Innovation Ecosystems in Geographically-Remote and Resource-Limited Regions with Indigenous Populations and considering Ancestral Science, Knowledge, and Practices: Intentional Development in the Pacific Islands of Hawai'i, Fiji, and New Zealand

by

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ABSTRACT

Innovation ecosystems provide a way to transform and diversify a regional economy. Much of the existing research focuses on mature economies in regions with strong foundational institutions and natural resources. The research herein uses the MIT Three-S (system, stakeholder, strategy) Framework to characterize regional ecosystems that are geographically-remote and resource-limited, specifically the Hawaiian Islands, Fiji, and New Zealand. Using measurements of entrepreneurial and innovation capacities and, where possible, interviews of local stakeholders, opportunities and challenges for these regional innovation ecosystems are identified. Attention is given to the counterpoint Indigenous peoples bring to a regional innovation ecosystem. Strategies are suggested for leveraging comparative advantages. Further research and testing is recommended to trial the effectiveness of innovation and entrepreneurship to drive the transformation of tourist economies towards diversification and becoming knowledge and digital economies.

Thesis supervisor: Philip Budden

Title: Tech Innovation, Entrepreneurship, & Strategic Management, MIT Sloan

Dedication

In light of the ongoing and devastating fire on the Island of Maui, I am humbled by the urgency of addressing real-world challenges that impact the very places we study and admire. With a heavy heart, I dedicate this thesis to the resilient people of Maui, who are currently facing the destructive forces of nature. I am at a loss for words for what else to write—please observe a moment of silence for this tragedy and immeasurable loss of people, place, and history.

To my beloved husband, Spencer,

You have been a source of love, strength, and inspiration throughout this incredible journey at MIT. Thank you for making Cambridge home. Your support, encouragement, and patience have guided me through trials. It has been your desire to give our children more grounding in their culture—that has influenced this thesis. This work is a testament to the enduring bond we share, and I dedicate it to you.

To my cherished children, who light up the world with their smiles and laughter,

Isabel, Ka‘iulani, Leona, and Enoka, you inspire me. Your innocence, curiosity, and boundless energy (especially when it comes to circumventing child-proofing) remind me beauty exists in every moment. I endeavor to create a legacy that you can be proud of. Each step I take is influenced by the desire to provide you with a world full of opportunities, love, wonder—and ties to your many heritages. Even at your young ages, I am impressed with your independence and entrepreneurial spirits. I hope that they continue to grow with you and that you do not fear failure and are willing to take risks and live lives of adventure and personal growth.

May this dedication stand as a testament to the love and gratitude I hold for each of you. Spencer, my partner in adventures, and my children—our greatest treasures. Your smiles and dreams drive me to do well. This work is more than a culmination of my efforts—it a reflection of team efforts and sacrifices. I look forward to discovering these places together.

With all my love and aloha, you mother, Holly

Figure 1: Nihipali Ohana March 2022,
(five months before starting MIT MS program).

Acknowledgments

> Yea, I know that I am nothing; as to my strength I am weak; therefore I will not boast of myself, but I will boast of my God, for in his strength I can do all things.
>
> Alma 26:12, The Book of Mormon

I am deeply grateful for the unwavering support and guidance of God, my Heavenly Father, throughout my journey in the SDM program and the intricate process of thesis research and writing. With His benevolent influence, I have forged invaluable connections, conducted insightful interviews, and experienced profound personal, professional, and spiritual growth. It is through this divine assistance that I was led to a thesis topic that resonates deeply with me, enriching my personal and intellectual journey.

My heartfelt gratitude extends to my beloved husband and lover, Spencer Nihipali. Amid the demands of semi-single parenthood, he has stood steadfast, offering unending support as I embarked on the MIT SDM master's program. To him and our children—Isabel, Ka'iulani, Leona, and Enoka—I extend my sincere appreciation for their patience and understanding as I undertook this thesis endeavor. Thank you to my parents for cultivating my love of learning and ties to my heritage.

A special acknowledgment goes to my sister, Annie Greenberg, for her invaluable edits, as well as to my brother, Scott, for his love and support. And to my grandparents who fostered my love of travel and learning about different cultures and peoples.

I extend my sincere gratitude to my advisor, Dr. Philip Budden, for not only encouraging my exploration of the fascinating realm of innovation ecosystems and regional entrepreneurship, but also for his extensive discussions, guidance, and educational input. His role has been

pivotal in guiding me through this complex thesis journey. Thank you for being my Ground Control.

To my cherished friends, I am grateful for your willingness to be my sounding board and your unending encouragement. A heartfelt thank you also goes to my fellow members of the Chevron cohort, whose shared experiences have been a source of inspiration. Thank you Declan for showing up when I needed you.

I thank Chevron for selecting me as a participant in the digital scholar program and for their generous financial support. Special thanks to Lee Jourdan for his insightful conversation about my involvement with the Native American Network, and to the NAN community for their warm welcome.

I would like to acknowledge Nina Lytton for her indispensable support of MIT's Native American and Indigenous Students, and for facilitating connections that help us embrace our cultures and strengthen our bonds. The Native American and Indigenous Association (NAIA) has been a welcoming community, and I am thankful for their acceptance.

Thank you Joan Rubin for being more than my advisor. I have enjoyed having you as a mentor and friend. My return to MIT has been an incredible experience, exceeding all expectations. The people and the learning environments have consistently provided fertile ground for personal growth and knowledge expansion. There are many others in Cambridge that have a place in my heart—who have made this experience one-of-a-kind.

My gratitude extends to those who played a role in shaping this thesis and those who generously shared their insights through interviews or connections within the ecosystems. To Steven Auerbach, Jim Wyban, Jason Ueki, Caroline Fry, Kamuela Enos, Lisa Pakele, Mark Ritchie, Murray Clay, Brett O'Riley, Lauren Nahme, Ian Town, Mitch Olson, Jaylene Wehipeihana, Dane Carlson, Evan Beachy, Donovan Kealoha, Keith Matsumoto, Zainab Kakal, Nuria Rull, David Summers, Maria Williams, Richard Lester, Doug Barrios, William Taylor, Patrick McVeigh, Michael Davies, and Andrew Hamilton—your contributions have enriched this thesis immeasurably.

Biographical Sketch

Holly Christine Greenberg was born to Michael and Marquita Greenberg and is of Jewish, Alaska Native (Yu'pik), and European descent. She was inspired from a young age regarding the entrepreneurial feats of her local grandfather, Frank, and travel agent grandmother, Rosita, to be interested in business and cultures around the world. Raised in the cultural melting pot of South Florida she developed a love for diversity and the value of different perspectives.

Holly joined MIT in the Minority Introduction to Technology, Engineering, Entrepreneurship, and Science program in the summer of 2003 and later began as a freshman with the Office of Minority Education's Project Interphase program in summer of 2004. With the support of the MIT Experimental Study Group (ESG) community, Holly found an informal mentor in Professor Alexander Slocum and friend in Alex Slocum, Jr. As such she explored and found a home in the Mechanical Engineering Department with the support of additional friends and mentors: Jonathan Hopkins, Taylor Roan, Mona Daniels, Laura Martini, Gerald Wilson, John Brisson, Amy Smith, Dave Wallace, Amos Winter, Emanuel Sachs, Maria Yang, and many others she knew from MITES and PI. John Brisson was instrumental in directing her to participate in the Cambridge-MIT Exchange where she matriculated at Sidney Sussex College, University of Cambridge, UK, for her junior year. Sir Peter Guthrie introduced her to the world of sustainable development, which led to her draw towards Amy Smith's D-Lab course with the opportunity to learn about development and design for emerging economies and rural communities.

In 2008, Holly joined a small D-Lab team in China for field study. Her experience was transforming, leaving her with more questions than answers as to what is really best, appropriate, and observations of how the best of intentions can be misinformed and not applicable. Dave Wallace's 2.009 engineering design capstone course and her engagement with Maria Yang's Ideation lab, led her to pursue an undergradute thesis exploring creativity, sense of humor, and personality type; and ultimately led her to the product development program at Brigham Young University for graduate school.

As she met with her prospective advisors at BYU Spencer Magleby and Larry Howell, Holly

recognized God pushing her toward missionary service for the Church of Jesus Christ of Latter-day Saints, and was assigned to Houston, TX as a Spanish speaking missionary. BYU graciously accepted her upon the completion of a mission, and she became part of the Compliant Mechanisms Research Group. There, her associations with undergraduate Matthew Gong pivoted her research to include principles of Origami to design flat folding compliant mechanisms and later found the BYU Origami club. In addition, Holly's accomplishments at BYU include collaboration with Samuel Wilding to yield two patents; friendships (and awards) from informal competitions in the Strategy club; publications; but, most importantly, cherished friendships.

As Holly finished her MS degree in Mechanical Engineering, a warm up interaction at a career fair led to interview practice and a surprising job offer from ExxonMobil in 2012. Her interest in manufacturing systems led her to accept a job offer in industrial lubricant sales, where she had the opportunity to access a variety of industries and learn how things are made.

In 2016 Holly joined Chevron as a business consultant in lubricants. Chevron has provided her with many mentors and this opportunity to return to MIT as a Chevron Digital Scholar and obtain a Masters degree through the System Design and Management Program. Holly's involvement with the Indigenous Working Group, Native American Student Association (now Native American and Indigenous Association), American Indian Science and Engineering Society, MIT Climate and Energy prize, Israel lab, and the Innovation Ecosystems for Regional Entrepreneurship Acceleration Leaders course led to the crafting of this thesis.

Holly is a person who sits at the seams, at intersections, never belonging entirely to one anything. Her mind works horizontally across disciplines. Her heritage, experience, current family, and internal sense of duty make her aspire to a thesis that develops her and others and has the potential to give back. In her own words: "I have another vision for MIT, or any university that will take it, to have a center or college of interdisciplinary and indigenous studies. A place where non-western knowledge systems are welcomed, preserved, and respectfully applied to inform and innovate in a non-exploitative and sustainable way."

At the time of this writing, Holly and her husband, Spencer Nihipali, are proud parents of their four Native Hawaiian, Alaska Native, and Jewish children: Isabel, Ka'iulani, Leona, and Enoka. It is her hope to highlight the value of Indigenous ecological knowledge, ancestral science and innovation, Indigenous knowledge systems as an opportunity to learn and better understand how to solve complex problems. Innovation needed for solving complex, socio-technical problems requires diversity in people, perspectives, and knowledge systems.

Contents

[1]Counterpoint is a musical term that refers to the technique of setting, writing, or playing melodies in conjunction with another.

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Chapter 1

Introduction

> Development is about transforming the lives of people, not just transforming economies.
>
> Joseph Stiglitz
>
> *Making Globalization Work*

This thesis is about people. It is about how people with ideas can be supported, connected, and empowered to change their livelihood. The path that an individual, household—or, more often a team—trudges to take an idea from concept to innovation cannot be done in isolation. Innovation equals invention plus commercialization, or more broadly: Innovation is "process of taking ideas from inception to impact." (Budden & Murray, 2018) Invention is relatively easy; innovation is complex. For that reason, the fields of innovation and entrepreneurship are increasingly studied. The commercialization of various inventions has changed society and economies. Researchers, governments, companies, and individuals have understood the need for innovation to drive their respective organizations forward. An innovation ecosystem is an environment entrepreneurs can use and leverage to market an idea. Regional innovation

ecosystems are studied to understand the roles of different institutions and stakeholders in fostering an ecosystem, where success means that the region supports growth more than it hinders it, primarily in terms of ability to scale from micro to small or medium to potentially large innovation-driven enterprise.

In the wake of the COVID-19 pandemic, many regions identified economic weaknesses. The war between Russia and Ukraine exposed additional dependencies. Increased frequency of natural disasters, brought about by climate change are also identifying and exacerbating economic hardships as such many regions are looking to change their sources of income and diversify towards becoming an information or knowledge economy. The energy transition is another reason governments are looking to diversify away from fossil fuels, and develop their own renewable grid. The trend towards an innovation economy has been boosted by the success of other economies like Silicon Valley, Cambridge and Boston, Israel, and Singapore. There has been an intentional shift of focusing on developing an innovation ecosystem in a region to promote entrepreneurship and technology development to drive economic and societal improvements.

The concept of innovation ecosystems is to develop an independent region where innovation-driven enterprises can sustainably grow and even thrive. This is not necessarily probable for a good portion of the world, and an innovation ecosystem will look differently given the context. This thesis will explore innovation ecosystems for regions that are geographically-remote and resource-limited. Many Pacific Island economies are heavily dependent on tourism. For example, tourism represents nearly a 25% of Hawai‘i’s economy, 34% of Fiji’s, and 5% of New Zealand’s GDP (and its largest source of foreign exchange since 2008 until the pandemic). These islands were chosen to understand how they are currently positioned in their innovation and entrepreneurial capacities.

This research hopes to benefit populations of the Pacific Island Nations who are often over-

looked as developing nations. The Asian Development Bank opens its executive summary of *Poverty: Is it an issue in the Pacific?* with the following quote:

> "Most people don't associate poverty with the Pacific. It is usually linked to the suffering of children in Africa or the backbreaking labor of so many in Asia. Both are a far cry from the image of a Pacific populated by healthy, smiling people living in a tropical paradise. But, as the people of the Pacific well know, the reality is not always as idyllic as the image." (Lightford et al., 2001)

1.1 Purpose of an Innovation Ecosystem

The non-profit MassChallenge provides an excellent view on the purpose of an innovation ecosystem.

> "Innovation ecosystems create an active flow of information and resources for ideas to transform into reality. Through these ecosystems, we are building a process by which more innovators and entrepreneurs can develop and launch solutions to solve real-world problems, faster. This process creates expertise in new areas, helps to diversify the economy, and allows businesses to meet their customers where they are. Additionally, an innovation ecosystem provides the means to create economic stability and resource sharing." ("What Is an Innovation Ecosystem and How Are They Essential for Startups?", n.d.)

Historically, innovation ecosystems have corresponded to a geographic region or city. "The Legatum Center was founded on the belief that entrepreneurs and their market-driven solutions are critical to advancing economic and social progress in the developing world. While

global prosperity has increased in recent decades, the progress is uneven, with the worst deprivations concentrated in specific parts of the globe." ("The Legatum Center at MIT - What We Do", n.d.)

The Pacific Islands are primarily developing economies and what has been termed the Global South. They are geographically-remote and often have little in terms of natural resources like oil, gas, or minerals. Land and people are also limited resources. Populations are often a diverse mix between indigenous and settlers.

This thesis examines Hawai'i, Fiji, and New Zealand to understand a range of social and economic conditions, entrepreneurship, and innovation capacities. *Intentional Development* is the concept that these regions may want to benefit from improving their innovation ecosystems in a thoughtful way to optimize positive and negative externalities to benefit existing residents. Thought is also given to how stakeholders should intentionally craft and design an innovation ecosystem with consideration to the traditions, culture, knowledge, and skills of the local Indigenous populations, to minimize Western bias and better set up for success and parity.

1.2 Small Island Developing States, SIDS

There are currently 52 small island developing states including 23 in the Caribbean, 20 in the Pacific, and 9 others in Africa, the Indian Ocean, Mediterranean or South China sea. Fiji is the only SIDS considered in this thesis. However, it is hopeful that in analyzing the ecosystem for Fiji, combined with looking at the international partners that are involved in the Fijian ecosystem, that there may be useful knowledge to apply to other SIDS. In addition, many of the American Pacific Islands are listed as SIDS and may potentially benefit as well from the Hawaiian ecosystem—especially from projects sponsored by government stakeholders.

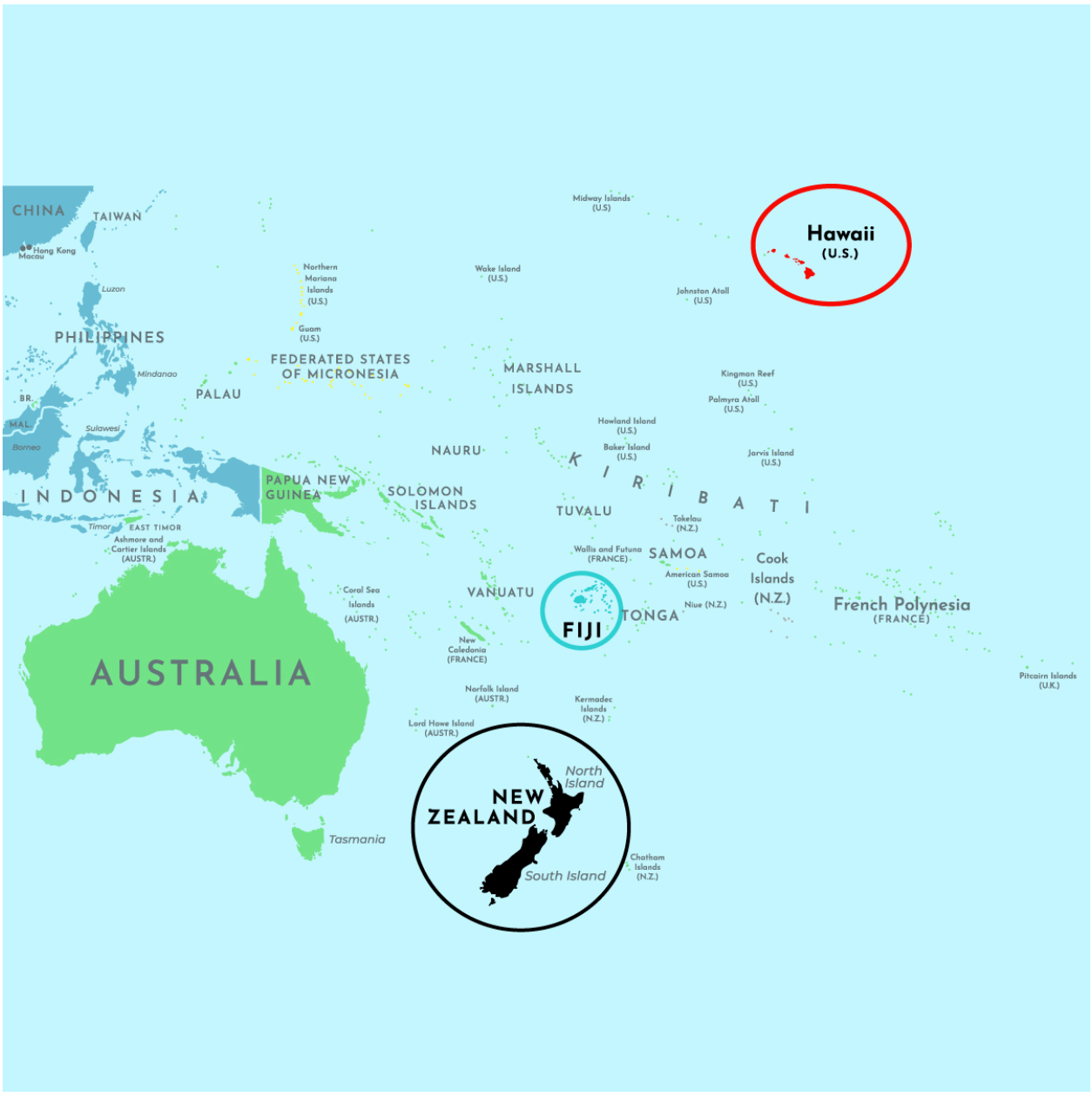


Figure 1.1: Map of Oceania

Table 1.1: Pacific Islands Table of Resources: Liabilities and how they might be Assets

Liability	**Asset**
Remoteness	Minimal light pollution, need for subsistence-based xyz, bricolage
Surrounded by water	Opportunity for ocean innovation, aquaculture, naval logistics, reef research, desalination, leading indicators for climate change
lower educated population	Opportunity to focus on applicable research problems
limited land	need to make it more efficient
climate	Much of the world has climate or will have climate similar to tropics
limited oil and natural gas reserves	Renewable fuels opportunity

As the name denotes, for SIDS, land is a limited resource. SIDS represent some countries most in need of economic development and that are more disadvantaged compared to other countries. They lack land and may often lack natural resources, and are frequently geographically-remote. While at the outset there are some glaring disadvantage, there is potential to transform these disadvantages to opportunities become specific innovation regions that leverage their conditions.

A cursory glance at the liabilities of these small island developing states includes: remoteness, coastal regions, food insecurity, need to be energy independent, ability to climate change, and increasing severe weather events. Some of the perceived liabilities and their corresponding assets or advantages are found in the corresponding Table 1.1:

The highest and best use of these resources falls under the management of the government of each SIDS. The use of these resources will be in partnership with other stakeholders like universities, corporate, and potentially entrepreneurs. As tourism economies seek to transform, they will need to look at their "assets and liabilities" in context and identify how to strategically position themselves in the innovation marketplace.

1.3 Intentional Development of Ecosystems

Economic development models are beyond the scope of this thesis. However, a systems perspective of a regional economy would have multiple inputs, outputs, and feedback loops. It is important to pursue the economic development of a region in a systematic approach to understand the overall system effects of various policies.

Regional economic development is defined as "the application of economic processes and resources available to a region that result in the sustainable development of, and desired economic outcomes for a region and that meet the values and expectations of business, of residents and of visitors (R. J. Stimson et al., 2006)."

There are many paths for a less diverse SIDS economy to achieve diverse and sustainable growth. A framework for economic development policy can include aspects for effective taxation, infrastructure development, manufacturing, foreign aid, stability, deregulation, among other strategies. Though the economic development models are beyond the scope of this thesis, the rise of globalization in the past 50 years as well as the shocks in supply chain from the COVID-19 pandemic and Russia-Ukraine war have started to change the way economic theory and models are created. Sometimes regional development is viewed as a product and other times a process (R. Stimson & Stough, 2023).

The following Figure 1.2 shows how some of the theory has shifted as economies transform from industrial to post-industrial economies.

The research presented in this thesis agrees with the contention that innovation, technology, and new businesses play an important role in the shaping of the economy. These regions have the opportunity to develop their institutions and people to support and continue moving towards the direction of a post-industrial economy. However, as changes in institutions, law,

Figure 1.2: Table of Attributes of old and new economies. (R. J. Stimson et al., 2006)

Table 1.1. Attributes of the old and new economies[a]

Economy-Wide Characteristics	Old Economy (Industrial)	New Economy (Post-Industrial)
Organizational form	Vertically integrated	Horizontal networks
Scope of competition	National	Global
Markets	Stable	Volatile
Competition among sub-national	Medium	High
Geographic mobility of business	Low	High
Role of government	Provider	Steer/row/end
Labour and workforce characteristics:		
Labour-Management relations	Adversarial	Collaborative
Skills	Job-specific skills	Global learning skills and cross-training
Requisite education	Task specialization	Lifelong learning and learning by doing
Policy goal	Jobs	Higher wages and incomes (productivity)
Production characteristics:		
Resource orientation	Material resources	Information and knowledge resources
Relation with other firms	Independent ventures	Alliance and collaboration
Source of competitive advantage	Agglomeration economies	Innovation, quality, time to market and cost
Primary source of productivity	Mechanization	Digitization
Growth driver	Capital/labour/land	Innovation, invention and knowledge
Role of research and innovation in the economy	Low moderate	High
Production methodology	Mass production	Flexible production
Role of government	Infrastructure provider	Privatization
Infrastructure characteristics:		
Form	Hard (physical)	Soft (information and organizations)
Transport	Miles of highway	Travel time reduction via application of information technology
Power	Standard generation plant	Linked power grid (co-generation)
Organizational flow	Highly regulated	Deregulation
Telecommunication	Miles of copper wire	Wireless and fibre
Learning	Talking head	Distance learning

[a] For a more extended discussion see Source: Jin and Stough (1998)

and policy occur, stakeholders need to be cognizant of the risks, and have opportunities to test hypotheses of intended outcomes for policies and programs.

1.4 Map of Thesis

The thesis flow is as follows: Chapter 2 provides context for the importance of innovation ecosystems and background on the MIT frameworks. Chapters 3,4, and 5 are overviews of the Hawai'i, Fiji, and New Zealand innovation ecosystems. Chapter 6 is a discussion comparing the ecosystems. Chapter 7 highlights Indigenous populations and Ancestral Science, knowledge, and practices and provide a complement to innovation ecosystems. Finally, Chapter 8 identifies opportunities for future work and summarizes conclusions.

Chapter 2

Overview of Innovation Ecosystems

The purpose of this chapter is to provide a background of what is meant by an *Innovation Ecosystem.* A brief discussion of innovation, its history for economic development, and various frameworks for comparisons of regions are outlined herein.

2.1 What is Innovation?

The MIT Innovation Initiative defines innovation as the "process of taking ideas from inception to impact." (Budden & Murray, 2018) While a standard definition of innovation is *Innovation = Invention + Commercialization*, this does not denote the impact that history has seen from innovation, which is its own robust area of research. Innovation can be categorized in many ways.

MIT faculty have set out a number of ways to differentiate among startups starting with the fundamental insight from 2012 that separates out standard SME startups from what the authors call "innovation-driven enterprises (IDEs)." (Aulet & Murray, 2013) In later work on

the terms used, one of those co-authors further differentiated these, with innovation-driven enterprises (IDEs) having one subset referred to as "deep-tech dolphins," a subset of IDEs that recognizes the need for longer-term R&D. (Budden et al., 2021) A "unicorn" is usually a digitally-focused IDEs that achieves hyper-growth and a valuation of $1 Billion. (Budden et al., 2021) Researcher David Birch identified a subset of enterprises which grew revenue year-over-year for four straight years (from a base of $100,000 revenue per year) and identified those as job-creating enterprises he termed "gazelles." (Budden et al., 2021)

2.2 History of Innovation for Economic Development

The industrial revolutions throughout the past 300 years have been characterized by inventions or the harnessing of various forms of energy. The first industrial revolution was largely catalyzed by mechanizing human and animal labor and harnessing energy from coal. The second industrial revolution is considered to have begun in the late 1800s with the harnessing of energy from electricity, gas, and oil. The transportation feats of planes and automobiles are some of the most influential inventions of this period. Nuclear energy and the rise of electronics and computers characterize the third industrial revolution. We have entered the fourth industrial revolution with the internet, more specifically, the industrial internet of things, digital transformation, and the energy transition.[1] ("The 4 Industrial Revolutions", 2019)

Historically, as societies moved from agricultural to industrial economies, cities or regions most often developed around specific industries based on regional strengths and resources. Manchester, England, is considered one of the first industrial cities. It thrived in textiles because of the cotton trade, canals, technology used, and technology developed. This sped up the process of turning cotton into materials through water wheels, the spinning jenny, and steam

[1]The energy transition is the overall structural change in the energy systems regarding supply and consumption; it also focuses on renewable energy sources.

engines. The canals facilitated the transportation of coal as well ("The World's First Industrial City | Science and Industry Museum", n.d.). Invention and innovation together industrialized Manchester to become "Cottonopolis." The city grew in wealth, population, and pollution.

Other cities throughout the world have developed around resources and industry. For example, the Wheat belt in the US is built around agriculture; the Rust Belt is the region experiencing an industrial decline with many iron and steel working industries. As areas like Silicon Valley, Tel Aviv, and London experienced economic growth through technology startups, other cities began to take note. "No more would people settle for the status quo and hope that existing anchor companies would continue to carry the economic load." (Case, 2022)

In the wake of the pandemic, many cities and regions are looking for greater economic diversity than their previous anchor income, and some are finding that creating an innovation ecosystem provides growth and momentum and a call for talent to return to a given region.

2.3 Innovation Ecosystems

A collision theory of innovation is based on perspectives and knowledge combining from different disciplines to create innovation. Building 20 at MIT was historically regarded as the 'Magical Incubator' because of the technology that came out of having 4,000 researchers in 20 disciplines within its walls. While this building was mainly a temporary structure created for research during World War II, it has been studied in different contexts to understand various components of creating an innovation ecosystem. People have tried replicating Building 20's ecosystem through strategic workspace design, programs for entrepreneurs, and even digital communities and meetups.

The word ecosystem is borrowed from biology. Ecology studies organisms and their interac-

tion with their surrounding environment, basically living things and their habitats. ("Ecology", 2023) In a regional innovation ecosystem, the metaphorical organisms are the various stakeholders interacting and providing support. The concept of innovation ecosystems is to try and develop a region where technology and entrepreneurship drive sustainable growth.

Aulet and Murray (2013) characterized two types of startup entrepreneurship: small-medium enterprises (SMEs) and innovation-driven enterprises (IDEs). Innovation-driven enterprises "pursue global opportunities based on bringing to customers innovations that have a clear competitive advantage and a high growth *potential*." (Aulet & Murray, 2013) Furthermore, there is a distinction between innovation-driven and technology-driven entrepreneurship; innovation is not limited to technology but can include aspects of process, business model, and more. (Aulet & Murray, 2013) In contrast, SMEs are more often local enterprises that operate with "traditional, well-understood business ideas and limited competitive advantage." (Aulet & Murray, 2013) SMEs are not to be diminished; they, in fact are critical parts of economies. In developing regions, SMEs have been expanded to include Micro-enterprises because of their scale; the abbreviation is all-inclusive for MSMEs. Figure 2.1 provides some distinctions between traditional SME Entrepreneurship and IDE Entrepreneurship.

One of the key distinctions is related to job creation. An IDE is seen to have a Moretti multiplier effect whereby an IDE creates five jobs for every job an SME creates.

> "Innovative industries bring 'good jobs' and high salaries to the communities where they cluster, and their impact on the local economy is much deeper than their direct effect. Attracting a scientist or a software engineer to a city triggers a multiplier effect, increasing employment and salaries for those who provide local services. In essence, from the point of view of a city, a high-tech job is more than a job. Indeed, my research shows that for each new high-tech job in a city, five additional jobs are ultimately created outside of the high-tech sector in that city, both in skilled oc-

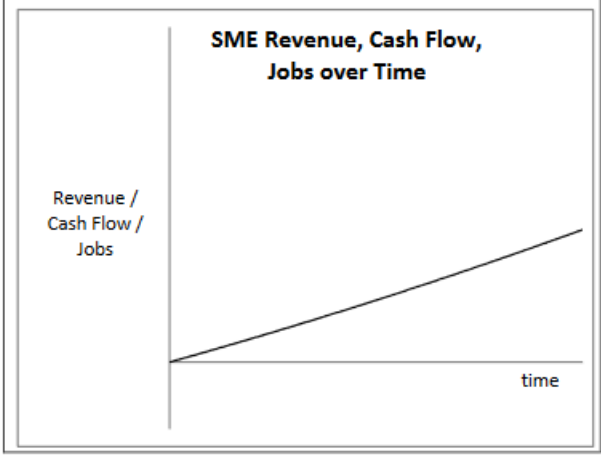
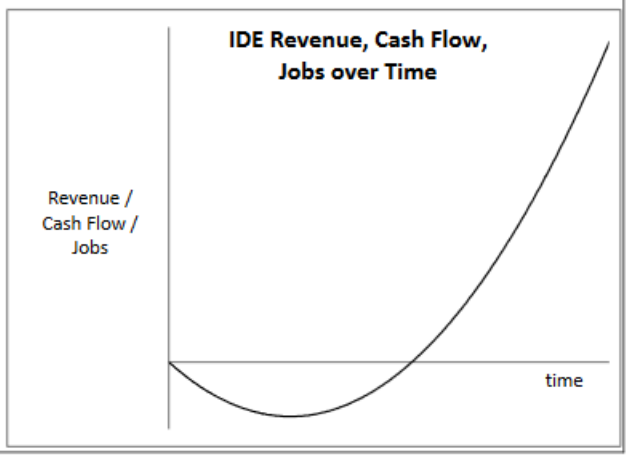
SME Entrepreneurship	IDE Entrepreneurship
Focus on addressing local and regional markets only.	Focus on global markets.
Innovation is not necessary to SME establishment and growth, nor is competitive advantage.	The company is based on some sort of innovation (tech, process, business model) and potential competitive advantage.
"Non-tradable jobs"—jobs generally performed locally, e.g. restaurants, dry cleaners, service industry.	"Tradable jobs"—jobs that do not have to be performed locally.
Most often family businesses or businesses with very little external capital.	More diverse ownership base including wide array of external capital providers.
The company typically grows at a linear rate. When you put money into the company, the system (revenue, cash flow, jobs, etc.) will respond quickly in a positive manner.	The company starts by losing money, but if successful will have exponential growth. Requires investment. When you put money into the company, the revenue/cash flow/jobs numbers do not respond quickly.
	

Figure 2.1: Distinctions between SME and IDE Entrepreneurship (Budden & Murray, 2019)

cupations (lawyers, teachers, nurses) and in unskilled ones (waiters, hairdressers, carpenters)." (Quoted in Budden et al., 2021)

2.4 Success of an Innovation Ecosystem

The health of an innovation ecosystem should be measured based on the region's objectives. Sometimes there is a view that a thriving ecosystem attracts talent, which can cause an imbalance in the residents and influx of people. For SIDS and other Pacific Islands, a result like this could devastate current residents. The Social Progress Index was first published in 2013 and is a potential way to benchmark success outside of economic indicators. Scott Stern, Petra Krylova, and Jaromir Harmacek wrote about the 2020 Social Progress Index and "define 'social progress' as the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential. This definition, established in consultation with a group of academic and policy experts, drives the framework of the Social Progress Index. It alludes to three broad elements of social progress, which we refer to as dimensions: basic human needs, foundations of wellbeing, and opportunity." (Stern et al., 2020)

An ecosystem's health could be measured by the talent cultivated that stays local and a region's ability to support an enterprise's growth. An alternate perspective is that in cases where resources (including people) are dispersed, an ecosystem has to look to other ecosystems, and the 'network' takes on a new definition beyond one ecosystem's immediate geography. The network of ecosystems can potentially be defined by partnerships and ability to build its strengths while mitigating its weaknesses with others. It becomes a collaborative effort to grow the pie beyond country or regional borders rather than compete for segments.

2.5 MIT's System, Stakeholder, Strategy (3S) Framework

Innovation-driven entrepreneurship is characterized using the System, Stakeholder, and Strategy Framework presented by MIT. In their paper *A Systematic MIT Approach for Assessing 'innovation-driven entrepreneurship' in Ecosystems*, Budden, Murray, and Turskaya (2019) present the frameworks for comparing regions globally, using statistics that can be generally found for a wide variety of regions.

2.6 System

The system is broken down into the four elements of foundational institutions; innovation and entrepreneurship capacities, comparative advantage, and—built upon all the rest—is impact. Figure 3.2 shows this as a pyramid model.

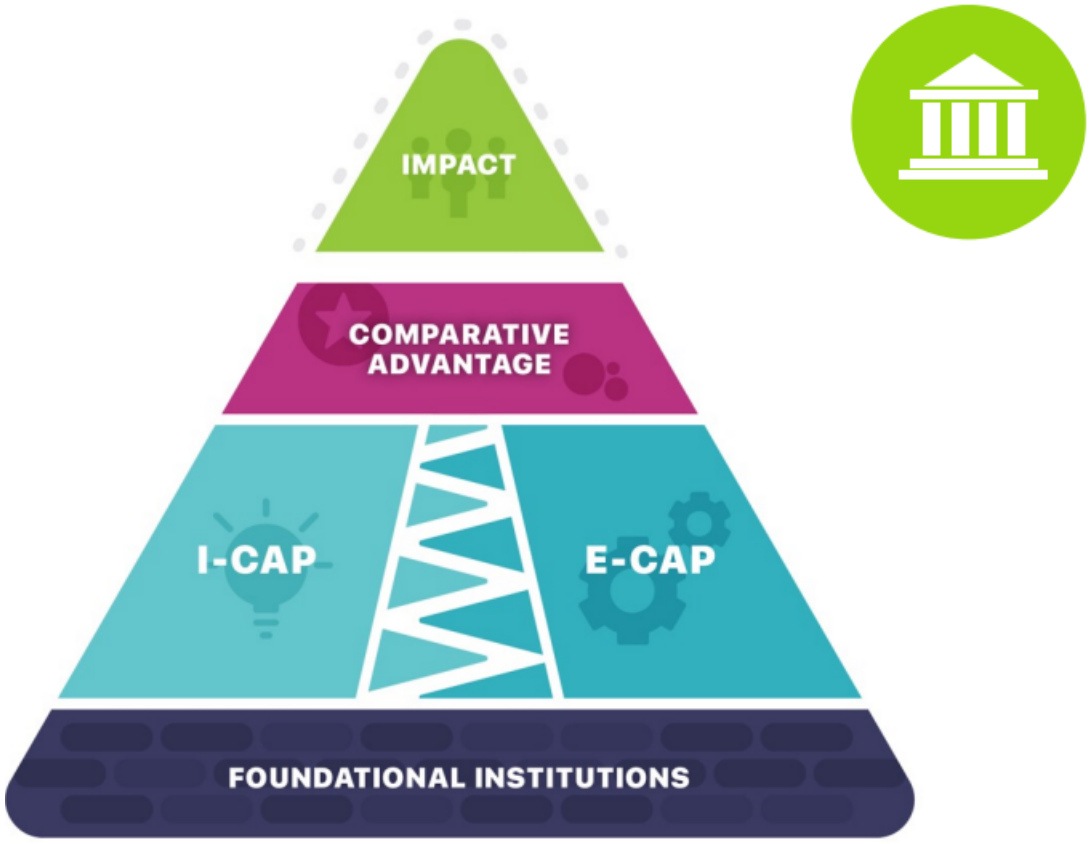
2.6.1 Foundational Institutions

The key foundational institutions are the rule of law, government stability, a measure of corruption, the ability to protect intellectual property, and general economic institutions.

2.6.2 Innovation and Entrepreneurship Capacities

The *Innovation Capacity (I-Cap)* of a geographic region considers the available resources (including institutions and people), and their combined abilities to take an idea and develop it to a stage of technological impact. *Entrepreneurship Capacity (E-Cap)* of a geographic region

Figure 2.2: The ‘System’ for innovation-driven entrepreneurship (Budden & Murray, 2019)



considers the available resources (including institutions and people) and describes their combined abilities to take an enterprise from startup through scale-up and become a sustainable business.

These capacities can be analyzed separately, and Budden, Murray and Turskaya (2018) wrote *A systematic MIT approach for assessing 'innovation-driven entrepreneurship' in ecosystems* providing an analysis and overview of metrics chosen for these capacities. In addition, the MIT innovation ecosystem website provides tools for comparing countries along these capacities over time.("MIT IEcosystem Explore Innovation", 2018) These metrics are based on existing statistics gathered by reputable organizations like the United Nations, World Bank, World Intellectual Property Organization, London Business School, and OCED.

The following subsections will be a brief discussion of the dimensions of entrepreneurship and innovation capacities and a brief overview of the parts of a region they attempt to characterize, whether it be the population, the infrastructure, or essentially an aptitude of a given region for technology and research. The nature of these capacities is that they are considered inputs into the system. These inputs can be changed, and as these inputs are improved, the output of innovation and technology commercialization will yield economic and spillover benefits to the region. Innovation and entrepreneurship capacities zigzag back and forth between one another because they are interrelated. These capacities can be broken down into dimensions of *Culture and Incentives, Demand, Infrastructure, Funding, and Human Capital* shown in Figure 2.3

Culture and Incentives

Culture and incentives describe the appetite for a region to be drawn toward entrepreneurship. It mainly considers a society's willingness to accept new businesses and, relative to innova-

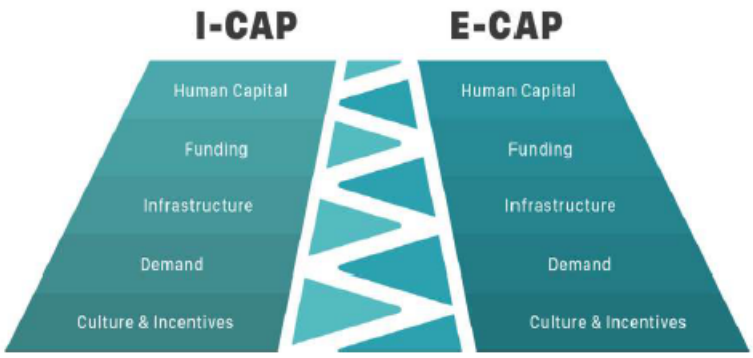


Figure 2.3: MIT Innovation and Entrepreneurship Capacity Dimension (Budden & Murray, 2019)

tion, the scientific resources available. More specifically, the statistics are designed to capture an understanding of a country or region's entrepreneurial abilities and conduciveness to allow entrepreneurs to thrive. These metrics are measures of economic freedom, survey data for the appeal of entrepreneurial careers, capabilities of the population in terms of science and engineering backgrounds, and the quality of research institutions. The data is gathered and published by organizations like the Heritage Foundation (regarding economic freedom), Global Entrepreneurship Monitor (as part of the Global Entrepreneurship Research Association of the London Business School), the Global Innovation Index (published by the World Intellectual Property Organization); and the Global Competitiveness Index (issued by the World Bank).

Demand

Demand describes the ability of that region's market to support technology and growth. A country's GDP is one of the most significant differentiations for an order. A larger GDP—especially per capita GDP, implies that a population has resources and can think more towards tomorrow, unlike a lower GDP per capita living in the tyranny of the moment, ensuring they have food and necessities for today. The subtext of demand is that there is money that can

be invested, public or private. Specifically, the government can procure advanced technology, universities and industries collaborate, and buyers can look beyond price when making decisions.

