received a number international awards.

The Automated Passenger Clearance System (e-Channel) won the top prize in the category of e-Government and Services of the “The Asia Pacific ICT Alliance (APICTA) Awards 2006” held in Macao. In the “Hong Kong Information and Communications Technology (ICT) Awards 2006”, the system scored the eGovernment Grand Award. It was also selected as one of the Hong Kong People Engineering Wonders in the 21st Century in HKIE Engineering Week 2013.

Dongtan – First Integrated Eco-city Planning Research Project

Dongtan, planned by Arup on Shanghai Chongming Island, kicked off the new chapter of eco-city development in Hong Kong & China, which reflects greater energy efficiency, better land usage, waste reuse, reduced resource consumption and reduced emissions. After the Dongtan project, Arup has been continuously exploring the eco-city model through doing much of the important interdisciplinary research work in sustainable urban development in connection with Dongtan Eco-City, which puts Arup at market leader position in Demand-side Energy Usage and IRM (Integrated Resource Management) in new generation of urban planning.

Those efforts contributed to the success of ‘Cities’ business of Arup in Hong Kong new towns (e.g. Lok Ma Chau Loop and New Territories North), service export to Mainland China (e.g. Shanghai Expo UBPA redevelopment, Beijing Changxindian Eco-community, Sino-Singapore Tianjin Eco-city and Wuxi Tiahu New Town) and the Asian region (e.g. Ninh Thuan integrated planning, Vietnam; New Songdo city, Korea) etc.

Through these projects, Arup has successfully implemented principles of urban ecology into urban design, planning and management. Specific indicators at different levels for master planning and controlled detail planning were developed to ensure that they can be implemented from an initial concept through to statutory enforcement.

The far-reaching influence of the Dongtan project can be summarized as follows:

- 1) Built up the ‘eco-city’ concept and formulated a methodology for eco-city planning, driving Hong Kong’s and China’s planning trends over the past decade with the focus on ecology;
- 2) Leading the global trend of sustainable development, striking a balance between environmental protection and economic development;
- 3) Pioneered the ‘total planning’ concept and developed an integrated resource management (IRM) model which includes various aspects such as energy, water, waste and ecological space. The model has been widely used and has become an essential part of low carbon planning today;
- 4) Introduced sustainable strategies and advanced technologies into the planning stage which ensured their implementation in the construction stage; and
- 5) Proposed a comprehensive vision and objectives spanning economic, social, resource and environmental dimensions, which has redefined urban planning.

Unmanned Aerial Vehicles (UAVs)

Before Dajiang Innovations Ltd. (DJI), Unmanned Aerial Vehicles (UAVs) were regarded as just a niche hobby for passionate aero modelers. But even for the most passionate of hobbyists, there were operational inconveniences. Professionally speaking, the cost of using helicopters for aerial photography could well be in excess of one hundred thousand Yuan, meaning that only organizations with decent funding could afford it.

Considering the market at the time, unmanned aircrafts and aerial photography were still fields largely unfit for any kind of consumer market. By introducing highly integrated products, and with an ethos of continuous technological innovation, DJI is filling the skies with easy-to-use drones, single-handedly popularizing aerial photography.

From the beginning, DJI has always focused on developing its own technology and products. The development and growth of DJI is also a history of combining and achieving its own technological breakthroughs and product innovations. Initially, DJI developed flight control systems. And after several years of research and development, DJI started to launch our high-quality flight control systems to the market. These flight control systems could stabilize model aircrafts during flight better than previous iterations.

With a keen awareness of the market potential for developing multi-rotors, DJI utilized accumulated technical knowledge on flight control and then started to develop integrated four-axis vehicles – proto-forerunners to UAVs or drones. It also began focusing on developing gimbals to meet the growing demands of aerial photography. With the integration of flight control systems, four-axis aircraft, gimbals, and other technologies, the tech bottleneck that had plagued drones for years started to free up for good. DJI products cut down the entry-level cost of aerial photography for consumers to only about several thousand Yuan. DJI was not only able to stimulate growing demands for aerial photography, but also, by happenstance, managed to spawn an entirely new field of electronic consumer products.

Apart from well-known consumer-level drones like DJI's Phantom series and latest Mavic Pro, DJI has also introduced the iconic Inspire series, intended for high-end professional filmmaking, as well as industry-leading handheld gimbals found in the Osmo and Ronin series. Behind every DJI product is state-of-the-art flight control, vision positioning, wireless image transmission, and obstacle sensing, not to mention a plethora of technical innovation and integration.

Today, DJI continues to focus on its research and development but with a clear and open mind. The company also provides airframes, modules, developer suites, and accessories for other companies and industries, achieving the application of drones in more fields than ever before. DJI is willing to cooperate with industry developers to help build a drone ecosystem as it continues to harness the future of possible.

The World's First Fully Digital Cordless Phone – VTech Tropez 900DX

Cordless phones have been replacing corded models for many years, because people enjoy the convenience of being able to move around freely while talking. In the late 1980s, however, all those on the market were analogue models operating on low frequencies. The sound quality and reception were poor and they could barely cover a few rooms. They were also expensive, well beyond what most households could afford.

