Analysis and Comparison of the Creation of University Spin-off Startups in Deep Tech between the United States and Japan

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ABSTRACT
Research-based universities have played a significant role in the economic growth of nations, particularly in the United States, where companies originating from these universities have generated substantial employment opportunities and revenue.

There exists a substantial disparity in the number of spin-off companies created from these universities between the United States and Japan. Although Japan is not far behind the United States in terms of patent numbers, it significantly lags behind in successfully commercializing research outcomes through the establishment of startups.

Therefore, this thesis focuses on the Massachusetts Institute of Technology (MIT), a leading institution in spin-off creation in the United States, and the University of Tokyo, the leading institution in Japan. The objective is to investigate how their university-based ecosystems, including university-supported venture capital initiatives and on-campus entrepreneurship programs, influence the establishment of university spin-offs. The analysis is conducted through interviews and a literature review to examine the impact of these ecosystems on the formation of university spin-off startups.

Many of the spin-off startups emerging from research-based universities fall under the category of "deep tech" companies, which are based on long-term research outcomes and require substantial investments and development time. Consequently, a funding gap referred to as the "valley of death" arises, presenting a unique financial challenge for entrepreneurs between research invention and commercialization. It is essential for entrepreneurs to overcome this funding gap, and thus, we also investigate how university spin-offs in Japan and the United States make fundraising choices to bridge the capital gap.

By conducting these surveys, we aim to gain insights into the effectiveness of university-affiliated venture capital firms, university spin-off startups, and the overall university ecosystem.

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List of Acronyms and Abbreviations

AMED	Japan Agency for Medical Research and Development https://www.amed.go.jp/en/aboutus/index.html
ATLA	Acquisition, Technology & Logistics Agency https://www.mod.go.jp/atla/en/soubichou_gaiyou.html
AUTM	Association of University Technology Managers https://autm.net/
CVC	Corporate Venture Capital
DOE	Department of Energy https://www.energy.gov/
GP	General Partners
I-Corp	NSF's Innovation Corps https://new.nsf.gov/funding/initiatives/i-corps/about-i-corps
ILP	MIT Industrial Liaison Program https://ilp.mit.edu/
IP	Intellectual Property
IRR	Internal Rate of Return
JST	Japan Science and Technology Agency https://www.jst.go.jp/EN/about/overview.html
KII	Keio Innovation Initiative, Inc. https://www.keio-innovation.co.jp/about/?wovn=en
LP	Limited Partners
METI	Ministry of Economy, Trade and Industry https://www.meti.go.jp/english/aboutmeti/data/meti_mission.html
MEXT	Ministry of Education, Culture, Sports, Science and Technology https://www.mext.go.jp/en/
MHLW	Ministry of Health, Labor and Welfare

	https://www.mhlw.go.jp/english/
MIT	Massachusetts Institute of Technology https://www.mit.edu/
MOD	Ministry of Defense https://www.mod.go.jp/en/
NEDO	New Energy and Industrial Technology Development Organization https://www.nedo.go.jp/english/introducing/introducing_index.html
NIH	National Institutes of Health https://www.nih.gov/about-nih/who-we-are
NSF	National Science Foundation https://www.nsf.gov/
POC	Proof of Concept
SBIR	Small Business Innovation Research https://www.sbir.gov/about
START	Program for Creating Start-ups from Advanced Research and Technology https://www.jst.go.jp/start/en/
STTR	Small Business Technology Transfer https://www.sbir.gov/about
TLO (MIT)	Technology Licensing Office https://tlo.mit.edu/
TLO (UTokyo)	Technology Licensing Organization https://todaitlo.com/
TUSIC	Tokyo University of Science Innovation Capital https://tusic.co.jp/
TUSIM	Tokyo University of Science Investment Management https://tusim.co.jp/#about
UTEC	The University of Tokyo Edge Capital Partners Co., Ltd.

	https://www.ut-ec.co.jp/english/about_utec/firm_profile
UTokyo	The University of Tokyo https://www.u-tokyo.ac.jp/en/about/about.html
UTokyo IPC	UTokyo Innovation Platform Co., Ltd. https://www.utokyo-ipc.co.jp/en/
VC	Venture Capital
VMS	Venture Mentoring Service
WERU Investment	WERU INVESTMENT Co., Ltd. https://www.weruinvest.com/

1. Introduction

1.1. Why University Spin-off Startups?

Considerable prior literature has emphasized the pivotal role that research-based universities play in fostering economic growth within countries[1]. The significance of this role was first quantified in a seminal study conducted by the Bank of Boston in 1997, which examined the economic ripple effects of the Massachusetts Institute of Technology (MIT), particularly through its technology transfer office (TLO)[2]. According to the study, MIT graduates and faculty have cumulatively founded 4,000 companies, created 1.1 million jobs, and generated annual world sales of $232 billion[3]. Subsequently, a study conducted by MIT in 2014 estimated that, cumulatively, MIT graduates have started more than 30,000 companies, created 4.6 million jobs, and generated about $1.9 trillion in annual revenue[4]. These findings highlight the further economic benefits that MIT graduates brought to the entire United States through the companies launched by MIT graduates between 1997 and 2014. Furthermore, 80% of the companies founded by MIT graduates have been in existence for more than 5 years, and 70% have been in existence for more than 10 years[5]. This compares very favorably to the U.S. as a whole, where half of new companies last 5 years and only 35% last 10 years[6]. Startups are the primary drivers of job creation in the US, with new and high-growth young firms accounting for 70% of total employment[7]. As a result, university spin-offs, which emerge from the university-based ecosystem, garnered substantial academic interest. Consequently, extensive research has been conducted on various aspects of university spin-offs, including the relationship between personal

[1]Rory P. O'Shea et al., "Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities," *Research Policy*, The Creation of Spin-off Firms at Public Research Institutions: Managerial and Policy Implcations, 34, no. 7 (September 1, 2005): 994–1009, https://doi.org/10.1016/j.respol.2005.05.011; Bank Boston, *MIT: The Impact of Innovation*, 1997; Edward B. Roberts, Fiona Murray, and J. Daniel Kim, "Entrepreneurship and Innovation at MIT: Continuing Global Growth and Impact," SSRN Scholarly Paper (Rochester, NY, April 15, 2019), https://papers.ssrn.com/abstract=2772695.
[2]Bank Boston, *MIT: The Impact of Innovation*.
[3]Bank Boston.
[4]Roberts, Murray, and Kim, "Entrepreneurship and Innovation at MIT."
[5]Edward B Roberts, "Entrepreneurship and Innovation at MIT: Continuing Global Growth and Impact," n.d.
[6]Roberts, Murray, and Kim, "Entrepreneurship and Innovation at MIT."
[7]Roberts, Murray, and Kim.

characteristics of researchers and entrepreneurship, university policies on the commercialization of university research results and their impact and evaluation, and the environmental factors that give rise to university spin-offs[8]. Some research have explored early-stage funding for university spin-offs, presenting examples of initial funding sources[9], and assessing how entrepreneurs' social capital at the time of founding influences the sustainability of their ventures[10]. However, previous studies have not examined the specific types of public or private funding raised during the early years of these startups, the fundraising journeys pursued, or the influence of support received from the university ecosystem or early-stage human resource decisions on fundraising outcomes. In addition, these studies have primarily focused on universities in the United States, with limited cross-country comparisons.

As for spin-off startups that emerge from research-based universities, many of them are so-called "deep tech" companies based on the results of long-term university research. In general, "deep tech" requires huge investment and time to develop. This causes a gap in entrepreneurship called the "valley of death," a unique funding challenge that entrepreneurs face between the invention of research and commercialization, and the problems here require early-stage entrepreneurs to overcome the "capital gap" in particular[11]. In other words, the ability to overcome this valley of death is the first turning point in commercializing research results, and examining the financial choices made by university spin-offs that have overcome this trial will fill the gap in research to date.

[8]O'Shea et al., "Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities."
[9]Christopher S. Hayter, Roman Lubynsky, and Spiro Maroulis, "Who Is the Academic Entrepreneur? The Role of Graduate Students in the Development of University Spinoffs," *The Journal of Technology Transfer* 42, no. 6 (December 1, 2017): 1237–54, https://doi.org/10.1007/s10961-016-9470-y.
[10]Scott Shane and Toby Stuart, "Organizational Endowments and the Performance of University Start-Ups," *Management Science* 48, no. 1 (January 2002): 154–70, https://doi.org/10.1287/mnsc.48.1.154.14280.
[11]Philip E. Auerswald and Lewis M. Branscomb, "Valleys of Death and Darwinian Seas: Financing the Invention to Innovation Transition in the United States," *The Journal of Technology Transfer* 28, no. 3 (August 1, 2003): 227–39, https://doi.org/10.1023/A:1024980525678.

Furthermore, while about 1,000 university spin-off startups were founded each year at universities across the U.S.[12], Japan, which boasted the second largest GDP until 2009 and the third largest GDP after China thereafter, has less than 1/10th of that number, about 80 spin-off startups each year[13], a significant difference from the U.S. On the other hand, according to a survey conducted by MIT between 2015 and 2017, Japan ranks second only to South Korea in the number of patent applications per million people, an indicator of "innovation capacity," with about 3,700, while the United States ranks ninth with about 1,600[14]. Thus, Japan is more active than the U.S. in patent application activities. In addition, since the population of the U.S. is about three times that of Japan, the number of patent applications filed in the U.S. is only about 1.1 times that of Japan. On the other hand, in terms of "density of new businesses (number of registered company incorporations per 1,000 population aged 15-64)," an indicator of "entrepreneurial capacity," Japan is almost at the bottom of the list[15]. This suggests that, assuming the same quality of patents in the US and Japan, Japan has good amount of research results but may have less ability to establish startups based on them. Therefore, by examining how the university ecosystem has supported spin-off companies in reaching initial funding, it is particularly important to identify what kind of support in U.S. universities contributes to the success of university spin-offs in reaching funding, in turn, will help to bridge the large differences between the U.S. and Japan. Therefore, this study will analyze the differences between U.S. and Japan in the initial funding of university spin-off startups in the field of deep tech, and compare the role and impact of each university's innovation ecosystem (Venture Capitals and other entrepreneurial support services) in contributing to the funding of initial phase. This will ultimately lead to a clarification of the causes of the above-mentioned differences in the number of spin-offs created in the U.S. and Japan, as well as the direction for increasing spin-offs in Japan and the desirable form of initial funding.

[12]Association of University Technology Managers, “AUTM US Licensing Activity Survey: 2020,” August 17, 2021, https://autm.net/AUTM/media/SurveyReportsPDF/FY20-US-Licensing-Survey-FNL.pdf.
[13]MEXT, “Form 7 (Rules for Industry-Academia Collaboration, Venture Business from Universities, Etc.) (Excel:578KB) Excel,” n.d., https://www.mext.go.jp/a_menu/shinkou/sangaku/1413730_00016.html.
[14] Toyo Keizai Shinposha, *Hitotsubashi Business Review 2020 SUM. 68, Vol. 1: Corporate Venturing*, 2020.
[15] Toyo Keizai Shinposha.

In the case of the U.S., we chose to focus my analysis on MIT, and in the case of Japan, we chose to focus on the University of Tokyo. The reason for this is that MIT has consistently created and led the top tier in the creation of university spin-off startups in the U.S., as it ranked first in the cumulative number of spin-offs created from 1980 to 2001 and ranked for first with Stanford University in 2015[16]. On the other hand, the University of Tokyo is also the number one university in Japan in terms of the number of spin-offs created and is a leader in the creation of university spin-off startups in Japan. Therefore, by comparing the top universities representing the U.S. and Japan, we will identify the necessary elements for the creation of spin-off startups in the deep tech field from universities.

Table 1.1 Number of startups established based on licensing in the U.S.

Year	2015	2016	2017	2018	2019	2020
Startup Formed (Total)	1,012	1,024	1,080	1,080	1,040	1,117

Source: AUTM(2021)[17]

Table 1.2 Number of startups established based on licensing in Japan

University / Year	2017	2018	2019	2020	2021
Startup Formed (Total of all universities)	86	83	83	88	75
The University of Tokyo	7	9	8	9	1
Osaka University	11	7	7	8	9
Nagoya University	6	3	3	7	4
Kyoto University	8	6	5	7	6
Kyushu University	2	8	5	7	2
Tohoku University	5	7	8	5	6
Hiroshima University	1	1	3	4	4

Source: MEXT (2023)[18]

[16]Association of University Technology Managers, *AUTM U.S. Licensing Activity Survey : FY 2015 /*, n.d.
[17] Association of University Technology Managers, "AUTM US Licensing Activity Survey: 2020."
[18] MEXT, "Form 7 (Rules for Industry-Academia Collaboration, Venture Business from Universities, Etc.) (Excel:578KB) Excel."

2. What is a University Spin-off Startup in Deep Tech?

2.1. Definition of "University Spin-off"

Previous studies have explored the concept of university spin-off startups, but a common perception has emerged that there is no universally agreed-upon definition for this term[19]. However, in reality, there exist both narrow and broad definitions of university spin-offs, and most surveys have employed one of these definitions consistently. The narrow definition of a university spin-off primarily revolves around intellectual property (IP) protection. The Association of University Technology Managers (AUTM) is a typical example, as they asked in their 2022 survey form, "How many STARTUP COMPANIES were formed that were dependent upon the licensing of your institution's technology for their initiation?", indicating that their definition is limited to ventures founded through licensing agreements a technology transfer office (TLO) [20]. Shane defines a university spinoff as "a new company founded to exploit a piece of intellectual property created in an academic institution"[21]. In addition, Japan's Ministry of Economy, Trade and Industry (METI) further classifies university spin-offs into five categories and defines one of them, "research result ventures," as "new ventures established for the purpose of commercializing patents or new technologies and business methods based on research results achieved at universities." This slightly broadens the narrow definition mentioned earlier. On the other hand, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) divides "research result ventures" into two types: "patent-based technology transfer type" and "non-patent-based technology transfer (or research result utilization) type". Thus, even within government organizations in the same country, definitions of university spin-offs vary. Depending on the specific context, various organizations adopt different definitions for university spin-offs. However, the narrowest definition, as proposed by Shane, characterizes a university

[19]Teresa Hogan and Quan Zhou, "Defining University Spin-Offs," *New Technology Based Firms in the New Millennium* 8 (January 1, 2010): 7–23, https://doi.org/10.1108/S1876-0228(2010)0000008004.
[20]AUTM, "AUTM-FY22-Licensing-Survey_Worksheet_1," n.d., https://autm.net/surveys-and-tools/surveys/licensing-survey/2022-licensing-survey.
[21] Hogan and Zhou, "Defining University Spin-Offs"; Scott Andrew Shane, *Academic Entrepreneurship: University Spinoffs and Wealth Creation* (Edward Elgar Publishing, 2004).

spin-off as " a new company founded to exploit a piece of intellectual property created in an academic institution". For statistical purposes, this is also the definition used by major institutions such as AUTM to count the number of university spin-offs.

In a broad sense, a university spin-off is defined as a startup that has leveraged various university resources, including funds, knowledge, human capital, equipment, and material[22]. This definition aligns with the definitions provided by the Japanese METI and MEXT. Moreover, an even broader definition may include cases where alumni are actively involved in the establishment of the enterprise. The study conducted at MIT mentioned earlier, employs this expanded definition. According to this study, the estimated cumulative number of companies founded by various stakeholders associated with MIT, such as alumni, students, and faculty, was around 30,000 as of 2014. In contrast, when using the narrower definition based on intellectual property (IP) as the foundation, the cumulative count of university spin-offs was 579[23]. These figures reveal a significant difference in numbers depending on the definition used. Therefore, the choice of definition greatly impacts the reported figures for university spin-offs.

Figure 2.1 Five Categories of University Spin-off Ventures as Defined by METI

Research Ventures

New ventures established for the purpose of commercializing patents and new technologies and business methods based on research results achieved at universities.

Collaborative Research Ventures

Ventures that have conducted joint research, etc. with universities within 5 years of their establishment in order to commercialize the technology and know-how possessed by the founders, including those that had no specific relationship with universities at the time of their establishment.

Technology Transfer Venture

[22] Hogan and Zhou, "Defining University Spin-Offs."
[23]Roberts, Murray, and Kim, "Entrepreneurship and Innovation at MIT."

Ventures that received technology transfer, etc. from universities within 5 years of their establishment in order to maintain and develop existing businesses, including those that had no special relationship with universities at the time of their establishment.

Student Ventures

Student ventures with deep ties to the university

Only those involving (or made by) current students are eligible.

Related Ventures

Other ventures closely related to the university, such as those funded by the university

Source: METI (2023)[24]

Figure 2.2 Definition and Classification of University Spin-off Ventures by MEXT

Definition

"University spin-off venture" refers to a company that is started based on a patent whose inventor is a faculty member or student of a university, etc., or a company that is founded by a faculty member or student of a university, etc.

Classification

Technology Transfer by Patent

Technology transfer other than patents

Transfer of human resources from universities, etc.

Other related

Source: MEXT (2023)[25]

[24] METI, "Survey on the Status of University-Launched Ventures 2022," n.d., https://www.meti.go.jp/policy/innovation_corp/start-ups/reiwa3_vc_cyousakekka_houkokusyo.pdf.

[25] "Status of Industry-Academia Collaboration at Universities, etc. in FY2021: Ministry of Education, Culture, Sports, Science and Technology," MEXT Homepage, accessed April 16, 2023, https://www.mext.go.jp/a_menu/shinkou/sangaku/1413730_00016.html.

2.2. Definition of Deep Tech

2.2.1 Growing Interest in Deep Tech and its Definition

In recent years, the term "Deep Tech" has become widely used to describe technology companies that require long-term, large-scale research and development in areas such as AI, quantum computing, biotechnology and life sciences, clean tech and climate change, space, and materials. Synonyms for "deep tech" include the words "Tough Tech[26]" and "Hard Tech," which are sometimes used to mean the same thing[27]. To begin with, the term "Deep Tech" is said to have emerged in 2014-2015[28]. Specifically, it was first mentioned by Swati Chaturvedi, who founded Propel(x), the world's first platform dedicated to angel investment in deep tech startups, based on her experience running MIT's angel investor group[29].

Deep Tech is a term used to refer to tech companies based on the results of long-term, large-scale funded research and development, including AI, quantum computing, biotechnology, clean tech, space, materials, robotics, and advanced manufacturing. While no uniform definition has been established, Swati Chaturvedi, mentioned above, defines Deep Tech as "companies founded on scientific discovery or meaningful engineering innovation."

The MIT Sloan School of Management's "What is "Deep Tech" and What are Deep Tech Ventures?" defines Deep Tech as "'science-based technology solutions associated with critical dimensions of uncertainty, a perspective that allows for the changing dynamics characteristic of a fast-changing technological landscape ". They then summarize the uncertainty-based approach and five criteria from the literature to define deep tech ventures as companies that "1) positioned at the scientific frontier, with long and uncertain R&D cycles, 2) building tangible, often regulated,

[26]"Home," The Engine, accessed April 15, 2023, https://engine.xyz/.
[27]Oihana Basilio Ruiz de Apodaca, Fiona Murray, and Lars Frolund, "What Is 'Deep Tech' and What Are Deep Tech Ventures?"," accessed April 15, 2023, https://reap.mit.edu/assets/What_Is_Deep_Tech_MIT_2022.pdf.
[28]Oihana Basilio Ruiz de Apodaca, Fiona Murray, and Lars Frolund.
[29]Oihana Basilio Ruiz de Apodaca, Fiona Murray, and Lars Frolund; "So What Exactly Is 'Deep Technology'? | LinkedIn," accessed April 15, 2023, https://www.linkedin.com/pulse/so-what-exactly-deep-technology-swati-chaturvedi/; "(2) Deep Tech vs General Tech | LinkedIn," accessed April 16, 2023, https://www.linkedin.com/pulse/deep-tech-vs-general-fateh-ali-/.

products and processes, 3) linked to key ecosystem stakeholders, especially Higher Education Institutions, 4) problem-oriented or mission-driven, and hence directed to the solution of public value failures, and 5) built through a dynamic de-risking cycle which recognizes the option space faced by founders and investors".

These approaches are intended to provide a comprehensive framework for defining Deep Tech and deep tech ventures, based on quantitative economic criteria as well as other qualitative and operational criteria as assessed by founders and their stakeholders. It also includes the ability to distinguish Deep Tech from Digital Tech.

Serial entrepreneur Fateh Ali also compares Deep Tech to General Tech, defining Deep Tech as " the PhD holders' startup club where these scientists and engineers with PhDs and advanced degrees are solving large problems facing the world such as global warming, fighting cancers and traffic congestions"[30]. He summarizes the differences between "General Tech" and "Deep Tech" as shown in Figure 2.3. Deep Tech is based on scientific discovery and engineering innovation. In Deep Tech, the qualification is postdoc and PhD, the founders are usually 35 years old or older, gestation is 5 years or more, multiple in-depth trials are required for testing, and regulatory approval is required in many cases.

[30]"(2) Deep Tech vs General Tech | LinkedIn."

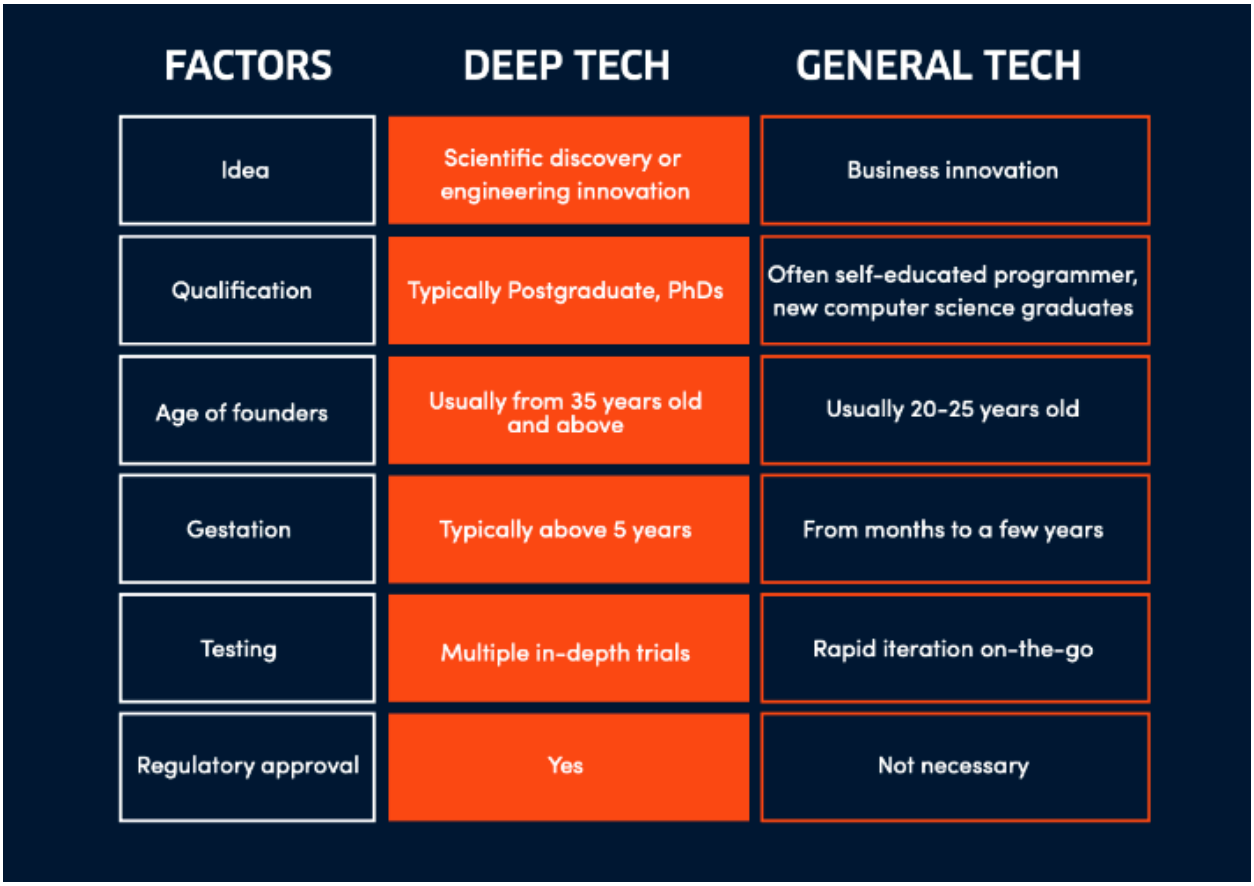

Figure 2.3 Deep Tech vs General Tech

Source: Fateh Ali (2021)[31]

The Engine, a venture capital firm established by MIT to help overcome the valley of death for commercial applications of promising research results, uses the term “Tough Tech” instead of “Deep Tech”. They define Tough Tech as "transformative technology that solves the world's most critical challenges through the convergence of breakthrough science, engineering, and leadership”[32]. And, as The Engine explains, Tough Tech is a company characterized by its proximity to academia, with research results that change our fundamental understanding of the world and revolutionize the processes, materials, systems, and components in the world. And as specific examples, Tough Tech cites fusion power plants, quantum computers with 100 times

[31] “(2) Deep Tech vs General Tech | LinkedIn.”
[32] “Tough Tech,” The Engine, accessed May 25, 2023, https://engine.xyz/tough-tech.

faster computation, biology and materials science, nanoscale manufacturing and robotics, AI and transportation, and others that combine cross-disciplinary knowledge[33].

Also, Deep Tech is fundamentally characterized by the fact that there is often a very well-established market, and there is a risk of deep technical problems rather than the product market suitability issues that VCs generally consider when investing, such as whether there is a market for the product[34]. This makes it difficult for VCs to be an all-encompassing source of funding for deep tech from the beginning to the end of Exit, and historically, public funding has been used to support the development of such technologies and the early days of deep tech in the early stages of establishment[35].

2.2.2 Importance of Deep Tech

Deep Tech is a technological field that will become increasingly important in the future, and its impact will be felt throughout society. Since deep tech can be, for example, the development of new therapeutic drugs to cure cancer and HIV, or the development of new energy sources such as nuclear fusion and fission, it can be a technology that will have a fundamental and very large impact on people's lives and social systems in the era in which it is realized. In addition, technologies such as semiconductors, AI, and quantum computers, for example, will give birth to new technologies through a significant increase in computing speed brought about by quantum computers. Deep tech is an extremely important field that will have a significant impact on national industrial competitiveness and national security because it is a fundamental technology for industry and business. Therefore, governments in the U.S., EU, Japan, China, and many other countries are currently taking the lead in investing huge amounts of R&D funds in order to develop these technologies.

[33]"Tough Tech."
[34]"HBS and MIT Sloan Technology and National Security Conference 2023," April 15, 2023.
[35] "HBS and MIT Sloan Technology and National Security Conference 2023."

In 2018, total combined public and private R&D spending in the United States was approximately $606.1 billion, of which the federal government spent 21% and the industrial sector 70%[36]. On the other hand, from the R&D implementation side, universities account for 12%, while the industrial sector spent 74% and the federal government 10%[37]. By the R&D stage, 17% is allocated to basic research, 19% to applied research, and 64% to development, with universities using 46% of the research funding for basic research[38]. In 2018, federal R&D funding was $135.8 billion and is estimated to rise each year to $159.6 billion by 2022[39]. Japan's science and technology budget (initial budget) is 4.4 trillion yen in 2020, about 4.3 trillion yen in 2023, and the proposed budget for 2024 is also about 4.3 trillion yen[40]. The U.S. has more than three times the R&D budget invested by the government than Japan.

2.2.3 University Spin-off Startups and Deep-Tech

As highlighted earlier, the development of deep tech is deeply tied to the substantial accumulation of research conducted at universities and research institutes. Universities, being prominent research institutions, serve as central locations and key hubs for the generation of deep tech, alongside corporate research institutes. Consequently, a characteristic of university spin-off startups that emerge from university research is their prevalence mostly in the realm of deep tech. Recognizing the pivotal role of startups in fostering the creation of new industries and driving economic growth, many countries are actively promoting startup development policies and fostering an entrepreneurial ecosystem.

[36]JST CRDS, "R&D Strategy in Major Countries (2022)," 2022, https://www.jst.go.jp/crds/pdf/2021/FR/CRDS-FY2021-FR-02.pdf; "U.S. R&D Increased by $51 Billion, to $606 Billion, in 2018; Estimate for 2019 Indicates a Further Rise to $656 Billion | NSF - National Science Foundation," accessed May 24, 2023, https://ncses.nsf.gov/pubs/nsf21324.
[37]JST CRDS, "R&D Strategy in Major Countries (2022)."
[38]JST CRDS.
[39]Congressional Research Service, "Science and Technology Issues for the 118th Congress Updated April 6, 2023," n.d., https://crsreports.congress.gov/product/pdf/R/R47373.
[40]"Outline for Science and Technology Budget Initial Budget Proposal for FY2023 Supplementary Budget for FY2022," n.d., https://www8.cao.go.jp/cstp/budget/r5yosan.pdf.

2.3. Basic Statistical Data

2.3.1. Numbers of University Spin-off Startups: US-Japan Comparison

Basic statistical data on university spin-offs, both in the broad and narrow sense, are presented below. First, a notable disparity can be observed between Japan and the United States. In 2021, the number of university spin-off startups in the United States, specifically those based on university intellectual property, reached a staggering 996, which is more than ten times the corresponding figure in Japan[41]. However, Japan has been implementing the "1000 University Ventures Plan" since 2001, a policy designed to boost the number of university spin-offs[42]. As a result, there has been a tangible increase in the number of university spin-offs, particularly led by institutions like the University of Tokyo[43].

In the United States, MIT has secured the top position in terms of cumulative spin-offs created between 1980 and 2001. Given MIT's status as a technology-focused university and these are spin-offs through licensing, it can be assumed that a significant portion of these spin-offs falls within the realm of Deep Tech. Since 1997, MIT has established a cumulative total of 579 new spin-off companies, with an average of approximately 24-32 new companies being formed annually, including 27 in 2022[44].