Infrastructure

Infrastructure is both digital and physical. Physical infrastructure, like roads or shipping lanes, allows for the transportation of goods. It also includes electricity and landlines. Digital infrastructure relates to communications done by cell phones, the Internet, etc. Infrastructure is mainly under the purview of the government. In the case of many small island developing states, infrastructure might be old or damaged from the more frequent natural disasters that occur in the area. Additionally, while there is more overlap between the I-cap and E-cap measurements of infrastructure, the metrics that speak most towards innovation capacity are the availability of the latest technologies and the sophistication of the production process, or how work gets accomplished.

Funding

Funding is a necessary part of an innovation or entrepreneurship ecosystem. It includes the ability of an entrepreneur to gain access to funds, whether it be loans, credit, or receive investments. It differs from demand in that funding considers amount of investments and the ease at which venture capital funding might be available.

Human Capital

Human capital innovation capacity includes characteristics such as the density of scientists and engineers in a population, the quality of stem education, the research professionals engaged in R&D per million of the population, and so forth. At a basic level, it also includes the population that attends to tertiary institutions.[2] The dimension of human capital also characterizes the population from which entrepreneurs are drawn, giving an idea of the level of technology innovation that supports people within a region. A higher proportion of STEM-educated people means greater availability of people with whom inventors and innovators can engage with one another to form teams and businesses.

2.6.3 Comparative Advantage

The critical points of David Ricardo's theory of comparative advantage consider a nation's ability to produce goods efficiently concerning specialization, mutual benefit, and gains in trade. In a nutshell, countries should specialize in producing goods that can be made more efficiently than other nations. In theory, by trading in goods they specialize in, countries can exchange their products with each other, benefiting both parties because each country pays a lower price than if they had produced it themselves. This should lead to gains in trade because overall production is increased and products are traded efficiently. Ricardo's theory assumes no transportation costs or trade barriers between countries.

Comparative advantage may look for historical strengths in specific industries, geography, and relative strengths given by position, and it may look at institutional power. The "comparative advantage of any region's economy is based on specific areas of strength that differentiate it

[2]Tertiary education is schooling beyond high school or secondary school education, inclusive of associates degrees.

from others….a region's comparative advantage will often find expression in geographical clusters or industrial sectors." (Budden et al., 2021)

Ricardo's theory originated in 1817 and referred to physical products at the time. Now, it can be extended to products of knowledge and digital transformation. Budden and Murray "also found that comparative advantage can be usefully expressed not only in backward reflection upon existing, well-defined clusters but in forward-leaning areas of expertise and specialization e.g., 'Oceans', Smart City Infrastructure, etc." (Budden et al., 2021)

Additional comparative advantage might include a country's ability to develop and harness knowledge. For example, some of the relative advantages of a country like Israel are the mandatory military service for both men and women, which provides training and life experience at a young age; the law of *aliyah* also permits talent from the Jewish Diaspora to return to Israel given Jewish heritage; and the Jewish identity as "People of the Book" reinforces the importance of education in young and older generations. Comparative advantage is not necessarily something that can be measured, or that can even be proven. As identified above, it might be an identity or even a stereotype that feeds into the narrative of knowledge and good production.

2.6.4 Impact

The overall purpose of strengthening foundational institutions, innovation and entrepreneurial capacities, and leveraging comparative advantages of reason is to generate impact on a region's economic and social progress. The impact metrics are subjective and unique to a given region and can include measurements of GDP, sustainable development metrics, survey data like the ease of doing business, or even the size and number of enterprises created, to name a few. Education, social progress index, and poverty levels are another dimension of impact for social

progress. The desired impact, informed by the innovation and entrepreneurship capacities, can guide the development of various policy and program interventions.(Budden et al., 2019)

2.7 Stakeholders

The term "military-industrial complex" reflects the notion of industry and government co-developing the industrial economy. In 1997, Etzkowitz and Leydesdorff wrote a book titled *Universities and the global knowledge economy: a triple helix of university-industry-government relations*, which discussed how the 1980 Bayh-Dole Act changed the nature of the relationships between universities and government-funded research, allowing a university to retain ownership of resulting inventions created and commercialize them. As a result, "technology transfer activities spread to a much broader range of universities, resulting in the emergence of an academic technology transfer profession and information media to service it." (Etzkowitz & Leydesdorff, 1997) Their research highlights the role of university-industry-government relations to spur economic growth based on innovation and knowledge and is called "The Triple Helix." (Etzkowitz & Leydesdorff, 1997)

Economies and social progress hinge on more than one or two institutions or stakeholders. Additional suggestions by Carayannis and Campbell in 2009 expanded this to create the Quadruple helix, which includes the public's role in civil society and the media. Later they expanded it to the Quintuple helix model to fit the natural environment and the production of knowledge and innovation relating to "green" knowledge for sustainable development. (Rapetti et al., 2023) The research in innovation ecosystems examines how networks of people and institutions facilitate the commercialization of inventions and yield spill-over economic benefits to a region.

Sometimes attempts are made to identify one stakeholder or institution as the leader of a given

ecosystem. Still, as a broader understanding is gained, a systems perspective emerges on how each stakeholder plays a role and cannot be isolated as the sole enabler of a region. Steve Case, in his book *The Rise of the Rest*, present a systems-type model of

> "the tech ecosystem is a wheel with seven spokes, connected and in motion. The spokes are comprised of (1) start-ups, (2) investors, (3) universities, (4) government, (5) corporations, (6) startup support organizations, and (7) local media. These entities use a variety of levers to help convene, educate, inform, and link startups. Their efforts, in turn, inspire an environment conducive to innovation and entrepreneurship." (Case, 2022)

Case goes on to emphasize the inter-relationship of these seven spokes. In 2010, Daniel Isenberg's Harvard Business Review article *The Big Idea: How to Start an Entrepreneurial Revolution* popularized the term "entrepreneurial ecosystem." (Isenberg, 2010) Isenberg developed domains of the entrepreneurship ecosystem; the World Economic Forum developed an ecosystem pillar model; Koltai, who created and ran the US State Department's Global Entrepreneurship Program, had a Six + Six model of functional pillars and actors; Spigel's model combined regional material, social, and cultural attributes for a model on entrepreneurial ecosystems. (Jafarov & Szakos, 2022) "Regional policies for entrepreneurship are currently going through a transition from increasing the quantity of entrepreneurship to the quality of entrepreneurship," where quality entrepreneurship focuses on growth and innovation-oriented entrepreneurship. (Stam, 2015)

Though these other stakeholder models exist, MIT's 5 Stakeholder Model is the framework that this thesis uses to analyze Hawaii, Fiji, and New Zealand. Commentary is provided where required regarding other key players, like NGOs, who might play a role when these stakeholders are lacking.

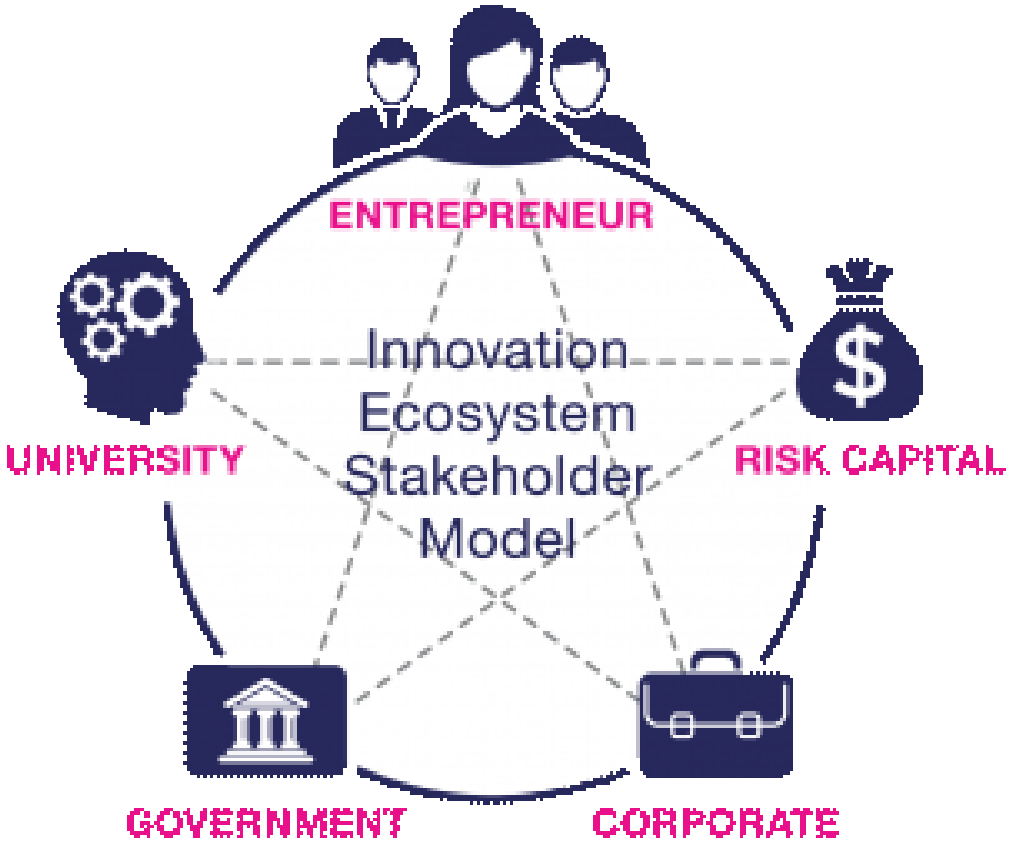
MIT's Stakeholder Framework identifies five key stakeholders of Universities, Entrepreneurs, Risk Capital, Corporate, and Government. Budden and Murray (2019) explain the importance of the stakeholders in the following:

> "Understanding those stakeholders' systemic roles – and aiming off for self-promotion by some, and understatement by others – is crucial to getting more accurate and nuanced perspectives on their contributions. Building on these examples (and on insights into the role of involved stakeholders), those seeking a more purposeful (and accelerated) approach to ecosystem-building today can assume that, by taking a more mindful and systematic approach, they might shift the odds more swiftly and more clearly in favour of success for their region." (Budden & Murray, 2019)

The MIT Stakeholder Framework builds on the stakeholders identified in the Triple Helix Model and expands the stakeholders necessary to consider Entrepreneurs and Risk Capital providers as critical to the success of an innovation ecosystem. (Budden & Murray, 2019) This framework's purpose is for specifically building and accelerating innovation ecosystems given what has emerged in the 21st century. Including these two stakeholders is critical to capturing the dynamic nature of innovation ecosystems. They have developed a framework for the comparison of different regional innovation ecosystems. This framework is shown in Figure 2.4

Entrepreneurs, Risk Capital, Corporate, Government, and Universities are stakeholders. While other models may include NGOs, support organizations, the natural environment, or other organizations, the MIT's Five Stakeholder Model focuses on these five because each of these stakeholders has the ability to become a leader in building and developing the regional innovation ecosystem. Other stakeholders–such as NGOs and support organizations–are often founded and funded by one of the original five stakeholders, while media is often a Corporation

Figure 2.4: Innovation Ecosystem Five Stakeholder Model



and the natural environment is seen by economists as a natural resource.

2.7.1 Government

Government plays a central role in facilitating innovation ecosystems by providing foundational institutions and infrastructure conducive to protecting intellectual property and scaling of IDEs. The government as an innovation ecosystem builder can provide resources in terms of people, offices, funding, etc. There are also often multiple levels of government, including municipal, state, and national levels, which may have corresponding names that differ from country to country. Government sponsored research demonstrates a connection between stakeholders, often more than one. Government funding can also be seen in facilitating grants and loans, or providing tax breaks for certain sectors. Additionally, logistics and digital connections are facilitated by infrastructure built and often sponsored by government. Lerner describes that "while the government can 'set the table' and create conditions for successful innovation-driven growth, it cannot lead such efforts." (Budden & Murray, 2019; Lerner, 2011)

2.7.2 Large Corporations

The Triple Helix refers to the interconnectedness of industry, government, and universities in creating an innovation ecosystem. However, the MIT Stakeholder Framework differentiates from industry, and more specifically focuses on large corporations. This change focuses on specific business entities whose presence in a region may play a role in research & development, technology transfer and commercialization, job creation, investment, policy advocacy, and collaborative partnerships. In addition, large corporations often drive innovation internally, and often establish open innovation programs that encourage external partnerships and co-creation. Through collaboration with startups, research institutions, and other stakehold-

ers, they can leverage diverse perspectives and expertise to develop comprehensive and transformative solutions.

Overall, large corporations may act as anchors in an innovation ecosystem by providing stability, resources, and mentorship. Corporations usually have multiple branches and needs for solutions in those respective branches. For example, human resources might need a solution for identifying gaps in its total remuneration to retain employees. Or, it might need a solution associated with the supply chain. Corporations can inform on a broad base of issues related to their operation and as such nurture IDEs that serve a corporation while not necessarily being in the same industry. Their symbiotic relationship with startups and other ecosystem participants can foster a dynamic environment to drive technological progress in their industry and beyond.

Large corporations, and their respective industries, may also play a role in determining the comparative advantage for a given region. Budden and Murray also note the drawback of corporations as potential leaders given they "have limitations in their role: they have shareholders to satisfy, some of whom might only have a short-term perspective, while the most global ones may shift their strategic direction and therefore their ecosystem commitment, through changing geographic priorities, and may even be less credible as an honest broker in regional leadership." (Budden & Murray, 2019)

2.7.3 Universities

Universities are tertiary educational institutions made up of multiple colleges engaging in research for a specific discipline. A university's role in an innovation ecosystem is significant to the development of IDEs because—as Richard Florida noted—it provides "science-based ideas, technical and scientific training, entrepreneurship education, sophisticated facilities"

and often have multiple people or offices associated with these roles like offices of technology transfer, innovation and research, research labs, entrepreneurship centers, etc. (Budden & Murray, 2019)

When considering a regional innovation ecosystem, Richard Lester provides this viewpoint on the importance of universities to local communities.

> "As local communities focus on the importance of innovation and an educated local workforce to their long-term prosperity, their attention has naturally turned to the contributions of local universities. These institutions are a primary source of the most valuable assets in the knowledge economy: highly educated people, and new ideas. The presence of universities may also attract other key economic resources to the region, including firms and educated individuals who may want to locate close by, as well as financiers, entrepreneurs and others seeking to exploit new business opportunities emanating from the campus. And one of the most appealing features of universities from a local perspective is, of course, that – unlike so many other participants in the local economy – they are immobile. A university is necessarily committed to its region for the long term." (Lester, 2005)

Universities are often a place where entrepreneurs of innovation-driven enterprises find resources, support, and make connections with other entrepreneurs. As individuals leave or graduate, they also provide a network of alumni and external resources to the greater community and even outreach programs to future students.

2.7.4 Entrepreneurs

The term entrepreneur is non-sector specific. There are many entrepreneurs throughout the globe, who have started successful SMEs and contribute to the economic development and health of a region. Others have focused on "social entrepreneurship" often as non-profit enterprises. A region will also have its share of histories of failure. These histories may color a region's perspective on entrepreneurship, and the culture and incentives of a region have likely evolved from these histories. Though an area might view its entrepreneurs as one collective, the subset of entrepreneurs of innovation-driven enterprises often have more specific backgrounds, characteristics, and needs from an innovation ecosystem.

The MIT Stakeholder Framework recognizes the "IDE entrepreneurs' central role in the innovation ecosystem [with] their voice critical to ecosystem building. Without this voice from the frontline of innovation, ecosystem building efforts may be undertaken in a vacuum, and not actually provide the support needed to accelerate IDEs: instead, efforts may simply provide what other stakeholders *imagine* that an IDE entrepreneur needs." (Budden & Murray, 2019) Brad Feld, an American Entrepreneur in Boulder, Colorado, suggests that "entrepreneurs are the only individuals who can meaningfully lead ecosystem building because they are leaders (and not 'feeders') on the frontlines." (Budden & Murray, 2019)

Feldman recognizes how entrepreneurs associated with a place play a particular role. "In my conceptualization, entrepreneurs, as the agents who recognize opportunity, mobilize resources, and create value, are key to creating institutions and building capacity to sustain regional economic development. Entrepreneurs benefit from the location. But entrepreneurs are also pivotal as agents of change that can transform local communities. The initial event or entrepreneurial spark that gives rise to prosperous regions is not deterministic, nor do they automatically set in motion path dependencies that automatically yield successful places. Hu-

man agency matters most–the building of institutions and the myriad public and private decisions that determine the character of the place." (Feldman, 2014)

2.7.5 Risk Capital

Risk Capital providers are an inclusive group of any person or organization that provides funding or in-kind donations to any enterprise. They include angel investors, venture capitalists, organizers of pitch competitions, and even corporate venture capital. Incubators, Accelerators, and co-working spaces are programs that may provide funding, programs, or space to assist a start-up. There has been creativity in crafting the types of organizations that fund start-ups. For example, in developing economies, various entrepreneurial support organizations might provide monetary and in-kind support, where funds come from integrating sources from government and private funds.

Risk Capital providers are an important stakeholder in an innovation ecosystem and their existence and investment sizes provide insight into the innovation ecosystem. As Budden and Murray describe,

> "they can provide an especially important window into the factors that may be limiting risk capital resources. Conversely, innovation ecosystems are especially salient to risk capital providers: they provide an efficient, geographically localized context for the identification of new ideas, teams and IDEs. And the deep social networks provide important sources of referrals and endorsements to investors with many investment choices and only limited time and investment capital."

The absence of risk capital providers calls into question the gaps that a region might have. Potentially, the lack could be related to the legal system and how it protects investors or intel-

lectual property. Feedback from entrepreneurs on their fundraising efforts informs about the strength of this stakeholder.

2.7.6 Other Key Players

The MIT 5 Stakeholder model is the tried-and-true model that can characterize innovation ecosystems across the globe. As indicated previously, MIT's Stakeholder Model consists of five stakeholders of Entrepreneurs, Government, Corporations, Risk Capital providers, and Universities. They have been selected because, over decades of study they are the consistent five and they can be leaders in further developing the innovation ecosystem. However, sometimes additional key players may arise. One of the criticisms of the Triple Helix model is that it is primarily oriented toward Western developed economies. Al Maainah discusses a gap in the literature in the following:

> "Transitioning from commodity production towards a service-oriented and knowledge-based innovation ecosystem is problematic, as is demonstrated by the number of economies remaining in the middle-income group. The application of one transition model Triple Helix demonstrates the problem: transition requires 'thick' institutional arrangements capable of generating and exploiting new knowledge embodied in goods and services, however by definition emerging economies have 'thin' institutions that they are in the process of developing." (Al Maainah, 2021)

What has been seen in regions—especially those with "institutional thinness"—is a response from non-governmental organizations, inter-governmental organizations, non-profit organizations, entrepreneurial support organizations, and others, emerge to try to fill the gaps related to the functions of a lacking stakeholder.

2.8 Strategy: Policies and Programs for building I-Cap and E-Cap

The impact section mentions that policies and program interventions can shift an ecosystem. The 1980 Bayh Dole Act, also known as the "Patent and Trademark Law Amendment," was a bipartisan bill passed unanimously in the Senate that influenced the commercialization of university technologies. The perspective on a systems level allows for the weaknesses and strengths of a regional ecosystem to be examined and contextualized by the various stakeholder groups. As the ecosystem is examined from that system-level perspective, policies, and programs can be crafted to encourage economic development.

2.9 Indigenous Populations and Ancestral Science, Knowledge, and Practices

A dichotomy exists between Indigenous peoples and settlers in various parts of the world. Indigenous populations refer to the group or groups of people who historically inhabited a region. In Hawai'i, the Indigenous are the Native Hawaiians; in Fiji, the Indigenous are the iTaukei; and in New Zealand, the Māoris. As time has passed, those dual populations have often not progressed at parity. This thesis examines efforts in Hawaii, Fiji, and New Zealand to bring Indigenous or marginalized peoples to parity.

Indigenous knowledge may provide an opportunity to complement technology and can be used in creating innovation-driven enterprises. More specifically, Indigenous knowledge refers to knowledge developed over time and usually passed down through oral tradition and apprenticeship practices. As climate change is a comprehensive and global challenge affecting things

like agriculture, food, and weather systems, Indigenous ecological knowledge is being incorporated into the search for solutions. As such, innovation-driven enterprises may potentially emerge from the combination of Indigenous environmental knowledge, a subset of Ancestral science, and Western technology. Chapter 7 discusses the roles of Indigenous populations and ancestral science, knowledge, and practices in building regional innovation ecosystems.

Chapter 3

Hawai‘i

3.1 Background

Nestled in the vast expanse of the Pacific Ocean, Hawai‘i is an archipelago that captivates travelers with its breathtaking beauty and unique cultural heritage, see Figure 3.1. Situated approximately 2,100 miles southwest of the mainland United States and 4,000 miles from Japan, this remote island chain comprises eight major islands, each boasting its distinct charm and allure. Hawai‘i’s strategic geographic location places it at the Pacific crossroads between East and West.

The archipelago’s position in the central Pacific also influences its climate, with warm temperatures and gentle trade winds. Hawai‘i’s location along the Pacific Ring of Fire has endowed it with a diverse topography, showcasing everything from lush rainforests and cascading waterfalls, to volcanic landscapes and iconic beaches of white, gold, and black sands.

Despite its allure, Hawai‘i’s remote location presents challenges regarding accessibility and

Figure 3.1: Map of Oceania, Hawai‘i in red.

economic dependencies. The geographic isolation makes Hawai‘i more vulnerable to supply chain disruptions and the impacts of climate change.

3.1.1 Brief Political History of Region

Hawai‘i was initially settled 1500 years ago by voyagers from the South Pacific. The Hawaiian Islands had higher population densities than any other Pacific Islands and they were unified under King Kamehameha in the early 1800s when he became the first king. Before European contact, Hawai‘i was a self-sustaining society with a sophisticated cultural and social structure. In the late 18th century, the arrival of European explorers, traders, and missionaries led to fundamental changes in Hawaiian society. Within the century, the US —via greedy plantation owners—overthrew the monarchy. The eventual annexation of Hawai‘i by the United States in 1898 signaled a pivotal shift in its trajectory. On August 21, 1959, Hawai‘i went from being a US territory to the 50th state in the United States of America. The Clinton administration formally apologized for the overthrow on the 100 year anniversary, and the current Biden administration has developed a strategy for the Pacific Islands.

3.1.2 Brief Socio-Economic History of Region

Hawai‘i’s more recent socio-economic history separates into eras of colonialism, plantations, and its integration into the United States. During the 19th century, the sugar and pineapple industries dominated Hawai‘i’s economy shaping its plantation era. The influx of immigrant labor, primarily from Asia and Europe, significantly impacted the islands’ demographics. The plantation system relied on the cheap labor and furthered a hierarchical social structure with significant racial inequalities. Despite economic growth driven by the export of these cash crops, the majority of the profits were funneled to American landowners and corporations.

The growing influence of American interests in the Hawaiian economy culminated in the overthrow of the Hawaiian monarchy in 1893, followed by its eventual annexation by the United States. Hawai‘i’s incorporation as a US territory further solidified its role as an agricultural supplier to the mainland, shaping its economic and social dynamics for decades. In the 20th century, Hawai‘i’s economy underwent further diversification with the rise of the tourism industry. Tourism became a central driver of economic activity. Hawai‘i has continued to evolve and face unique socio-economic challenges, including issues related to land use, affordable housing, and preserving its Indigenous culture and identity amidst rapid modernization and globalization.

Currently, the State of Hawai‘i has the following demographics: 37.1% Asian, 25.2% White, 10.3% Native Hawaiian, 11.1% Hispanic or Latino, and 24.7% mixed ethnicities. (*The State of Hawaii Data Book 2021 - Table 15.32*, 2021) And there are more Native Hawaiians living outside of the state of Hawai‘i than within it due to the economic conditions.

The primary challenge that Hawai‘i faces today is how to diversify its economy from the dependency on tourism to one that is more self-sufficient. I chose Hawai‘i as an ecosystem to study because it is geographically-remote and has limited natural resources when considering mineral deposits and crude oil. Its resources include climate, water supply, soil, vegetation, ocean, rock, gravel, and sand. The Hawaiian Government has recognized some of the challenges the state economy faces as it depends mainly on hospitality and tourism—especially considering the low wages in this sector. The state Comprehensive Economic Development Strategy (CEDS) Committee identified the following weaknesses:

1. “Stereotype of being merely a vacation destination
2. Perception of boondoggle location
3. Over-reliance on tourism and development
4. Lack of a diversified economy

5. Other substitute tourism destinations" (*Hawaii Statewide Comprehensive Economic Development Strategy*, 2016)

The CEDS Committee goes on to identify weaknesses and threats to its economy, such as

1. "Climate change and sea level rise
2. Growing polarization in the community and the loss of Hawai'i's historical context
3. Changes in values and the loss of commonly shared values
4. Bypassed by the global economy
5. High cost of living" (*Hawaii Statewide Comprehensive Economic Development Strategy*, 2016)

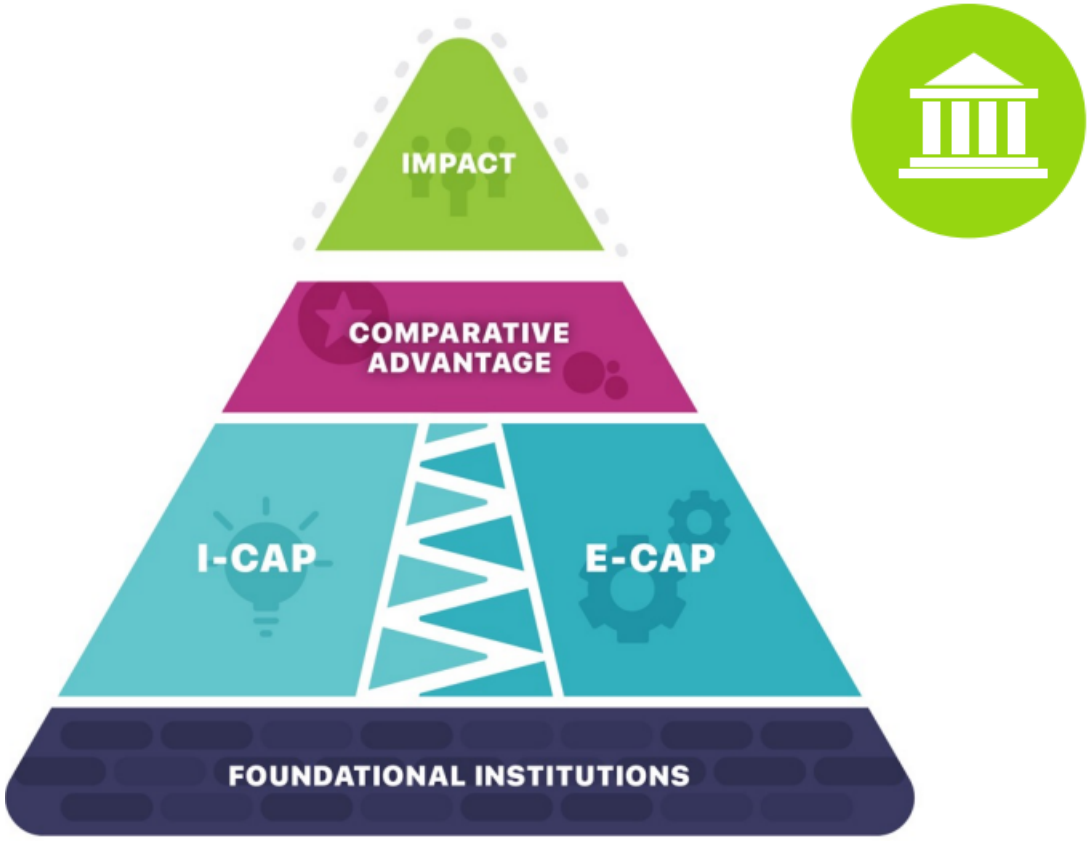
In addition to the standard targeted industry clusters of Hospitality and Tourism, the 2016 CEDS document identified industry sectors, including national security; healthcare; research, innovation, and technology; agriculture and food production; energy; manufacturing; and creative industries. (*Hawaii Statewide Comprehensive Economic Development Strategy*, 2016)

What follows is an analysis organized by the MIT 3-S framework, as mentioned in Chapter 2. This framework allows for systematic analysis of a proposed region, including its system, stakeholders, and strategies.

3.2 System

To understand Hawai'i's innovation ecosystem—both its current state and potential—it is analyzed as a 'system'. This system is broken down into the four components of foundational

Figure 3.2: The System for innovation-driven entrepreneurship (Budden & Murray, 2019)



institutions, innovation and entrepreneurship capacities, comparative advantage, and impact. Figure 3.2 shows this as a pyramid model.

3.2.1 Foundational Institutions

As part of the United States, Hawai‘i benefits from the federal government in terms of infrastructure, rule of law, and funding, to name a few. In addition, as a US state, it draws from the best practices of other US states in managing its affairs. Furthermore, patents and intellectual property are protected as part of US law.

3.2.2 Innovation and Entrepreneurship Capacities

Even though Hawai‘i is a US state, gathering data has posed challenges. At the time of this writing, the various data points came from different periods, with some preceding the COVID-19 pandemic. The data is presented with the best intentions and represents a real-time snapshot. What follows is an analysis of the categories across innovation and entrepreneurial capacities.

Figure 3.2 shows a staircase zigzag between a region's entrepreneurial and innovation capacities. There are various statistics and reports to comb through for collecting these facts and perceptions of a given area. The data collected can be found in the appendix. Informational interviews with various stakeholder groups were conducted to add context to these statistics and inform on the veritable state of the Hawaiian innovation ecosystem.

Culture and Incentives

From the lens of culture and incentives, data on Hawai‘i's entrepreneurial capacity is insufficient, given that the data available is on a country level. Regarding business freedom, it is assumed that the legal ability to operate a business in Hawai‘i is the same as in the mainland US. In terms of the favorability and characteristics for Hawaiians to become entrepreneurs, numerous interviews referenced the high cost of living and real estate. The high cost of living means that people must be more successful and achieve success more quickly in Hawai‘i than on the mainland. For perspective, in Hawai‘i the poverty level for a one-person household is $23,445 per year as opposed to on the mainland (48 contiguous states), where it is $12,880 per year. (*The State of Hawaii Data Book 2021 - Table 15.32*, 2021)

This substantial difference would likely increase the fear of failure, because the threshhold for success is higher. While 9.8% of all Native Hawaiian families were in poverty in 2021,

when looking at families with children that jumps to 15.8%. When considering specifically families with children under five years old, the poverty rate is 19.6%. (*The State of Hawaii Data Book 2021 - Table 15.32*, 2021). Compare this to the total population of Hawai'i, where those numbers are 8%, 12.2%, and 9.1%, respectively.

Businesses must follow a different trajectory and cannot always leverage space at home. The homes in Hawai'i are often multi-generational for Native Hawaiians and are, on average smaller. Real estate, and space, are also expensive and short on hand. This also indicates a potential reason why entrepreneurship is sometimes considered harder in Hawai'i—not to mention, the regional price parity for Hawai'i is the highest in the nation at 113.2 in 2021. ("Real Personal Consumption Expenditures by State and Real Personal Income by State and Metropolitan Area, 2021 | U.S. Bureau of Economic Analysis (BEA)", 2021)

Looking through the lens of innovation capacity, in 2019, all science and engineering degrees conferred represented 37.1% of the total, according to the NSF, which included fields of "biological and agricultural sciences, engineering, physical sciences, social sciences, computer sciences, mathematics and statistics, and psychology...[though] associate's degrees and professional degrees are not included." ("Hawaii | National Science Foundation - State Indicators", n.d.) Ultimately, though, if only 51% of secondary school graduates go on to tertiary education, this represents 19% of the total population having science, engineering, or social science degrees.

The H Index was a metric chosen to represent the quality of scientific research institutions because data was not available from other sources. It is a metric that could be quantified across geographies as opposed to mere survey data from the Global Competitiveness Index. The H index quantifies citations and productivity for the given region. It is related to the number of journal publications and citations and is a way to compare authors, areas, institutions, etc. The source did not provide the data for all of the United States, but for comparison, the H index for

the state of Hawai‘i is 9.11, while Massachusetts represents the highest H index at 47.02. (*H Index for States and Countries*, 2023)

Finally, the number of patents awarded per 1000 individuals in science and engineering occupations is 6.09 in Hawai‘i versus 22.45 across the US. (“Hawaii | National Science Foundation - State Indicators”, n.d.)

Demand

In 2022, The US GDP is $26 Trillion, while Hawai‘i’s is $98 Billion. Since the market scale is much smaller in Hawai‘i, many businesses need to get out of the state to penetrate a larger market. There are programs like the “Made in Hawai‘i” initiative that the Hawaiian Government sponsors through the Hawaiian Technology Development Corporation office. At the outset, there is a need to think beyond the state and target national and international customers. There is support through government programs to help products go offshore successfully to international markets such as Japan.

Regarding I-Cap demand metrics, none were available for Hawai‘i. Qualitatively there are some university-industry research collaborations, but the number of research universities in Hawai‘i is limited compared to the US as a whole. However, as part of the US, this number could be improved because it is relatively common for US companies to collaborate in research.

Infrastructure

In terms of infrastructure, access to the internet is high, with 88.2% of the population having internet subscriptions. This statistic is part of both I-Cap and E-Cap. Additionally, 93.6% of households have a computer. Qualitatively, from interviews, the general impression was that

internet infrastructure improved over the pandemic.

All in all, it is expected that Hawaiians may be somewhat limited in terms of the "availability of latest technologies" based on an interview with coordinators of the TropicalAg Tech Conferences, now called the THRIVE Hawai'i Agrifood Summit. They work to bring mainland agricultural technologies to Hawai'i and adapt to the local environment. It is likely that in terms of other technologies, because of the association of Hawai'i to the US, technology diffusion occurs in specific fields.

Funding

Regarding Funding E-Cap, looking at solely the VC investment for 2019 total and contrasting between Hawai'i and the US. VC investment in Hawai'i is reported at $78.9M. This is less than a 1/10th of a percent of the total country, which is reported to be $132.7B. ("Pitchbook", 2023) The number of VC deals reported 2014 through 2022 for Hawai'i represent 0.2% for the entire nation; specifically, 614 deals reported in Hawai'i, vs 229,200 across the US. ("Pitchbook", 2023)

Regarding I-Cap, funding Hawai'i has received relatively small amounts of funding from public sources compared to the US—it differs by roughly a factor of 6. R&D expenditure as a percentage of GDP is low at 0.70%. Again, much of the data did not exist for Hawai'i specifically.

The University of Hawai'i has been awarded an NSF Innovation Engine grant. The National Science Foundation selected Hawai'i as one of 44 NSF Regional Innovation Engines Development Awards for Type 1. The Type-1 award is up to $1M for up to two years for a development phase. The goals of the NSF Engines program are to boost innovation capacity, create sustainable innovation ecosystems, and demonstrate inclusive economic growth. ("Hawaii | National Science Foundation - State Indicators", n.d.) There will be more on this in the university stakeholder section.

Human Capital

In Hawai‘i, 46.8% of individuals ages 25-44 are post-secondary degree holders. This on par with the US at 46.2% The most significant comparison that can be made is concerning educational attainment of Native Hawaiians vs. total population in Hawai‘i: 11.4% of Native Hawaiians 25 and older have a Bachelor's degree and 7% have a graduate or professional degree, compared to 22.2% and 13.1% of the Total population of Hawai‘i. ("Economy Briefs from the GII 2022", 2022; "Hawaii DOE | High School Class of 2021 College Enrollment Recovering from Pandemic", 2022)

The CEDS plan calls for a focus on education as part of the economic development plan of Hawai‘i. Work is being done at various levels of the education system to help children and young adults. Some programs focus on computer programming, others on design thinking and problem-solving, and others on assisting students to understand their cultural roots and have a systems perspective. Specifically, many programs are geared towards Native Hawaiians and for teaching them what might be best termed Ancestral Sciences. Culturally, there is great respect for the *‘āina* or land. In interviews with Kamehameha Schools (primary and secondary schools for Native Hawaiians), comments were made about stepping up from silo STEM classes to a more interdisciplinary education focused around the *‘āina* the *waiwai* (water systems), and other natural resources.

Hawai‘i's human capital innovation capacity is emerging. The standards for human capital are related to Western markers of innovation capacity in terms of the engineering and science degrees. According to the NSF, there are 22.5 STEM graduates in Hawai‘i per 1000 people ages 18-24, vs. 25.51 on the mainland. ("Hawaii | National Science Foundation - State Indicators", n.d.) These statistics do not capture the full knowledge of the Indigenous populations and their generational knowledge, which is termed "Ancestral Science."

3.2.3 Comparative Advantage

Hawai‘i possesses a unique and diverse range of comparative advantages that make it stand out as a special region in the global landscape. A primary advantage lies in its tourism sector, which capitalizes on the state's exquisite natural beauty, tropical climate, and vibrant cultural heritage. Hawai‘i's picturesque beaches, volcanic landscapes, and numerous outdoor activities make it a sought-after destination for travelers. Its position between the US West Coast and Eastern Asia attracts tourists from many regions. The cultural richness of the aloha spirit further enhances its appeal. As a result, Hawai‘i has become a tourism hotspot, welcoming millions of visitors annually, providing significant economic benefits, and supporting various industries and businesses related to hospitality and leisure.

Another key comparative advantage of Hawai‘i lies in its historical agricultural prowess. The fertile volcanic soil and year-round favorable weather enable the cultivation of an array of tropical fruits, such as pineapples, papayas, and bananas, as well as high-quality macadamia nuts and coffee. The "grown in Hawai‘i" label has become synonymous with premium, locally sourced produce, driving agricultural exports and supporting the growth of agribusinesses. Furthermore, Hawai‘i's unique biodiversity presents opportunities for biotechnology and pharmaceutical industries as researchers explore the region's rich flora and fauna for potential discoveries. Hawai‘i's commitment to sustainable practices and renewable energy initiatives further aligns with its agricultural strengths, making it a promising player in the global movement towards green technologies and responsible resource management.

The comparative advantages of Hawai‘i include the following Table 3.1 as provided in the DBEDT report written with UH Shidler College of Business regarding assets.

Various organizations have looked at Hawai‘i's comparative advantages and the needs for the economy. There is a focus on sustainable food systems, including agriculture and aquacul-

Table 3.1: Hawaiian Islands Table of Advantages from seeming Liabilities (Ritchie, 2023)

Liability	**Advantages**
Remoteness	Minimal light pollution can serve as a test model for a more subsistence-based culture, reduce outside dependence on imports, be closer to Japan, and be a popular destination for Asian tourists
Surrounded by Ocean	Opportunity for ocean innovation, aquaculture, research with reefs (410,000 acres of the living reef), desalination, a leading indicator for climate change
Limited land	Need more efficiency for sustainable food systems, more efficiency in general
Climate	Hawai‘i tropical climate is representative of numerous climates in other countries. 270 days of sunshine a year
Volcanic Island	Geothermal research; volcanic properties in soil
Military Bases	Federal government funding
Oral Histories	Different Styles of Learning, respect for Tradition and Elderly

ture, clean energy, and incorporating Indigenous knowledge to solve these challenges and the looming threat of climate change.

3.2.4 Impact

The impact combines the foundational institutions, entrepreneurial and innovation capacities, and comparative advantages. The choice for measuring the impact depends on the stakeholder. One flawed economic metric might be GDP. Its flaw is relative to the fact that for Hawai‘i, the “highest and best use of land” is high rises and the tourism industry, but the COVID-19 pandemic proved that it is not a robust solution. Diversification is necessary for the economy to thrive.

Alternative metrics might include job creation for the local population, average household income relative to inflation increase, percentage of people below the poverty level, or other social metrics. Suppose the focus industry is on agriculture and aquaculture. In that case, the

impact may be seen in lowering the cost of food per household, a decrease in obesity levels, or other metrics of social progress. The Social Progress Index looks at metrics that are indicative of progress outside of economic goals; this could provide an alternate standard index for comparison. (Stern et al., 2020) Another dimension of impact is environmental. Hawai'i is the first state to commit to having a 100% clean renewable electricity portfolio by 2045. In addition, the Hawai'i Clean Energy Vision has a net-negative emissions goal.

3.3 Stakeholders

The MIT model for innovation ecosystems has five stakeholders. There are many groups within the following stakeholder categories: entrepreneur, risk capital, corporate, government, and university. Interviews were conducted to add context to the research. The anecdotes provided are generalizations and not from a statistically significant population. More thorough research could be done to understand the stakeholders. Figure 3.3 on the following page lists various organizations by stakeholder group and whether they primarily build innovation or entrepreneurship capacities.