So when the US Federal Communications Commission liberalised the 900MHz bandwidth, VTech saw an opportunity and developed the world's first fully digital cordless phone, the Tropez 900DX. Introduced in 1991, it brought a significant increase in range and quality.

VTech continued to improve performance and reduce costs, and in 1996 brought out the 910 ADL. Priced below US\$100 and with superior performance, it flew off the shelves in record numbers, setting the stage for digital cordless phones to become a popular consumer electronics product.

VTech has since become the leading manufacturer of cordless phones in the world.

The World's First Children's Smartwatch with a Build-in Camera – VTech Kidizoom Smartwatch

VTech's first step towards its Kidizoom Smartwatch came with the development of its first digital camera, Kidizoom Camera.

Impressed with VTech's reputation for making children's electronics, a customer asked why we didn't offer a digital camera for kids, a market that was then untapped. The resulting Kidizoom Camera was brought to market in record time, about eight years ago. It made the exciting world of digital photography accessible to young children for the first time.

Advances in miniaturisation soon allowed our engineers to shrink the technology down, making a camera small and light enough to fit into a wrist-watch. A marvel of miniaturisation, in 2014 the Kidizoom Smartwatch became the first children's smart watch in the world to feature a built-in camera, allowing kids to take photos and record videos with the device. Controlled through a touch screen interface, the rechargeable watch features over 50 digital and analogue clock face designs, as well as four learning games, a voice recorder, a timer and an alarm clock – all housed in a robust, splash-proof design.

The Kidizoom Smartwatch has been popular with children and parents alike. Gaining numerous top industry awards, million units have been sold in the past two years.

A Pioneer in the International Display Technology Arena

Hong Kong is well known as an international financial centre. However, its capacity for innovation should not be ignored, so as its role in boosting technological development in Mainland China. Headquartered in Hong Kong and listed on the Main Board of the Stock Exchange of Hong Kong, Solomon Systech Limited (“Solomon Systech”) is a leading semiconductor company specializing in the design, development and sales of display IC solutions which enable a wide range of applications including smartphones, smart TVs and other smart devices including consumer electronics products, wearables, portable devices and industrial appliances.

Since its establishment in Hong Kong in 1999, Solomon Systech has adopted an innovative fabless business model to focus on building its core competences in display IC design, supply chain management and global marketing. In less than two decades, Solomon Systech has grown from strength to strength into now an international display IC solutions provider with a total workforce of over 400 people and a strong IP portfolio of over 550 patents. It has become a key supplier of world-class brands, covering a comprehensive range of display technologies, and also a leading player with new display driver ICs occupying a major market share globally.

Most importantly, Solomon Systech has pioneered many “world’s first” product categories and developed cutting-edge technologies throughout the years. Recently, it has become one of the very few to have successfully developed and started mass production of single-chip In-cell touch display driver IC (TDDI), which is becoming a de facto standard for high-end smart devices.

Solomon Systech’s incessant pursuit of innovation and excellence in different aspects has earned itself key awards, including the Hong Kong Awards for Industries for Technological Achievement, Export Marketing as well as Productivity and Quality, Hong Kong ICT Awards Best Innovation (Innovative Technology), EDN China Innovation Award, China Chip Award, HKEIA Grand Award for Outstanding Innovation and Technology Products, etc. This also best proves the success of its innovative fabless business model.

As a pioneer in the international display technology arena, Solomon Systech has not only played a pivotal role in spearheading the development of innovation and technology industry in Hong Kong and in nurturing industry talents; but it is also poised to facilitate the country's transition from an exporter of manufactured goods to an exporter of technology, and contribute to Mainland China's strong drive of innovation to boost the economy amid the global innovation trend.

Technology Development of E-Lock for Facilitating Customs Clearance

To ensure the transshipment of goods via Hong Kong is under strict control, the Hong Kong Customs and Excise Department (C&ED) launched the E-Lock System for enhancing intermodal transshipment cargoes' efficiency and reliability, and facilitating logistics flow of customs clearance since November 2010.

Based on C&ED Intermodal Transshipment Facilitation Scheme (ITFS)'s requirements, Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies (LSCM) had incorporated the E-Lock innovation with Global Positioning System (GPS), specialized password, data encryption, automatic remote control, streamlined interfaces, operation compatibility, and data interoperability in the technology development.

The E-Lock System facilitates the customs clearance procedures from 2-3 hours to 5 minutes by reducing duplicate inspection on the same shipment at the entry points of boundaries between Hong Kong and the Mainland. The container of a registered truck is locked by an E-Lock before leaving the control point. Thus, it can be traced all the way via GPS. In case the truck deviates from its original route, or the container is opened illegally on the way, the E-Lock system will set off the alarm and notify C&ED at once to take immediate action.

Upon arrival to the air or sea cargo terminals, if C&ED determines it is unnecessary for inspection, the E-Lock will then be opened automatically for goods loading onto the aircraft or vessel. Otherwise, the E-Lock has to be unlocked by C&ED officials with a handheld device and a set of random one-time-use-only password for inspection at the unloading area.