In contrast, in the case of the University of Tokyo, according to a survey by MEXT, the number of university spin-offs established through technology transfer of patents is only 7 to 9 companies each year. In addition, according to the Intellectual Property Department of the University of

[41] "Technology Transfer Licensing Survey | AUTM," accessed May 25, 2023, https://autm.net/surveys-and-tools/surveys/licensing-survey/2021-licensing-survey.
[42] "Materials Submitted by Diet Member Hiranuma" (METI, n.d.), https://www.meti.go.jp/policy/innovation_corp/start-ups/senshaplan.pdf.
[43] "University Venture Database (METI/Ministry of Economy, Trade and Industry)," accessed May 5, 2023, https://www.meti.go.jp/policy/innovation_corp/univ-startupsdb.html.
[44] "TLO Statistics | MIT Technology Licensing Office," accessed February 3, 2023, https://tlo.mit.edu/engage-tlo/tlo-data/tlo-statistics; MEXT, "Form 7 (Rules for Industry-Academia Collaboration, Venture Business from Universities, Etc.) (Excel:578KB) Excel."

Tokyo, a cumulative total of 132 licenses have been granted to startups[45], and since this includes grants to existing startups, it means that, at least cumulatively, there are less than 132 newly established spinoff companies. Thus, there is a four to five-fold difference.

Table 2.1 Number of University Spin-off Startups in the U.S.

US	University spinoffs in the broad sense (e.g., including those established by university students)		University spinoffs in the narrow sense (patent and license based)	
	Cumulative total	Newly established	Cumulative total	Newly established
1997~2017	-	-	15,000+	1,080
2018	-	-	16,000+	1,080
2019	-	-	17,000+	1,040
2020	-	-	18,000+	1,117
2021	-	-	19,000+	996

**"-" means there is no data available*

Source: AUTM, 2017~2021

[45]University of Tokyo, "University of Tokyo Intellectual Property Report 2022," n.d., https://www.ducr.u-tokyo.ac.jp/content/400104425.pdf.

Table 2.2 Number of University Spin-off Startups in Japan

Japan	University spinoffs in the broad sense (e.g., including those established by university students)*METI's definition		University spinoffs in the narrow sense (based on university intellectual property)	
	Cumulative total	Newly established	Cumulative total	Newly established
~2015	1,773	24	-	-
2016	1,846	73	-	59
2017	2,093	247	-	86
2018	2,278	185	-	83
2019	2,566	288	-	83
2020	2,905	339	-	88
2021	3,306	401	-	75
2022	3,782	477	-	-

**"-" means there is no data available*

Source: METI (2023)

Table 2.3 Number of MIT Spin-off Startups

MIT	University spinoffs in the broad sense (e.g., including those established by university students and alumni)		University spinoffs in the narrow sense (Intellectual Property Based)	
	Cumulative total	Newly established *estimated	Cumulative total	Newly established
1995	-	900+	99	13
1996	-	900+	105	6
1997	4,000	900+	122	17
1998	-	900+	141	19
1999	-	900+	158	17
2000	-	1,300+	189	31
2001	-	1,300+	218	29
~				
2015	30,000*	-	386	28
2016	-	-	412	26
2017	-	-	439	27
2018	-	-	471	32
2019	-	-	496	25
2020	-	-	528	32
2021	-	-	552	24
2022	-	-	579	27

**Sector breakdown of narrowly defined university spinoffs: 36% physical sciences and hardware, 21% therapeutics, 26% software, and 14% medical devices in 2022*

**"-" means there is no data available*

**"*" means estimated number*

Source: MIT TLO (2023)[46], AUTM (2015)[47], Rory P. O'Shea et al. (2005)[48], Roberts et al. (2019)[49], Bank Boston (1997)[50], Roberts et al. (2011)[51]

[46] "TLO Data | MIT Technology Licensing Office," accessed February 3, 2023, https://tlo.mit.edu/engage-tlo/tlo-data.
[47] Association of University Technology Managers, *AUTM U.S. Licensing Activity Survey : FY 2015 /*.
[48] O'Shea et al., "Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities."
[49] Roberts, Murray, and Kim, "Entrepreneurship and Innovation at MIT."
[50] Bank Boston, *MIT: The Impact of Innovation*.
[51] Edward B. Roberts and Charles E. Eesley, "Entrepreneurial Impact: The Role of MIT," *Foundations and Trends® in Entrepreneurship* 7, no. 1–2 (August 27, 2011): 1–149, https://doi.org/10.1561/0300000030.

Table 2.4 Number of UTokyo Spin-off Startups

The University of Tokyo	University spinoffs in the broad sense (e.g., including those established by university students) *METI's definition		University spinoffs in the narrow sense (Intellectual Property Based)	
	Cumulative total	Difference from the previous year *nearly newly established	Cumulative total	Newly established
2016	227	-	-	9
2017	268	41	-	7
2018	271	3	-	9
2019	268	-	-	8
2020	323	55	-	9
2021	329	6	-	1
2022	371	42	~ 132	-

**"-" means there is no data available*

Source: METI (2023), MEXT (2023), UTokyo (2023)

3. Research Objective and Methodology of Study

In this section, we present the research questions and objectives, followed by an overview of the scope and methodology employed in this study.

3.1. Research Questions

As mentioned earlier, while the United States has successfully generated over ten times the number of university spin-off startups compared to Japan, despite its comparable number of patent applications, significantly lags behind in the creation of such startups.

One of the primary challenges faced by deep tech startups prior to commercialization is the "capital gap" or "valley of death," which represents a critical funding hurdle and often serves as the initial turning point towards success for university spin-off startups.

Hence, this study examines the university ecosystem's contribution to the formation of university spin-off startups in the United States and Japan, with a particular focus on overcoming the "valley of death." The university ecosystem encompasses university-affiliated or related venture capital (VC) firms and university-provided startup supporting services including gap funding and mentoring services. Additionally, short case studies are conducted on the fundraising journeys of university spin-off startups from MIT and UTokyo that have either successfully overcome or are on the verge of overcoming the "valley of death." Based on these analyses, the study aims to achieve the following objectives:

1. Enhance the actions and policies of the Japanese government and universities in expanding the ecosystem for creating university spin-off startups in Japan, using the successful U.S. ecosystem as a benchmark.
2. Assist entrepreneurs of university spin-off startups who are considering future funding in overcoming the challenges posed by the "valley of death."

In light of the above, the research questions addressed in this study are as follows:

1. How does the university ecosystem differ between the United States and Japan?
   1.1 How do the objectives and investment policies of university-related VC differ between the United States and Japan?
   1.2 How does the support provided by the university ecosystem to university spin-off startups differ between the United States and Japan?
2. What fundraising choices do university spin-off startups make?

To analyze these differences, key individuals in each respective area were interviewed, and their insights were supplemented by a literature review. The scope and methodology employed in this study are elaborated upon in the subsequent sections.

3.2. Scope of Study

Although the definition of "university spin-off" exhibits some variability as discussed earlier, it can be inferred that the majority of university spin-off startups arising from the licensing of university intellectual properties (IPs) through technology transfer offices (TLOs) are primarily rooted in the deep tech domain. For instance, MIT's spin-off startups span various sectors, with a focus on Physical Science & Hardware, Therapeutics, Software, and Medical Devices & Diagnostics & Research Tools[52]. Notably, apart from certain software-based ventures, these sectors demand extensive time and investment for development. Consequently, this study considers university spin-offs established through TLO licenses as deep-tech university spin-offs and includes them in the investigation. To facilitate a comparison between leading universities in Japan and the United States, MIT, renowned for its significant number of startups based on licenses, and the University of Tokyo, a top-ranked Japanese institution for university spin-offs, were selected. Additionally, to examine cases at Japanese private universities, VC firms affiliated with Waseda University, Keio University, and Tokyo University of Science were also included in this study. In the context of short case studies, the inclusion criteria encompassed university spin-off startups as previously defined, as well as one case study of a startup not directly associated with IP licensing but originating from an MIT laboratory, as MIT born startup.

Moving on to the university ecosystem analysis, the first focus rested on university-related venture capital firms, including those established by universities themselves. For MIT, the survey targeted The Engine, a VC founded by the institution, while for the University of Tokyo, UTEC, a UTokyo-related VC, and UTokyo IPC, a VC of a subsidiary of the university, were surveyed. Private universities were also considered, with VC firms associated with Tokyo University of Science, Keio

[52] “TLO Statistics | MIT Technology Licensing Office.”

University, and Waseda University included in the study. The selection of these three private universities was based on their prominent research status within the private university sector in Japan.

Regarding the ecosystem and resources within the universities, the study emphasized identifying the internal mechanisms contributing to the formation of deep-tech university spin-off startups. Specifically, these resources encompassed grant programs, customer discovery practice initiatives, and mentoring services.

3.3. Methodology

3.3.1. US: Massachusetts Institute of Technology

In our study, we first focused on analyzing the ecosystem that contributes to the creation of deep tech spin-offs at MIT. To gain insights into this ecosystem, we conducted interviews with the representative from The Engine, a VC firm founded by MIT, and complemented the findings with relevant literature. This investigation aimed to examine the role of university-related VC and their investment policies. Additionally, we explored the internal support services within MIT that facilitate the establishment of university spin-offs. This analysis was based on interviews with representatives from these services and a review of existing literature.

For the purpose of conducting short case studies, we interviewed co-founders of five MIT spin-off startups to gain a deeper understanding of their fundraising journeys. It is worth noting that MIT has seen the establishment of 579 spin-off companies through licensing via the Technology Transfer Office (TLO). However, the TLO does not publicly disclose the complete list of these companies. Therefore, we relied on various sources to confirm spin-off companies that were founded through licensing from MIT. From this group, we approached several spin-off companies to request interviews, considering a balanced representation across different industry sectors. Ultimately, we conducted interviews with five companies that agreed to participate within a specific time frame. To supplement our understanding of their fundraising journeys, we gathered

information from Pitchbook and Crunchbase, which provide access to comprehensive data on private and public capital markets, as well as government databases. It is important to note that the selection of these five companies does not represent a diverse range of funding sources, as four out of the five received funding from The Engine. Additionally, it is important to acknowledge that industries such as AI and software, hardware including quantum computers and semiconductors, and the space sector were not included in the case studies.

3.3.2. Japan: The University of Tokyo and others

In our study, we conducted an analysis of the ecosystem that contributes to the creation of deep tech spin-offs at the University of Tokyo (UTokyo), following an examination of trends and policies related to university spin-off startups in Japan. To gain insights into this ecosystem, we conducted interviews with UTEC, a VC firm with a partnership with UTokyo, and UTokyo IPC, the VC of the University of Tokyo to investigate the role of university-related VCs and their investment policies. Additionally, we conducted a literature review to supply interviews. To provide a more comprehensive understanding of university-related VC in Japan, we also interviewed VCs from Japanese private universities, namely Waseda University, Keio University, and Tokyo University of Science. Furthermore, we analyzed the role of internal services within UTokyo that support the establishment of university spin-offs, drawing on interviews with their representatives and existing literature.

For the purpose of conducting short case studies, we interviewed co-founders of six UTokyo spin-off startups to gain insights into their fundraising journeys. UTokyo has announced a cumulative total of 123 startups licensed by their Technology Transfer Organization (TLO). However, this number includes licenses granted to existing startups, including overseas ones, making the exact number of spin-off companies unknown. Moreover, the University of Tokyo TLO does not disclose the complete list of companies. Therefore, we identified spin-off companies founded through licensing from UTokyo through various sources and requested interviews with a selected number of companies, considering a balanced representation across different industry sectors. Ultimately, we conducted interviews with six companies that agreed to participate within a

specific time frame. To supplement our understanding of their fundraising journeys, we gathered information from Pitchbook and Crunchbase, which provide comprehensive data on private and public capital markets, as well as government databases. It is important to note that the selection of these six companies does not represent a diverse range of funding sources, as three out of the six companies received funding from UTokyo IPC. Additionally, it is important to acknowledge that industries such as heavy energy (e.g., nuclear fusion), hardware (e.g., quantum computers and semiconductors), and the space sector were not included in the case studies.

4. MIT Ecosystem Related to the Creation of a University Spin-off Startups

In this chapter, we delve into an in-depth investigation and analysis of the ecosystem at MIT pertaining to the establishment of university spin-off startups. We commence by presenting the findings from a literature review in Section 4.1., which shows the insights gleaned from previous research conducted on the subject of university spin-off startup creation at MIT.

Subsequently, in Section 4.2., we examine the crucial role played by various services offered by MIT in facilitating the creation of spin-off startups in the deep tech field. By reviewing these services, we aim to gain a comprehensive understanding of the specific mechanisms and support structures that contribute to the success of MIT spin-offs.

4.1. Literature Review-Insights from previous research

MIT has been widely studied in the context of university spin-offs. A 2007 study conducted a systematic analysis using MIT as a case study, given its position as the leading generator of spin-offs in the United States[53]. The study highlights that MIT's success can be attributed to its strong

[53]Rory P. O'Shea et al., "Delineating the Anatomy of an Entrepreneurial University: The Massachusetts Institute of Technology Experience," *R&D Management* 37, no. 1 (2007): 1–16, https://doi.org/10.1111/j.1467-9310.2007.00454.x.

science and engineering resource base, including the quality of its research faculty, the support provided by organizational mechanisms and policies such as the Technology Licensing Office, and the culture within the faculty that fosters entrepreneurship [54]. To fully comprehend the development of these resources and organizational mechanisms, the authors argue it is necessary to consider the historical context and emergence of MIT in the local environment [55]. The study suggests that while external institutions can learn from the MIT example, attempting to replicate specific elements of the MIT model may yield limited success due to the complex interplay of spin-off dynamics[56].

In a 2017 study of eight early-stage university spin-offs from MIT, their initial fundraising efforts were presented. These spin-offs benefited from the support provided by MIT's Venture Mentoring Service (VMS) [57]. They collectively raised over $70 million in their early years, with more than 80% of the funding coming from research grants, including programs like the Small Business Innovation Research (SBIR) and other public research funds[58]. Personal resources and small prizes from competitions supplemented the grants[59]. The spin-offs also obtained equity-type funds from individuals closely associated with the founders, such as family, friends, and professors[60]. The authors further explain that in the post-graduation phase, equity investments primarily came from angel investors connected to the founders' key contacts, who had non-financial motivations. The funding primarily supported further technological development through hiring qualified researchers and engineers[61]. As the spin-offs matured, professional investors became necessary to secure larger financing for organizational transition, commercialization, job creation, and capital investment[62]. Four out of the eight spin-offs received substantial equity investments exceeding $50 million from venture capital firms[63].

[54]O'Shea et al.
[55]O'Shea et al.
[56]O'Shea et al.
[57]Hayter, Lubynsky, and Maroulis, "Who Is the Academic Entrepreneur?"
[58]Hayter, Lubynsky, and Maroulis.
[59]Hayter, Lubynsky, and Maroulis.
[60]Hayter, Lubynsky, and Maroulis.
[61]Hayter, Lubynsky, and Maroulis.
[62]Hayter, Lubynsky, and Maroulis.
[63]Hayter, Lubynsky, and Maroulis.

From these two previous studies, it is suggested that when attempting to transfer the MIT model to other regions, it is important to recognize the complex ecosystem and learn from it rather than simply copying it wholesale. Therefore, it is imperative to carefully assess and determine which characteristics and elements of the MIT ecosystem should be integrated into the relocation site, considering the historical background and intricate nature of the existing ecosystem. Furthermore, there is an indication that the availability and composition of funding sources, such as public funding, venture capital, and angel investors, may vary depending on the stage of the company's development. Different stages of growth necessitate different types of financial support. This dynamic funding landscape underscores the critical importance of public grants, particularly during the early stages of a spin-off's journey. The following ecosystem and startup case studies will take this into account in the analysis.

4.2. MIT On-campus Service

4.2.1. Overall

MIT is deeply committed to entrepreneurship education and the commercialization of research outcomes with a wide array of resources distributed throughout the university. The Sloan School of Management stands at the forefront of this effort, offering numerous courses related to startups and entrepreneurship and action learning experiences that simulate the process of launching ventures in various domains, such as mobility, climate and energy, biotech, and more. Notably, the New Enterprise course provides students with hands-on experience in starting a business, regardless of their field of study[64]. In addition, the MIT D-Lab offers a variety of courses which aim to solve real-world problems by designing products using design thinking[65]. In addition, there are various Entrepreneurship Competitions, including the MIT $100K Entrepreneurship Competition, a pitch event led primarily by MBA students; the MIT Climate & Energy Prize; the MIT Water, Food & Agriculture Innovation Prize; and the MIT Sloan Healthcare Innovations Prize,

[64] "MIT Subject Listing & Schedule Fall 2023," accessed May 25, 2023, http://student.mit.edu/catalog/index.cgi.
[65] "ABOUT," accessed May 2, 2023, https://d-lab.mit.edu/about.

all of which offer small cash prizes for the winners[66]. Additionally, numerous hackathons sponsored by companies are held in diverse fields, such as the MIT Sloan Product Management Hackathon sponsored by Google and the Future of Wellbeing Hackathon sponsored by Samsung[67]. Furthermore, students at MIT organize conferences spanning various fields, featuring esteemed speakers, thereby creating abundant networking opportunities with investors, entrepreneurs, and industry professionals. These conferences serve as platforms for knowledge exchange and collaboration, allowing attendees to connect with influential individuals in their respective industries.

MIT's entrepreneurial programs encompass a wide range of initiatives, including the Deshpande Center, which provides funding for commercial research; the Venture Mentoring Service that offers mentoring services to entrepreneurs at MIT; the MIT I-Corps program, which focuses on customer discovery; the Startup Exchange that facilitates connections between industry and MIT-affiliated startups; the Martin Trust Center for Entrepreneurial Education; and MIT Sandbox Innovation Fund Program, which provides small grants for early-stage company ideas. These programs are just a glimpse of the comprehensive services available on campus to support entrepreneurial endeavors. Additionally, The Engine, a venture capital fund and accelerator dedicated to Deep Tech, plays a pivotal role in bridging the financial gap between deep tech research and commercialization. Furthermore, the E14 Fund, a smaller venture capital firm, specifically supports the MIT Startup Community[68]. Figure 4.1 provides a visual representation of MIT's entrepreneurship-related programs, demonstrating their comprehensive coverage throughout the entire entrepreneurial journey.

[66]"MIT $100K," MIT $100K, accessed May 2, 2023, https://www.mit100k.org.
[67]Mirei Rioux, "Hack with Samsung 2022," MIT Media Lab, accessed May 2, 2023, https://www.media.mit.edu/events/samsunghackathon2022/; "MIT Sloan Product Management Hackathon," Career Advising & Professional Development | MIT, January 19, 2023, https://capd.mit.edu/blog/2023/01/19/mit-sloan-product-management-hackathon/.
[68]"About Us," E14 Fund, accessed May 2, 2023, https://www.e14fund.com/about.

In this section, we offer an in-depth overview of several key initiatives, namely The Engine, Deshpande Center, Venture Mentoring Service, MIT I-Corps, and Startup Exchange, all of which play crucial roles in fostering the creation of MIT spinoffs, particularly in the deep tech domain.

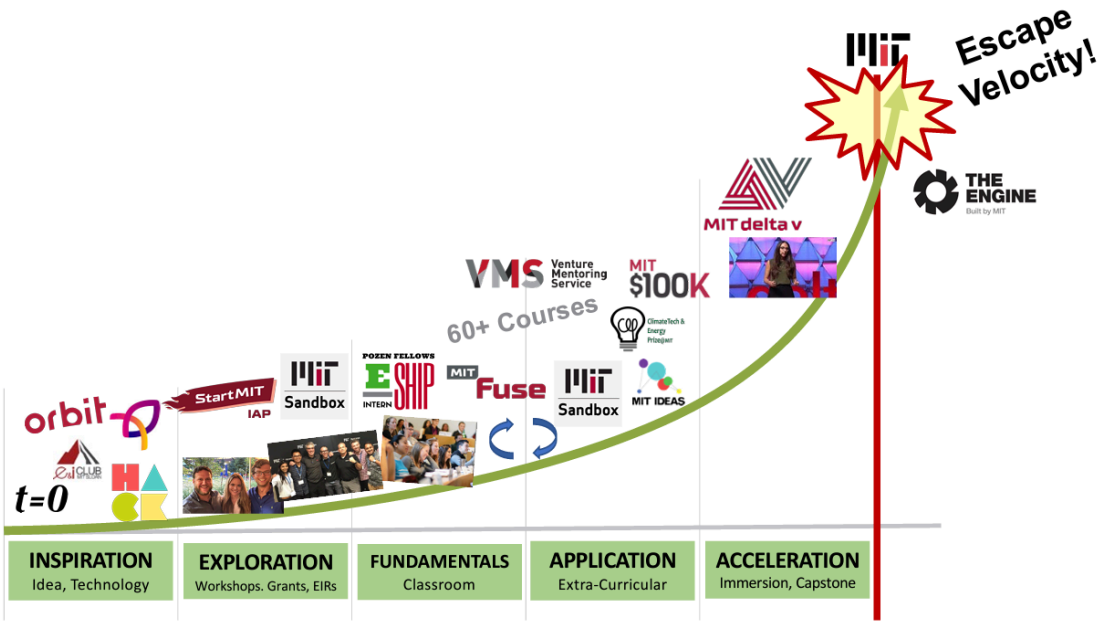

Figure 4.1 Entrepreneurship Ramp

Source: Martin Trust Center for MIT Entrepreneurship (2023)[69]

4.2.2. The Engine Built by MIT

(1) Founding History

The Engine, an accelerator and a venture capital fund launched by MIT in 2016, seeks to bridge the gap between research and commercialization, filling a need that most angel investors, seed funds, and VCs do not invest in and currently underserve: difficult but promising technologies

[69] "Home Page," The Martin Trust Center for MIT Entrepreneurship, accessed May 21, 2023, https://entrepreneurship.mit.edu/.

"Tough Tech", which is equivalent to deep tech[70]. The Engine was founded as MIT's solution to a challenge that MIT leadership has heard from many faculty and alumni entrepreneurs: "It is difficult for companies developing capital- and time-intensive technologies to get sustained support"[71]. L. Rafael Reif, the MIT President at the time, cited three main reasons for MIT to launch The Engine: to provide "patient" capital to entrepreneurs developing innovative technologies, to keep startups in the region, and to provide a successful example to aspiring entrepreneurs in developing innovative technologies[72]. According to MIT's explanation at the time of its founding, The Engine prioritized breakthrough ideas over initial profits, shortened the time it took for startups to become "VC ready," and required less equity than usual to startups, allowing founders to retain more control over their companies[73]. The Engine appointed Katie Rae, a veteran tech innovator, entrepreneur, and investor, as CEO[74]. She has a strong background in managing startup accelerators and business-innovation programs in Boston and Cambridge[75]. The criteria for the position included extensive experience at leading startup accelerators and venture capital firms, as well as in-depth knowledge of the local innovation and entrepreneurial ecosystem, making Rae's selection a very lengthy process[76]. To launch its first fund, The Engine raised $200 million in initial funding from limited partners, above its initial goal of $150 million, with MIT contributing $25 million of that as a limited partner[77]. The Engine was built by MIT, but operates independently of MIT, and as part of its organizational design, The Engine's evaluation committee consists of outside experts to avoid any conflicts of interest[78].

[70] Michael A. Cusumano, "MIT's 'The Engine':VC Fund, Incubator & Ecosystem for 'Tough Tech'"; "MIT Launches New Venture for World-Changing Entrepreneurs," MIT News | Massachusetts Institute of Technology, October 26, 2016, https://news.mit.edu/2016/mit-announces-the-engine-for-entrepreneurs-1026.
[71] "MIT Launches New Venture for World-Changing Entrepreneurs"; "Home," The Engine, accessed April 18, 2023, https://engine.xyz/.
[72] "Community forum gives insight into how The Engine will run," MIT News | Massachusetts Institute of Technology, December 2, 2016, https://news.mit.edu/2016/the-engine-community-forum-1202.
[73] "MIT Launches New Venture for World-Changing Entrepreneurs."
[74] "The Engine Names Startup and Investing Veteran Katie Rae as President and CEO," MIT News | Massachusetts Institute of Technology, February 13, 2017, https://news.mit.edu/2017/the-engine-katie-rae-president-ceo-0213.
[75] "The Engine Names Startup and Investing Veteran Katie Rae as President and CEO."
[76] "The Engine Names Startup and Investing Veteran Katie Rae as President and CEO."
[77] "MIT Launches New Venture for World-Changing Entrepreneurs"; "The Engine announces investments in first group of startups," MIT News | Massachusetts Institute of Technology, September 19, 2017, https://news.mit.edu/2017/the-engine-announces-investments-first-group-startups-0919.
[78] "Community forum gives insight into how The Engine will run."

(2) Investment Policy

The Engine invests in any startup in the Greater Boston area, regardless of whether or not it has a relationship with MIT. The Engine's Partner Michael Kearney explains The Engine's investment policy as follows.

"MIT made a very important decision when they founded the Engine not to limit it to MIT, simply because we want to be in the top quartile return profile. As a venture firm, you need to have access to a lot of opportunities in order to do that."

Currently, The Engine has two core funds and a following fund with $672 million total assets under management, and of those 48 portfolio companies, about 60% are MIT-related startups, about 20% are Harvard, and another 20% are Tufts University and Northwestern University and industry, among others[79]. They look at 1,000 potential investment opportunities per year, but invest in only 6-8 of them, for a closing ratio of less than 1% to the opportunity, and 80% of deals are dropped at the first step of the investment decision process[80]. According to Kearney, although the Engine does not have an internal target for the number or percentage of investments in MIT-related startups, the result is that about 60% of their investments are in MIT-related companies, and the majority of the potential companies they can invest in are from MIT. Kearney spoke about the Engine's policy on which technical areas to invest in, as follows.

"We're not thesis-driven upfront like we need to do a quantum investment in oxonium qubits or whatever. It is more like where do we see the fields emerging and the researchers that are working in those fields? and then we will go talk to those researchers and gauge interest in commercialization"

[79]Michael Kearney, Interview with Partner of the Engine, April 25, 2023; The Engine, "The Engine Report 2022," n.d., https://engine.xyz/reports/engine-report-2021-2022#chapter-the-full-report.
[80]Michael Kearney, Interview with Partner of the Engine.

The Engine is also working with student interns to begin setting up "what is that landscape of the different fields where we could be interested," "who is active and producing," and "where are the discontinuous jumps in knowledge"[81].

(3) Investment Decision Criteria

Team, Market, Technology, and Impact are the four factors that The Engine considers when making investment decisions. Kearney said that these four are common VC considerations and that what is unique to The Engine is the granularity of these factors. He explained as follows:

“On the team side, because of our early-stage remit on translating breakthrough science, we believe what we do is we fund oftentimes first-time entrepreneurs who are coming out of the lab. What do we look for in the team at that moment where other investors are probably looking for years of experience in the industry? We're looking for potential growth, in particular, the potential for that person to emerge as a leader and a CEO and to develop the skills necessary to do that, and it's very hard. So that is probably the biggest hurdle for us. There's a technology piece which we got to get to. We assessed the market in deep tech, in tough Tech. I think oftentimes, innovators are innovating into existing large markets, which I think is helpful. It's not always true. But that is a reality of tough tech in many spaces. I work mostly in energy. It's definitely true in energy. Then impact, we're not impact investors. But I think it's embedded in the DNA of what we're doing.”

Regarding the technical due diligence process, they undertake the following key activities within The Engine.

“There are three things we do before we are exposed to an idea. We have done a whole bunch of landscaping work often around the field and have a sense for it. An example would be hydrogen production. We've done a variety of different landscapes around electrolysis around pyrolysis around other things on how do you actually produce hydrogen, what are the costs

[81] Michael Kearney.

across, where are there technical jumps that can be made, who's making those jumps, so that when an opportunity comes in, we are up the learning curve, not all the way but we're up it. Then oftentimes, we will do a deeper dive into the specific approach being considered to place it in more granularity within that landscape. And we'll do that internally with our team. We have a pretty large team. I think that's necessary for what we do. Because we need people of varying technical expertise and the ability to actually run up that learning curve themselves. And then the third thing we will do is we'll talk to experts in the field that can validate whether we did that correctly. And so that's on the technical diligence side."

(4) Strategies that Enable the Attainment of High Returns as a VC in Deep Tech Area

As previously discussed, The Engine operates as a VC with a primary objective of generating substantial returns. However, VCs often face challenges in achieving high returns from deep-tech investments due to the inherent uncertainties and prolonged timeframes until exit associated with such tough-tech ventures, which constitute The Engine's investment focus. Thus, one Japanese university-affiliated VC, for instance, limits its deep-tech investments to approximately 30% of its overall portfolio to maintain its desired returns as a VC[82]. In contrast, The Engine, as a VC, strives for significant returns, and the viability of this pursuit is made possible through a combination of internal strategies and external environmental factors. First, Michael Kearney, partner at The Engine elucidates that the organization adopts a strategic approach internally, encompassing considerations of time horizon, frequency of experiments, and capital intensity.

"The goal is to be a top decile quartile venture. What does that mean? That means that we have a longer time horizon to return capital to our limited partners. Unlike a traditional 10-year closed-ended venture fund, we have 18 years. What that means is, if you are going to have an exit in that time, over a longer period of time, the exit has to be larger. You are only making bets on companies that could exit in a really foundational way down the road. Historically, it's also true, so that's this division. It is also true that a lot of these spaces have not exited in that way for a variety of reasons. Time horizon is one. We think a longer-term fund gives you a better shot at

[82]Yuichi Katayori, Interview with CEO of Tokyo University of Science Innovation Capital, March 19, 2023.

that. Experimentation cadence and matching with the venture capital flows into companies is another. Capital intensity is a third. The Engine, as MIT set it up, is two parts. It is patient capital and it is the set of services, equipment and access to all of it here that is supposed to accelerate that pace of experimentation. So that is the experiment. If you put those two things together, can you get to a return profile that is in the top quartile of venture return? That's what we are executing on. I think that's internal to what we do."