3.3.1 Entrepreneurs

Hawaiian entrepreneur and journalist Ryan Okawa said, "visibility is a problem." There are not many success stories of Hawaiian startups.(R. Ozawa, 2023) "If you ask a bunch of local people what kind of business they'd start if they had the funds, you're likely to hear about a bunch of restaurant and cafe concepts, clothing or craft stores, more than a few boba tea shops, and maybe a tour or transportation company or two," Ryan Ozawa began a recent article in the *Honolulu Star Advertiser*. (B. R. Ozawa & June 27, 2023) These are the startups with

I-Cap building	Stakeholder Group	E-cap building
Code for Hawaii	Entrepreneurs	Creative Lab Hawaii
Hawaiians in Tech		HiCapacity (makerspace)
Startup Hawaii		BoxJelly (coworking space)
Cohana (part of Maui Research and Technology Cer		Entrepreneurs Sandbox (joint operation between HTDC and BoxJelly)
DevLeague (coding school)		Hanalei Initiative
Dev-Island Kauai (coding school)		Hub Coworking Hawaii
Keiki Coders (coding school)		Treehouse Coworking
Tropical AgTech Conference		Waiwai Collective
East Meets West Conference		Workshop Coworking Hawaii
Ryan Ozawa (organizer of resources and Entrepreneur)		Kauai Makerspace
		Maui Makers
		Ourspace Hawaii
Hawaii Venture Capital Association	Risk Capital	Sultan Ventures
Blue Startups (Accelerators)		Reinmkr Satsang
Elemental Excelerator		Pacific Healthcare Ventures
HATCH (Accelerator – aquaculture)		Surf Club Ventures
Builders VC		UH Student Venture Fund
Earthshot Ventures		Mana Up (accelerator – product and VC fund)
Startup Capital Ventures		Hawaii Angels
Pono Island Capital		Koa Capital Partners (PE)
Alpaca VC		Tradewind Capital Group (PE)
Decisive		Coyote Ventures (women's health and wellness)
		Purple Mai'a
UH Office of Innovation and Commercialization	Universities	UH Pacific Asian Center for Entrepreneurship
HITIDE – Hawaii Technology Innovation Developme		
		UH Schidler college of Business
		Kamehameha Schools
		Design Thinking Hawaii
Temenos Ag (software)	Large Corporations	Obayashi (Construction)
Hawaiian Electric Industries (renewable electricity		Hawaiian Airlines (Tourism)
Research Corporation of the University of Hawaii		Hawaii Pacific Health (Health Care)
(no Fortune 500 companies in the state)		Don Quijote (retail)
		Matson (shipping)
		Hawaiian Holdings (air transport)
Hawaii Technology Development Corporation	Government	Office of Hawaiian Affairs
DBEDT		
US Federal Government, NSF		
Military		
Pacific International Center for High Technology Re	Misc	Rising Tide (program, connector)
(established with legislature, UH, now NPO)		Tidepools @ Central Pacific Bank (workspace and meetingro
Ulupono Initiative (advocacy company)		Common Ground (accelerator – food and beverage industry)
American Indians in Science Engineering Society, Hawaii Chapter (professional org)		FoundHer (accelerator – Native Hawaiian, Pacific Islander, and/or Asian women and mothers in Tech, Fashion, Health and Wellness, Food Systems, and Keiki/Education)
		Hawaii Investment Ready (accelerator)
		Mana Up (accelerator – product)
		SIIP Hawaii – 4 month long incubator
		XLR*HI / Pre-X
		Inpeace center for entrepreneurship
Hawaii Women in Tech	Meetup Groups	Startup Oahu (was Honolulu Startup Drinks)
Hawaii XR		
Kauai Tech		
Maui Techies		
Oahu Tech Meetup Group		
PyHawaii: Python Users Group		
Hawaii Tech Group	Facebook Groups	Big Island Startups
Maui Techies		

Figure 3.3: List of Hawaiian Organizations by Stakeholder Group

which locals in Hawai‘i are familiar and play into the demand that the tourism industry creates. He continues, “Hawai‘i leaders and policymakers have been pushing for more local tech companies for decades, both to diversify our distressingly tourism-dependent economy and to create knowledge-based businesses that can be built digitally and can scale easily. Despite this repeatedly resurgent drumbeat, however, the list of Hawai‘i-born breakout tech successes is dismally short. Verifone, Cheap Tickets, maybe Digital Island, and Pihana Pacific make the cut. Sure, the University of Hawai‘i helped develop the technology behind the earliest version of the internet, but that was 50 years ago. The issue isn’t so much a lack of imagination, but a lack of role models and success stories.” (B. R. Ozawa & June 27, 2023)

The article aims to discuss a new pitch competition called ‘Next Round,’ funded by an Asia-Pacific investment firm named Two Towers Private Equity, and founded by Hui Jung “Justin” Paik. Justin’s ties to Hawai‘i include graduating from the college preparatory ‘Iolani School in 1981. He aims to build up the Hawai‘i tech sector and have three local companies on the NASDAQ by 2030. As mentioned, Cheap Tickets and Verifone got their starts in Hawai‘i—but they eventually left. There are other entrepreneurs there that have found that once their companies reached a specific size, the ecosystem could no longer support them, so they moved to the mainland.

Ryan Ozawa himself puts together many resources for Hawaiian Tech entrepreneurs. His vision is for a more sustainable Hawaiian economy, which adds the technology innovation ecosystem as a strong “fourth leg” to the “three-legged stool” metaphor of the Hawaiian economy comprising tourism, military, and government. The resources and meetups that Ryan organizes are helpful for people to intermix and learn from each other and develop the “entrepreneur” element of the stakeholder group. He noted that since the COVID-19 pandemic, an increase of talent has been coming to Hawai‘i, including remote workers from tech companies. There is hope that these workers with ties to stronger tech ecosystems will be willing to “open their Rolodexes” to local talent. (R. Ozawa, 2023)

Another entrepreneur building the ecosystem is Pierre Omidyar who founded E-bay and created the Ulupono Initiative, an advocacy company that invests in startups. The Omidyars made Hawai‘i their home in 2006. Since then, they have donated more than $100 Million to various philanthropic causes. Ulupono Initiative is a firm that has a dual checkbook approach with for-profit investments and grants focusing on local food, fresh water, energy, and waste reduction sectors. Ulupono Initiative has shifted from effecting change through a market-centric approach to policy and regulatory advocacy, though ultimately, President Murray Clay described them as a platypus. (Clay, 2023) The Omidyars represent entrepreneurs who have moved to Hawai‘i and invested heavily in the state, both politically and philanthropically.

In contrast is the homegrown success story of SPF shrimp development. This success of the ag-tech sector took place in Kona, HI. Dr. Jim Wyban is an example of a scientist turned innovator who now is giving back to the Hawaiian community. He describes his accomplishment as having built a bridge between research scientist to entrepreneur and recognizes that commercialization is the hardest step-—and one that is not talked about academically. Dr. Wyban developed SPF shrimp (specific pathogen-free) as a research scientist at the Oceanic Institute, a non-profit research institution. Upon identifying the greater yields of the SPF shrimp, he went to his superiors at the Oceanic Institute suggesting commercialization. They responded that commercialization was not part of their wheelhouse. Dr. Wyban took the opportunity, quit his job, and moved to Kona where the Natural Energy Lab (an aquaculture park) is located. He continued to work on developing and perfecting the SPF shrimp. In the process, Taiwan heard about his work and decided to test it for themselves—they had excellent results—and with their leading status in the shrimping industry, their results made headlines. Demand for the SPF shrimp increased.

During the development of the SPF shrimp, Dr. Wyban learned different ways of obtaining funding. He also identified that entrepreneurs were largely isolated individuals and wanted to help bring them together. In 2016, Dr. Wyban founded HIplan, the Hawai‘i Island Busi-

ness Plan Competition, which was born out of that desire to develop the ecosystem and bring entrepreneurs together.

Jim Wyban and Jason Ueki are organizers of the THRIVE Hawai'i Agrifood Summit, previously known as Tropical AgTech Conference. They organized the conference-turned-summit to fulfill a need they identified while running HIplan. Their strategic vision is to increase food security (since over 85% of food is imported), create high-paying jobs outside of Honolulu, develop sustainable food, agriculture, and aquaculture solutions for the Asia Pacific Region, and export that knowledge to others. Currently, many Hawaiians that farm still need outside jobs to support themselves. According to Ueki, they want to "create a new legacy that is built for smallholder farms and diversified agriculture using innovative solutions developed [in Hawai'i]." Within this legacy, they identify "two goals of introducing new tech-based solutions to Hawai'i's agrifood systems. One is to protect and enhance what is working (mostly exports from Hawai'i), and the other is to develop new solutions to transform what is not working. These transformative solutions will likely be smallholder solutions that improve local agrifood systems for local consumption. In that sense, we believe the IP created can be exported to other smallholder producers that serve smaller local markets." (Wyban & Ueki, 2023) They believe Hawai'i can become a role model for non-industrial agriculture by using and developing technologies. They want to figure out how the tools and technologies of the mainland industrial farms can be adopted and adapted for small parcels, small farms in Hawai'i, and export the resulting IP around the world. Ultimately, Dr. Wyban summarized, "Ag is the last economic sector to be disrupted by technology... because of legacy, it is relatively low value, and difficult because of long, complex timelines—living things have growth cycles." (Wyban & Ueki, 2023)

Culturally many organizations are working to change peoples' mindsets towards entrepreneurship by giving them the skills, instilling resilience, and showing that it can be achieved in a culturally appropriate way. While having a failed startup can be a badge of honor in Silicon

Valley or Tel Aviv, it is not regarded as such in Hawai‘i. To some, having a tech ecosystem in Hawai‘i is a negative aspect of the Westernization of Hawai‘i and that it betrays the historical culture of caring for the *‘āina*. Another challenge for entrepreneurs in Hawaii is that "the networks are smaller, you are not able to find 'outliers,'" referring to those people that might gravitate to working at startups with the right skillset and risk tolerance. In many cases, most target customers are on the mainland, and entrepreneurs in Hawai‘i are likely not well-connected to the industry. Furthermore, to succeed in the island economy, connections to outside larger economies are needed.

3.3.2 Risk Capital

Entrepreneurs have commented that institutional funding is relatively tough to secure. Though Oahu has an investment community, startups will likely be giving up more equity and have to show more cash flows to get much-needed capital.

Risk Capital funding beyond the angel and seed rounds is limited in Hawai‘i. Small enterprises are present, but funding opportunities are limited in the series A and beyond rounds as they need to scale. Quite a few incubators and accelerators aid tech and nontech startups. Some organizations even focus on supporting Native Hawaiian businesses, like Mana Up. Mana Up is a business incubator accelerator for Hawai‘i-based consumer goods brands. HATCH is an accelerator specific to the aquaculture sector. Blue Startups is a better-known accelerator and a public-private partnership funded by the State of Hawai‘i, Hawai‘i Technology Development Corporation, the Tetris Company, and private investors. Blue Startups also host an East Meets West global conference in Oahu and have Startup Paradise Demo Days in Honolulu and San Francisco. Chenoa Farnsworth, Managing Partner at Blue Startups, also previously founded the Hawai‘i Angels non-profit. In speaking with David Summers, a serial entrepreneur from the mainland now based in Hawai‘i, he commented that Blue Startups is dedicated to building

the startup community, has a good training program, and makes introductions with people both local and mainland.

The Office of Naval Research (ONR) strategically invests in Elemental Excelerators, which provides non-dilutive funding. Elemental Excelerator is designed for breakthrough technologies in science or energy. As mentioned, the Ulupono Initiative is a risk capital provider with a dual checkbook approach. Some of Ulupono Initiative's investments include Ibis Networks with their Intelisocket™ for reducing plug load energy consumption and BioEnergy Hawai'i; in addition, they championed performance-based regulatory framework for Hawaiian Electric and partner with Hawai'i Green Growth to apply data-driven metrics to identify progress in local food, energy, conservation, and human capital issues.

Donavan Kealoha is the Managing Director of Startup Capital Ventures x SBI Fund, a VC firm with offices in Honolulu, HI, and Menlo Park, CA. He is also one of three co-founders of Purple Mai'a, a non-profit Hawaiian EdTech organization whose mission is "to educate and empower the next generation of culturally grounded, community serving technology makers and problem solvers." Kealoha is Native Hawaiian and was raised on Lāna'i by his grandparents during the days of the last pineapple plantations in Hawai'i. He was encouraged to go to school and earn a BA in Hawaiian language and education before he found his way to high-growth entrepreneurship.

At the time, it appeared folks running big businesses had law degrees and saw it as table stakes[1]. Given his lack of formal business experience and academic business training, Donavan felt a law degree would provide credibility and access. While in law school, he participated in business plan competitions and before launching a deep-tech company, which went on to raise venture capital financing. He joined Startup Capital Ventures in 2015, which required extensive travel to the Bay Area. While there, he developed critical connections and learned from

[1] In business meaning the minimum entry requirement

those in that ecosystem. Startup Capital Ventures has the crucial benefits of being plugged into the Bay Area. Though some might say Hawai‘i lacks in terms of risk capital providers, Donavan thinks about it differently: “capital always finds a good deal,” and there are opportunities to find non-dilutive funding before approaching VCs.

3.3.3 Universities

The University of Hawai‘i Manoa is the only university in Hawai‘i classified as an R1 research institution. Brigham Young University is considered an R2 research institution at its campus in Utah, but their Hawai‘i sister campus has no research classification. In addition, there are fourteen remaining institutions of higher learning, including colleges, universities, and community colleges, which currently have no research designation. The University of Hawai‘i is a public university and requires government funding for support along its various units. Given the support from the state, an interviewee commented that sometimes budgets may get politicized. Despite this, UH remains part of the university stakeholder group because the research actors, professors, research scientists, and students can engage with outside parties to gain funding and are not considered government employees. Below is a list of research institutions, with at least ten connected to the UH system.

1. University of Hawai‘i System
2. UH Manoa School of life sciences
3. UH Pacific Biosciences Research Center
4. UH John a Burns School of Medicine (JABSOM)
5. UH Cancer Center
6. Daniel K Inouye College of Pharmacy at UH Hilo
7. National Energy Laboratory of Hawai‘i (NELHA)

8. UH Institute for Sustainability and Resilience
9. Hawai‘i Natural Energy Institute (a research unit of UH School of Ocean, Earth Sciences, and Technology)
10. US Navy Wave Energy Test Facility
11. Hawai‘i Center for Advanced transportation technologies (HCATT)
12. UH College of Tropical Agriculture and Human Resources (CTAHR)
13. Hawai‘i Agriculture Research Center (HARC)
14. Hawai‘i Institute of Marine Biology (HIMB)
15. UH Applied Research Laboratory – “The ARL is the latest of five Navy-sponsored university-affiliated research centers.”
16. Hawai‘i Marine Education and Research Center (Hawai‘i MERC) , a non-profit
17. Pacific Asian Center for Entrepreneurship (PACE)

UH also has resources like the Office of Innovation and Commercialization, which is being built up to aid with commercializing their research. The Interim Director, Steve Auerbach, hails from a history of corporate innovation and is working to move technology out of the lab and into the market. There is a common theme of Lean Startup Methodology. Under the OIC, UH tries to improve the presence of business involvement through the Hacking4x (H4X) challenges, NSF I-Corps, Patents2Products, HITIDE, and UH Ventures. The Hacking4X challenges “are semester-long courses that offer students opportunities to work in multidisciplinary teams to identify and develop solutions to real-world problems using the Lean Startup methodology.” (News, 2023) UH works with industry and government to identify real-world challenges that need solutions. Past challenges include hacking for defense and hacking for oceans.

UH is part of the NSF I-Corps—a virtual entrepreneurship training program for startups with deep-tech innovation. This program helps any UH affiliate develop skills in testing the market

and developing business strategy. Patents2Products is a paid "unique fellowship opportunity to develop entrepreneurship skills and gain business fluency while advancing the development and commercialization of impact-driven technologies at the University of Hawai'i." (News, 2023) This program is for PhD candidates or postdoctoral researchers. UH also has HITIDE, which stands for Hawai'i Technology Innovation Development Ecosystem and is a one to two-year incubator program for deep-tech innovations with commercialization and community-impact potential. HITIDE tailors to the needs of the startup. Finally, UH Ventures, LLC is "forming a UH-affiliated venture fund through seed capital from the State of Hawai'i and private funding from domestic and international investors. The fund will invest in UH-developed intellectual property as well as IP co-developed with private companies and partner organizations." (News, 2023)

UH Systems received the NSF Engines Development Award (2305455). The NSF Engine program is designed to "boost innovation capacity, create sustainable innovation ecosystems, and demonstrate inclusive economic growth." ("About NSF Engines", n.d.) The NSF Engines program is different because it aims to

> "embed a culture of innovation and form coalitions of diverse sectors and organizational types such as businesses, two-year colleges, and minority-serving institutions. The program is unique in its approach to ... drive economic growth in regions that have not fully participated in the technology boom of the past few decades; and build a new model for driving breakthrough, cross-sector research." ("About NSF Engines", n.d.)

Specifically, the grant to UH Systems is a Type 1 award for a 24-month planning cycle to develop a case for a multi-million dollar Type 2 award that would span an extended period. UH's focus is on sustainable food systems, including aquaculture and agriculture. One of the goals is to bring together Indigenous knowledge systems and Western science and technology to combat

food insecurity and reduce food imports. UH will lead the Climate Resilient Food Innovation Network (CRFIN) and work with 18 minority-serving institutions in the Pacific Islands. These 18 institutions include 10 UH campuses; American Samoa Community College; Chaminade University, College of the Marshall Islands (Majuro); College of Micronesia (Pohnpei); Hawai'i Pacific University; Northern Marianas College; Palau Community College; and the University of Guam.

Other program partners listed on UH's website include the East-West Center (a government-established program for research collaboration); NELHA (a state-subsidized industrial park); Elemental Excelerator (Risk Capital, non-profit); HATCH (aquaculture accelerator, entrepreneur programs, risk capital); Hawai'i Good Food Alliance (network of local food production to distribution organizations, a non-profit with some potential ties to government funding); HTDC (government agency bridge to industry); Hawai'i 'Ulu cooperative (Cooperative, farmer-owned business); and PDC Global (UH manages Pacific Disaster Center and supports both government and non-governmental organizations in over 70 partner countries). While the current CRFIN program partners are skewed mainly toward university collaborations. The organizations that work with the entrepreneurs are networks and cooperatives in style. One of the vulnerabilities of the CRFIN in staying at a higher level of networks and cooperatives is the distance those organizations create to the entrepreneur. Emphasis should be made to close this gap and build up entrepreneurs in the aquaculture and agriculture areas, especially at a grassroots level.

From the previous analysis, there is an opportunity to shift the mental models of Hawaiians to be more entrepreneurial. UH might consider partnering with youth-serving organizations to improve opportunity for success as an innovation engine specifically targeting diverse and under-served populations, given the multi-year approach integrating secondary school institutions that teach indigenous techniques to agriculture and aquaculture. Various educational farms focus on instilling principles of indigenous ecological knowledge within students and

showing that agriculture and technology have a meeting point.

In terms of facilitating entrepreneurial capacity development, UH's Shidler College of Business and Pacific Asian Center for Entrepreneurship are additional offices that help with the commercialization of technology and startups in general. The business school is active in research, despite being small, and Mr. Shidler, for whom the college is named, donates substantial amounts and also pushes for entrepreneurship. UH's medical school is also an opportunity for facilitating innovation related to improving the health of Native Hawaiians and others.

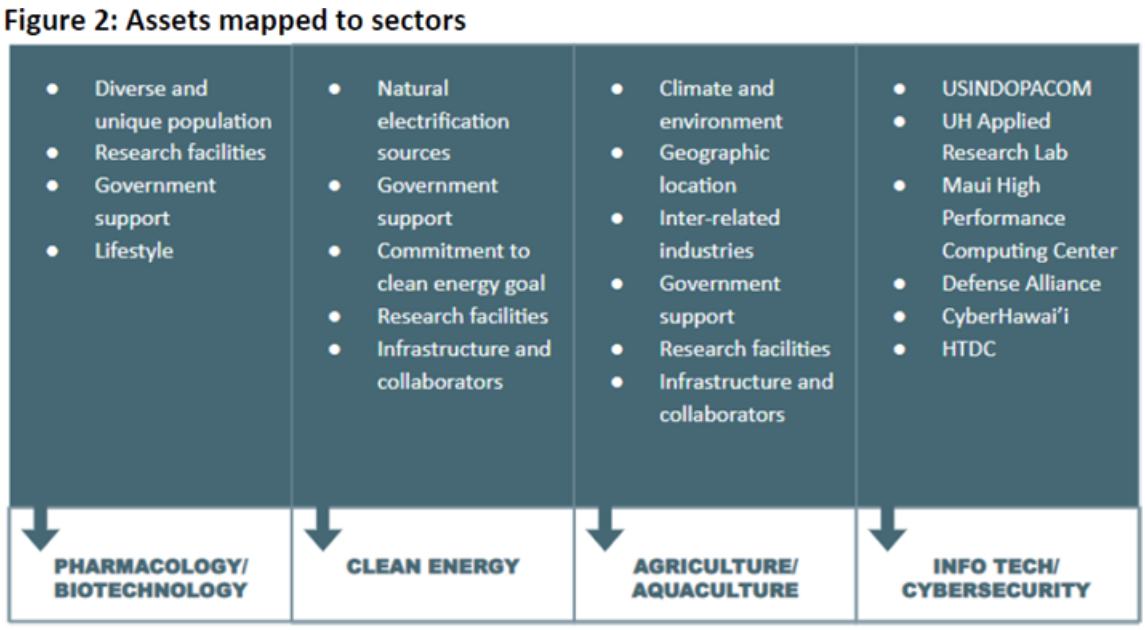
With its many resources and the type 1 Engine grant, UH is poised to lead the innovation ecosystem of Hawai'i.

3.3.4 Large Corporations

Amongst those interviewed, the perspective was consistent that Hawai'i is lacking in large corporations—especially in tech. Those at Hawai'i's Department of Business, Economic Development, and Tourism commissioned a project with the Shidler College of Business at UH to identify corporations that could be attracted to Hawai'i. The study began with identifying Hawai'i's assets and mapped those assets to specific sectors. Ultimately four sectors were identified: Pharmacology/Biotechnology; Clean Energy; Agriculture/Aquaculture; and Information Technologies/Cybersecurity. The following Figure 3.4 shows the mapping that the report identified:

In discussion with Steve Auerbach, Interim Director at the UH Office of Innovation and Commercialization, he mentioned the importance of identifying good corporate strategic partners for innovation ecosystem building. Strategic partners may be found in Asia, including companies like Mitsubishi or Takeda Pharmaceuticals, to name a couple. (Auerbach, 2023) Currently, no Fortune 500 companies have a presence in the state. If Hawai'i is to lure a corpo-

Figure 3.4: DBEDT Asset mapping to sectors



ration, it must intentionally choose one that can be mutually beneficial. Another option is to investigate the potential for Hawaiian Electric Industries to become a corporate advocate and stakeholder for the ecosystem. Because of the extensive hospitality and healthcare sectors, a corporate stakeholder may be found in a tourism or healthcare corporation, where the corporation is interested and invested in innovation of enterprise services.

3.3.5 Government

As a US state, Hawai‘i has access to resources from local, state, and federal governments through various policies and programs. The role of government in the innovation ecosystem is to provide the rule of law, infrastructure, and policy support to technology research, development, and commercialization. One of the interviewees commented that it is tough to do business in Hawai‘i because of all the regulations, even stating that Hawai‘i is sometimes

referred to as “the People’s Republic of Hawai‘i”, a nod to communist China.

One of the top three industries in Hawai‘i is the military, which has spaces in the state and supports various research initiatives. In addition to the military, other governmental resources identified by DBEDT are listed below. These are offices, programs, and policies that help with innovation. In addition, the Office of Hawaiian Affairs is a resource for Native Hawaiians seeking funding and entrepreneurial support.

Government Resources: (most from DBEDT document)

1. Enterprise Zones
2. Department of Health and Human Services
3. Hawai‘i Clean Energy Initiative
4. Hawai‘i State Energy Office
5. Renewable Energy Technologies Income Tax Credit
6. National Oceanic and Atmospheric Administration (NOAA)
7. Hawai‘i Food Producers Fund
8. The Made in Hawai‘i with Aloha (MIHA) Branding Program
9. US Indo-Pacific Command (military)
10. Hawai‘i Technology Development Corporation
11. Maui High-Performance Computing Center (MHPCC)
12. County of Hawai‘i Department of Research and Development
13. Department of Business, Economic Development, and Tourism
14. Federal Funding Programs (8a)
15. Federal Agency Grants

In an interview with Mark Ritchie, a Branch Director of the Department of Business, Economic Development and Tourism (DBEDT), he highlighted the impact COVID-19 had on the Hawaiian economy and how there is an increased effort to diversify and make the Hawaiian economy more sustainable. One component of economic development is the need for office and industrial space for growing companies. Unfortunately, he noted that in Hawai‘i, the highest and best use of land is often for luxury high rises—unlike in Cambridge, where he noted that the *highest and best use* of land has been for wet lab space for biotech companies. His viewpoint of the stakeholders within Hawai‘i is that the state has a strong entrepreneurial community supported by various government business support programs. Still, the state is weak regarding large corporations and venture capital. The large corporations that Ritchie highlighted by their presence in Hawai‘i were mostly associated with tourism and travel, such as Hawaiian Airlines and some energy companies. He noted that the state has programs to fund venture capital firms in Hawai‘i and the mainland so that those firms will look at Hawai‘i companies for possible equity investments. DBEDT also works with various state, federal, and non-profit organizations such as women's business centers, veteran business centers, and small business development centers that are helping to grow businesses and diversify the economy. The government of Hawai‘i has done some excellent work with technology parks, co-working spaces, and business accelerators. For instance, there is about to open a Food Innovation Center in central Oahu that helps with food development and testing, which is modeled after a similar project in New Zealand.

At this time, the 2022 Hawai‘i Comprehensive Economic Development Strategy (CEDS), released every five to six years, was unavailable. Instead, the 2016 CEDS document was available and identified statewide target cluster industries, including hospitality and tourism; national security; health care; research innovation and technology; agriculture and food production; Energy; Manufacturing; and creative industries. It will be interesting to see how the CEDS report changes after the experience of COVID.

One of the economic development tools identified by Mark was the Enterprise Zone (EZ) Partnership program, which gives tax credits to businesses that are located in (or move to) economically challenged areas of the state (EZs), and receive tax credits in exchange for creating jobs. Another organization of interest that is administratively attached to DBEDT is the Hawai‘i Technology Development Corporation (HTDC), which was created to be a government-industry bridge to promote and grow technology-based companies and jobs in Hawai‘i. Lastly, consistent funding for a strategic, metrics-based approach to economic growth is one key to successful economic development. When funding and strategy become politicized during legislative sessions, this hinders economic development progress.

3.3.6 Other Key Players

Also amongst the interviews were stakeholder groups that specifically target the development and support of Native Hawaiian and Pacific Islander groups. In interviews with these groups some additional cultural barriers they are helping people overcome were identified. These include perceptions of failure, financial literacy, plantation mentality (whites, haoles, as leaders and Natives as laborers), and combating the viewpoint that technology is Westernization.

Additionally, some educational institutions are working to transform single subjects into systems-based learning—more in line with previous cultural practices. Indeed the Hawaiian Cultural Renaissance is helping to preserve and propagate Indigenous knowledge systems through coding, agriculture, language, health, economics, and other key areas.

I heard from multiple interviewees that the story of Maui essentially portrays the demigod as an innovator. I share a few of these stories here as a examples of cultural influence. The stories of Maui originate from Polynesian mythology and are known across different cultures, including Hawai‘i and New Zealand. Maui is a heroic and mischievous demigod who is often

portrayed as a trickster and innovator. He is known for his many adventures and feats that showcase his cleverness and creativity.

One of Maui's most famous feats is the "snaring of the sun." ("The Ancient Legend of Maui – The Maui Miracle", n.d.) In this story, the days were too short for people to complete their tasks, so Maui devised a plan to slow down the sun's movement across the sky. He climbed to the top of a tall mountain and used his enchanted jawbone to lasso the sun's rays and slow them down, allowing people to have longer daylight hours for their activities. Maui is also known for his accomplishment of "fishing up islands." ("The Ancient Legend of Maui – The Maui Miracle", n.d.)

Maui is often considered an innovator due to his resourcefulness and ability to solve problems through creative means. His feats involve using his wit and cunning to bring about positive changes for his people—impact. He used his intelligence and magical abilities to make life better for the people of the islands, whether it was by lengthening the days or creating new landmasses for them to inhabit. In addition to his feats of innovation, Maui is also known for his adventurous spirit and willingness to take risks. He is a symbol of courage, determination, and the power of human ingenuity. Through his stories, Maui teaches lessons about the importance of creativity, adaptability, and thinking outside the box to overcome challenges and improve the world around us.

3.4 Strategy: Policies and Programs

The third part of the MIT Three-S framework is strategy. The traditional MIT approach is to strategize for problem-solving. The overall purpose of an innovation ecosystem is to have stakeholder involvement in driving innovation to improve opportunities for entrepreneurs and create positive externalities—spill-over benefits—for the population. The geographic-

remoteness and resource limitations of an island economy create higher stakes and require the intentional development of the ecosystem. It is important to balance policies and programs to benefit existing residents. The following is paragraph discusses a politician's point of view regarding some of the government tech investments.

A recent opinion piece in the *Honolulu Civil Beat* written by former state senator Russell Ruderman disagreed with political leaders and business developers promoting high tech as the solution for Hawai'i's economy. Ruderman instead advocated for low-tech developments in food, education, housing, and healthcare, which might not seem as exciting but would be more beneficial to Hawai'i. He stated, "I am in the food business. But this is not about my business; it's about our society. Food businesses tend to succeed because people like to eat repeatedly! It doesn't depend on tourism, the internet, or specialists from the mainland. It brings benefits to both employees and customers. The same is true in education, health care, and housing." (Ruderman, 2023) He highlights the failed development project of the Hu Honua, a biomass plant that would burn trees for electricity, as an unneeded project pushed for by "off-island investors that saw an opportunity for profit and the greedy politicians who were paid to support it" and would have resulted in higher utility costs, hazards, and pollution. In addition, he lists the Superferry, 30-meter telescope, first responders tech campus, stadium, and rocket launch facilities as failed developments and short-sighted political plays. And while not opposed to high-tech in principle, he advocated for intentional investments for the residents rather than investments that attract outside talent, and drive up housing costs, only for them to eventually return to the mainland. He concludes his piece: "It's simple really. Invest in and prioritize what the people actually need, and we will create a better Hawai'i." (Ruderman, 2023)

The challenges of an island economy mean it is crucial to produce goods and services which serve the residents to avoid the high cost of imported substitutions. It is also important to produce goods—tangible or digital—that can be exported. Creating a sustainable ecosystem requires short-term and long-term checkpoints to ensure policy and strategy shifts develop the

ecosystem in the intended ways. The government should be responsible for identifying how to test the intended effectiveness of various programs and counter detrimental side-effects. Also, given that the primary research institution in Hawai‘i is a public university, the government has additional power and influence in the ecosystem, which need to be checked and balanced.

3.4.1 Indigenous Opportunities

In terms of legal regard for Indigenous knowledge, a UH law journal article discusses the evolution of recognizing Indigenous Ecological Knowledge (IEK) since there is progress toward "deeper harmonization between the law of human rights and the law of environmental protection; and near realization of the principle of indigenous self-determination," as well as responses to climate crises. (Forman, 2018)

Regarding the Native Hawaiian population access to land in Hawai‘i, Article XII of the Constitution of the State of Hawai‘i designates lands and revenues toward a Native Hawaiian rehabilitation fund. The Federal government's Hawaiian Homes Commission Act of 1920 supports the use of lands for Native Hawaiians. However, it defines Native Hawaiians as having a blood quantum of "not less than one-half part of the races inhabiting the Hawaiian Islands before 1778." Bill HR 9614 was introduced to Congress in December 2022 to lower that blood quantum. If that bill succeeds, this will allow Native Hawaiians to lease specific lands and potentially provide more space than the current space-constrained multi-generational homes.

The ability for Native Hawaiians to affordably remain in their homeland goes hand-in-hand with their ability to pass inter-generational Indigenous Knowledge. The Hawaiian cultural renaissance has led to public schools incorporating more of the Hawaiian language and culture in their curriculum. Kamehameha Schools also play a role in connecting Native Hawaiians with their culture by providing culture-based education. Kamehameha Schools

> "work[s] to remove barriers to learning, we help students deepen their connection to culture and *ʻāina*. Building upon the knowledge passed down by their ancestors, they're prepared to navigate challenges and opportunities in our modern society. In order to achieve meaningful change, we must coordinate and align with others to create a better Hawaiʻi." ("Kamehameha Schools", 2023)

Donavan Kealoha co-founded non-profit Purple Maiʻa for "educating and empowering the next generation of culturally grounded, community serving technology makers and problem solvers." The organization started first with teaching children to code and has expanded to include innovation programs around ancestral science and workforce development programs. (Kealoha, 2023) Kealoha's vision for the tech ecosystem in Hawaiʻi intertwines the Hawaiian culture with technology and entrepreneurship for cultivating a diverse economy. Some of the tenets he focused on in our conversation are copied from the website below.

1. "We can express our ancestry through modern applications; we can honor our kūpuna with our actions and creations in today's technological context...Hawaiians have a demonstrated history of adopting and excelling at modern innovations.
2. Redefining wealth...
3. It's become popular to claim the title 'entrepreneur.' The idea of the self-made man (and now, girl boss) looms over this word. But entrepreneurial agency exists in a circular feedback loop with place. An entrepreneur is someone who recognizes (kilo) opportunities (value) in a context (place) and connects resources (relationships) in order to create employment and benefit a whole region. Entrepreneurs don't just build businesses; they leverage social capital and spark culture change. They build institutions that become the

keystone species of sustainable ecosystems. Importantly, we mean ecosystem here literally–not as a metaphor for industrial organization, but as a concept better called a biocultural system.

4. ‘Diversifying the economy’ can be the justification for any and all economic activity...The motto we choose is Eahou. Ea [meaning] Sovereignty, rule, independence; Life, air, breath. [And] Hou [meaning] New, fresh, recent
5. Eahou means taking in a breath of fresh air to breathe new life into our context. And since we are dreamers–and more importantly–doers, we accomplish this through learning and doing (k)new stuff: ‘ike kupuna, aloha ‘āina, a worldview that sought to care for place (as if it were kin) and people (because we all kinda related).
6. Purple Maiʻa is an entrepreneurial institution that seeks to embody eahou. We are what Maryann Feldman would call an organization with, ‘norms of openness, tolerance for risk, appreciation for diversity, and confidence in the realization of mutual gain for the public and the private sector.’ ...
7. We call what’s coming The Mālaplex [māla means garden, plantation or field], a space organized to solve challenges like climate change, soil depletion, and ecosystem collapse through ‘āina-centered innovation. The Mālaplex takes the tech campus and makes it a diversified mala. It’s a space for mālama-ing the soil, literally and figuratively. The pillars of the Mālaplex are: KIA (Knowledge, Innovation and Application)... (“Kā Purple Mai’a Mākia”, n.d.)

Purple Maiʻa is an example of an entrepreneurial support organization that does not fall clearly into a particular stakeholder group, but is emerging as a leader championing the Native Hawai-

ian demographic and incorporating ancestral knowledge with innovation.

3.5 Opportunities for Impact

Given Hawai‘i’s inability to change its location or resources, the innovation ecosystem of Hawai‘i has opportunities to develop through intentional policies and data-driven programs. While preliminary assessment using MIT’s Five Stakeholder model identified weaknesses of corporate and [sustainable] risk capital presence, it also showed the strength of the University of Hawai‘i’s reach, indigenous knowledge systems, and ultimately the incredible network of the State government and programs. UH was selected for a type 1 Innovation Engine Program by the NSF and could serve as an anchor institution for other universities in the American Pacific Islands. As an Innovation Engine, UH would do well to increase the number of IDEs in the Hawaiian market by enhancing its ability to commercialize the technology that comes out of the current research in the UH system. Government can support the development of IDEs for non-UH students by providing support for technology to be patented for the intention of commercialization. This can be accomplished through a variety of means, and creativity should be used to identify opportunities to encourage this. For example, part of a lawyer’s renewing of their Hawaiian Bar Credentials could be to provide a certain number of hours pro-bono work to help entrepreneurs with protecting their intellectual property developed in Hawai‘i or other tasks. Another idea is the creation of a position specifically devoted to increasing patents originating from Hawaii with a stipulation of commercializing in Hawai‘i for a certain number of months. This could be done by hosting trainings as part of hack-a-thons and pitch competitions and inviting promising solutions for consultation.

The food security problem was highlighted by multiple sources as a hardship for many of the local residents. The Hawaiian innovation ecosystem can advance tropical island agriculture

and aquaculture. Along this path, technology, sustainability, local needs, local expertise, Indigenous ecological knowledge, and *kuleana*, responsibility, or duty, toward the *ʻāina* can be accomplished. This can be achieved through the development of agriculture and aquaculture technologies that engender the 'buy local' trend. AgriTech has usually been developed on an industrial large scale, but there are opportunities for developing small-scale adaptive technologies. Developing new plants is also a patentable technology. There are a variety of partnerships that could be made with other nations or organizations to advance agricultural research to mitigate research timelines associated with growth and lifecycles.

Considering the main sector of tourism, industry partnerships could be formed to enhance the tourist experience. Hawaiʻi could implement an innovation tax for the hospitality industry, and others, to support local innovation efforts. This does not have to be to their detriment, either. As a flourishing destination for tourists, this provides a great opportunity for a hospitality company to develop and test technologies that improve the tourist experience. Or these large corporations could support innovation around enterprise solutions. The other resource the hospitality industry may have at times is space. Unused space can be used for a multitude of things, including meeting spaces, hosting meetups, supporting knowledge transfer through entrepreneurs in residence, or even storage space.

Another idea, given the space constraints in both housing and industrial space, is that digital literacy should be improved and developed across age groups. The ability to code and develop apps, along with skills like problem identification and design thinking, should be nurtured in the various school systems. Opportunities to merge Indigenous knowledge within technology can be a way to integrate and preserve and teach future generations.

Additionally, with more Native Hawaiians living outside of Hawaiʻi, the government can incentivize the re-connection and possible return of Native Hawaiian talent through programs akin to the law of *aliyah* that has helped Israel's diaspora. Along the same lines, exchange

programs with other research universities can provide university students with STEM majors the opportunity to practice research at other institutions.

Government can also support public programs to help change the cultural narrative of tech entrepreneurs. This can be with the public school curriculum, media programs for children and adults, technology fairs, etc.

Competitions are a good way for multiple stakeholders to get involved. There could be challenges like creating a robot that can dance the hula, which would lead to actuation mechanisms that can be commercialized and sold to a variety of industries. Another might relate to capturing tidal energy.

3.6 Hawai‘i Summary

In summary, the UH is poised to be the leader of the innovation ecosystem in Hawai‘i as it works to develop itself as an Innovation Engine. Through the process, UH has identified focus sectors, created entities conducive to increased I-Cap and IDEs, and created an office of Indigenous Innovation. As more technology is patented and commercialized, additional risk capital providers may be attracted. Government can set policies to encourage returning talent and parity in terms of education between Native Hawaiians and others. In addition, the government will need to push economic diversification over short-term interest.

The lack of a large corporation as a stakeholder means that the ecosystem may need more talent development, private sector facilities, and the aggregation of regional know-how for a specific technical sector. Careful thought should be given to which corporations would be good candidates and whether external incentives should exist.

Finally, Hawai‘i is a culture of story-telling. As successes occur, the stories need to be told. Donavan Kealoha talked about the importance of “showing people the realm of possibility,” people are tech savvy, but consumers of content and they need to be shown a different paradigm. (Kealoha, 2023) As people hear stories of innovation and entrepreneurship—especially from people that look like them—there will be an opportunity to attract a more diverse demographic of innovation entrepreneurs.

Chapter 4

Fiji

4.1 Background

Situated approximately 2,100 miles southwest of Hawai‘i and about 1,300 miles northeast of New Zealand, Fiji occupies a strategic location in the Southern Pacific Ocean. This geographic positioning has contributed to the nation's appeal as a popular travel destination, offering a convenient stopover for travelers journeying between the Americas and Oceania or Asia. The relatively short flight distances from main points of interest, such as Hawai‘i and New Zealand, have facilitated a steady flow of tourism to Fiji, boosting its prominence as a tropical paradise.