In March 2016, C&ED and the Customs Administrations of Guangdong Province formally launched the Single E-lock Scheme of which a “Green Lane” was built at the Hong Kong-Mainland boundary with a single E-Lock for separate monitoring. There are as many as 264 routes under the scheme shuttling between the 5 clearance points at the air cargo terminals and 7 clearance points at the sea container terminals of Hong Kong, and the 22 clearance points in the Guangdong Province. In addition, 80 percent of the air-land intermodal transshipment cargoes currently enjoy the seamless clearance facilitation provided by ITFS. The Scheme will enhance the trade facilitation measures to cope with the rapid development of the cross-boundary e-commerce logistics.

Evolution of the Light-Weight and Low-Cost NFC RFID Reader Chip

In January 2012, Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies (LSCM) introduced the LS1001 UHF RFID reader chip, tailor-made for near-field-communication (NFC) and mobile applications. The reader chip is a major deliverable from a R&D project namely “Lightweight RFID Reader Chip for NFC and Mobile Applications” supported by the Government’s Innovation and Technology Fund (ITF).

The LS1001 UHF RFID reader chip reader chip takes a great leap forward in bringing the RFID technology to people’s everyday life by addressing the need of a lightweight, low cost, low power consumption and easy-to-operate reader device in the market. It is compatible with ISO 18000-6C standard and ideal for item level identification and data retrieval in NFC application.

Owing to the R&D advancement, the well-developed light-weight and low-cost reader chip had incorporated the LSCM designed **Smart Blind Cane** with the application of smartphone in 2014. This enables visually impaired to identify places with adequate navigation information and eventually allows them to broaden their social lives.

The **Smart Blind Cane** project was participated in the 44th Geneva International Exhibition of Invention in Switzerland on April 2016 and been awarded the “Gold medal with congratulations of the jury”.

To foster a sustainable city-wide adoption of these technologies, this year Hong Kong Society For The Blind collaborated with LSCM to develop a Blind Community Cloud Platform. Other than facilitating navigation, the platform also integrates multiple information sources and applications from different parties like restaurant menu, household/ office/ shop item identification, etc. By interconnecting locations with smart navigation aids, the visually impaired community can enjoy a seamless navigation aid service and living assistance across different premises and regions.

Flexible Battery

Wearable and flexible are the most important trend for electronic device but their shape and form are restricted by conventional battery which is stiff and bulky.

Since 2013, Nano and Advanced Materials Institute (NAMI) has developed the world's leading highly flexible, super-safe, powerful and rechargeable lithium ion batteries based on nano sponge solid electrolyte that offers below impressive features:

Highly Flexible - NAMI's Flexible Lithium Ion Battery can keep very stable voltage output when being bent, or even folded, at different angles while conventional lithium ion batteries with liquid electrolyte can never deliver such high performance in the same condition.

Super Safe: No explosion! No fire! Still works for hours after being damaged! - No liquid electrolyte leaks out even though parts of the battery is damaged or cut away. Nano sponge electrolyte prevents the anode and cathode from contacting directly to cause short-circuit, which significantly improves the safety of lithium ion batteries.

Powerful - The capacity of NAMI's flexible battery is 50 times higher than other brand in the market and is comparable to conventional lithium ion batteries.

Rechargeable - Charging of NAMI's flexible battery is 20 times faster and life cycle 20 times longer than current brands in the market.

NAMI was granted the Technological Achievement Award in the 2016 Hong Kong Awards for Industries (HKAI) with its Flexible Battery Technology for Wearable Electronics.

NAMI has worked with a number of local companies since 2015 to integrate the flexible battery platform to electronic products like wrist band for smart watch, battery for cellphone, and applications on sportswear sensor.

NAMI is now developing new functions/properties to upgrade the flexible battery platform for the latest development of wearable device. With support of various industrial partners, NAMI will develop different flexible battery prototypes for different wearable/Flexible electronic devices such as safe flexible batteries for hearing aid, wireless rechargeable coin cell with flexibility, and flexible battery for electronic interactive device, etc.

Revolutionized Germ-repellent Plastics

Biocide-based antimicrobial technology has been widely adopted in the plastics industry for decades. However, due to the potential threat of “superbugs” – drug-resistant germs caused by the abuse of biocides, different authorities, such as the US Food and Drug Administration, begin to launch more stringent regulations and ban the use of biocides. The healthcare experts at Nano and Advanced Materials Institute (NAMI) have developed an innovative approach to cope – germs repellent plastics without biocides.

In contrast to traditional biocides which inhibit the growth of germs by killing them, NAMI’s germ-repellent technology prevents germs from attaching to the surface so that they cannot gather into colonies or biofilms. By stopping them from reproducing and aggregating, the bacteria would not be able to harm us.

In line with the biocide-free property, NAMI’s germ-repellent plastics do not result in leaching of toxic chemicals that would otherwise kill germs. This may cause skin allergy among some people and in a long run may accumulate in the body. The anti-fouling compound in NAMI’s germ-repellent plastics is strongly bonded on a molecular level to the plastic structure. It is proven to be leach-minimal, in compliance with the food grade regulations of FDA and European Union and it is non-toxic to human cells as well.

In terms of manufacturing workflow, NAMI’s germ-repellent plastics can be blow-moulded, injection-moulded or extruded directly using regular machines as normal thermoplastics. The germ-repelling property is intrinsic and no second step or post-treatment equipment is needed. What’s more, as opposed to existing antimicrobial coatings that are susceptible to scratch because of poor adhesion between the coating and the plastic substrate, NAMI’s anti-fouling compound is fully integrated and ingrained into the plastics, making it a lot more durable.

