COLLABORATIVE HORIZONS:

Exploring Science and Research Partnerships between New Zealand and China

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NEW ZEALAND

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CONTENTS

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FRONT COVER: Zhitan Sun (Innovation leader – China); Jin-ping Zhang (Senior scientist – MARA-CABI Joint Laboratory); Gonzalo Avila (Senior Scientist – Plant & Food Research); Juhong Chen (PhD student)

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NEW ZEALAND

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FOREWORD

New Zealand is managing its important relationship with China in an increasingly complex environment. The prevailing narrative describes a challenging balancing act for our country between economic benefit and geopolitical risk.

This framing obscures the reality that there are multiple other areas of engagement and collaboration which also form part of the bilateral relationship. Whether it be the interpersonal relationships that bind increasing numbers of Chinese and New Zealanders, our links and exchanges in education and sport, art and culture, or climate change and biodiversity, we need to view New Zealand-China relations as the totality of contact in many areas. Often these collaborations are so established and unproblematic that they escape widespread attention.

Scientific and wider academic research collaboration and partnership between New Zealand and China is one of those strands of the relationship that deserves more focus and recognition.

Our bilateral cooperation in this area has a long history, with Dr Li Lairong's work on kiwifruit in the 1940s pre-dating the establishment of the People's Republic of China. Yet many of our bilateral research success stories are not well known. It is possible to detect sentiment that engaging with China in this field must universally be difficult or somehow 'risky'.

This report, written by Peter Graczer and Peter Griffin, was commissioned to shine more light on an overwhelmingly positive area of engagement that brings many benefits to both countries.

The data in the report reveals China as one of New Zealand's leading research partners across multiple disciplines. It paints a rich picture of the value to us of research partnerships that in some cases have continued for decades. We benefit in areas as diverse as accelerated access to medical breakthroughs, biosecurity preparedness against invasive pests, better understanding of our ocean environment, fruit species improvement and sustainable development of our tourism sector.

I particularly commend the case studies throughout the report that have been included to illustrate the depth of cooperation in these and other areas. They demonstrate the human stories behind the research achievements, and offer fascinating insights into how partnerships commence and why they continue for so long – even if impacted to some degree by the recent Covid period.

No international research collaboration is without challenges: the authors identify some factors affecting New Zealand and China, and describe the processes that are in place to ensure research is for the right, positive purposes. This is an approach New Zealand should rightly take with all collaboration partners.

Our heartfelt thanks to the organisations that contributed sponsorship support for this report: the University of Waikato, which is a member of our Council, and the North Asia Centre of Asia-Pacific Excellence. We are also grateful to the many organisations and individuals who agreed to be interviewed as part of the authors' research.

JOHN McKINNON
Chair, New Zealand China Council

EXECUTIVE SUMMARY AND KEY FINDINGS

As a small exporting country with limited funding for science and research, New Zealand relies on leveraging international science and research skills for our economic benefit, to advance our own research agendas and make valuable contributions to solutions for issues that affect us globally.

This is reflected in the government's 2021 Science, Research and Innovation Report, which emphasises that connectivity with international researchers is essential for growing both the quality and impact of New Zealand research.[1]

Partnering with China in science and research has become increasingly important for New Zealand, not only because it has become our key export market, but also because it has emerged as one of the world's leading innovators and a global leader in research.

Given the ambition, funding and quality of Chinese science, there is obvious potential for New Zealand to benefit from continued collaboration in areas that are important to New Zealand. Yet, concerns have been raised around risks associated with research engagement with China, and there are few sources of information that provide an overview of the scope, scale and benefits of collaboration. The New Zealand China Council (NZCC) has accordingly commissioned this report in order to:

- Outline the current scope and scale of science and other research collaboration between New Zealand and China;
- Identify the key benefits of and future potential of science and other research collaboration, and;
- Consider the challenges of science and other research collaboration.

KEY FINDINGS

The scope of science and research collaboration between New Zealand and China is broad, and continually expanding.

- New Zealand's science and research collaborations with China are focused on food science, environmental sciences and health and biomedical sciences, following the established government-to-government priority areas.
- Outside these official priority areas, researcher-to-researcher collaboration has expanded over time to include areas such as social science, tourism, marine science, architecture and planning, renewable energy, conservation and the arts.

The scale of science and research collaboration between New Zealand and China is growing rapidly.

- The total number of scientific publications featuring New Zealand - China collaboration almost doubled between 2017 and 2022, increasing from 898 to 1761.
- The share of New Zealand publications co-authored with China increased from 7.7% in 2017 to 11.6% in 2022, a relative increase of 51%.
- This share is lower than Australia, where 16.7% of all publications included Chinese co-authors in 2022, and similar to the United Kingdom.

There are valuable and unique key benefits from collaborating with Chinese partners in science and research.

- Key benefits identified by researchers were expertise, technology, infrastructure and facilities not available within New Zealand.
- Other benefits identifed were access to China's unique environment for agricultural and horticultural research, and access to China's market and industry supply chains.

1 https://researchscienceinnovation.nz/strengthening-connections/index.html#offset-growing-international-research-collaboration

There are also challenges and barriers to science and research collaboration between New Zealand and China.

- Limited funding opportunities for research in New Zealand was identified as a key ongoing barrier to collaboration.
- Covid-19 had a significant impact on almost all collaborative research activity, slowing progress and putting some projects on hold for a year or longer.
- While participants in bilateral collaboration are aware of risk and guidance is available, managing risk is not always straightforward.

China's appetite for science and research collaboration remains strong, with good future potential for new areas of cooperation.

- Most New Zealand researchers indicated that China is willing to expand collaboration with New Zealand, both in the number of projects, visits and exchanges between institutions and also in the areas for collaboration.
- Areas of collaboration identified as having good future potential include regenerative farming, pest control, new drug discovery, the modernisation of Traditional Chinese Medicine, mitigating greenhouse gas (GHG) emissions from agriculture, water conservation and marine science.

CHINA'S INTERNATIONAL SCIENCE AND RESEARCH COLLABORATION

When three taikonauts, the Chinese word for astronauts, boarded the Tiangong space station on November 29, 2022, it marked a milestone not only for space exploration but also for China's scientific ambitions.

China's modern international science and research collaboration began in the late 1970s and early 1980s as the country opened up and reformed its economy and society, allowing for more scientific exchanges and research cooperation.

Up to that point, the People's Republic of China's approach to science from the late 19th century embodied the motto: "Chinese essence, Western application".

"The outer shell of the application (用) could be practically adopted from abroad, as long as the Chinese essence (体) was preserved as the cultural identity," is how science historians have characterised it.[2]

SCIENTIFIC REAWAKENING

That changed with the end of the Cultural Revolution in 1976 with Deng Xiaoping expressing his desire to rebuild China's scientific capabilities so that it could form one of the "Four Modernisations", alongside industry, agriculture and defence that would help transform the country.

New policies encouraged international collaboration agreements, the outward mobility of Chinese doctoral students, and joint research centres and scientific programmes with EU, US and ASEAN nations.[3]

Reforms of the science and technology system in 1985 saw a shift in focus towards applied science which was reinforced in the 1990s when science was increasingly seen as an enabler of the national development goals outlined in successive Five Year Plans.

With the aim of "rejuvenating the country through science and education" [4] (科教兴国) international scientific exchanges increased and international collaboration involving Chinese scientists flourished, particularly in the areas of chemistry and physics.

China continued to adapt Western science to its needs, however a push for greater independence in science and technology was evident in policy directives from the late 1990s, accompanied by increasing investment in domestic science infrastructure.

Over the past two decades, China's investment in scientific infrastructure has increased dramatically, with total spending of nearly 3.09 trillion yuan in 2022 (US$456 billion), a 10.4% increase from the previous year, according to the China National Bureau of Statistics.[5]

SCIENCE MEGA PROJECTS

China is now home to some of the most significant international "Big Science" projects globally, such as the Five-Hundred-Metre Aperture Spherical Telescope (FAST), one of the world's largest radio telescopes located in Guizhou province. Moreover, China's increased investment in basic and applied science, government laboratories, and universities is reflected in the rapid growth of scientific collaborations between Chinese and international researchers.

In 2015, Chinese researchers co-authored 71,000 papers with researchers from 188 countries, an increase of 4.4% compared to 2006.[6] China's sheer publishing volume has made it the leading international partner for researchers in many countries, including the United States. As the scientific journal Nature reported in 2021, a key driver of the rapid rise in co-authored scientific publications

2 https://www.mpiwg-berlin.mpg.de/observations/end-learning-west-trends-chinas-contemporary-science-policy
3 https://link.springer.com/article/10.1007/s10734-021-00712-9
4 https://www.sciencedirect.com/science/article/abs/pii/S1059056023000692
5 http://english.scio.gov.cn/pressroom/2023-01/30/content_85080177.htm
6 https://ncste.org/uploads/www/201712/200927279unk.pdf

worldwide is China's focus on science and research and the importance it places on international collaboration.[7]

In the 21st century, science is highly interconnected, and multinational research efforts have become the norm, particularly in areas of international relevance. The Chinese diaspora is now a key part of international collaboration, with scientists of Chinese heritage working in institutions all over the world.

SELF-RELIANCE AS A STRATEGY

China's "Made in China 2025" strategy introduced in 2015 sought to achieve self-reliance in key emerging industries, including automation, IT, robotics and artificial intelligence. Subsequent Five Year Plans have placed innovation front and centre in the country's priorities.

The Chinese People's Political Consultative Conference and National People's Congress meetings held in March 2023 further advanced this strategy with announcements of a reform programme including the establishment of a new body called the Central Science and Technology Commission, likely to be led by high-level officials, possibly even by President Xi Jinping.

President Xi's desire for greater self-reliance in key areas of science and technology reflects the complexities of the geopolitical environment and sensitivity around advanced technology development, such as quantum computing and artificial intelligence.

The Ministry of Science and Technology (MoST) will be refocussed on key efforts to meet top national priorities, implementing the policy directives of the Commission. Responsibility for some of its current administrative tasks such as project funding and evaluation will be handed to sector-specific Ministries.[8]

These reforms are being interpreted as a move towards more centralised control over research, and questions have been raised about the impact the new emphasis on self-reliance could have on international collaboration. Some observers believe the shift will restrict international research collaborations in certain areas, while others point out the Chinese research community has so far continued to welcome international collaboration.[9]

When it comes to tackling significant global issues such as climate change, environmental degradation, and the impacts of ageing populations and pandemics, China's strategy for scientific collaboration suggests it will continue to partner with institutions and researchers worldwide to do so.

7 https://www.nature.com/articles/d41586-021-01570-2
8 https://www.science.org/content/article/china-rolls-out-radical-change-its-research-enterprise
9 https://www.nature.com/articles/d41586-023-00744-4

NEW ZEALAND – CHINA SCIENCE AND RESEARCH COLLABORATION

ORIGINS OF SCIENCE AND RESEARCH COLLABORATION

The origins of science and research collaboration between New Zealand and China can be traced back to 1904 when kiwifruit seed was initially brought from China to New Zealand and used to breed the country's first commercial cultivar.[10] During the 1920s and 1930s, a number of professors from Chinese universities made visits to New Zealand, expressing interest in the country's agricultural and horticultural developments.[11]

The first Chinese scientist to work in New Zealand was Professor Li Lairong, who arrived in 1941 and spent three years at the Botany and Plant Diseases Divisions of the Department of Scientific and Industrial Research (DSIR) before returning to China. Professor Li continued to foster collaboration with New Zealand throughout his career, eventually being made an Honorary Member of the Royal Society of New Zealand.[12]

Political and social change and upheaval following the founding of the People's Republic of China in 1949 resulted in limited international engagement. A small number of unofficial visits still took place, including a group that travelled from Christchurch to China in 1956 with an interest in education, archaeology and primary production, facilitated by the Chinese People's Association for Cultural Relations.[13] Among others, P J Alley, the brother of writer and activist Rewi Alley visited China in 1966 to study developments in building, teaching and engineering, despite the ongoing Cultural Revolution.[14]

Following New Zealand's establishment of diplomatic relations with China in 1972 the first official exchanges between New Zealand and China were set up which included scientific contacts and visits between both countries.[15] In 1974 a delegation from the Royal Society of New Zealand visited China at the invitation of the Chinese Academy of Sciences, the first official scientific mission to enter China as it sought to re-establish contacts with Western scientific organisations.