Fiji's geographic proximity to neighboring countries and territories, such as Vanuatu, Tonga, and New Caledonia, has fostered regional connections and facilitated trade and cultural exchange throughout the South Pacific. See Figure 4.1. The archipelago's location within the tropics endows it with a pleasant climate, attracting tourists seeking a tropical escape year-round. However, despite its strategic location and tourism potential, Fiji's geographic isolation can also pose logistical challenges for development and access to essential resources, further

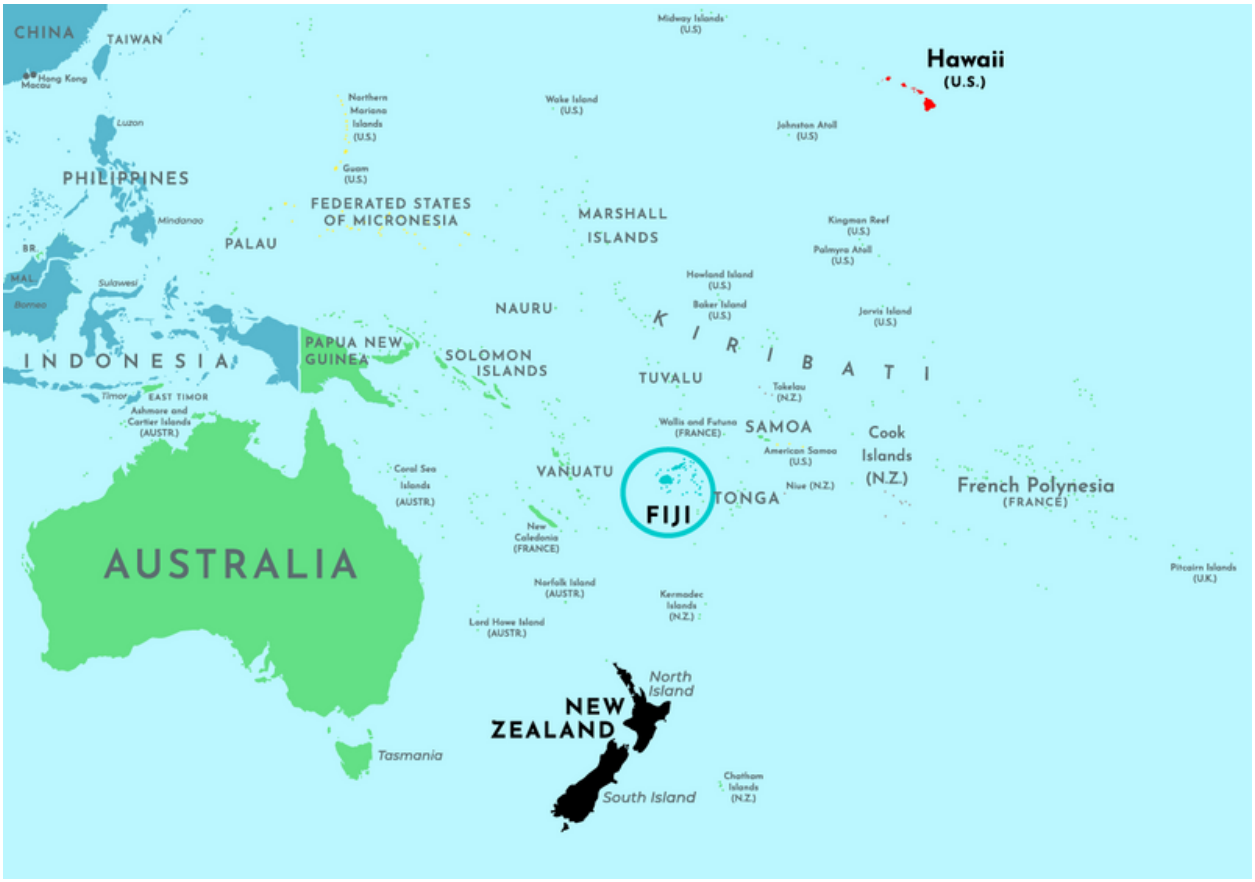


Figure 4.1: Map of Oceania, Fiji in turquoise

underscoring the importance of sustainable strategies to address socio-economic disparities and ensure the equitable growth of the nation.

4.1.1 Brief Political History of Region

Fiji was first settled over 3000 years ago. The earliest European maps showing Fiji date back to 1789, and "in the 1800s, merchants, traders, and whalers frequented the islands." ("Fiji", 2023) Various chiefs and kings competed for power, and in 1865 Fijian chief Seru Epenisa Cakobau organized the groups into the Confederacy of Independent Kingdoms of Viti, which became the Kingdom of Fiji in 1871. After some economic issues, this kingdom was ceded to the United Kingdom in 1874. Under British rule, more than 60,000 Indians were brought in to improve the economy by providing labor. Once their contracts as indentured workers were complete, many elected to stay in Fiji.

Fijian society today is divided into three ethnicities: iTaukei (indigenous Fijians), Europeans, and Indo-Fijians. Fiji became independent from the British in 1970. Leading up to 1970 and even after, tensions between the indigenous Fijians and Indo-Fijians have resulted in new constitutions, reformed constitutions, coups, and elections. The population of Fiji is approximately 947,000 people. Currently, the iTaukei make up 56.8% of the population, while Indo-Fijians are 37.5%; Rotumans are at 1.2%, and the remaining 4.5% is a mixture of Europeans, mixed European, other Pacific Islanders, and Chinese. ("Fiji", 2023) (Rotuma is a Fijian dependency, an island with a distinct language and ethnicity.) Three languages are spoken: English, iTaukei, and Fiji Hindi.

Fiji's economy is tourism-based and was largely affected by the COVID-19 pandemic. Of the small island developing states, it has one of the strongest economies with an estimated GDP of $9.5B in 2021, similar to New Caledonia ($11.1B, 2017 estimate), with only Australia ($1.2

Trillion, 2021 est), New Zealand ($220B, 2021 est), and Papua New Guinea ($36.5B, est) having stronger economies. However, the GDP per capita is lower, and roughly 29.9% of the population lives below the poverty line.("Fiji", 2023)

In December of 2022, Fiji elected a new leader after the People's Alliance Party, the National Federation Party, and the Social Democratic Liberal Party formed the Coalition government. The previous Prime Minister, Josaia Voreqq (Frank) Bainimarama, had been in power since a bloodless coup in 2006. It is not the purpose of this thesis to comment on the political history of Fiji and the numerous coups and contested elections; instead, the point is to recognize the political instability. The current PM Sitiveni Rabuka served as PM from 1992–1999 and was sworn in on December 24, 2022. He has three deputy prime ministers from differing political parties as part of the coalition agreement.

As an aside, the South Pacific region is vulnerable to China. For example, China brings in its construction workers for large projects and does not provide jobs for local people.

4.1.2 Brief Socio-Economic History of Region

Despite the nation's natural wealth and potential for tourism, a considerable portion of its population struggles to escape poverty. Poverty in Fiji is particularly evident in rural and remote areas, where limited access to education, healthcare, and basic infrastructure perpetuates a cycle of deprivation. The prevalence of poverty in Fiji underscores the need for comprehensive and sustainable development strategies that address the root causes and promote inclusivity, allowing all Fijians to share in the benefits of the nation's prosperity.

Fiji is in the low 'tier 4' grouping of the social progress index. It is considered a small island developing state by the United Nations. Fiji's infrastructure has lagged, and efforts to build an innovation ecosystem require greater access to the internet. In terms of Fiji's export basket,

this can be summarized by the below Figure 4.2 provided by OEC.

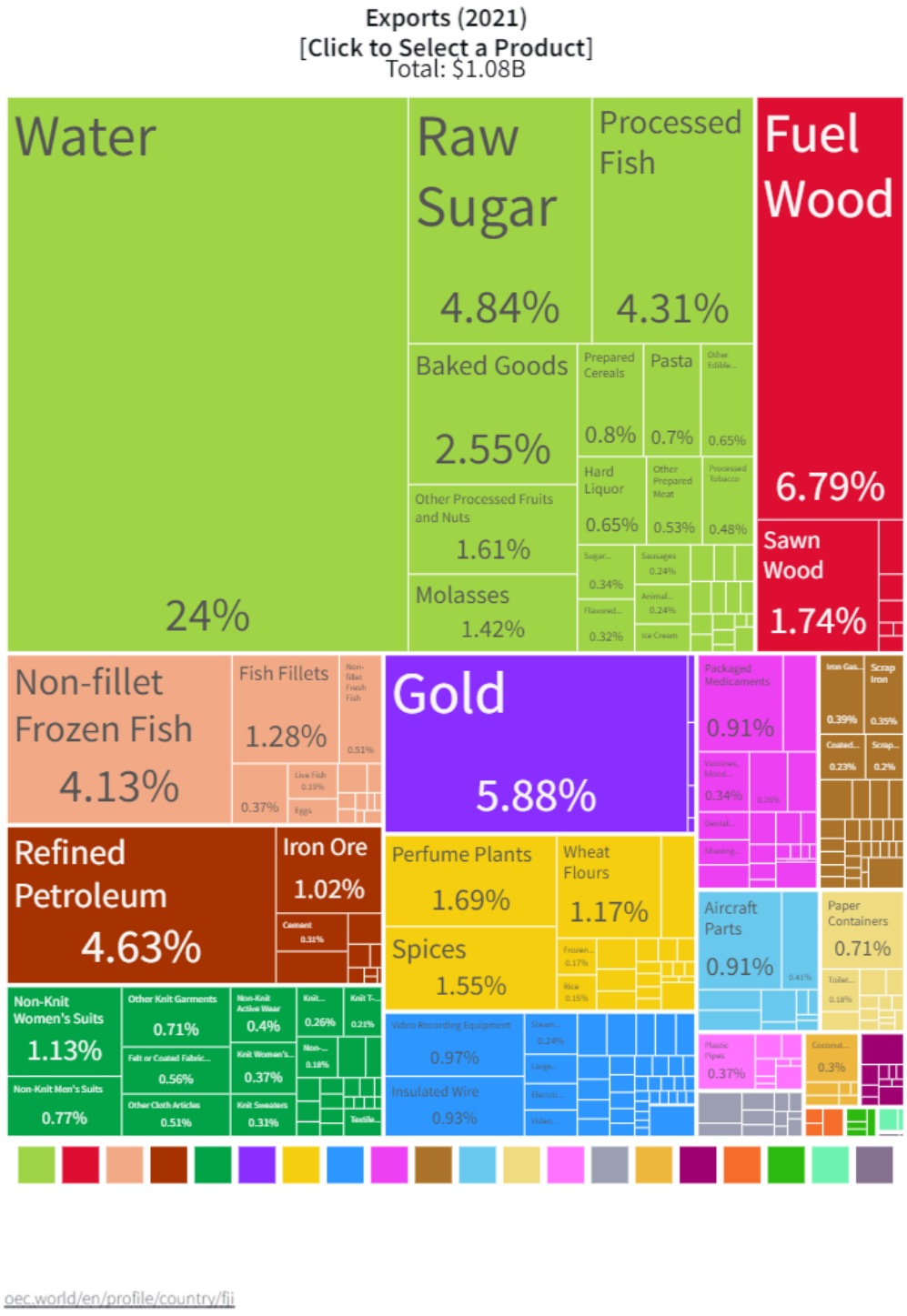


Figure 4.2: Fiji's Exports 2021 (Growth Lab at Harvard University, n.d.)

The most significant section (light green) represents the food sector, and the exporter *Fiji Water*

likely contributes to the 24% water export. Other industries are fuel wood, gold, frozen fish, refined petroleum, iron, perfume plants, spices, textiles, and aircraft parts. In addition, the following graphic shows their export partners. Despite the distances, most of Fiji's exports are to the US, second to Australia, third to China and a close fourth, to New Zealand. See Fig 4.3.

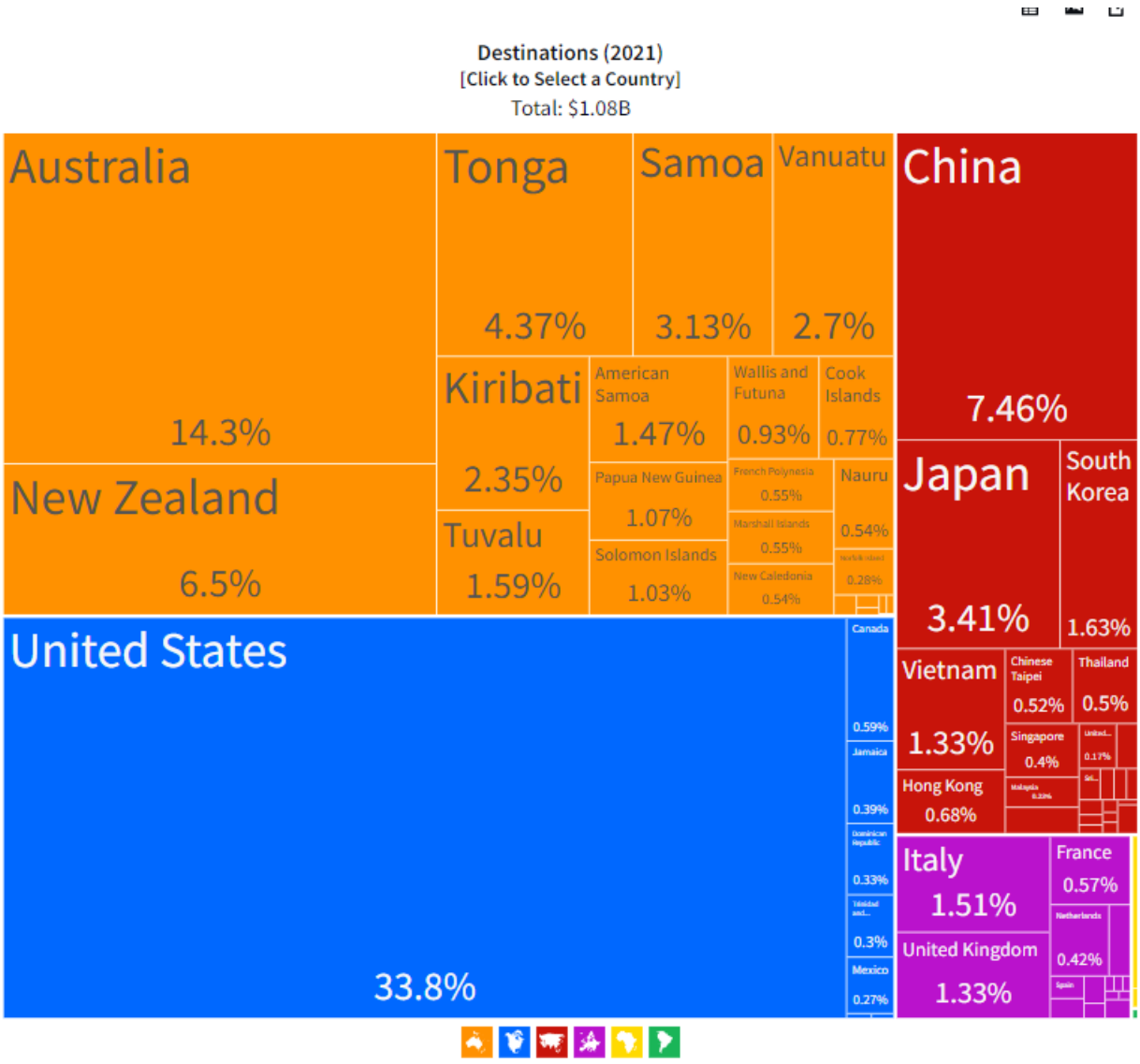


Figure 4.3: Fiji Export Destinations (Growth Lab at Harvard University, n.d.)

4.2 System

The MIT "system" approach is broken down into the four elements of foundational institutions, innovation and entrepreneurship capacities, comparative advantage, and impact.

4.2.1 Foundational Institutions

Fiji is a member country of the Asian Development Bank, a financial institution created by 31 members that came together to "foster economic growth and cooperation in one of the poorest regions in the world," which are a largely agricultural. Regarding financial institutions, Fiji has six commercial banks, four credit institutions and hosts one of two stock exchanges of the Pacific Developing member countries of the ADB. (Asian Development Bank, 2019)

Regarding legal rights, Fiji had an index score of 5, compared to Papua New Guinea and Samoa, who each scored 9; New Zealand, which scored 12; and East Asian and Pacific countries averaged 7.1. This strength of the legal rights index comes from answering 12 questions regarding the law's capabilities. Fijian law allowed the affirmative answering of the following questions related to businesses:

1. "Does the law allow businesses to grant a non-possessory security right in a single category of movable assets, without requiring a specific description of collateral?
2. "Does the law allow businesses to grant a non-possessory security right in substantially all of their assets without requiring a specific description of collateral?
3. "May a security right extend to future or after-acquired assets, and does it extend

automatically to the products, proceeds, and replacements of the original assets?

4. "Is a general description of debts and obligations permitted in collateral agreements; can all types of debts and obligations be secured between parties; and can the collateral agreement include a maximum amount for which the assets are encumbered?

5. "Does the law allow parties to agree on out-of-court enforcement at the time a security interest is created? Does the law allow the secured creditor to sell the collateral through public auction or private tender, as well as for the secured creditor to keep the asset in satisfaction of the debt?" (*Doing Business 2020: Fiji*, 2020)

The law notably lacks protection for creditors in instances of liquidation and a default outside of insolvency procedures and collateral registry capabilities.

4.2.2 Innovation and Entrepreneurship Capacities

Data for Fiji are difficult to assemble, even though it is a sovereign state. At the time of this writing, the data points come from different periods, with some prior to the COVID-19 pandemic. The data is presented with the best intentions and represents a real-time snapshot. What follows is an analysis of the categories across innovation and entrepreneurial capacity.

In the pyramid diagram, Figure 3.2 there is a staircase that zigzags between entrepreneurial and innovation capacities for a given region. The data can collected can be found in the appendix. Informational interviews were held with two researchers of the entrepreneurship ecosystem.

Culture and Incentives

A case study conducted by the World Bank across 190 economies measures and compares various indicators in starting a business. This study provides insights into the time and costs associated with starting a business in Fiji's largest city Suva, compared with the largest city in other economies. In Fiji, the time in terms of the number of days to start and operate a business was 40 days, compared to New Zealand, which ranked top at 0.5 days. Furthermore, the cost to start a business represented 14.5% of income per capita in Fiji compared to the average of 3.0% for OECD high-income countries and 17.4% for East Asia and the Pacific. Finalized scores amongst geographically similar economies for starting a business rank New Zealand top at number 1 with a score of 100, Samoa (ranked 46, score 92.6), Marshall Islands (ranked 83, score 88.4), Regional average of East Asia and Pacific (score 83.9), Papua New Guinea (rank 142, score 80.1), and finally Fiji (rank 163, score of 73.6). (*Doing Business 2020: Fiji*, 2020) The cost of starting a business was also highlighted in discussions with Nuria Rull and Zainab Kakal, who researched entrepreneurship in the Pacific Islands for the UNDP. (Kakal, 2023; Rull, 2023)

In terms of innovation capacity, data on Fiji is limited. H index was used as a substitute metric for comparing the quality of scientific research institutions.The H Index is 4.25 for Fiji while Hawai'i's is twice as strong at 9.11, and the top-ranked US state of Massachusetts is ten times stronger at 47.02. In addition to understanding how early Fiji is in its technology development, the number of utility patents (in the US) filed from Fiji total 11 from 1965 through 2015. ("Utility Patent Applications By Country of Origin, Calendar Years 1965 to Present", n.d.)

The Heritage Foundation scored Fiji at 58 out of 100 regarding business freedom (compared to the US at 70.6). (Kim, 2023) While the GEM report did not list data for Fiji, in 2015, data for Tonga was collected. While they are two separate countries with different cultures, the data listed here provide some information to compare relative to the region. The cultures between

Tonga and Fiji are believed to be similar enough to use the Tongan GEM data to inform us on Fiji for a relative similarity given some of their geographic and economic data similarities. Tonga's GDP per capita is $6,100, while Fiji's is $10,400. ("Fiji", 2023) Fiji is roughly 24 times larger than Tonga in square kilometers and nine times in population. Fiji's economy is about 1.4 times the size of Tonga. In terms of poverty, only 22.5% of the population in Tonga is below the poverty line, while in Fiji, it is 29.9% of the population. ("Fiji", 2023)

That said, Tonga's entrepreneurial intention is only about 5.69% of the population, though 90% see entrepreneurship as a desirable career choice. This is juxtaposed with a high fear of failure rate of 64.75%. In general, the status of successful entrepreneurs is high. The fear of failure is one of the pieces of data that stands out. Given the previous similarities, it is expected that Fiji and Tonga would score similarly.

Demand

Fiji's domestic market scale is challenging, as it is rather small at $4.3 Billion in terms of GDP (purchasing power parity) in 2022. For reference, the size of Hawai'i's GDP is $98.21 Billion. The market size means that start-ups likely need to expand internationally to grow. Legislation that would make it easier to export goods might be favorable.

Regarding I-Cap demand metrics, Fiji scored 65.2 on the Trade, Competition, and Market Scale in the Global Innovation Index. This is higher than New Zealand's score of 57.7 but far lower than the US score of 96.2. (University et al., 2015)

Infrastructure

Regarding infrastructure, the number of internet subscriptions in Fiji is roughly 46.33% of the population, while in the US, it is 74.55%. Regarding logistic performance, on a scale of one to five, Fiji scored 2.3, the US scored higher at 3.8, and New Zealand at 3.6. ("World Bank Open Data", 2023) However, another study found that 87.66% of individuals use the internet, according to a study in 2021 by Pacific Data Hub. ((SPC), n.d.)

Funding

Fiji's credit institutions are limited; as mentioned previously, there are four commercial lenders within Fiji. To add greater context, a 2020 country profile report for Fiji about the ease of doing business earned a score of 25.0 (and ranked 165) in terms of getting credit, compared to New Zealand (score 100.0, rank 1), Papua New Guinea (score 70.0, rank 48), Samoa (score 45.0, rank 119), and a regional average score of 58.0 for East Asia and the Pacific. (*Doing Business 2020: Fiji*, 2020)

Regarding Innovation Capacity funding, Fiji spends roughly 1% of its GDP on research and development, according to the UN, which aggregated data amongst small island developing states. This is around the same percentage of Hawai'i, 0.70%, and New Zealand, 1.40%, but the GDP of Fiji is substantially smaller at $4.3 Billion compared to Hawai'i's $98.2 Billion. (Division, n.d.)

Regarding funding entrepreneurial capacity, according to Pitchbook, only three venture capital deals were reported over the 2014-2022 period. Regarding total general investment in Fiji, Pitchbook identified the total as $16.65 billion dollars, (roughly 10% of the investment in Hawai'i). ("Pitchbook", 2023) Most of the investment activities in Fiji are mergers and acqui-

sitions, PIPEs, buyouts, and a handful of joint ventures. In terms of VC investment, a couple deals are listed with out data, and those that have data only sum to $30,000. ("Pitchbook", 2023)

Human Capital

Fiji's human capital in terms of the percent of school graduates in tertiary education is low at 53%. More positively, the entrepreneurship perceived capabilities in GEM for Tonga noted a 56.16%, while New Zealand is at 59.81%, and the US at 66.8%. ("Global Entrepreneurship Monitor", 2023)

According to UNESCO for SIDS, there are roughly 924 researchers or professionals engaged in R&D per million people in the population, and Fiji's population is nearly one million. In contrast, professionals in New Zealand surpass the US at 5,854.1 and the US at 4,829.1. ("UIS Statistics Sustainable Development Goals", 2023; University et al., 2015)

4.2.3 Comparative Advantage

Fiji's main comparative advantage is its fresh water, which represents 24% of the exports. Fiji does not have much in the ways of comparative advantage relative to major economies. However, relative to neighboring SIDS, Fiji has some advantages. Compared to other SIDS, Fiji's comparative advantage is its more developed economy, which sees around 850,000 tourists annually, generating 40% of the GDP. In addition, despite the decline of Fiji's once substantial export of sugar in the 1970s, Fiji showed it could adapt. In the 1980s, Fiji's garment industry emerged, though again it eroded, and Fiji again pivoted to other niche markets, including internationally known brand Fiji Water and Pure Fiji cosmetics. (Asian Development Bank, 2019) Fiji has shown its ability to pivot and continues to build and rebuild after challenges

including natural disasters like cyclones.

Fiji is known to experience greater than average natural disasters, and climate change likely will increase this frequency. Opportunities exist to explore traditional meteorological and traditional meteorological knowledge in rebuilding agricultural and food production systems after natural disasters. Fiji's volcanic islands may serve as an opportunity for geothermal research. With two medical colleges in Fiji, there is an opportunity for continued medical research for both urban and rural communities. Traditional medicine treating body and spirit is another opportunity. Much of Western medicine focuses on physicality. Traditional medicine focuses on healing both body and spirit. Research in sustainable and healthy food systems and traditional medicines, is an opportunity.

Fiji is also blessed with some mineral deposits, including gold. There is currently one operating gold mine and another deposit is being explored. As such, Fiji might be a location for deep-sea mineral extraction research. However, the experience of Nauru[1] serves as a warning against detrimental mineral extraction.

4.2.4 Impact

Fiji is mainly a country of MSMEs and can achieve very little change without substantive efforts to develop infrastructure and invest in educational programs. To achieve the growth needed to bring the country into the 21st Century, Fiji will need to increase its productivity and development of IDEs. Fiji is a SIDS with land as a constraint. Transforming to a digital or knowledge-based economy would be a potential strategy around that land constraint.

[1]Nauru was exploited by the phosphate mining industry. Nearly 80% of its surface was strip mined and now there is significant environmental damage.

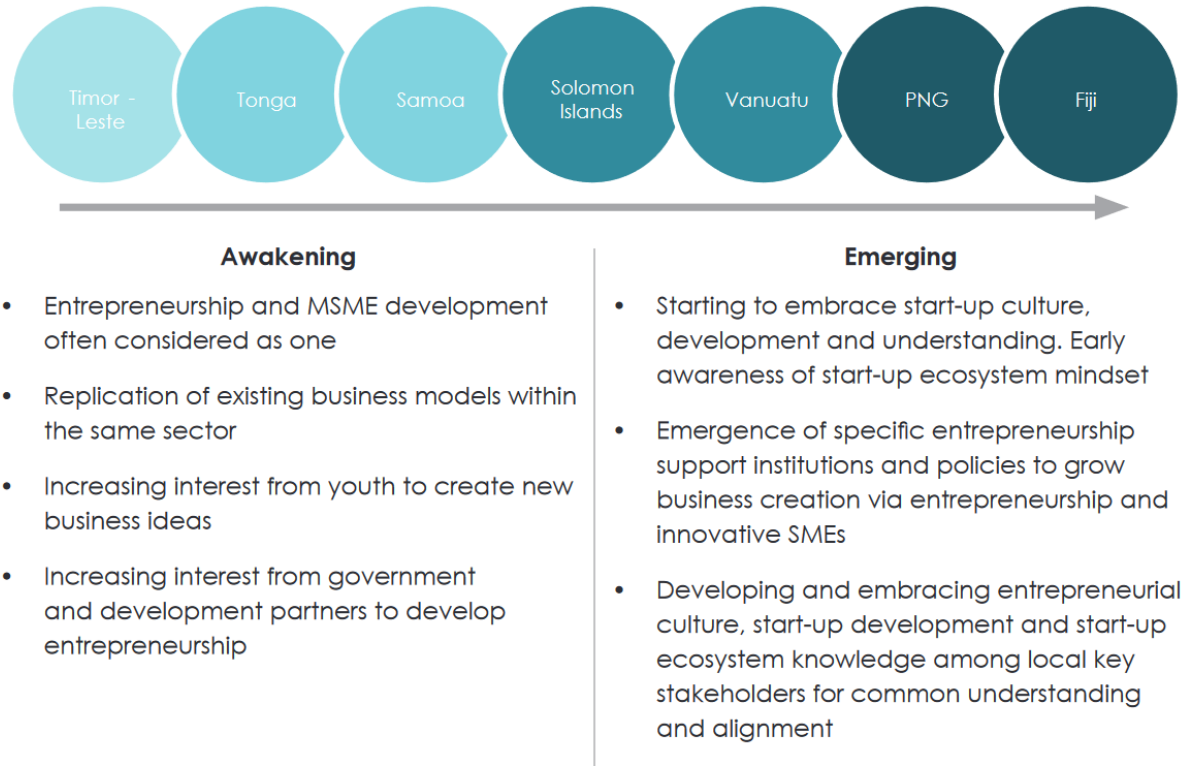


Figure 4.4: Figure from Rull and Kakal (2021) on Pacific Island Entrepreneurship Scale

4.3 Stakeholders

MIT has a five stakeholder model for innovation ecosystems. Much of the stakeholder analysis for Fiji comes secondhand from a publication by the Pacific Digital Economy Programme, funded by the Australian government and overseen by other United Nations programs. In a study of seven Pacific Island Nations, Fiji was classified on a scale of the awakening-to-emerging entrepreneurial ecosystem to stand out as the most emerging entrepreneurial ecosystem, Figure 4.4.

There are many stakeholder groups within the following categories. In the report *Entrepreneurship Ecosystem in the Pacific*, the authors recognize that "most Entrepreneurship Support Organizations (ESOs) in the ecosystem are funded fully or partially through donors, without long-term plans for financial stability" and that these donors often are trying to repeat what has been

successful in other areas, as opposed to adapting to the local environment. (Rull & Kakal, 2021) Even when ESOs operate with in-country support, funds may not last beyond a specific time period or project. When the money runs out, talent may leave the ecosystem. Furthermore, they recognized that a significant portion of connections are made between people as opposed to organizations, which can lead to an overreliance on peers. (Rull & Kakal, 2021)

4.3.1 Entrepreneurs

Researchers for the UNDP identified Fiji as having more working institutions and initiatives that spanned more years than peer nations of the study. In Fiji, they saw not just micro-entrepreneurship but instances of businesses being technology-enabled. Varied business models occurred more in Fiji than in other geographies. Ultimately, the sentiment towards entrepreneurship seemed to be it was something to do if people could not get a normal job—it was a second choice. As such, entrepreneurship is not a subject focused on by the universities.

There are various challenges to entrepreneurship beyond perception—for example, the cost and time to start a business. However, in the wake of COVID-19, some entrepreneurs were found to have come together to share in the risk and costs of a business license.

The researchers for the UNDP interviewed 200 entrepreneurs. One of the stories mentioned illustrated how startups would take on community life. If a startup had some success and needed to hire people, there might be pressure to involve family and need to involve the town. This sometimes meant hiring or involving people that were not qualified. Otherwise, people would be seen as not sharing or living the culture's values. They describe this below:

> "Cultural norms in the Pacific place heavy value and significant influence on community, family, and cooperative/collective support. These dynamics can be a source

of inspiration and innovation for entrepreneurs and can facilitate community/-family support in their enterprises. These influences can motivate creating a new local business to serve a community's needs or spur innovative solutions that incorporate and preserve traditional culture.

"The inverse relationship is, unfortunately, also a reality. Pressures to support and assist families can present a significant burden to a fledgling business. Perceptions of shared assets and communal responsibilities can also blur the lines between business assets and communal goods. The study found that entrepreneurs are often in a position where the interests of their businesses and their cultural responsibilities to their communities are at odds. Another finding of the study was the unfortunate prevalence of prejudice and discrimination in the business ecosystem.

"Discrimination on the basis of issues like age, gender, and disability is prevalent... largely due to traditional/cultural hierarchies and structure". Study respondents cited this issue as impacting entrepreneurs in both their personal (e.g., their confidence and self-value) as well as professional (e.g., access to support services, finance, community support) lives."(Rull & Kakal, 2021)

To develop local talent some NGOs would import previously successful programs to Fiji but not adapt to the local culture. For example, because Fiji has a strong oral tradition different from other cultures, disconnects would occur. Another example is entrepreneurs prematurely disqualifying themselves access to a program. In addition, navigating the resources and knowing where to go for support is a challenge. The lack of predecessors and locals to direct them is seen as a challenge. Figure 4.5 below shows the incubators and accelerator support in Fiji at the time of the UNDP research—they are few in number.

FIGURE 5: Ecosystem actors by category and business stage in Fiji

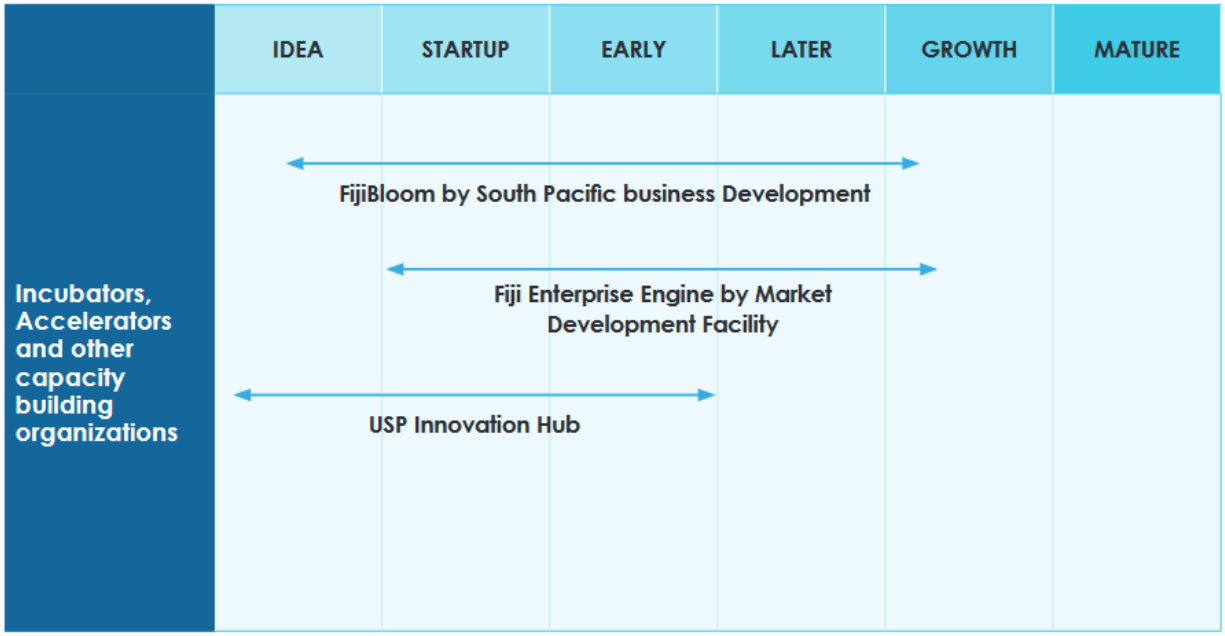


Figure 4.5: Incubators, Accelerators, and other Capacity Building Organizations in Fiji. (Rull & Kakal, 2021)

4.3.2 Risk Capital

Access to finance is also a problem in Fiji. It is geographically-remote and not well connected to the rest of the world. Possibilities to scale up are reduced.

The Fiji section of the UN entrepreneurship report provides the following insight.

> "While lack of finance is an issue, it is the appropriateness of finance provided which is a key problem. While donor funding is available from the government and the international agencies operating in the region, it doesn't catalyze enterprise as it should. There is a need to bridge the gap between investors and businesses. Investment readiness programs or underwriting services can play a role in filling this gap. Particularly diaspora groups in Australia, New Zealand, and the United States could be used to attract more catalytic capital for businesses. Impact

> investing, angel networks, and pitching events are being explored as well." (Rull & Kakal, 2021)

Pitchbook reported sixteen investors in Fiji, with only nine having an active portfolio, and three firms having made investments in the past year. The US-based International Finance Corportion (IFC), is the most active and is the impact investing arm of the World Bank Group. They have made a total of 996 investments in Fiji, with 322 in their active portfolio, and 42 investments in the last twelve months. ("Pitchbook", 2023) The only other investments made in the last twelve months listed by Pitchbook were Japan International Cooperation Agency, an economic development agency, and the Fiji National Provident Fund, a firm that manages a pension fund. ("Pitchbook", 2023)

4.3.3 Universities

PIURN is the Pacific Island Universities Research Network that leads projects and conferences to connect fourteen member universities. Fiji has three universities that participate in PIURN: the University of the South Pacific, Fiji National University, and the University of Fiji. The overall purpose of the PIURN is

> "enhancing research and development collaboration in science, technology, and innovation, building upon the quality educational capacity of these universities, to better serve the needs and aspirations of Pacific communities. In addition, in recognizing Science, Technology & Innovation (ST&I) as an engine of sustainable development and green economic growth, PIURN is established to support the development of a ST&I Framework for the Pacific." ("About - Pacific Island Universities Research Network", 2019)

The University of the South Pacific (USP) has its main campus in Suva, Fiji. It is not a system of universities; it has eleven branches or extension campuses in other countries. It is a public research university jointly owned by twelve Pacific Island countries, specifically, the Cook Islands, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu.

USP was established in 1968, and in 2017 had roughly 30,000 students, with roughly 10% as postgraduate students. USP has schools of accounting, finance, and economics; business and management; information technology, engineering, mathematics, and physics; agriculture, geography, environment, ocean, and natural sciences; law and social sciences; Pacific arts, communication, and education; environment and sustainable development; and colleges of foundational studies and continuing vocational education and training.

The USP cultivates research and innovation that is to help the communities of member countries achieve sustainable development goals. In terms of innovation, the UNDP assisted the USP in creating the Innovation Hub and co-working space to facilitate networking and "serve as a platform for learning, mentoring and south-south knowledge exchanges for the governments, faculty, researchers, entrepreneurs and social innovators across the Pacific region." ("Innovation Hub and Co-working Space Launch at the University of the South Pacific | United Nations Development Programme", n.d.)

The message from the Research Office of Fiji National University (FNU) explains that FNU is committed to research and innovation for the betterment of Fiji's economy and development. The priority research areas include health and well-being; agriculture; computer science and artificial intelligence; science, engineering, and climate change; education, social science, arts, and humanities; and business and economics.

FNU also receives funding from external universities and governments for research. For ex-

ample, the University of the Sunshine Coast is listed as sponsoring research in fruit production and agricultural research; Grand Challenges Canada is sponsoring pre-eclampsia research; the French Ministry of Foreign Affairs and International Development is supporting research for promoting health in primary schools; and an Australian Pharmaceutical company is sponsoring research in post-partum hemorrhaging. ("Research Projects", n.d.) FNU's history of health sciences dates back to the Fiji School of Medicine (established in 1885) and Fiji School of Nursing (established in 1893). Some of the achievements of the medical college include having the Pacific Research Centre for the Prevention of Obesity and Non-Communicable Diseases named as a WHO Collaborating Centre, graduating the first female oral surgeon in the Pacific, and hosting various conferences and educational symposiums. ("Research Projects", n.d.) In addition, the research of the Fiji Institute of Pacific Health Research includes strategic themes of food security; diseases, inequality, and poverty; maternal health; health systems; and indigenous health and medicines, to name a few.

Finally, the University of Fiji is funded by the Arya Pratinidhi Sabha (Arya Representative Society), a Hindu religious organization initially formed to assist Fiji Indians in legal matters. It was established in 2004 and celebrated its first graduates in 2017. The basic coursework is in the Fijian and Hindi languages; Hindi is the main language of Fiji's largest ethnic minority. The University of Fiji was created to "provide high quality, affordable higher education to the many students who had no access to other tertiary institutions" and was legally assigned powers in the University of Fiji Act of 2011.("University Profile – The University of Fiji", n.d.) As a budding university, the University of Fiji tries to work with other universities and organizations to have joint research and publications and gain credibility.

4.3.4 Large Corporations

There are a lack of large corporations in Fiji. Some of the largest companies (by revenue) in Fiji include Vodafone Fiji ($455M); Fiji Airways ($430M); Sugars of Fiji ($421M); Water Authority of Fiji ($408M); Carpenters Motors ($272M); Telecom Fiji ($233M); Guirennaiao (apparel and retail, $193M); Vinod Patel (home improvement and hardware retail, $173M); Fiji Electricity Authority ($159M); and Coca-Cola Europacific Partners Fiji ($122M). In addition, the Fiji National University ($420M)and the University of South Pacific ($348M) have substantial Revenue. ("Search Companies in Fiji | ZoomInfo.Com", n.d.)

Fiji has some mineral deposits that are owned or mined by foreign companies. Foreign companies back some of the mining investments or projects. For example, Vatukoula Gold Mine (Emperor Gold Mine) is the chief producer of gold and silver and is listed on the London Stock Exchange, but the majority shareholder is Chinese company Zhongrun Resources Investment Corp. Lion One Metals Limited is an Australian company owned the promising Tuvatu alkaline gold project, expected to become the second commercial gold mine in Fiji. Additionally, Dome Gold Mines, an Australian Company, is an emerging exploration company focused on identifying and developing mineral deposits in Fiji.

The International Trade Administration (part of the US Department of Commerce) characterized Fiji as an

> "economic, transportation, and academic hub of the South Pacific Islands. The government welcomes foreign investment, and parliament passed the Investment Act 2021 to improve the ease of doing business in Fiji. The government's investment and trade promotion agency, Investment Fiji, registered 12 investment projects valued at $7.64 million (FJD $16.2 million) from American investors in 2021. Exports to Fiji totaled over $180 million in 2021. The United States is Fiji's

> top export market. In 2021, US consumers bought over $230 million in Fijian goods and services last year. Fiji has trade and investment potential and offers incentives to encourage investments in agriculture, residential housing development, energy, audio & visual, retirement village/aged care facilities, health sector, tourism, manufacturing, and information communication technology (ICT)/business process outsourcing (BPO) sector." (75, 2022)

Investment Fiji uses Fiji's reputation as the Pacific hub to market to investors. Investment Fiji is a government actor to support premium investment and export opportunities to create a positive impact.

Overall, there did not seem to be a specific large corporation that could play a role as a stakeholder in developing the innovation ecosystem of Fiji. While the presence of multinational corporations and innovation is comparatively very weak in Fiji, there is a potential opportunity. Chinese businesses have been investing in infrastructure and construction projects in Fiji. A criticism is that China will bring in talent and its workers to work on these projects rather than employ local Fijians. China's investments include loans for road construction, dams, hotels, and bridges. Also, in 2022 Fibre Network Engineering Communications, an Australian company, began operations in Fiji. (Pryke, 2020)

4.3.5 Government

The Fijian government is primarily investing in infrastructure that can support multiple parts of economic development. Funding is largely given to support social developments and community needs. There does not appear to be an innovation strategy. However, there are programs designed to help entrepreneurs, education, and cope with climate change.