The extruded end products, as well as the plastics pellets, appear almost the same between the germ-repellent and regular plastics. Negligible change in physical properties allows NAMI’s germ-repellent technology to be adopted in a wide range of plastics substrates for various applications, from daily consumables to medical devices.

Features of NAMI’s Germ-repellent Plastics:

- Inhibit growth of germs
- Leach-free, without leading to biocide resistance
- One-step, integrated into common manufacturing processes
- Durable, negligible change in physical properties

Financial Technologies (FinTech)

ASTRI is dedicated to helping Hong Kong to position itself as a premier, global Fintech hub. By driving innovation and development in FinTech, ASTRI seeks to enhance operational efficiencies of local financial institutions and bring greater convenience and security to consumers, benefitting both the financial sector and the consumers.

The HKMA-ASTRI FinTech Innovation Hub is neutral ground where industry players can collaborate to innovate. Located at ASTRI's premises in Hong Kong Science Park, the Hub is supported by the institute's highly capable FinTech researchers, as well as its hardware and software IT infrastructure. ASTRI has developed a Cyber Intelligence Sharing Platform for the financial industry in Hong Kong where data, information, and intelligence related to cyber-threats can be collected, compiled, and shared among the member organisations.

ASTRI, in collaboration with the Hong Kong Monetary Authority (HKMA) and the Hong Kong Institute of Bankers (HKIB), facilitates a localised cybersecurity certification scheme – Certified Cyber Attack Simulation Professional (CCASP) training programmes. CCASP is supported by the Council of Registered Ethical Security Testers (CREST) International.

Bank of China (Hong Kong) Limited and ASTRI established the BOCHK-ASTRI FinTech Collaboration Centre to develop latest FinTech solutions and applications, benefitting both the sector and the customers. The Centre focuses on various areas including: Blockchain, electronic payments, cybersecurity, big data analytics, and behavioural recognition technology.

BOCHK recently introduced Blockchain technology for property valuation, using an application developed by ASTRI which can be used to create a decentralised network of banks and surveyors through which the latest valuations can be listed, verified and shared - in a matter of seconds. It is probably the first production-grade Blockchain-based mortgage system to be launched by a bank in this region.

ASTRI and t.Axiom jointly developed an 'Intelligent Investment Platform' capable of analysing large-scale financial data, quantitative model calculation and processing, to provide efficient and accurate analysis of historical and real-time data. Bank of China (Hong Kong) adopted this platform, and organised the 'Smart Investment' contest in partnership with ASTRI.

The HSBC-ASTRI Research and Development Innovation Laboratory (RDI Lab) promotes innovation in FinTech as advocated by the SAR Government. The Lab works in various areas including artificial intelligence on Chinese character recognition, behavioural biometrics authentication, big data analytics, Blockchain, Cybersecurity, facial and other biometric recognition, and internet finance.

HSBC has adopted an artificial intelligence system for reading Chinese characters developed by ASTRI. The system recognises millions of different versions of characters, including traditional and modern script, and continuously learns to improve its accuracy. Applying this technology is enabling HSBC to enter basic customer information such as addresses faster and more accurately.

ASTRI is working with Thailand's central bank, the Bank of Thailand (BOT), on cybersecurity and developing financial technologies (FinTech) – to help enhance the efficiency and security of the country's electronic transactions, as well as the resilience of its financial system against cyber-threats. ASTRI and ETDA, an e-commerce agency under the Thai Ministry of Digital Economy and Society, are jointly carrying out FinTech R&D projects, covering areas such as cybersecurity and Blockchain.

Smart City

Information and Communication Technology (ICT) facilitates every aspect of the Smart City paradigm. Almost all Smart City Applications are enabled by combination of several ICT-based sensor devices, new network technologies, intelligence and security technologies. By leveraging a wide spectrum of research efforts, ASTRI's Smart City initiative is well-positioned to play a key role to establish a strong Smart City ecosystem for Hong Kong and this region.

To support the HKSAR Government strategy in transforming Hong Kong into a Smart City, ASTRI is working with the 'Energising Kowloon East Office' (EKEO) and Lands Department to develop various smart city applications like GIS, smart parking and smart community. These are being piloted in the East Kowloon smart city project.

ASTRI's GIS system is an integrated seamless indoor and outdoor navigation system. It can cover both outdoor areas such as pedestrian's pathways, alleys, bridges, as well as some indoor premises such as shopping malls. The system will also provide other services such as enquiry on nearby information and broadcast real time special notice.

ASTRI developed Portable Interactive Projectors and Interactive Touch Panels for six NGO sites in Hong Kong to help build an elderly-friendly smart city. The technology setup was applied to enhance braintraining activities. Taking into consideration movement constraints of the elderly, the device is designed in such a way that the elderly can handle it with ease. ASTRI also supported Hong Kong Housing Society's AFC (Age Friendly City) Lounge Carnival and provided demonstration to other NGOs and government organisations.