Kearney expounds on the external factors that contribute to The Engine's feasibility on high returns, highlighting two key elements. Firstly, he underscores the significance of technological advancements that have substantially enhanced the pace of experimentation, enabling more efficient and rapid development and iteration processes. Secondly, he emphasizes the expansion of the technology-driven market, which can be attributed to the U.S. government's strategic industrial policy. This policy framework has created an environment conducive to the growth and proliferation of technology-based ventures, thereby facilitating market opportunities and avenues for commercialization. Kearney explains as follows:

"I think there are a set of external features that are also important to note. The ability to experiment in these spaces has radically changed in the last decade. The amount of simulation going into all of the work here is massive. I started a battery company 13 years ago and we were testing, I think we at one point put together a Gantt chart where we needed to be testing, basically 400 batteries a month in order to see the climb and performance of the road to go up an S curve to get to the market performance that we needed to hit. Today, a lot of that can be done "*in silico*" in computational models, because those models have gotten so good. Compute power is what it is and the ability to predict performance through a set of analytical tools is unprecedented in the field. And so, I think that is an external feature that is promising for folks investing in deep tech for sure."

"The third is a set of markets that have developed around these technologies. On the climate side, it's a real big deal. The IRA (Inflation Reduction Act) created markets out of thin air for a

bunch of stuff here in the United States, and this is going to be replicated elsewhere. The Chips Act (CHIPS and Science Act) is creating competition in advanced systems in lots of different fields, which I think is really important. So, there's this kind of layer of industrial policy that plays a role here because we're no longer an economy that is only optimizing on cost, but it is now seriously national security, environmental issues, etc. So, like there's a reason to think that also matters. All of that is to say that is why I think we could possibly be in that top quartile venture. Again, we need to put points on the board and show."

(5) Complementary dynamics between funds and an accelerator

While the preceding discussions have predominantly centered around The Engine's venture capital facet, Kearney underscores the necessity of dissecting The Engine into two distinct entities: a fund and an accelerator. He highlights the following observations:

"The fund has a mandate. The Accelerator has a mandate. The accelerator mandate is to make stuff happen faster. The fund is to provide patient capital. They necessarily need to work together because of the complementarity within. On the accelerator side, there's a lot of important value, a public benefit perspective. It is an accelerated public benefit corporation. And I think that is critical because you then have a mission and you're executing the mission and you are beholden to the board on that mission."

In essence, the fund, operating as a VC, functions with the core objective of generating financial returns, while the accelerator operates with a pronounced emphasis on public-oriented objectives. The symbiotic complementary relationship between the two entities engenders accelerated growth, leveraging the fund's investments in conjunction with the accelerator's comprehensive support and laboratory facilities.

(6) Summary and Analysis

The establishment of The Engine aimed to address the specific needs of deep tech ventures by providing patient capital, showcasing successful entrepreneurial stories, and fostering the

growth of the overall Boston ecosystem by retaining top-tier startups in the region. The Engine functions as a dual entity, encompassing both a high-return-focused fund and an accelerator with a public-oriented mission, synergistically reinforcing each other's objectives.

First, as a fund dedicated to investing exclusively in deep tech, the Engine's strategy for achieving high returns is not to limit its investments to MIT. Instead, it actively seeks diverse investment opportunities across the technological landscape. Second, by setting a long-time horizon of 18 years, the fund strategically positions itself to maximize returns upon exit. Third, the fund employs a rigorous selection process, meticulously choosing companies with the potential for substantial returns upon exit - an investment rate of 1% or less per opportunity). Lastly, the fund leverages the density of capital and collaborates with accelerators to facilitate accelerated growth. This expedites the process of experimentation, enabling a faster iteration and validation of technologies.

However, it should be noted that the efficacy of this strategy is still unfolding, as it still takes time for the invested companies to exit.

4.2.3. Deshpande Center

(1) Overview

The Deshpande Center at MIT offers faculty members small research grants designed to facilitate the translation of their research findings into tangible social applications[83]. This Grant from the Center is representative of MIT's efforts to fill the funding gap that exists in the commercialization of research within the realm of deep technology.

In 2002, the Deshpande Center was established with a donation from philanthropist Gururaj "Desh" Deshpande and his wife Jaishree to assist in the social implementation of MIT's groundbreaking research[84]. Because of this background of its foundation, the Deshpande

[83] "Mission & Values," *Deshpande Center for Technological Innovation* (blog), accessed April 22, 2023, https://deshpande.mit.edu/mission-values/.
[84] "Mission & Values."

Center's funding does not come from MIT, but comes from individual and corporate donations, necessitating significant effort from the team to engage in fundraising activities. Consequently, the team operates independently from MIT in terms of financial support[85].

For research projects that the Deshpande Center believes can leave the lab and move forward toward commercialization in two to four years, it will provide $50,000 in the first year, followed by $100,000 or $150,000 in the subsequent year, with a maximum funding cap of $250,000 in funding[86]. It is important to note that once a company spins out of MIT and starts its own operations, the grant from the Deshpande Center ceases. In other words, companies that receive the grant are unable to seek additional funding from venture capitalists or other sources from the following month onwards[87]. However, the Deshpande Center may exercise flexibility in cases where funding has been provided for one year, and a company wishes to spin out of MIT in the eighth or ninth month[88]. Nevertheless, once the spin-out occurs, funding from the Deshpande Center terminates.

Upon receiving a grant, participants will benefit from mentorship and engage in a two-pronged approach to technology development and market compatibility research. Currently, market compatibility research is conducted through the MIT I-Corps, an NSF grant-funded program. , Prior to the establishment of MIT I-Corps, the Deshpande Center itself conducted market development courses. Although MIT I-Corps now oversees this aspect, grantees of the Deshpande Center are required to participate in the MIT I-Corps program, which involves conducting 15-20 customer surveys[89].

[85] Leon Sandler, Interview with Deshpande Center, April 19, 2023.
[86] "MIT Deshpande Center Grants," *Deshpande Center for Technological Innovation* (blog), accessed April 22, 2023, https://deshpande.mit.edu/mit-deshpande-center-grants/; Leon Sandler, Interview with Deshpande Center.
[87] Leon Sandler, Interview with Deshpande Center.
[88] Leon Sandler.
[89] Leon Sandler.

(2) Objectives of Deshpande Center

The primary objective of this funding is to get the research results to the point where they leave the university for commercialization, for example, to get enough experimental data to make them more attractive to investors[90]. Leon Sandler, who has been a member of the Deshpande Center since 2006 and is currently its Executive Director, emphasizes the importance of substantiating patents with tangible data to demonstrate the technology's viability and commercial potential. He states the following;

“Patents don't mean anything without real data. So, you can patent stuff that has no commercial value. But it's so that they can do whatever experiments they need to do to actually show that the technology has a good chance of working, that's the key”

Therefore, the allocated funds are specifically directed towards deep tech endeavors and are not intended for traditional IT ideas aimed at creating platforms like a second Facebook or Twitter. It should be noted that only faculty members are eligible to apply for the grant. They give money to faculty but not to students. This is a big difference from the MIT Sandbox Innovation Fund Program, another MIT entre program, where students can receive a certain amount of money . This distinction arises from the divergent missions of the two programs. As Sandler explains, Sandbox focuses on providing entrepreneurial education and experiential learning for students. In other words, the goal is not to create a company and commercialize the technology. On the other hand, the Deshpande Center's funding aims to support further research and technological advancement at MIT. Unlike other entrepreneurship-focused programs such as VMS, the Martin Trust Center, and Sandbox, the Deshpande Center, as highlighted by Leon Sandler, operates with a different focus and objective.

" We are not focused on entrepreneurship. We are focused on innovation. So, what do we mean by innovation is getting this technology that's being developed in the labs at MIT, out into the world to be commercialized. So, innovation and commercialization, that's our focus. It happens

[90]Leon Sandler.

that we also do entrepreneurship because people spin companies out but that's not our core focus. “

Consequently, the Deshpande Center does not care whether the resulting technology is commercialized through a startup or an established large company. The ultimate goal is to ensure that the technology is deployed in the world, making a meaningful impact.

(3) Why the Exit After the Project is Almost Always a Startup

However, it is observed that startups tend to achieve more successful outcomes in most cases, resulting in the prevalence of startups as the preferred path for commercialization. Leon Sandler states as follows:

"We don't care if there's a technology that is developed, and it does not go into a startup but it gets licensed to a large company. We would say that's fine because our goal is not to start companies, our goal is to get the technology into the world where it can have an impact. That's our goal and mission.”

Sandler further underscores the significance of startups in achieving success, emphasizing that, ultimately, startups have a higher likelihood of thriving in the commercialization process.

“However, I will tell you that large companies generally cannot take university technology and develop it further. It doesn't work. That's why we ended up doing startups because to take something that's research out of university and just give it to a large company and expect them to bring it to market, it doesn't usually succeed. I have not seen one case of it succeeding, maybe there are some but it doesn't succeed because when you take the university technology which is very, very early, it needs a very focused team that's very motivated. This is what they want to do. And they have to change direction a lot. That doesn't fit with the way of large companies. Large companies are really good at developing certain things. But generally, they're incremental to their business. And they can't pick up the stuff from here and somehow develop it and it doesn't

work. So that's where most of our stuff will go into startups. If there was something which could be licensed and a large company could do a good job. That's fine. And we've tried that once or twice, but it hasn't worked because it just dies. It gets stuck. It's not invented here and then people are working on six other things and it just goes nowhere. Whereas if you take it into a startup, you have a very, very focused team that's very motivated, they feel ownership and they drive it forward."

(4) Selection Criteria

The acceptance rate for applications depends on the size of the annual budget, but is approximately 20~40% [91] . The selection process for projects at the Deshpande Center incorporates several criteria to ensure a rigorous evaluation. The decision-making is entrusted to an external committee comprising approximately 30 individuals from outside MIT. This diverse committee plays a pivotal role in the selection process, providing their expert opinions and insights.

i. Criteria 1: Can Technology Leave MIT in 2-4 Years?

Among the key selection criteria is the assessment of whether the technology in question possesses the potential to transition out of MIT within a specific timeframe of two to four years. The maturity level of the technology is a crucial factor considered during this evaluation. If the technology is deemed ready for immediate departure from MIT or if the applicants can secure funding without assistance, the project may not be eligible for funding from the Deshpande Center. Conversely, if the technology is still in the early stages of scientific development, it may be considered too premature for funding at that juncture. Thus, the Deshpande Center seeks projects that fall within the optimal range, where they can provide a valuable boost to propel the technology forward. Sandler explains as follows:

The first thing is" Do we think this technology could leave MIT in two to four years? How mature is it? Two to four years, or three to four years. If it's something that could leave MIT tomorrow,

[91] Leon Sandler.

we don't fund it because they don't need us. If they can raise money tomorrow, they're already there. They are beyond where they need us. And we have some who come to us, and they're looking to start a company three months later, and we say “If you're there, just start the company. Don't come to us”. So that's on the one side. On the other hand, we'll have some people who come to us and we look and we say “This is still early science. It's too early.” So, it has to be in the right spot where with a little bit of help it can get. It's not quite there. So that's the state of technology.”

ii. Criteria 2: Is There a Market Opportunity?

The second criterion for project selection at the Deshpande Center pertains to assessing the presence of a market opportunity. While the market need does not necessarily have to be extensively defined at this stage, it is essential to have a comprehensive understanding of the potential market for the project. The Deshpande Center seeks projects where there is a reasonable belief that a market opportunity exists, even if the specifics of the market may require further definition. Sandler explains as follows:

" The second thing is we have to look at this and believe that there is a market opportunity. But it doesn't have to be very well defined. At this stage, it could still need definition but we have to understand what is the market. If somebody doesn't know where this is going to go or they have some vague idea, we don't want us to be like, they could spend a year, we've had this happen a year or two years and then they cannot find a market. So, you want an idea- What are you going to do with this? Who's going to buy it? Why they're going to buy it, but it doesn't have to be fully refined. It can still be early ideas that seem reasonable to the committee. So, if the committee says “Oh, it's reasonable, I think they're going to use this for patients with heart trouble”. If somebody says “There's 10 other ways of doing it. I don't think anybody would ever buy this”. They say no, that sounds reasonable. “

iii. Criteria 3: Is the Team Committed?

The third criterion for project selection at the Deshpande Center revolves around assessing the motivation and commitment of the team to pursue commercialization. This factor plays a pivotal role in determining the project's potential for success. The Deshpande Center seeks teams that exhibit strong dedication and motivation towards the commercialization of their research. Sandler explains as follows:

"Third thing is the team motivated and committed to commercialize. So that's a key thing. We look for people who are very, very motivated to have this commercialized. What we do not want to fund are people who want to do research projects, who are looking for funding for PhDs or postdocs. And really, all they say is "we'll just get a patent. We'll give it to the licensing office and they'll license it". And if we ask them, "how do you plan to commercialize this?" and we have a meeting with them that not only do they send us a proposal, but they like most places that do a presentation and the committee will ask questions. And if we don't see anybody on the team who's really committed to commercializing, we won't fund. It doesn't matter if the other stuff looks good. We still want to fund it because our experiences, if there's nobody at MIT, who is serious about wanting to commercialize, it will never get commercialized. Because it's a lot of work and effort."

And as for team commitment, Sandler says that faculty commitment is deemed vital for project success as well as student or postdocs.

"If the faculty member isn't interested, they're not going to be easy to work with and that's where we work. We need the faculty to respond to our emails to come to meetings to do things. They're the ones who control the lab who control everything."

iv. What They Don't Care About: Market Size

He then went on to explain what does not come into the decision-making factors.

“Here's what we don't look at and care about. We do not care about whether it's going to be a giant business or a little business. We're not like venture capitalists who are looking for fortune. So, we could fund something if we think the total business is $10 million or a billion dollars. It doesn't matter to us. Here’s the key things about the market size. The market size has to be big enough to be able to attract enough investment dollars for what you need to do. So let me give you an example. Let's say you are coming up with some simple device. And when it leaves MIT maybe it cost you $2 to $4 million to develop it or less. But the market is only going to be 20 million. That's fine because you will probably find some investors or some companies or some sources of money, and you'll be able to develop it because they look at a $20 million market and the returns would be there. On the other hand, if you're going to develop some drug delivery systems, some medical device, something else where it's going to cost you 40 to 100 million to do that because you have to do patient clinical trials. You'll never get the money unless you have a $200 million to $300 million market because no one will invest. So that's we're looking at that piece. “

v. Mentorship Structure

The Deshpande Center relies on volunteer mentors and selection committee members to provide mentoring services[92]. These individuals contribute their time and expertise without receiving any form of payment, including honorariums or travel expenses. The decision not to compensate mentors is twofold: first, there is no necessity to do so, and second, remuneration could alter the nature of their relationship. The mentors, being individuals who possess financial resources, are not motivated by monetary compensation but rather by a genuine desire to contribute meaningfully.

The time commitment expected from mentors and selection committee members varies. Committee members are required to dedicate approximately 20 hours per year to reviewing proposals and attending the annual selection meeting[93]. On the other hand, mentoring a project

[92] Leon Sandler.
[93] Leon Sandler.

involves meeting with the mentee about once a month, either in person or online, with a preference for an initial in-person meeting. Additionally, three formal meetings are held for each project, and one year after the project's initiation, there is an hour and a half meeting that the mentor must attend.

To maintain a constructive and secure environment for mentoring, strict rules are imposed on mentors. Mentors and committee members are prohibited from investing in the projects and are required to adhere to conflict of interest and confidentiality agreements. So, mentors are just doing it to help the team. This framework ensures that mentees receive advice and guidance within a safe and unbiased setting. This approach is also implemented by the VMS (Venture Mentoring Service) and is regarded as one of the key factors contributing to successful mentorship.

The recruitment of mentors primarily relies on referrals from existing mentors. The Deshpande Center explores the motivations of potential mentors and assesses their suitability for the project area. It is crucial to ensure that mentors are genuinely driven by a desire to assist the project.

Once individuals become mentors, they tend to maintain their mentorship roles for an extended period. Some mentors have been actively engaged for as long as 5 to 10 years, and others have served for an impressive duration of 17 years. Sandler explains as follows:

“We have mentors who have been doing this for 17 years for 10 years. So, our mentors stay for a long, long time. Because they really liked this. I mean some dropped out but a lot of the mentors stay. Once somebody becomes a mentor, they will usually stay for you know, it could be 5, 10, 17 years one time.”

In building relationships with mentors, the Deshpande Center emphasizes the significance of in-person interactions. Prior to the COVID-19 pandemic, mentorship activities primarily took place in person, and after being 100% online with Covid, they have now moved to a hybrid.

Nonetheless, the Deshpande Center continues to underscore the importance of face-to-face interactions. Mentor interviews, for instance, are typically conducted in person, and in-person attendance is encouraged for other meetings as well.

Regarding mentor retention, the Deshpande Center also keeps several things in mind. First and foremost, treating individuals appropriately is a fundamental principle. This entails striving for operational efficiency and organizational effectiveness. Second, mentors must feel that their contributions are meaningful and valued. The Deshpande Center actively listens to the input provided by mentors, including their perspectives within the selection committee. If mentors feel unheard or their suggestions are disregarded, their motivation to participate in subsequent years may wane. Additionally, the Deshpande Center recognizes the importance of providing mentors with quality meals, acknowledging the significance of such seemingly trivial but impactful gestures. Lastly, the Deshpande Center fosters a sense of community among mentors. By ensuring the high quality of mentors, interesting and valuable connections are facilitated within this exclusive group.

(5) Past Results

The Deshpande Center's project accomplishments include the following: since 2002, the Deshpande Center has funded more than 190 projects with grants exceeding $20 million[94]. These projects have supported the work of more than 400 faculty members, graduate students, and postdoctoral researchers. 48 spin-off startups have emerged from those projects, resulting in a spin-off rate of approximately 25%[95]. Among these spin-offs, 23 operate in the healthcare sector, while 11 are focused on climate change and energy. Cumulatively, these spin-offs have secured funding exceeding $1.3 billion[96]. Five of the spin-offs have received investment from The Engine[97]. It is important to note that the projects that did not result in spin-offs should not be

[94] "Impact," *Deshpande Center for Technological Innovation* (blog), accessed April 23, 2023, https://deshpande.mit.edu/impact/.
[95] "Impact."
[96] "Impact."
[97] "Portfolio," The Engine, accessed April 23, 2023, https://engine.xyz/companies; "Spinouts," *Deshpande Center for Technological Innovation* (blog), accessed April 23, 2023, https://deshpande.mit.edu/spinouts/.

considered failures[98]. Some of these technologies are highly complex and are still in the laboratory phase, with a projected timeline of around 10 years before reaching a marketable product[99]. While the spin-off rate serves as one indicator of success, the Deshpande Center does not overly concern itself with this metric. They recognize that the mere act of spinning off a company does not guarantee long-term success in subsequent years.

(6) Support for Fundraising

The Deshpande Center recognizes the critical importance of fundraising for entrepreneurs, but they do not directly participate in the process of raising money[100]. They firmly believe that entrepreneurs must demonstrate their ability to secure funding independently, as it is a fundamental skill necessary for running a successful business and selling to customers. This approach serves as a test to evaluate the entrepreneur's capabilities. While the Deshpande Center does provide support in terms of documentation and facilitating introductions to potential investors, the responsibility for raising funds ultimately rests with the entrepreneur themselves[101].

(7) Expanding Horizontally

It is worth highlighting that Deshpande Center operates with a lean team of as few as three individuals. Previously, the team consisted of four members, but after the number was reduced to three, labor costs for the difference were used to fund investments in projects.

Furthermore, while the Deshpande Center has experienced significant success with its current model, they advise individuals from external contexts who are contemplating establishing a similar model in another area to secure commitment and the necessary funding from the university management team. This approach is crucial in relieving the center's staff from the

[98] Leon Sandler, Interview with Deshpande Center.
[99] Leon Sandler.
[100] Leon Sandler.
[101] Leon Sandler.

burden of fundraising, enabling them to dedicate their time and efforts to effectively running the center and supporting innovative projects.

(8) Summary and Analysis

The Deshpande Center plays a vital role in facilitating the transition of university research into impactful commercial ventures by providing comprehensive financial and practical business support. This entails leveraging Deshpande Center funds to generate research data that enhances its appeal to potential investors and enables technology development outside of the university. What sets this program apart is its holistic approach, combining financial support with a practical accelerator program that offers hands-on opportunities for customer discovery in collaboration with MIT I-Corps, as well as valuable guidance on commercialization through mentorship services. In other words, the program is thoughtfully integrated with a customer discovery program to assess the market fit of the technology in a safe state before it is brought out of the laboratory, thus mitigating the risk of developing products with no demand. Such an approach ensures a seamless transition to the fundraising phase after engagement with the Deshpande Center.

It is worth noting that all mentors involved in the program are volunteers. The Deshpande Center devotes considerable attention to the meticulous selection of mentors and the cultivation of a cohesive mentor community to ensure the sustained engagement of these invaluable resources. Furthermore, the center operates with a lean team comprising just three individuals who handle both fundraising and day-to-day operations, with one member of this team possessing over a decade of experience in the center. The remarkable efficiency and effectiveness of the Deshpande Center's operational model, which requires only a minimal team of three individuals, holds tremendous potential for the horizontal expansion and successful implementation of this model in diverse regions.

4.2.4 Venture Mentoring Service (VMS)

(1) Overview

VMS, established in 2000 as a supporting system for emerging entrepreneurial ventures at MIT, encompasses a mentoring service that offers practical guidance from a diverse group of approximately 200 industry mentors[102]. This support is accessible to various MIT stakeholders, whether they possess mere ideas, are in the early stages of building a company, or have already scaled their ventures into larger enterprises[103]. The most famous MIT spinoffs that have used VMS include Gingko Bioworks, a bioengineering platform company and a unicorn company.

To date since 2000, VMS has provided assistance to over 4,400 MIT entrepreneurs and 3,100 ventures[104]. Furthermore, VMS fostered the creation of over 410 new ventures[105]. The dedicated pool of active mentors stands at 196, and the program receives an average of 15 to 20 applications from entrepreneurs each month[106].

(2) History

The history of VMS dates back to 1997, when MIT Professor Alec Dingee and Professor David Staelin each approached President Bob Brown with a similar proposal for how MIT could support emerging entrepreneurial ventures, and as a result, the President charged the two with developing VMS and it was formally launched in January 2000 under the auspices of the MIT Provost's Office, with Dingee as volunteer director[107]. In 2003, Bose Corporation's first employee and eventual president, and former MIT Vice President Sherwin Greenblatt was appointed Director of VMS and Alec Dingee was appointed Chairman; as of April 2023, four full-time and one part-time staff members work here[108]. In addition, VMS Outreach, a program to launch VMS

[102]"VMS History | Venture Mentoring Services," accessed April 22, 2023, https://vms.mit.edu/mit-venture-mentoring-service/vms-history.5/26/23 3:24:00 PM
[103]Louis Goldish, Interview with Louis Goldish, Senior Venture Advisor of VMS, April 14, 2023.
[104]VMS, "VMS By the Numbers," March 24, 2023.
[105]VMS.
[106]Louis Goldish, Interview with Louis Goldish, Senior Venture Advisor of VMS.
[107]Louis Goldish; "VMS History | Venture Mentoring Services."
[108]Louis Goldish, Interview with Louis Goldish, Senior Venture Advisor of VMS.

in another region, is run by two people; similar to the Deshpande Center, this program is also run by a very small number of people.

(3) Features of VMS

A noteworthy characteristic of VMS is its provision of practical guidance. Admission to VMS requires a genuine aspiration to establish and thrive in the business realm, emphasizing the program's focus on practical entrepreneurship. Although entrepreneurial education was being offered at MIT at the time, there was a big difference between education and practice, and VMS was founded to fill that gap[109]. What differentiates VMS is that, first, it offers very practical advice; second, the mentors work in a team; third, it offers a long-term service; and fourth, the mentors are detached from investment and management; they only offer advice. Louis Goldish, Senior Venture Advisor at VMS and who joined VMS in 2001, cited the following four points.

i. Practical business advice

"First, we are very, very practical. We are less concerned where a venture is going to be five years from now, where it's going to be five weeks from now. And we want to help them actually go into the marketplace and make progress. Rarely will entrepreneurship education say go out and call 10 people and see what they think about your product."

It should be noted that they do not give technical advice, but specialize in business advice, for the following reasons, according to Sherwin Greenblatt.

"In general, the knowledge that we share is not technical knowledge. One of the advantages of being at MIT is if you're in a given field, chances are the world expert is in that field as well. Here it is here, you know, it is a professor or researcher here, so there's no need for us to provide that knowledge. Usually, the individual can go and find it themselves. And it's right around. So, the knowledge that we focus on is the knowledge of business. How do you take your ideas and how do you match them to the business world? And so that might require some expertise in the area

[109]Louis Goldish.

of business that you're interested in, but not a technical knowledge of your business knowledge. And so, we tend to have although we have mentors who are technically experts, their advice is usually on the business side."

ii. Team Mentoring

"Another thing that makes us different is that we mentor in teams, not alone. So, it's not just one person giving you advice or three people giving you a different time. You will have a team of entrepreneurs who meet with you all together at the same time."

Sherwin Greenblatt explained how the program adopted team mentoring instead of one mentor as follows.

"It was one on one mentoring…..And then as time went on, we became better at doing that. But one of the principal discoveries was what we call team mentoring. We were doing one on one mentoring, we would have a number of volunteers, each one would be assigned to a different entrepreneur, and they would work with them. Interesting story, a group of mentors came to me and said, we enjoy working together, would you mind if we mentored our ventures together as well? And being an engineer, I thought, well, that's very inefficient, you know, having multiple people do what one person ought to be doing. And so, I wasn't very enthused, but they are volunteers. They said we want to do this and so I said, Okay, let's do it. And for all of us, it was an eye opener, really an amazing, amazing thing because what we found is that one mentor has a great deal of knowledge and knows a lot of things, but doesn't know everything. And so, when you're mentoring someone, you will do the best you can't to share your knowledge. So sometimes the advice that you give is of great wisdom and of great depth. But sometimes when you don't know very much about it, you don't really know what to tell someone what you make it up, so to speak, because you're the mentor, you always have to say something and so the quality of mentoring would vary. Sometimes it would be very good and sometimes not. But when you have a team of mentors, what happens is that the pool of knowledge between them becomes very, very deep, and whatnot. And so, in almost every area, one mentor or the other can give

good advice. And if they can't, because they're working as a group, they'll admit that they don't have good advice and they'll go get you some in some way. So, the quality of mentoring took a giant step when we discovered team mentoring. And then after we realized what the benefits were, we exclusively adopted a team mentoring model. And that was that made a big difference in our approach."

iii. No time horizon

"Third, in our case, once you are in VMS you are in for the rest of your life. And the reason for that is that…….when we look at a venture when it's just starting out, it needs advice just about anything to tell them but as they move on one year, two years, five years, 10 years. Their needs change as they mature and grow, but they still need advice so they can come back to us. There is no time limit. So, it's not like they're in for a year and then you're on your own."

iv. Strict rules for mentors

"And then last, our mentors have very strict rules about what they can and cannot do. They are here merely to give advice. They're not here to invest. They are not here to sell services. They are not here to look for their next job. They are here just to give advice. Why? And the reason for that is so that you can feel comfortable and tell them everything and expect that they're on your side. A mentor cannot say to you, you put me on your team and I can really help you."

" If the mentor goes ahead and invests or you ask him or her to be on your team, they can no longer be mentors through the VMS, they're now part of your team. They can mentor others. And that means that you tell me what you need. I'll tell you what I think you should have. And I'm not worried about whether I'm going to make money on it or whatever. I just want to help you. And therefore, they have very strict rules about that. So, you can feel comfortable telling us everything."

v. Summary and Others

The mentors are very realistic in their advice: first, they provide very realistic advice; second, they are a team of mentors; third, they provide a long-term service; and fourth, the mentors maintain a distinct separation from investment and recruiting, focusing solely on providing valuable advice and guidance. The fourth characteristic is particularly important: VMS intentionally distances itself from investments, such as fundraising. VMS deliberately maintains this separation to avoid potential conflicts of interest that could compromise the quality of guidance provided. By abstaining from financial involvement, VMS ensures the safety and integrity of the mentoring relationship, preventing any undue influence or considerations related to monetary matters. VMS has about 200 mentors at any given time, half of whom are MIT alumni and half of whom are not. The recruitment of mentors primarily occurs through referrals from existing mentors, ensuring a rigorous selection process. Prospective mentors undergo a comprehensive interview that gauges their availability, willingness to contribute, adherence to rules, and commitment to mentorship. Additionally, they receive specialized training to reinforce the importance of actively listening to entrepreneurs and assisting them in problem-solving rather than providing outright solutions. This rigorous selection and training process contributes to the overall quality and effectiveness of the mentors. To ensure ongoing quality assurance, VMS employs a feedback system where mentees rate their meetings on a scale of 0 to 5 after each session. If a meeting receives a rating of 3 or below, VMS initiates an interview to identify areas of improvement and formulate an action plan. The average rating for all meetings currently stands at an impressive 4.7. Furthermore, based on accumulated experience, VMS maintains a guideline that mentoring sessions should not exceed 90 minutes, allowing for adequate discussion time while avoiding unnecessary prolongation.

(4) Support for Fundraising

While VMS keeps its distance from financial matters, it does not imply a lack of assistance in fundraising efforts. For ventures that are ready to raise money, VMS actively supports them in crafting a compelling pitch that effectively conveys their value proposition. Additionally, mentors often facilitate connections between entrepreneurs and potential investors, leveraging their

networks to create valuable opportunities. Since 2006, VMS has also invited investors to an event called Demo Day, where VMS carefully selects about 20 ventures to present. VMS exercises meticulous discretion in ensuring that these ventures are truly investment-ready, substantiating their viability and offering a compelling case for investment. The demo day serves as a platform for ventures to showcase their potential and deliver a polished and impactful presentation.

In addition, the advice that VMS gives to potential entrepreneurs is to make sure that they really need to raise funds at this moment. Goldish highlights that in certain cases, it may be advantageous for entrepreneurs to first deepen their technology or refine their business idea before pursuing fundraising activities. This approach ensures a solid foundation and maximizes the prospects of success when engaging with potential investors.