In 2016, the Fijian Parliament unanimously approved the climate treaty known as the Paris Accords and became the first country to formally approve the deal. The Fijian government has created the Fijian Sustainable Bond Framework to support efforts of climate adaptation and moving towards green and blue economies. Specific efforts include investments in green energy, green shipping, sustainable fisheries, and coastal protections.

Furthermore, in 2021-2022, Fiji made provisions in the national budget for a Telecom ICT Park. The Park is to host a research and development center, a data center, and an incubation center for entrepreneurs. In addition, the Park comes at a time when the Business Processing Outsourcing sector continues to be one of the fastest-growing industries, employing about 3,000 Fijians and bringing in $90 million annually. ("ICT Park Ushers In New Technological Era For Fiji", 2022)

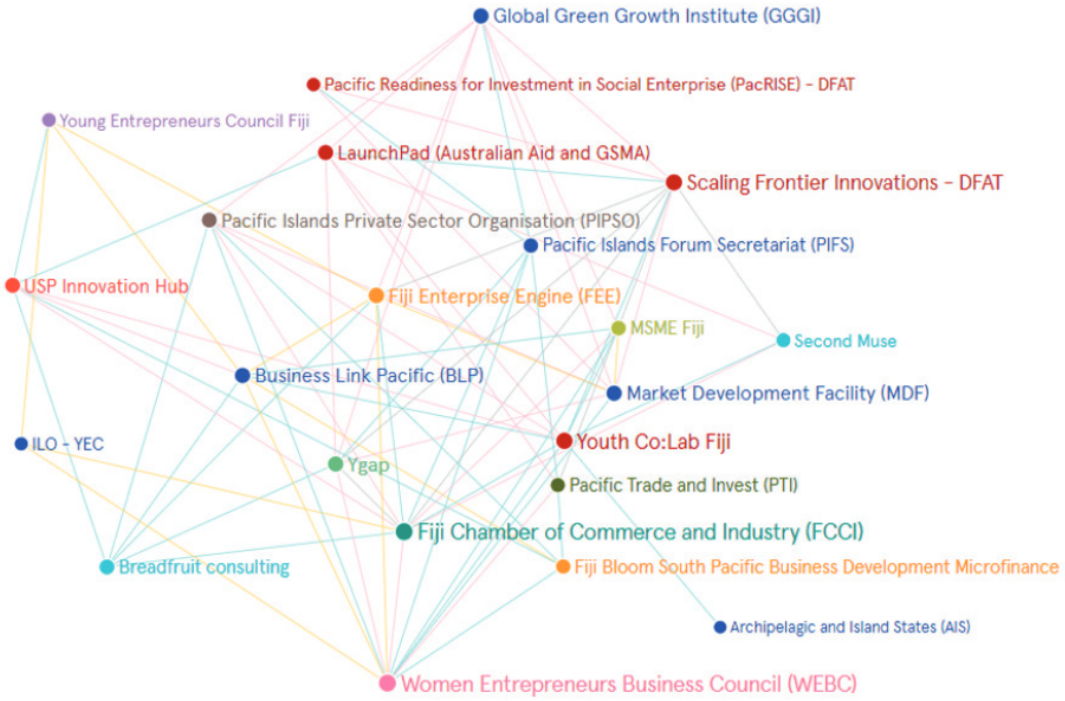
4.3.6 Other Key Players

The strongest stakeholder group was often considered to be "development partners," such as the UN, USAID, and other non-profit or non-governmental organizations. (Many of these receive their funding from one of the original stakeholders in the MIT model.) However, these partners are not without their challenges. Often NGOs would want to replicate their successes elsewhere and fail in adapting to local culture. Sometimes NGOs might want to hire local talent but would not be able to find the people with the specific capabilities desired, so the issue of local adaptability became a chicken-or-egg problem.

A network analysis of the entrepreneurial support organizations was conducted by the UNDP. Figure 4.6 was published in the UNDP report showing the connectedness of various organizations and programs in the Fiji ecosystem.

Figure 4.6: Fiji Entrepreneur Support Organizations Network

(Rull & Kakal, 2021)



Market Development Facility is an Australian Government initiative that works with the Fijian community to empower females and grow a diversified and inclusive tourism industry. Figure 4.7 is a continuation of the graphic categorizing various entrepreneurial support organizations, with a majority being other key players derivatives of the 5 Stakeholder Model:

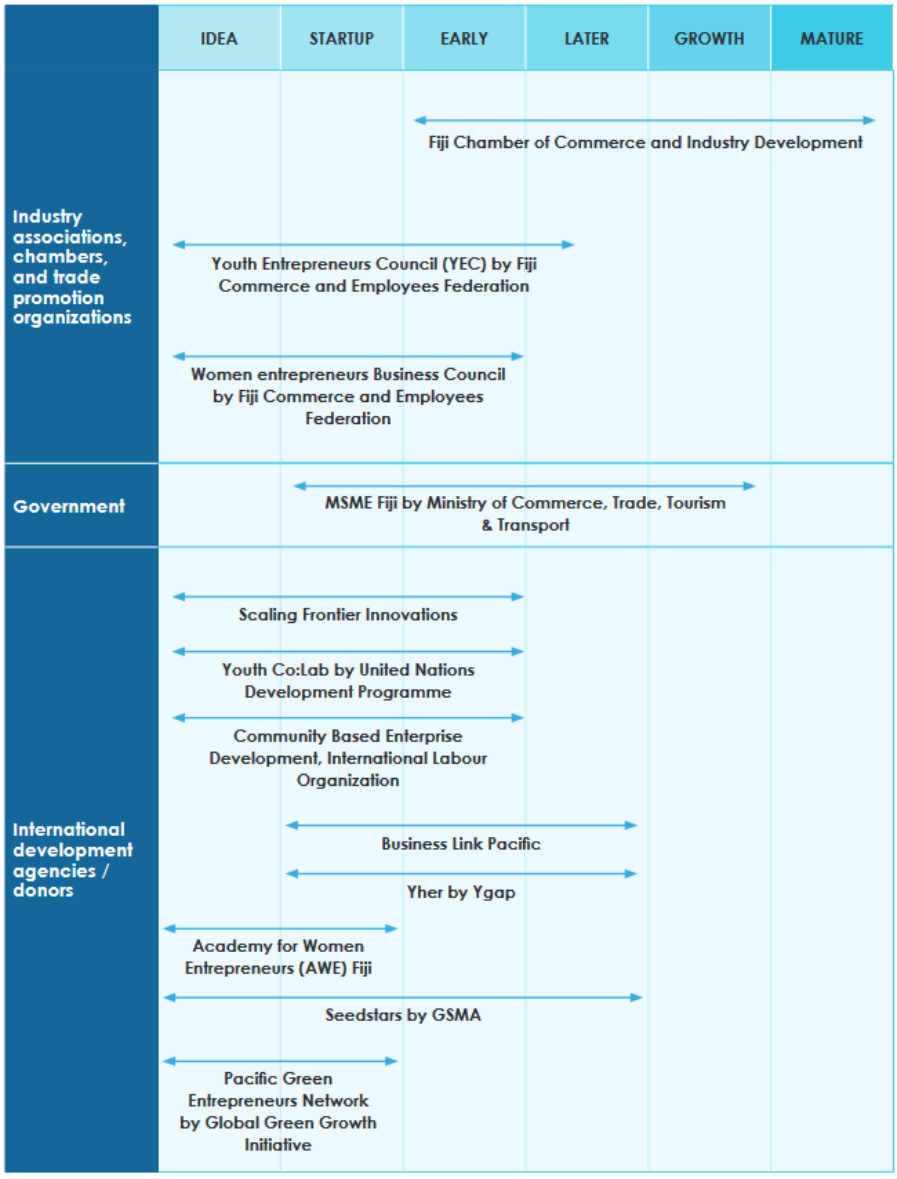


Figure 4.7: Entrepreneurial Support Organizations by Type and Start-up Phase. (Rull & Kakal, 2021)

4.4 Strategy: Policies and Programs

Overall, the research and statistics regarding Fiji show that while it is one of the more developed small island developing states in the Pacific islands, it still has a long way to catch up with the rest of the world. To increase the velocity of its development, Fiji should focus on

building innovation capacity beginning with infrastructure. Infrastructure is the purview of the government. Though there has been recent political volatility between coups, elections, and the very new coalition government, this new coalition government has focused on bringing together all Fijians. An address at the 2023 National Economic Summit given by Prime Minister Rabuka reiterated that messaging. The government is working to rebuild some of the infrastructure. It reestablished the Public Works Department to improve rural roads. Fiji's infrastructure is severely behind, as was discussed in the I-Cap and E-Cap sections. As infrastructure is strengthened, local Fijians need to learn skills and not use outside labor as has happened in the past.

That said, Fiji is making strides to improve entrepreneurship and the standing of MSMEs in the economy. Some of these strides include making it easier for businesses to do business in Fiji, programs for entrepreneurs, infrastructure projects, and even the formation of a coalition government that might be promising for continuing to grow the economy. *MSME Fiji*, the Ministry of Trade, Co-operatives, Small and Medium Enterprises, is responsible for improving opportunities for micro, small, and medium enterprises to be developed. Programs like the Young Entrepreneurship Scheme are to help younger members of the population start and expand businesses to become job creators. Additionally, "pre-covid the MSME Sector contributed 18% to Fiji's GDP and 60% to the national workforce," and it is acknowledged that this part of the economy played a substantial role in recovery. ("Trade Enhancement Program", n.d.) As such, the government is investing in programs for improving entrepreneurial access to funds. However, Fiji lags in its ability to foster innovation-driven enterprises. As part of MSME Fiji, a portion of that ministry should be devoted to developing and commercializing technology. MSME Fiji can coordinate with universities to specifically develop innovation-driven enterprises. MSME Fiji should work with other government Ministries to upskill the population in terms of digital fluency and coding.

Fiji is taking a step in the right direction to strengthen education. The Fijian government an-

nounced in early 2023 that tertiary education would be free for students that gain admission and agree to a bond service period, determined by a 1.5 or 2 multiplier for the number of years for which students receive tuition or tuition and allowance, respectively. (Fijivillage, 2023) The budget allocation is to sponsor nearly 11,000 new students and fund approximately 9,000 current students. The Fiji government's support for students to have tuition assistance in exchange for bond service will hopefully improve the number of STEM students and professionals in Fiji. Another idea is to support students with international experience specifically related to technology and research that could be useful to Fiji. Supporting these efforts allows people to become immersed in higher-functioning ecosystems and learn tacit knowledge. They can, in turn, bring back skills, experience, know-how, and—most importantly—vision for participating in an innovation ecosystem. This will help to strengthen the Entrepreneur Stakeholder Group.

There is an opportunity to partner with other universities around the globe to study climate change and its effects on tropical climates. Universities in Fiji need to apply research to create technologies that can become commercialized. Universities and governments should work together to make sure technologies are patented. Then, the University of South Pacific and Fiji National University should identify how they might export some of their research. There can be great strength in sharing knowledge and becoming known as a collaborator. While the PIURN exists, there is also a greater network. The association of Pacific Rim universities includes 61 research universities across Australia, Canada, Chile, China, Columbia, Ecuador, Hong Kong, Indonesia, Japan, Malaysia, Mexico, New Zealand, Philippines, Russia, Singapore, South Korea, Taiwan, Thailand, and the United States. There may be an opportunity for the Fijian universities to join this association.

One of the UNDP researchers had some insights into comparing the Pacific Island ecosystem to Africa. Some of the basic struggles are the same with lack of capital. Africa seems to be pushing harder for a startup culture, and the government is more aware of the benefits of entrepreneur-

ship, specifically around the development of IDEs, and prioritizing it. In Africa, there are often local entrepreneurs who lead incubators and accelerators. Another area of opportunity for Fiji from Africa are organizations connecting researchers, like Afrilabs. While African countries are geographically better connected than other countries in the Global North, an organization like this might be useful in bringing people together amongst the Pacific Islands.

The Corporate stakeholder group was also noticeably weak, and Fiji needs to be intentional with how it invites international corporations to become stakeholders in the innovation ecosystems. Like Hawai'i, Fiji can leverage its tourism sector and invite corporations to invest in local innovation.

4.4.1 Indigenous Opportunities

Fiji is divided into 14 provinces with over 300 dialects. The iTaukei are considered the Indigenous Fijians, while Indo-Fijians are a large minority group of Fijian citizens of Indian descent and makeup 37.5% of the population. Not much was commented on in terms of programs for indigenous Fijians, likely because they are the dominant ethnic group. Programs focused on minorities like women. Also, in light of the political volatility, there is a focus on bringing people together and improving conditions for all Fijians. Another division in terms of resources is the urban-rural divide, where many of the resources are more commonly found in urban centers.

What might be termed Indigenous knowledge in other contexts was more often termed traditional knowledge, likely because the Indigenous are still the majority ethnic group. The rural-to-urban migration in Fiji has disrupted the inter-generational passing of knowledge. Where communities once had certain families responsible for being keepers of knowledge, that has changed. Also, Elders have been dying off at faster rates than knowledge could be passed.

Generally, the traditional knowledge systems are passed from older generations to younger generations in an oral tradition. Traditional knowledge includes the preparation and use of medicinal herbs and other materials, agricultural practices, meteorology, fishing practices, and preparation of traditional foods, including kava. "Community Elders have the knowledge to share regarding adaptation measures relevant to natural disaster preparedness, risk reduction, food production systems, and weather forecasting. It is critical to codify and preserve their knowledge and enable its transmission to younger generations." In addition, handicrafts like textiles, weaving *pandanus* mats or mats from *kuta* (water reeds), as well as fans, baskets, and rope from coconut husk, are cultural traditions to be preserved.

The UNDP wrote a report about youth in Gau who organized a one-week *Traditional Technologies Exposition*. The youth recognized that there were very few Elders left on the island and brought together 107 people from eight communities, ranging from age 8-69. Females participated in weaving, cooking, dancing and singing, and fishing activities. At the same time, men participated in weaving, planting, construction, fishing, ceremonial rights, and dancing and singing practices. The report identified "a new culture of dialogue across generations was initiated as a result of the Expo. Youth who participated in the Sawaieke Expo displayed what they learned at the Lomaviti Festival (Lomaviti is one of the 14 provinces in Fiji). Led by Sawaieke youth, efforts are also taking place in Gau's two other districts for young people to contribute to keeping their culture alive." ("SCEFI Emblematic Stories", n.d.)

A further result of the Expo was a change in the responsibility of knowledge transmission; both young people and Elders became stewards of this responsibility. It also was an innovative way to transfer knowledge and became a learning experience for the Elders of Sawaieke to understand younger generations. In addition, younger people gained new confidence in speaking out at village and district meetings and now feel heard and respected in those spaces. This experience and outcomes were shared with the iTaukei Ministry's Department of Language and Culture, and efforts are being made to integrate traditional practices into school curricula.

4.5 Fiji Summary

Fiji's innovation ecosystem is like a seedling slowly emerging from the soil. It is weak and does not have strong connections, but it is working to form them. In terms of entrepreneurship, there are some latent capabilities and cultural challenges to overcome. From the MIT Stakeholder Model analysis, Fiji's universities and government emerged as the likely leaders for the next phase of ecosystem development. While there are many ESOs present in Fiji, and they are considered a strong group, those organizations are not sustainable, and many are only fulfilling a program for an established time frame. Fiji's implementation of a bond service program in exchange for tertiary education is a step in the right direction. Fiji should encourage its youth to develop skills in STEM areas, especially coding. The USP should work with its professors and students to generate new IP and protecting it with patents. This could be achieved through working with other universities who have started and maintain functional technology transfer offices.

With most of Fiji's export basket associated with food products, Fiji should work to innovate in agriculture and food technology. The government has allocated an additional budget towards improving agricultural production with subsidies for weedicide and fertilizer. *Agricultural technology* is a sector that Fiji-based universities can work in to develop impactful innovations. In addition, Fiji has its share of natural disasters and has an opportunity to innovate around the needs that arise in those situations. The medical school also provides opportunities and resources in the health sector, which needs attention in the Pacific Islands. Indigenous ecological, meteorological, and medicinal knowledge may provide opportunities for innovation in these sectors. Digital and knowledge-based technologies are areas with shorter cycle times, quicker feedback rates, and have great potential for developing innovation-driven enterprises.

Chapter 5

New Zealand

We have no money, so we must think.

Ernest Rutherford

5.1 Background

New Zealand is a sovereign island nation with two main landmasses: the North Island and the South Island. It is located approximately 1,500 kilometers (930 miles) east of Australia. The Māori Indigenous population is believed to have settled in New Zealand around the 13th century. In 1769, British explorer James Cook became the first European to reach New Zealand. British colonization began in the early 19th century. The population is now 71.8% European ethnicity, 16.5% Māori, 15.3% Asian, and 9.0% Pacific peoples.

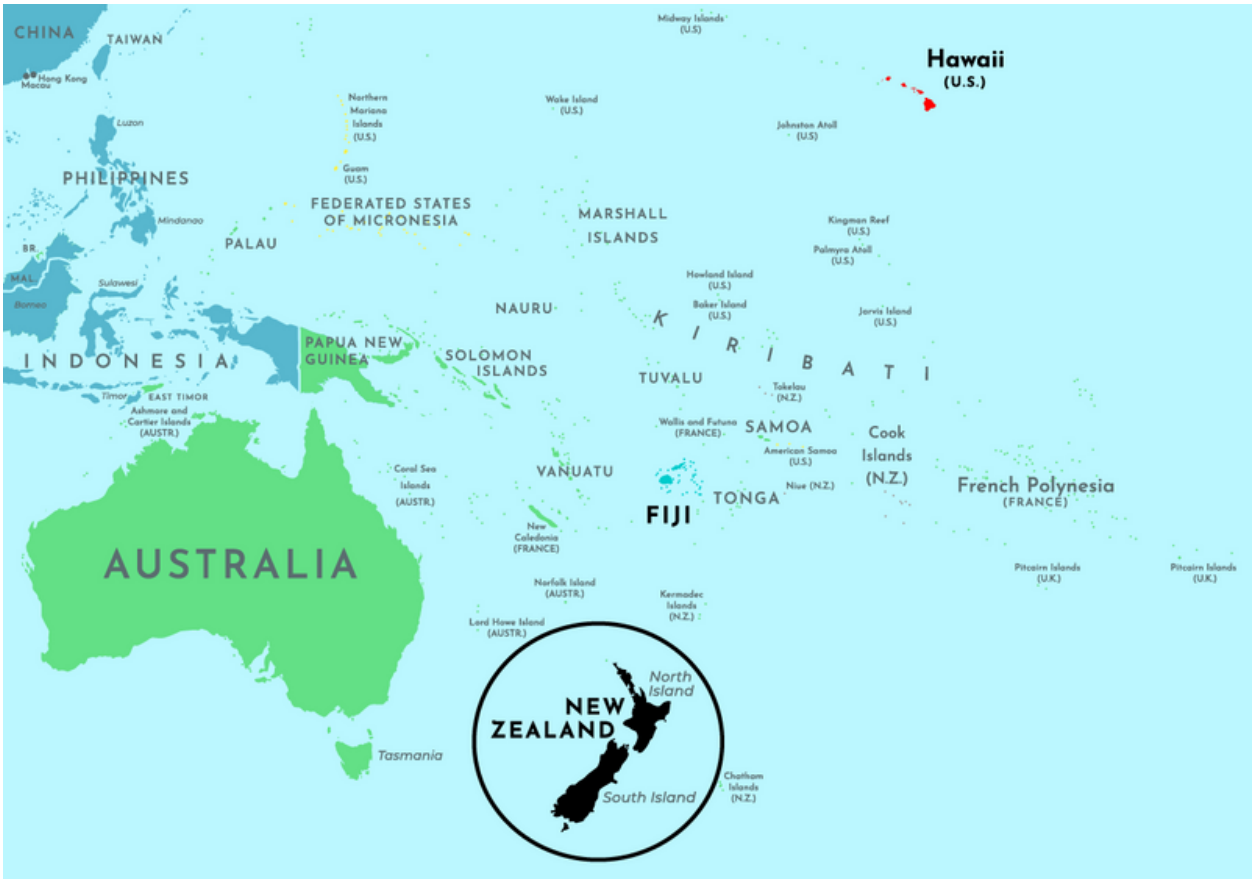


Figure 5.1: Map of Oceania, New Zealand in black.

5.1.1 Brief Political History of Region

In 1840, the Treaty of Waitangi was signed between the British Crown and the Māori chiefs, establishing New Zealand as a British colony and granting Māori land rights while recognizing British sovereignty. However, there were differing understandings of sovereignty and land ownership, which led to conflicts, displacement, and loss of cultural heritage over the years.

New Zealand gradually gained more autonomy from Britain throughout the late 19th and early 20th centuries. In 1907, New Zealand became a self-governing Dominion within the British Empire. By 1947, it adopted the Statute of Westminster, which granted full sovereignty and allowed New Zealand to pass laws independently of the British Parliament.

Domestically, as New Zealand asserted its own identity and sovereignty from Britain, political changes unfolded with policies focusing on healthcare, education, and social security. These developments laid the groundwork for a more inclusive and equitable society. On the international front, New Zealand navigated its own foreign policy. However, alongside these progressive changes, the legacy of colonialism and the Treaty of Waitangi, signed between the Indigenous Māori and the British Crown, remained unresolved.

In 1991, six people filed a claim known as the Treaty of Waitangi claims. They represented themselves and their Indigenous community (*iwi*) and focused on current issues rather than events from the past. Specifically, it dealt with the rights of the Māori people concerning their native plants, animals, and cultural treasures (*taonga*). This included the use and protection of Māori symbols and designs and their cultural heritage rights related to these treasures. New Zealand's political landscape was and is undergoing a reevaluation of its historical injustices and working towards a more just and inclusive future, striving to honor its commitment to the Indigenous peoples and address the disparities that had persisted since the early colonial period and is "developing a whole-of-government approach to responding." (Commission, 2021)

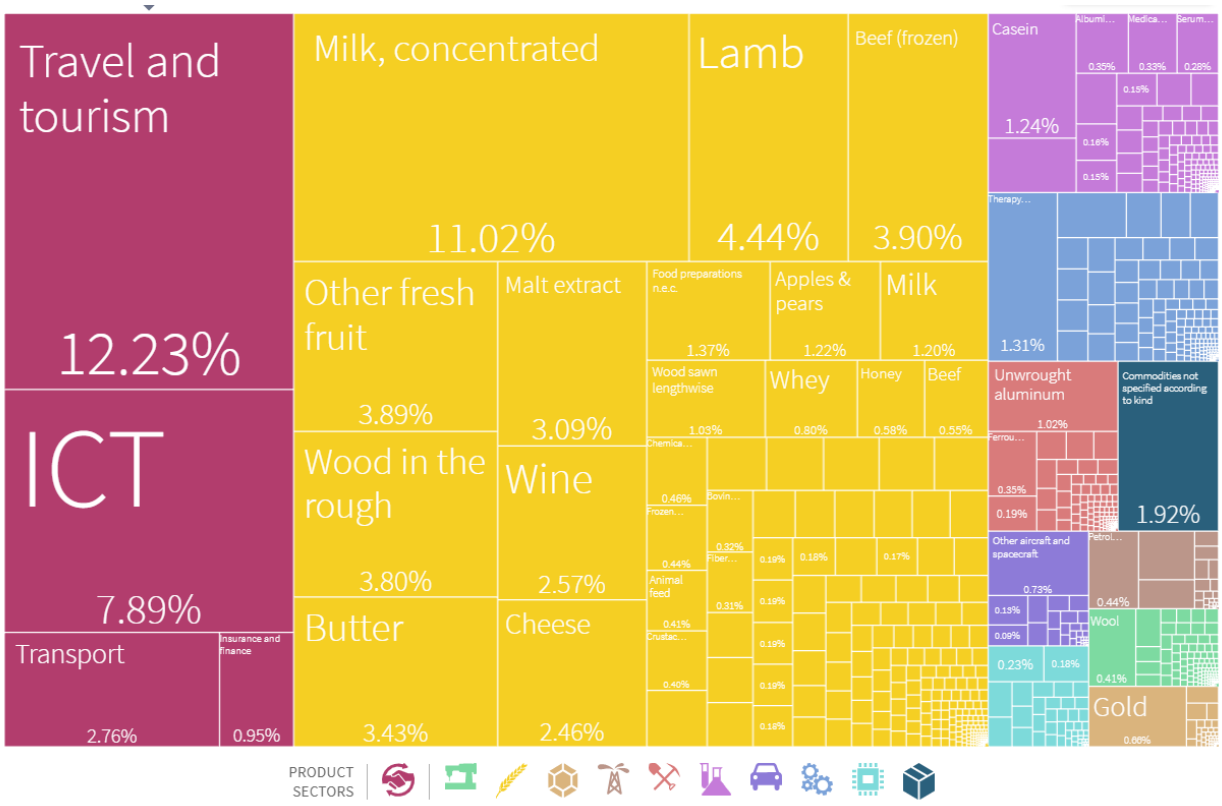


Figure 5.2: 2020 Export Basket of New Zealand (Growth Lab at Harvard University, n.d.)

Currently, New Zealand follows a parliamentary democracy with a constitutional monarchy. The head of state is the British monarch, King Charles III, and the New Zealand Prime Minister leads the government. New Zealand is known for its stable political environment and progressive policies.

5.1.2 Brief Socio-Economic History of Region

The country's economy historically relied on agriculture, mainly sheep farming, which earned it the nickname "the Land of the Long White Cloud" due to the abundance of sheep and the picturesque landscapes. Over the years, the economy has diversified, and sectors such as tourism, horticulture, dairy farming, and manufacturing have become significant contributors. Figure 5.2 shows the export basket of New Zealand.

Travel and tourism make up 12.23%, while ICT (information communications technology) represents 7.89%. The bulk of the exports represented by yellow is agricultural. In addition, the top three export destination countries are China (33.02%), Australia (11.91%), and US (10.95%). (Growth Lab at Harvard University, n.d.)

The tourism industry benefits from New Zealand's beautiful lands, which host many endemic species of flora and fauna. The country is also recognized for its commitment to environmental conservation and sustainability.

New Zealand blends Māori and European influences; government offices have English and Māori names. Inclusion of the Māori language, arts, and customs has been increasingly present. New Zealand is also known for its national rugby team, the All Blacks, who, before every game, perform the *haka*, a Māori ceremonial dance.

5.2 System

MIT's Regional Entrepreneurship Acceleration Program (REAP) had a cohort from New Zealand participate about a decade ago. This involved a team with people representing each stakeholder group (ie entrepreneurs, risk capital providers, universities, corporate, and government) coming together to analyze New Zealand's innovation ecosystem. It was interesting to hear reflections from a team member who upon doing the investigation, found New Zealand to have greater innovation and entrepreneurship capacities than they expected.

5.2.1 Foundational Institutions

New Zealand has mature foundational institutions characteristic of a small advanced economy, like Denmark, Israel, or Finland. New Zealand inherited and adopted British Common Law as a part of the British Empire. The Parliament also creates laws, as do the courts of New Zealand. The Intellectual Property Organization of New Zealand oversees patent and trademark registration.

5.2.2 Innovation and Entrepreneurship Capacities

Culture and Incentives

In the context of business freedom, New Zealand scores 78.9, higher than the US and Fiji, and ranks fifth throughout the entire world. Only Singapore, Switzerland, Ireland, and Taiwan rank higher, with Singapore scoring 83.9, the highest. (Kim, 2023) Despite that high score, entrepreneurship, in terms of intentions and societal views, is lower rated than the US. ("Global Entrepreneurship Monitor", 2023) According to GEM data, only 61.44% view entrepreneurship as a desirable career choice in New Zealand. ("Global Entrepreneurship Monitor", 2023) However, it's not necessarily because of a fear of failure, as that fear of failure rate is close to half of the US at about 22% of the population. ("Global Entrepreneurship Monitor", 2023) In addition, 72.73% of New Zealanders feel that successful entrepreneurs have high status, which is on par with The US at 79.86% of the population. ("Global Entrepreneurship Monitor", 2023)

Regarding innovation capacity, roughly 23% of university graduates in New Zealand are studying science and engineering. ("Economy Briefs from the GII 2022", 2022) But, according to the global competitiveness index (GCI), New Zealand score was 9/100[1] in a survey regarding the

[1] In previous years, the GCI used a 1-7(best) score for this metric and New Zealand score 5.4/7 in 2016, however

quality of scientific research institutions and ranked 47/140 countries. (Schwab, 2018) For context, the US scored 100, and is top ranked with six other countries.

Regarding another measure for the quality of scientific research institutions, the H-index for New Zealand was found to be 15.06, while Hawai'i's is 9.11, and Fiji's is 4.25. ("Country and State Rankings, h-Index | IDEAS/RePEc", n.d.) This indicates that more research is published out of New Zealand. Another point of comparison is that Massachusetts holds the highest H-index among the US states, with a value of 47.02. ("Country and State Rankings, h-Index | IDEAS/RePEc", n.d.)

While not a measurement of innovation capacity, patent data was also looked at to supplement understanding. In 2015, there were 690 utility patent applications from New Zealand to the US—a metric that has been trending upward. ("Utility Patent Applications By Country of Origin, Calendar Years 1965 to Present", n.d.) Figure 5.3 shows how New Zealand's upward trend compares to other nations like China, Israel, Norway, and Singapore. However, a more appropriate measure might be to understand how many patents per 1000 people of the population. For Australia, it is 0.15; for China, it is 0.015; Israel 0.99; New Zealand is 0.15; Russia 0.01; Singapore 0.32, and for the US roughly 0.90. New Zealand's US utility patent applications are at the same rate as Australia's. However, it is at approximately 15% of Israel's utility patent rate and 17% of the US patent rate.

Demand

New Zealand's domestic market scale is more than twice that of Hawai'i's at $235 Billion USD. (Schwab, 2018) This means that more of the local market could potentially absorb the technologies produced. Regarding the buyer sophistication survey, the Global Competitiveness Index rated New Zealand at 4.2, compared to the US at 5.1, out of 7 (best). (Schwab, 2018)

it changed its method for quantifying research institutions prominence

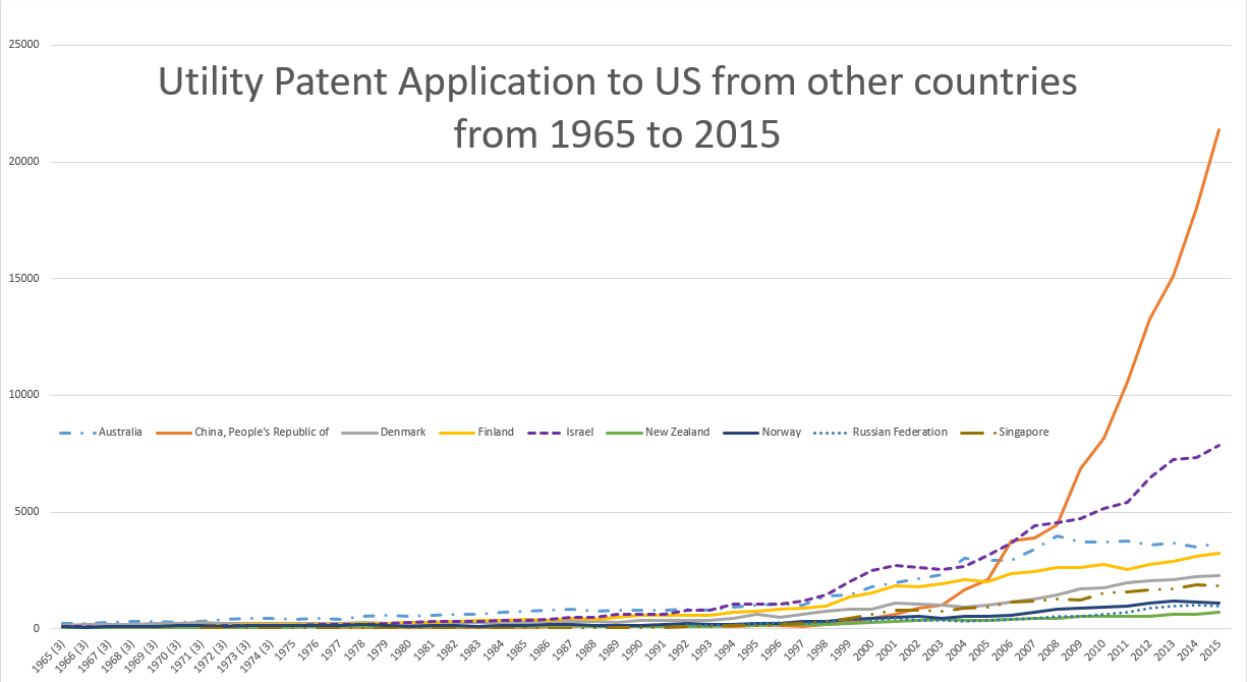


Figure 5.3: Utility Patent Applications to the US from Selected Countries.("Utility Patent Applications By Country of Origin, Calendar Years 1965 to Present", n.d.)

On the innovation capacity side, the survey question regarding government procurement of advanced technology projects scored New Zealand at 3.8. At the same time, the US was higher at 5.09/7 (best). (Schwab, 2018) Regarding Trade, Competition, and Market Scale, the Global Innovation Index scored New Zealand at 57.5 compared to the US at 96.2. In 2015, Fiji's score was 65.2 for comparison. ("Economy Briefs from the GII 2022", 2022; University et al., 2015) Regarding University-Industry collaborations, New Zealand scored 55.5 while the US scored 79.6. ("Economy Briefs from the GII 2022", 2022; University et al., 2015) The conclusion drawn from this is that New Zealand has the opportunity to advance its position in trade, competition, and market scale.

Infrastructure

New Zealand's infrastructure is excellent, outscoring the US regarding electricity and telephone infrastructure and the number of internet users, at 88.2%. ("MIT IEcosystem Explore

Innovation", 2018) Furthermore, the internet bandwidth is roughly 8% higher in New Zealand and people have greater access. (Schwab, 2018) New Zealand scored slightly lower regarding the availability of the latest technologies, with survey data at 5.94 vs. 6.54 in the US. ("MIT IEcosystem Explore Innovation", 2018) Meanwhile, the US and New Zealand scored equally in terms of product process sophistication. ("MIT IEcosystem Explore Innovation", 2018)

Funding

Regarding Funding, New Zealand is ranked sixth, just three countries behind the US. The New Zealand population accesses loans more easily than the US, scoring 5.74 vs. 5.31 on the Global Competitive Index. ("MIT IEcosystem Explore Innovation", 2018) Comparing the number of VC deals in New Zealand vs Hawai'i over the years 2014 through 2022, New Zealand had 2,651 while Hawai'i had 614. ("Pitchbook", 2023) When adjusting for population, there were 15% more deals occurring in New Zealand than Hawai'i. Furthermore, when comparing the VC investment amounts provided by Pitchbook, investment in New Zealand totaled $32.79 Billion USD, while investment in Hawai'i was $4.44 Billion USD; again normalizing by population New Zealand had $2 in investment for every $1 investment in Hawaiian enterprises received from VC firms. ("Pitchbook", 2023) In terms of overall research expenditure, the US spends roughly 270 times more than New Zealand, and when normalized for population, it equates to 4.3 times more. ("MIT IEcosystem Explore Innovation", 2018) This essentially says that for every dollar spent in New Zealand per person on R&D, $4.30 is spent in the US.

Human Capital

Regarding Human Capital, the percentage of school grads in tertiary education in New Zealand is 80.3%, while the US has 87.9%. ("Economy Briefs from the GII 2022", 2022) According to

the GEM, 59.81% of the population is seen as having perceived capabilities of entrepreneurs. At the same time, it is slightly higher in the US at 66.8%. ("Global Entrepreneurship Monitor", 2023)

According to the GCI, New Zealand has a relatively high availability of scientists and engineers and comparable quality of STEM education relative to innovation capacity. ("MIT IEcosystem Explore Innovation", 2018) Student performance at age 15 shows that New Zealanders outscore both Israel and the US in terms of science and maths. (Hendy & Callaghan, 2013) Finally, according to UNESCO, in New Zealand, there is a higher proportion of researchers and professionals engaged in R&D per million of the population: 5,854.1 in New Zealand, vs. 4,829.1 in the US, vs. 924 in SIDS. (University et al., 2015)

The data is clear—human capital innovation and entrepreneurship capacities in New Zealand are favorable for a robust innovation ecosystem.

5.2.3 Comparative Advantage

New Zealand boasts diverse comparative advantages that have positioned it as a competitive player in the global economy. The comparative advantages of New Zealand, based on current exports, are mainly agricultural, tourism, and ICT. The thriving agricultural sector harnesses the country's fertile land and favorable climate. New Zealand is also known for its high-quality dairy products, such as milk, butter, and cheese, as well as premium meat products, like beef and lamb. These agricultural exports have earned the country a reputation as a reliable and trusted supplier worldwide. Additionally, New Zealand has incorporated innovative agricultural technologies, such as precision farming and sustainable practices, allowing it to increase productivity while minimizing environmental impact. The spin-out A2 Milk unicorn emerged from the dairy sector.

Another significant comparative advantage of New Zealand lies in its clean and green image, which has fueled the growth of its tourism industry. The country's landscapes have been featured in many films and encompass majestic mountains, pristine beaches, and unique geothermal wonders. The Māori culture has become intertwined with New Zealand's identity, adding cultural richness to the tourist experience. New Zealand's commitment to sustainable tourism practices and eco-friendly initiatives resonates with environmentally conscious travelers, bolstering its reputation as a responsible and desirable travel destination. As a result, tourism has become a vital pillar of the New Zealand economy, providing employment opportunities and economic growth while showcasing the nation's stunning natural assets.

The New Zealander identity associated with the "number 8 wire" is a comparative cultural advantage that helps breed an identity associated with problem-solving. "New Zealanders call Kiwi ingenuity 'number 8 wire,' [because] in the country's colonial days, the only plentiful resource was 8-gauge fencing wire, and New Zealanders learned to fix and make anything with it." (Isenberg, 2010)

5.2.4 Impact

New Zealand has had a few unicorn startups; the first unicorn was Rocket Lab. Rocket Lab was founded by Peter Beck in 2006 and developed the Electron rocket. This small, low-cost launch vehicle could transport up to 660 pounds to various orbits. Rocket Lab relocated its headquarters to California in 2013 to be closer to its major suppliers and customers and to draw from the talent pool in Huntington Beach. Rocket Lab was valued at $4.8 Billion after it went public via a SPAC (Special Purpose Acquisition Company) merger in 2021. Today Rocket Lab operates from two launch sites, one in New Zealand and another in the US. A2 Milk is another unicorn from New Zealand, this time in the dairy industry. A2 Milk produces milk without certain protein types, allowing it to be more easily digested. Xero, a Wellington-based

accounting software company, is also a New Zealand unicorn and is the largest New Zealand firm by the current 2023 market cap. LanzaTech, a biotech IDE, is a fourth unicorn with New Zealand origins. Its primary technology is ethanol production while being carbon negative. In 2014, LanzaTech moved its headquarters and invested in a research center in Skokie, Illinois, as part of the Illinois Science and Technology Park. And in 2022, LanzaTech went public via a SPAC deal and had a valuation of $2.2 Billion.

New Zealand's four unicorns are in four different sectors. As such, it is expected that New Zealand can also support a variety of IDEs developed in similarly diverse sectors.

5.3 Stakeholders

New Zealand has stakeholders interested in its transformation towards an innovation economy. In 2013, Shaun Hendy and Paul Callaghan published a book *Get off the Grass: Kickstarting New Zealand's Innovation Economy.* They examine aspects of New Zealand's economy and look at other small countries like Denmark, Finland, and Israel for insights into how New Zealand can overcome its disadvantages.

5.3.1 Entrepreneurs

New Zealand has a heritage of problem-solving with its number 8 wire stories. With four unicorns under their belt and the legends of the number 8 wire as part of the cultural identity of New Zealanders, entrepreneurship is viewed favorably.

Hendy and Callaghan share two stories of innovations from New Zealand to show a cultural flaw that "New Zealanders are more comfortable with developing goods and services that ex-

ploit the credentials of the environment rather than intellect." (Hendy & Callaghan, 2013) The two stories are shared below:

> "The first is a brand of high-performance outdoor clothing made from fine merino wool. In the early 1990s, Kiwi Jeremy Moon stumbled across the idea for merino undergarments during a visit to Brian Brakenridge's farm on remote Pohuenui Island in the Marlborough Sounds. Today, Moon has turned the idea for Merino clothing into a company with revenues of US $100 million: Icebreaker. Although much of Icebreaker's manufacturing is now carried out offshore, the product is still based on New Zealand-grown merino wool. Icebreaker has become an iconic New Zealand company.
>
> "The second innovation, the water-repellant breathable material marketed as Gore-Tex, underpins the revenues of a US $3 billion company, W. L. Gore and Associates. Gore-Tex, the company's main product, uses a material that was first invented by John Cropper in Auckland in the 1960s: expanded polytetrafluoroethylene or stretched Teflon, the breathable but water-repellant material that makes Gore-Tex the premium brand for wet-weather clothing today. Unfortunately, rather than exploiting his invention from New Zealand, Cropper chose to commercialize his technology by selling it to an American company without patenting it. A few years later, a patent for the technology was successfully filed by the Gore family. So despite the fact that the process to make stretched Teflon was invented here in New Zealand, we are not an exporter of expanded polytetrafluoroethylene today...
>
> "To sell Icebreaker to the world, Jeremy Moon simply painted a picture that reinforced the notion that New Zealand is a land rich in natural resources. To sell a clothing made out of expanded polytetrafluoroethylene, we would have to own up to the rest of the world that we were a clever people who could do things they couldn't." (Hendy & Callaghan, 2013)

The cultural flaw may also be rooted in what an interviewee described as "tall poppy syndrome"—as people are criticized for their success and ambition, they choose to keep a low profile and minimize their achievements. Kea New Zealand, a firm that connects Kiwi businesses with Kiwi mentors, has an award called "World Class New Zealanders." This award includes a trophy with the image of a person emerging from the poppies as a tongue-in-cheek representation.