FRAMEWORK FOR SCIENCE AND RESEARCH COLLABORATION

The framework for science and research collaboration between New Zealand and China governments involves national-level agreements and a five-year roadmap process to jointly set priority research areas and agree on new and ongoing initiatives. New Zealand government agencies including the Ministry of Business, Innovation and Employment (MBIE), Education New Zealand (ENZ) and the Health Research Council (HRC) oversee key funding activity and national policy settings.

Key New Zealand organisations collaborating with China in science and research are its Crown Research Institutes (CRIs), universities (including their commercial/research arms), Te Whatu Ora (Health New Zealand), Centres of Research Excellence (CoREs), independent science organisations and publicly listed companies.

Many New Zealand organisations hold numerous institution-to-institution or departmental-level MOUs and other agreements with partners in China, covering different areas of research cooperation such as biological science, computer science, marine science, health science, agricultural science and others.

10 Yunliu Zeng & Xueren Yin (2021) Chinese horticulture: From basic research to industrial applications, New Zealand Journal of Crop and Horticultural Science, 49:2-3, 75-77
11 *The Dominion*, 59/17805, 3 July 1923 and 23/154, 26 March 1930
12 Obituary: Li Lairong (Li Lai-Yung), Reprinted from the Proceedings of the Royal Society of New Zealand, 1991-1995.
13 *The Press*, 93/27938, 9 April 1956
14 *The Press*, 105/31034, 14 April 1966.
15 Anne Marie Brady, New Zealand China Relations: Common Points and Differences, New Zealand Journal of Asian Studies December 2008, p.2

Established centres for collaborative or China-focused research at universities include Waikato University's China-New Zealand Tourism Research Unit, Auckland University's Innovation Institute China, Victoria University's New Zealand Contemporary China Research Centre, and the New Zealand Centre at Peking University which involves all eight New Zealand universities.

In 2001 the New Zealand Chinese Scientists Association was founded and consists of members with PhD degrees working in fields such as science, engineering, agriculture, medicine, business, literature, art, law, education and management. The association organises seminars, research meetings, promotes dialogue between senior and young scientists, and presents awards. It also facilitates mutual visits and research collaborations between New Zealand and China.

New Zealand has also had a science and innovation counsellor at its Embassy in Beijing since 2013, responsible for developing connections with government, science and policy organisations and businesses. China was the third region where New Zealand appointed a science and innovation counsellor, following the US and Europe in 2004.[16]

BILATERAL AGREEMENTS

New Zealand and China's first bilateral agreement in science and research was the 1987 Agreement on Scientific and Technological Cooperation, which set up a framework for cooperation including visits, the exchange of scientific information and materials, joint research, seminars and conferences.[17] The 1987 agreement was renewed in 2003, identifying initial opportunities for research priority areas including animal husbandry, biotechnology and health research.[18]

In 2010 the New Zealand - China Strategic Research Alliance (SRA) was established between New Zealand's then Ministry of Science and Innovation (MSI) and China's Ministry of Science and Technology (MoST). The SRA was set up to expand research and science collaboration and to link education, research and markets, to help ensure that research would result in economic returns.[19]

The first Five-Year Roadmap for New Zealand-China Science and Technology Cooperation was signed in 2012 to refine bilateral priority research areas, identifying Food Safety and Security, Non-Communicable Disease and Water Research as areas to focus collaborative research efforts.

Three New Zealand-China Research Collaboration Centres (CRCCs) were established in 2016 in each of the priority areas to align existing cooperation and build new connections between New Zealand and Chinese researchers and institutions. Each CRCC is hosted by a New Zealand university that partners with CRIs, other New Zealand universities and their subsidiaries, National Science Challenges and independent science organisations. The establishment of these three centres was the first time that collaboration with China was lifted to the national level, with previous work being undertaken at the scientist-to-scientist and organisation-to-organisation level.[20]

The second Five Year Roadmap, signed in 2018, updated the bilateral research priority areas to Food Science, Health and Biomedical Sciences, Environmental Science and Advanced Technology. In 2019, a Memorandum of Arrangement (MOA) Relating to Science and Research Cooperation was signed between MBIE and the Chinese Academy of Sciences (CAS). The purpose of the MOA is greater bilateral science and research collaboration, recognising China as a major contributor to global science.

In May 2023, Chinese Minister of Science and Technology Wang Zhigang visited New Zealand to discuss the third Five-Year Roadmap. During the visit, both countries confirmed their commitment to the long-standing science relationship.[21] In June 2023, the third Five-Year Roadmap was announced during Prime Minister Chris Hipkins' visit to China, retaining the priority areas of Food Science, Health and Biomedical Sciences and Environmental Sciences and discontinuing the priority area of Advanced Technology.[22]

16 https://www.beehive.govt.nz/release/new-science-innovation-counsellor-china
17 Agreement between the Goverment of New Zealand and the Government of the Peoples' Republic of China on Scientific and Technological Cooperation, 18 New Zealand Treaty Series 1988, No. 27, Ministry of Foreign Affairs
18 Agreement between the Goverment of New Zealand and the Government of the Peoples' Republic of China on Scientific and Technological Cooperation, New Zealand Treaty Series 2003, No. 16, Ministry of Foreign Affairs
19 https://www.beehive.govt.nz/release/new-alliance-strengthens-nz-china-science-links
20 MBIE Catalyst funding for the three centres will conclude in early 2024 at the end of their current contracts. This funding will be allocated to other collaborative opportunities with China.
21 https://www.beehive.govt.nz/release/new-zealand%E2%80%93china-science-relationship-affirmed
22 https://www.mbie.govt.nz/assets/china-new-zealand-5-year-roadmap-2023-2027.pdf

COLLABORATING FOR A CURE: DEVELOPING AFFORDABLE CAR T-CELL THERAPY IN NEW ZEALAND THROUGH PARTNERSHIP WITH CHINA

Collaboration between Wellington's Malaghan Institute and Chinese partners is leading to breakthrough cancer treatment and laying the foundation for better health outcomes for New Zealanders, sooner.

CAR T-cell therapy is a type of immunotherapy that uses a patient's own immune cells to fight cancer. It is being hailed as a major breakthrough in treating certain types of haematological cancers, with around a 50% complete response rate against B-cell lymphomas.

For New Zealanders, however, the treatment is not available. In special cases, usually paediatric, it comes with a hefty price tag as patients currently have to travel to Australia and cells need to be manufactured in the United States, bringing total costs to around $1 million per individual.

Thanks to collaboration between the Malaghan Institute of Medical Research and the Guangzhou Institute of Biomedicine and Health (GIBH) to conduct CAR T-cell therapy clinical trials in New Zealand, this could soon change.

The trials were initiated through an existing relationship between GIBH and New Zealand's Maurice Wilkins Centre, of which the Malaghan Institute is a collaborating organisation. Professor Peng Li from GIBH, who developed a new form of CAR T-cell technology, was aware of the work Malaghan had been undertaking in cancer immunotherapy and reached out in 2017 to discuss running clinical trials in New Zealand.

Malaghan General Manager Mike Zablocki says Professor Li had formed a local company, Hunan Zhaotai Medical Group, to commercialise the technology in China and wanted to run trials in a

country with a westernised regulatory environment. A joint venture called Wellington Zhaotai Therapies was then set up between the two parties.

Zablocki says the arrangement shows Malaghan's Chinese partners were after a genuine collaboration with New Zealand rather than a purely commercial transaction.

"They didn't want to just do a fee-for-service arrangement, they wanted a partnership. So we set up a joint venture and licensed essentially all of the IP into this joint venture for all territories outside of China."

Zablocki says that if the trials go as planned, the collaboration will give New Zealanders access to the CAR T-cell therapy through the public health system a decade sooner than if we had to wait in line with the rest of the world.

"It was huge for us because we wanted to bring the treatment to New Zealand, and we knew it was going to take an absolute age if we weren't involved in its development, so partnering with China has given us access to the IP that we now have the freedom to use."

Malaghan has also used a mix of government and philanthropic funding to run the clinical trials. Zablocki says the absence of a commercial investor means there won't be the same pressure to maximise return on investment into the market once the treatment is available.

"So we can basically deliver it at an affordable price point to increase the uptake within New Zealand and ensure it is widely available."

The collaboration has faced challenges during the COVID-19 pandemic, with meetings being conducted virtually instead of in-person. Nonetheless, the collaboration has continued with regular meetings and discussions, and the results of phase 1 trials are expected to be published in mid-2023.

Zablocki says that beyond the current trials, Malaghan already has a number of lab-based collaborations underway with its Chinese partners looking at potential new targets for CAR T-cell therapy.

"There are so many parts of the world crying out for this treatment, and we've now got a really nice system where the early IP is tested and proven in China and New Zealand can play a really strong role. So this could be the start of a really substantial biotech company."

FUNDING OF SCIENCE AND RESEARCH COLLABORATION

New Zealand has a number of key public funding mechanisms specifically established to support collaborative science and research with Chinese partners, as well as general contestable research funding mechanisms which are available for collaborative science and research projects with China. Almost all collaborative projects are based on a co-funding model, with researchers applying for funds in their respective countries.

CATALYST FUND

A major source of New Zealand public funding is the Catalyst Fund, largely administered by MBIE to support strategic research and large-scale pre-research collaborations in targeted areas.

Catalyst funds projects annually under the China Strategic Research Alliance (SRA), one each in the bilateral priority areas of Food Science and Environmental Science, with Chinese partners applying for funding through MoST. New Zealand and China contribute 10 million RMB ($2.3 million NZD) a year for funding under the SRA, split equally between the two countries.[23] Assessment criteria for project applications include the creation of new knowledge, long-lasting partnerships and benefits aligned to the wider economic, social and environmental goals of New Zealand. The Catalyst Fund also provided funding for the NZ China Research Collaboration Centres from 2016.

The Royal Society administers Catalyst funding to support the New Zealand-China Scientist Exchange programme and a seed funding programme for early-stage research projects. The Health Research Council (HRC) also administers $405,000 of Catalyst funding for the 2022 NZ-China Biomedical Research Alliance, a bilateral biomedical research programme between New Zealand and China.

NEW ZEALAND-CHINA TRIPARTITE PARTNERSHIP FUND

In 2005 the New Zealand and Chinese ministries of education agreed to formally support the development of strategic research relationships between higher learning institutions. The New Zealand-China Tripartite Partnership Fund (TPF) connects a New Zealand university with two Chinese universities in an existing partnership programme known as the "Two Brothers" arrangement.[24]

The TPF expands funding for research collaboration between New Zealand and China beyond the priority areas targeted by the Catalyst Fund, supporting projects in the arts, humanities and social sciences, alongside sciences and applied sciences. Since 2012, the TPF has funded joint research including in conservation, minority language preservation, information and media literacy, renewable energy, teacher training and climate change.[25]

OTHER FUNDING SOURCES

A number of other contestable funding mechanisms are also available for collaborative science and research between New Zealand and China, including the Royal Society-administered Marsden Fund and the MBIE-administered Endeavour Fund. Further funding sources

23 Arrangement on a Five Year Roadmap for New Zealand—China Science and Technology Cooperation 2018-2022
24 https://www.enz.govt.nz/assets/E-News-December/2022-Tripartite-Fund-Guidance-and-Call-for-Proposals.pdf
25 New Zealand Tripartite Fund Overview 2012-22 (Education New Zealand)

include grants for businesses to engage with R&D with China, as well as funding from international and multilateral organisations, endowments, investment revenue and philanthropic donations.