ASTRI, together with Fujian Sunnada Network Technology Co. Ltd., performed a series of live demonstrations of latest LTE, 5G and V2X (Vehicle to Everything) infrastructure and applications technologies supported by ASTRI's advanced wireless and network technologies at the Mobile World Congress (MWC) 2017 in Barcelona, Spain.

In a related development, a Smart Mobility Consortium (the Consortium) on Cellular-Vehicle-to-Everything (C-V2X) technologies has been formed by the Hong Kong Applied Science and Technology Research Institute (ASTRI), HKT Limited (SEHK: 6823) (HKT), Huawei Technologies Co. Limited (Huawei) and Qualcomm Technologies, Inc.

ASTRI has successfully developed commercial-grade TD-LTE technologies to build the railway Communication-based Train Control (CBTC) signalling network system. It has already been deployed at Wuhan Metro Line 6, the first subway signalling system in China using the LTE technologies. ASTRI's network solution has high reliability on handover and enhanced failure handling mechanisms during the train movement. These enhance the safety, reliability and efficiency of subway line operation.

Talent nurturing and spin-off

As the largest applied R&D institution in Hong Kong, ASTRI strives to develop innovative and commercially viable technologies. At the core of ASTRI's strategy is transferring technologies to various industries. In that process, ASTRI also grooms and nurtures technology talents that can serve Hong Kong and its enterprises. For the institute, building an 'Optical Communications Component Group' from scratch, and then turning it into a successful business venture - what is now a part of TDK SAE Magnetics (HK) Limited - is a great examples of successful technology transfer.

Dr Frank Tong, who is currently the CEO of Hong Kong Applied Science and Technology Research Institute (ASTRI), took up the position of Head of Optical Communications Component Group at the institute in 2001 as a secondee from the Chinese University of Hong Kong (CUHK). ASTRI entrusted him with building its Optical Communications Component team from scratch. He built it from hiring the researchers to obtaining resources to structuring the working processes. Under his leadership, the team within ASTRI accomplished a high level of success, developing high-speed laser packaging for some of the most sophisticated and largest devices. As the components packaging business migrated from the West to mainland China, the business opportunity also grew manifolds. ASTRI's mission is to develop technologies that enhance the competitiveness of Hong Kong and its enterprises. Dr Tong's team sought to achieve exactly that – driving innovation that positioned Hong Kong prominently in the relevant market, and developing solutions that helped businesses to offer best-in-class products to their consumers.

Having delivered strong, sustainable results over a few years, the group spun-off from ASTRI in 2004 when SAE Magnetics Ltd – currently a fully owned subsidiary of TDK Japan – acquired its people, logistics, and patents for USD 14m. Apart from being the first successful spin-from a government funded R&D centre, it remains one of the biggest cases of a 'Hong Kong home-grown' technology business earning major revenues for the Government Treasury. As ASTRI delivered against its mission, its spun-off team continued to add value to the industry while being part of another successful commercial enterprise which maintains Hong Kong as its base.

Dr Frank Tong went on to work as a Vice President at SAE Magnetics (HK) Ltd for eight years. During his tenure there, he pioneered the establishment of its optical component business unit and, by the time of his departure, SAE had launched many advanced optical and laser products that are still being used in data centres, data communications, as well as in the consumer electronics market. Globally-famous brands like Sony, 3M, Blackberry, Mercedes as well as Chinese electronic giants like O-Net and Hisense have either acquired or used technologies developed by the team led by Dr Tong. However, what makes him the happiest is the accomplishment by his former team members - many of his former team members are in prominent positions in leading technology companies.

Dr Tong credits this accomplishment to a dedication to building teams and developing talents. ASTRI, the institute he currently leads, remains passionately committed to this goal. Talented, highly competent R&D professionals at ASTRI continue to pursue innovation and excellence in various areas of applied science and technology – helping enterprises to become more competitive, and citizens to have a better way of life. Commitment to people and teams is at the core of everything that ASTRI does - as the famous Chinese proverb suggests, "If you want one year of prosperity, grow grain. If you want 10 years of prosperity, grow trees. If you want 100 years of prosperity, grow people."

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将深港福田-落马洲大河套片区确定为国家 战略，创建世界级产业技术创新中心

干 勇 李行伟 陈嘉正 高贊明 陈繁昌 陈清泉 徐扬生

程伯中 赵雅各 蔡宇略 李安国 林垂宙 吕 坚 潘乐陶

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刘韵洁 钱清泉 刘人怀

中国工程院和香港工程科学院“香港及珠江三角洲协同创新发展战略研究”联合课题组曾在深圳、香港调研，广泛接触了工程科技、高校及科研院所、企业、青年学生等各界人士。联合课题组一直关注怎样创造合作平台和机会，使香港高智力人才和强大的师资力量培养的理工科青年精英融入到中华民族复兴的

现代化建设中来，并同时为香港地区的发展作出贡献。

课题组考察了深圳皇岗口岸、福田保税区和香港落马洲河套毗邻将近 4 平方公里的片区，并获悉 2017 年 1 月 3 日香港特别行政区政府和深圳市政府签署了“关于港深推进落马洲河套地区共同发展的合作协议”，双方协商确认河套土地业权，互换过境土地，按“共同开发、共享成果”原则，合作推动河套地区发展。深港双方备忘录中提出：因应港深近年在创新及科技的重大发展，及两地在优势互补下产生的巨大协同效应，双方同意除共同发展“港深创新及科技园”外，港方也支持深方在深圳北侧发展科技创新，共同建立“深港科技创新合作区”。