Successful entrepreneurs and wealthy philanthropists are often the source of angel investments. However, one of the interviewees recognized that New Zealand lacks a strong culture of philanthropy because there are not as many wealthy people nor as many successful entrepreneurs.[2]

New Zealand did draw the attention of Paypal Founder Peter Thiel, who started Valar Ventures to support the New Zealand ecosystem—though its creation was an action more for the purpose of acquiring New Zealand citizenship and skirt residency requirements. Another part of Thiel's citizenship application would be "involvement with the San Francisco landing pad for Kiwi companies [which] reportedly ended once his three-year sponsorship deal expired in 2013." (Cox et al., 2018) Thiel's involvement as an outsider is a very different one from that of the Omidyar's in Hawai'i, who remain invested in the ecosystem through the Ulupono Initiative and are residents of the state.

Compare this to the following story shared by Andy Hamilton:

> About five or six years ago, two engineering interns worked at Rocket Lab for Peter Beck. He encouraged them to start a business. They had a couple of goes at it, and eventually, they started a fenceless farming business called Halter. Halter is a fenceless farming and animal health business where Bluetooth collars go on cows. Peter loved the idea, loved the founders, and invested in the company. He brought

[2]This hypothesis could be a separate thesis, so it is left here as mainly an opinion from a REAP team member.

> it to Icehouse ventures and they invested, and Peter arranged for DCVC to invest in that company. And they got the doors of Silicon Valley open to them. They got all of the expertise from the partners and team at DCVC and other investors to help harness their pre-seed into seed and then into series A rounds. Essentially, they got all of the benefits from the most competitive venture ecosystem in the world—coming into New Zealand. The talent that has come into the company has been extraordinary. The professionalism around how you grow a high-growth business [or IDE] has also come into the market. That is a good example of someone invested in the venture ecosystem paying it forward, leveraging his connections and networks for another company. The more that it happens, the stronger the ecosystem gets. (Hamilton, 2023)

Entrepreneurs with *strong ties* to place are a source for building the regional innovation ecosystem.

5.3.2 Risk Capital

Up until recently, the main source of investment was through angel investors. Ice Angels, Enterprise Angels, and Angel HQ are a few of these investor groups. Ice Angels evolved to become Icehouse Ventures, an early stage venture capital (VC). I had the opportunity to speak with Andy Hamilton, who is the co-Founder of Ice Angels and the founding CEO of The Icehouse (started in 2001 and continued in that role until February 2020). Since 2010, Andy has also been the Director of Hamilton Ventures. Having decades of experience on the funding side, Andy said he wants the following for New Zealand: "I want to see a startup ecosystem that contributes to the wider country and takes our country and our people forward. Having a functioning ecosystem that supports the ambitions and develops the capabilities of the founders as they go on their very challenging journeys would be a good thing." (Hamilton,

2023)

Investments in “tech” over the past five years (2018 to mid-2023) identified 53 investors headquartered in New Zealand. (“Pitchbook”, 2023) The Pitchbook search used the keyword “tech” to identify those investors that would likely invest in innovation-driven enterprises. The types of these tech investors break down to be: 4 accelerators/incubators; 8 individuals as angel investors along with 3 Angel groups; 7 corporations; 1 fund of funds; 4 government; and 18 venture capital firms; and the remaining a variety of investor type classifications. (“Pitchbook”, 2023) Amongst these risk capital providers is K1W1, a VC firm started by the family office of Sir Stephen Tindall. They have a portfolio of over 150 investments, and their success stories include LanzaTech and Rocket Lab. Other notable names are Icehouse Ventures (which evolved from Ice Angels), Angel HQ, Enterprise Angels, NZVC, Movac, GD1, Pacific Channel, and NetX (New Zealand), to name a few. Movac is one of the older technology investors, actively investing since 1998. Pacific Channel focuses on deep tech. GD1 stands for Global From Day One and is an early-stage tech VC. Nuance Capital is another VC firm in deep tech, looking at advanced engineering, science, IP, blockchain, and deep AI.

Since about 2010, VCs have started being open to investing outside their immediate region. New Zealand has benefited from that shift. While originating from Australia, Blackbird VC is another risk capital provider in the New Zealand Market. Blackbird’s portfolio is worth more than $7 billion, and one of Blackbird’s notable investments is Zoox, the Aussie-founded, now California-based autonomous vehicle company. California-based Khosla Ventures was involved with both Rocket Lab and LanzaTech.

The Risk Capital stakeholder group is smaller in New Zealand as it is still an emerging market for IDEs, and venture funds invest across multiple stages and sectors. New Zealand’s ecosystem has been compared to Sydney and Melbourne.

Scale-Up New Zealand is an open platform developed by Callaghan Innovation and has an interactive visualization of the risk capital providers and startups seen in Figure 5.4.

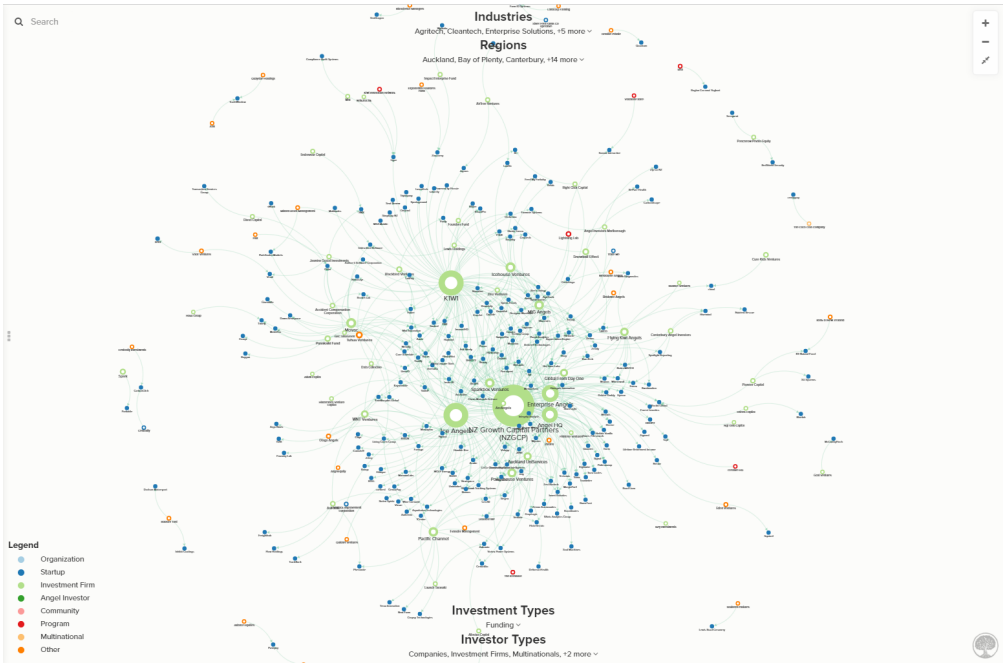


Figure 5.4: Screenshot of Scale-Up New Zealand's Platform describing Current Funding ("Scale-Up NZ", 2023)

Zooming in on one of the larger investment firms, New Zealand Growth Capital Partners, is seen in the following Figure 5.5:

As of July 2023, New Zealand Growth Capital Partners raised $1 billion in three years. It was established by the New Zealand Government in 2002 and operates two funds-of-funds designed to encourage private investment by putting money alongside investor money, essentially de-risking the investment. They support early-stage technology businesses in New Zealand. *Aspire* (direct seed, as a co-investor) and *Elevate* are the names of these funds, and the total investments made number more than 150.

Company-X, a company specializing in software integration, is an investor in Hillfarrance Venture Capital, a $36 million New Zealand-based early-stage venture fund. I chose to include Hillfarrance in this list because of their appointment of Aisha Ross as a general partner–he is

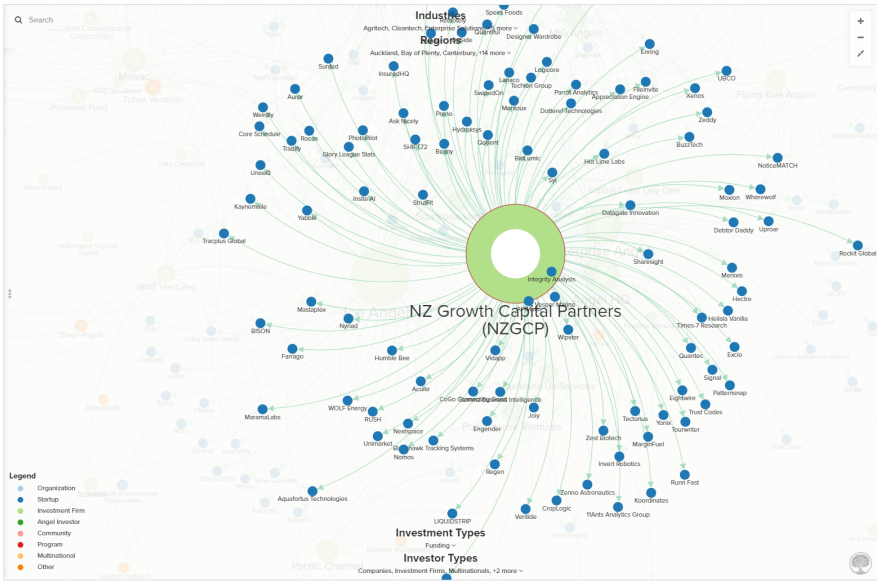


Figure 5.5: Screenshot of Scale-up New Zealand's Platform describing Funding of New Zealand Capital Growth Partners ("Scale-Up NZ", 2023)

one of the few Māori in this space. He was involved with the "establishment of

1. *Ahikōmako*, the Center of Māori Innovation and Entrepreneurship
2. *Pākihi*, a series of workshops offered nationally with a focus on assisting Māori small businesses to grow sustainably
3. *Kōkiri* a Māori technology accelerator focused on developing early stage Māori technology ventures with a global focus and high-growth potential to scale and grow." (Gardner, n.d.)

5.3.3 Universities

New Zealand is home to eight universities, with each of them having faculties of the sciences and business. In contrast, only six have faculties of engineering. The University of Auckland is the largest and highest ranked university in New Zealand and also features the only medical school. The total external research funding in 2021 was $261.3 Million (about $158 M USD); for

comparison, in the same year, the University of Hawai'i reported receiving about $347 Million extramural research awards.

Dr. Ian Town, Chief Science Advisor at the Ministry of Health and former MIT REAP team member, discussed the MedTech-iQ *Tāmaki Makaurau*, which brings together the government agencies, areas, and their universities to create a regional hub. The four areas are *Tāmaki Makaurau* Auckland, *Pōneke* Wellington, *Ōtautahi* Christchurch, and *Ōtepoti* Dunedin. These regions help to provide specific expertise to the national health tech ecosystem. For health tech, Dr. Town sees the role of government as being greater because it might be too risky for angel investors. The Medtech-iQ initiative aims "to put New Zealand on the map for medical device and digital health innovation and attract new investment partners." (Town, 2023)

The Faculty of Engineering at the University of Auckland is at the forefront of groundbreaking research and innovation, tackling diverse challenges across engineering disciplines. The faculty's research endeavors include sustainable infrastructure development, advanced materials and manufacturing processes, renewable energy technologies, intelligent transportation systems, and biomedical advancements. The research centers in engineering are:

1. Acoustics Research Center
2. Advanced Thermal Engineering and Aerodynamics Center (ATHENA)
3. Center for Advanced Materials Manufacturing and Design (CAMMD)
4. Center for Automation and Robotic Engineering Science (CARES)
5. Center for Intelligent Manufacturing and Mechatronics (CIMM)
6. Center if Neural Engineering and Cell Technologies (CoNECT)
7. Circular Innovations (CIRCUIT) Research Center
8. Engineering Education Research Center
9. Engineering Solutions for Natural Hazards Mitigation

10. Geothermal Institute
11. Green Energy Engineering Center
12. Infrastructure for Community Futures Research Center (ICFRC)
13. Māori and Pasifika Engineering Research Center (MPERC)
14. *Te Pūnaha Ātea*| Space Institute
15. Transdisciplinary Modelling and Engineering Research Center (TME)
16. Transportation Research Center
17. Water Research Center ("Research by Faculty - The University of Auckland", n.d.)

The University of Auckland Faculty of Science also has numerous research centers and co-hosts the Ngā Ara Whetū - Center for Climate, Biodiversity & Society with the business school. From exploring fundamental principles in physics and chemistry to delving into complex ecosystems and biodiversity in biology and environmental science, the faculty's research efforts connect *Mātauranga Māori*[3] and science in the Māori led Center called *Te Pūtahi o Pūtaiao*. Furthermore, the faculty houses state-of-the-art laboratories and facilities, enabling scientists to push the boundaries of their respective fields and collaborate across disciplines. Whether it is deciphering the mysteries of the universe through astrophysics, developing novel materials for advanced technologies, investigating infectious diseases and public health concerns, or driving sustainable solutions for environmental conservation, the Faculty of Science at the University of Auckland plays a central role in New Zealand, by shaping the future of scientific discovery and making a positive impact on society and the world. The larger faculty centers are:

1. Center for Computational Evolution

[3] "*Mātauranga Māori*" refers to the traditional knowledge, wisdom, understanding, and cultural heritage of the Indigenous Māori people of New Zealand. It encompasses a wide range of knowledge systems, including language, arts, history, customs, spirituality, navigation, land use, and more.

2. Future Food Research Center
3. NAOInstitute (Natural, Artificial, and Organizational Intelligence)
4. *Te Ao Mārama* – Center for Fundamental Inquiry
5. *Te Pūtahi o Pūtaiao* ("Research by Faculty - The University of Auckland", n.d.)

Additionally, there are school and department-level research centers:

1. Center for Anti-Microbial Research
2. Center for Biodiversity and Biosecurity
3. The Discovery Center for Fundamental Research
4. George Mason Center for the Environment
5. Center for Goldwater Wine Science
6. Center for Green Chemical Science
7. Center for Health and Rehabilitation Research
8. Center for Innovative Materials for Health
9. Center for Machine Learning for Social Good
10. Center for Mathematical Social Sciences
11. Cyber Security Foundry
12. Climate Systems Laboratory
13. Center for Transdisciplinary Biophysical Imaging ("Research by Faculty - The University of Auckland", n.d.)

The University of Auckland has substantial resources and research centers. They also have a technology-transfer office with 'Intellectual Property Managers and Commercialization Managers' who help find collaborators in the industry. They have created over "45 companies [in

the past five years] and licensed over 430 patent families." ("IP and Innovation | UniServices", 2023) For comparison, in 2022 alone, MIT's Technology Licensing Office had 27 startup companies formed and filed 311 patents. (TLO, 2022)

5.3.4 Large Corporations

Compared to other small advanced economies, New Zealand lacks large corporations; it has zero Forbes Global 2000 companies. The report on *New Zealand firms: Reaching for the frontier* (2020), eloquently explains the significance of large exporting firms:

> "Around these large businesses exists an ecosystem of many smaller businesses supplying complementary products or specialized inputs. Supporting them are researchers and innovators in both public and private employment, a pipeline of highly educated graduates, investment in enabling infrastructure and regulations, and investors with deep knowledge and understanding of the particular industry.
>
> "Large firms play an important role in breaking into international markets and are frequently embedded in deep clusters. For example, Denmark has well-established large firms in shipping (Maersk), pharma (Novo Nordisk), renewable energy (Vestas), brewing (Carlsberg), as well as Lego, Grundfos, and others." (Commission, 2021)

Most of New Zealand's large businesses focus on the domestic market. Three of the top twenty firms by revenue are based on natural resources. (Commission, 2021) Fonterra is a cooperative of 9,000 dairy farmers that, if public, would likely earn a position on the Forbes Global 2000. However, it has a chronic problem of being cash poor and does not invest in R&D. Other candidates, based solely on market value, might include Fisher & Paykel Healthcare and Xero; these two companies were 'born global.' (Commission, 2021) Other large businesses that have

expanded regionally include Datacom, EBOS, and Beca.

An additional benefit of large corporations is their innovation arm and the patents that result from it. Hendy and Callaghan (2013) remark on New Zealand's weakness of IP, saying, "New Zealand is not, in fact, the land of innovators that the myth of our number-eight-wire mentality suggests. In fact, per capita, the average OECD country produces four times as many patents as New Zealand." (Hendy & Callaghan, 2013) Hendy and Callaghan (2013) propose that the lack of patents in firms can be attributed to the lack of production of complex products. (Hendy & Callaghan, 2013) The number of patents by firms has been shown to follow a power distribution, which means that firms with complex products have a higher number of patents and patents joint-owned with supporting businesses. As New Zealand develops multinational corporations that deliver complex goods, patents will likely increase.

5.3.5 Government

The New Zealand Government's vision is:

"By 2027, New Zealand will be a global innovation hub, a world-class generator of new ideas for a productive, sustainable, and inclusive future." (Ministry of Business, Innovation and Employment, 2019)

The New Zealand government is 'institutionally thick' compared to Hawai'i and Fiji and has various branches working to achieve this vision. The Ministry of Business, Innovation, & Employment developed a draft *New Zealand's Research, Science, and Innovation Strategy*. In this strategy, the government targets a rise in R&D spending to become 2% of the GDP. Figure 5.6 shows how New Zealand has been performing and would need to change to achieve that goal.

The government's draft strategy identifies the weakness of New Zealand connections.

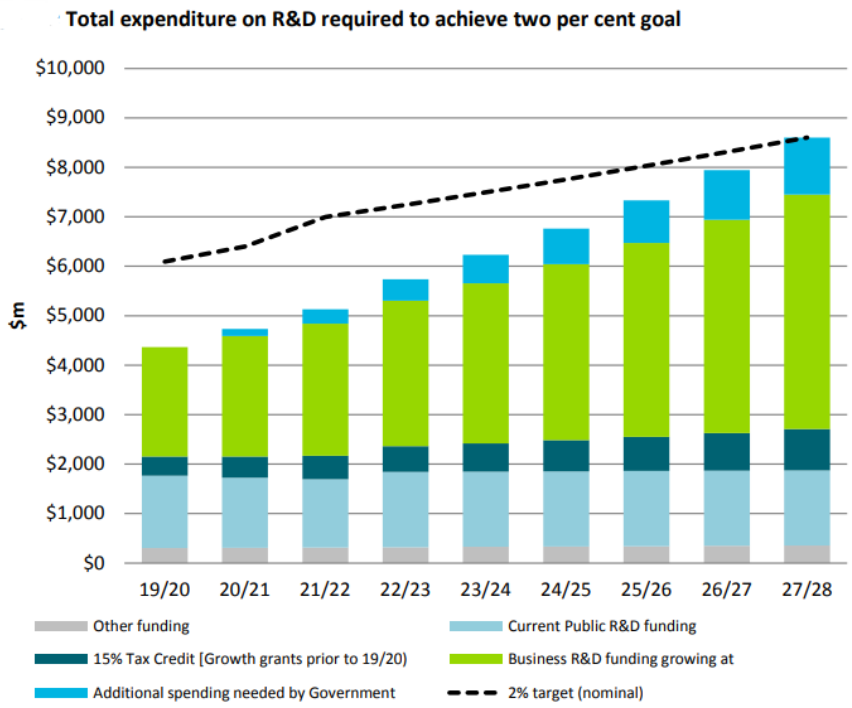


Figure 5.6: Past and Targeted R&D Spend in New Zealand (Ministry of Business, Innovation and Employment, 2019)

> "Connections are at the core of many of the issues in the RSI system. Both excellence and impact are underpinned and enhanced by strong connections. The process of innovation itself is almost entirely reliant on connections – both random and structured interactions between different knowledge sets that lead to new opportunities, ideas, and solutions.
>
> "Enabling stronger connections is likely to make the greatest difference to the performance of the RSI system." (Ministry of Business, Innovation and Employment, 2019)

Furthermore, the draft strategy proposes taking action in five areas:

1. Making New Zealand a Magnet for talent
2. Connecting research and innovation

3. Start-up^scale-up
4. Towards an entended *'Vision Matauranga'*
5. Building firm foundations (Ministry of Business, Innovation and Employment, 2019)

Callaghan Innovation, the government's Innovation Agency, plays a central role in achieving this vision for the future. Callaghan Innovation is named after the late Sir Paul Callaghan, a premier scientist and co-author of the book *Get off the Grass: Kickstarting New Zealand's Innovation Economy.* This government agency comprises more than 200 of New Zealand's leading scientists and engineers to support high-tech businesses at every level and growth stage. They aid in connecting people, providing tailored technical solutions, skills-development programs, and funding. Callaghan Innovation partners with other government agencies, research organizations, tech incubators, regional businesses, universities, and Crown Research Institutes. The primary industries are CleanTech, Food and Beverage, Health, Manufacturing and Industry 4.0, Primary Industries, Technology, and Māori Economy.

The New Zealand Government established Centers for Research Excellence (CoRE) in 2001, In 2001, the government established Centers of Research Excellence to "support growth in research excellence and the development of world-class researchers in areas of existing excellence that are important to New Zealand's future development." (Commission, 2021) These CoREs are run in partnership with a host university. The list of the CoREs funded from 2021 until 2028 is in the following Figure 5.7

Figure 5.8 depicts the various governmental support programs for New Zealand innovators.

Centre of Research Excellence	Research area	Host
Bio-Protection Research Centre	Environmental protection (pest management solutions)	Lincoln University
Coastal People: Southern Skies	Climate change	University of Otago
Dodd-Walls Centre for Photonic and Quantum Technologies, Te Whai Ao	Photonic and quantum technologies	University of Otago
Healthy Hearts for Aotearoa New Zealand – Manaaki Mānawa	Heart and respiratory diseases	University of Auckland
Ngā Pae o te Māramatanga – New Zealand's Māori Centre of Research Excellence	Māori communities	University of Auckland
Te Hiranga Rū QuakeCoRE: Aotearoa New Zealand Centre for Earthquake Resilience	Earthquake resilience	University of Canterbury
Riddet Institute	Innovations in food and related sciences	Massey University
Te Pūnaha Matatini – Aotearoa New Zealand Centre of Research Excellence for Complex Systems	Complex systems	University of Auckland
The MacDiarmid Institute for Advanced Materials and Nanotechnology	Advanced materials and nanotechnology	Victoria University of Wellington
The Maurice Wilkins Centre	Molecular biodiscovery (human diseases)	University of Auckland

Source: Tertiary Education Commission (2020).

Note:

1. The TEC currently invests in both the Brain Research New Zealand / Rangahau Roro Aotearoa and the Medical Technologies CoREs. The funding for these CoREs ends in June 2021. The TEC will fund two new CoREs instead: Coastal People: Southern Skies and Healthy Hearts for Aotearoa New Zealand – Manaaki Mānawa.

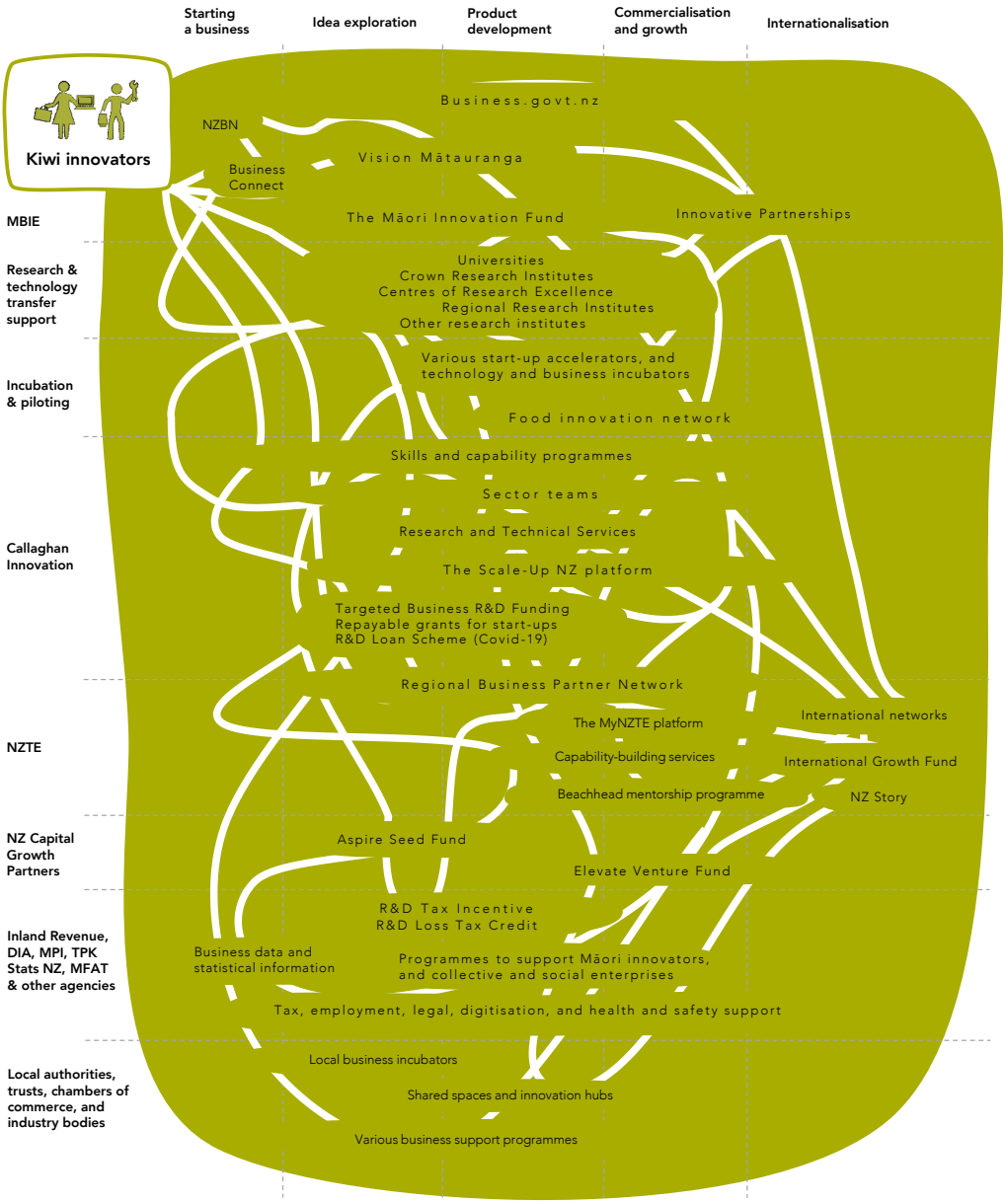
Figure 5.7: New Zealand Centers for Research Excellence (Commission, 2021)

5.3.6 Other Key Players

Patrick McVeigh, a latecomer to the MIT REAP Team and an experienced economic development leader and consultant, pointed to an area called the "Wynyard Quarter Innovation Precinct" to show how well it has done in attracting people to live and work in the tech sector. The media design school is also based in the precinct to involve the university stakeholder. Still, the precinct could enhance the connections with the research sides of the university and have increased international corporation presence. He also mentioned the "Go Hard on Tech" strategy, an industry-led strategy (via Auckland Unlimited) and joining with a government task force to create a tech ecosystem in Auckland. This initiative is values-led and exists to improve inclusivity of women and Māori in the tech sector.

One thing I appreciate about the various reports on the innovation ecosystem strategy for New Zealand is the inclusion of Māori firms. There is a sense of humility that New Zealand can learn from the Māori and the Māori firms, and it is written about as complementary rather

Figure 6.8 Firms' interactions with government support for innovation



Notes:

1. The diagram illustrates major innovation support programmes that government partly or fully funds, and that interact directly with Kiwi innovators. Appendix B briefly describes these programmes.
2. The diagram presents the innovation journey as having five stages. In practice, a firm's innovation journey is seldom straightforward or linear. Firms may move backwards and forwards between stages, or have different projects at different stages at the same time.
3. Abbreviations: DIA: Department of Internal Affairs, MBIE: Ministry of Business, Innovation and Employment, MFAT: Ministry of Foreign Affairs and Trade, MPI: Ministry for Primary Industries, NZBN: New Zealand Business Number, NZTE: New Zealand Trade and Enterprise, TPK: Te Puni Kōkiri.

Figure 5.8: "Firms' interactions with government support for innovation" (Commission, 2021)

than trade-offs. (Commission, 2021)

5.4 Strategy: Policies and Programs

New Zealand's innovation ecosystem has been characterized as having "big barriers and weak incentives." (Davies, 2023) Scaling up in New Zealand poses unique challenges like time zones, and the incremental cost of going from New Zealand to another country—is considerable. Michael Davies shared the "3 B's" of business ownership mentality that has existed in New Zealand: the Bach (usually a modest beach house), the boat, and the BMW. Some say this indicates a struggle to move beyond that mentality of upper-middle-class comforts to grow global enterprises. In contrast, others have differing views and believe that it is not so much as "weak incentives," but rather that developing a company beyond New Zealand is extremely challenging with many risks. It is clear: if IDEs are to succeed in New Zealand, they need to have a global mindset from inception.

The New Zealand Productivity Commission report on *New Zealand Firms: Reaching for the frontier* uses the term "frontier firms," which I believe are synonymous with IDEs. The strategies outlined in this document are well-reasoned, and I will not attempt to repeat them all in this section. New Zealand has a much more advanced innovation ecosystem than Hawai'i or Fiji, and the strategies and recommendations in this report reflect that.

Growing globally brings with it the logistics challenge of exports from New Zealand. Going "weightless" in terms of digital and knowledge exports is an opportunity for New Zealand and one where New Zealand firms are growing their productivity more than other small advanced economies.

"The selected focus areas should be ones in which New Zealand already has a mea-

> sure of existing or emerging competitive advantage in global markets, and the ability to gain critical mass. An example of an area of existing strength is the primary sector (both on-farm/orchard/forest and processing) and examples of emerging strengths are certain "weightless" activities (eg, health technology, creative, and digital goods and services)." (Commission, 2021)

A specific sector within this weightless sector is the gaming industry which has averaged 42% a year for the past six years; the New Zealand gaming industry consists of 42 smaller companies. (Commission, 2021)

The New Zealand Government identified five "high potential" focus sectors for enabling "the scaling up of highly productive and internationally competitive firms." These areas are:

1. Advanced manufacturing
2. Agritech
3. Digital technologies
4. Food and beverage manufacturing
5. Forestry and wood processing (Commission, 2021)

Hendy and Callaghan tell the story of where they view opportunity:

> "But the real opportunities are likely to be in new technologies that are complementary to their core businesses. Thinking in terms of sectors might be convenient, but if Fisher & Paykel had defined itself solely by whiteware back in the 1960s, its descendant Fisher & Paykel Healthcare would not exist today. Respiratory humidifiers, superconducting electromagnets, quartz-crystal oscillators and microwave-reheatable cappuccino containers: our brilliance lies in the 'weird

> stuff.' Let's build an innovation ecosystem that can identify these niches. Let's exploit the complementary technologies that lie between our existing strengths. We have a good platform on which to build." (Hendy & Callaghan, 2013)

New Zealand has much to offer in a variety of sectors. Patrick McVeigh spoke about New Zealand's success in various sectors. Supporting businesses along the value chain needs to be improved. He called the ecosystem an "unfinished product," explaining that you can find things that work well but are not necessarily ubiquitous. (McVeigh, 2023) He mentioned the tension that comes from a company exiting, since the media commentary might be that New Zealand IP is moving offshore and abandoning the local economy—rather than understanding the growth and reinvestment that comes to the ecosystem by doing so. An additional tension to consider is the resentment that can develop when a particular city emerges as a major economic player, such as the case with Auckland:

> "New Zealand needs Auckland to succeed in order for New Zealand to succeed but there is also this tension—from a political sense—that Auckland is doing ok, what about the rest of the regions? The rest of New Zealand? It can be a bit of a challenge for government to be seen supporting Auckland when there are very real issues to address in other parts of New Zealand as well." (McVeigh, 2023)

The challenge for New Zealand is more likely to be leadership and execution. This tension might exist politically for representation of the various cities to recognize and leverage the power of agglomeration, meaning that they should not see their areas competing with Auckland but rather look at how to connect into that ecosystem as a hub and spoke model. (McVeigh, 2023) Another challenge mentioned is the timing of the upcoming elections and how the government is sensitive to high-spend initiatives around this time.

5.4.1 Indigenous Opportunities

The New Zealand Intellectual Property Office has established Māori Committees for intellectual property, one for trademarks and another for patents. It is impressive that they will consider when "an invention is derived from Māori traditional knowledge" or whether "commercial exploitation of such an invention would be contrary to Māori values." (Employment, 2023)

The University at Auckland established a "Research Manager, *Vision Mātaranga*" position to support the national *Vision Mātaranga* policy. This position sits within the Office of Research Strategy and Integrity. Jaylene Wehipeihana is the inaugural research manager, and her role is helping create a research strategy under *Vision Mātaranga*. Her work is to educate researchers that are Māori, interact with Māori, have Māori research team members, and others conduct research with processes and approaches that are culturally safe. In addition, her position serves to develop those researchers and labs become "champions" for the considering the Māori communities at the inception of research as opposed to an afterthought. (Wehipeihana, 2023). Her work helps to bring institutional racism, and unconscious bias, to light and shift the research from being transactional to relational. While many New Zealand institutions have been making progress in terms of meaningful inclusion, she recognizes that some research portals are exclusive by design when it comes to restricting submission mediums. That flexibility of those mediums could allow for Māori research to be presented in a more accessible way. Another disadvantage is the lack of appropriate Māori or Indigenous reviewers on committees that would understand the significance of various cultural concepts. (Wehipeihana, 2023)

New Zealand is increasingly looking to the Māori people for inspiration, learnings, and guidance. As evidenced by the 250 page report on *New Zealand Firms: reaching for the frontier*, the

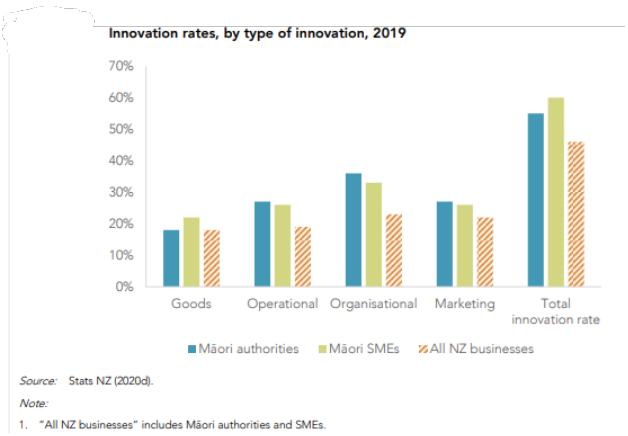


Figure 5.9: Innovation Rates of Māori authorities and SMEs compared to all New Zealand businesses. (Commission, 2021)

word Māori appears 743 times, an average of nearly three times per page. One of the strengths this report highlights is the Māori values in business and their " 'Multiple bottom line' approach. This approach balances multiple values and objectives—spanning social, cultural, financial, environmental, spiritual, and political domains." (Commission, 2021) The report goes on to acknowledge,

> "The Māori have a long tradition of entrepreneurship, innovation, and technology adoption. Colonization resulted in the loss of wealth and assets. Still, recent decades have seen a revival in Māori entrepreneurial activity. Today, Māori enterprises extend into a variety of high-tech industries, either as business operators or partners, as well as innovative social enterprises." (Commission, 2021)

The report includes the following Figure 5.9 showing innovation rates by type of innovation and compares between Māori authorities, Māori SMEs, and all New Zealand businesses.

Furthermore, it is understood that the market pays a premium for goods that are produced sustainably and socially responsible, and that this growing consumer demand represents opportunity for Māori goods.

5.5 New Zealand Summary

New Zealand has strategies that look at the practices of similar small advanced economies. New Zealand is working to set policy and build further upon its strong foundations to become an economy that can support IDEs rather than merely start them. The challenge of scaling IDEs is one that Israel is also facing. Brett O'Riley, Chief Executive of EMA (Employers and Manufacturers Association) and MIT REAP team alum talked about how one of Israel's biggest strengths is leveraging the Jewish Diaspora and that New Zealand has the potential to do the same. New Zealand has also encouraged the risk capital stakeholders to evolve from being primarily angel investors to inviting venture capital by creating the NZGCP and its fund-of-funds, similar to Israel's Yozma initiative.

New Zealand will continue to evolve by building and strengthening connections and partnerships within its ecosystem as well as leveraging the success and mentoring available from the Kiwi diaspora. They are also setting an example for treating the Māori and Pasifika peoples as a protected class for research and working with them in co-development projects with perspectives of interdependence rather than a hierarchical nature.

Chapter 6

Analysis

This chapter compares the three ecosystems using the MIT System-Stakeholder-Strategy Model. There are specific sections on stakeholders and innovation and entrepreneurship capacities, followed by a discussion on institutional thinness. An idea is presented of how various support organizations emerge to fill in gaps of non-functioning stakeholders. A section on strategy concludes this chapter.

6.1 System Comparison

The innovation ecosystems of Hawai‘i, Fiji, and New Zealand were examined to answer the research question of what innovation ecosystems look like in geographically-remote and resource-limited regions and to hypothesize methods to improve innovation and entrepreneurship capabilities to become regions where innovation-driven enterprises (IDEs) develop and thrive. Population is estimated to be 1.4 million in Hawai‘i, 950,000 in Fiji, and 5.1 million in New Zealand. (“Fiji”, 2023) Furthermore GDP per capita is estimated at $58k, $10k, and $43k re-

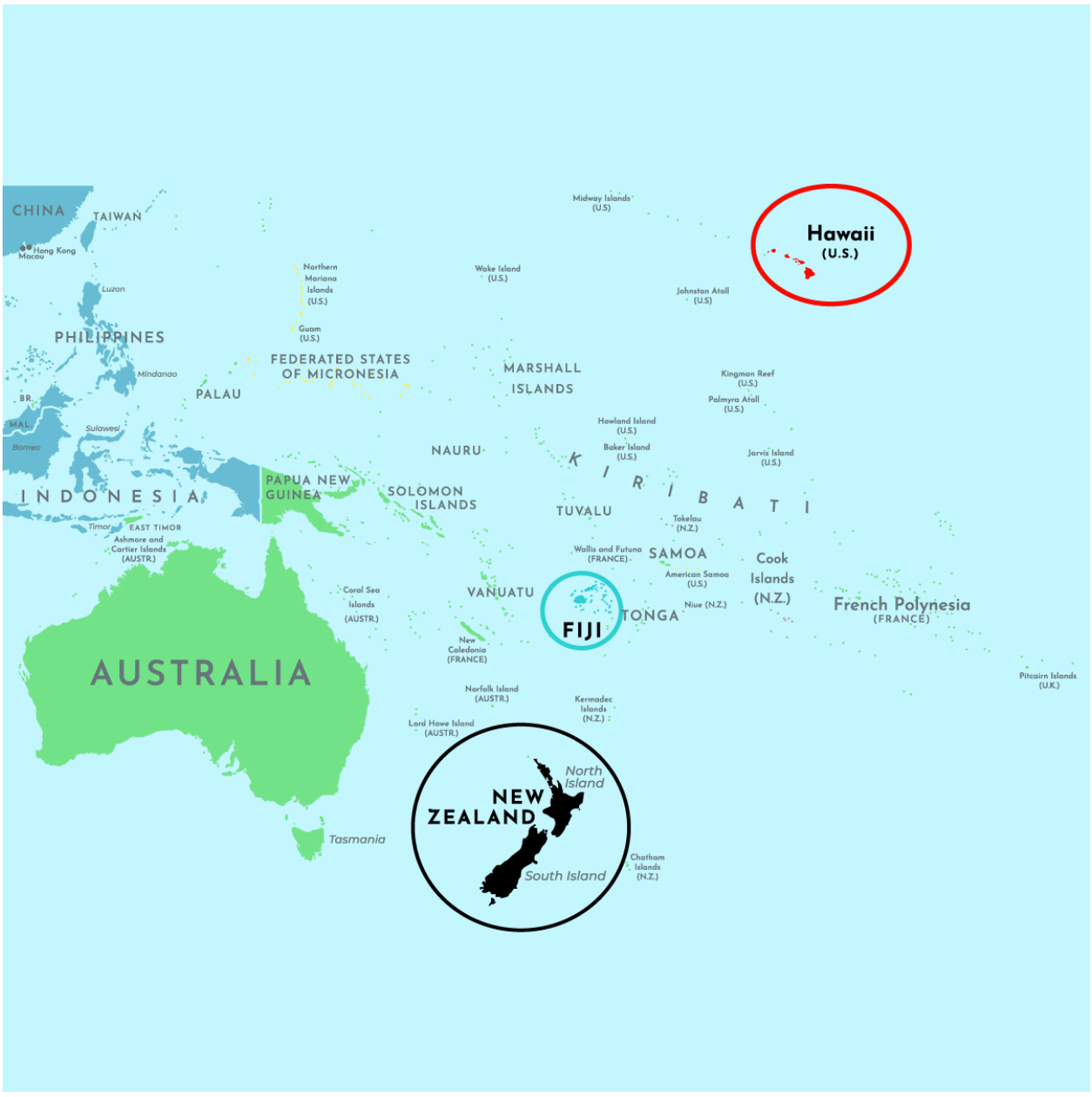


Figure 6.1: Map of Pacific Islands

spectfully. Hawai‘i represents a geographically-remote area of the United States, with an economy heavily influenced by tourism. New Zealand represents another geographically-remote country, part of the British Commonwealth, greater in landmass, with an economy largely based on agriculture, tourism, and horticulture exports. (OECD, 2022) Last, Fiji represents an emerging, sovereign economy of the SIDS in the Pacific and is characterized by being largely built around the tourism and services industry. (“Fiji”, 2023)

Regarding geographically-remote groups, Hawai‘i, Fiji, and New Zealand represent a range of physical distances from more significant economic hubs. In addition, their economies rely heavily upon services, especially in the tourism sector. Furthermore, these regions are resource-limited regarding population, natural resources, and land. Note for context: New Zealand’s land area is just under ten times the land area of Hawai‘i. These three regions are also significantly affected by global warming and climate change. Hawai‘i and New Zealand have similar GDP per capita levels, and operate similarly concerning government providing the rule of law, protections for investors, and physical and digital (ICT) infrastructure.