CHINESE FUNDING

While co-funding is the dominant model for collaborative research between China and New Zealand, there are circumstances in which Chinese funding directly supports New Zealand researchers.

For example, there are instances in which a Chinese institution has covered travel or accommodation costs for researchers, or funded a New Zealand institution to relieve a researcher of a portion of their teaching duties to allow them to engage in more research collaboration. Another example is when a wholly funded Chinese project has taken on New Zealand researchers to enable it to proceed successfully.

China also provides support for research in New Zealand in the form of scholarships for Chinese PhD students to complete part of their studies in New Zealand. The China Scholarship Council (CSC) is the Chinese Ministry of Education's non-profit organisation that provides support for international academic exchange with China and is the primary vehicle through which the Chinese government awards scholarships.[26]

Although the CSC is not a direct funding source for collaborative research between New Zealand and China, a large number of New Zealand universities and Crown Institutes host CSC students who contribute to their research programmes while in New Zealand. This is seen by universities and Crown Research Institutes as a way to build and enhance their research capacity in the context of constrained funding or resources.

RISKS

Collaboration with overseas partners in science and research also comes with concerns about risk. These include claims the Chinese government has accessed military technology from New Zealand through research funding, student exchanges and other activities.[27] In 2021, Universities New Zealand responded by issuing Trusted Research – Protective Security Requirements (TR-PSR) to help senior university leaders manage and minimise the potential risk of international partnerships while recognising such collaborations are essential to successful research environments.[28]

TR-PSR includes a risk management framework and states that university researchers, research offices, senior management and councils have specific accountabilities to manage potential risk. These include due diligence processes for funding applications and research proposals that involve international collaborators from any country.

For CRIs and other research organisations, applicants for MBIE funding are referred to Trusted Research Guidance for Institutions and Researchers which sits alongside TR-PSR and includes steps to be taken by researchers to protect research and staff from potential theft, misuse, or exploitation.[29]

Researchers and scientists spoken to during the preparation of this report were all aware of the risks associated with projects involving overseas partners, including Chinese partners. A number of them reinforced that processes were in place to identify and assess risks that included assessment by management and senior leaders of organisations.

26 https://cset.georgetown.edu/publication/the-china-scholarship-council-an-overview/
27 https://ojs.victoria.ac.nz/pq/article/download/6826/5974/9558
28 https://www.universitiesnz.ac.nz/sites/default/files/uni-nz/Main%20guide_as%20single%20pages.pdf
29 https://protectivesecurity.govt.nz/assets/Campaigns/PSR-ResearchGuidancespreads-17Mar21.pdf

STRENGTHENING PEST CONTROL MEASURES: A COLLABORATIVE EFFORT BETWEEN NEW ZEALAND AND CHINA TO MITIGATE THE THREAT OF BROWN MARMORATED STINK BUG

Joint research between Plant and Food Research and partners in China into an invasive pest is helping to avoid a multi-billion dollar biosecurity catastrophe in New Zealand.

"To put it simply, it would be our worst nightmare."

As the Science Team Leader of Biological Control & Insect Rearing at Plant and Food Research (PFR), Gonzalo Avila is serious about the brown marmorated stink bug (BMSB) and the havoc this pest would wreak on our horticulture industry.

Native to China, Japan and Korea, the BMSB is now a global problem, having spread to Europe, Eurasia and the Americas. In the United States, it has caused billions of dollars in damage to horticulture and agriculture since it was accidentally imported in the late 1990s.

New Zealand could well be next. Recent data shows live BMSBs have been detected at the border in a range of goods, equipment, and cargo. Avila says the economic impact would be catastrophic if the pest breaches our borders and becomes established in New Zealand.

"It will heavily impact everything, and no one will escape from it....Kiwifruit, apples, wine, every vegetable you can imagine will be impacted as well."

The good news is that, unlike other regions, we've had time to plan and prepare for its arrival. This includes a BMSB Council set up in 2017 under the Government Industry Agreement for Biosecurity Readiness and Response (GIA). The Council is a formal partnership between the government and the horticultural industry, with an Operational

Agreement (OA) that outlines the readiness and response activities to be undertaken, how decisions are made, and how activities are funded.

PFR's collaborative research with China is one of these key activities. Because the BMSB has a number of natural enemies in China, scientists worldwide have partnered with Chinese researchers to identify insect biocontrol agents - beneficial insects used to control pests - to manage and limit damage from BMSB in their own countries. Chief among these is the parasitoid Trissolcus japonicus, commonly known as the samurai wasp. Despite its intimidating name, the samurai wasp is harmless to humans and has recently started to be deployed in the US and some European countries to help control BMSB.

Avila made connections with Chinese researchers in late 2017, establishing a relationship with the Centre for Agriculture and Bioscience International (CABI) China and the Institute of Plant Protection (IPP) at the Chinese Academy of Agricultural Sciences (CAAS). Alongside Chinese researchers, Avila has been conducting laboratory and field work to assess how effective the samurai wasp would be in New Zealand, as well as determining optimal release numbers and frequency to avoid economic damage.

"It's one thing to do laboratory experiments in a petri dish, but it's very different to see it performing in the wild. That's why it is really important to study how it actually works in the environment in China, not just in the laboratory setup."

The risk assessment involved in introducing a new biocontrol agent into New Zealand is understandably a rigorous one. Avila says a comprehensive research package has been developed for the samurai wasp, as part of a pre-emptive biocontrol research programme started for BMSB in late 2015, including the economic benefits of its introduction and bioclimatic modelling to ensure its distribution will cover areas affected by BSMB and not threaten New Zealand's native stink bugs.

But the risk of letting BSMB to establish and spread in the country is obviously greater. In what is a world-first, New Zealand's Environmental Protection Authority approved in 2018 (under strict controls) the release of the samurai wasp as part of an eradication programme, in the event of a BMSB incursion. Research on BMSB and the samurai wasp in China has continued since then in order to keep improving NZ's biocontrol preparedness for BMSB, and Avila believes this shows the importance of his research collaborations with China to ensure New Zealand is ready.

"Usually, a biocontrol agent is only brought in after a pest has become established and eradication has failed. The problem is that by this time, the pest has already spread. The benefit of pre-emptive biological control is that we can select, screen, and pre-approve the most promising biocontrol agent of a target pest before its arrival, so we can be ready to press the red button as soon as the pest arrives in the country."

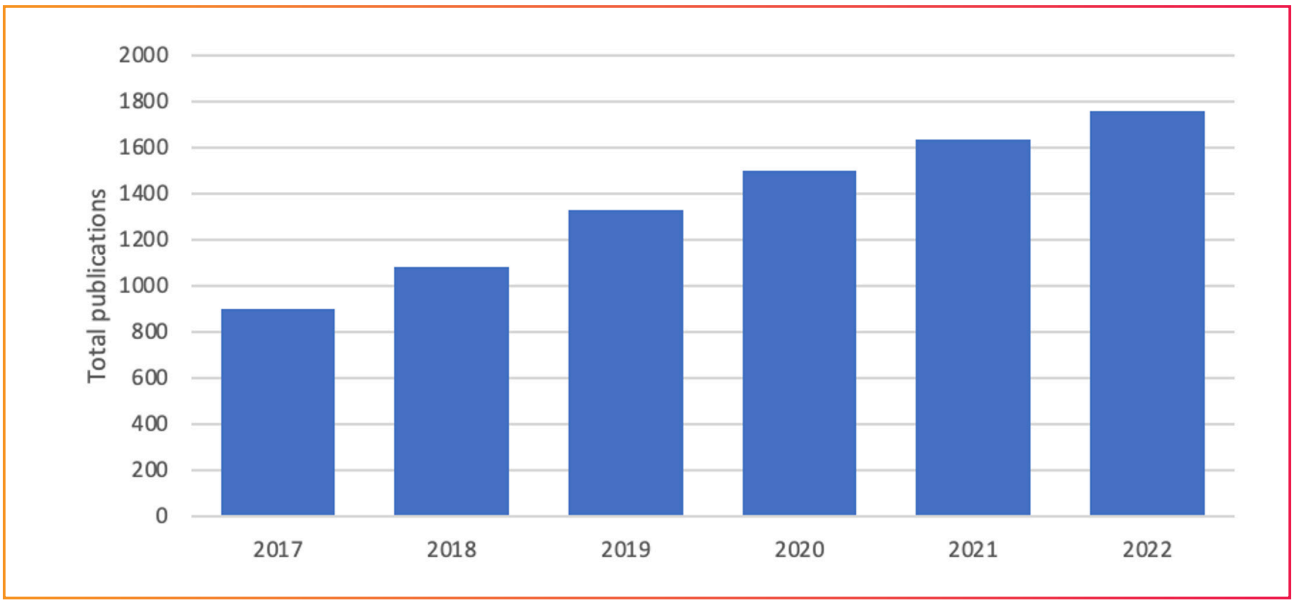
Avila is now hoping to continue collaborating with his Chinese partners on a new project to advance the global fight against BSMB. This will involve artificially rearing samurai wasps in a lab by mimicking BSMB eggs with man-made ones.

"Recreating an artificial stink bug egg is something no one has tried before. We'll be doing actual rocket science with this one - if it gets funding, it's going to be very, very interesting."

SCALE OF NEW ZEALAND – CHINA SCIENCE AND RESEARCH COLLABORATION

Figures from Scopus, an international database of peer-reviewed research, allow a broad analysis of how many publications with authors from New Zealand include co-authors from other countries. This bibliometric approach provides an indication of the scale of New Zealand's science and research with China, with the caveat that the methodology has limitations, including underrepresentation of the humanities disciplines.[30]

Figure 1: Total number of publications per year with New Zealand and China co-authors



The figures show that the total number of publications featuring New Zealand-China co-authors almost doubled between 2017 and 2022, increasing from 898 to 1761 (Figure 1). The proportion of all New Zealand publications which feature Chinese co-authorship also increased over this time, from 7.7% to 11.6%, a relative increase of 51% (Figure 2).

30 *The Australia - China science boom*, James Laurenceson and Michael Zhou, Australia - China Relations Institute, July 2020.