“Fundraising is not necessarily the most important thing. In many cases, we tell them, what do you need money for? You're still in school, or you're just writing software and why do you need money now? Because if you think about it, there are three types of raising money. One is friends and family, which give you money because they love you. Or they feel that that you're a good person and you have a good idea. The second is government grants which are usually for beginning research organizations. And then the third is what I'll call financial investors. Venture capital, angels. So the first issue is, do they really need money because if you think about it, particularly if you're dealing with a financial investor, they want to know A: if I give you money, how will I make money and B: what is my risk in giving you money, meaning will I ever make any money by giving you some and in many cases, you’re just starting out, you don’t have customers yet. It sounds like a good idea. Your value of the company will be very low. So, therefore, if I give you $100,000 I want 80% of your company. On the other hand, if after a while you say, we now have customers, we have people that are interested, we can have our first prototype product. Now your value has gone up and my $100,000 may get me only 10% of your company. So sometimes it's wise not to get financial investors yet, but get your project going.”

Sherwin Greenblatt also says that while VC is the first funding source that comes to mind, non-VC options should also be considered, and advises the following

“One of the first things we do is we try to educate entrepreneurs on all the possibilities for funding. So, if you go around and you talk to the funders, they'll tell you, you got to go to a VC and you got to get money from a VC. And they'll say that's the only way to raise money, but that's not so. And in fact, for many of the ventures that we work with, that's probably an inappropriate method for raising funds. So, we might talk about everything, friends and family, Individual investors, funds of course, but also strategic fundraising, through companies, through grants, either government or private grants. Those also provide fundraising and many, many other things, private investors, Wealth Management funds and things like that. So, we're a non-traditional as well as traditional sources. And what we try to do is find out what's best for the individual and for the idea that they have. We don't raise but we might say, well, here's some people you might talk to, okay, that are in this area of funding, or here's some others that are in this area of funding.“

(5) Formation and Maintenance of a Mentor Community

Finally, regarding the creation of a mentor community to attract and retain mentors, Sherwin Greenblatt stated

“When we were starting, the founders and myself as director, we were thinking about how we can make this a service that lasts, that people will continue to come. And one of the things we realize is that we needed mentors, who were willing to commit themselves to being a mentor for a long period of time so that they can become experienced in what we're doing and pass that experience along to our mentors. So the question is what attracts a mentor to a volunteer organization? Why would they want to stay? Mentoring is interesting. There are a lot of people who like to do that. But mentoring by itself can be very empty. When you're a mentor, what you're doing is you're sharing your expertise with someone and then someone is absorbing that expertise. And after a while, it's one-sided and gets boring. Mentors will typically mentor an

organization for a while and then they'll leave the organization. They won't. We wanted to think about how we could make our organization so interesting that mentors wanted to stay?"

VMS focused on creating a community where mentors would want to stay.

"The concept was to create a community of mentors. Not just have mentors come and mentor, but somehow be part of a community. And what we found when we talk to mentors is that these mentors are entrepreneurs themselves. And entrepreneurship is a very lonely activity because you're out there trying to start something. It's new people always resist things that are new. You're pushing people to do things. You don't have a lot of colleagues that you can talk to and you're on your own. And so, what we wanted to do is create amongst the mentors, a community where they could talk with each other and work with each other. So the mentoring being part of an organization that provided you with something, So a couple of things we did. So, one thing was the team mentoring. Now you weren't on your own giving to someone who was taking, you're also sharing your knowledge with the other mentors. And you were seeing your point of view, but you're also seeing other mentors' points of view on issues. That's interesting. That's exciting for mentors. And so, a mentor really responded to being a part of the team. And as part of that, mentors would then establish relations with each other. And then sometimes those would lead to ventures that they started and things like that. So, it was a community that was forming."

And VMS also holds mentor-only meetings to build community.

"And so other ways in which we've done is that each month we have a meeting of our mentors. We ask all the mentors to come together and share information about VMS. We share information about other ventures and new ventures. And so, there's a community activity of people getting together and it's a chance for mentors to talk with each other informally, and to meet with each other. So that's a secret if you wish to know how to make successful mentoring organizations not just a mentor, but to create a purpose for the mentors to come together. And

many of the mentors say I will volunteer for a lot of things. But this is the only thing where I feel like I'm part of it. And I feel I have colleagues I can talk to and get something personally out of it."

In order to maintain the mentor community, the selection of mentors is very strict, thus creating a mentor community of selected people.

"We're very selective with our mentors. So, the mentors know that their colleagues aren't just people who volunteered. There are people who were selected just by themselves. And so, there's a spirit there. We're the special. We're the ones who are selected. So that's how you make an organization that that where people want to come. They want to be there."

(6) Summary and Analysis

VMS possesses several unique characteristics that contribute to its effectiveness. First, it distinguishes itself from educational programs by providing highly practical and realistic business advice, which proves invaluable for entrepreneurs navigating the complex startup landscape. Second, VMS employs a team mentoring approach, ensuring that startups benefit from the collective wisdom and diverse perspectives of experienced mentors. Third, it offers long-term support, recognizing that sustained guidance is essential for the continuous growth and development of startups. Fourth, the mentors involved in VMS maintain a clear separation from investment and recruiting activities, focusing solely on providing expert advice. Having evolved over two decades of experience, the VMS program has garnered significant acclaim and is widely adopted by MIT entrepreneurs, including four of the five companies interviewed for this study. The program's effectiveness stems from its well-established framework, encompassing team mentoring and a mentor not-to-do list. However, the true essence of VMS lies in its ability to maintain a pool of high-caliber mentors. Developed by two MIT professors and a former president of Bose, a prominent global company, VMS benefits from the prestige, commitment, and extensive networks of these individuals. Hence, it is unsurprising that the caliber of mentors they were able to assemble is exceptionally high. This highlights the importance of having exceptional initial leadership with high commitments within the organization, ideally, someone

like a retired former president who is an alumnus of the university and possesses extensive industry connections. Such individuals can lend credibility and attract high-quality mentors to the program. Once the program is operational, it is crucial to establish a structure that fosters the formation and sustainability of a vibrant mentor community.

In terms of the impact on entrepreneurs, the VMS program plays a vital role in raising awareness about fundraising needs and options and the associated risks of investment. By engaging with entrepreneurs and soliciting their input, VMS offers an excellent platform for entrepreneurs to understand various financing options and develop a comprehensive understanding of investment risks. Feedback from program participants in our interviews indicates that VMS is particularly beneficial during the early stages of a startup when general advice is most sought after. As companies mature and require more specialized guidance, the frequency of utilizing the program tends to decrease due to the limited availability of domain-specific experts. Therefore, VMS is most valuable during the pre-startup and post-startup, providing essential support and guidance throughout these critical phases.

4.2.5 MIT I-Corps (Innovation Corps)

(1) Overview

The I-Corps program was established by the National Science Foundation in 2011 to take NSF and other funded basic research projects from the laboratory to society commercially through experiential learning using a customer discovery process[110]. The program's mission is to "reduce the risk associated with translating technologies from the laboratory to the marketplace"[111]. The underlying concern behind the program's inception was the significant annual investment in research funding by the NSF in the United States, with a relatively limited practical application of these research outcomes[112]. It became evident that the primary obstacle was not of a technical nature, but rather a business problem arising from the lack of market demand for the innovations

[110]"About I-Corps," NSF - National Science Foundation, accessed April 29, 2023, https://new.nsf.gov/funding/initiatives/i-corps/about-i-corps.
[111]"NSF's Innovation Corps (I-Corps™)," NSF - National Science Foundation, accessed April 29, 2023, https://new.nsf.gov/funding/initiatives/i-corps.
[112]Roman Lubynsky, Interview with Executive Director, MIT I-Corps.

developed by researchers[113]. In other words, what the researchers created was something that no one wanted to buy[114].

In 2014, MIT became a site assigned to a specific individual agency called the I-Corps Site, and a site program was launched called MIT I-Corps, and in 2018 this became the NSF node with regional responsibility, New England I- Corps, which will help and support those other sites as well[115]. MIT I-Corps also collaborates with other entrepreneurship programs within MIT, such as the MIT Sandbox Innovation Fund Program and The MIT-Pillar AI Collective (a one-year pilot program providing seed grants for projects in AI, machine learning, and data science), and runs several MIT Exclusive programs for them[116].

Roman Lubynsky, Executive Director, MIT I-Corps, said the program aims to create entrepreneurs and also to expand the career path possibilities for researchers. He states as follows:

"I-Corps is not really focused on creating startups. That's great. If that happens, we want to see the technology make it but it's really about entrepreneurs, learning new skills. And the researchers that go through this tell us that it has positively impacted their professional development and how they approach their research. PIs tell us that they write better research proposals and they can get more funding. And the students and postdocs tell us that it really helps build confidence in themselves in their research, and modified how they think about all of that. And eliminated some new career path options. See everybody, most of the students that were the postdocs and PhD students we work with, most of them. Not all of them, but most of them Plan A is to become a professor because that's what they've been being trained for. Right? MIT has 1600 postdocs and there are about 30 new faculty positions a year that are available.

[113] Roman Lubynsky.
[114]Roman Lubynsky.
[115] "MIT selected as ninth NSF Innovation Corps Node; set to serve the New England region," MIT News | Massachusetts Institute of Technology, September 4, 2018, https://news.mit.edu/2018/mit-selected-ninth-nsf-innovation-corps-node-new-england-0904; "NSF Award Search: Award # 1832931 - I-Corps Node: New England Regional Innovation Node (NERIN)," accessed May 25, 2023, https://www.nsf.gov/awardsearch/showAward?AWD_ID=1832931&HistoricalAwards=false.
[116]Roman Lubynsky, Interview with Executive Director, MIT I-Corps.

the math is not good, right? And these are at MIT. These are all pretty much world-class people right there. And so, I think, you know, and these are smart people, they've realized that the odds aren't great that they're going to end up as a professor at a top institution, right, because there's just not enough spots and not that they're not qualified or capable. It's just that there are not enough spots to go, so they are kind of thinking of Plan B's right? So maybe the job in the pharma company or industry or maybe it creates a company and started."

MIT I-Corps and regional NE I-Corps consist of two programs, Sparks and Fusion, which may lead to the NSF National Teams program conducted by NSF[117]. Sparks is a free three-week online course. Participants will talk to at least a dozen prospective clients to quickly research whether there is a market for their technology and understand who will use it and why[118]. The next step, the Fusion program, is open to Sparks graduates who are potential candidates for future SBIR (Small Business Innovation Research) proposals, and the team receives coaching and funding to conduct 12 new interviews and conduct additional customer Discover[119]. Subsequent NSF National Teams programs will include a cohort of approximately 24 teams[120].

(2) Summary and Analysis

The National Science Foundation's (NSF) I-Corps program plays a pivotal role in facilitating the transition of startups, including the crucial fundraising phase, by providing entrepreneurs with an opportunity to assess the product market fit of their product before bringing the laboratory's outcomes out of the lab. The program has proven highly advantageous for two MIT spinoff startups in the short case studies, equipping them with essential skills to conduct market research and validating the market fit of their offerings, thereby underscoring the program's value. Additionally, the program boasts a well-established framework, mandating participants to conduct interviews with a predetermined number of potential customers, ensuring the program's quality remains unaffected by the program operator.

[117]"I-Corps Spark Courses @ MIT," accessed April 29, 2023, https://icorps.mit.edu/mitspark.
[118]"I-Corps Spark Courses @ MIT."
[119]"I-Corps Spark Courses @ MIT."
[120]"About Teams," NSF - National Science Foundation, accessed April 29, 2023, https://new.nsf.gov/funding/initiatives/i-corps/about-teams.

4.2.6 MIT Startup Exchange

(1) Overview

The MIT Startup Exchange is an organization under the MIT Corporation Relation, along with the MIT Industrial Liaison Program (ILP), which is "a membership-based program for large organizations interested in long-term, strategic relationships with MIT" and engage organizations in all sectors worldwide[121]. Founded in 1948, ILP typically has a membership of more than 200 of the largest global companies with annual revenues of $500 million[122]. The ILP appoints a dedicated director to oversee each company, ensuring that they provide avenues for fruitful discussions between the company and MIT faculty and researchers based on their research and strategic issues and needs. In this manner, the ILP serves as a bridge between MIT and the industry, fostering collaboration and knowledge exchange[123]. Around 2013, ILP member companies of this ILP made a request to connect with MIT-related startups, which led to the official launch of the MIT Startup Exchange in 2014[124]. The program provides startups with opportunities for demos, exhibitions, lightning talks, and one-on-one meetings with large companies, with the mission of realizing partnerships, such as joint research and demonstration projects, between MIT-related startups based on technology and science and ILP member large companies[125]. As of January 2022, 1,400 MIT startups were enrolled in the program, which facilitates nearly 600 private meetings per year between ILP members and startups. Of the startups working in the program, 82% were co-founded by MIT alumni, 19% were co-founded by MIT faculty, and 15% were based on licensed MIT technologies[126]. According to Catarina Madeira, Director of the MIT Startup Exchange, they receive approximately 150 new registrations each year, and to participate, startups must meet multiple eligibility criteria. The first prerequisite is

[121]"About | ILP," accessed April 28, 2023, https://ilp.mit.edu/about.
[122]"Industrial Liaison Program | MIT Research Administration Services," accessed April 28, 2023, https://ras.mit.edu/finding-funding/find-funding/corporate-engagement/industrial-liaison-program; Catarina Madeira, Interview with Director, Startup Exchange, April 28, 2023; "Membership | ILP," accessed April 28, 2023, https://ilp.mit.edu/membership.
[123]"Membership | ILP."
[124]"MIT Startup Exchange: Creating Powerful Synergies," MIT for a Better World, accessed April 28, 2023, https://betterworld.mit.edu/mit-startup-exchange-creating-powerful-synergies/; Catarina Madeira, Interview with Director, Startup Exchange.
[125]Catarina Madeira, Interview with Director, Startup Exchange.
[126]"MIT Startup Exchange."

that the startup must be technology and science-based and be an MIT connected startup[127]. MIT connected startups encompass a diverse range of enterprises that are either built upon licensed MIT technologies or are founded and/or led by individuals associated with MIT, including faculty, staff, and alumni (with a minimum one-year program completion)[128]. Startups must be at the pilot stage, ensuring their readiness to benefit from the resources and support provided by Startup Exchange. An exception to the general pilot-stage requirement for MIT connected startups is observed in cases where ventures necessitate a longer time horizon, particularly those involved in the intricate domain of drug discovery. For earlier-stage startups, alternative programs such as the MIT Sandbox Innovation Fund Program or MITdesignX may be recommended. And finally, startups may remain in the Startup Exchange program as long as they meet the criteria of being a startup. In other words, decisions are made based on indicators such as year of establishment, number of employees, revenue, recurring customers, and other indicators such as startups starting to acquire smaller startups.[129]

Participating startups gain access to a range of opportunities provided by the Startup Exchange. These include attending introductory sessions, applying for and being selected to pitch at conferences worldwide, participating in exhibitions and online demo days held four times a year[130]. Such opportunities are disseminated through newsletters and other communication channels, and the Startup Exchange may also proactively approach startups directly for meetings with companies, etc.[131]. Additionally, through collaborative initiatives with ILP member companies, the Startup Exchange co-hosts conferences in various regions worldwide, where selected startups can pitch or exhibit, with travel expenses covered by the program. These conferences often feature the presence of esteemed MIT professors specializing in related fields[132]. In addition to this, the Startup exchange's flagship program is STEX25, in which 25

[127]Catarina Madeira, Interview with Director, Startup Exchange.
[128]"About | STEX," accessed April 28, 2023, https://startupexchange.mit.edu/about; Catarina Madeira, Interview with Director, Startup Exchange.
[129]Catarina Madeira, Interview with Director, Startup Exchange.
[130]Catarina Madeira.
[131]Catarina Madeira.
[132]Catarina Madeira.

companies are selected each year to receive customized support, such as photography and video[133]. The program is unique in that there are no open applications; the selection process relies on recommendations from key MIT-related stakeholders, such as The Engine, Deshpande Center, MIT nano, CSAIL (MIT's Computer Science and Artificial Intelligence Laboratory), etc.[134]. Following on this, Startup Exchange and ILP members conduct interviews to determine the 25 startups for the year on a rolling basis[135]. The program does not basically find investment partners but rather aims to increase the value of startups through partnerships such as joint research and demonstration projects, although there have been some cases that have resulted in acquisitions by ILP participating companies[136]. The Startup Exchange is operated by four full-time employees as of 2023[137].

(2) Summary and Analysis

Although Startup Exchange does not directly offer funding opportunities to startups, its primary focus lies in fostering connections between startups and large corporations, aiming to cultivate partnerships for technology development through joint research and demonstration projects, and thus increasing the value of startups. They offer startups various avenues to showcase their innovations, including opportunities for demonstrations, exhibits, lightning talks, and one-on-one meetings with prominent corporations. Consequently, this platform indirectly contributes to the potential for future funding by facilitating valuable networking and partnership-building opportunities. Additionally, Startup Exchange actively collaborates with a range of internal programs, effectively identifying and promoting 25 promising startups every year. By doing so, it grants these 25 startups the chance to gain significant exposure beyond the confines of the university environment, enhancing their prospects for success.

[133]"STEX25 | STEX," accessed April 29, 2023, https://startupexchange.mit.edu/stex25; Catarina Madeira, Interview with Director, Startup Exchange.
[134]Catarina Madeira, Interview with Director, Startup Exchange.
[135]Catarina Madeira.
[136]"Magna International Acquires MIT Spinoff Optimus Ride | STEX," accessed April 29, 2023, https://startupexchange.mit.edu/news/magna-international-acquires-mit-spinoff-optimus-ride; Catarina Madeira, Interview with Director, Startup Exchange.
[137]Catarina Madeira, Interview with Director, Startup Exchange.

4.2.7 Technology Licensing Office (TLO)

MIT's Technology Licensing Office (TLO) bridges the connection from MIT's research community to industry and startups by strategically evaluating, protecting, and licensing technology[138]. TLO spends nearly $20 million annually on patent protection- both efforts to get patents issued and efforts to maintain patents thereafter and about 60% of that is reimbursed directly by companies licensed from MIT[139]. It means that MIT's self-funding budget is approximately $8 million $. There are about 24~32 Startup companies launched through licensing from TLO each year[140]. For example, in 2022, there are 354 US patents issued and 27 startups founded[141]. 579 startups have been founded cumulatively from 1997 to 2022, with a cumulative total of 23,347 disclosures received and a cumulative total of 3,301 license agreements executed[142]. In other words, 17% of the total number of licenses granted have been to established startups.

(1) General Path to Spin-off Startup Establishment through TLO

i. Step 1 Decide whether to proceed with patent protection

The general journey when the results of research at MIT are licensed through TLO to establish a startup starts with the technology disclosure. If there are potential interests for patents, they will look at the technology disclosure and make some assessments regarding whether or not MIT should invest in patent protection[143]. There are a lot of factors that affect that decision. First, they assess whether or not the technology is even patentable from a law perspective by assessing three criteria of novelty, non-obviousness, and utility[144]. If it is potentially patentable, they'll also consider business factors relating to the likelihood of their being able to commercially license the invention to a company that will develop and commercialize the technology[145]. There is also a

[138] "About the TLO | MIT Technology Licensing Office," accessed May 12, 2023, https://tlo.mit.edu/engage-tlo/about-tlo.
[139] Deirdre Zammit, Interview with Associate Director, Licensing of Technology Licensing Office at MIT, May 12, 2023.
[140] "TLO Statistics | MIT Technology Licensing Office."
[141] "TLO Statistics | MIT Technology Licensing Office."
[142] "TLO Statistics | MIT Technology Licensing Office."
[143] Deirdre Zammit, Interview with Associate Director, Licensing of Technology Licensing Office at MIT.
[144] Deirdre Zammit.
[145] Deirdre Zammit.

comparison between a slight modification of existing technology and a completely new one[146]. If it is just a slight improvement of existing technology, it would not be attractive to obtain a patent compared to investing in a patent on something that's absolutely new[147]. Therefore, they will take such factors into consideration when deciding whether to proceed with patent protection.

ii. Step 2 Licensing Partners

Deirdre Zammit, Associate Director, Licensing, Technology Licensing Office (TLO) at MIT, explained the case where a startup is founded based on licensing from TLO as follows

"As it relates to startup companies, most often, the startup companies that come to our office, seeking commercial licenses to our intellectual property, typically have at least one researcher that was involved in the technology as part of the company. Not always, but usually because very often it might be a graduate student or a postdoc that's leaving MIT that wants to try to pursue the technology they worked on at MIT within a startup company. So, when it's very helpful when those researchers tell us early that they may want to try to pursue a startup company. So, we know this information and we could plan for the management of the intellectual property to consider there might be a startup in the future. But then also, if we have established companies approaching us for licensing the same technology, we at least know that there's also interest in a startup opportunity so we can figure out should we license the technology to an existing company? Should we license the technology only to the startup or should we license the technology to both?"

iii. Option Agreement

Startups, in particular, may not sign a license agreement at the beginning, but may sign what is called an option agreement for a short period of time, usually one year. This gives a startup or other company that is not ready to negotiate a license with TLO a short period of time to prepare. The startup can also obtain funding under this option agreement, as Zammit explains

[146] Deirdre Zammit.
[147] Deirdre Zammit.

“An option agreement is usually short term agreement, usually about one year where we give the company rights to evaluate the MIT Technology do internal research relating to the technology. And they have the right to come back to us within that one-year period, and tell us that they're ready to discuss a license agreement with MIT. They don't have the ability to perform commercial activity during the option agreement period. Very often these option rights are exclusive option, right so we're holding the intellectual property for the company for one year during the option period. And the option agreement is also an asset that they can use to explain to inventor investors. We have the exclusive ability to go back to MIT within the one year and request license negotiation. So, it allows the company to raise money from investors with the option agreement. Eventually when the company wants to start negotiations for a commercial license. It has to present a business plan to MIT that explains how the company plans to develop and commercialize the technology so we require a business plan from the company before we start license negotiations. Because the what the business plan explains to us that they're committed to developing the technology and commercializing the technology. And they explain to us their timelines for development and commercialization, and they have to show us evidence that they have the resources needed to pursue that business plan including a team and capital and other resources. So very often a startup company when they first engage us, they're not ready with a full business plan. So, for that reason, we often will do the option agreement because they need time. To validate the market opportunity, develop the team gets some financing lined up, and then they can come back to us later with a business plan and request that they start negotiating a license agreement with MIT.”

(2) Good Cases to be a Startup

According to Zammit, some types of technology work better with startups than others, and some work better with large companies, which Zammit explains as follows

“There's some technologies that may be better with a startup company versus a large company and vice versa. Like as an example, if we have a technology that is an improvement on an existing

industry. It probably makes sense to license that technology to an existing company, yet you know, technologies that maybe are very unique and like don't fit in existing companies are often better for startup company. There are some established companies that do take risks and invest in very early-stage technology. But much of the technology from MIT is very early stage. It's university-level, research, like basic research, maybe starting to be a little apply but usually basic research only. And there were many years that is often required to take technology from a university to the point where there's commercial sales. So very often, startup companies are willing to take risk, and there are investors willing to take the risk. Some large companies will also do it, but it's more maybe we see it more with startup companies where they're willing to take the risk and invest many years in the development and this is also in the video that I'll show you. So, I think you'll see how we define when it may be better fit for a startup versus large company."

And while forms of licensing can be exclusive or non-exclusive, startups very often have to be truly exclusive; Zammit explains:

"Very often a startup really needs exclusivity because it cannot attract venture capital or other investment, if it only has non-exclusive rights, especially if it's early stage. Risky technology. Whereas very often an established company can be satisfied with just non-exclusive rights, because an established company may have other advantages like access to supply chain access to customers, you know, existing manufacturing facilities that differentiate it from competition, so they only need not exclusive license. But usually, startup company needs exclusive rights to justify the investment in the technology."

(3) Availability of TLO Support for Startup Establishment

Zammit explains that there is not much TLO support for startups creation because there are many resources in Boston and around MIT.

"It's helpful when we know in early days if one of the inventors is interested in a potential startup opportunity in technology, there's a lot of other resources on campus or in the Boston area that

can help startup companies, develop business plan, validate that there's a market opportunity relating to the technology. There's a lot of resources to help teams identify like what kind of team do we need and where's the money going to come from as far as us running the company? So, our office does not get very involved in helping people sleep we don't help set up the company like the company has to work independently of us to establish the company and formed the company legally. And we direct them to other resources in on campus or in the Boston area. But we really don't help in creating the startup. We just do the licensing."

Therefore, they do not make referrals to VCs, but they often introduce I-Corps and VMS as a referral to resources within MIT. Zammit explains that:

"I often recommend to them the I-Corp program. I think that's a good way for them to validate and understand if there's a business opportunity related to the technology. So, you can kind of see that, like the usually when I'm working with them in the beginning, like it's a very early stage not even ready to create a company. They're still trying to figure out whether or not the technology has a fit in the market. So, I'd say I introduce people quite a bit to the I-Corps program. And then I also reference the venture mentoring service because I think those individuals can better connect them to find the people that can help them the best."

(4) Active Nature of TLO

Zammit explains that:

"At MIT, we're fortunate enough that we get a lot of disclosures without proactively going to researchers asking for disclosures notwithstanding we ideally are meeting with our investigators at a frequent you know frequently enough like maybe every year or every six months to touch base and do like portfolio reviews with them to review an intellectual property that we already have in their portfolio, trying to get their interpretation and ideas about like the market fit for the different technologies. And in those discussions, we may ask about well, what's what are you working on? And what might we see in the future? A lot of other universities do have to

proactively go to researchers to get disclosures at MIT, that's something which we don't have to invest in because we get a lot of disclosures already, but notwithstanding, we try to do outreach with the departments to make sure that investigators know that they disclose inventions to us"

(5) Summary and Analysis

The process of establishing a spin-off startup through the TLO begins with assessing the potential for patent protection. When researchers express their interest in pursuing a startup, the TLO takes it into account during the management of the intellectual property. The TLO recognizes that certain technologies are better suited for startups, while others may be more suitable for large companies. According to TLO, when commercializing research results, licensing to existing companies is appropriate for technologies that improve existing technologies, while licensing to startups is appropriate for completely new and unique technologies. Option agreements are often signed by startups, providing them with the rights to evaluate the technology and prepare for future licensing negotiations. These agreements also help startups raise funds from investors. And, because there are many resources in MIT and Boston to support startups, TLO does not need to provide support for startup creation and only does licensing.

5. MIT Spin-off Startup Short Case Study

5.1. Overall

Here we present short case studies of five MIT spin-off startups including one MIT Born Startup, based on interviews and a literature review. The five startups are deep tech in the fields of biotechnology and life sciences, climate change and energy, and manufacturing. Of the interviewees, two are MIT faculty and co-founders, one is a former MIT post-doctoral CEO, one is a former international MIT post-doctoral CEO, and one is an MIT graduate who was successfully matched as an outside industry management talent.

The primary focus of the interviews revolved around the funding trajectory, encompassing both pre and post-company founding phases. By delving into the funding experiences of these startups, we aim to shed light on the challenges, strategies, and successes encountered during their fundraising endeavors. The interviews were supplemented by a literature review, which constitutes the short case study as a whole.

The following provides guidance for the upcoming short case study from the venture capital perspective. It offers insights into the evaluation and investment process of VCs. Understanding the VC's viewpoint helps us analyze their criteria and decision-making factors in engaging with university spin-offs.

For entrepreneurs, the goal in fundraising "should be to get several term sheets"[148]. Brad Feld, a US entrepreneur and venture capitalist, and Jason Mendelson, who has experience in the tech industry and VC, state that. Term Sheets are "a letter expressing his interest in investing, along with his proposed terms". In their book "Venture Deal," they describe the key points to keep in mind when raising capital for an entrepreneur, and here are the main points

First, every VC is different, and the same proposal may be accepted by one VC and rejected by another. In fundraising, the first and most important step is to determine the amount to be funded before initiating the fundraising. This amount will determine the funding source. It is also important not to ask for more than the required amount. When speaking with multiple investors, it is important to find a lead investor. The lead investor will take the lead role, including submitting the term sheet. Ideally, it is important to have multiple lead VCs compete for the lead.

We conduct the short case studies keeping these perspectives in our mind.

[148] Brad Feld and Jason Mendelson, *Venture Deals : Be Smarter than Your Lawyer and Venture Capitalist* (Wiley, n.d.).

5.2. Kytopen

(1) Founding History and Initial Pre-seed Fundraising

Kytopen is a biotechnology company providing scalable technology for engineered cell therapies that spun out of Professor Cullen Buie's lab at MIT in June 2017; co-founded by MIT Associate Professor Cullen Buie and former MIT postdoc and research scientist Paolo Garcia[149]. Kytopen's origins date back to 2013, when Prof. Cullen Buie won a DARPA Young Investigator Award, the funds from which enabled him to hire Paulo Garcia as a postdoctoral fellow. Garcia was given the opportunity to pursue the commercialization of their early ideas through an MIT postdoctoral grant (Translational Fellows Program), and two years later, in 2015, they were selected to join the NSF National Innovation Corps (I-Corps), which helps researchers commercialize their technologies, and conducted market research, including interviewing over 100 people[150]. What they learned at I-Corps was that their technological ideas did not solve a major market problem. So, to further their research, they applied for NSF's Partnerships for Innovation: Accelerating Innovation Research- Technology Translation (PFI: AIR-TT), which allowed them to conduct further research. While advancing and applying for NSF's SBIR (Small Business Innovation Research), they began meeting with The Engine in 2017[151]. At the time, The Engine had just been founded and an email was being rolled out within MIT soliciting research for potential investment, and they created a one-page document and applied for it. Later, in early 2017, they met with members of The Engine and The Engine expressed interest in their technology. In this regard, Associate Professor Cullen Buie recounted his meeting with The Engine's head, Katie Rae;

"We told her we actually were not planning to start a company yet. We were planning to submit the SBIR and then if the SBIR was funded, we would then start a company, but she actually felt we could move faster. And in many ways, we started the company in order to be able to accept the funding from The Engine."