In the systematic analysis of the innovation ecosystems of Hawai‘i, Fiji, and New Zealand, a range of institutional thickness and economic complexities were analyzed. When possible, stakeholders or people with first-hand knowledge were interviewed to understand the current SME vs. IDE dynamic and inform on conditions where statistics lacked context. A comprehensive review of startups in each ecosystem was not conducted to point to a count or proportion of innovation-driven enterprises in each region. Instead, since innovation-driven enterprises are often identified in hindsight, innovation and entrepreneurship capacities were examined to understand how well these economies can support innovation-driven enterprises.

Hawai‘i and New Zealand have government programs concerned with their development as innovation ecosystems. From the remarks made by the Permanent Secretary, Mr. Shaheen Ali, of the Fiji Ministry of Trade, Cooperatives, Small and Medium Enterprises, at the Research and

Innovation Scheme for Enterprises (RISE) Program Launch, Fiji supports developing an innovation economy. This speech was given on January 22, 2020, at the beginning of the COVID-19 pandemic. Since then, Fiji has formed the People's Coalition Government, an alliance of three political parties. Mr. Shaheen Ali remained in his role and was on the board to create Investment Fiji. As such, the conclusion is that Fiji is beginning to create an ecosystem supportive of innovation. For Fiji to achieve this end, it must act intentionally—and quickly. As a SIDS, Fiji lags economically and in the Social Progress Index.

6.1.1 I-Cap and E-Cap Comparisons

Relative to US averages, Hawai'i lags behind the US in terms of R&D funding. The only exception is in the area of "average annual federal small business innovation research and small business technology transfer funding per $1 Million of GDP," where Hawai'i's SBIR federal funding is $1.88 for every dollar spent across the nation. ("Hawaii | National Science Foundation - State Indicators", n.d.) One interviewee mentioned SBIR 8a funds being a crutch that Hawaiian startups might lean on too much and hinder growth because without government support the business would be insolvent. When comparing the VC investment amounts provided by Pitchbook, investment in New Zealand totaled USD 32.79 Billion, while investment in Hawai'i was USD 4.44 Billion. Normalizing by population New Zealand had $2 in investment for every $1 investment in Hawaiian enterprises received from VC firms. ("Pitchbook", 2023) Moreover, New Zealand public R&D expenditure as a percentage of total R&D expenditure outpaces the US at 69.22% compared to 43.95%. However, US business expenditure on R&D as a percent of total R&D expenditure is 62.32% compared to New Zealand at 39.78%. ("MIT IEcosystem Explore Innovation", 2018)

In terms of human capital, post-secondary degree holders among individuals 25-44 years old in Hawai'i is 46.8% (the US is 46.2%), however of the class of 2021 graduates, only 51% were en-

rolled in tertiary education, compared to 87.9% in the US—a difference that should be explored. ("Hawaii | National Science Foundation - State Indicators", n.d.; "Hawaii DOE | High School Class of 2021 College Enrollment Recovering from Pandemic", 2022) Another distinction in human capital is between New Zealand and the US, where New Zealand has approximately 1,000 additional researchers or professionals engaged in R&D per million people. (University et al., 2015) And relative to culture and incentives, New Zealand stands out in terms of its low fear of failure rate at 21.98% compared to the US at 43.06%. ("Global Entrepreneurship Monitor", 2023) Finally, the infrastructure between Hawai'i and New Zealand is comparable.

As a SIDS, Fiji lags behind all except in terms of tertiary enrollment, where data collected for 2019 finds 53% of Fijians are enrolled in tertiary education, while the 2021 data for Hawai'i showed 51%. ("Hawaii DOE | High School Class of 2021 College Enrollment Recovering from Pandemic", 2022; World Bank Group, 2019) In context, New Zealand tertiary enrollment in 2022 was found to be 80.3%. ("Economy Briefs from the GII 2022", 2022) Generally, Fiji's Innovation and Entrepreneurial Capacities are at entry-level.

6.2 Stakeholder Comparisons

Amongst Fiji, Hawai'i, and New Zealand, entrepreneurs are an emerging group. New Zealanders have had a reputation for "make-it-work" inventions with their stories of the number 8 wire.[1] Figure 6.2 shows a model that New Zealand published, which is how they might consider their own ecosystem and what their perceived gaps indicate—specifically the importance of anchor firms as the plant's main stem.

Hawai'i is entrepreneurial, with many people having MSMEs as side gigs, and Fijians have

[1] "New Zealanders call Kiwi ingenuity 'number 8 wire': In the country's colonial days, the only plentiful resource was 8-gauge fencing wire, and New Zealanders learned to fix and make anything with it.")(Isenberg, 2010)

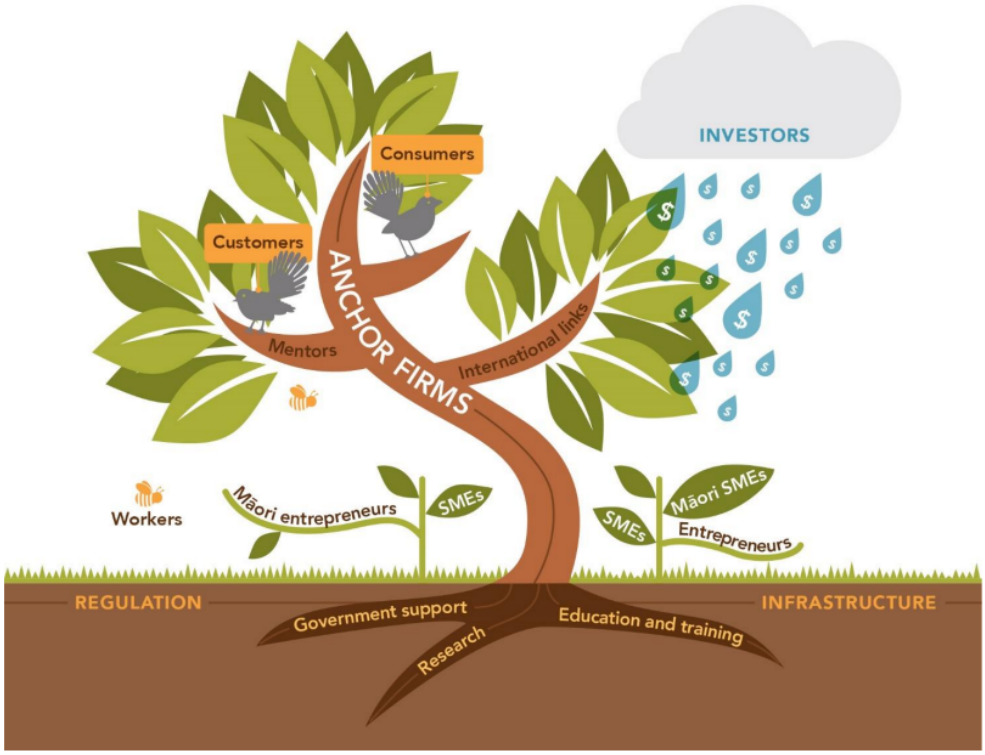


Figure 6.2: An Innovation Ecosystem Model for New Zealand (Commission, 2021)

budding entrepreneurs who are often held back by the communal view of success. These regions have more government support measures and policies towards building infrastructure. Government interest in diversifying economies seems to be a priority for the areas, especially after the COVID-19 pandemic. Corporate stakeholder involvement in the ecosystems is considered weak across all. Risk Capital Providers are also less present in the specific region; there are more grant opportunities in both Fiji and Hawai'i, which are not necessarily sustainable sources of capital. The University stakeholder group is considered more vital for other stakeholders and is actively working towards more entrepreneurial programs and research. Fiji is the least advanced among the three regions and may do well to leverage research through networks.

While stakeholders' relative strengths and weaknesses are similar across the regions at a high level, the levels of bandwidth for each stakeholder are generally the most advanced in New

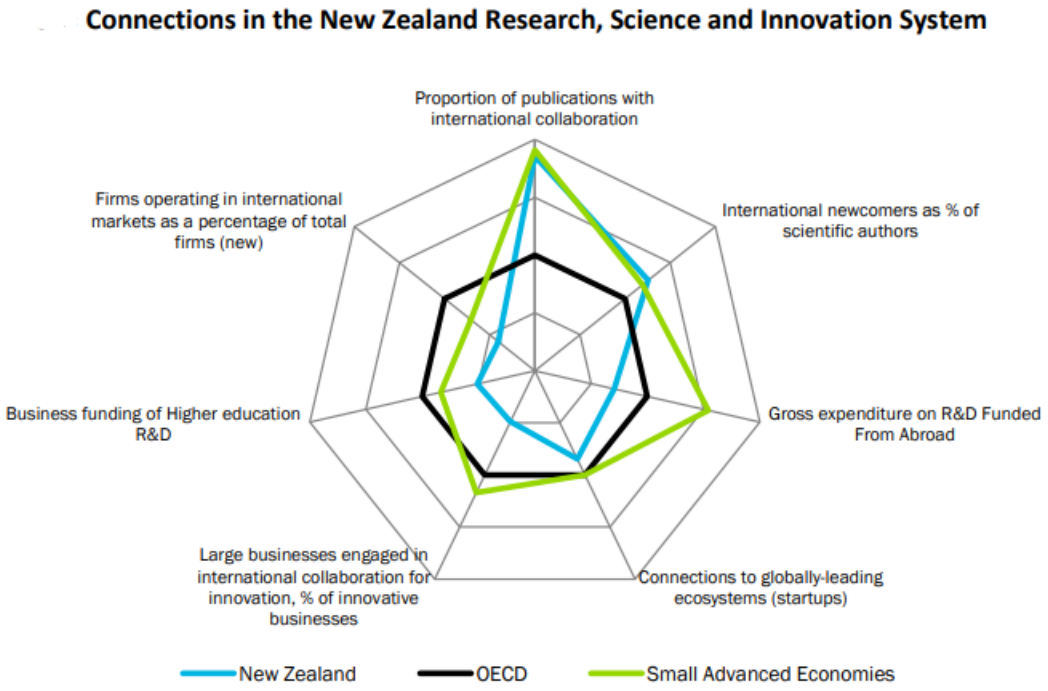
Zealand, followed by Hawai‘i and then Fiji. Regarding the count of University stakeholders, New Zealand has eight, Hawai‘i has eleven (though only one is a top-tier research institution), and Fiji has four. While less dense than the Silicon Valley count of 33 universities, there is potential for universities to leverage partnerships as part of various networks, including PIURN and APRU.

In addition, having a low number of risk capital providers, successful and serial entrepreneurs, and multinational corporations limit the opportunities for stakeholders of each category to engage one another. Success in fostering and retaining innovation-driven enterprises will be more challenging in these regions because of the need for more Stakeholders—both in terms of quality and quantity. New Zealand has the most robust stakeholder group and can serve as a model for continuing to iterate its innovation ecosystem.

The spider chart in Figure 6.3 identifies New Zealand's performance compared to similar small advanced economies. New Zealand assessed its connections by comparing against OECD and small advanced economies. The spider chart depicts New Zealand's innovation ecosystem as having the primary gap of "few firms operating in international markets," followed by low industry funding of university research and "large businesses engaged in international collaboration for innovation."

6.3 Coping with Institutional and Stakeholder Thinness

The previous three chapters have provided an up-close look at the innovation ecosystems of Hawai‘i, New Zealand, and Fiji. Research and data have informed Hawai‘i, New Zealand, and Fiji's innovation, entrepreneurial capacities, and stakeholder strengths. The purpose of this research was to understand and provide value to regions that are geographically-remote and resource-limited. The proposed benefit is economic development through innovation ecosys-



Note: The figure above on business funding of higher education R&D does not include investment by business into CRIs. Indicators are derived variously from the OECD's Main Science and Technology Indicators database, Scopus bibliometric database, and Startup Genome's Global Startup Ecosystem Report 2019. They have been normalised to OECD average = 1.

Figure 6.3: New Zealand Ratings for Innovation Ecosystem (Ministry of Business, Innovation and Employment, 2019)

tems, where innovation ecosystems breed more SMEs and specifically innovation-driven enterprises for their multiplier effect on job creation.

In her article *The Character of innovative places: entrepreneurial strategy, economic development, and prosperity,* Maryann Feldman highlights the difference between "economic growth—the simple increase in aggregate output and economic development—and the movement to a higher, more productive and prosperous growth trajectory." (Feldman, 2014)

Feldman goes on to say:

> "One economic development mistake that we are moving beyond is to assume that the key to success is to adopt the conditions observed in Silicon Valley—an active research university, strong venture capital investment, and lots of networking events. These are the attributes of a fully functioning innovative ecosystem that not only reflects about 40 years of development, but that is not easily transferred to others, especially small and under resourced places. The truth is that it is impossible to compete against Silicon Valley using the Silicon Valley model." (Feldman, 2014)

Stakeholders are not just the institutions themselves but also the functions they perform. Networks of research institutions like PIURN essentially act to create a porous system boundary so that Fiji's innovation ecosystem can leverage support from outside of its immediate region. It is not the mere number of these institutions that created a thriving ecosystem, rather, it was the various functions that those universities provided.

The lens of *form* and *function* can be applied to the MIT stakeholder model. In developed countries, the institutions and their processes have been standardized. However, other support organizations emerge in developing regions to fill functional gaps. Figure 6.4 shows the standard

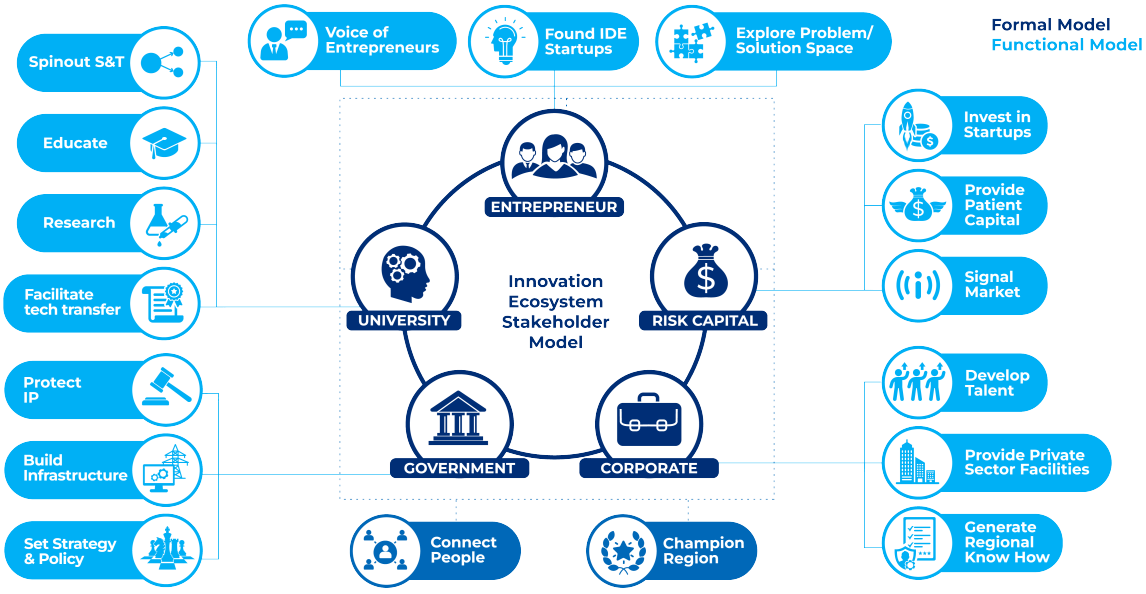


Figure 6.4: MIT Stakeholder and potential analysis of functions

MIT Five Stakeholder Model with extensions to the high-level functions of each stakeholder outlined in Budden and Murray's paper (2019). (Budden & Murray, 2019) By examining the articulated functions of the central five stakeholders, gaps are more easily identified, and compensating organizations can be categorized in regions without fully functioning stakeholder groups. Organizations are classified as a particular stakeholder based upon the origination of funding. Looking at both the functional and formal model and where organizations map to allows understanding of the mismatch and gaps of stakeholder groups.

A university is a system, and is holistic in nature. While breaking it down to the sum of its parts may be a disservice, breaking it down into its functions as they relate to the development of innovation and entrepreneurship capacities and the creation of innovation-driven enterprises allows university functions to be compared, and gaps can be identified. A university's primary functions are educating, collaborating, and sharing knowledge. However, as in the lens of technology development and commercialization, there are more functions a university can contribute to in the innovation ecosystem. For example, this is shown in a study done at MIT exploring knowledge transfer from university to industry. MIT faculty patent-holders shared

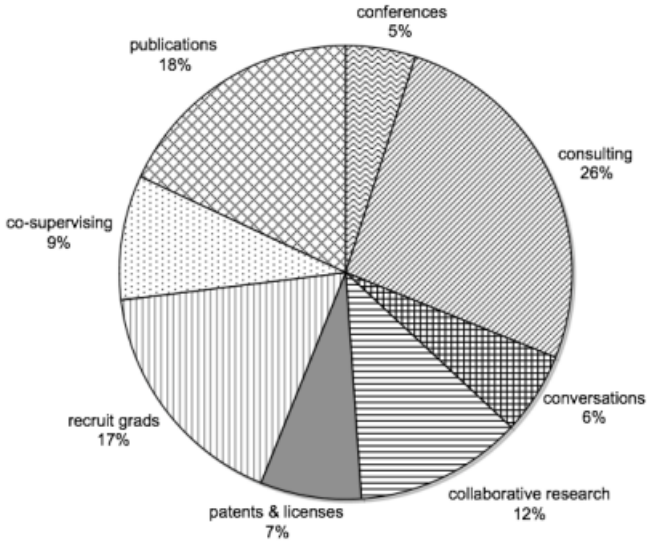


Figure 1: Perceptions by MIT faculty patentholders of relative importance of alternative channels of knowledge transfer from university to industry

Source: A. Agarwal and R. Henderson, "Putting patents in context: Exploring knowledge transfer from MIT", *Management Science*, vol. 48, no. 1., January 2002, p. 44.

Figure 6.5: Perceptions by MIT faculty patentholders on the relative importance of knowledge transfer between university and industry (Lester, 2005)

their perceptions of the importance of alternative knowledge-transfer channels between university and industry. (Lester, 2005) Universities do more than educate, and this study shows it is through the varying forms of knowledge exchange that its faculty generate patents. As such, universities can help facilitate the activities of consulting, collaborative research, patents and licensing, publishing, conferences, etc.

Figure 6.5 shows how patent-holding university faculty members at a mature university (MIT) view the importance of different channels for facilitating knowledge transfer between universities and industries.(Lester, 2005) Opportunities for consulting with industry were considered the most significant. This increases understanding of the problems faced by industry and guides faculty research towards solving problems for application rather than mere curiosity.

6.4 Building Individual and Collective Capabilities

Innovation-driven enterprises are developed and run by people. The majority of IDEs provide products or services that are more strongly associated with STEM than SMEs. For an IDE to grow and stay in each region, the region must be capable of providing adequate opportunity for that human capital to develop. In addition, to increase the number of IDEs, technology transfer capabilities must be strengthened to allow technology to leave the lab and be impactful. Furthermore, the origins of Silicon Valley trace back to the beginnings of a few IDEs, including Hewlett Packard starting in Palo Alto in 1939, and William Shockley, inventor of the transistor in 1940, who left Bell Labs in 1956 to start Shockley Semiconductor Labs in Mountain View so that he could be closer to his sick mother. Shockley hired many graduates from MIT, as local human capital was not yet available. Then the notorious "Traitorous Eight" employees left Shockley and started Fairchild Semiconductor, which went on to be an incubator of many future IDE enterprises in Silicon Valley.

Feldman believes that the entrepreneurs for a given region can help that place to thrive.

> "Entrepreneurs excel at being able to identify opportunities that are not obvious to others. Their familiarity with the history and context of a place may enable entrepreneurs to see opportunity that is not obvious to others and defies traditional analysis. But this perception of opportunity that is not obvious to others is the essence of entrepreneurial advantage. And when entrepreneurs act upon placed-based opportunity, they are in a position to apply their skills and potentially create prosperity and economic change. Certainly, the contemporary efforts of Tony Hseih (founder of Zappos) in downtown Las Vegas or Dan Gilbert (founder of Quicken Loans) in Detroit can best be described as the application of an entrepreneurial mind-set to changing local economies. (Feldman, 2014)

For this reason, it is pivotal for a region's success to have regional entrepreneur champions. These people have ties to place and the mental familiarity of history, context, and opportunity. For this reason, it is also essential to work with Indigenous peoples to help characterize the local strengths. Indigenous peoples and Elders are keepers of place-based knowledge and have an opportunity to revive and restore the knowledge, which can be a comparative advantage.

6.5 Strategy

6.5.1 Mitigating Geographic Disadvantage

One of the main challenges for geographically-remote ecosystems is that enterprises need to think globally to succeed in developing IDEs at the outset. Another aspect of this is the hindrance of distance, which can indicate a logistical disadvantage, added cost for exporting physical goods, and the need for strong ties to an international market and customer. This part of developing strong ties must occur for small economies to succeed. These strong ties are often forged between ecosystems through the mobility of people.

> "To make the ecosystem alive, a risk-taking entrepreneurial culture is essential. Another special feature is the continuous movement of ideas and people. People should be able to move easily between companies and from research institutions to business and vice versa. Interactive and dynamic firms are at the core of the regional innovation ecosystem." (Davis, n.d.)

An additional area for research and innovation relates to the time zone differences. Time zone disadvantage is widespread amongst nations in the South Pacific, whereas other regions of the world have found a way to leverage their time zone difference with key markets. Develop-

ing tools to unite global workforces and allow for better sharing and increased productivity of large, multinational Corporations will provide increased technical job opportunities in varying timezones. For example, firms can decrease their cycle time between designs if tools are developed so that collaboration on product design does not have to wait for people to sleep and be back the next day. While some collaboration tools exist, they must be developed further to capture the learning between multiple parties and reduce the time figuring out what the person previously did and why. Collaboration tools can also help design for inclusivity and more comprehensive market appeal. Technologies associated with these tools could go beyond mere code and apps, also having virtual reality, holograms, and other metaverse characteristics.

Furthermore, these tools can help universities in these areas consult with global industries. By increasing New Zealand, Hawai'i, and Fiji's university interactions with industry research focus can be honed towards application. Increased consulting and collaboration with industry partners will presumably contribute to increased tech transfer.

Generally speaking, geographic distance can become moot with development of the right digital tools and technologies for the knowledge economy. Software IDEs—ranging from health technology to digital goods and services—have the advantage of being "weightless," where "weightless industries are those that produce knowledge-intensive goods and services whose value is high relative to their transport costs." (Commission, 2021) Furthermore weightless industries are promising given

> "The scope to continue increasing living standards through increasing exports of natural resources is constrained by environmental limits. For example, in many areas more intensive use of existing agricultural land, or bringing new land into production, will make it difficult for the country to achieve its low-emissions and water quality goals. Adding value without increasing environmental impact is another reason the 'weightless' sector holds such promise for New Zealand (Greenaway-

McGrevy et al., 2020)."(Commission, 2021)

6.5.2 Mitigating Resource Limitations

The populations and resources are smaller in the Pacific Islands. Land and space between islands and countries are a constraint on the movement of people and knowledge sharing. The creation of innovation ecosystems has to be strategic and intentional to effectuate progress sustainably and justly.

Comparative advantage must be leveraged——some clues to comparative advantage from a productivity perspective based on what the economies already produce. For Hawai'i, Fiji, and New Zealand the export basket is primarily focused on tourism services and agriculture. Research in identifying product sectors for future growth is the work of Ricardo Hausmann, who founded the Growth Lab at Harvard Kennedy School to look at increasing productivity and innovation for economic growth. The theory of productive knowledge is summarized by:

> "The secret of modern societies is not that each person holds much more productive knowledge than those in a more traditional society. The secret to modernity is that we collectively use large volumes of knowledge, while each one of us holds only a few bits of it. Society functions because its members form webs that allow them to specialize and share their knowledge with others." (Hausmann, 2013)

With specialization, societies can increase their productive knowledge, but they also increase their reliance on the value chain of complementary systems. The work of the Growth Lab is to assess economies and capabilities of production and help countries utilize their tacit knowledge from their current manufactured products to identify sister industries where that tacit knowledge can transfer well. The key point that Hausmann's research makes is that comple-

mentary specialized knowledge can lead to productivity and, I would add, innovation. It is advancing people's technical expertise through STEM education and tacit knowledge through various mechanisms that stakeholders identified by MIT—ie Corporate, Government, Universities, Risk Capital, and Entrepreneurs—can facilitate.

Development along the value chain of specific sectors needs to occur as well. The value chain consists of producing and distributing goods and services from elemental components to maintenance and end-of-life of a product or service. It also includes the capacities for production to scale. For example, agriculture technology, or Ag Tech, might be able to increase the production of an ag-widget, but if there is not enough capacity at a co-packing plant, then adding value to the ag-widget would not be able to take place. As R&D focus sectors are selected for a given region, attention must be paid to the constraints for the development of the ensuing technologies so that the area can support and retain IDEs through the "escape velocity" phase so that the area can benefit from those IDEs. (Budden et al., 2021)

Beyond the physical value chain for product and service refinement is the support value chain, or the body of IDE supporters, mentors, coaches, and guardians of investments that help motivate, share best practices, and keep an IDE on target. This support value chain largely consists of the entrepreneurs of a given region and the risk capital providers who attach accountability to their investments.

Beyond the supply chain of physical goods is the supply chain of human capital, meaning skilled workers that can support technology startups and research firms. Daron Acemoglu, an MIT economist, "suggested that a mismatch between the availability of skilled workers and the needs of firms can lead to a low-productivity trap as firms fail to innovate and people avoid training as researchers." (Hendy & Callaghan, 2013) It becomes somewhat of a chicken-or-egg problem between firms investing in R&D in an area given ample skilled workers vs. people investing in education that teaches them R&D skills if there is a market demand for

that research.

While Fiji supports increasing tertiary education through government bond service, additional strategies to develop the respective economy's skills should be employed. For example, Fiji might consider incentivizing STEM degrees and postgraduate studies. Governments might also work with universities or students to make sure the desired proportion of skills is developed amongst Ph.D. students—generally speaking, degree programs in hard sciences generate different skill sets than engineering. Rebalancing public spending to target specific demographics is a lever for each government to exercise cautiously.

6.5.3 Partnering of Advantages

While in each of the respective chapters for Hawai'i, Fiji, and New Zealand, comparative advantages were presented as part of the model, I have found it hard to understand the order of magnitude of those advantages relative to the rest of the world. For economic development, Stimson and Stough discuss and describe the concept of collaborative advantage.

> "Both comparative advantage and competitive advantage strategies were and are heavily entrenched in a win/lose scenario. More recently, economic development and planning has promoted strategies that seek to develop and promote collaborative advantage, where firms and regions are encouraged to 'collaborate in competition' for strategic advantage, particularly through partnerships and alliances. That reflects a change in business attitudes, in which businesses and organizations that might once have considered themselves rivals, are now actively seeking strategic alliances, partnerships, and other forms of collaboration to explore opportunities and synergistically induced benefits for winning, creating and expanding business and business opportunities.

> "There also emerged in the search for sustainability and economic growth a win/win scenario as a strategy to achieve economic development. This strategy is loosely referred to as collaborative advantage. It represents a more recent paradigm that has been emerging in regional economic development strategy planning, and it is one that is dependent on a greater integration, cooperation and collaboration among business, governments and communities. It is this new thrust toward collaborative advantage and how to achieve it that has become a common element in the new and emerging approaches to regional economic development strategy formulation, planning and implementation since the mid-1990s.(R. Stimson & Stough, 2023)

6.5.4 Unifying around Common Challenges

Research Partnerships

There is a question of whether Fiji and other SIDS, might be too resource-limited, especially considering human capital resources and minimal research institutions, to become innovation ecosystems unto themselves. Nuria Rull, one of the researchers involved in assessing entrepreneurship in the Pacific Islands, commented that an organization similar to AfriLabs, an organization that networks innovation centers across Africa, might help build up innovation and entrepreneurial ecosystems in the Pacific Islands. AfriLabs is an innovation hub with the most significant African network of technology hubs and innovation centers. The partnership allows people to unite resources and knowledge and strategically and tactically bring up innovation capabilities across the continent.

Amongst the Pacific Islands are members of the British Commonwealth, the American Commonwealth, the French Commonwealth, and other smaller sovereign nations. The region's

commonwealth historicity provides a general foundation of common law. In addition, strong regional economies, including the US, Australia, Japan, China, and New Zealand, amongst others can help provide a supporting structure.

Unite Around Climate Change

In the *2023 Global Risks Report*, five of the top ten risks for the next two years are related to environmental issues and the societal risk of "large-scale involuntary migration," which may result from climate change as a sixth. (*WEF Global Risks Report 2023*, 2023) In terms of the ten year risk outlay the top six risks are climate change related. This is increasingly relevant to the Pacific Islands, which are more affected by climate change. The first key focus areas of the Pacific Community (SPC) is "Resilience and Climate Action." Many of the Pacific Islands have ratified the Paris Climate Accords and have also committed to energy independence from fossil fuels and the use of renewable energy. The sixth area is "Planetary Health." As what has been termed the Global North looks for solutions to problems brought about by climate change (for which it is largely responsible), there is also wisdom in turning towards Ancestral science, knowledge, and practices. Indigenous peoples have relied on their knowledge systems relating to the earth and its resources for adapting to change.

The Pacific Community (SPC) is an organization that promotes this. They state they "interweave science, technology, and innovation with cultural wisdom and Indigenous knowledge for our region's collective betterment." (Pacific Community (2015-), 2022) The Pacific Community (SPC) is "the principal scientific and technical organization supporting development in the Pacific Region... [it is] an international organization with a mandate articulated in Article IV of the Canberra Agreement; and one of nine member agencies of the Council of Regional Organisations of the Pacific (CROP) (Pacific Community (2015-), 2022).

There is an opportunity for SIDS to collaborate and leverage a pool of resources when considering economic development as a systems problem. Many are already doing so as part of various networks, including the Pacific Islands Universities Research Network; Pacific Community; Asian Development Bank; Pacific Partners Initiative; and UH Climate-Resilient Food Innovation Network. Through these networks, there are opportunities to collaborate and solve challenges like the following.

1. Climate Change
2. Energy Independence from Fossil Fuels
3. Food Insecurity
4. Resource Limitations including Humans
5. Geographic Isolation and Effects on Trading Partners
6. Foundational Institutional Effectiveness

The Pacific Community (SPC) has a strategic plan oriented around solving and combating some of these challenges. Their strategic plan is summarized in the Figure:

Ancestral science may be instrumental in sustainable food and agricultural systems. Indigenous perspectives often have a reverence for the land and water resources of the earth. Sustainability and movements towards green and blue economies are essentially secular counterparts of those deeply held traditions. The third key focus area of SPC is "Food Systems," including sustainably producing and consuming crops, fish, and other food systems. The second and fourth key focus areas of the SPC are "Natural Resources and Biodiversity" and "Equity, Education, and Social development," the Indigenous perspectives and knowledge systems should be included. New Zealand's Vision Mātauranga recognizes the "science and innovation potential of Māori knowledge, people and resources" and has embedded their Vision Mātauranga policy across all priority investment agencies. ("Vision Mātauranga | Ministry of Business,

Figure 6.6: Pacific Community SPC Goals and Key Focus Areas Graphic (Pacific Community (2015-), 2022)

Innovation & Employment", n.d.)

The remaining focus areas of the SPC are "Sustainable Economies and Livelihoods" and "Transforming Institutional Effectiveness." These two focus areas are interrelated. Sustainable economies and livelihoods are dependent on institutional effectiveness. Institutional effectiveness from the lens of innovation and entrepreneurship capacities can be one guiding perspective.

6.6 Summary of Discussions

Hawai'i, Fiji, and New Zealand, were compared with respect to their system and stakeholder engagement. The MIT Five Stakeholder Model—as outlined in Budden and Murray (2019)—was expanded to identify the traditional roles of each stakeholder. This mapping allows for functional gaps to be recognized amongst the various stakeholders and how the entrepreneurial support organizations fit in to address these gaps when possible. Strategies were discussed for mitigating the disadvantages of being geographically-remote and resource-limited. Partnerships were highlighted as an opportunity to strengthen international ties, especially around the widespread and mutual problems climate change poses to the Islands.

The following chapter discusses the opportunity to draw upon the benefit of diversity from Indigenous peoples and their ancestral science, knowledge, and practices.

Chapter 7

Indigenous Counterpoints[1] to Innovation Ecosystems

> Every culture is by definition a vital branch of our family tree, a repository of knowledge and experience, and, if given the opportunity, a source of inspiration and promise for the future.
>
> *Wade Davis*
>
> *The Wayfinders*

Within many cultures are art forms, cultural practices, Ancestral science, and histories about making things and problem-solving. Thirteen years ago, I studied for an MS in mechanical engineering and was a part of the Compliant Mechanisms Research Group at Brigham Young University and befriended fellow lab mate and long-term origamist Matthew Gong. My re-

[1] Counterpoint is a musical term that refers to the technique of setting, writing, or playing melodies in conjunction with another.

search evolved into looking at origami, yes, paper folding, for design rules for flat folding compliant mechanisms, among other things. Origami traces its roots to Japan around a 1,000 years ago, and may have existed in China. In the past century, mathematicians, engineers, and scientists have been looking to origami to understand, model, and create innovations in daily life. For example, car airbags use origami models, heart stents, solar arrays, bulletproof shields, and more. Origami is a Japanese cultural art-form that has found a place in Western science and technological innovation. If applying mathematics, science, and engineering integrated with origami can yield so many innovations, much innovation can likely develop based on Indigenous knowledge and practices.

The universal problem that each nation is affected by is climate change. Ancestral science, or Indigenous ecological knowledge, can supplement the solution space because Indigenous knowledge embodies a history of survival and life and wisdom distilled across generations. Indeed,

> "to build a sustainable world in an era of profound economic and environmental interdependence, each person, each country, each organization is challenged to sift through the wisdom and know-how of their heritage, to take the best from their histories, leave behind lessons that no longer serve them, and innovate, not for change's sake, but for the sake of conserving and preserving the values and competence they find most essential and precious." (Heifetz et al., 2009)

In accordance with Kovach's *Indigenous Methodologies*, I discuss my own social location. (Kovach, 2021) I am part *Yu'pik* Alaska Native, but I grew up in Florida, far away from my culture. I also identify with being ethnically and culturally Jewish (though religiously Christian), and I am married to a part Native Hawaiian. As such, I have a wide lens of cultural background, though I have not had the privilege of being immersed in any one culture. I have earnestly endeavored to grasp the intricacies of Indigenous understanding to convey my growing un-

derstanding of the cultures and knowledge systems mentioned here. I am trained formally as an engineer, and it is my intent to write in a way that opens a pathway to further learning.

Julia Watson's book *Lo-TEK: Design by Radical Indigenism*, begins with a tongue-in-cheek expression. Lo-TEK, or "Traditional Ecological Knowledge", is defined as "a cumulative body of multi-generational knowledge, practices, and beliefs." (Watson, 2019) The term "radical indigenism" was coined by Princeton Professor—and Cherokee Nation citizen—Eva Marie Garoutte for rebuilding knowledge and exploring Indigenous philosophies to generate new ideas and conversations. (Watson, 2019).[2]

Julia Watson explains:

> "While 'modern' societies were trying to conquer Nature in the name of progress, these Indigenous cultures were working with it.
>
> "Indigenous technologies are not lost or forgotten, only hidden by the shadow of progress in the remotest places on earth. While society values and preserves the architectural artifacts of dead cultures, like the four-thousand-year-old Pyramids of Giza, those of the living are displaced, like the six-thousand-year-old floating island technology of the Ma'dan in the southern wetlands of Iraq. Extending the grounds of typical design, Lo-TEK is a movement that investigates lesser-known local technologies, traditional ecological knowledge (TEK), Indigenous cultural practices, and mythologies passed down as songs or stories. In contrast to the homogeneity of the modern world, indigeneity is reframed as an evolutionary extension of life in symbiosis with nature." (Watson, 2019)

Many conversations with Hawaiian stakeholders discussed efforts to teach younger generations principles from Indigenous knowledge systems. Ancestral science reveres the earth and

[2] "Designed by radical indigenism imagines a movement that rebuilds an understanding of Indigenous philosophies in relation to design to generate sustainable and climate resilient infrastructures."(Watson, 2019)

its gifts to us. Indigenous people and knowledge add a dimension to the innovation ecosystem. The following is an attempt to answer the question: *how do Indigenous peoples and Ancestral science, knowledge, and practices enhance an innovation ecosystem and yield IDEs?*

7.1 Indigenous Enhancement of Innovation Ecosystems

7.1.1 Indigenous applications to the system

MIT's 3-S framework for comparing innovation ecosystems examines systems, stakeholders, and strategy. (Budden & Murray, 2018) Considering the system: the foundational institutions, specifically the rule of law, can help protect Indigenous ecological knowledge and resources. In addition to I-cap and E-cap, Ancestral science provides a tacit knowledge that can enhance Western understanding of ecological systems, navigation, weather systems, etc. Indigenous knowledge can be a comparative advantage as well. Amongst Indigenous populations, there are many different styles of passing knowledge inter-generationally. The styles of oral tradition, apprenticeship, practice of craft, and teaching from Elders may be formal or informal. Throughout time, these knowledge systems were considered valuable by Indigenous people. Regarding problem-solving, Indigenous peoples bring unique perspectives to the table. Heifitz (2009), a leadership though leader says, "the answers cannot only come from on high. The world needs distributed leadership because the solutions to our collective challenges must come from many places, with people developing micro-adaptations to all the different micro-environments of families, neighborhoods, and organizations around the globe." (Heifetz et al., 2009)

Sometimes this knowledge is termed Ancestral sciences, Indigenous innovation, or Indigenous ecological knowledge. Knowledge of the land can and does differentiate what types of technol-

ogy and innovation can thrive in a given area. For example, you would not have geothermal studies and innovation in a non-geothermal resourced location, or it might exist but is not a natural strength of the region itself and may not be as competitive compared to other areas or regions with geothermal activity—just one example. Ecological knowledge can also include various information from the basic charting of stars to the harnessing of wind for worldwide sailing using traditional sailing techniques, which are also categories of Indigenous ecological knowledge.

From a cultural perspective, Indigenous cultures might personify Earth [3] and consider it a stakeholder, but I chose to consider it part of the system. It would not be fair to Earth to consider it a silent stakeholder. Instead, the land, the water, and resources were the initial reasons for living in a particular place—and for this reason, should be considered part of the foundation for an innovation ecosystem.

7.1.2 Indigenous enhancements to Stakeholder

The University of Hawai'i has made Indigenous innovation a part of its Innovation Engine plan. Kamuela Enos sits as director of the UH Office of Indigenous Knowledge and Innovation, where one of the goals is to "translate Ancestral sciences and technologies in the context of research and innovation for societal impact." ("UH Office of Indigenous Knowledge and Innovation", n.d.) Looking to the wisdom of past generations is not new. In fact, during the reign of King David Kalākaua, he "founded the Hale Nauā Society [in 1886] to revive the study of the ancient scientific knowledge of Native Hawaiians in combination with modern science." (McGregor & MacKenzie, 2013) The period under the reign of King Kalākaua was a time of cultural renaissance and of developing a strong national identity. A second Hawaiian Cultural Renaissance began in the 1970s with Hawaiian language revival, increased cultural practices,

[3] In many Indigenous cultures, the earth is thought of as a loving ancestor.

and the historic sovereignty movement.