Figure 2: Proportion of NZ-China publications as a proportion of NZ total publications

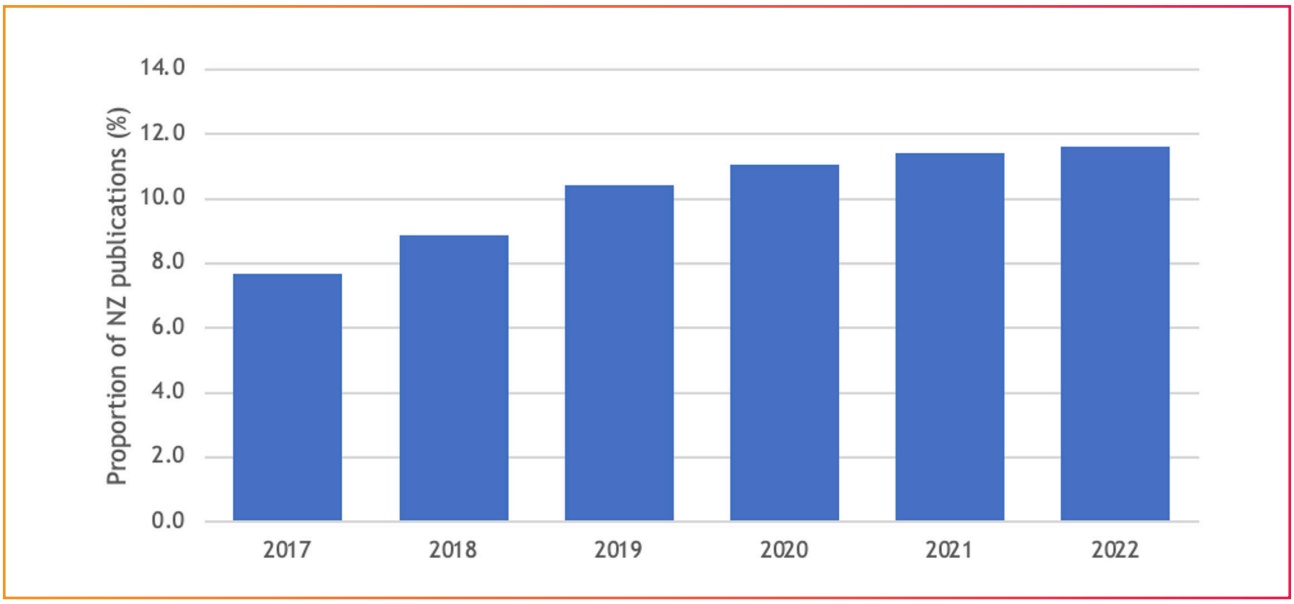
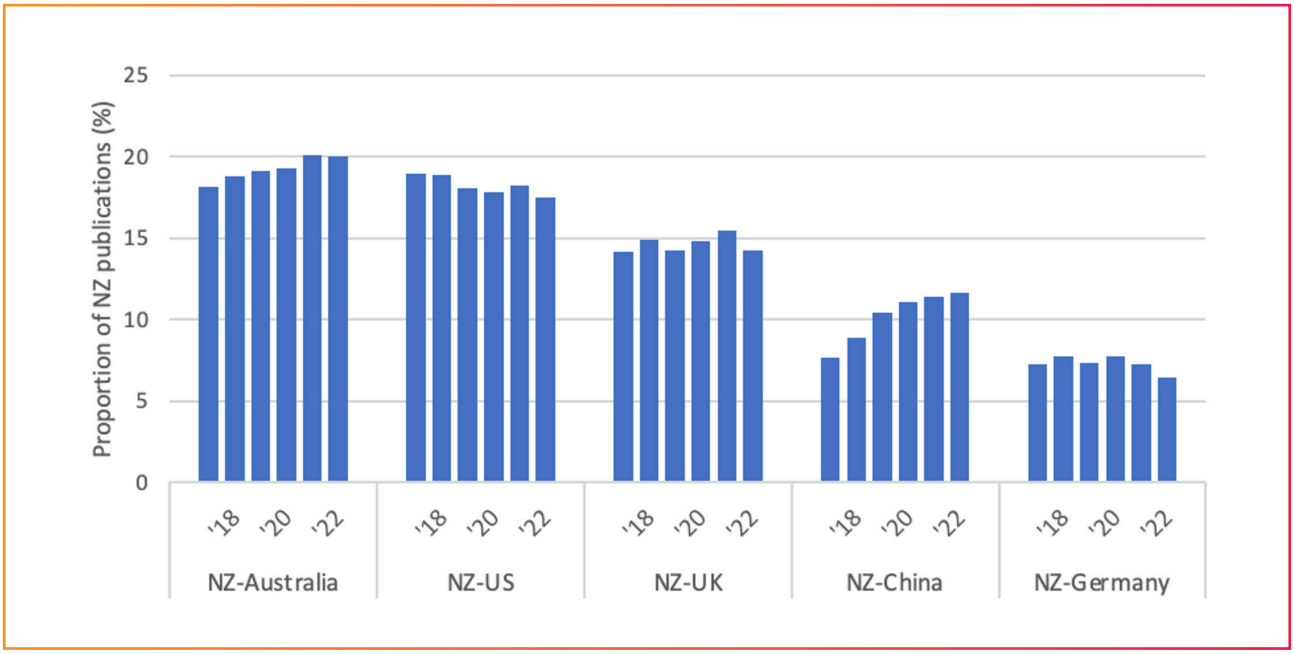


Figure 3 shows China now ranks fourth as New Zealand's international research partner, behind Australia (20%), the US (17.5%) and the UK (14.2%). This is a ranking increase compared to a 2016 report from MBIE which showed China ranked sixth.[31] The figures also show that China was the only major research partner where the proportion of co-authored research increased from 2021 to 2022, rather than declined.

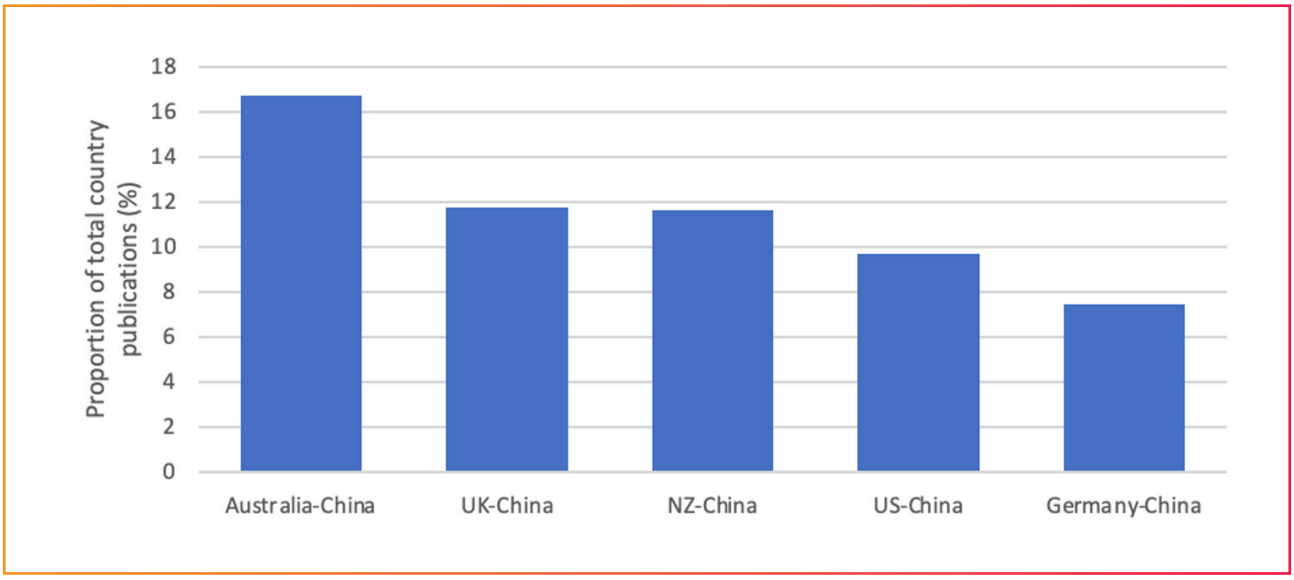
Figure 3: Proportion of total NZ publications featuring collaborating country, 2017-2022



31 https://www.mbie.govt.nz/assets/5794b50a6f/2016-science-and-innovation-system-performance-report.pdf

Comparing New Zealand's level of collaboration with China in science and research with our major international research partners provides an indication of the intensity of our research engagement. Figure 4 shows Australia ranks first, with 16.7% of total publications including China co-authors. The UK ranks second (11.8%), followed by New Zealand (11.6%), the US (9.7%) and Germany (7.4%).

Figure 4. Number of publications with China per country as a proportion of country total, 2022



The Scopus database also includes information about publication research areas, linked to 27 subject areas. Table 1 shows Physics and Astronomy is the subject area where NZ researchers collaborate the most with China, in relative terms. Of all NZ publications in this area (776 in 2022), 29.0% featured China co-authors. As shown in column 1 of Table 1, this is followed by Materials Science (28.1%), Energy (24.2%), Chemical Engineering (23.5%), and Chemistry (23.1%).

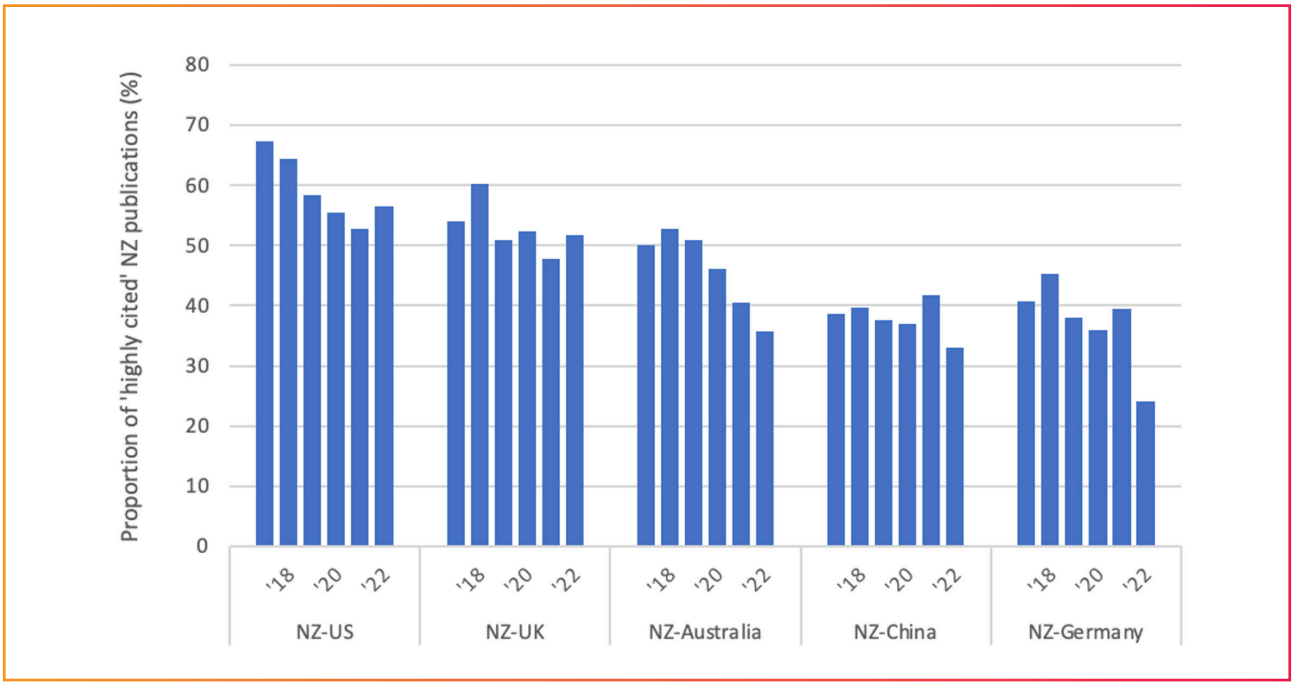
Table 1: NZ-China joint research in 2022 (by proportion of total NZ and China publications per subject area) vs NZ and China research in 2022 (by proportion of global publications in subject area)

Subject area	NZ-China publications as a proportion of total NZ publications (%)	NZ-China publications as a proportion of total Chinese publications (%)	NZ share of global publications (%)	China share of global publications (%)
Physics and Astronomy	29.0	0.2	0.2	38.9
Materials Science	28.1	0.1	0.2	43.6
Energy	24.2	0.1	0.2	43.9
Chemical Engineering	23.5	0.1	0.2	43.6
Chemistry	23.1	0.1	0.2	40.8
Engineering	22.6	0.2	0.3	43.3
Computer Science	21.7	0.2	0.3	35.5
Decision Sciences	15.6	0.3	0.5	26.0
Pharmacology, Toxicology and Pharmaceutics	15.1	0.1	0.3	30.3
Mathematics	14.4	0.1	0.3	31.8
Environmental Science	13.9	0.2	0.6	36.2
Earth and Planetary Sciences	13.8	0.3	0.8	38.3
Agricultural and Biological Sciences	13.6	0.4	0.9	30.5
Biochemistry, Genetics and Molecular Biology	13.5	0.2	0.5	32.1
Immunology and Microbiology	13.0	0.2	0.5	30.6
Dentistry	13.0	0.6	0.4	10.1
Economics, Econometrics and Finance	12.4	0.8	1.1	16.3
Multidisciplinary	10.9	0.3	0.7	21.2
Business, Management and Accounting	8.3	0.6	1.2	16.1
Psychology	7.6	0.6	0.9	11.4
Neuroscience	7.0	0.1	0.5	26.0
Arts and Humanities	6.7	0.8	0.6	4.8
Medicine	6.4	0.2	0.6	19.3
Veterinary	6.1	0.3	0.8	15.2
Social Sciences	6.1	0.5	0.9	10.0
Nursing	5.8	0.4	0.8	11.9
Health Professions	4.4	0.4	1.0	11.8

Alongside the data from Scopus, Web of Science is a research database that also indexes scientific publications and includes data on author country of residence. Web of Science also identifies high impact 'highly cited' articles. These are papers that perform in the top 1% based on the number of citations received when compared to other papers published in the same field in the same year, giving an indication of the quality as well as the quantity of research.