[149]"3 Questions: Cullen Buie on a New Era for Cell Therapies," MIT News | Massachusetts Institute of Technology, February 3, 2023, https://news.mit.edu/2023/3-questions-professor-cullen-buie-new-era-cell-therapies-0203.
[150]"3 Questions"; Prof. Cullen Buie, Interview with Prof. Cullen Buie, Co-founder of Kytopen, 10 April, 2023, April 14, 2023.
[151]Prof. Cullen Buie, Interview with Prof. Cullen Buie, Co-founder of Kytopen, 10 April, 2023.

Following this, in late 2017, The Engine, along with Horizon Ventures, provided them with $750,000 in seed funding in the form of a convertible note. Kytopen was one of the first seven startups in which The Engine invested. Cullen Buie had this to say about the funding:

"We use that money initially to refine the market and we were initially looking in the space of industrial biotechnology, so using our technology to engineer bacteria that might produce interesting chemicals. But what we learned very quickly is that there was a bigger market in the space of using the technology to engineer human cells for human therapeutics."

(2) The Big Pivot

They made the transition from bacteria to human applications, a major technological pivot in early 2018. They said that while the main original technology used was the same, the application was very different and was a fairly large pivot. Then, in 2018, they hired two immunologists and an engineer with experience in the field of human cell engineering to pave the way for the successful completion of that pivot. And the data gained from this led to a seed round of funding in 2019. Kytopen also received 225,000 $ for SBIR Phase I in 2018 and approximately 948,000 $ for SBIR Phase II in 2019 as public funds, which were earmarked for technology development[152].

They only worked at Kytopen about one day a week in the early stages of the startup because they were working at MIT, and it was not until January 2018 that Paul Garcia left MIT and transitioned to full-time work. Therefore, they did not use a lot of funds in the early days, and The Engine's initial funding covered the costs. In addition, The Engine provided lab space, which contributed greatly to the success of their pivot. Prof. Buie explained that as follows:

[152] "NSF Award Search: Award # 1722157 - SBIR Phase I: Robust Nanofiltration to Enable Challenging Chemical and Pharmaceutical Separations," accessed May 9, 2023, https://www.nsf.gov/awardsearch/showAward?AWD_ID=1722157&HistoricalAwards=false; "NSF Award Search: Award # 1831203 - SBIR Phase II: Robust Nanofiltration to Enable Challenging Chemical and Pharmaceutical Separations," accessed May 9, 2023, https://www.nsf.gov/awardsearch/showAward?AWD_ID=1831203&HistoricalAwards=false.

"I think the biggest thing is that they have lab space, so they had space for us. That allowed us when we made the pivot to have some scientists and engineers in the lab, fabricating early prototype devices and doing biology experiments on those devices. And that space was really critical for us to be able to make that pivot. Because in many ways, there are a lot of aspects of our technology that were discovered at Kytopen at the company. Not here at MIT. And so having the Engine space allowed us to do that."

(3) VC Seed Rounds and Public Grants such as SBIR

Subsequently, Kytopen raised a $3.6 million seed round of funding from The Engine and Horizons Ventures and angel investors in May 2019[153]. These several angel investors each invested between $50,000 and $100,000. In addition, following SBIR Phase I in 2018, approximately $948,000 was awarded for SBIR Phase II in 2019, which was earmarked for technology development. Additionally, in December 2019, they were awarded grants by Mass Ventures' Small Business Innovation Research (SBIR) Targeted Technologies (START) program, a quasi-public VC in Massachusetts, which awarded Kytopen a 100,000 grant and awarded an additional $200,000 the following year[154]. The funds were designed to cover gaps in activities not covered by the NSF SBIR but important activities for startups, and could be used for attending conferences and trade shows[155].

Thus, Kytopen raised a combination of private and public funding in the early years of its foundation, and Prof. Buie mentioned the importance of using both, as VC funding is more flexible and can further increase credibility in the market, while public funding is a bit more restrictive. They first used funds from Mass Venture and NSF, both public funds, for specific tasks that were core to Kytopen. For example, NSF funds were used to commercialize their technology, mostly paid to engineering consulting firms and manufacturers, specifically for technology development. The same was true for the Mass Venture funds; in fact, to apply for Mass Venture,

[153]"PitchBook Profile - Kytopen," accessed April 23, 2023, https://my.pitchbook.com/profile/186690-52/company/profile.
[154]Charlie Hipwood, "START Funds Give Kytopen Early Boost | MassVentures," accessed April 23, 2023, https://www.mass-ventures.com/news/start-funds-help-propel-kytopen.
[155]Hipwood.

one had to have an NSF SBIR, as these funds were designed to cover what the SBIR did not cover, and these funds were applied to expanding Kytopen's technical capabilities. The VC funds, which came from the private sector, were then used to cover other non-technical expenses such as marketing, market research, customer discovery, business development, and rent payments. And, of course, funding is important, but angel investors have the additional advantage that they have more time and can be expected to make intangible contributions, such as advising the company, compared to VCs. However, it was also pointed out that angel investors have a wide variety of needs, and that managing a large group of angel investors is labor-intensive because they only invest relatively small amounts of money. And Kytopen's fundraising was not too difficult in the early stages, he said. Regarding fundraising, Prof. Buie explained as follows:

"We actually didn't have a lot of difficulty early. So, the Engine signed on early and so then when it was clear, we needed to do a seed round, the Engine was a natural lead investor and Horizons Ventures, they came about in an interesting way. One of their associates, saw an article about me in MIT News, which have been four or five years ago and reached out to me, and so we had a discussion. And that person became very interested in Kytopen and ultimately wound up writing a check in our seed round, and they've actually been an investor ever since."

As for the other angel investors who invested in the seed round, they met them through networking with several people they knew. However, they had difficulty in acquiring business talent, and after the first business person left Kytopen after six months, an experienced angel investor with time to spare worked for them about one day a week, and that person took on the business part of Kytopen.

Subsequently, Kytopen received an additional seed investment of $3.1million in 2020 from Mass Ventures as the lead investor and other angel investors[156]. In addition, Kytopen received a grant

[156]"PitchBook Profile - Kytopen."

award of up to $2 million from the National Institutes of Health (NIH) in June 2021[157]. Then, in September 2021, in a Series A, Northpond Ventures, a Cambridge-based leading science-based VC in the bio and life sciences space, became the lead investor by investing $15 million in Kytopen, Kytopen raised a total of $30 million from 9 investors consisting of Mass Ventures ($0.8 million), The Engine, Horizon Ventures, other VCs and CVC angel investors[158].

(4) Fundraising and Product Market Fit Story

Although Kytopen has been able to raise funds smoothly as described above, Prof. Buie reflected on Kytopen's journey as follows

"We did not hire a really strong business or business development person early on. And so then by the time we were getting to our Series A, we still didn't really have our market worked out very well. Even at Series A, we had the technology, proof of concept, but we didn't really have a strong product market fit story. And I think that hurt us. And I don't think that has anything to do with the funding. I think it's just the nature of us as a founding team. And some of our early hires. We didn't have someone who could really translate what we were doing into a value proposition very well. And you know, me and my co-founder weren't very good at that. And so, I think that hurt us at Series A, we were still able to raise the money. But I think it hurt us because we were only able to add one additional institutional investor- we added North Pond ventures, but everyone else we added was more angels or existing investors."

In particular, this suggests that the failure to hire skilled business development personnel in the stages leading up to reaching the Series A round and the failure to draw a strong product market fit story may be related to the failure to add many new investors in the fundraising.

[157]"Kytopen Awarded NIH Grant of up to $2M to Unlock the Power of Engineered Natural Killer (NK) Cells via Flowfect® Platform - Kytopen," accessed April 24, 2023, https://www.kytopen.com/news/kytopen-awarded-nih-grant-of-up-to-2m-to-unlock-the-power-of-engineered-natural-killer-nk-cells-via-flowfect-platform.
[158]"PitchBook Profile - Kytopen"; "Kytopen Raises $30M in Series A Funding, Led by Northpond Ventures, to Transform Non-Viral Delivery via the Flowfect Platform - Kytopen," accessed April 24, 2023, https://www.kytopen.com/news/kytopen-raises-30m-in-series-a-funding-led-by-northpond-ventures-to-transform-non-viral-delivery-via-the-flowfect-platform.

(5) Support and Benefits from the MIT Ecosystem

They have benefited from the MIT ecosystem in addition to The Engine. First, Paulo Garcia was selected for the Translational Fellows Program, a now-defunct program for postdocs that allows them to explore commercial ventures one day a week with a salary[159]. This gave Garcia time to do a lot of research on the industry and opportunities to learn the different funds available, and since this program incorporated MIT I-Corp's first program, Spark, they were able to move on to I-Corp's next program, Fusion., He also came to learn about The Engine through this program[160]. They also used VMS early on, which was helpful, especially before and after startup, in that they were still able to get basic, general advice about starting a company. After the start-up, they began to seek more highly specialized advice specific to their problems and used VMS less frequently.

Prof. Buie shared the experience with VMS as follows.

"We've worked with VMS early on, so for a few years, we were probably meeting with them once or twice a quarter, just about what we were working on, even before we actually had the company. But then also after the company was founded, the VMS was reasonably helpful. The problem would be it was hard to get people that could help us in our specific industry. They had get general advice, but getting people with specific to our problem was a little bit harder. So, it was helpful early on where you need general advice."

In addition, from their experience, Prof. Buie felt that the ecosystem at MIT was not integrated and the various services were dispersed, so their ability to successfully use them depended largely on their ability to network and obtain information. In addition, he noted that the training

[159]"| RLE Translational Fellows Program Information SessionRLE at MIT," accessed April 29, 2023, https://www.rle.mit.edu/rle-translational-fellows-program-information-session/; Hayter, Lubynsky, and Maroulis, "Who Is the Academic Entrepreneur?"; Prof. Cullen Buie, Interview with Prof. Cullen Buie, Co-founder of Kytopen, 10 April, 2023.

[160]Roman Lubynsky, Interview with Executive Director, MIT I-Corps; Prof. Cullen Buie, Interview with Prof. Cullen Buie, Co-founder of Kytopen, 10 April, 2023.

provided by the technical degree programs at MIT rarely addresses the skills necessary to be a successful entrepreneur, and that there is a need to provide educational programs on a broader range of career paths. There are various types of engineers, including those who are suited to be CEOs, those who are suited to be CTOs, and those who should concentrate on R&D. Since becoming a CEO is currently a popular career choice and everyone want to be CEO, but not everyone is built to do that. He suggested that there is a need for a program to help people think about what role they should play in a company.

(6) Summary and Analysis

One of the distinctive aspects of Kytopen is its initial private funding from The Engine, a venture capital firm established by MIT. Following the recommendation of The Engine, the co-founders opted for private funding as a pre-seed investment during the early stages of the company, even when their research was still relatively immature, rather than waiting until they obtained SBIR funding and further advanced their research before establishing the company. This allowed them to pivot their core technology at an early stage by conducting market research in their initial focus area, and also allowed them to hire engineers to obtain research data, which led to subsequent seed round fundraising. It is also clear that the provision of lab space, as part of the potential role of university-related VCs, played a significant role in the development of Kytopen's technology.

The case study also yields valuable insights into the role of private and public funding, particularly the influence of university-related venture capital firms, general venture capital firms, and angel investors. As highlighted by Professor Buie, public funds often come in the form of targeted grants with specific missions and limited applicability, often specializing in technology development. Therefore, a balanced approach involves securing subsidies for core technological development while relying on private funds to cover additional costs. Additionally, local government subsidies can complement central government subsidies, filling funding gaps and ensuring comprehensive support for early-stage startups.

Furthermore, the experience and networks of angel investors appear to hold greater significance than the financial benefits of their investment. In this case, university-related venture capital firms provided pre-seed funding, significantly accelerating the pace of growth, underscoring the importance of seed funding from such entities.

In the context of Series A fundraising, Prof. Buie's analysis reveals a lack of a compelling product market fit story. This deficiency hindered the attraction of new investors, emphasizing the criticality of effectively communicating the marketability of the product during the initial fundraising stages.

Lastly, Kytopen's acquisition of funding from Horizon Venture was triggered by an article in MIT News highlighting Prof. Buie's research. This indicates that research articles and theses can serve as catalysts for attracting interest from venture capital firms and other investors. Michael Kearney of The Engine also acknowledged this aspect, underscoring the importance of externally disseminating research results in the deep tech field through articles and theses.

5.3. Quaise Energy

(1) Founding History and Initial Angel Investment

Founded in 2018, Quaise Energy is a company that develops millimeter-wave drilling systems for geothermal power plants[161]. The company's foundation can be attributed to the licensing of technology developed by Paul Woskov, a research engineer affiliated with MIT's Plasma Science and Fusion Center (PSFC)[162]. This case is an example of how MIT's research results were successfully matched with outside management personnel to establish a startup.

[161]"Quaise Energy," Quaise Energy, 2024, https://www.quaise.energy/.

[162]"MIT Spinout Quaise Energy: Working to Create Geothermal Wells Made from the Deepest Holes in the World | MIT Energy Initiative," accessed April 25, 2023, https://energy.mit.edu/news/mit-spinout-quaise-energy-working-to-create-geothermal-wells-made-from-the-deepest-holes-in-the-world/.

CEO and Co-Founder of Quaise Energy, Carlos Araque joined The Engine as Technical Director after more than a decade of experience in the oil and gas industry with the company Schlumberger[163]. In July 2017, Woskov came to The Engine for advice on how to commercialize a technology he had been developing in the lab for 10 years. Woskov and Araque discussed how to get the technology out of the lab and into society[164]. In the process, in August 2017, Araque met with Vinod Khosla, a billionaire angel investor who had been interested in geothermal energy and Woskov's technology, and in ongoing discussions with him over the next year or so, it was suggested that Araque himself become CEO and form a company[165]. Araque recalled the time and stated the following.

"He basically says, Hey, Carlos. I like this idea. I like you. I'll give you a million dollars. So, you can start a company"

According to Araque, he had a family at the time and could not decide to start a business right away, but after meticulous preparations and reaching a state of readiness, he decided to start a business. Araque and Matt Houde, who worked for geothermal company AltaRock Energy, co-founded Quaise Energy. Then, in 2018, they agreed to receive $1 million in the form of a convertible note from Vinod Khosla[166].

Araque recalled the time and explained it as follows.

"It took me a long time to say yes. Because I first wanted to make sure that I could build this company so I wanted to understand what would be needed like I was helping Paul trying to understand how to be the company. But Vinod Khosla told me you build it, I say okay, how would I build it? How would I follow my own advice that I'm giving to Paul? Because Paul's network is

[163]"MIT Spinout Quaise Energy: Working to Create Geothermal Wells Made from the Deepest Holes in the World | MIT Energy Initiative."
[164]Carlos Araque, Interview with Quaise Energy, April 14, 2023.
[165]Carlos Araque.
[166]Carlos Araque.

different from mine. Who would I hire and when? And what would be the milestones? How do I build a staircase to get more money and more money and more money? And that process took more than a year. And I eventually said Okay, I'm ready. I want to do these. I think we can be successful. I think this is important. I will accept to take $1 million and that's the birth of the company."

(2) Formation of the Consortium to Obtain Public Grant from DOE

The $1 million given by Vinod Khosla was then used to obtain a Grant from the Advanced Research Projects Agency-Energy (ARPA-E) of the Department of Energy (DOE) to advance technology development and, since the Grant is a deferred payment type, $1 million fund was used to create cash liquidity to execute the Grant. Because of the huge amount of money involved in developing technologies in the energy sector, Araque felt it was imperative to obtain public funding, so he developed a strategy to form a consortium of various organizations to go and get an ARPA-E Grant from the DOE. His team wrote grant applications, went to various places, and even found partners to apply for the grant. As a result, MIT, Quaise Energy, Lawrence Livermore National Laboratory, Impact Technologies, and AltaRock Energy formed a consortium to apply for this grant[167]. The Grant was awarded on a cost-share payment basis, i.e., the DOE contributed about $3.8 million because the subsidy rate was about two-thirds or so, and Atlarock contributed about $1 million, for a total project of about $5 million[168]. And Quaise Energy was the project manager, and as a result, Quaise Energy won ownership of IP[169]. According to Araque, Quaise winning the IP was key to the success of the company. The main recipient, Atlarock, allowed this because Atlarock was a shareholder in Quaise Energy. Araque had to work out a detailed strategy for getting the IP, which he describes as follows.

[167]"ARPA-E Project | Millimeter-Wave Technology Demonstration for Geothermal Direct Energy Drilling," arpa-e.energy.gov, accessed April 25, 2023, http://arpa-e.energy.gov/technologies/projects/millimeter-wave-technology-demonstration-geothermal-direct-energy-drilling.
[168]"ARPA-E Project | Millimeter-Wave Technology Demonstration for Geothermal Direct Energy Drilling"; Carlos Araque, Interview with Quaise Energy.
[169]Carlos Araque, Interview with Quaise Energy.

"So all of these details have to be weaved together for everything to work. So, this is where experience comes into play in this. When you look at the complexity here, the agreements, the legal paperwork, somebody with experience has to be the mastermind of all of that. In that case, that was me. Because I have a lot of experience doing these in oil and gas. I did it for more than 15 years. So that's really how Quaise was born. How we all started the journey"

Araque was the one who initially sought to get the big grant. He explained his reasons as follows.

"For especially the project thing and it was because we want to be engaged full time. So, we need full-time salaries. No, I didn't want to just work on something else. I don't believe SBIR is very well suited for hard technologies. You really need commitment, which makes them very expensive. That's the reason we looked for that big grant, but it comes with that requirement. So Atlarock facilitated that and they got ownership in place. So, with this money, we start building stuff. Now we have the money to build things or start reusing things that we go to our national lab in Tennessee, Oak Ridge National Labs, and we borrow their stuff we say, Can we borrow your gyrotron? Can we borrow your waveguides? Can we borrow the building? And they say well no, you cannot borrow you have to pay us. But that's part of the money. And then we start building, building, building. First large prototype, getting results and with that, I can then go and do this."

(3) Moving on to Fundraising from VCs and CVCs

Then, in August 2020, the first private VC funding was raised with The Engine as the lead investor, two other VCs, Safer Partners and Collaborative Fund, and angel investor Vinod Khosla, with a seed of $ 5 million[170]. In April 2021, the company received a $12 million seed from Corporate Venture Capital of Nabors Industries, the world's largest land-based drilling rig fleet company, through $7 million of cash and $5 million of SAFE (Simple Agreement for Future Equity)[171]. A SAFE is a legal contract that gives the investor the right to purchase equity in the future and with

[170]"Seed Round - Quaise - 2020-06-08 - Crunchbase Funding Round Profile," Crunchbase, accessed May 2, 2023, https://www.crunchbase.com/funding_round/quaise-seed--85d14016; Carlos Araque, Interview with Quaise Energy.

[171]"PitchBook Profile - Quaise Energy," accessed May 2, 2023, https://my-pitchbook-com.libproxy.mit.edu/profile/435871-72/company/profile; Carlos Araque, Interview with Quaise Energy.

this, early in the future and with this, early-stage startups can use to fund their business without valuing the company or giving up equity initially[172]. In June 2022, the company raised $51.99 million from 22 investors in a Series A financing, with Safer Partners and TechEnergy Ventures as lead investors[173].

To successfully raise funds from these private VCs, Araque and Matt Houde needed to build a team. He describes the process of building a team and obtaining funding from VCs and CVCs as follows:

"VCs want to see a team. So, at that point, it was just two of us, Matt and me. That's not enough. If they're going to give me $5 million, they say who's your team? So, I had to pull two of my colleagues from Schlumberger – one living in England and one living in Houston, I said, "Guys, would you join me?" And it took a year for them to understand it and to say yes. So, from here, I was just telling "I knew this was coming in the future. Would you come with me and understand what we're doing?" They traveled and I pay for their travel, they come to the lab, and see what they're doing. And eventually, I was able to go to the VCs and say, "Here's my team- me, Matt, Henry, and Frank; four of us. This is the plan, and this is what we've done. Here are some results. It's working. Here's the team. Here's the plan for that team." That's what unlocks this."

This is how The Engine-led seed funding of $5 million in August 2020 was realized. And for subsequent CVC and VC funding, this $5 million was used to move forward and make it happen, as Araque explains below.

"So that's truly $5 million that comes to us to the account. So now we have a lot more money. Now we have liquidity. And we start hiring people. We build a team of 10 people and will be continued to spend that money to build more, get more milestones, and eventually get into

[172]"SAFE vs. Convertible Note: What's the Best for Seed-Stage Funding?," accessed May 2, 2023, https://blog.hubspot.com/the-hustle/safe-vs-convertible-note.
[173]"Series A - Quaise - 2022-02-08 - Crunchbase Funding Round Profile," Crunchbase, accessed May 2, 2023, https://www.crunchbase.com/funding_round/quaise-series-a--67b79580; "PitchBook Profile - Quaise Energy"; Carlos Araque, Interview with Quaise Energy.

corporate VCs and tell them hey, “We would like to work with you.” I wanted them to compete with each other. Both said yes. But one of them gave us a lot more money. One of them proposed $12 million. The other one proposed $3 million. $Yes, So that was that but at that time, we had a team of 10 people and we had a lab in Houston. We had a building with workers working full-time. And it continues to go. By this time, we had a lot more progress. We had our own equipment. We didn’t need to work in Oak Ridge National Labs anymore. We could do it ourselves. And we hire like 25 people now. We convinced a lot of investors to give us money $52 million. So now the company started totally changing. I mean, when you have $50 million, you can do a lot of things. So that’s where we are now. And we’ll see what happens here.”

(4) Reflecting on the Fundraising Journey

Reflecting on the series of starting a company from scratch and raising funds, Araque stated that the first was the most important and the most difficult, as follows:

“Once you have money and you’re fine, it’s okay. This is the very beginning which is very difficult because you have nothing. You’re building something out of nothing. Well, not entirely. I mean, there was 10 years of work by MIT. That’s important because they did that work. I could tell you “Investors, look,10 years of work works. Let’s go.” But it’s still hard. Because it’s a university. It’s academic. It’s small scale. So, it really takes a very special team to start pulling that out and moving forward if those sticks.”

And Araque analyzed his own success in raising funds for this first and most difficult part of the project as follows

“There is the difficult part in this. The investor is working with very little information, it’s a very risky bet. The investor is working with very little information on two things. One, how well does the technology work because very little has been done? Two, how good is this team? Who is Carlos, who is this guy? Why can I trust him? He came from Schlumberger, but that’s a large corporation. Is he going to be okay, as an entrepreneur as it is a very different skill set? So that’s

really where they're taking a leap of faith with the founder and with the technology. If you're a repeat founder or a founder that has done it once, twice, or three, then they're not taking a bet. They said, well, you're a proven founder, you know how to raise money, you know how to move things, but I was a first-time founder. It helped that I had worked in venture capital because at least I knew something about that world. It wasn't like, I have no idea how a VC round works and I have no idea what a convertible note is. No, I knew all of those things because I was working in a venture capital firm for a year. I think is a combination of those two that gave him the confidence to say, Okay, this guy clearly knows technically because he's done it. He understands venture capital, because of the way he's negotiating with him. I think that's really the people you have to look for to make it possible. I could have gone to a venture capital fund. And probably they would have given me $250,000. It's normal. They will give you a little bit of money, not $ 1 million, maybe 250K~300K. And you could say, Okay, thank you. You can pay yourself a salary, but you run out of money and you cannot hire somebody to help you. And you cannot fly other people to come and join you. Or maybe you could do all of that. But surely, you cannot inject liquidity into the graph. You wouldn't have money for it. So, these things have a certain scale. And I think some kinds of investors are starting to understand that some things are just expensive, that they don't work with $500,000 that you need millions of dollars for them to even begin to work."

(5) Summary and Analysis

The Quaise Energy case is a case in which the results of the laboratory were successfully matched with outside business personnel with industry and VC experience. In addition, as this case clearly shows, large federal grants are basically postpaid and cost-sharing, which poses a challenge for early-stage companies with tight cash flow to obtain them on their own. Therefore, it is necessary to form a consortium to overcome this obstacle, but the results suggest that it is difficult to lead the formation of a consortium and acquire such a large grant without business experience such as forming such a consortium. Furthermore, it was pointed out that, especially in a field such as the energy industry where it is difficult to build even a prototype without large funds, large funding is required even in the initial stage, and a small amount of grant like SBIR does not make

much sense. In this case, the angel investor provided the necessary funds to obtain public funds, and the angel investor also proceeded with the formation of the company, indicating the significant role played by angel investors in the United States.

Furthermore, in this case, it can be seen that in the early stages, investors, in this case angel investors, pay attention to the eligibility of executive management personnel (CEO) as a major factor in making investment decisions. The investment is made on the premise of technology, looking at the potential of the management personnel's technical understanding and managerial skills. In this case, the CEO, Carlos Araque, has planned very strategically and has been successful in raising funds to date, suggesting that there is a large element of management competence.

It also suggests the importance of "Team" in raising funds from private VCs. Araque has been successful in raising funds from VCs by drawing experienced personnel from his previous firm, forming a strong management team, and raising funds.

5.4. Kano Therapeutics

(1) Founding History

Kano Therapeutics is a single-stranded DNA startup for precision genome editing, founded in 2021 by Floris Engelhardt, a postdoctoral fellow at Professor Mark Bathe's BioNanoLab at MIT, Professor Mark Bathe, and John Vroom of MIT Sloan. They licensed the lab's research results[174]. Their funding journey began with a university prize of $20,000, the 2021 Sloan Healthcare Innovations Prize, the MIT Sloan School of Management's pitch competition open to student entrepreneurs innovating in the healthcare space in 2021[175]. Then, in June 2021, Engelhardt was selected by Activate Global, a nonprofit accelerator, for Activate's 2021 Fellows and received

[174]Floris Engelhardt, Interview with Floris Engelhardt, CEO of Kano Therapeutics, April 21, 2023; "Kano Therapeutics," The Engine, accessed April 26, 2023, https://engine.xyz/companies/kano-therapeutics.
[175]"MIT Team Improving Gene Therapies Wins Sloan Health Care Prize," MIT News | Massachusetts Institute of Technology, March 1, 2021, https://news.mit.edu/2021/team-improving-gene-therapies-wins-sloan-health-care-prize-0301; "MIT SHBC 2023," MIT SHBC 2023, accessed May 1, 2023, http://www.sloan-hbc.mit.edu/innovations-prize-2021.

$290,000 as a founder stipend[176]. She also participated in four different accelerator programs, including this one, to network in the Boston ecosystem, which gave her many contacts to connect with investors[177].

"So, I already had people in place that I had relationships with, when we actively started fundraising."

In February 2022, Roche, a global pharmaceutical and health care company, gave them a price ticket to rent shared laboratory space at Lab Central near MIT for one year at no cost, and from March 2022, they started to use an office at Lab Central[178].

(2) Initial Fundraising from VCs

And in May 2022, with The Engine as the lead investor, the company received a seed round of $2.1 million from The Engine, Amino Collective, and one angel investor[179]. With this round Kano Therapeutics managed to put themselves in a position to choose VCs; they spoke with about 10 private VCs and secured investment offers (term sheets) from 3 VCs[180]. They also did not want to do a long fundraising round, so they did an intensive fundraising round over a short period of 2 months and finally accepted an investment from The Engine[181]. Engelhardt states as follows:

"We had to turn down the other two. We already were trying to get them still in the round. We already had double the amount of money that we originally wanted to raise. And the Engine wanted to put in more money. So, in the end, we decided that we had to turn down the other

[176]Activate.org, "Activate Introduces Cohort 2021 Fellows: Two Dozen Science Entrepreneurs Launching Hard Science Ventures," accessed April 26, 2023, https://www.prnewswire.com/news-releases/activate-introduces-cohort-2021-fellows-two-dozen-science-entrepreneurs-launching-hard-science-ventures-301306910.html; "PitchBook Profile - Kano Therapeutics," accessed April 26, 2023, https://my.pitchbook.com/profile/498494-26/company/profile.
[177]Floris Engelhardt, Interview with Floris Engelhardt, CEO of Kano Therapeutics.
[178]Floris Engelhardt.
[179]Floris Engelhardt.
[180]Floris Engelhardt.
[181]Floris Engelhardt.

ones. And we just went with Amino Collective as a follow-up because they were willing to put in smaller amounts of money."

And in terms of the deciding factor for the VC, Engelhardt said the key criterion was who would be a Board Member of Kano Therapeutics.

"I think we made a matrix. We had a table like deciding it and it was a combination of valuation for the company and the reputation of the funds. And then one big factor was mentorship in year one, how much like what is that mentorship structure? Mentorship by the person who will join the board. So just like mentorship, anyone and board member like maybe the board member made that a defense because we knew were going for a price round. And so, the idea was who's going to be on the board and how good will be the for the connection be? And we currently have Ann DeWitt on our board. And she convinced me that she's the right person to help us, like, get the company off the ground and get us ready for the real race."

Kano Therapeutics did not receive a government grant in its early stages because Engelhardt, the shareholder of more than half of Kano Therapeutics, was from Germany, was not a US citizen, so she was not eligible for federal grants like SBIR and the only option was private funding[182]. And now that she is eligible to apply, they plan to apply for research funding from the NIH's Advanced Research Projects Agency for Health (ARPA-H), which began in 2022.

Therefore, they focused their fundraising on VCs, and as mentioned above, it was very successful. Engelhardt attributes the success to Kano Therapeutics' big vision and story and the specific problems that exist today. By creating a synthetic gene with Kano Therapeutics' technology and placing it in a patient, overriding the wrong functionality in the human genome, they can treat Alzheimer's, Parkinson's, muscular dystrophy, and more[183]. The fact that they were able to tell

[182]Floris Engelhardt.
[183]Floris Engelhardt.

this very straightforward story that everyone could relate to gives them an advantage with regard to fundraising.

Kano Therapeutics raised $2.1 million in the seed round, which was just about the amount they needed. Originally, this amount was more than double what they wanted to raise. With this funding, their current team of 6 people will be able to operate for 20 months. Therefore, Engelhardt said, Kano Therapeutics needs to raise the money by the end of 2023, as they currently have funds until the beginning of 2024.