为进一步推动香港及珠三角地区的协同创新发展，促进两地经济的转型升级，提出如下建议：

建议中央将深港福田-落马洲大河套片区确定为国家战略，充分发挥一国两制优势资源，提升香港在国家战略中的地位，并作为启动粤港澳大湾区规划的核心引擎。将此列入香港回归二十周年中央支持香港未来发展的重大战略，提出对深港跨境合作协同建设创新与科技合作区的愿景。

在国家的层面给以更大的关注和定位，将福田-落马洲大河套片区作为一盘棋统一考虑，将这一跨境片区作为一个整体，继上海、北京之后，在南方建设一个全新的国际创新中心：“深港国际科技创新中心”，有序布局国家重大项目，支持珠江三角洲产业升级，对接香港的基础研究、源头研究、人才聚集和新技术成果境内外联合创新创业，在科研体制上实现新突破。以“一体

“两翼一盘棋”的思路，配合香港发展。支持深港合作共同打造世界级科技、产业创新中心（建设的高端产业平台和融入国际化的新兴产业领域详见附件）。

国家给予该片区特别的先行先试政策，对深港联合建设国际科技、产业创新中心进行顶层设计。将最大限度的发挥香港全球最佳投资环境的优势，最大限度的植入市场经济的活力，最大限度的吸引包括内地的一流科技创新资源在内的全球创新资源配置。在全球产业回归本土的趋势下，为人才、资金、技术和服务的聚焦提供新的空间和平台。把握最佳机遇，将福田-落马洲大河套片区作为粤港澳大湾区发展新动能、深港合作新平台、国际化创新型城市建设新窗口、国际科技产业创新中心新高地的抓手。

基于上述背景，建议中央决策，将这一区域定位为“深港福田-落马洲科技产业创新特别合作区”。请国家有关部门在规划粤港澳大湾区时给以明确定位，对有关区域范围、基本功能、政策导向、合作模式等给以指导，并争取在香港回归二十周年之际宣布，开启新的征程。

附件：香港及珠三角地区协同创新发展战略研究报告摘要

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附件：

香港及珠三角地区协同创新发展战略研究报告 (摘要)

项目背景：2016年5月，中国工程院与香港工程科学院共同设立了“香港及珠三角地区协同创新发展战略研究”咨询研究项目，项目主要研究如何将香港的科技资源和国际化优势与珠三角地区巨大的市场需求及产业基础有效整合起来，发挥双方的互补优势，协同推进香港及珠三角地区的科技创新与产业升级，打造世界级科技及产业创新高地。

本报告摘要是在中国工程院及香港工程科学院联合课题组研究成果基础上形成的。

珠三角地区和京津冀、长三角地区并称我国的三大经济圈，在我国经济社会发展中具有举足轻重的地位，其中，珠三角地区人均GDP在我国三大经济圈中居首位。香港和珠三角地区的合作，是在“一国两制”的基础上，具有亚太经济服务中心功能的国际化大都市与竞争力不断提升的区域经济中心城市之间的衔接和合作，这就决定了两地合作不仅局限于两地之间，它的合作定位须提升到整个中国融入世界并参与国际竞争的战略地位上来。

2015年，香港服务业占本地生产总值比重为93%，制造业

占本地生产总值 1.2%¹，香港经济存在结构失衡、青年失业率高等深层次问题亟待解决。香港迫切需要进入一个通过创新的模式推动经济发展的新时代。有效整合香港的科技资源和国际化优势以及珠三角地区可观的产业基础，促进两地经济的转型升级，不仅是两地实现长期健康发展的客观需要，也是我国在新一轮国际竞争中建立国家竞争优势的客观需要。

一、香港科技创新的基础与优势

香港高校具有较强的基础科研实力。2017-18 年 QS 世界大学排名中²，香港有 5 所大学³入围全球排名前 100 的大学，为全球主要城市或地区之冠。其他全球主要城市或地区中，伦敦有 4 所大学入围列第二，波士顿有 3 所大学入围，旧金山湾区、纽约、芝加哥、巴黎、北京分别有 2 所大学入围。另外，根据大学教育资助委员会 2014 年的评定，香港的大学研究成果中，51% 的项目被国际专家评为达到世界领先水平或卓越水平，其余绝大部分达到国际或区域水平。深圳市获批的 65% 的科技部 973 项目、40% 的国家自然基金委项目由在深圳的香港高校科研院所主导承担⁴。

从专业分布来看，香港在信息技术、电机及电子工程、智能制造、生物科技与医疗健康、金融与大数据技术、新材料、智慧城市、环境与可持续发展、海洋科技等领域具有高水平的学术和科研实力。从研发支出看，截至 2016 年 5 月，香港创新及科技基金已资助 5200 个项目，共约 113 亿港元，其中，信息技术、