Figure 5 shows that in 2022, New Zealand researchers were co-authors on 182 articles categorised as 'highly cited' by Web of Science.[32] In terms of collaboration on these publications, we see that China is again ranked fourth as an international research partner (33.0% of NZ's 'highly cited' articles co-authored with China researchers), behind the US (56.6%) and the UK (51.6%), and Australia (35.7%), and ahead of Germany (24.2%).

Figure 5. Proportion of NZ 'highly cited' publications including co-authors from other countries, 2017-2022



In contrast to Figure 3, we see that the US and UK rank ahead of Australia as research partners on high-impact research. When it comes to 'highly cited' papers featuring NZ researchers, collaborations with the US, UK, and Australia are more common than those with China.

It also appears that NZ collaborations in highly cited papers with the US, Australia, and Germany have declined over the last six years, while collaboration with the UK and China has remained more stable. However, New Zealand-China collaborations declined from 41% of all New Zealand highly cited papers in 2021 to 33% in 2022.

32 Across all years, the total number of New Zealand 'highly cited' publications ranged from 146 to 216.

SUSTAINABILITY MEETS FOOD SAFETY: NEW ZEALAND-CHINA JOINT RESEARCH DEVELOPING BIOSENSOR TO ENSURE FRESHNESS IN FOOD

Scion Research's Yi Chen is developing a new biosensor packaging label that will not only detect freshness in seafood and communicate with customers - it will also be completely biodegradable.

Seafood exports are a vital industry for New Zealand, with more than 80 countries importing $2 billion worth of our products annually, which are renowned for their freshness, quality and sustainability.

Underpinning this valuable source of export revenue and employment is New Zealand's trusted reputation for exacting quality standards. But maintaining our position as a world leader, particularly in premium seafood markets, is no easy matter.

One major challenge is New Zealand's distance from key export markets. Any delay or disruption to our supply chains can have serious impacts, leading to spoiling, wastage and economic losses.

"These products are all high value, and as we've seen though Covid, there can be long waiting times and shipment times which can be a big problem for fresh seafood and other meat exports."

It's here that smart packaging technology is gaining attention for its ability to measure and let customers know their food is fresh. While biosensor technology in packaging isn't new, its high-cost and use of trace metals have acted as barriers to industry uptake in the past.

This may now be about to change. Yi Chen, an expert in biodegradable electronics at Rotorua-based CRI Scion Research is leading a team developing a sustainable biosensor derived from natural carbon materials which can measure

specific gases present in seafood to determine their freshness and quality.

Funded by the New Zealand-China Food Protection Network, Scion is partnering with Plant and Food Research, Auckland University of Technology (AUT) and Zhejiang University in Hangzhou, China to develop the first prototype. The connection with Zhejiang, an internationally recognised leader in food biosensor technology, gives the team access to China's expertise as well as links to industry supply chains so they can undertake trials more easily and receive direct feedback.

"As a New Zealand research organisation, it can be hard to establish contacts with supply chains within China. So having key collaborators in the country, they have that already. It's very important to try all these things in real life."

The involvement of AUT also gives New Zealand students valuable experience in developing technology for industry, and aims to generate further collaborations under the umbrella of the New Zealand-China Food Protection Network.

Yi says that while collaboration with Chinese partners is critical to the success of the project, it's still very much a New Zealand industry driven innovation.

"There are biosensors in Europe and other regions, but they're not built for New Zealand's premium exports or the demands for freshness that come with those. Maintaining our reputation for food quality despite our long supply chains is a unique challenge, and that's what we're tackling here."

FOCUS AREAS OF SCIENCE AND RESEARCH COLLABORATION

FOOD SCIENCE

Food safety and security is a large and established area of New Zealand-China science and research collaboration. The New Zealand-China Food Protection Network, hosted by Massey University, plays a national coordination and funding role while CRIs and other universities are involved across a wide range of projects. The high level of collaboration in this area reflects our long-standing trade linkages with China, underpinned by New Zealand's exports of primary food products.

AGRICULTURE

With China taking a large share of New Zealand's meat and dairy, a significant amount of research is conducted in both countries to support exports from New Zealand, as well as New Zealand's operations on the ground in China. Academic collaboration also takes place between researchers at New Zealand universities and CRIs and Chinese partners to advance understanding of livestock biology and genetics in both countries.

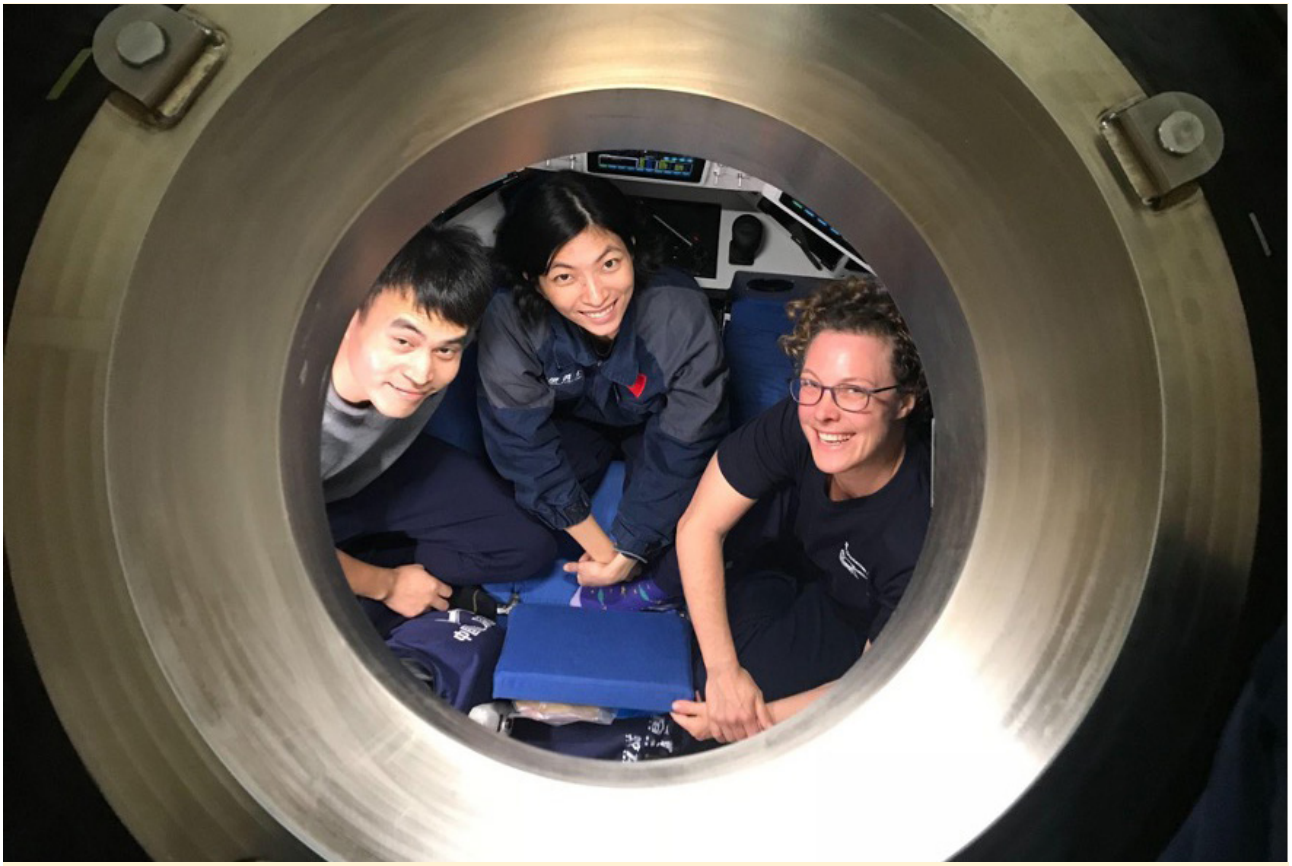
The development of China's dairy industry over time has opened commercialisation opportunities to match New Zealand's scientific capabilities with the needs of industry partners in China. AgResearch, one of New Zealand's largest Crown Research Institutes, proactively entered the China market in 2015 and announced a joint international research centre the following year. AgResearch now has around 30 different collaborations in China in two key areas: the commercial provision of science consultancy services as well as academic collaboration.

Science consultancy services are provided by AgResearch to major Chinese food companies including Yili, Bright Dairy and New Hope, leveraging the scientific knowledge and skills developed over time in New Zealand to support new research activities. Academic collaboration is carried out in partnership with the Chinese Academy of Agriculture Sciences (CAAS), other major research institutes and universities in areas of mutual benefit: rumen microbiology, pest control, meat packaging and food safety microbiological controls. AgResearch has also carried out market research with partners in China into consumers' preferences for fermented dairy foods and fermented meat products.

A number of New Zealand universities have engaged in collaborative agricultural research with China for several decades. Lincoln University, whose Gene-Marker Laboratory was the first in the world to develop and commercialise DNA tests for identifying superior animals was established in part using technology created by a Chinese PhD studying at Lincoln in the 1990s. Collaboration between scientists at Lincoln and Chinese institutions has since focused on sheep, cattle and goats that produce cashmere fibre. In all three species, the emphasis is on understanding the genetics of production-limiting diseases, as well as improving the efficiency of production systems in both countries.

Dairy co-operative Fonterra has had a presence in China for more than 40 years, and now operates research and development "application centres" (FACs) in Wuhan, Guangzhou, Shanghai, Beijing and Chengdu, as well as a Shanghai innovation centre. These centres are part of a network linked to Fonterra's Research and Development Centre (FRDC) in Palmerston North, with teams in New Zealand and China working closely to research and develop products in line with changing market needs.[33]

33 https://www.nzherald.co.nz/the-country/listen/updated-fonterra-application-centre-opened-in-guangzhou/LCFOVERNODUHHWHDS6DZMRVSA4/



EXPLORING THE DEPTHS: A JOINT NEW ZEALAND-CHINA RESEARCH EXPEDITION IN THE KERMADEC TRENCH

Stretching over 1,000 kilometres in length and reaching a depth of 10,047 metres, the Kermadec Trench is one of the deepest oceanic points on Earth and is recognised as potentially important for its marine biodiversity. But despite sitting entirely inside New Zealand's Exclusive Economic Zone, our knowledge of the trench remains limited.

Ashley Rowden, Principal Scientist - Marine Ecology at New Zealand's National Institute of Water and Atmospheric Research (NIWA) says there are strong scientific and environmental imperatives to improve our understanding of the trench, including its potential role in carbon sequestration.

"If we want to understand our marine environment, we have to look in that trench. In terms of the coverage of New Zealand's seafloor, it's around 15%, the same as our continental shelf. It's a very large and important marine habitat about which we know next to nothing."

The challenges and costs of operating in such a deep and remote location mean almost all of New Zealand's research into the Kermadec Trench has come off the back of international voyages. Since 2007 NIWA has collaborated with British, American and Danish-led teams, leveraging their technology and equipment to obtain samples and other data.