“We have money until early next year, but we will need to fundraise this year because you also don't want to just like slow down too much. And because if you don't spend money, you don't accelerate. A lot of people say, “Oh, I raised money. We've got so much runway. We've got it down.” But on the other hand, VC money means “start the clock, you need to accelerate, push and get data”.

In addition, Engelhardt noted that, with respect to private VC funding, it is important to keep the following in mind:

“You need to find new investors every round because you need to show that you can convince new people to invest in your technology. I would say then very, very few companies ranging from the same investor over and over again. It's super hard, especially because then there's no competition that they can just put the numbers on the table and delegates that they want. So, you probably want to get out there and get others right.”

(3) Experience in Talent Acquisition

Engelhardt said she had a very difficult time acquiring talent after Kano Therapeutics was established.

"The worst months of my life trying to get the first people in the boat- just because it's so hard to find people that fit into the team from culture and expertise, and that are willing to take the risk to come to such an early startup. And back then, last year, we tried over the summer, never tried to hire people over the summer. No one wants to work in July or August. No one wants to switch jobs in July or August. They all want to still take the vacation at the old company. They switch in September. So big learning outcome never try to hire July or August. As soon as we tried to hire in September we hired two people. Then again like two months. Later, it was easy. So big, big learning, never try to hire over some occasion."

(4) Support and Benefits from the MIT Ecosystem

Kano Therapeutics also benefited from the MIT ecosystem in a number of ways in addition to 2021 Sloan Healthcare Innovations Prize. First is a class called "New Enterprise", an entrepreneurship course at the MIT Sloan School of Management[184]. Engelhardt participated in this class, which is a project-based learning class that follows the entrepreneurial process. Although the team she joined was not in the life sciences or in a field related to her field of study, she found the experience very helpful in understanding the entrepreneurial sequence. Kano Therapeutics also used VMS and Startup Exchange[185]. VMS was very helpful, especially in the early stages. Specifically, they were able to have access to very senior people in the industry, and they read and reviewed their applications in terms of grant applications. Although Kano Therapeutics now receives less mentoring services from VMS, they meet with their mentors about once every six months to update them on what is going on[186]. The Startup Exchange gave them the opportunity to showcase their technology in a webinar to the industry, which has been very useful for them.

(5) Summary and Analysis

Kano Therapeutics has demonstrated remarkable success in its early-stage fundraising efforts by effectively attracting multiple lead investors and securing term sheets from various venture

[184]Floris Engelhardt.
[185]Floris Engelhardt.
[186]Floris Engelhardt.

capitals. CEO Floris Engelhardt, who owns a majority stake in the company, strategically focused on private funding from the outset due to her status as a non-U.S. citizen, which made her ineligible for government grants such as the SBIR. Engelhardt's participation in accelerator programs and her network of venture capitalists and investors provided valuable access to potential funders. Additionally, her prior exposure to entrepreneurship, acquired through MIT Sloan's renowned New Enterprise course, instilled a deep understanding of the entrepreneurial process and bolstered her potential, despite this being her first venture.

The early inclusion of John Vroom, an MBA student, in the team and the presence of a business-oriented team member from the start facilitated the establishment of a robust team at an early stage. This strategic team composition played a significant role in Kano Therapeutics' success.

Furthermore, Kano Therapeutics effectively communicated a strong market fit story by presenting a compelling vision and solution to address an existing problem in the field of genome editing. This compelling narrative contributed to the company's ability to choose among different VCs for fundraising.

Moreover, this case highlights the significance of human resources, meaning who joins the board, in the decision-making process when selecting a VC. VCs are looking at “humans”, looking for a strong team, while entrepreneurs are emphasizing the same point of view. It also indicates the importance of bringing in new investors in order to obtain investment offers from multiple VCs for each round of fundraising.

The risks associated with VC funding are also pointed out in terms of the need to accelerate development in order to achieve results the moment the investment is accepted, and this is a point that entrepreneurs should keep in mind.

In summary, Engelhardt had a comprehensive understanding of the entrepreneurial process through the New Enterprise course and succeeded in investor networking, and in addition, she

had formed a strong team with a member in the business field from the beginning. Finally, her strong commitment to entrepreneurship, as evidenced by her series of actions, led to successful fundraising.

5.5. Via Separation

(1) Founding History and the Deshpande Grant and MIT I-Corps

Via Separation, a startup focused on membrane technology for separations for industrial decarbonization, was established in 2017 by MIT Department of Materials Science and Engineering Professor Jeff Grossman and two PhD graduates Shreya Dave and Brent Keller[187]. The company's foundation was built upon licensing the intellectual property derived from Shreya Dave's PhD research.

Shreya Dave's entrepreneurial aspirations began during her undergraduate studies, where she recognized her desire to leverage technology for impactful change rather than pursue a traditional academic path[188]. With a keen interest in product development and market-driven technology, she contemplated the potential commercialization of the technology she was researching as part of her PhD program[189]. Recognizing her lack of knowledge in commercialization, she talked to her Project Investigator, Professor Jeff Grossman, and they applied to the Deshpande Center's program[190]. Accepted into the Deshpande Center's 2015 project on "Fouling-resistant nanoporous membranes," Dave found the program immensely valuable in equipping her with the skills necessary to engage with potential clients[191]. Simultaneously, she discovered that the initial market fit she envisioned for her technology was not optimal. This realization prompted her to join MIT I-Corps in 2016, where she delved into customer discovery and gained deeper insights into the market fit of her product. She then joined

[187]"Via Separations," The Engine, September 19, 2017, https://engine.xyz/companies/via-separations.
[188]Shreya Dave, Interview with CEO of Via Separation, April 4, 2023.
[189]Shreya Dave.
[190]Shreya Dave.
[191]"Fouling-Resistant Nanoporous Membranes," *Deshpande Center for Technological Innovation* (blog), accessed May 2, 2023, https://deshpande.mit.edu/projects/fouling-resistant-nanoporous-membranes/.

MIT I-Corps in 2016 to understand the market fit of the product, did customer discovery., Subsequently, she went on to NSF National I-Corps, where she was awarded a $50,000 Grant[192]. In addition, $289,990 in grant funding was received from the Massachusetts Clean Energy Center and other sources[193].

”Once we understood what we were developing and for whom, we were able to apply for more NSF SBIR program and to the Massachusetts Clean Energy Center, which was grant funding as well, and at the same time fundraising from venture capitalists. So, each of those played a very important role in our ability to launch the company in 2017.”

(2) Fundraising from VCs

In 2017, Via Separation was awarded $1.2 million from The Engine, angel investors, and other investors in a seed round led by The Engine[194]. Via Separation was among the first seven startups that The Engine invested in. They were originally pitching to another venture capital firm that didn't seem to be focused on their sector and recommended they consult with The Engine, which led to a seed investment[195]. They then obtained NSF SBIR Phase I ($225,000) in 2017, SBIR Phase II ($1,228,000) in 2018, a seed round of $4.8 million in 2019 from VCs like Safer Partners and The Engine, and raised $38 million in Series B in 2021 from Private Equity and Impact Fund. In addition, in 2022, it won a Grant of about $2.8 million to scale up in DOE's APRA-E[196].

[192]Roman Lubynsky, Executive Director, MIT I-Corps, “NSF I-Corps Program New England Regional Innovation Node.”

[193] “PitchBook Profile - Via Separations,” accessed May 2, 2023, https://my-pitchbook-com.libproxy.mit.edu/profile/186656-14/company/profile.

[194]“PitchBook Profile - Via Separations.”

[195]Shreya Dave, Interview with CEO of Via Separation.

[196]“Press Release | U.S. Department of Energy Announces $100 Million to Boost Commercialization of Eight New Clean Energy Technologies,” arpa-e.energy.gov, November 22, 2022, http://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-100-million-boost-commercialization; “Via Separations | Arpa-e.Energy.Gov,” accessed May 2, 2023, https://arpa-e.energy.gov/technologies/projects/scalable-graphene-oxide-membranes-energy-efficient-chemical-separations.

As mentioned above, Via Separation was successful in raising funds from private sources, and Dave explained the benefits related to the fact that they were able to raise funds from private VCs as follows:

"I think it was very helpful getting the private money because it offered technical validation that what we were doing was likely to work. I won't say it was my strategy because we were it just happened."

(3) Support and Benefits from the MIT Ecosystem

As for the MIT ecosystem, Dave says she has benefited from many things besides the Deshpande Center[197]. One such benefit was the classes she took at MIT. She participated in a product development class in the Department of Mechanical Engineering and Energy Venture (now Climate and Energy Venture), an entrepreneurship course in the energy field offered by MIT Sloan[198]. In addition, the networking she gained while running the MIT Energy Conference, a student-run energy conference, was very helpful in starting her company[199]. They also participated in the Startup Exchange - where they did not end up finding an industry partner, but she found the opportunities it provided very helpful[200]. In terms of talent acquisition, Via Separation has had no difficult challenges, and although it currently has 50 employees, it has been able to connect with MIT and a network of Boston-area universities and hire from companies like GE, SpaceX, and Exxon Mobil[201].

(4) Summary and Analysis

Via Separation was able to leverage its MIT ecosystem connections, including Deshpande Center and MIT I-Corps, to develop its technology and gain a better understanding of the marketability of its product. By participating in the Deshpande Center and I-Corps, they were able to identify and develop market-compatible technologies before establishing their company, which allowed

[197]Shreya Dave, Interview with CEO of Via Separation.
[198]Shreya Dave.
[199]Shreya Dave.
[200]Shreya Dave.
[201]Shreya Dave.

them to apply for public funding and raise private funds with a better product market fit story. It is also noteworthy that these programs enabled the company to pivot from a field that did not have a good market fit to one that did, prior to the establishment of the company. It is also noted that NSF's public funding contributed to the launch of the company, albeit in a small amount, in the early stages of its establishment.

As a preliminary step, CEO Shreya Dave took product development and venture classes at MIT, and built business skills such as customer discovery through I-Corp and others, which helped prepare her for entrepreneurship. As Michael Kearney of The Engine pointed out, VCs focus on initial managerial potential, and the courses and programs at MIT provided an opportunity for potential entrepreneurs to prepare for that as well. It can also be noted that from the beginning, Via Separation was successful in obtaining both private and public funding, and was able to take advantage of the characteristics of both and use them successfully.

In addition, the Via Separation case provides an illustration of the point made by Brad Feld et al. that VCs are different from one VC to another, and the same proposal may be accepted by one VC and rejected by another. They spoke with other VCs during the fundraising process, where they were introduced to The Engine. This illustrates the importance of meeting VCs who are a good match for the company in fundraising.

5.6. VulcanForms

(1) Founding History and Initial Technological Development by Self-funding

VulcanForms is a digital production system company based on its industrial 3D printing technology founded in 2015 by MIT alumnus Martin C. Feldmann and Professor John Hart at Mechanical Engineering[202]. As of May 2023, the company had over 400 employees and has grown

[202]"Industrializing 3D Printing," MIT News | Massachusetts Institute of Technology, November 28, 2022, https://news.mit.edu/2022/vulcanforms-printing-manufacturing-1128.

rapidly[203]. Feldmann and Prof. Hart met as a student and a professor in 2013. After graduation, Feldmann became a research specialist in Prof. Hart's lab and the two got the idea to make 3D printing an industrially relevant method and decided to start a company outside of MIT[204]. So, while VulcanForms was not founded with a license of MIT IP, it was founded on an idea that was born in an MIT lab, and they call themselves an MIT born startup[205].

They received initial guidance through MIT's Venture Mentoring Service, founded VulcanForms in 2015, and self-funded the technology for two years until 2017 when they received their first $2 million funding[206]. Explaining why they did not rush for funding in the early stages of startup, Prof. Hart states the following:

“We intentionally decided not to raise funding or seek to raise funding right away. And that was because we felt it was important to ourselves to demonstrate that we had something valuable before we wanted to raise money and take on the risk and the expectations that come with investment. I'm not saying that we would have been able to raise $2,000,000 years earlier or not, but just that was our approach.”

Prof. Hart explains the benefits of not rushing to raise funds as follows

“It would not have gotten the same if we had gone to eclipse in 2015 when we just had a more rudimentary pitch deck in no technology demonstration. But We probably could have raised some funding and saved the easing on our bank account. But it was more of like a personality thing. We felt we wanted to demonstrate it to ourselves first. That's not always necessarily the best way but it's just the way that we went about it. And I think what was also important is aside from like the technology demonstration, our understanding of why we were doing this what we were trying to do also matured because while you're building the prototype, you think about the

[203] “PitchBook Profile - VulcanForms,” accessed May 9, 2023, https://my-pitchbook-com.libproxy.mit.edu/profile/268366-51/company/profile.
[204]“Industrializing 3D Printing.”
[205]Prof. Anastasios John Hart, Interview with co-founder of VulcanForms, May 3, 2023.
[206]“Industrializing 3D Printing”; Prof. Anastasios John Hart, Interview with co-founder of VulcanForms.

technology and what you're proposing and all those things and like now our vision of what we where we want to go is of course much more mature than it was in 2017. It matures with time it hasn't changed fundamentally, but it matures with time."

This suggests that accepting an investment necessarily involves risks as well as benefits, and also suggests the dangers of accepting an investment out of hand.

Regarding the two years until the funding was ready, Prof. Hart continued his explanation as follows:

"Martin gets the credit for making the company possible. I was there (VulcanForms) but I was also here (MIT), and He supported himself fully. We shared the expenses to rent some space to test the prototype. He used the hobby shop (MIT's a fully-equipped wood and metal shop), he built things in his living room, and then we had a basic, not a 3D printer in full but a basic prototype. And when we found we had de-risked it enough, we were feeling like we were running out of money, running out of time. We wrote a business plan, and then we went fundraising."

(2) Initial Fundraising from VCs

As mentioned above, the team, for reasons of technical readiness and depletion of funds and time, then began fundraising and successfully raised $2 million from Eclipse Ventures, a VC in Pal Alto, CA, in June 2017. Regarding the process, Prof. Hart states the following:

"I can't say fundraising was easy. But we were able to raise funding fairly quickly. We connected with investors who had an interest in our thesis and that's what was most important about that process. We had no idea what to do, what's important in terms of the pitching strategy and the incorporation, and all those things. Like many new entrepreneurs, we were scrambling but we were able to make it work. And a large part of that is, of course, finding the mentors and advisors to get to that stage. Then we met the Eclipse ventures and we ended up accepting seed funding from them."

In addition, they negotiated with several VCs and succeeded in putting themselves in a position to choose which of several VCs to receive the investment from. The decision to choose Eclipse Ventures was not based on valuation or the amount of the investment, but on who would join the board of directors. Prof. Hart described this in the following way:

"They wanted to and we allowed them to take the whole round, and they were not giving us the highest valuation we were offered nor the largest amount of money, but we felt the best fit with them because they had a strong interest back then. Seven, six years ago they were investing in manufacturing companies, investing in industrial companies, and the partner who has been on our board Greg (Gregory Reichow), prior to joining Eclipse was the VP of production at Tesla and so he understands manufacturing and operations. And that was very important to us. So not only it's fortunate to hit it right where you get, venture investment at the early stage of a high-risk endeavor, but also to meet Eclipse and Greg was very important, as well because we had not only an investor but an investor with a meaningful understanding of what we were proposing and where we needed to go."

The $2 million that they were able to raise was used to hire their first employee, a VP of Engineering, to secure a full-scale space, and to build our first prototype, which they call Alpha. This first employee, who joined VulcanForms before they started fundraising, has a strong entrepreneurial background and he was a perfect match for Feldmann and Prof. Hart and helping them with the business plan and getting pitching and getting pitched. them with the business plan and go pitching and get that confidence and experience[207].

It was important to the VCs to know who was part of the team, and all three went to Eclipse Ventures in Palo Alto when Eclipse Ventures made its investment decision.

[207]Prof. Anastasios John Hart, Interview with co-founder of VulcanForms.

"I didn't go on all the pitching but when we went to pitch to Eclipse, I think it was a second time before they were ready to make their decision. We all fly out because Eclipses is in Palo Alto, fly up to the Bay Area. We sat down with Greg (Gregory Reichow), for 15 minutes in Eclipse and he wanted to meet all of us together and that in-person interaction was so important to their decision to make an investment."

(3) Series A Fundraising

This was followed by a Series A fundraising in late 2018, with Eclipse Ventures as lead investor, and Fontinalis Partners, Industry Ventures, Atlas Innovate, and Ray Stata, an MIT alumnus and founder of Analog Device, the leading semiconductor company invested $21 million in the company[208]. In May 2019, Fontinalis Partners invested an additional $5 million in the company[209]. With these funds, they got a good way toward the first production machine that they call beta. In May 2020, also with Eclipse Venture as lead investor, Fontinalis Partners, Atlas Innovate, and Boston Seed Capital for a Series B investment of $77 million[210]. In July 2022, a Series C investment of $250 million was made[211].

Thus, VulcanForms was able to bring in more or less almost every investor in every round, as well as bring in new investors. In attracting new investors, Prof. Hart took advantage of the MIT network.

"When we were starting to raise series A and we were in touch with Eclipse, we wanted to help bring in some new investors. I thought of Ray Stata. I did not know him. But I reached out to a colleague who I thought knows him. The colleague introduced me to Ray and Ray ended up investing and joining the board."

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[208] "Series A - VulcanForms - 2018-12-28 - Crunchbase Funding Round Profile," Crunchbase, accessed May 3, 2023, https://www.crunchbase.com/funding_round/vulcanforms-series-a--2287fc71; Prof. Anastasios John Hart, Interview with co-founder of VulcanForms.

[209] "Venture Round - VulcanForms - 2019-05-03 - Crunchbase Funding Round Profile," Crunchbase, accessed May 3, 2023, https://www.crunchbase.com/funding_round/vulcanforms-series-unknown--328bd1c2.

[210] "Series B - VulcanForms - 2020-05-15 - Crunchbase Funding Round Profile," Crunchbase, accessed May 3, 2023, https://www.crunchbase.com/funding_round/vulcanforms-series-b--14829cca.

[211] "Series C - VulcanForms - 2022-07-05 - Crunchbase Funding Round Profile," Crunchbase, accessed May 3, 2023, https://www.crunchbase.com/funding_round/vulcanforms-series-c--055b0236.

(4) Summary and Analysis

The case of VulcanForms provides a compelling illustration of a company's trajectory, starting with self-funding for technological development, followed by private funding and subsequent rapid growth. It serves as the second case study, following Kytopen, that highlights how external dissemination of research results, such as articles and theses, can pave the way for fundraising in the deep tech field.

Moreover, this case emphasizes the criticality of timing in commencing fundraising efforts. It underscores the potential risks associated with seeking private funding during the early stages of a startup, particularly contingent upon the maturity of the core technology. The CEO of Kano Therapeutics also emphasizes the importance of raising funds when the startup is poised to accelerate its entrepreneurial endeavors.

Additionally, for entrepreneurs, while the monetary offer from venture capitalists holds significance, the primary determinant lies in who will assume a position on the Board of Directors, mirroring the experience of Kano Therapeutics.

Furthermore, during VulcanForms' transition to fundraising, a team member with a strong entrepreneurial background joined the venture. This addition greatly contributed to strengthening the business side of the team by assisting in the creation and presentation of the business plan, thereby enhancing the team's overall strength and supporting the development of the product market fit story.

VulcanForms secured investments and board memberships from Gregory Reichow, the former VP of production at Tesla, representing Eclipse Ventures, as well as MIT alumnus Ray Stata, the founder and entrepreneur behind Analog Devices, who has his own name for the Stata Center on the MIT campus. The inclusion of such experienced and accomplished individuals, in addition to

the funding, played a crucial role in the subsequent fundraising success and rapid growth of VulcanForms.

5.7. Conclusion on How MIT Spin-off Startups Made Fundraising Choices

(1) Implications from the Short Case Studies

The first key takeaway from the aforementioned five case studies is the importance for startups to secure investment offers from multiple venture capitals, as this enables them to obtain more favorable investment terms. As mentioned earlier, VulcanForms and Kano Therapeutics were able to select their VCs by garnering offers from multiple investors, with the final decision determined by who joins the Board. The VulcanForms case particularly highlights how the identity of the VC representative on the Board carried significant weight in the decision-making process, even when the offered amount by other VCs was relatively higher. The CEO of Kano Therapeutics also emphasized the significance of this aspect in their VC selection.

Second, the cases of Kytopen and Kano Therapeutics underscore the importance of access to laboratory facilities provided by VCs or larger companies. Given that technology development lies at the core of deep tech startups, the availability of labs was found to be crucial in supporting their progress.

Third, investment from angel investors offers the advantage of human support. While many startups received investments from angel investors, as observed in the case of Kytopen, their contributions often extend beyond financial resources. Angel investors, who often possess more time and experience compared to VCs, provide valuable human resources by offering business advice and guidance. However, it should be noted that in certain cases, such as Quaise Energy, angel investors can also provide significant financial contributions. Kytopen's case also highlights the challenge of managing multiple angel investors when securing investments from numerous individuals.

Fourthly, the significance of leveraging available university support programs prior to embarking on entrepreneurial ventures is evident. In the case of Kytopen, the CEO participated in a commercialization program, while the CEO of Via Separation conducted further research for commercialization through a project at the Deshpande Center. Furthermore, four companies (Kytopen, Via Separation, Kano Therapeutics, and VulcanForms) received support from VMS, and three of them (Kytopen, Via Separation, and Kano Therapeutics) utilized Startup Exchange. These examples showcase the substantial impact such support programs have had on the future funding prospects of deep tech startups.

Lastly, during the initial investment phase, the composition of the team members is also crucial as a criterion for VCs to decide on executing the investment, assuming that the technology and market fit are present. This is evident in the cases of Quaise Energy and VulcanForms, where the expertise and experience of team members played a significant role in attracting VC investments.

(2) Use of Public vs. Private Funds

Kytopen, Via Separation, and Quaise have experienced growth by striking a balance between public and private funding sources. The utilization of public funds followed a typical trajectory, commencing with the NSF's I-Corps program, which specializes in customer discovery and business-oriented activities. Subsequently, these startups secured small grants through the NSF's SBIR Phase I and Phase II programs to further develop their technologies. Concurrently, Kytopen and Via Separation attracted seed investments from VCs. However, Quaise Energy, recognizing that SBIR funding may not suffice for sustainable business continuity within certain industries, opted to solely rely on private funding from the outset. Moreover, energy-focused startups like Via Separation and Quaise Energy received substantial grants in the range of millions from the Department of Energy's ARPA-E program. Kano Therapeutics also plans to seek funding from a similar NIH program called APRA-H subsequent to their initial VC funding. To summarize, the NSF's I-Corps program serves as a platform for customer discovery and establishing a product-market fit. Public funds from the SBIR program, along with private funding such as pre-seed

investments, are subsequently utilized to advance technology development. The resulting data and prototypes serve as the foundation for Series A funding rounds and larger grant acquisitions. The funding of the five MIT spin-off startups and the MIT services they used are listed in the Table below.

Table 5.1 Summary of MIT Spin-off Startups Short Case Studies

Company		Kytopen	Via Separation	Quaise Energy	Kano Therapeutics	VulcanForms
Founded Year		2017	2016	2018	2021	2015
Industry		Biotech & Life Sciences	Energy/Advanced Manufacturing/ Advanced Materials	Energy/ Advanced Engineering/ Advanced Materials	Biotech & Life Sciences/ Advanced Manufacturing	Advanced Manufacturing
Interviewee		Co-Founder and MIT Faculty	CEO and Co-Founder	CEO and Co-Founder	CEO and Co-Founder	Co-Founder and MIT Faculty
The Engine Funding		✓	✓	✓	✓	
VC		✓	✓	✓	✓	✓
CVC		✓		✓		✓
Angel Funding		✓	✓	✓		✓
Accelerator Program					✓	
Public Grant	I-Corps	✓	✓			
	DOE		✓(ARPA-E)	✓(ARPA-E)		
	NIH	✓				
	SBIR(NSF)	✓	✓			
	SBIR START (Mass Ventures)	✓				
Deshpande Center			✓			
Venture Mentoring Service (VMS)		✓	✓		✓	✓
MIT Startup Exchange		✓	✓		✓	
University Prize					✓	
Other MIT Service		*CEO joined Translational Fellows Program	*CEO took the Climate & Energy Venture class and the product design class		* CEO was honored as one of MIT's Innovative Women in Entrepreneurship 2020 *CEO took the New Enterprise class at Sloan	

6. Japanese University Ecosystem Related to the Creation of a University Spin-off Startup

6.1. The Overview of University Spin-off Startup Creation in Japan

In Japan, the "1000 University Ventures Plan," a policy initiative to bolster the number of university spin-offs, was introduced in 2001 with the goal of increasing the number of university

spin-off startups to 1000 in three years[212]. This initiative aimed to foster competition in university research, drive organizational management reforms, and develop effective technology transfer strategies.[213]. Prior to this, the "Law for the Promotion of University Technology Transfer (TLO Law)" was enacted in 1998 to establish a system in Japan to collectively manage university research results and generate income through patenting and licensing, which could be utilized for research expenses[214]. This law promoted the establishment of technology transfer organizations (TLOs), and the University of Tokyo established the Center for Advanced Science and Technology Incubation (CASTI), which received an approved TLO license[215]. In 1999, the "Act on Special Measures for Industrial Revitalization and Innovation of Industrial Activities" established a Japanese version of the Bayh-Dole system. In April 2000, the Law for Strengthening Industrial Technology Capability was enacted to strengthen the technological capability of Japanese industry, and included various measures to promote the use of research results at universities and other institutions. In the same year, a partial revision of the National Personnel Authority's regulations also allowed national university faculty members to concurrently serve as executives of companies that utilize research results[216]. Furthermore, the Law on the Improvement and Efficient Promotion of R&D Capability through the Promotion of R&D System Reform (now renamed the Law on the Revitalization of Science and Technology and the Creation of Innovation), which was revised in 2018, allows national universities to invest in startups for the commercialization of R&D results. In addition, with the implementation of the Industrial Competitiveness Enhancement Law in 2014, the top four national universities - the University of Tokyo, Kyoto University, Osaka University, and Tohoku University - were allowed to invest in certified VCs whose business plans were approved by the Minister of Education, Culture, Sports, Science and Technology and the Minister of Economy, Trade and Industry.

[212] "Materials Submitted by Diet Member Hiranuma."
[213]"Materials Submitted by Diet Member Hiranuma."
[214]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups* (Toyo Keizai Shinbunsha, 2021).
[215]"Yearbook - The University of Tokyo, Industry-Academia Collaboration Promotion Division," accessed May 7, 2023, https://www.ducr.u-tokyo.ac.jp/organization/history.html.
[216]MEXT, "11. System for National University Faculty Members to Hold Concurrent Jobs: Ministry of Education, Culture, Sports, Science and Technology," accessed May 5, 2023, https://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu8/toushin/attach/1366611.htm.

In Japan, there are a total of 807 universities. According to the 2023 World Ranking by TIMES magazine, the University of Tokyo holds the 39th position, while Kyoto University is ranked 68th. Moreover, among the top 600 spots, there are 10 Japanese national universities listed, including Tohoku University, Osaka University, Nagoya University, and Tokyo Institute of Technology[217]. In other words, the top 10 universities in the Japanese national rankings are all national universities. The QS World University Rankings 2023 also place the University of Tokyo at 23rd and Kyoto University at 36th, with the top 9 universities consisting solely of national universities[218]. These top-ranked institutions almost overlap with the top universities in Japan in terms of the number of science and technology research grants and the number of research projects selected[219]. As described above, many of Japan's leading research universities are national universities, which have traditionally been subject to investment restrictions based on their role as educational institutions. However, as mentioned above, deregulation has gradually eased the restrictions, allowing national university faculty members to become board directors of startups and national universities to invest in them.

In METI's Survey of University Spin-off Ventures 2022, the rankings of university spin-off startups are as follows: University of Tokyo (1st), Kyoto University (2nd), Osaka University (3rd), University of Tsukuba (4th), Keio University (5th), Tohoku University (6th), Tokyo University of Science (7th), Kyushu University (8th), Nagoya University (9th) and Tokyo Institute of Technology (10th)[220]. According to METI officials, the figures in this survey may vary depending on the extent to which universities track university spinoff startups, so it is important to keep this in mind.

[217]"World University Rankings," Times Higher Education (THE), October 4, 2022, https://www.timeshighereducation.com/world-university-rankings/2023/world-ranking.
[218]"QS World University Rankings 2023: Top Global Universities," Top Universities, accessed May 5, 2023, https://www.topuniversities.com/university-rankings/world-university-rankings/2023.
[219]"Allocation of Grants-in-Aid for Scientific Research for FY2020 : Ministry of Education, Culture, Sports, Science and Technology (MEXT)," MEXT, accessed May 6, 2023, https://www.mext.go.jp/a_menu/shinkou/hojyo/1422129_00001.htm; "Allocation of Grants-in-Aid for Scientific Research for FY2022 : Ministry of Education, Culture, Sports, Science and Technology (MEXT)," MEXT, accessed May 6, 2023, https://www.mext.go.jp/a_menu/shinkou/hojyo/1422129_00004.htm; "Allocation of Grants-in-Aid for Scientific Research for FY2021 : Ministry of Education, Culture, Sports, Science and Technology (MEXT)," MEXT, accessed May 6, 2023, https://www.mext.go.jp/a_menu/shinkou/hojyo/1422129_00002.htm.
[220]"University Venture Database (METI/Ministry of Economy, Trade and Industry)."

However, there is much overlap between the above university rankings and the top universities in METI's survey of university-launched ventures.