¹ 数据来源：香港创新及科技咨询委员会报告，2017 年 3 月。

² 数据来源：Quacquarelli Symonds 机构对世界大学的排名。

³ 入围全球 100 强的五所大学分别是，香港大学、香港科技大学、香港中文大学、香港城市大学、香港理工大学。

⁴ 数据来源：深圳市科学、技术和创新委员会，2014 年。

电机及电子工程、制造科技占资助总额的 66%，其余依次是生物科技、新材料、环保技术等⁵。另据大学教育资助委员会 2014 年的评定，学科项目中达到世界领先水平的比重依次是：信息技术（27%），自然科学（24%），生物科技（12%），工程学（10%），电机及电子工程（10%），医疗健康（10%）。

香港六大著名高校重点科技研究领域见附表 1，香港科研机构及孵化加速机构重点发展的领域见附表 2。

二、珠三角地区产业发展基础与技术创新需求

珠三角地区是我国制造业及对外贸易物流的重要基地。2015 年，珠三角地区实现地区生产总值 6.23 万亿元，增速达 8.6%，人均 GDP 为 10.6 万元。珠三角地区规模以上工业企业数量 31765 个，涉及从业人员 1182.2 万人。总的来看，先进制造业增加值占规模以上工业比重达 53%；从企业规模来看，中小微型企业是最主要的类型，占 95.9%；从行业看，计算机、通信和其他电子设备制造业是该地区的绝对优势产业，当年工业增加值达到 6236.3 亿元，占所有行业工业增加值的 26.3%，其余优势行业依次是电气机械和器材制造业（10.6%），汽车制造业（6.0%），电力、热力生产和供应业（5.2%），化学原料和化学制品制造业（5.6%）⁶。

近年来，珠三角地区的先进制造业和高技术产业得到了快速发展，虽然具备了加工装配高新技术产品和高附加值产品的能力，涌现了一批有国际竞争力的企业，但同时仍然存在原创技术

⁵ 数据来源：香港创新及科技咨询委员会报告，2017 年 3 月。

⁶ 数据来源：《广东统计年鉴 2016》，中国统计出版社，2016 年。

缺乏、关键零部件和关键设备制造能力相对滞后的问题。根据广东省“十三五”规划统一部署，结合目前珠三角地区9个城市自身的发展基础，珠三角地区未来将重点发展先进电子信息制造业、先进装备制造业、先进材料制造业、生物医药产业、新能源产业等重点产业，这些领域均对技术创新有迫切需求。这和香港的科技创新资源有诸多契合点，尤其是在先进电子信息制造业、先进装备制造业、先进材料制造业和生物医药产业等领域。如能把香港的优势资源和国内的优势有效结合起来，通过“香港研发+珠三角地区产业化”的方式促进两地纵深互动，将知识转化为创新技术，促进区域经济的转型升级，将是一个非常好的双赢局面，并有潜力成为具国际影响力的创新科技产业中心。

珠三角地区先进制造业重点发展的领域见附表3，珠三角地区战略性新兴产业重点发展的领域见附表4，珠三角现代服务业重点发展的领域见附表5。

三、建议

香港和珠三角地区在创新资源和产业基础方面各有优势和不足，双方有很强的互补性。但是，两地在协同创新方面也面临体制机制等诸多障碍。香港基础科研实力雄厚，创新资源优势突出，但官产学研之间的协作并未打通，产业技术相对薄弱，和珠三角地区的协同创新缺少了共性技术和产业化技术的对接环节。此外，体制的不同也在一定程度上导致了双方的合作的局限性，影响了协同创新的深度和广度。为此，提出如下建议：

（一）建设“深港国际科技创新中心”

建议发掘深港边界地区的战略价值，深港双方合作发展河套地区及深港边界毗邻地区为“深港国际科技创新中心”。引进国内外顶尖企业、研发机构和高等院校建立科研合作基地，深方把深圳河北侧毗邻河套地区约三平方公里区域打造成为“深方科创园区”，支持河套地区建设“港深创新及科技园”，双方向国家争取政策，构建一个具有对应聚集力和协同效应的“深港国际科技创新中心”。

建议在“一国两制”的框架下，在河套地区对内地与香港之间的人才、资金等创新要素的跨境流动作出特殊安排，先行先试，推动两地创新要素无缝对接和自由流动。在河套及周边地区优化科技资源与金融资源有效对接机制，建立覆盖科技创新与产业发展全过程的科技金融综合体系。

（二）着力打造“粤港澳科技湾区”

根据香港科技创新基础和优势，以及珠三角地区产业发展基础与技术创新需求，建议双方在先进电子信息制造、先进装备制造、先进材料制造、生物医药、新能源等重点产业加强合作，在大数据科学和电子商务、智慧城市、环境与城市治理等重点领域加强合作，共同推进优质成果商业化。

整合现有创新资源，建设虚拟-实体结合的网络化“粤港澳区域创新中心”，作为“粤港澳科技湾区”建设的重要抓手。联合广州天河、东莞松山湖、深圳南山等地的创新资源，以及香港工程科学院、港科院、香港六所著名高校，香港科技园、香港应