In 2021, the Director of China's Institute of Deep-Sea Science and Exploration (IDSSE) approached NIWA with a proposal to conduct a two-month joint voyage to the trench. Due to resource constraints in New Zealand, all costs were borne by IDSSE, which also agreed to split the voyage into two month-long trips to accommodate the preferences of the New Zealand researchers.

Rowden says the key benefit of collaborating with IDSSE was having access to the deep ocean submersible, Fendouzhe, the deepest diving scientific submersible in the world. This allowed New Zealand researchers to see the trench environment first-hand rather than using a camera on a remotely operated vehicle.

"You look at things very differently when you see them in real life, as opposed to looking at a video. That allowed us to increase our perception of the environment which was fantastic. This is a tool worth millions of dollars and is something New Zealand would simply not be able to attain."

Using the submersible also allowed a large volume of samples to be obtained more easily than the traditional, time-consuming method of physically dropping sampling devices like grabs and corers to the ocean floor to catch sediment and organisms.

"You have to wind down a wire which takes at least three hours, and at least three hours to wind back. If your sample has failed, you've wasted six hours. Taking a submersible to the bottom allows you to pick and choose samples, and bring them back up intact and relatively undisturbed. It's extraordinary and offers completely new insights."

Rowden says IDSSE was open to NIWA conducting its own specific research and experiments throughout the voyage, open to NIWA keeping samples in New Zealand for analysis and open to sharing data after the voyage.

The next step in the collaboration is a post-voyage workshop to develop a plan for processing the samples. With the discovery of species new to science likely numbering in the hundreds, Rowden expects the process of describing them, analysing their genetics and publishing the results to take many years, if not decades.

NIWA also aims to sign an MOU with IDSSE which covers new research into sea canyons and in the Antarctic, as well as continuing the work in the Kermadec Trench and other trenches worldwide. Rowden says there is good scope for future collaboration with China that matches our scientific interests and expertise with China's capacity to fund tool development, as well as its larger pool of human resources to process samples quickly.

"We have incredible marine scientists in New Zealand but we don't have deep-sea capability like submersibles that can reach the ocean floor. Collaborations between New Zealand and Chinese institutes in the future will be about access to those tools, and access to people so we can get more things done."

HORTICULTURE

Much like agriculture, scientific collaboration with China in horticulture has grown steadily over time as the country has become an increasingly important market for New Zealand's fruit and vegetable exports.

Horticulture-focused CRI Plant & Food Research has a strong tradition of collaboration with China, undertaking science and research collaboration in 11 Chinese provinces, and commercial activities with Chinese companies in three provinces. Plant & Food Research's key science partnerships in China cover a variety of fruit crops and focus on plant protection, genomics, colour, breeding and other activities. Significant partners include CAS and CAAS institutes, and universities including, Northwest A&F University, Nanjing Agricultural University and Sichuan Provincial Academy of Natural Resource Sciences. Collaboration platforms such as the China-New Zealand Belt and Road Joint Laboratories on Kiwifruit in Sichuan province and China–New Zealand Joint Apple Research Centre in Shaanxi province have also been established.

Plant & Food Research regularly sends New Zealand-based employees to China, hosts Chinese research visitors in New Zealand, and co-publishes a large number of scientific papers with Chinese partners each year.[34] Current research projects include investigating aspects of the biology and impacts of the brown marmorated stink bug (BMSB) in kiwifruit, as well as the biology and performance of its most promising biocontrol agent (samurai wasp) in order to enhance biocontrol preparedness of New Zealand's horticultural industries against BMSB (see case study on p.14), and a two-year collaboration to study the potential impacts of climate change on biological control systems.

PACKAGING COMPLIANCE AND PERFORMANCE

Other collaborative research areas being driven by New Zealand's food exports to China include food contact packaging regulatory compliance as well as performance in the supply chain. Research in these areas aims to help exporters with overcoming supply chain, logistical, transportation and regulatory issues to ensure products arrive at the export markets in great condition.

Ongoing changes to China's regulations for food-contact packaging, including the use of food-contact materials such as plastics, rubber, inks, and adhesives have presented unique challenges for New Zealand exporters. In response, Rotorua-based CRI Scion, formerly the New Zealand Forest Research Institute, has worked with the New Zealand China Food Protection Network (NZCFPN) to establish a platform for knowledge exchange to help local stakeholders understand how changes impact them and the necessary steps required to gain compliance.

In 2018, a Scion researcher spent a week in China with a Chinese food contact compliance expert from Jinan University as well as visiting the Guangzhou Customs District Technology Center (IQTC) National reference laboratory for food contact material (FCM). The compliance expert subsequently visited New Zealand to give a seminar on Chinese food contact requirements to interested parties from industry and academia at Scion. Because of this work, Scion was able to develop a network of expert contacts in China which acts as a valuable source of information for industry stakeholders in New Zealand regarding ongoing packaging-related issues.

34 See for example Chen J, Avila GA, Zhang F, Guo LF, Sandanayaka M, Mi Q-Q, Shi S-S, Zhang J-P 2020. Field cage assessment of feeding damage by Halyomorpha halys on kiwifruit orchards in China. J Pest Sci 93: 953–963.

Scion is also leading a project funded by the NZCFPN in partnership with Zhejiang University (Hangzhou, Zhejiang) to develop a low-cost and biodegradable sensor label for seafood freshness detection (see case study p.21). Another collaboration in the quality assurance space is being led by the University of Otago in partnership with Xi'an Jiaotong-Liverpool University and Renmin University, looking at intercultural labour relations and their impact on food assurance practices in different countries.

ENVIRONMENTAL SCIENCE

Collaboration between New Zealand and China in water and environmental sciences has been undertaken for several decades. Joint research in this area now encompasses water quality and conservation, deep sea exploration, climate change, pest control, beneficial insects and seismology.

WATER AND SOIL

The New Zealand China Water Research Centre, hosted by Lincoln University, includes AgResearch, Landcare Research, Plant and Food Research, Lincoln Agritech, and The University of Otago. It aims to coordinate and facilitate long-term collaborations between New Zealand and Chinese scientists in the areas of water quality and quantity, and mitigation of water contamination by agrichemicals, greenhouse gas emissions and climate change.

The Centre has spent a number of years identifying key partners in China based on their specific expertise, as well as identifying key issues of mutual interest and concern. This means joint funding applications can be made that target research of particular benefit to New Zealand as well as China. One area of focus for the Centre is developing closer collaboration between China and Māori as significant landholders and exporters. This has involved bringing Chinese scientists to visit Ngāi Tahu-operated dairy farms and facilitating dialogue.

Recent collaborative research projects with Chinese partners include a study into the mitigation of nitrate leaching into waterways, comparing losses with grazing systems in New Zealand to indoor farming systems in China. With New Zealand increasingly adopting housed practices for livestock and China also using grazing systems, creating and sharing this information and research can benefit both countries.

Another area of research is phosphorus losses from farms. Limiting the amount of phosphorus and nitrogen from farm effluent can improve water quality and prevent eutrophication. In New Zealand, phosphorus is often limited in inland water bodies, but phosphorus losses from dairy effluent can contribute to eutrophication, which leads to excessive plant and algal growth and can poison fish and other water life. Joint research is attempting to study, quantify and mitigate phosphorus losses from farms.

A third area of collaboration is nitrous oxide greenhouse gas emissions from farms, and the importance of identifying the different microbes involved in the process in order to mitigate the emissions. The study of bacteria using DNA sequencing is required, and China has expertise in this area. Several PhD students have been partially funded by the Water Research Centre and have benefited from being supervised by Chinese experts, resulting in successful research outcomes and joint publications.

COLLABORATIVE INNOVATION IN CANCER THERAPY: NEW ZEALAND-CHINA JOINT RESEARCH ON TUMOUR-TARGETED THERAPEUTICS FOR SMOKING-RELATED LUNG CANCER

Biomedical researchers in Auckland and Guangzhou are developing an innovative tumour-targeted therapeutic that could improve the quality of life for cancer patients all over the world.

The Auckland Cancer Society Research Centre (ACSRC) is the country's acknowledged heavy hitter in cancer drug development. Its reputation is driven by staff like Associate Professor Jeff Smaill, who has led drug discovery programmes in collaboration with partners in New Zealand and overseas for almost 30 years.

During a 2012 trip to Guangzhou led by Professor Peter Sheppard from the University of Auckland, under the auspices of the Maurice Wilkins Centre (one of New Zealand's national Centres of Research Excellence), Smaill and his ACSRC cancer biology collaborator Associate Professor Adam Patterson visited the Guangzhou Institutes of Biomedicine and Health (GIBH). There they met Professor Ke Ding, one of China's leading medicinal chemists in the space of anti-cancer drug design. The parties found they shared professional interests including a focus on the same class of molecules, and soon formed a collaborative working relationship.

"The group in Guangzhou were kindred spirits, in terms of the type of science we do. We had very similar interests in the types of cancer targets we were seeking, the drugs and the types of approaches we might use."

Smaill and Patterson had previously developed a technology to selectively release compounds into

tumours, avoiding some toxicities associated with drugging normal tissues often seen with traditional chemotherapies. They were seeking to extend their approach to a second example and had chosen a cancer target to address called the fibroblast growth factor receptor (FGFR), prevalent in 7% of all cancers and of particular importance in up to 20% of patients with smoking-related lung cancer.

But with overseas competitors also working on FGFR inhibitors and a long development process ahead of them, Smaill and Patterson needed to collaborate to retain their competitive advantage. They turned to Professor Ding and convinced him to help take the project forward.

"It's quite difficult to do drug discovery in New Zealand from scratch in isolation. You have to build quite a big team, and it can take quite a long time. We knew we had competition all around the world, and that's challenging in terms of intellectual property generation. So we convinced Professor Ke Ding that this was a target we thought was worth getting after."

With an MoU signed between the ACSRC and GIBH and funding from the Health Research Council of New Zealand and the NZ-China Strategic Research Alliance, work began on what Smaill describes as a "fully integrated collaboration" with chemistry and biology being carried out in both countries, and molecules being exchanged between centres and tested to identify active compounds.

"They had expertise in some regards that we didn't, they had the infrastructure and ability to put a lot of chemistry resources into the project. They had a lot more PhD students than we had, a lot more people on the ground and a lot more funding. So they were able to gear up pretty quickly."

A commercialisation and collaboration agreement was signed between the two organisations, and in 2020 a pharmaceutical company in Guangzhou was found to take an FGFR-targeted compound from the collaboration, called LX-132, to clinical trial in China. Despite Covid slowing down the process, Smaill expects Phase 1 trials to start at the end of 2023, and hopes the drug can be ready for the market by 2027.

Smaill says working with Chinese partners in addition to collaborating with scientists in Europe and the US adds value by opening up more opportunities for dual funding and giving New Zealand-based researchers a wider network of contacts to help advance new projects.

"It's having a fantastic impact and providing great clinical opportunities for New Zealand patients. I'm really proud of the fact that we've opened doors, and other people have come through those doors and started up some really great science. And I only see it getting better."

MARINE SCIENCE

New Zealand's National Institute of Water and Atmospheric Research (NIWA) has collaborated with Chinese partners since 2018. With funding from the New Zealand-China Strategic Research Alliance, it has partnered with China's Institute of Oceanology, Chinese Academy of Sciences (IOCAS) to research seamounts and hydrothermal vents in the Western Pacific Ocean. This involved advising on the design of a survey of the ocean floor and holding workshops in New Zealand to jointly collate and analyse data. The knowledge gained about the role of seamounts at regional scales has important implications for understanding the distributions of biodiversity, its resilience and possible recovery if damaged by human activities and identifying areas that could be important for protection.[35]

More recently, NIWA has collaborated with China's Institute of Deep Sea Science and Engineering (IDSSE) on a joint voyage to survey biodiversity in the Kermadec Trench, enabling NIWA scientists to gain new valuable knowledge about one of Earth's deepest oceanic trenches that sits almost entirely within our New Zealand's Exclusive Economic Zone (see case study p.24).