6.2. The University of Tokyo On-campus Service

6.2.1. Overall

The University of Tokyo has undergone major organizational changes since its incorporation as a national university in 2004: in April 2004, the Industry-University Collaboration Division (now the Industry-University Collaboration Promotion Division) was established, the former technology transfer office Center for Advanced Science and Technology Incubation(CASTI), Inc. was renamed the University of Tokyo TLO Corporation, and the University of Tokyo Edge Capital (UTEC) was established.[221] The Industry-University Collaboration Division has established a close "three-party collaboration system" with the University of Tokyo TLO and UTEC, and has been working in a tripartite manner to support university spin-off startups.[222] Specifically, the Industry-University Collaboration Division and TLO disclose invention information and conduct on-campus marketing to UTEC, and based on this information, UTEC provides hands-on support and invests as a VC in startups from the University of Tokyo.[223] UTEC earns capital gains, a portion of which is donated to the University of Tokyo through donations and other means. In September 2004, the University of Tokyo established the first incubation facility for entrepreneurs and startups aiming to commercialize the University of Tokyo's research results, which is called "Industry-University Collaboration Plaza Incubation Facility"[224]. In May 2005, an entrepreneurship course called "UTokyo Entrepreneur Dojo" was launched as a non-credit program.[225] In June 2007, the "UTokyo Entrepreneur Plaza" was opened with offices and wet labs available for use[226]. In 2009, TLO became a wholly owned subsidiary of UTokyo, and the Komaba Collaborative Research Building

[221]"Yearbook - The University of Tokyo, Industry-Academia Collaboration Promotion Division."
[222]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[223]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[224]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[225]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[226]"Yearbook - The University of Tokyo, Industry-Academia Collaboration Promotion Division"; "University of Tokyo Entrepreneur Plaza," Industry-University Co-Creation Promotion Headquarter, accessed May 7, 2023, http://www.ducr.u-tokyo.ac.jp/activity/venture/incubation/eplaza.html.

Incubation Room began operating on the Komaba Campus, where first- and second-year undergraduate students mainly study. In 2010, “Innovation and Entrepreneurship" lectures were offered; in 2015, UTokyo IPC, UTokyo's VC, was accredited and established, and the first fund was formed in 2016; in 2016, the Hongo Tech Garage project was launched to provide maker space for students; in 2018, the University of Tokyo South Building Entrepreneur Lab, which can be used as an office and wet lab, opened[227] . UTEC and UTokyo IPC also occupy this location. 2019 saw the launch of the UTokyo FoundX program and the opening of the UTokyo Entrepreneur Hub on the Kashiwa campus. The UTokyo FoundX program provides educational programs and offices for early-stage entrepreneurship for UTokyo students, graduates, and researchers[228]. Thus, efforts to create university spinoffs have advanced significantly over the past 20 years. In the following, we will take a closer look at UTEC, UTokyo IPC, and key programs dedicated to university spinoff creation in the deep tech field.

[227]“Yearbook - The University of Tokyo, Industry-Academia Collaboration Promotion Division”; *Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[228]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.

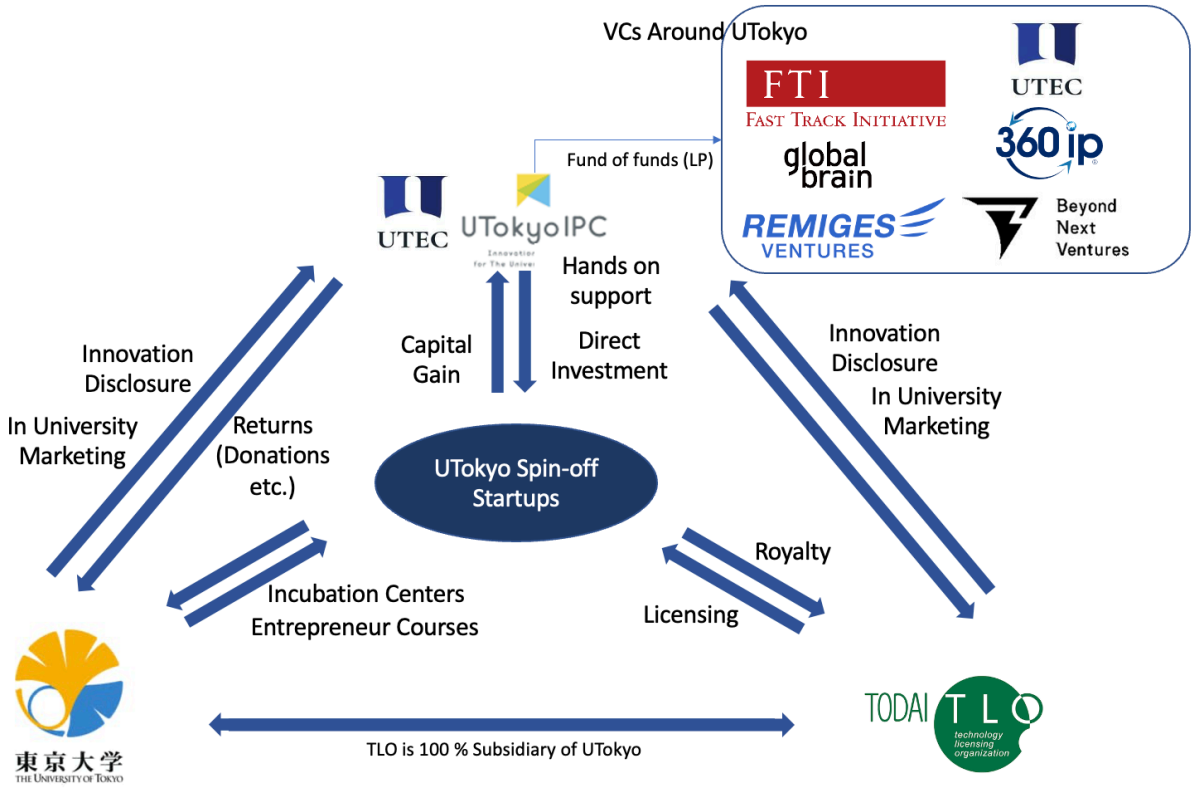

Figure 6.1 Ecosystem of UTokyo
Source: Shigeo Kagami (2021)[229],UTokyo IPC (2023)[230](Translated and Modified from Mechanism of Tokyo University Venture Support)

6.2.2. UTokyo Edge Capital (UTEC)

(1) UTEC History and Overview of UTEC Funds

In 2004, coinciding with the University of Tokyo's transition to a national university corporation , the University of Tokyo Edge Capital Partners Co., Ltd. (UTEC) was founded as a venture capital firm with a specific focus on nurturing the University of Tokyo's proprietary seed and early-stage technologies[231]. This establishment was made possible through a collaborative partnership with the University of Tokyo, positioning UTEC as a key "technology transfer-related entity" responsible for facilitating the commercialization of UTokyo's research outcomes and actively

[229] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups* (Toyo Keizai Shinposha, 2021).
[230] UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), "Innovation Initiatives at The University of Tokyo."
[231] *Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*; Edward Elgar Publishing, Jerome S. Engel, and Shigeo Kagami, *Clusters of Innovation in the Age of Disruption* (Cheltenham, England ; Edward Elgar Publishing, 2022).

participating in the formation of startup ventures. Leveraging its exclusive access to UTokyo's valuable intellectual property, UTEC has forged a strong working relationship with both the University of Tokyo and UTokyo TLO, working in tandem to drive the successful commercialization of UTokyo's innovations[232].

As of the end of 2022, UTEC has made investments in over 140 companies, with 20 companies successfully completing mergers and acquisitions (M&As), and 19 companies successfully completing initial public offerings (IPOs). The performance history of each fund is illustrated in the following chart.

UTEC commenced its venture capital activities by establishing its inaugural fund in July 2004. Since then, the firm has successfully launched five subsequent funds in the years 2009, 2013, 2018, and 2021[233]. The fund sizes progressively increased from 8.3 billion for the first fund, to 7.15 billion yen for the second, 14.57 billion yen for the third, 24.31 billion yen for the fourth, and 30.41 billion yen for the fifth fund, culminating in a total fund size of approximately 85 billion [234]. As of the end of 2022, UTEC has made investments in over 140 companies, with 20 companies successfully completing mergers and acquisitions (M&As), and 19 companies successfully completing initial public offerings (IPOs)[235]. The following Table shows the overview of each fund to date. Among UTEC's notable achievements, PeptiDream stands out as a remarkable success story. As a representative company nurtured by the first fund, UTEC played a pivotal role from its inception in 2006 by facilitating the collaboration between a researcher and a business person by matching the two, leading to its establishment. UTEC also served as the lead investor for the company's seed investment in 2008[236]. PeptiDream achieved significant milestones, including its listing on the Mothers stock exchange in 2013 and subsequently on the First Section of the Tokyo

[232]Edward Elgar Publishing, Engel, and Shigeo Kagami, *Clusters of Innovation in the Age of Disruption*.
[233]UTEC, "FIRM PROFILE｜UTEC," UTEC, accessed May 7, 2023, https://www.ut-ec.co.jp/about_utec/firm_profile/.
[234]Edward Elgar Publishing, Engel, and Shigeo Kagami, *Clusters of Innovation in the Age of Disruption*; Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*.
[235]UTEC, "Introduction of UTEC."
[236]Edward Elgar Publishing, Engel, and Shigeo Kagami, *Clusters of Innovation in the Age of Disruption*.

Stock Exchange (TSE) in 2015[237]. Additionally, UTEC has been instrumental in guiding numerous other startups through successful exits, earning the firm high recognition as "a key player in fostering the University of Tokyo Venture Ecosystem"[238]. In terms of industry standing, UTEC secured the third position among Japan-focused venture capital firms based on assets under management (AUM) in 2022, following JAFCO Group and SPARX Asset Management[239]. UTEC's AUM reached 79.7 billion yen. Furthermore, UTEC's fourth fund (UTEC 4 Limited Partnership) ranked third in the category of top-performing Japan-focused venture capital funds with a fund size of 10 billion yen or more, boasting a notable net internal rate of return (IRR) of 34.8%[240].

Table 6.1 Overview of UTEC Funds as of February 2023

Fund (Founding Year)	Fund Size (Billion yen)	Investments
No. 1 (2004)* Dissolved in 2018 ; Liquidated in 2019	8.3	34 companies
No. 2 (2009) *Dissolved in 2021	7.15	13 companies
No. 3 (2013)	14.75	31 companies
No. 4 (2018)	24.31	34 companies
No. 5 (2021)	30.41	33 companies

Source: UTEC (2023)[241] *and Hitotsubashi Business Review (2021)*[242]

UTEC operates as an independent entity separate from the University of Tokyo. Tomotaka Goji, the CEO and Co-Founder of UTEC, brings his expertise to the firm, having earned an MBA from Stanford University and worked for the Ministry of Economy, Trade and Industry. When founding

[237]Edward Elgar Publishing, Engel, and Shigeo Kagami.
[238]*Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.
[239]Preqin and Japan Venture Capital Association (JVCA), "Performance Benchmark Update for Japanese Venture Capital 2022," September 1, 2022.
[240]Winnie Hsu and Aya Wagatsuma, "The Japanese Venture Capital Star Bagging 35% Returns Mining Science Papers for Gold," The Japan Times, March 16, 2023, https://www.japantimes.co.jp/news/2023/03/16/business/corporate-business/japan-venture-fund-tech-start-ups/.
[241] UTEC, "INVESTMENT POLICY｜UTEC," UTEC, accessed May 13, 2023, https://www.ut-ec.co.jp/about_utec/investment_policy/.
[242] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*.

UTEC, Goji carefully considered several key factors that shaped the foundation of the firm. He explains as follows:

"I was very careful to note that while it is important to source various intellectual property and human resources in cooperation with the University of Tokyo, the fund is a limited liability investment business, collecting capital from institutional investors who are LPs, it must be managed in a way it is able to generate a proper return. Therefore, the fund must be disciplined as a professional firm like VCs in Silicon Valley. Of course, we have to build a close relationship with the university, but at the same time, we have to build governance as a professional firm and have a kind of tension between the University of Tokyo and UTEC. UTEC was formed through a combination of these factors like glasswork."

(2) Investment Policy and Decisions

When it comes to identifying potential investment opportunities, UTEC employs various strategies. First, they collaborate closely with the University of Tokyo's Intellectual Property Department and Technology Licensing Organization (TLO), which facilitates the disclosure of inventions and research outcomes from UTokyo to UTEC[243]. Regular meetings with TLOs help maintain a strong partnership in this regard. Additionally, UTEC proactively makes donations to UTokyo laboratories and other universities, which not only provides valuable financial support but also grants them access to information and potential investment prospects through these channels[244]. Furthermore, utilizing big data analysis of researchers described below, UTEC can identify and reach out to exceptional researchers working on trending topics[245]. Initially, UTEC's first fund primarily focused on startup companies originating from the University of Tokyo. However, with the second fund, UTEC deliberately expanded its scope of support to include startups that leverage technologies and human resources with synergies to the University of

[243]Tomotaka Goji, Interview with CEO and Co-founder of The University of Tokyo Edge Capital Partners Co.(UTEC), April 20, 2023.
[244]Tomotaka Goji.
[245] Tomotaka Goji.

Tokyo, in addition to those directly connected to the university[246]. Starting from the third fund, UTEC responded to societal demands by supporting university-originated startups not only from the University of Tokyo but also from other universities and research institutes across Japan and even abroad. This inclusive approach allows UTEC to cover a wide range of fields, regardless of the specific domain[247]. From the fourth fund onwards, UTEC shifted its investment strategy towards companies possessing outstanding scientific and technological capabilities, as well as strong teams capable of addressing global markets and challenges[248].

When it comes to making investment decisions, UTEC places significant emphasis on technology-focused ventures. Therefore, the primary criterion for investment is the technological aspect, particularly in the fields of biotechnology and physical sciences. To assess the technological readiness and potential of researchers, UTEC utilizes big data analytics. This approach, developed by UTEC CEO Tomotaka Goji during his time as a PhD student at UTokyo, involves analyzing research papers, citation counts, and patent information on a researcher-by-researcher basis. Through this comprehensive analysis, UTEC is able to evaluate researchers, determine the maturity of their research, and identify promising research outcomes[249]. He explains as follows:

"We scrape the latest research papers data, and then we break it down not by paper, but by author, and we create a network by researcher, by hot topic, and we can see who is growing.

[246] UTEC, "HISTORY｜UTEC," UTEC, accessed April 20, 2023, https://www.ut-ec.co.jp/about_utec/history/; UTEC, "How to Promote the Innovation Ecosystem ～How to Support University-Launched Ventures UTEC's Initiatives," https://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu16/001/shiryo/__icsFiles/afieldfile/2011/09/09/1309433_2.pdf; UTEC, "Establishment of UTEC No.1 Investment Limited Partnership｜UTEC NEWS｜UTEC-University of Tokyo Edge Capital Partners," UTEC, accessed May 13, 2023, https://www.ut-ec.co.jp/news/utec_news/utec_news-07012004/.

[247] UTEC, "UTEC Activities and Current Status and Challenges of Bio/Medical Ventures," https://www.mhlw.go.jp/file/05-Shingikai-10801000-Iseikyoku-Soumuka/0000116428.pdf.

[248] UTEC, "Establishment of UTEC No.4 Investment Limited Partnership｜UTEC NEWS｜UTEC-University of Tokyo Edge Capital Partners," UTEC, accessed May 13, 2023, https://www.ut-ec.co.jp/news/utec_news/utec4%E5%8F%B7%E6%8A%95%E8%B3%87%E4%BA%8B%E6%A5%AD%E6%9C%89%E9%99%90%E8%B2%AC%E4%BB%BB%E7%B5%84%E5%90%88%E3%81%AE%E8%A8%AD%E7%AB%8B%E3%81%AB%E3%81%A4%E3%81%84%E3%81%A6.

[249]Tomotaka Goji, Interview with CEO and Co-founder of The University of Tokyo Edge Capital Partners Co.(UTEC); "Unlikely Venture Star Bags 35% Returns by Mining Science Papers," *Bloomberg.Com*, March 14, 2023, https://www.bloomberg.com/news/articles/2023-03-14/unlikely-venture-star-bags-35-returns-by-mining-science-papers.

There is a high correlation between this result and startup foundations and exits like IPOs, and M&A. Therefore, we are actually implementing this in our firm. So if you put in a keyword, you can analyze the network of researchers who have written papers that contain that keyword."

Furthermore, the ultimate investment decision at UTEC is supplemented by the input of external experts, including professors and industry professionals. While the composition of teams and the capabilities of the CEO are significant factors, it is not always the case and their importance may vary depending on the industry. As recounted by Goji, there was a unique case involving Gaianixx, a startup specializing in monocrystalline voltage, where the investment was made at a stage when no CEO candidates were available, and the CEO was recruited subsequent to the investment. Moreover, UTEC actually invests in only a small fraction, approximately 1 out of 100 ± 50, of the investment opportunities that are evaluated[250].

Figure 6.2 presents UTEC's investment performance, indicating that since the No. 2 fund, the majority of investments have primarily targeted seed and early-stage companies. Building on the lessons learned from the first fund, UTEC established an investment policy that focuses on lead investment and seed or early-stage investment. Goji elaborated on the rationale behind this policy as follows.

“All of the members of UTEC at the time of its establishment, with the exception of myself, were from VC backgrounds. At the time, many Japanese VCs did not make seed investments, so we invested only money, as minority shareholders, in companies that had already been established and were in the pre-IPO stage. However, this first fund invested in 34 companies, about a quarter of which were lead investments, but most, or should I say all, of the returns ended up coming from seed and early-stage investments. That was one of the reasons why the second fund started to invest in seed or early of early-stage companies and to invest almost exclusively as a lead investor, where we are on the board of directors and work with them on management and hiring managers. "

[250]Tomotaka Goji, Interview with CEO and Co-founder of The University of Tokyo Edge Capital Partners Co.(UTEC).

"A deep tech startup goes from basic research to Exit of IPO or M&A, and we start a discussion with researchers prior to incorporation and form a company together. The majority of our investments are in the seed stage or early stage, and we are also the leads. Our pattern of success is that we are almost always one of the co-founders."

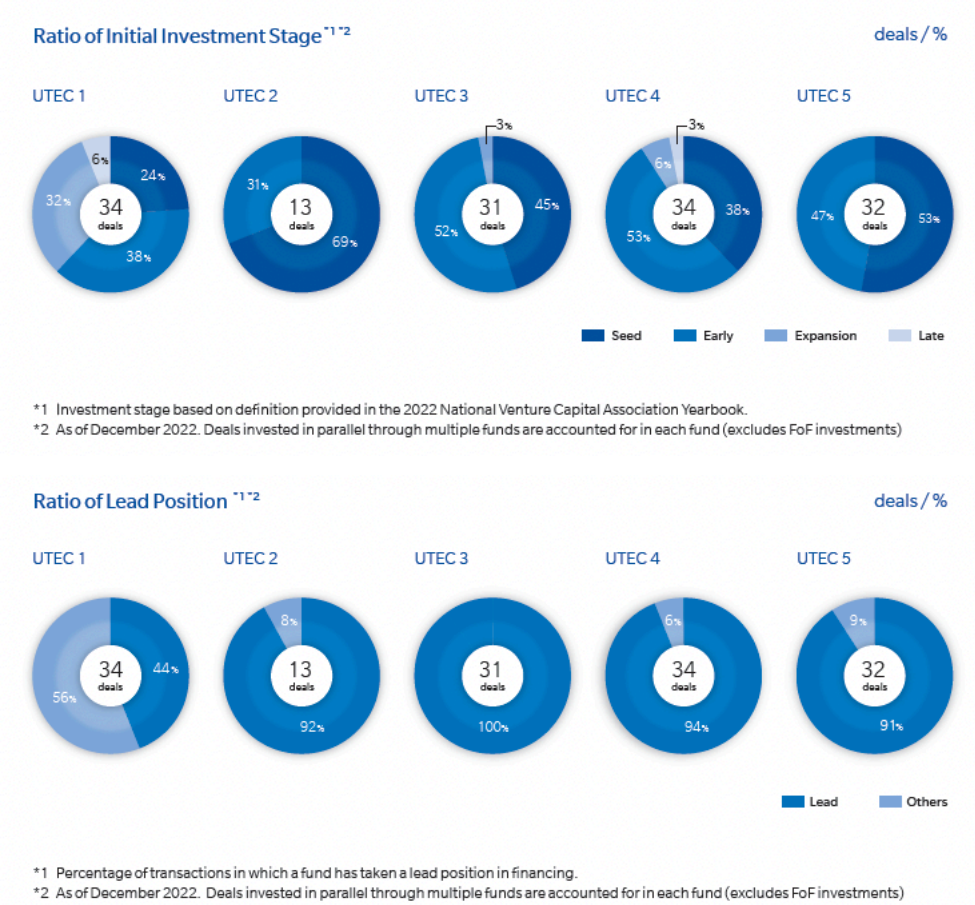

Figure 6.2 Overview of UTEC Funds as of December 2022

Source: UTEC (2022)[251]

[251] UTEC, "UTEC Brochure 2022," n.d., https://www.ut-ec.co.jp/english/admin/wp-content/uploads/2019/01/UTEC-Brochure_202212_EN_webup.pdf.

(3) Accelerator Program for Commercialization Support

UTEC launched the UTEC Founders Program in 2021, which encompasses two distinct tracks: the Equity Track and the Grant Track[252]. Under the Equity Track, seed-stage startups have the opportunity to receive investments of up to 100 million yen. On the other hand, the Grant Track provides commercialization support for up to one year, along with non-equity, non-borrowing, and non-repayable grants of up to 10 million yen. The Grant Track follows a rigorous selection process conducted every six months to support startups and pre-stage teams. This expedited process aims to minimize fundraising timelines and enable startups to concentrate on launching their businesses. Once the grant is approved, the program further offers comprehensive support for startups, including mentoring, HR assistance, professional services, expert-led study sessions, networking opportunities, and more[253].

(4) UTEC-UTokyo FSI Research Grant Program

Since 2020, UTEC has also provided research support to researchers conducting advanced research at the University of Tokyo under the "UTEC-UTokyo FSI Research Grant Program[254]. The program is unique in that it does not require grant recipients to submit reports, allowing them to dedicate their efforts to research endeavors. Instead, the program emphasizes the submission of research papers to esteemed academic journals, prioritizing fundamental research over short-term practical applications or commercialization prospects. The grant amounts awarded through this program are up to 20 million yen or 5 million yen, depending on the specific circumstances[255].

(5) Summary and Analysis

UTEC stands as one of Japan's long-standing venture capital firms closely associated with universities, boasting an impressive history of nearly two decades. Notably, UTEC distinguishes itself by already cultivating successful models like PeptiDream. Since its inception, UTEC has

[252] "UFP -UTEC Founders Program-," UFP, accessed May 22, 2023, https://ufp.jp/.
[253] "UFP -UTEC Founders Program-."
[254] "UTEC-UTokyo FSI Research Grant Program | UTokyo," accessed May 22, 2023, https://www.u-tokyo.ac.jp/ja/research/systems-data/utec-utokyo_fsiresearchgrant.html.
[255] "UTEC-UTokyo FSI Research Grant Program | UTokyo."

fostered a strong partnership with the University of Tokyo and its Technology Licensing Office (TLO), concentrating efforts on commercializing the university's seed innovations. Over time, UTEC has progressively expanded its scope to encompass national and global endeavors in research commercialization.

UTEC's notable achievement lies in its hands-on approach, rendering support to nascent ventures even prior to their establishment. Acting as a quasi-cofounder, UTEC nurtures and guides these companies, ultimately leading them toward successful exits. Consequently, the firm primarily invests in seed and early-stage enterprises, often assuming a leading investment role. In evaluating technologies, UTEC leverages big data analysis to assess researchers' networks, thus effectively appraising the researchers and their technologies. This method instills confidence when making investment decisions. Additionally, by harnessing the potential of big data analytics within the research community, UTEC identifies research outcomes exhibiting promising prospects for commercialization. As a venture capitalist, the CEO of UTEC places significant emphasis on supporting basic research initiatives and also grants financial awards to further such research endeavors.

6.2.3. UTokyo Innovation Platform Co.

(1) History of UTokyo IPC

UTokyo Innovation Platform Co., Ltd. (UTokyo IPC) is a venture capital company wholly owned by the University of Tokyo[256]. Currently, it manages two funds with a combined total of 50.6 billion yen. In 2014, the Japanese government enacted the Industrial Competitiveness Enhancement Act, which introduced a framework allowing national university corporations and similar entities to invest in university spin-off startups through university funds. These university funds, executed by certified venture capital firms acting as unlimited liability partners, aim to promote innovation by leveraging research outcomes from universities[257]. This allows the top

[256]"UTokyoIPC - Utokyo Innovation Platform Co.,Ltd.," UTokyoIPC - Utokyo Innovation Platform Co.,Ltd., accessed May 7, 2023, https://www.utokyo-ipc.co.jp/.
[257]MEXT, "For the Expansion of the Functions of National Universities Expansion of Eligible Projects for Investment," https://www.mext.go.jp/content/20200323-mxt_hojinka-000006012_5.pdf.

four national universities, the University of Tokyo, Kyoto University, Osaka University, and Tohoku University, to invest in certified VCs whose business plans have been approved by the Minister of Education, Culture, Sports, Science and Technology and the Minister of Economy, Trade and Industry.[258] The Japanese government has allocated a total of 100 billion yen to these four universities, with the University of Tokyo receiving 41.7 billion yen, Kyoto University receiving 29.2 billion yen, Osaka University receiving 16.6 billion yen, and Tohoku University receiving 12.5 billion yen[259]. The certified venture capital firms backed by these universities have established funds utilizing this 100 billion yen, supplemented by over 20 billion yen from private sources[260]. UTokyo Innovation Platform Co., Ltd (UTokyo IPC), as the accredited venture capital firm of the University of Tokyo, was established in 2015 within this framework.

(2) Investment Policy

The basic philosophy of these accredited VCs is "to complement the private sector without unreasonably interfering with the activities of similar private sector businesses and to take the initiative in providing support for specific research projects that are difficult for private sector businesses alone to fully implement, while securing as much financing from private sector businesses as possible, including loans from the private sector" [261]. This philosophy was established in response to discussions surrounding the pressures faced by the private sector.

And because of this basic philosophy, initially, only investments in university spinoffs related to one's own university were basically allowed. However, under the revised Industrial Competitiveness Enhancement Act that came into effect in July 2008, university spin-off startups

[258]METI, "Investment in VC, Etc. by National Universities, Etc. (METI/Ministry of Economy, Trade and Industry)," accessed May 7, 2023, https://www.meti.go.jp/policy/innovation_corp/syusshi.html.
[259]MEXT, "For the Expansion of the Functions of National Universities Expansion of Eligible Projects for Investment"; UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), "Innovation Initiatives at The University of Tokyo."
[260]MEXT, "For the Expansion of the Functions of National Universities Expansion of Eligible Projects for Investment"; Nikkei Business e-edition, "Can National Universities Become 'Earning Universities'? Three Challenges Facing Accredited VCs," Nikkei Business e-edition, accessed May 7, 2023, https://business.nikkei.com/atcl/gen/19/00356/020100026/.
[261]MEXT, METI, UTokyo IPC, "Publication of the Contents of the Specific Research Results Utilization Support Project Plan," November 4, 2015, https://www.meti.go.jp/policy/innovation_corp/syusshi/151104_tokyo.pdf.

that promote commercialization through collaboration with other universities and companies, etc., were added as investment targets[262]. With the above background, at the stage of its establishment in 2015, UTokyo IPC was only allowed to make indirect investments, which are LP investments in private VCs, and direct investments in its own university spin-off startups[263]. And as for indirect and direct investments, the government granted permission for four types of investments, categorized as areas where private venture capitals may not have sufficient resources to adequately address[264].

Table 6.2 Scope of Investments of the Accredited Venture Capital

1) Indirect investment (applicable to venture capital with substantial quality and quantity as envisioned by the University) If a private VC that lacks experience with university spin-off startups or is involved in seed and early-stage university spin-off startups and could benefit from support from UTokyo IPC, UTokyo IPC could make an LP investment in the private VC's fund.
2) Co-investment (applicable to venture capital of the quality and quantity envisioned by the university, minority investments, etc.) Co-investment with private VCs, where the private sector is ahead but where support from UTokyo IPC is effective in response to a request from the investee or the private VC supporting the investee, is allowed.
3) Corporate partnership investment (applicable to partnerships with business companies envisioned by the university) When investing with a company based on intellectual property rights that are joint applications created through joint research between the university and a

[262]MEXT, "For the Expansion of the Functions of National Universities Expansion of Eligible Projects for Investment"; METI, "Investment in VC, Etc. by National Universities, Etc. (METI/Ministry of Economy, Trade and Industry)."
[263]MEXT, METI, UTokyo IPC, "Publication of the Contents of the Specific Research Results Utilization Support Project Plan."
[264]MEXT, METI, UTokyo IPC.

company that is a business enterprise, or based on seed technology that combines university technology and company technology.

4) Investment involving collaboration among multiple universities, research institutes, etc. (applicable to a rich supply system of seeds not only for the University of Tokyo, but also for universities and research institutes, etc. in collaboration with each other as envisioned by the university)

For large-scale technology development projects based on specific fields, UTokyo IPC establishes a framework for collaboration with universities, research institutes, and other organizations, as well as business companies, to actively promote startup development projects.

Source: METI (2023)[265]

The criteria for investment in startup companies is that it is expected to exit within 5 to 10 years after business is launched, although it is possible for the investment period to be longer than 10 years[266]. Furthermore, the fund aims to achieve a return "in excess of at least the total revenue required for all of our (UTokyo IPC's) expenditures over the life of the business," which is a low return target compared to private VCs[267]. This approach stems from the initial discussions surrounding national university venture capital firms, which emphasized a patient capital approach, accepting break-even returns to tackle socially significant challenges[268]. However, later, as the number of public-private funds with large deficits increased, the government changed its stance to pursue returns, and as a result, when the second fund was established, UTokyo IPC solicited fund investments targeting an estimated internal rate of return (IRR) in the single-digit range[269]. However, being a certified venture capital firm entails certain restrictions on investment targets, which can limit opportunities, making it challenging to strike a balance between these restrictions and maintaining returns[270]. In addition, this university VC itself, as a

[265] MEXT, METI, UTokyo IPC.
[266]MEXT, METI, UTokyo IPC.
[267]MEXT, METI, UTokyo IPC.
[268]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC, April 17, 2023.
[269]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa.
[270]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa.

permanent organization, is ultimately intended to be self-sustaining, relying solely on private-sector funds. Considering this perspective, if a third fund were to be established, it is expected that attracting investments from private-sector investors would be difficult without demonstrating a return on the fund, as government funding is no longer available[271].