Also, we are currently seeing sustainability and climate change-focused risk capital providers, governments and corporationss pushing for renewable energy goals, universities conducting earth-preserving research across various disciplines, and social impact-conscious entrepreneurs motivated to preserve the earth.

7.1.3 Indigenous enhancements to strategy

From the lens of strategy, sustainability principles are often in line with the spirit of Ancestral science. Indigenous peoples can provide insights into the maintenance of ecological diversity for which they contribute to the protection of over 80% of the world's biodiversity. ("World Bank Open Data", 2023) In addition, Indigenous peoples have a legacy of being marginalized, forced off the land, and having traditions disrespected or being victims of cultural misappropriation. As such, policies and programs can be developed to bring indigenous populations closer to parity, whether through supporting indigenous-owned IDEs, protecting Indigenous data and IP, building up the infrastructure of Indigenous communities, or providing opportunities for the intersection of Ancestral and Western science and technology.

A 2019 University of Hawai'i Law Review article presents the "evolving international recognition of Indigenous ecological knowledge (IEK) as a valuable tool for protecting environmental commons through the principle of inter-generational equity." (Forman, 2018) This article advocates for the international protection of IEK.

Markets are also moving towards sustainable and responsibly sourced products from companies with certain value propositions. Indigenous-run businesses are often operated in a way to convey values. To reiterate from Chapter 5 on New Zealand, the report on *New Zealand Firms: reaching for the frontier* highlights the strength of the Māori values in business and their

" 'Multiple bottom line' approach. This approach balances multiple values and objectives—spanning social, cultural, financial, environmental, spiritual, and political domains." (Commission, 2021)

7.2 Utilizing Indigenous Resources in the Right Way

The pursuit and application of Ancestral science, Indigenous knowledge, and Indigenous innovation must be done thoughtfully and respectfully. Indigenous scholarship needs to occur with Indigenous peoples in a working partnership. This collaborative approach is essential to develop this process for innovation—it is a process innovation focused in the right way, not having inherent power dynamics of trying to save a particular group. New Zealand has recognized the Māori values as being a comparative advantage and its *Vision Mātauranga policy* is helping to guide research and innovation with the Indigenous peoples in a right way.

I choose to repeat the following paragraph from Chapter 5, New Zealand, to show how the University of Auckland manages the research associated with New Zealand *Vision Mātauranga policy*, which is a policy around "unlock[ing] the innovation potential of Māori knowledge, resources, and people." ("Vision Mātauranga | Ministry of Business, Innovation & Employment", n.d.)

The University at Auckland established a "Research Manager, *Vision Mātaranga*" position to support the national *Vision Mātaranga* policy. This position sits within the Office of Research Strategy and Integrity. Jaylene Wehipeihana is the inaugural research manager, and her role is helping create a research strategy under *Vision Mātaranga*. Her work is to educate researchers that are Māori, interact with Māori, have Māori research team members, and others conduct research with processes and approaches that are culturally safe. In addition, her position serves to develop those researchers and labs to become "champions" for considering

the Māori communities at the inception of research as opposed to an afterthought. (Wehipeihana, 2023). Her work helps to bring institutional racism, and unconscious bias, to light and shift the research from being transactional to relational. While many New Zealand institutions have been making progress in terms of meaningful inclusion, she recognizes that some research portals are exclusive by design when it comes to restricting submission mediums. That flexibility of those mediums could allow for Māori research to be presented in a more accessible way. Another disadvantage is the lack of appropriate Māori or Indigenous reviewers on committees that would understand the significance of various cultural concepts. (Wehipeihana, 2023)

The rise of artificial intelligence has coincided in time with a self-awareness of colonial narratives. Ownership of Indigenous data and history has always been contentious, and AI has exacerbated this tension. The First Nations Information Governance Center (FNIGC) came about in Canada because of unethical information use. FNIGC is working on strategies for First Nations data governance through developing new infrastructure and institutions. Jason Lewis at Concordia University, and of Hawaiian-Samoan descent, is a Co-director of Indigenous Futures Research Center, Co-director of Aboriginal Territories in Cyberspace, and Director of Initiative for Indigenous Futures, to name a few appointments. Lewis was editor of the *Indigenous Protocol and Artificial Intelligence Position Paper*, which can be referred to as a collection of viewpoints for Indigenous Protocol and AI. Lewis has led various initiatives that combine his expertise in digital media, art, and Indigenous studies to address the complexities of Indigenous data ownership. One notable project is the "AbTeC (Aboriginal Territories in Cyberspace)" initiative, which he co-founded. AbTeC explores how Indigenous communities can use digital platforms to tell their stories, challenge stereotypes, and engage with technology on their terms. It emphasizes the importance of Indigenous communities being at the forefront of data representation and usage conversations. Through his work, Lewis has highlighted the potential of digital media and interactive technologies to empower Indigenous communities

in reclaiming control over their data. His projects often involve collaboration with Indigenous artists, scholars, and community members to create innovative platforms that reflect Indigenous perspectives accurately and respectfully.

As mentioned in Chapter 3 Hawai'i, Forman's UH Law Review (2019) explores how the TEK of Native Hawaiians can contribute to keeping the environment healthy and how global legal institutions might play a part in this effort. Additional legal infrastructure might need to be developed to apply this knowledge in specific ways. Legal questions around data sovereignty remain as well. However, below are stories of technologies and enterprises built on that knowledge's intersection.

7.2.1 Application of Indigenous Practice

Kamuela Enos, Director of Indigenous Innovation at the University of Hawai'i, shared the following story about how he realized that the principles he was learning at university were the same principles taught in traditional Hawaiian practice.

> "It helped [me] understand economics from an Indigenous perspective. They were managing an endowment. The size of the fish was the corpus; at all points, they met every day and fed that, and they understood how big that school of fish was. Then they also understood who had to eat up on the shore, the beneficiaries, and their carrying capacity. Knowing how much they could take from that without it crashing its ability to track and maintain the school. That was the corpus, the principle, and the interest they took off the top. And they did the same thing with the Taro farmers; they didn't extract all the kalo they grew and sold it; they knew what part they could pull off the top, and 90% of the kalo stayed in the field. And genetically, the kalo and that school of fish passed on generations with the people,

like the endowment." (Enos, 2023)

This story serves as an example of how wisdom transfers across disciplines. Enos wants "to be at the intersection of how we create jobs using Ancestral thinking so that we are creating powerful opportunities for employment." (Enos, 2023) In our discussion, Enos articulated practical lessons in his Four Step Model for learning from Ancestral science and co-creating a future. The discussion began with positioning "Restoration as Innovation Practice" because an "Ancestral practice is optimized for regenerative models of existence with landscapes versus extractive." (Enos, 2023)

Step One: "We Restate Our Value." Rather than talk about "Hawaiian culture" the conversation shifts to "Ancestral sciences and Technologies of Integrated Bio-Systems. Management." (Enos, 2023) The difference in Ancestral science is different from contemporary science because it comes from a different epistemology. Enos explains that "contemporary sciences, in a reductionist sense, is focused on extraction and design on ownership and is developed by universities in service of corporations, and kind of exists under an anthropocentric world view: that land is merely raw materials for production." (Enos, 2023) Rather from an Indigenous perspective, the practices are under a "bio-centric" world view, also having self-sufficiency not just across the community, but within valleys, and even in families. The land is even considered an 'Elder' and is the original teacher.

Step Two: "Reframing: from Decolonoization to Indigenization." (Enos, 2023) Enos uses a *Triple Piko Analysis Framework* where people need to conduct the following analysis:

1. *Piko O* is a connection to ancestors, "what Ancestral practice are you bringing into a contemporary space?"
2. *Piko I* connection to contemporary generations, "how is this Ancestral practice being deployed by lineal descendants to restore agency and executive

decision-making to Indigenous communities?" He notes this is not as a breaking away from contemporary society but as co-existing as peers.

3. *Piko A* connection to future generations, "by establishing contemporary agency, what platform is it providing future generations to the inalienable right to abundance, which was the hallmark of our ancestry?" (Enos, 2023)

Step Three: "Re-enter into Contemporary Practices." Enos (2023) gave the example of working at *MA'O Farms* and how they would operate a farm enterprise in exchange for a tuition waiver at the regional community college—essentially, translating from Ancestral framework of success to a contemporary metric of success. Historically the most valuable resource in the community is the youth, and *MA'O Farms* operated along this principle investing in the educational aspect, but beyond that, investing in the whole ecosystem of the area.

Step Four: "Reestablish Our Agency," to show how using their model helps hit the general contemporary success metrics. (Enos, 2023)

Enos emphasizes the principles of "kinship—with land and to each other—shapes our economic futures." (Enos & Tamanaha, 2022) By starting with Ancestral science and layering on contemporary sciences, there is potential for significant opportunity for innovation and community development. I conclude discussing this section with Enos and Tamanaha's own words:

> "The practice of Ancestral sciences and integrated systems management is not romantic, does not live in the past tense, and is not easy. It is born of commitment and rigor—physical, intellectual, and spiritual. Kinship—like all relationships—requires work: of Indigenous peoples, of immigrants, of settlers, and the descendants of colonizers. All of us. Zero-sum schemes, scarcity-minded policies, and extractive practices have led us to our current state. Now we can grow a resilient eco-

nomic future seated in our Ancestral sciences and integrated systems management—–in the wisdom of our places." (Enos & Tamanaha, 2022)

7.2.2 Hōkūlea and Hikianalia: Double-hulled Sailing Canoes

In the 1970s, the Polynesian Voyaging Society (PVS) was founded by individuals wanting to rebuild canoes similar to the Ancestral Hawaiians. Though it had been about 600 years since these canoes had been seen, the quest brought people together to build the *Hōkūleʻa*, meaning "Our Star of Gladness" and the name for Arcturus. In 1976, the *Hōkūleʻa* made its first successful voyage from Hawaiʻi to Tahiti—using traditional wayfinding techniques, demonstrating

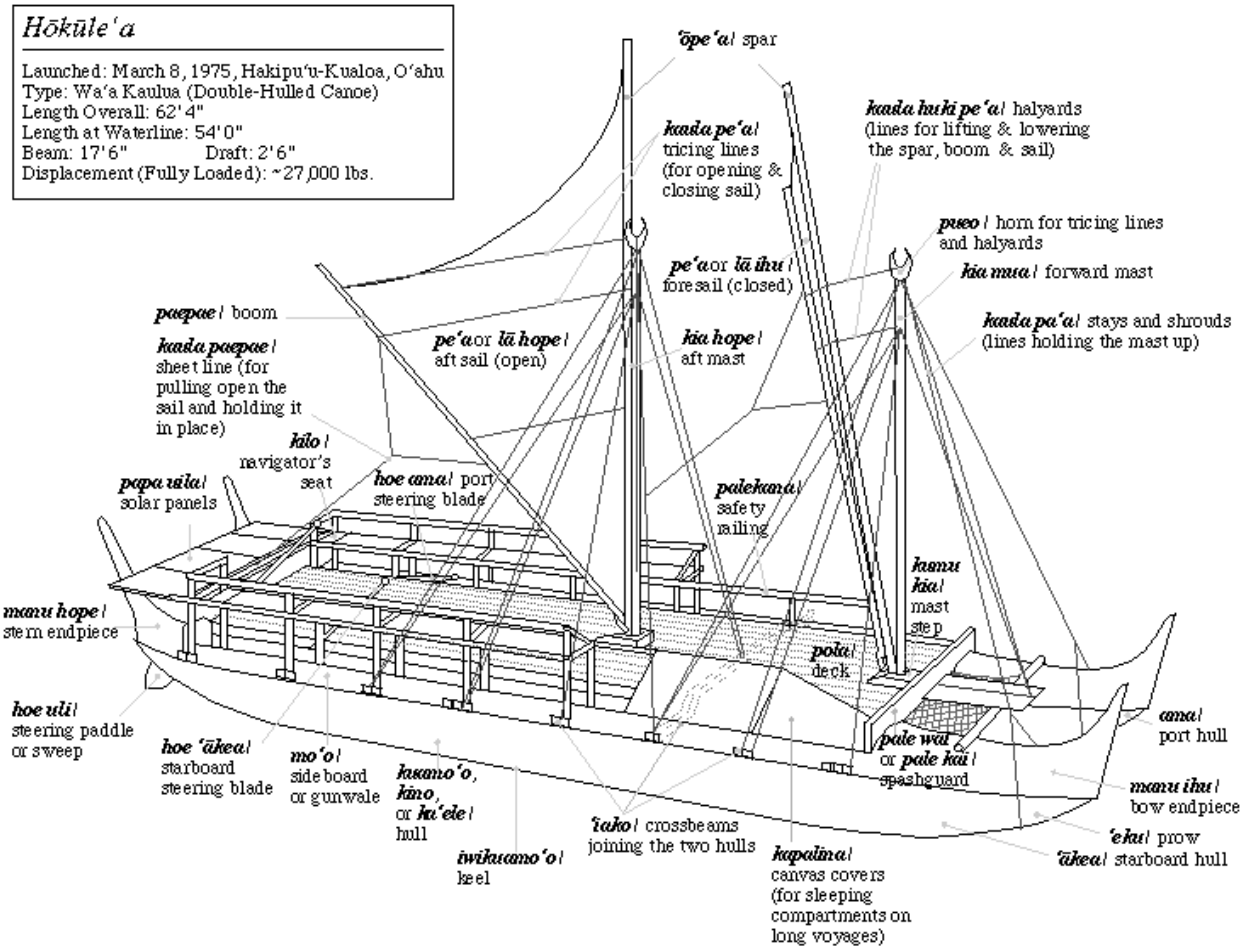


Figure 7.1: 1973 Drawing of Hōkūleʻa from PVS ("Hōkūleʻa Image Gallery (From 1973)", n.d.)

Figure 7.2: 1999-2000 "*Hōkūleʻa* rigged for upwind sails to the Marquesas and Rapanui; Boomless triangular sails and jib to help the canoe drive into the wind." ("Hōkūleʻa Image Gallery (From 1973)", n.d.)

ancient Polynesian navigational methods learned from Mau Piailug, a Micronesian navigator. ("The Story of Hokulea", n.d.) The *Hōkūleʻa* continued to make journeys to Aotearoa (New Zealand)) and Rapa Nui (Easter Island). The *Hōkūleʻa* continues to sail, and in 2023 she has been sailing along British Columbia. ("The Story of Hokulea", n.d.)

The PVS built the *Hikianalia* as a sister ship to the *Hōkūleʻa*. *Hikianalia* is the Hawaiian name for the star Spica which rises with *Hōkūleʻa* (Arcturus) in Hawaiʻi. On September 15, 2012, the *Hikianalia* was launched. *Hikianalia* was also constructed using traditional methods but integrates modern technology for navigation and communication. "*Hikianalia* combines the latest ecological technology with the heritage of the voyaging tradition. Each of [her] hulls contains an electric motor powered by onboard photovoltaic panels that convert sunlight to electric propulsive energy. With a zero carbon footprint, her design supports the *ʻMālama Honuaʻ* intent of the Worldwide Voyage."(Forman, 2018; "The Story of Hokulea", n.d.) The PVS explains:

> "'*Mālama Honuaʻ*, means 'to care for our Earth.' Living on an island chain teaches us that our natural world is a gift with limits and that we must carefully steward

> this gift if we are to survive together. As we work to protect cultural and environmental resources for our children's future, our Pacific voyaging traditions teach us to venture beyond the horizon to connect and learn with others. The Worldwide Voyage is a means by which we now engage all of *Island Earth*—bridging traditional and new technologies to live sustainably, while sharing, learning, creating global relationships, and discovering the wonders of this precious place we all call home. (Forman, 2018; "The Story of Hokulea", n.d.)

Together the *Hōkūleʻa* and *Hikianalia* symbolize the revival of ancient Polynesian navigation techniques and the importance of preserving Indigenous knowledge —while also adapting to the challenges of the modern world. These voyaging canoes have significantly fostered a deeper understanding of Polynesian culture, navigation, and the interconnectedness of the world's oceans. Additionally, the *Hikianalia* represents the complementing of contemporary and Ancestral sciences.

7.2.3 Honohu, a tech startup out of UH

Hohonu is an example of a technology startup birthed in a Hawaiian fishpond—-in service to an underserved community trying to restore an 800-year-old fishpond. It is owned partly by an organization that represents about 40 fishponds across the state. Hohonu's technology includes low-cost water level data sensors and forecasting technology. Donavan Kealoha told me about this company and described the story recognizing the analogous reciprocity of the fishpond and the community to extend to how Hohonu partners with the community. Kealoha sees this as an opportunity for communities to lean-in to technology. (Kealoha, 2023)

While the initial purpose was water level monitoring, this technology can help in climate adaptation and mitigation strategies, especially concerning coastal flooding. Hohonu has won nu-

merous awards and, in 2023, raised a $1.8 million pre-seed funding round. It is currently in nearly 100 locations across the US and has captured over 900,000 hours of water level data across 12 coastal states. Hohonu was part of the *Purple Maiʻa Foundation* incubator program, which "was created to nurture and support innovative and grounded founders, who are focused on regenerating Hawaiʻi ecosystems." ("Tech Startup, Hohonu, Raises $1.8M to Better Respond and Adapt to Flooding and Climate Change on a Global Scale", 2023) The opportunities for Honohu are in government with federal agencies and municipalities, coastal restoration, and aquaculture farming.

7.2.4 Of Architectures and Ecosystems

The world of architecture and urban planning has taken a specific interest in Indigenous knowledge and practices. Ancestral science has solved problems for hundreds if not thousands of years without contemporary scientific understanding. For example, ancient architecture in hot regions has made life comfortable with no energy input, yet these techniques are ignored. Innovations like the living root bridges of the Khasis in India and the Waru Waru agricultural terraces of the Inca in Peru solved problems allowing people to live and provide for their communities amongst some of the harshest conditions. "The living root bridges and root ladders of the Khasis are examples of infrastructure that are responsive, productive, adaptable, and resilient." (Watson, 2019) While the root bridges and ladders are not likely to be replicated and sold, there is a lot to learn concerning the roots and construction of materials science. Similarly, the Subak rice terraces of the Subak, Bali, produced large amounts of grain without chemicals and maintained productivity while other irrigated agricultural systems usually declined. (Watson, 2019) While these are more traditional ecological practices, their sustainability provides ecological evidence and knowledge that can be applied. There is an immense opportunity when integrated with technology.

7.3 Summary

Indigeneity can complement the MIT Innovation Ecosystem Framework by bringing in cultural notions of the land and environment as part of the foundational institutions considered. Indigenous knowledge, TEK, and Ancestral sciences are starting to be investigated in universities. Indigenous entrepreneurs have opportunities to innovate based on traditional knowledge systems. Specifically, the New Zealand *Vision Mātauranga* policy is looking to Māori knowledge, resources, and people to be part of their innovation ecosystem. Considering strategy, Governments are developing laws and protections for Indigenous IP, TEK, and Indigenous Data. Governments are also providing funding specifically for Indigenous-owned enterprises and Indigenous research. A component of the NSF Innovation Engines Program is diversity and inclusion. The UH has developed the position for Indigenous Innovation under their VP of Research.

As with all intersections of cultures and knowledge systems, care should be taken to conduct research in the right way and co-developed for mutual beneficence. Stories were provided of technologies integrating contemporary and Ancestral sciences and practices. Indigenous involvement through knowledge systems, stakeholders, and strategies should be done in a co-development process, and narratives need to shift from historically having power dynamics to relationships of mutual beneficence, where all are edified together. This will require learning, and learning requires humility.

With the COVID-19 pandemic and migration patterns, Indigenous knowledge and skills are being lost at an alarming rate: from health and curative medicine to food production and preservation techniques and even construction techniques. The intersection of Indigenous knowledge and Ancestral science with contemporary science and technology provides opportunities for innovation that can also be culturally fulfilling and restorative. I hope that by

working with diversity and inclusion in mind, not just of people—but inclusive of knowledge systems, we can solve problems and promote peace and understanding.

Chapter 8

Intentional Innovation Ecosystem Development: Conclusions

> We must create economic opportunity, build a culture of entrepreneurship, get people to take responsibility for improving their lives, rather than putting them in a position where they sit back in their poverty and blame others for it.
>
> *Paul Kagame*
>
> *President of Rwanda*

The MIT Innovation Initiative defines innovation as the "process of taking ideas from inception to impact." (Budden & Murray, 2018) Impact does not occur in a vacuum—it results from numerous stakeholders and their networks facilitating an environment where ideas can be presented, iterated, and launched. The environment and its stakeholders create the ecosystem.

In recent decades, geographies like Silicon Valley, Kendall Square, London, Berlin, Bangalore, and Tel Aviv have facilitated the emergence of many technology companies and attracted the interest of numerous individuals of varying backgrounds to study why and how these regions resulted in a higher proportion of successful startups and experienced surges of economic growth. The goal—to repeat the recipe and engender change in other areas.

In 2010, Daniel Isenberg's Harvard Business Review article *The Big Idea: How to Start an Entrepreneurial Revolution* popularized the term "entrepreneurial ecosystem." (Isenberg, 2010) Isenberg developed domains of the entrepreneurship ecosystem; the World Economic Forum developed an ecosystem pillar model; Koltai, who created and ran the US State Department's Global Entrepreneurship Program, had a Six + Six model of functional pillars and actors; Spigel's model combined regional material, social, and cultural attributes for a model on entrepreneurial ecosystems. (Jafarov & Szakos, 2022) "Regional policies for entrepreneurship are currently going through a transition from increasing the quantity of entrepreneurship to the quality of entrepreneurship," where quality entrepreneurship focuses on growth and innovation-oriented entrepreneurship. (Stam, 2015)

While the previous models focus on general entrepreneurship ecosystems, the MIT model specifies *innovation ecosystems* to distinguish the types of enterprises that result in the greatest impact on economies: innovation-driven enterprises (IDEs).

Innovation ecosystems go beyond entrepreneurial ecosystems because they focus on developing both innovation and entrepreneurial capacities to create high-growth startups: innovation-driven enterprises (IDEs). Budden and Murray characterize SME and IDE Entrepreneurship to distinguish the value IDEs bring to an ecosystem. As such, innovation ecosystems provide an increased opportunity for people to be empowered to change their livelihood.

This thesis analyzed three Pacific Island regions using the MIT System-Stakeholder-Strategy

Framework. My initial questions revolved around how geographically-remote and resource-limited regions might be suited to benefit from the MIT innovation ecosystem model. I chose Hawai‘i, Fiji, and New Zealand primarily for their relative remoteness, tourist and agrarian economies, and mixed indigenous and settler populations. The following are the accomplishments of this research:

1. Analyze three Pacific Islands regions using the MIT System-Stakeholder-Strategy Framework.
2. Assess stakeholders using the MIT Five Stakeholder Model.
3. Identify the emergence of Entrepreneurial Support Organizations resulting from the stakeholders' gap and when institutions are less extensive than counterparts in other ecosystems.
4. Provide strategies for the leaders of these innovation ecosystems to consider.
5. Frame Indigenous populations and Ancestral science, knowledge, and practices as a counterpoint to contemporary innovation.

8.1 Hawai‘i Summary

Considering Hawai‘i, the UH is poised to be the leader of the local innovation ecosystem as it works to develop itself as an Innovation Engine. Through the process, UH has identified focus sectors, created entities conducive to increased I-Cap and IDEs, and established an office of Indigenous Innovation. As more technology is patented and commercialized, additional risk capital providers may be attracted. The government can set policies to encourage returning talent and parity in terms of education between Native Hawaiians and others. In addition, the government will need to push economic diversification over short-term interest.

The lack of a large corporation as a stakeholder means that the ecosystem may need more talent development, private sector facilities, and the aggregation of regional know-how for a specific technical sector. Careful thought should be given to which corporations would be good candidates and whether external incentives should exist.

Finally, Hawai'i is a culture of story-telling. As successes occur, the stories need to be told. Donavan Kealoha talked about the importance of "showing people the realm of possibility," people are tech savvy, but consumers of content and they need to be shown a different paradigm. (Kealoha, 2023) As people hear stories of innovation and entrepreneurship—especially from people that look like them, there will be an opportunity to attract a more diverse demographic of innovation entrepreneurs.

8.2 Fiji Summary

Fiji's innovation ecosystem is like a seedling slowly emerging from the soil. It is weak and does not have strong connections, but it is working to form them. Regarding entrepreneurship, there are some latent capabilities and cultural challenges to overcome. From the MIT Stakeholder Model analysis, Fiji's universities and government emerged as the likely leaders for the next phase of ecosystem development. While there are many ESOs present in Fiji and they are considered a strong group, those organizations need to be more sustainable, and many are only fulfilling a program for an established time frame. Fiji's implementing a bond service program in exchange for tertiary education is a step in the right direction. Fiji should encourage its youth to develop skills in STEM areas, especially coding. The University of the South Pacific (USP) should work with its professors and students to generate new IP and protect it with patents, perhaps through working with another university whose technology transfer office exists.

With most of Fiji's export basket associated with food products, Fiji should work to innovate in agriculture and food technology. The government has allocated an additional budget towards improving agricultural production with subsidies for weedicide and fertilizer. *Agricultural technology* is a sector that Fiji-based universities can work in to develop impactful innovations. In addition, Fiji has its share of natural disasters and has an opportunity to innovate around the needs of those situations. The medical school also provides opportunities and resources in the health sector, which needs attention in the Pacific Islands. Indigenous ecological, meteorological, and medicinal knowledge may provide opportunities for innovation in these sectors. Digital and knowledge-based technologies have shorter cycle times and quicker feedback rates and great potential for developing innovation-driven enterprises.

8.3 New Zealand Summary

New Zealand has strategies that look at the practices of similar small, advanced economies. New Zealand is working to set policy and build further upon its strong foundations to become an economy that can support IDEs rather than start them. The challenge of scaling IDEs is one that Israel is also facing. Brett O'Riley, Chief Executive of EMA (Employers and Manufacturers Association) and MIT REAP team alum talked about how one of Israel's biggest strengths is leveraging the Jewish Diaspora and that New Zealand has the potential to do the same. New Zealand has also encouraged the risk capital stakeholders to evolve from being primarily angel investors to inviting venture capital by creating the NZGCP and its fund-of-funds, similar to Israel's Yozma initiative.

New Zealand will continue to evolve by building and strengthening connections and partnerships within its ecosystem and leveraging the success and mentoring available from the Kiwi diaspora. They are also setting an example for treating the Māori and Pasifika peoples as a pro-

tected class for research and working with them in co-development projects with perspectives of interdependence rather than a hierarchical nature.

8.4 Indigenous Counterpoint

Indigeneity can complement the MIT Innovation Ecosystem Framework by bringing cultural notions of the land and environment into the foundational institutions considered. Indigenous knowledge, TEK, and Ancestral Sciences are starting to be investigated in universities. Indigenous entrepreneurs have opportunities to innovate based on traditional knowledge systems. Specifically, the New Zealand *Vision Mātauranga* policy is looking to Māori knowledge, resources, and people to be part of their innovation ecosystem. Considering strategy, Governments are developing laws and protections for Indigenous IP, TEK, and Indigenous data. Governments are also providing funding specifically for Indigenous-owned enterprises and Indigenous research. A component of the NSF Innovation Engines Program is diversity and inclusion. The UH has developed the position for Indigenous Innovation under their VP of Research.

As with all intersections of cultures and knowledge systems, care should be taken to conduct research in the right way and co-developed it for mutual beneficence. Stories were provided of technologies integrating contemporary and ancestral sciences and practices. With the COVID-19 pandemic and migration patterns, indigenous knowledge and skills are being lost at an alarming rate: from health and curative medicine to food production and preservation techniques and even construction techniques. The intersection of Indigenous knowledge and ancestral science with contemporary science and technology provides opportunities for innovation that can also be culturally fulfilling and elevate previously marginalized populations. I hope that by working with diversity and inclusion in mind, not just of people—but inclusive

of knowledge systems, we can solve problems and promote peace and understanding.

8.5 Big Picture

Hawai‘i is trying to develop as an Innovation Engine that can potentially support efforts in the other Islands outside of Oahu and the greater American Pacific Islands. New Zealand is also working on a similar problem with having a primary innovation ecosystem developing in the city of Auckland and other regions that are part of the national ecosystem. Fiji and Hawai‘i have economies a fraction of the size of New Zealand. They can learn from New Zealand's investment into creating an ecosystem where innovation-driven enterprises can survive.

New Zealand's risk capital sector has evolved from being primarily angel investors to having venture capital firms. Hawai‘i has a few firms which have island and mainland offices. The stakeholders with strong ties and connections to more established innovation ecosystems are those who stand to make the most impact in an ecosystem by opening doors to the stronger established one. Saxenian's article *The new Argonauts* examines how highly-skilled foreign-born but US-educated engineers, entrepreneurs, managers, lawyers, and bankers have the institutional knowledge, cultural, and linguistic capabilities to benefit their homelands, reframing the negative "brain drain" to "brain circulation." (Saxenian, 2006) Saxenian states:

> "As foreign-born, but US-trained engineers transfer know-how and market information to their countries of origin, and help jump-start local entrepreneurship, they are allowing their home economies to participate in the information-technology revolution. Because of their experience and professional networks, these cross-regional entrepreneurs can quickly identify promising new market opportunities, raise capital, build management teams and establish partnerships with other specialist producers—even those located far away. This decentralized re-

> sponsiveness is a vitally important advantage which few multinationals have." (Saxenian, 2006)

The MIT Five Stakeholder Model was expanded to identify the traditional roles of each stakeholder as outlined in Budden and Murray (2019), and entrepreneurs—as individuals—are the most portable, along with angel investors, who are usually individuals. Government and universities are fixed, though universities have international students, exchange programs, professors, and international research collaboratives, which help to facilitate some "brain circulation." The relation of stakeholder groups and their primary functions allowed for gaps to be recognized and characterize how entrepreneurial support organizations attempted to address these gaps.

Strategies for mitigating remote geographies included the production of digital tools that could be exported more easily and globally than tangible goods. Additionally, tools for allowing these economies to benefit from their time zones and increase productivity for corporations are an area of opportunity. The essential advantage being that digital tools do not have the time constraints of growth cycles that come with agrarian and medical research and development. Finally, the most impactful strategy would be the development of networks external to the regions allowing increased accessibility to larger markets—especially across the Pacific and the wider global market. Saxenian (2006) summarizes the importance of the stability and development of home country foundational institutions to attract returning talent in the following:

> "Cross-regional networks develop only when skilled immigrants are both willing and able to return to their home countries to do business in large enough numbers to create close links to the technical community in the home country. This requires political stability, economic openness and a certain level of economic development, notably a high level of technical education. It often builds on multi-

national companies' investments in research and development which have helped develop a local skill base as well as an infrastructure which supports entrepreneurship. Political leaders must also be committed to removing institutional obstacles to entrepreneurship-led growth." (Saxenian, 2006)

Strategies for mitigating the limited-resource nature of regions include the development of technologies to aid in the production of goods usually imported. For example, Hawai'i imports roughly 80% of its food and would benefit from developing small-scale (and potentially scalable) agriculture and aquaculture technologies are sectors that can benefit both its domestic needs, and then address international markets. Medicine is considered as well, given the existing institutions and the lack of neighbors and accessibility. Medicine, however, is a longer-term investment best supported by the government. Additional research and development addressing cross-regional problems like climate change offers opportunities for partnership and analysis that can make global impacts.

Limitations on natural resources require a reassessment of natural resources endemic to a region. Within every challenge is an opportunity—and regions need to understand the assets they have creatively. This includes the volcanic origins and potential for geothermal; endemic biodiversity; lack of light pollution; opportunity for ocean-based innovation; and contributions from Indigenous peoples and their scholarship.

8.6 Opportunities for Future Work

Innovation ecosystems are dynamic and evolving. The research of each innovation ecosystem is multidisciplinary, and much of the literature is published by and for the different stakeholders in varying mediums. The statistical research assessments are done by various institutions like the United Nations, Global Innovation (by Cornell, World Intellectual Property Organiza-

tion, and INSEAD), World Economic Forum, and Global Entrepreneurship Monitor, among others. Academic research is conducted by economists, management scientists, manufacturing and engineering academics, political scientists, urban planning academics, and general scientists. Other scholarship emerges as epistemologies expand to include ancestral sciences and Indigenous knowledge and practices. Industry professionals, governments, non-profits, and intra-governmental organizations also have their perspectives and research. Finally, successful entrepreneurs like Steve Case, Brad Feld and many others also have their contributions to this area of study.

Furthermore, innovation ecosystems are studied using various paradigms including Isenberg's Domains (2010), WEF Pillars (2013), Six+Six Model by Koltai (2016), attributes by Spigel (2017), MIT innovation-driven entrepreneurship by Murray and Budden (2017), Triple Helix, Integrative models by Stam and Van de Ven (2021) among others generated by the various authors from different institutional perspectives named in the previous paragraph. The research can take the form of, but is not limited to, economic analysis, network theory, systems theory, and case studies. Borrowing from religious studies and Indigenous methodologies, studying complex subjects requires contextual understanding, engaged scholarship, personal positioning, interdisciplinary approaches, and holistic education. Specifically, articulating one's social location, or personal positioning, helps other readers and researchers understand how authors' positions, experiences, and biases shape their work. Additionally, the anthropology classification of insider-outsider perspectives would help engage others in understanding regional innovation ecosystems from varying points of view. For example, I wrote this thesis from an outsider's perspective, from the social location of an Indigenous-ethnically Jewish-European settler descendant and graduate student in MIT's professional system design and management program.

Future work studying innovation ecosystems should classify all research from varying stakeholder perspectives and at varying time continuums. The research aims to be applied, and

models and frameworks from varying perspectives should ultimately be developed for specific stakeholders and regard the stakeholders' realm of control and sphere of influence. The field of system dynamics can be used to model how stakeholders' changes in a region's inputs could result in greater IDE output and, ultimately, economic or social progress. Furthermore, the models are only as good as their usefulness. Developing the innovation ecosystem frameworks to understand how to test policies and programs strategically helps each stakeholder understand the impact they can make in an innovation ecosystem.

Regarding Ancestral science and Indigenous peoples, knowledge and practices, the research and application of these knowledge categories can be expanded. As more Indigenous peoples are being educated in Western universities, they are essentially domestic analogs of the Argonauts discussed by Saxenian. They provide opportunities to bring skills back to their culture and people and opportunities to contribute Indigenous concepts and paradigms to innovate and create new technologies. Many Indigenous peoples, in addition to the Hawaiians and the Māori, are experiencing cultural renaissances at this time, and it will be interesting to watch how these newer generations raised with technology fluency and having greater cultural identity will innovate.[1]

8.7 Closing Remarks

Innovation ecosystems are complex systems that are studied within varying frameworks and models. No singular model is perfect and comprehensive. However, the MIT Three-S Framework and Five-Stakeholder Models provide for the systematic comparison of different geographies using generally available data. The metrics are inputs characterizing the strength of a region's innovation and entrepreneurship capacities amongst the categories of culture and incen-

[1] As an aside, this may result in Indigenous people and knowledge systems becoming a protected class and potentially having specific legal implications regarding data sovereignty and IP.

tives, demand, infrastructure, funding, and human capital. The MIT brand of entrepreneurial ecosystems focuses on innovation ecosystems whereby the most impactful entrepreneurship results from innovation-driven enterprises. These IDEs complement the existing SME ecosystem, which often pre-exists and elevates the culture and incentives of entrepreneurship in a given region.

I am pleased to contribute these analyses and hypotheses regarding the innovation ecosystems of Hawai‘i, Fiji, and New Zealand to offer ideas and strategies for geographically-remote and resource-limited regions hoping to improve their economies through innovation ecosystems. I encourage the readers to look at the academic resources cited for further understanding and applicabilities of these models for your given regions.

Appendix A

Innovation and Entrepreneurship Capacities Data

In this Appendix are the data compiled for Hawai‘i, US, Fiji, and New Zealand. The following is a list of sources referenced in the preparation of the tables having E-Cap and I-Cap data.

DBEDT	Hawai‘i Department of Business, Economic Development & Tourism
DNE	Does Not Exist
GCI	Global Competitiveness Index
GEM	Global Entrepreneurship Monitor
GII	Global Innovation Index
HF	Heritage Foundation
HI	(*H Index for States and Countries*, 2023) MIT
MIT Iecosystems database	
NSF	National Science Foundation
OECD	Organization for Economic Cooperation and Development
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WB	World Bank

Table A.1: Acronyms for Data Sources

The following are the tables of the data amassed for the dimensions of E-Cap and I-Cap.

E-Cap: C & I	Source	Metric	Hawai'i	US	New Zealand	Fiji
Business Freedom	HF	score	DNE	70.6	78.9	58
Entrepreneurial Intention	GEM	% pop	DNE	13.58	11.18	5.69[1]
Entrepreneurship as a desirable career choice	GEM	% pop	DNE	75.9	61.44	90.57[1]
Fear of Failure Rate	GEM	% pop	DNE	43.06	21.98	64.75[1]
High Status to successful entrepreneurs	GEM	% pop	DNE	79.86	72.73	75.35[1]
I-Cap: C & I						
Graduates in Science & Engineering	GII	% pop	37.10	33.9	23	DNE
Quality of Research Institutions	GCI	rank	DNE	1	47	DNE
Patents awarded per 1000 Individuals in Sci & Eng occupations	NSF	number	6.09	22.45	DNE	DNE
H Index for country, representing quality of scientific research institutions	HI	H Index	9.11	47.02 [2]	15.06	4.25

Table A.2: Table of E-Cap and I-Cap for Culture and Incentives Data

[1] Data for Tonga, since Data for Fiji did not exist.

[2] Massachusetts H-Index for comparison. Massachusetts was the highest H-Index in the US.

E-Cap: Demand	Source	Metric	Hawai‘i	US	New Zealand	Fiji
Buyer Sophistication	GCI	scale	DNE	5.1	4.2	DNE
Domestic Market Scale	GII	GDP Bn PPP	$98.2	$22,939	$235	$4.3
I-Cap: Demand						
Gov’t procurement of advanced technology products	GCI	scale	DNE	5.09	3.8	DNE
Trade, Competition, & Market Scale	GII	score	DNE	96.2	57.7	65.2
University-Industry Research Collaborations	GII	scale	DNE	79.6	55.5	DNE

Table A.3: Table of E-Cap and I-Cap for Demand Data

E-Cap: Funding	Source	Metric	Hawai‘i	US	New Zealand	Fiji
Ease of Credit	GII	rank	DNE	3	6	65
Easy access to loans	GCI	scale	DNE	5.31	5.74	DNE
VC Deals	GII	$Bn	DNE	296	.2	DNE
Venture capital availability	GCI	DNE	DNE	4.3	DNE	
I-Cap: Funding						
Business expenditure on R&D as a % total R&D	UNESCO	%	DNE	62.32	39.78	DNE
Business-performed R&D as a % of Private Industry Output	NSF	%	0.43	2.95	DNE	DNE
Public R&D expenditure as a % of total R&D	UNESCO	%	DNE	43.95	69.22	DNE
Average Annual Federal SBIR and Small Business Tech Transfer Funding per $1M of GDP	NSF	$	$312.21	$168.13[3]	DNE	DNE
R&D expenditure in ‘000 current PPP$	UNESCO	$000	DNE	502M	1.85M	DNE

Table A.4: Table of E-Cap and I-Cap for Funding Data

[3] For comparison, $667.92 for Massachusetts

E-Cap: Human Capital	Source	Metric	Hawai'i	US	New Zealand	Fiji
Post-secondary degree holders among individuals 25-44 years old	NSF	%	46.8	46.2	DNE	DNE
% School grads in tertiary education	GII	%	51	87.9	80.3	53
Entrepreneurship perceived capabilities	GEM	% pop	DNE	66.8	59.8	56.2 [1]
I-Cap: Human Capital						
Availability of scientists and engineers	GCI	scale	DNE	5.53	4.73	DNE
Quality of STEM education	GCI	scale	DNE	5.45	5.25	DNE
Researchers/Professionals engaged in R&D per million population	GII	count	DNE	4829	5843	924
STEM graduates per capita	OECD/NSF	count	22.50[4]	25.50[4]	2369[5]	DNE

Table A.5: Table of E-Cap and I-Cap for Human Capital Data

[4] Between the NSF and OECD and MIT Iecosystems platform the data was likely a different unit, or a different scale. For this reason, only the data between Hawai'and US was compared with each other.

[5] Data from MIT Iecosystems platform, for year 2012

E-Cap: Infrastructure	Source	Metric	Hawai'i	US	New Zealand	Fiji
Electricity and telephony infrastructure	GCI	score	DNE	123.7	134.9	DNE
Logistics Performance	WB	score	DNE	3.8	3.6	2.3
Number of Internet users	UN, DBEDT	% pop	88.2	74.55	88.22	46.33
I-Cap: Infrastructure						
Availability of latest technologies	GCI	scale	DNE	6.54	5.94	DNE
ICT access	GII	score	DNE	89.5	93.2	46
Internet Bandwidth	GCI	bit/s	DNE	99	108	DNE
Product Process Sophistication	GCI	scale	DNE	5.09	5.09	DNE

Table A.6: Table of E-Cap and I-Cap for Culture and Incentives Data

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