The University of Auckland has also been working to establish collaboration with Chinese universities in the field of marine science. These include Zhejiang University, one of the University of Auckland's strategic university partners, and Shanghai Ocean University. Still in the early stages, work is focussed on identifying common areas of interest and has included a research workshop for researchers in both countries on 'blue carbon', or carbon stored in coastal and marine ecosystems.

Marine science expertise at the University of Auckland and Chinese universities are also considered to be complementary. While Auckland has strengths in marine ecology and conservation, China has advanced expertise in marine engineering. This presents the opportunity for New Zealand researchers to leverage their knowledge and support the sustainable development of marine environments in China.

OTHER AREAS OF RESEARCH

Crown Research Institute GNS Science has collaborated with Chinese researchers in areas including carbon capture and sequestration, the authentication of bioplastics, and more recently in the field of earthquake forecasting.

Relationships have been established with the China Earthquake Administration (CEA) and the Institute of Geology and Geophysics at the Chinese Academy of Sciences (IGGCAS) with the aim of testing New Zealand's forecasting models in China. Because New Zealand's seismic models improve the more they are tested against real-world observations, China's large number of quakes and seismically active areas present a significant opportunity to enhance our forecasting capabilities.

Landcare Research is a Crown Research Institute that focuses on environmental sustainability and biodiversity. Under the China Scholarship Council (CSC) programme, the institute regularly hosts visiting Chinese researchers who work on projects that are of economic value to New Zealand. Recent projects have included the examination of viruses affecting honeybees and the publication of a comprehensive reference book identifying beneficial

35 https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/catalyst-fund/funded-projects/catalyst-strategic-new-zealand-china-joint-research-partnerships-2020-2021/

insects that support biocontrol practices in New Zealand.

HEALTH AND BIOMEDICAL SCIENCES

Collaboration in health has grown steadily over the past twenty years to encompass population health, non-communicable and infectious diseases, drug discovery and the use of Traditional Chinese Medicine (TCM), including its relevance to the integration and sustainability of rongoā Māori within New Zealand's health system. Recently funded projects demonstrate the wide range of research being carried out in health, such as the use of TCM for treating tinnitus, and the development of a new smart oral delivery system for peptides and proteins that could allow diabetes patients to produce insulin without the need for frequent injections.

Key organisations involved in collaborative health research are universities and their associated health research centres, public health agencies, research networks such as the Maurice Wilkins Centre, New Zealand-China Non-Communicable Diseases Research Collaboration Centre (NCD CRCC) and independent organisations such as the Malaghan Institute.

NON-COMMUNICABLE DISEASES

The NCD CRCC, hosted by Otago University, is a national network that builds and strengthens non-communicable disease (NCD) research partnerships that mutually benefit New Zealand and China. Priority research areas include critical health issues facing both countries, such as heart and brain diseases, cancer and diabetes, and the modernisation of TCM with relevance to these conditions.

The Centre has formed high-level relationships in China and now has fourteen MoUs with Chinese universities and health institutions based on specific research objectives and programmes. Key partners are the China National Center for Biotechnology Development and the China Scholarship Centre, and activities include workshops, seminars and scholarly exchanges.

Two focus areas of health research collaboration for the NCD CRCC are the modernisation of TCM, and brain research. In 2019, the NCD CRCC provided funding for the School of Pharmacy at the University of Otago to collaborate on the modernisation of TCM with researchers from the School of Pharmacy at Chengdu University of Traditional Chinese Medicine (CUTCM), China. The project aims to develop improved bioactivates and formulations with increased activity and reduced toxicity using cutting-edge techniques. A new Bachelor of Pharmaceutical Science degree at Otago sees students spend part of the course at CUTCM, ending up with a degree from both institutions.

Brain research has been a priority research area for NCD CRCC since it was formed, and the centre now has established collaborations with institutions in China including Fudan University Huashan Hospital Shanghai and Shanghai Mental Health Center, China. Current projects that have received funding from both New Zealand and China are focussing on Huntington's disease, artificial intelligence and Parkinson's disease, Alzheimer's disease, and schizophrenia.

REVITALISING A MINORITY LANGUAGE: NEW ZEALAND-CHINA JOINT RESEARCH SHEDS LIGHT ON THE MIAO LANGUAGE IN CHINA

Massey University researchers are collaborating with Beijing Jiaotong University and Guizhou University to help revitalise a minority language in China, and by doing so are building knowledge to help tackle the loss of endangered languages worldwide.

The Miao are a group of linguistically-related peoples living primarily in southern China's mountains. Commonly known in the West as the Hmong, the Miao in China are experiencing a significant decline in their language due to the prevalence of Mandarin, along with demographic changes and other factors.

Mingsheng Li is originally from Yunnan province and now an Associate Professor at Massey University's School of Communication, Journalism and Marketing. With a keen interest in language preservation, he identified an opportunity to research the extent of decline in the Miao language in Guizhou province as well as identifying strategies and approaches to avoid its disappearance.

"The disappearance of language means the disappearance of culture. UNESCO has called for the preservation and protection of endangered languages, and we found Guizhou to be an ideal location to study as 40% of people live in rural areas, mainly ethnic minorities, and Miao is the largest ethnic group in the province."

The project was made possible with support from the New Zealand-China Tripartite Partnership Fund, which partners a New Zealand university with two Chinese universities in a 'three brothers' arrangement. Working with Beijing Jiaotong University and Guizhou University, Mingsheng and

his team have undertaken a major survey of Miao language in Guizhou to quantify the number of native speakers remaining in the province.

The survey was designed at Massey, with Minsheng advising Chinese partners on how to carry out the research, collect and analyse the data. The results have confirmed his hypothesis that Miao language is endangered in Guizhou, with just 5.5% of respondents using the language as their mother tongue. With this knowledge in hand, Minsheng believes there are strategies that can maintain, protect, and revitalise the Miao language, including from New Zealand.

"Since 1987 Māori has been an official language in New Zealand, Māori language immersion schools have been supported, these actions have all contributed to the protection and revival of Māori language so I think what New Zealand does is good for China to consider."

Mingsheng highlights the importance of bilingual education, cultural tourism and native language media as effective tools to help preserve endangered languages like Miao. He uses the examples of Māori tourism ventures which have generated economic benefits for Māori in New Zealand, as well as the role of Māori Television.

"Media has a powerful impact on the survival of language, and social media in particular as more people use mobile phones to communicate. The Miao need specialists who can build apps in their own language, so the combined roles of media and education are critical."

Mingsheng says New Zealand can benefit from his research and the growing body of knowledge globally on the preservation of endangered languages.

"Language loss is a universal issue. According to some research, the world loses one language every two weeks, so it's important we take urgent action to address this. The more we understand how languages can be preserved, the less likely it is that we will see languages and cultures disappear."

POPULATION HEALTH

The Waitematā District Health Board (now Waitematā District, Te Whatu Ora Health New Zealand) has collaborated with China for more than 15 years, hosting and sending delegations to gain an understanding of the Chinese health system. This in part reflects the substantial population of Chinese New Zealanders living in the Auckland region. The DHB signed a heads of agreement (HoA) with the Health and Family Planning Commission of Shandong Province in 2016 and established the Asian International Collaboration initiative in 2017.

The Asian International Collaboration initiative is now an established platform for sharing expertise, knowledge and skills to improve the wellbeing of populations in both countries, and collaborates in five priority areas: digital transformation services, big data analytics and precision medicine, system integration leadership and talent, and facility and capacity building.[36]

Current projects include a remote ECG monitoring programme that involves the development of a single lead ECG patch using AI to detect and monitor for an irregular heartbeat such as atrial fibrillation. The patch, being built in partnership with the Auckland Bioengineering Institute and a manufacturer in Hangzhou Zhejiang province, could provide an innovative solution to the long waiting list for traditional ECG Holter monitors currently experienced by New Zealand patients.

A more recent area of collaboration is how New Zealand can learn from China's experience of integrating Traditional Chinese Medicine (TCM) with Western medicine. Te Aka Whai Ora, the new Māori Health Authority, is focussing on the development and future sustainability of rongoā Māori, a traditional healing practice grounded in te ao Māori. Understanding the success factors in integrating TCM and modern medicine presents a significant opportunity for this to be achieved, and to benefit New Zealand patients of all backgrounds.

Seeding grants have been made available by Te Whatu Ora Waitematā District for research into two aspects of integration of rongoā Māori Practice, TCM and Western medicine: understanding the diversity of rongoā Māori and exploring its possible applications in Western medical settings, and clarifying the similarities and differences between rongoā Māori and TCM for a better understanding of how potentially rongoā Māori, TCM and Western medicine can work collectively to improve experiences and health outcomes for all New Zealanders.

BIOMEDICINE AND DRUG DISCOVERY

Another key area of collaboration between New Zealand and China in health is the discovery of new medicines.

The Maurice Wilkins Centre (MWC) is one of New Zealand's seven Centres of Research Excellence and a national institute in biomedicine science sitting under the TEC, comprising all New Zealand universities and other organisations focussing on infectious disease, metabolic disease and cancer therapeutics.

MWC has engaged with China since 2012 when it was invited to attend the SRA / Five Year Roadmap meeting as the biomedicine representative from New Zealand. A Joint Centre for Biomedicine was established in 2015, and the Centre has since continued to leverage and connect New Zealand's capabilities with China's growing pool of research talent, large institutions and manufacturing capabilities for mutual benefit.

In 2020, the Centre launched the Catalyst-funded China-Maurice Wilkins Centre Collaborative Research Programme (C-MWC), which expanded cooperation by funding new research and giving New Zealand scientists access to expertise, technology, equipment and facilities not available within New Zealand, as well as enabling further engagement via symposiums, workshops and researcher-to-researcher introductions.

36 https://www.waitematadhb.govt.nz/about-us/asian-international-collaboration/

Key accomplishments include the co-development of a tumour-targeted therapeutic for lung cancer between Auckland University and Chinese partners going to clinical trial in China in 2023, and collaboration between the Malaghan Institute and Chinese partners to undertake clinical trials of CAR T-cell therapy in New Zealand, allowing for earlier availability and potentially curative treatment options for patients with certain cancers (see case study p.10).

OTHER RESEARCH AREAS

The range of discipline areas in collaborative research between New Zealand and China is expanding every year. The following are examples of joint research and projects that represent the diversity of the current research ecosystem.

LANGUAGE PRESERVATION

A recently Tripartite Partnership Fund (TPF) funded research collaboration partners Massey University with Beijing Jiaotong University and Guizhou University in Southwestern China in a project to study the Miao minority language in Guizhou province. This involves a major survey to quantify the number of native speakers left in the province.

The project is significant not only for its potential impact on the preservation of the Miao language but also for its contribution to broader research on minority language endangerment and language revitalisation around the world (see case study p.32).

ARCHITECTURE AND PLANNING

A number of New Zealand universities have collaborations in architecture and planning with China. These include Te Herenga Waka–Victoria University of Wellington, which has formed a partnership with Zhengzhou University to establish a joint design and architecture institute. The cooperative institute will serve as a platform for educational collaboration, cultural exchange, and talent development" between China and New Zealand.[37]

For several years, Auckland University's School of Architecture and Planning has also collaborated with leading Chinese universities in Hong Kong, Henan, Nanjing, Beijing and Shanghai on creative and research projects, resulting in co-publications, conferences, and presentations at the Venice Biennale of Architecture.

Working alongside Chinese partners in architecture and planning has given Auckland University researchers valuable insight into the rapid urbanisation occurring in China, including its scale, speed, and dynamism. Through these collaborations, they have developed a better understanding of how to respond to the challenges that arise from these processes.

