Research Assessment Exercise 2020
Impact Overview Statement

University: The University of Hong Kong
Unit of Assessment (UoA): 11 - Mathematics & Statistics
Total number of eligible staff of the university in the UoA: 28

(1) Context – context for the individual case studies
Members in the UoA have long been engaged in interdisciplinary research across sectors spanning industry, logistics, financial services, social economics, and biomedicine. Research undertaken by the unit's four research groups: 1) Optimisation and Operations Research; 2) Biostatistics and Social Statistics; 3) Stochastic and Actuarial Modeling and 4) Big Data Science have made important impact by: a) improving the efficiency of decision making processes in public institutions; b) optimizing product design; c) developing statistical and A.I. tools/software for medical diagnostics and DNA mixture and paternity analysis.
The main non-academic user groups, beneficiaries or audiences for the UoA are:
  i.   Government or public organisations through consultancies, e.g. *Hong Kong Highways Department, Hospital Authority*;
  ii.   Industrial sectors including engineering, data science services, transportation and pharmaceuticals, achieved through collaborative grants, contract research and consultancies, e.g. *Johnson & Johnson Pharmaceuticals*, *Huawei, Suoxinda Data Technology Co., Ltd, TCL* PhD studentships of *Telephone Communication Limited*;
  iii. Health and social care and biomedicine, in both private and public sectors, e.g. *Social Welfare Department* of Hong Kong and *Peking University Cancer Hospital*;
  iv.   Financial and insurance sectors through consultancies, e.g. *Wells Fargo, Wing Lung Bank.*

(2) Approach to impact – the unit's approach to impact during the assessment period
The mechanisms to promote interactions with non-academic user groups, beneficiaries or audiences have been:
Initial contact with new users. Our applied research is underpinned by extensive outreach and provision of continuous professional development. The programmes of Master in Statistics and Master in Data Science recruit part-time students from diverse professions including, e.g., banks, insurance companies, casinos in Macau and government departments. These two master programmes have been a pipeline to many potential end-users and collaborators (e.g. alumni who are now senior officials in Government or high-rank managers in companies), leading to impact via joint projects and consultancy. This will be further strengthened with the launch of a new pan-UoA programme in Applied A.I. In addition, we also met potential non-academic users in workshops organized by the HKU Knowledge Exchange Office and the Big Data Research Cluster (e.g., the symposium *Data Science and Deep Learning* in 2018 with >200 attendees from government and industry such as *Hospital Authority* and *Tencent*). To increase reach, we have also been conducting training workshops (e.g. 2-day forensic DNA workshop on "Advanced Kinship Analysis" for forensic scientists in the *Health Science Authority* of Singapore Government in 2014).

Engaging with users to develop impact through consultancy work and internship projects. About 20% of the members in the UoA have been engaged in consultancy work for public organizations (e.g. the Hospital lift system simulator project for *Hospital Authority*) or industries (e.g. *Nvidia*). The UoA provided or secured funding to support students or research assistants involved in such consultancy work. For example, since 2018, *TCL* has been funding six PhD students to develop deep learning techniques for medical imaging analytics and facial recognition.

Exploring research impact through forward citations. Fundamental research work in mathematics and statistics can lead to interesting and possibly unexpected applications by end users not known to us. We therefore encourage our researchers to pay attention to end users who cite their works, as

those applications may testify to the unforeseeable impact of our research (e.g., Markov chain models applied to enable improvisation by a robotic musician *Shimon*). Once we have identified such end users, we contact them and provide support to their applications to further enhance impact of our research. Traditionally, the UoA has been working to help create new impact and foster translations of our research and consultancy work for the societal good.

(3) Strategy and plans – strategy and plans for supporting impact

Our strategy to deliver impact from research has been through strategic expansion in Optimisation and Statistical Learning and enhancing support mechanisms for impact to be realized.

i) *Strategic expansion: Optimisation and Statistical Learning.* During the assessment period, the research focus in applied mathematics has extended from Operations Research to Optimisation because of its importance in big data, pattern recognition and machine learning. Research focus in statistics has also shifted considerably to big data science and statistical learning. The UoA has recruited one Professor and one Chair Professor (also the UoA Research Division Director) who are leading experts in optimisation and pattern recognition. The Optimisation and Operations Research group and the Big Data Science group now complement and interact well with each other in AI-related research, and are well-positioned to further extend collaborations to industries (e.g., banking and AI startups in biomedical fields). This will strengthen our connections in industries so that we can translate our research into impact more effectively.

ii) *Providing advisory mechanisms to create impact.* The UoA has set up an External Stakeholder Advisory Board which consists of representatives from various stakeholders including data science companies (*Suoxinda Data Tech Inc*), *Hospital Authority*, consultancy (*AECOM Asia Co. Ltd.*) and IT companies (*TCL, Nvidia AI Technology Center*). The Board meets regularly and works closely with our impact coordinator XM Yuan, so that we can maintain close ties with our alumni and interact effectively with industrial collaborators to create an impact-driven research environment.

iii) *Extra support for translating research into impact.* We encourage our researchers to form small teams to supervise undergraduates and research students on capstone projects, industrial applications or consultancy work that may lead to impact. Members who have made substantial contributions to impact may benefit from relief of their teaching loads or be rewarded additional graduate student places. The UoA also provides funding to support research students/assistants who work with our researchers to create impact through delivering consultancy work.

(4) Relationship to case studies

Built upon the strengths of the UoA in Operational Research, Optimisation and Biomedical and Social Statistics, we foster and enhance the impact of our research in response to the high demand for consultancy services. Examples of the diverse works done (but not submitted) by the UoA in the RAE impact window include: *generating, scheduling and rostering of shift crew-duties* [consultancy for the Hong Kong Airport Services]; and *Hospital lift system simulator* [consultancy for the Hospital Authority]. The two impact case studies submitted are: 1) *statistical assessment and user-friendly software for complex paternity and kinship testing and DNA mixture analysis in legal contexts*; and 2) *Statistical underpinning of a standardised home care assessment tool for the elderly in Hong Kong.* Impact case study 1 originated from consultancy by WK Fung for the Hong Kong Legislative Council on "DNA Analysis in Parentage Testing". The software developed for statistical assessment of complex paternity and kinship testing and DNA mixture analysis in criminal forensics has been widely distributed online and hence used by many users from private and public sectors worldwide. Impact case study 2 stemmed from consultancy by Eddy Lam for the Social Welfare Department. A uniform comprehensive assessment tool to evaluate the health outcomes and care needs for Hong Kong elders was developed. It was statistically validated and an effective screening algorithm for service matching and setting access priorities was developed using innovative influence diagnostic methods for discriminant and factor analyses. The tool helps clinicians to develop individualized care plan effectively, match elderly with timely and appropriate care needs, thereby increasing quality of life cost-effectively in the fastest-growing sector of the population.