科学院、香港生产力促进局等创新资源，瞄准在国际竞争方面有强大产业带动能力的产业与技术，建设“制造强国”创新链，催化世界一流技术水平的产业链。

（三）理顺科技创新合作机制

进一步深化《粤港合作框架协议》的内涵。在政府层面上，建立香港和珠三角地区产业技术创新委员会。香港方面负责梳理香港高校、科研院所具有产业化潜力的技术，形成清单；内地方方面建立企业的技术需求清单；形成定期对话联络机制，就推动实施的障碍和措施交流意见，推动香港科技成果落地转化。同时，建立督导机制统筹双方的创新及科技合作工作安排，统筹协调、监督指导两地政府间已签署的与创新和科技合作相关的各项协议、备忘录、意向书的推进与落实。

附表：

- 1.香港六大著名高校重点科技研究优势领域
- 2.香港科研机构及孵化加速机构重点发展优势领域
- 3.珠三角地区先进制造业重点发展的领域
- 4.珠三角地区战略性新兴产业重点发展的领域
- 5.珠三角现代服务业重点发展的领域

附表 1 香港六大著名高校重点科技研究优势领域

机构名称	重点领域
香港大学	生物医学、神经科学、化学、新能源、智能电网、新材料、计算科学与信息技术、药物、基因组学、综合生物学、食品安全与质量
香港科技大学	纳米科技、神经科学、生物科技、电子、无线通信、信息技术、人工智能、大数据、机器人及自动化技术、新能源、燃料电池、土木及环境水利工程、智慧城市、环境和可持续发展
香港中文大学	化学、生物医学、电子及信息通信技术、机器人与自动化技术、智慧城市、环境与持续发展
香港城市大学	无线通信技术、海洋环境、材料科学、生物医学
香港理工大学	土木、建筑、结构及环境工程、可持续城市发展、纺织、复康治疗、先进制造技术、轨道交通
香港浸会大学	环境与生物分析、中医药、化学、信息技术、新材料

附表 2 香港科研机构及孵化加速机构重点发展优势领域

机构名称	重点领域
伙伴国家重点实验室	脑与认知科学、新发传染性疾病、肝病研究、合成化学、生物医药技术、农业生物技术、消化疾病研究、华南肿瘤学、植物化学与西部植物资源持续利用、海洋污染、毫米波、分子神经科学、先进显示与光电子技术、环境化学与生态毒理学、手性科学、超精密加工技术
国家工程技术研究中心 香港分中心	专用集成电路系统、人体组织功能重建、重金属污染防治、贵金属材料、轨道交通电气化和自动化、钢结构
香港应用科技研究院	金融技术、智能制造、新一代通信网络、医疗健康
香港创新科技署研发中心	汽车零部件、信息与通信技术、物流及供应链管理应用技术、纳米科技及先进材料、纺织及成衣研发
香港科技园公司	电子、信息科技、绿色科技、生物科技、精密工程
香港数码港	信息及通信科技

附表 3 珠三角地区先进制造业重点发展的领域

产业	重点领域
先进装备制造业	智能制造装备、船舶与海洋工程装备、轨道交通装备、节能环保装备、通用航空装备、新能源装备、汽车制造、卫星及应用
先进材料制造业	精细化工、高端精品钢材、高端有色金属合金和金属基复合材料、新型无机非金属材料、高性能有机高分子材料及复合材料、新型稀土功能材料、战略前沿材料
先进电子信息制造业	集成电路及关键元器件、信息通信设备、操作系统及工业软件、新型显示、智能终端

附表 4 珠三角地区战略性新兴产业重点发展的领域

产业	重点领域
高端信息电子产业	新型显示、新一代移动通信、物联网、云计算、三网融合、下一代互联网、地理空间信息系统、软件和集成电路设计、数字家庭
生物医药产业	生物医学、生物育种、诊断试剂、创新药物、中药现代化、医疗器械、生命健康
新能源产业	核电、太阳能、风电
新材料产业	先进金属材料、新型无机非金属材料、高性能有机高分子材料及复合材料、特种精细化工材料、新型稀土功能材料、前沿新型材料
新能源汽车产业	整车、关键零部件、配套设施、环境治理
半导体照明（LED）产业	关键技术及产业化
节能环保产业	节能技术和产品

附表 5 珠三角现代服务业重点发展的领域

产业	重点领域
现代金融	金融信息化、科技金融
现代物流	物联网、条码自动识别
信息服务	信息传输服务、物联网、三网融合、电子商务、云计算、行业软件
科技服务	研发设计、检验检测、知识产权、科技孵化
服务外包	信息技术外包：软件开发测试、技术培训等 商务流程外包：呼叫中心、人力资源管理等

项目组成员名单

项目由中国工程院与香港工程科学院共同设立，中国工程院干勇院士和香港工程科学院李行伟院士担任项目组长，项目组成员由双方院士、专家共同组成。

顾问：徐匡迪 周济

组长：干勇 李行伟

成员：陈嘉正 高赞明 陈繁昌 陈清泉 徐扬生

程伯中 赵雅各 蔡宇略 李安国 林垂宙

吕坚 潘乐陶 滕锦光 唐韦章 韦志成

黄永成 张统一 李培根 邬贺铨 钱清泉

刘人怀 刘韵洁 程京 曾路 张玉阁

张克科 陈玮 等

报：中共中央办公厅、国务院办公厅、全国人大办公厅、全国政协办公厅。

送：中央和国务院有关部门及单位；工程院院士。

咨询工作办公室编发