As part of this partnership, University of Auckland has also welcomed Chinese PhD students studying contemporary architecture and planning challenges in China. Their recent research topics include the phenomenon of 'villages within cities,' where traditional rural communities are absorbed by expanding cities and face complex land ownership issues.

By engaging with these issues through collaboration and research, University of Auckland gains knowledge to help respond to the challenges of urbanisation and globalisation in the future.

37 https://www.thepost.co.nz/a/nz-news/350010267/vic-uni-launches-joint-architecture-design-institute-with-china-s-largest-university

BRIDGING THE CULTURAL DIVIDE: THE NEW ZEALAND-CHINA TOURISM RESEARCH UNIT

Tourism has been one of the most notable success stories of all New Zealand services exports to China. In 2019, more than 400,000 Chinese tourists visited the country, boosting regional economies and earning New Zealand $1.6 billion in revenue.*

The tourism industry in New Zealand is also complex and ever-changing. Operators need to adapt to the competitive environment, global economic conditions and events, technology advancements, shifting domestic attitudes and other factors.

Collaboration in tourism research benefits New Zealand not only by helping the industry better understand and cater to the important Chinese market, but also by demonstrating openness and fostering a positive reputation.

The University of Waikato plays a pivotal role through the Beijing Union University China-New Zealand Tourism Research Unit. After several years of visiting China Professor Chris Ryan established the unit in 2013, and in total has spent approximately 22 years developing a network of academic, government and industry expertise in both countries.

An early contact of Ryan's was Professor Gu Huimin from Beijing International Studies University, a leading Chinese academic in the fields of hospitality and tourism. Partner institutions in China now include Beijing Union University, the University of Hainan and Sun Yat-sen University.

Ryan says the unit's work has been valuable to New Zealand at a number of levels, from advising individual operators and government agencies to building knowledge that supports the industry to grow sustainably and successfully. Through his networks, Ryan has also assisted New Zealand with market access for inbound Chinese travellers.

*_Normal Service Resumed? Assessing future prospects for New Zealand-China services trade_, New Zealand China Council, November 2022.

"Through my research I made connections with the person who drew up the Chinese travel law that approved specific countries as destinations. I was able to facilitate discussions for them with industry in New Zealand to help get the wheels turning."

This helped facilitate arrangements in 2014 when Professor Zhang visited New Zealand for a conference held at the University of Waikato.

Like many academics, Ryan has also leveraged his platform to engage in public advocacy in support of New Zealand's tourism messaging in China. A recent example was the resumption of outbound travel for Chinese citizens, which saw the US and UK impose quarantine testing on arrivals. Ryan appeared on Chinese media to reassure travellers that New Zealand was open to tourism.

"Academics are held in high esteem in China and their opinions are often sought after by decision-makers. New Zealand was following the science which said testing wasn't needed, so I was able to reinforce that particular message to a huge audience in China."

Looking ahead, Ryan believes quality research will remain critical to the success of tourism in New Zealand. This includes understanding how New Zealanders perceive tourism so issues can be addressed through considered policy and best practice.

"Going back to 2019, we could see that New Zealanders' perception of international tourism was becoming less favourable. We've reached the point where about 40% of the population in an annual survey are expressing reservations because of issues such as overcrowding."

It also includes understanding how the preferences and expectations of Chinese travellers are continuing to evolve. Ryan's work in partnership with the Shaanxi History Museum in Xi'an and other tourism sites in China shows how advanced the use of smart tourism, advance bookings and 5G technology is being deployed to enhance visitor experiences. One of his recent studies looked at how a museum in Shandong used eye tracking technology to map the spatial-temporal behaviour of visitors to improve their learning experience.

"We're nowhere near this in New Zealand. We've got to think very, very carefully about the use of smart tourism, the use of quotas and the implementation of forward booking systems. If not, we'll be taking visitors who are going to be blown away by the fact they can just turn up and walk in, and increasingly question why this is the case."

CONCLUSIONS

Interviews with approximately 20 New Zealand-based scientists and researchers who collaborate with Chinese partners were conducted for the preparation of this report.

These covered the rationale for China being selected as a partner, how connections were established and maintained; language, culture and distance as barriers to success, key funding mechanisms, the impact of Covid-19, differences in research styles and methodologies and areas for potential collaboration in the future.

CHINA'S APPETITE FOR INTERNATIONAL COLLABORATION

Much has been made of China's recent focus on achieving self-reliance in key areas of science and technology, such as its ambition to be the world leader in artificial intelligence by 2030. China observers are looking for signs that the country is pulling back from collaboration with international partners. The evidence doesn't suggest that is the case, despite the move towards more nationalistic policies governing the science domain in China.

"In fact, while structural domestic changes in recent years have started to affect international collaboration projects, there is no clear indication yet of an overall (quantitative) decline in scientific collaboration as fostered by the PRC," Max Planck researchers note.[38]

Dual-use technology development remains a problematic area for collaboration, though collaboration on basic scientific research that underpins areas including quantum computing, space science, and artificial intelligence continues at pace, with high-impact, co-authored papers finding their way into top journals.

New Zealand researchers' substantive scientific collaborations with China are mainly in the areas of environmental science, biotechnology, agri-tech and medical science. The two countries have found natural alignment on a series of science-related goals, a relationship that doesn't look to be threatened by growing geopolitical tensions between the US and China.

Around half of the scientists and researchers spoken to said they had discussed China's latest reforms with their Chinese partners, but there was no indication yet that these would impact collaboration in any way.

Moreover, a number of respondents reported increased interest in New Zealand as a destination of choice among Chinese PhD students due to the country being perceived as balanced in its relationship with China compared to the US, which typically would have been considered a more desirable and prestigious option.

RATIONALE FOR COLLABORATING WITH CHINA

The main rationales given for collaborating with China were access to the country's unique environment; its infrastructure and technology, scientific expertise and human resources.

Access to China's unique environment was a particularly important rationale for research in agriculture, horticulture and pest control. For example, many of the crops subject to research in New Zealand, such as kiwifruit, apples and pears originated from China or nearby regions. Consequently, many of the pests that affect these crops originate from the same areas, making field research in China invaluable. China's large dairy industry and commonalities in agricultural science were other reasons given for collaborating with China, including shared interests in driving efficiencies, improved production and greater sustainability in farming systems.

Access to China's scientific infrastructure and technology was identified as an important rationale for respondents from all priority research areas. This included laboratories, instruments and research stations, as well as China's manufacturing capabilities. Many respondents said that leveraging China's investment in large-scale

38 https://www.mpiwg-berlin.mpg.de/observations/end-learning-west-trends-chinas-contemporary-science-policy

scientific infrastructure significantly sped up progress with projects or made them more efficient.

Access to expertise in China was also mentioned by respondents across the board, particularly in areas where Chinese scientists, researchers and institutions are regarded as among the best in their fields.

Another rationale for collaboration mentioned by some respondents was access to China's industry and supply chains. Collaboration with Chinese partners allowed researchers to understand changes in industry regulations and needs which allowed New Zealand researchers to support export-related innovations.

ESTABLISHING CONNECTIONS

There was significant variation in how connections were established between New Zealand and Chinese researchers. Connections from personal networks established through working internationally (including in China) were mentioned by many respondents.

In some cases, there were pivotal early meetings such as group trips and delegations to China that established initial connections.[39] Several respondents also reported meeting key partners at international conferences. The importance of face-to-face interaction and travel to China was highlighted by most respondents, many of whom said they were able to establish connections after visits to Chinese institutions and maintain them over the long term.

The role of New Zealand's CRCCs in setting up connections was also emphasised by several respondents, both in establishing high-level connections at all levels of government in China and in building long-term, enduring relationships through ongoing workshops, visits and exchanges. Several respondents noted the centres have also been successful in leveraging China's expertise and infrastructure to advance research in areas that matter to New Zealand, from critical health issues to understanding and mitigating agriculture's contribution to climate change.

BENEFITS

Respondents identified clear mutual benefits in terms of the outcomes of their specific research projects. For New Zealand, these included better outcomes for health, more robust export industries, advances in agricultural and horticultural production and benefits for New Zealand's wider environment.

Other major identified benefits of collaborating with Chinese partners were: access to scientific infrastructure and facilities not available in New Zealand, the ability to leverage greater human resources for research and testing and access to China's unique environment. For research conducted on a commercial basis, revenue was also given as a key benefit of collaboration. Export focused researchers identified the ability of Chinese partners to establish contacts with importers, supply chain and logistics companies as a valuable benefit.

A number of respondents also identified the showcasing of New Zealand's research expertise as a benefit of collaboration. They felt that as a small country with limited resources, New Zealand is often not high on the list of preferred research partners, and that collaboration with China puts our expertise on the map, both in China and with other large partners. The positive effect that collaboration has on student recruitment in China for New Zealand universities was also identified.

Many respondents also pointed out that relationships with Chinese partners endured after collaborative projects, frequently leading to further co-funded projects or providing advice and assistance on an ongoing basis.

CHALLENGES AND BARRIERS

Language was rarely identified as a barrier to collaboration between New Zealand and Chinese, and where it was identified, the barriers were minor or technical. Almost all respondents indicated that English was the language used in collaboration, with a small number making use of translators.

39 For example, via the China-Maurice Wilkins Centre Collaborative Research Programme.

Respondents emphasised that English is the language of global science; that Chinese partners were generally reading the same publications, and that proficiency was improving all the time, especially among younger Chinese partners. Respondents indicated that language was more likely to be a barrier when discussing commercialisation arrangements or other business-related aspects of collaboration, rather than the science itself.

Many collaborations also involved Chinese New Zealanders who are fluent in both Mandarin and English and were, therefore, able to overcome language challenges faced by non-Mandarin speakers in research teams.

Differences in research styles were identified by some respondents. These included more rigid reporting requirements, less willingness to accept unexpected results, and less of the curiosity-driven, problem-solving mindset prevalent among New Zealand researchers. Differences in the way New Zealand and Chinese organisations bid for funding were also raised by several researchers, which made it difficult to secure the co-funding required for projects to get off the ground.

Moreover, limited funding and resources for science in New Zealand were identified as a general challenge, with many pointing out that Chinese partners had access to much larger funding pools and opportunities. Leveraging available funding from China in the form of PhD students funded by the Chinese government to study in New Zealand was identified as a way for institutions to carry out research that would otherwise not be able to take place.

Delays in processing Chinese PhD student visas due to National security checks (NSC) were also raised as an issue by a small number of researchers, with some students waiting more than a year for their applications to be approved. Immigration New Zealand states that NSCs are required to enable border protection agencies to prevent people who may pose a risk to national security from entering the country, and are assessed by the New Zealand Security Intelligence Service (NZSIS).

IMPACT OF COVID-19

Covid-19 had a significant impact on almost all researchers, slowing their progress and putting some projects on hold for a year or longer.

For researchers who were working to establish relationships with Chinese partners at the outbreak of the pandemic, the inability to travel or conduct face-to-face meetings and workshops had been particularly disadvantageous.

For those in more advanced stages of collaboration, progress was still achieved by shifting meetings and communication online and relationships were able to be maintained. A small number of respondents indicated that projects were able to carry on at the same speed, despite pandemic restrictions.

Most reported that with China's borders now open to international travellers, they were intending to or were already resuming in-person visits and exchanges with Chinese partners.

FUTURE OPPORTUNITIES

Respondents across the board were optimistic about the future of New Zealand China science and research collaboration. Most had the sense that China is willing to expand collaboration with New Zealand, both in the number of projects, visits and exchanges between institutions and also in the areas for collaboration.

Most respondents also identified a pipeline of future collaboration building on recent and current projects, and pointed to areas where New Zealand and China could mutually benefit from joint research in the coming years. These included regenerative farming, pest control, new drug discovery, the modernisation of Traditional Chinese Medicine, mitigating GHG emissions from agriculture, water conservation and marine science.