At the time of its establishment, UTokyo IPC had a relatively wide range of investment targets for UTokyo-related startups, not only those based on UTokyo's intellectual property but also student-initiated startups at UTokyo, etc. Kazuhiko Kakehi, a UTokyo IPC partner since 2014 when UTokyo IPC was established, recalls the discussions at that time and explains as follows:

“In a sense, we tried to take a broad range of opportunities at this time. First of all, when we started UTokyo IPC, we did not necessarily have a good idea of how to handle a VC. On the other hand, at the University of Tokyo, Professor Shigeo Kagami had been running the Entrepreneur Dojo (entrepreneur course) since 2005, and there were discussions that student startups born from the Dojo should be in a position to receive our investment and it would be better to a bit broaden the scope of the UTokyo related startups.”

(3) Overview of UTokyo IPC Funds

Since its establishment in 2015, UTokyo IPC has managed two public-private funds: Kyoso No. 1, established in 2016, with a 15-year term and a fund size of 25 billion yen, focuses on supporting private venture capital investment activities[272]. The investment targets of Kyoso No. 1 include co-investment alongside private VCs and "Fund of Funds" investments, which refer to LP investments in private VCs. This Kyoso No. 1 exclusively made direct investments in startups affiliated with the University of Tokyo, partly to adhere to the principle of not pressuring the private sector and partly because 23 billion yen of the 41.7 billion yen government contribution to the University of Tokyo was invested in Kyoso No. 1[273]. Additionally, Kyoso No. 1 invested a

[271]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa.
[272]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), “Innovation Initiatives at The University of Tokyo.”
[273]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC); Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC.

total of 5 billion yen in six private VC firms (UTEC, Fast Track Initiative, Regimes Ventures, global brain, Beyond Next Ventures, and 360ip Japan) that possess deep knowledge of research and technology and provide extensive hands-on support[274]. The investment stages for Kyoso No. 1 include pre-seed, seed, and early-stage investments through "Fund of Funds" investments, as well as early, middle, and later-stage investments through direct investments[275]. Established in 2020, AOI No. 1 has a 15-year term, a size of 25.6 billion yen, and a policy objective of supporting innovation of companies, and the investment targets are carve-outs from companies, Joint Ventures for technology commercialization, and existing pre-seed venture business collaborating with companies[276]. AOI No. 1 also received 18.6 billion yen among total fund size of 25.6 billion yen from the 41.7 billion yen invested by the government in the University of Tokyo[277]. Moreover, following the legal revision in 2008 that allowed investments in other universities and corporate ventures, UTokyo IPC is also permitted to invest in a wide range of opportunities corresponding to the amount invested by private LPs[278].

The number of companies directly invested in through co-investment by Kyoso No.1 Fund is 35. In terms of the percentage distribution of the number of companies invested, life science accounted for 37%, hardware such as robots 14%, space 9%, AI 17%, IT and services 23%, and thus so-called "Deep Tech" accounted for 73% of the total[279]. Since Kyoso No. 1 Fund is a co-investment, it is basically an early, middle, and in some cases, a late-stage investment, and the size of each investment is in the order of 100 million yen digits[280]. The number of companies invested in by AOI No. 1 is 28, with 25% in life sciences, 18% in hardware and materials such as robotics, 21% in AI, and 36% in IT and services, with so-called “Deep Tech” accounting for 64% of the total[281].

[274]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), “Innovation Initiatives at The University of Tokyo.”
[275]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC.
[276]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), “Innovation Initiatives at The University of Tokyo.”
[277]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC).
[278]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC); Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC.
[279]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), “Innovation Initiatives at The University of Tokyo.”
[280]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC.
[281]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC), “Innovation Initiatives at The University of Tokyo.”

Kakehi, who was at the University of Tokyo's Industry-University Collaboration Division prior to UTokyo IPC's establishment and was involved in discussions before and after its establishment, explains the above background and the role of the UTokyo IPC as follows:

"In 2014, at a meeting of venture experts or something, there was a discussion about the venture structure, and there was an argument that startup companies, VCs, universities, and business enterprises should have a deeper relationship with each other as the four key stakeholders. Based on this, the University of Tokyo aimed to emulate it a little and, in providing startup support, by deepening relationships with VCs, companies, and other universities, with the University of Tokyo at the center. Given that, UTokyo IPC has taken the form of a fund in which each fund has its own role to play in the venture support process. Therefore, the purpose of the first fund is to deepen the relationship between VCs, the University of Tokyo and startups. What we are actually doing is to have VCs approach the University of Tokyo with a "fund of funds", so that the seeds generated by the University of Tokyo can be turned into startup businesses by those VCs. On the other hand, it takes time for deep tech startups to raise the next round of funding before they can make a sale, so we can help private VC firms continue to make investments by cooperating with them, or we can invest directly in the next round in which they have made an initial investment. When we opened the lid, we found that AI and IT are available now, but really by 2019 or so, it was life sciences, hardware, and space, and there was no IT-related business at all. IT startups can generate sales without fundraising. Therefore, even if we did not make additional investments, they would be fine only with private VC firms. However, deep tech startups were still unable to make sales, so we were asked to invest together. As I mentioned earlier, in 2019 and 2020, the situation was such that only life science companies were involved. Gradually, we were asked to raise a large amount of funds or from a balancing perspective, the ratio of IT is increasing."

(4) Accelerator Program for Pre-seed Development

UTokyo IPC has been operating the "1st Round Program", an accelerator program for pre-seed development, since 2017. This program provides an ideal environment to achieve the first round of funding ("1stRound") for teams aiming to start a business or startups associated with co-sponsoring universities (13 universities including the University of Tokyo, Nagoya University, Kyushu University, and Waseda University) within 3 years of establishment, prior to obtaining funding from VCs[282]. The support includes up to 10 million yen with no strings attached and non-dilutive funds, a development environment including cloud resources and offices, and 6 months of hands-on supports by experts at no cost[283]. The background of starting this program was that the Kyoso No. 1 Fund had the dilemma of not making pre-seed or seed investments even though it was a university VC, and at that time in 2017, a few private VCs were investing tens of millions yen as a private VC making seed investments in the deep tech sector. It was a time when the University of Tokyo also started the GAP Fund in 2018, and UTokyo IPC also started this program by organizing that it would be good to have a reverse investment that startups could receive[284].

(5) Summary and Analysis

UTokyo IPC stands out as a distinctive entity due to its status as a government-approved fund, which consequently entails various constraints regarding investment targets and methods. As a result, the initial fund primarily focuses on investing in university spinoffs associated with the University of Tokyo and LP investments in private venture capital firms as fund of funds investments. However, with the advent of the second fund along with legal reform, the scope of investment has expanded beyond the confines of the University of Tokyo. This experience has underscored the challenge of confining investments solely to one's own university when seeking favorable returns.

The distinguishing feature of UTokyo IPC is its extended 15-year time horizon of their funds, setting it apart from funds with shorter 10-year terms. This longer timeframe allows for

[282]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC).
[283]UTokyo Innovation Platform Co., Ltd. (UTokyo IPC).
[284]Kazuhiko Kakehi, Akihiko Asami, and Takashi Furukawa, Interview with UTokyo IPC.

investments to be made with a relatively more expansive perspective. Through LP investments in deep-tech venture capital firms, UTokyo IPC has successfully fostered an increased number of VCs investing in UTokyo-affiliated startups, thereby fostering the growth of the University of Tokyo's ecosystem. Moreover, the utilization of the accelerator program, 1st Round, has proven beneficial for numerous entrepreneurs, facilitating smooth startup processes and subsequent fundraising activities.

6.2.4. UTokyo TLO

In 1998, the "Law for the Promotion of Technology Transfer at Universities (TLO Law)" was enacted, and the University of Tokyo established the Center for Advanced Science and Technology Incubation (CASTI), which was renamed as the University of Tokyo TLO in 2004. Together with the Industry-University Collaboration Division and UTEC, the University of Tokyo Technology Licensing Organization (TLO) plays a role in finding research results within the University of Tokyo and connecting them to UTEC in a "three-party collaboration system". The University of Tokyo has an annual self-funded patent budget of approximately 200 million yen, about a quarter of MIT's $8 million[285]. There are about 7 to 9 start-ups established through licensing through TLO every year. In 2021, 568 invention disclosures were submitted, 409 patent applications were filed, approximately 7,300 patents are held, and the total number of executed license agreements is 4,033[286]. The total number of start-up companies that have licensed intellectual property rights from the University of Tokyo is 132[287].

(1) Typical Path to Spin-off Startup Establishment through TLO

The typical journey when research results at UTokyo are licensed through TLO and lead to the establishment of a startup starts with technology invention disclosure.

[285] University of Tokyo, “University of Tokyo Intellectual Property Report 2022”; Deirdre Zammit, Interview with Associate Director, Licensing of Technology Licensing Office at MIT.
[286] University of Tokyo, “University of Tokyo Intellectual Property Report 2022.”
[287] University of Tokyo.

i. Step 1 Decide whether to Proceed with Patent Protection

Keiko Honda, Executive Vice President of UTokyo TLO, gives the following explanation

"There is an internal rule at the University of Tokyo that says that university professors must submit an invention disclosure when they have completed an invention. When you submit it, we, the TLO, visit the professors for an interview based on the disclosure. It is a simple form, and the volume of the information is about the size of an A4 sheet, like an academic conference paper, so it is difficult to understand the content of the invention without interviews. So, basically, we interview the professors and ask them to include such peripheral data, and then the University of Tokyo TLO conducts a patent search. In addition to the patent search, we also conduct market research and consider whether there is a possibility of commercialization in the future. We then write a recommendation to the university as to whether it would be better to succeed the inventor's right to obtain a patent and file an application on that basis."

ii. Step 2 Introducing to VCs and Companies

For those patent applications that are decided to be filed, they will introduce the technology to VCs and companies, and for those that are found interesting by the VCs, the VCs will consider the possibility of creating a startup.

Honda explains the process as follows.

"If the university decides to apply for the patent after our writing a recommendation, we will introduce the invention to the company or, in some cases, if we think there is more potential for a startup than introducing it to a company, we will approach a venture capital firm and ask if there is a possibility for a startup with this technology. This is the most orthodox flow within the university, but it is already well known within the university that the TLO will come for a hearing after the invention disclosure has been submitted, so some researchers skip that procedure and ask for a preliminary consultation. We give advice to the researchers to submit an invention disclosure at this time, or to submit a disclosure after obtaining more data on the invention."

As for introductions to VCs, they not only introduce them to UTEC and UTokyo IPC, but also to other private VCs who are investing in the deep tech field[288]. On the other hand, there are cases where VCs do not support them if they do not share the same scenario as TLOs are thinking[289]. The option agreement mentioned in the MIT TLO part is also used at the University of Tokyo, not only for startups but also for existing companies. On the other hand, according to Honda, at the University of Tokyo, startups often start immediately with a license agreement rather than an option agreement. This is because it is easier to raise funds from VCs and others on the grounds that it has obtained formal licensing authority over the underlying technology. However, after the startups have established a license agreement for the basic technology, they often conclude an option agreement when introducing improved or peripheral technologies.

(2) Role of TLOs and the Required Human Resources

Currently, the University of Tokyo TLO has about 40 staff members in total, of which about 20 are actually in charge of communicating with the researchers who are the inventors[290]. Some of these 20 are science majors with PhD holders, while others have humanities backgrounds[291]. The reason for this is that the University of Tokyo has a wide range of research fields and some of these fields are fused together, so it is not realistic to have staff from all backgrounds, and the role of a communicator with researchers is more important as an ability required of a TLO staff member[292]. In other words, the ability to explain a researcher's invention to a company in catchy terms is all that is required to do the job of a TLO[293]. Therefore, there is no such thing as a life science team, and although Honda also holds a PhD in medicine, she sometimes works in the IT field. She also said that rather than having knowledge of a certain field, it is more important to have thinking tools such as what kind of invention to consider as a broad invention and what kind

[288]Keiko Honda, Interview with Vice President of UTokyo TLO, April 4, 2023.
[289]Keiko Honda.
[290]Keiko Honda.
[291]Keiko Honda.
[292]Keiko Honda.
[293]Keiko Honda.

of data to obtain to obtain broader rights[294]. As for market research, the researchers always have a world they are aiming for, so they first ask how this technology will contribute to society in the future, and at the same time, they identify companies and other entities that have potential for product development by determining what kind of environment must be in place in the surrounding area for this invented technology to be used [295].

(3) Summary and Analysis

The University of Tokyo's technology transfer organization (TLO), UTokyo TLO, in collaboration with the Industry Alliances Division, UTEC, and UTokyo IPC, is responsible for discovering and commercializing research results within the University of Tokyo. The process of establishing a startup through TLO has been shown to be similar at MIT and UTokyo, and begins with a decision on patent protection. Once a patent application is decided, the first step is to determine whether the technology is suitable for a startup or an existing company, based on the nature of the technology. And for the process after that, UTokyo TLO is more active than MIT, asking UTEC, UTokyo IPC, and other VCs about the possibility of startups. However, if the TLO's scenario cannot be shared with the VC, it may be difficult to turn it into a start-up.

6.2.5. Industry Alliances Division, The University of Tokyo

(1) Organization Overview

The Industry-University Collaboration Division (currently the Industry-University Collaboration Promotion Division) was established in April 2004 as a university-wide organization under the direct control of the President to actively promote industry-university collaboration, including inter-organizational collaboration between the University of Tokyo and business enterprises[296]. This organization consists of the "Startup Promotion Department," which provides startup support centered on incubation projects and entrepreneurship education in collaboration with the Graduate School of Engineering, the "Industry-University Innovation Promotion

[294]Keiko Honda.
[295]Keiko Honda.
[296] "Industry-Academia Collaboration Promotion Division Organization," UTokyo Industry-Academia Collaboration Promotion Division Organization, accessed May 16, 2023, http://www.ducr.u-tokyo.ac.jp/organization/organization.html.

Department," which designs ecosystem-based innovation models that lead to business creation and creates a variety of exit strategies, and the "Intellectual Property Contracts and Management Department" is responsible for the management and utilization of intellectual property and research contracts in general. The division works in close collaboration with related external organizations such as the University of Tokyo TLO, UTokyo IPC, and UTEC. In the area of startup support, the Industry-University Collaboration Division is primarily responsible for managing the aforementioned incubation facilities and organizing entrepreneurship education[297].

(2) Creating an Ecosystem-type Environment rather than a Project-type Environment

Prof. Toshiya Watanabe, Director of the Industry-Academia Collaboration Promotion Division, points out that in order for researchers to consider entrepreneurship as an option, it is necessary to create an environment where entrepreneurs are around them, and that this must exceed a certain "density". In fact, in the lab of Prof. Yutaka Matsuo in the field of AI, who is an entrepreneur with strong ties to industry, most of the students include entrepreneurship as an option[298]. Prof. Watanabe states as follows:

“When you don't have someone like that around you, you can't be influenced by what they do based on information on the Internet, so when you have someone close to you, a professor, or for students, their classmates, and more than one person founding a company, it suddenly becomes an option. That kind of thing comes up, but it has to be beyond a certain density. If only one of your acquaintances goes to a venture company, he or she is just an eccentric, so if there are two or three of you and the density exceeds a certain level, then founding a venture company or startup becomes an option."

Therefore, from the perspective of the Industry-Academia Collaboration Division, it is necessary to create high "density" places such as Matsuo Lab here and there. He then points out that an important perspective is not to talk about which project or program is superior or which

[297] “Industry-Academia Collaboration Promotion Division Organization.”
[298] Toshiya Watanabe, Interview with Director of Industry-Academia Collaboration Division, The University of Tokyo, April 13, 2023.

combination is better, but to create an ecosystem that encourages service improvement through a competitive environment, in a sense, by having various service goods of startup support provided within the ecosystem. In a sense, it is important to create an ecosystem that promotes service improvement through a competitive environment[299]. Therefore, the Industry-Academia Collaboration Division is the designer of that ecosystem, and it is letting them compete. This is a similar point made by overseas universities such as SkyDeck, an accelerator at UC Berkeley, and the U.S. is basically working with such a concept[300].

Prof. Watanabe points out that UTokyo IPC's investment in six VC firms as an LP has contributed greatly to the expansion of UTokyo's ecosystem by increasing the number of players in the university's ecosystem. However, since the start of this project by UTokyo IPC, the amount of private investment has increased tenfold, making it a very effective investment inducement[301]. If they try to increase this by another 10 times or so, it would be better to further increase the volume of service supply and intensify competition, but on the other hand, that would be painful, so people would not easily agree to it[302].

Also, there are more and more intramural educational programs, which are becoming more competitive, which is a good direction, Prof. Watanabe points out. In the case of Japan, however, he points out that when this happens, people start to talk about "separation and decentralization," which is not a good thing.

(3) Japan Following the U.S.-Differences in History between the U.S. and Japan

According to Prof. Shigeo Kagami (currently Deputy General Manager, Industry-University Collaboration Promotion Division), who has been leading the university venture creation ecosystem as Director of the Commercialization Promotion Department of the Industry-University Collaboration Division and Auditor at UTEC since 2004, first, when comparing MIT and

[299] Toshiya Watanabe.
[300] Toshiya Watanabe.
[301] Toshiya Watanabe.
[302] Toshiya Watanabe.

the University of Tokyo, they have overwhelmingly different historical backgrounds. He points out that in the U.S., the Bayh-Dole Act was enacted in 1980, TLO was established, and various programs have been accumulated over a long history, while in Japan, the TLO Act of 1998 and the Japanese version of the Bayh-Dole Act were enacted in 1999, and the process started from there. He also pointed out that one of the major differences in the U.S., which has been cultivated through the long history of the U.S., is that venture capital is basically founded by former founders of companies. In the case of Japan, there are many cases where former bankers and securities firms have started venture capital firms. In this history, the University of Tokyo has been accumulating history, and there are examples of entrepreneurs from the University of Tokyo setting up VC firms, such as the Real Tech Fund established by the founder of Euglena, which invests in technology[303]. Therefore, he points out that they are just now going from the very first stage to the next stage, and compared to what MIT, Stanford, and other US universities have cultivated, they are still in the process of developing this kind of thing.

Prof. Kagami emphasized the criticality of having the right individual to assume the role of CEO in the establishment of university spin-off startups.

"The outflow of human resources from large companies is especially important for deep tech ventures that use research results. In addition to the fact that deep tech has quite long legs, industry knowledge is also very important. So the mobility of people with that kind of experience is the biggest challenge."

PeptiDream, for which UTEC provided hands-on support, was able to successfully match a researcher and a business person, and was able to develop a global business relatively quickly[304]. However, Prof. Kagami points out that the biggest challenge is how to make something like this.

[303] Shigeo Kagami, Interview with Prof. Shigeo Kagami, April 18, 2023.
[304] Shigeo Kagami, Interview with Prof. Shigeo Kagami.

(4) Summary and Analysis

The University of Tokyo's Industry-University Collaboration Division (now the Industry-University Collaboration Promotion Division) is an organization that promotes industry-university collaboration, including partnerships with businesses. This organization conducts activities such as startup support, entrepreneurship education, and intellectual property management. It also collaborates with the University of Tokyo TLO, UTokyo IPC, and UTEC. The organization's perspective is that it is important to develop an ecosystem-type environment and aims to create an ecosystem that encourages service improvement through a competitive environment.

It has been pointed out that in order for researchers to consider entrepreneurship as an option, they need an environment where entrepreneurs are around them and a certain density is necessary. It is important to create a competitive environment by expanding the University of Tokyo's ecosystem and providing diverse startup support.

It is important that UTokyo IPC has invested in contributing to the expansion of the University of Tokyo's ecosystem, and this has had the effect of inducing investment. However, for further expansion, it is necessary to increase the supply of services and intensify competition, but it is painful and may not receive favorable opinions.

The difference in the history of industry-academia collaboration between Japan and the U.S. is also pointed out. In the U.S., venture capital has been mainly founded by former companies founders throughout its long history, whereas in Japan, many start-ups are initiated by individuals from banks and securities firms, but recently, VCs by entrepreneurs have begun to appear, and it is pointed out that Japan has moved to the next stage.

6.2.6. University of Tokyo Deep Tech Startup Support Program

(1) GAP Fund Program

The Gap Fund Program began in 2018 as part of the Support Program for the Utilization of Specific Research Results. This is an intramural grant program to promote the commercialization of

research results at the University of Tokyo. The University of Tokyo provides support of 6 million yen per project for implementation proposals that aim to commercialize research results[305]. The support is "to subsidize the necessary expenses and provide advice and other support for research projects that aim to verify or improve the practicality (PoC = Proof of Concept) of research results with a view to commercialization, with intellectual property rights(This includes patents and software copyrights for which applications are to be filed.), etc. at the core," and covers all research fields[306]. Specific examples include the creation of prototypes to verify the practicality of research results, trial runs to improve the practicality of research results, and additional testing and data acquisition to improve the practicality of research results[307]. Therefore, in principle, applicants are required to already own the core intellectual property rights. According to UTokyo, the maximum grant amount is approximately 6 million yen, the period is one year, and the number of grants awarded is approximately 10. The University of Tokyo GAP Fund Program Steering Committee will first conduct a written review as the first round of screening, followed by hearings as the second round of screening, to determine which research projects will be adopted from the viewpoint of whether the proposal is an effective R&D proposal for social implementation. After the program is completed, the selected projects will be shared with the Industry-Academia Collaboration Division, the University of Tokyo TLO, the University of Tokyo IPC, and UTEC for the purpose of examining the feasibility of commercialization. As a result of the past 12 adoptions, the number of adoptions has ranged from 3 to 19, and the adoption rate varies from year to year, but is generally between 30 and 50 percent. In addition, TLO and other organizations are also providing support including intellectual property rights for R&D results, licensing activities using those results, and support for creating startups, but not to the point of providing hands-on support. The program does not require the establishment of a startup as a prerequisite for application, and also accepts as one of its outcomes the interest of companies in licensing or joint development, which is commercialization other than startups.

[305] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*.

[306] Hitotsubashi University Innovation Research Center.

[307] Hitotsubashi University Innovation Research Center; Taka Umada, "The University of Tokyo GAP Fund Program - Open Call for the First Phase of FY 2018," *Medium* (blog), February 21, 2018, https://tumada.medium.com/utokyo-gap-fund-30034e73590.

(2) Deep Tech Entrepreneurship Course

The "Deep Tech Entrepreneurship Course" was launched in August 2021 as part of the Entrepreneurship Education Design Endowed Chair, providing a credit-bearing program for entrepreneurship career education [308]. This course is designed for undergraduate, graduate, and PhD students at the University of Tokyo and focuses on the field of deep tech. [309]. The undergraduate course, titled "Invitation to Deep Tech Entrepreneurship," emphasizes the exploration of big ideas and pictures that bridge overarching concepts with cutting-edge technologies, incorporating immersive fieldwork such as visits to research laboratories. On the other hand, the graduate and PhD course, named "Deep Tech Entrepreneurship Practical Exercise," provides students with the opportunity to present their business proposals based on their research outcomes to relevant faculty, companies, entrepreneurs, and venture capitalists. This exposure enables them to refine their proposals and increase their chances of securing external funding. The course consists of 13 classes, each lasting 105 minutes, and is offered in the evenings and at night[310].

The Deep Tech Entrepreneurship course has received generous donations totaling 120 million yen from various contributors, including Industrial Growth Platform, KDDI, UTEC, and Matsuo Institute and is scheduled to run through June 2024[311]. Industrial Growth Platform is a consulting company, KDDI∞ Labo is an open innovation Business Co-Creation Platform operated by the telecommunications company KDDI, UTEC is a venture capital firm, and Matsuo Institute is a startup support organization affiliated with Matsuo Lab, Graduate School of Engineering, University of Tokyo. Normally, endowed courses have a duration of three years, with a maximum extension of five years. Any plans for a longer duration require approval from the Council on

[308]"The University of Tokyo, Industrial Growth Platform, KDDI, UTEC, and Matsuo Research Institute Establish Endowed Chair to Accelerate Entrepreneurial Creation," Faculty of Engineering, The University of Tokyo, August 19, 2021, https://www.t.u-tokyo.ac.jp/press/foe/press/setnws_20210819132333323158563 10.html.
[309]"List of Courses | The University of Tokyo Faculty of Engineering Industry-University Cooperative Education," accessed May 4, 2023, https://iacollabedu.t.u-tokyo.ac.jp/related-lectures/.
[310]"Lecture 2022 (Semester A for graduate students) - Entrepreneurship Education Design Endowed Chair," August 8, 2022, https://entredu.t.u-tokyo.ac.jp/2022a/.
[311]Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo, May 3, 2023.

Education and Research[312]. Therefore, the organizers aim to sustain this course in some form in the future[313]. The establishment of this endowed chair was driven by the fact that, as of 2021, approximately 400 startups affiliated with the University of Tokyo had been established. However, these startups were predominantly concentrated in specific fields, with approximately 30% in IT application software and another 30% in the bio-healthcare sector[314]. There was a desire to foster commercialization in fields that require more time, such as manufacturing (13%), environment and energy (5%), chemicals and materials (2%), and IT hardware (semiconductors, etc.) (4%), as well as other areas accounting for approximately 15% [315]. The University of Tokyo took the initiative to address this need and develop the Deep Tech Entrepreneurship course, which aims to achieve three key objectives: cultivating entrepreneurs, establishing an educational framework for entrepreneurship development, and fostering a robust startup ecosystem[316].

The roles of the aforementioned donors and the University of Tokyo in this endeavor are as follows.

Table 6.3 Main Role of Each Party

The University of Tokyo	Research on the grand design of seamless entrepreneurship education at the University of Tokyo, and collaboration with entrepreneurship-related courses on campus
Industrial Growth Platform	Providing knowledge in business startup, financing, monetization concepts, and business economics from various perspectives, including business, finance, and management

[312]"The University of Tokyo Endowed Chair Guidelines," n.d., https://www.u-tokyo.ac.jp/content/400009796.pdf.
[313]Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo.
[314] Faculty of Engineering, The University of Tokyo, "Endowed Chair in Entrepreneurship Education, The University of Tokyo."
[315]"The University of Tokyo, Industrial Growth Platform, KDDI, UTEC, and Matsuo Research Institute Establish Endowed Chair to Accelerate Entrepreneurial Creation"; "Entrepreneurship Education Design Endowed Chair," March 1, 2021, https://entredu.t.u-tokyo.ac.jp/.
[316]"The University of Tokyo, Industrial Growth Platform, KDDI, UTEC, and Matsuo Research Institute Establish Endowed Chair to Accelerate Entrepreneurial Creation."

KDDI	Providing knowledge on new business development that combines technological seeds and social needs Providing fieldwork opportunities with business companies using the KDDI ∞ Labo network
UTEC	Providing knowledge about manufacturing, environmental and energy business models, and successful global startups
Matsuo Research Institute	Providing knowledge about the realities of a startup's business concept - company formation - early startup period

Source: UTokyo (2021)[317] *(Translated by the author)*

The course is meticulously planned and overseen by a distinguished team of four professors: Professor Ichiro Sakata, Professor Shigeo Kagami, Professor Yutaka Matsuo, and Associate Professor Kenji Tanaka, all hailing from the Graduate School of Engineering. Each professor brings valuable expertise to the table, with Professor Sakata affiliated with METI, Professors Kagami and Tanaka having industry backgrounds, and Professor Matsuo being a researcher closely connected to industry. Their extensive industry ties further enrich the course's design and management[318]. The curriculum design and management responsibilities are entrusted to Yukihiro Murata, seconded by Industrial Growth Platform, and a staff member seconded by Matsuo Institute. Assisting them are a dedicated group of over 10 student TAs, many of whom hold advanced degrees and some possess industry experience[319]. The mentorship system is structured in a manner where each TA is assigned to 6-7 students, while students independently arrange interview appointments for individual consultations with experts. This approach acknowledges the diverse research themes pursued by students and ensures tailored advice is readily available. Additionally, the decision to adopt a student-driven appointment system for interviews with experts is informed by the challenge faced by the administration in compiling a comprehensive

[317] "Entrepreneurship Education Design Endowed Chair."
[318] Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo.
[319]"Entrepreneurship Education Design Endowed Chair"; Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo.

roster of experts capable of providing tailored guidance. So far, this system has proven effective and well-received in practice[320].

Yukihiro Murata, who assumes the role of curriculum design and operations, emphasizes that the course primarily serves as career education, enlightening science students about the possibilities of initiating their own ventures and commercializing their research outcomes should they pursue a career in academia. Simultaneously, the course acts as a central hub, facilitating connections between students and accelerator programs affiliated with universities and donor companies, as well as the NEDO Entrepreneurs Program (NEP), NEDO's program to discover talent and foster entrepreneurship in the deep tech field. Mr. Murata spoke as follows

“What we did in seeking what we can do in terms of creating unicorns was to try to increase the number of people who might go to the various accelerator programs. Students who are serious about studying and doing research often reject the terms "entrepreneurship" and "business" because they feel they are not grounded. In this context, we thought it was important for students to have a sense of both publicity and profitability when deciding whether or not to pursue a deep-tech business or when deciding on a theme for their thesis, so we approached this first. That is something that only an educational institution can do, so I think it made sense."

And for the course for graduate and PhD students, the goal is to have approx. 5 students out of 30 students step up to the accelerator program within 1 year[321].

As per Murata, the present enrollment figures for the course indicate approximately 90 undergraduate students and 30 graduate students. Following the completion of the course, a selected group of 30 exceptional individuals will be offered an invitation to participate in the Deep Innovation Creation Ecosystem (DICE) community, a one-year accelerator program. Once admitted to DICE, these students are further provided with opportunities to go to the United

[320]Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo.
[321]Yukihiro Murata.

Kingdom, Silicon Valley, Boston, and New York. This training framework has been purposefully designed to cultivate the participants' autonomy, granting them the freedom to arrange their own appointments with relevant stakeholders and orchestrate the necessary program activities for successful implementation.

Although this course has just begun, current results include some people applying for and being selected for grants such as the University of Tokyo GAP Fund and NEDO's program[322]. In addition, starting in April 2023, they have formed a partnership with Ochanomizu Women's University and are working to expand this deep tech course to other universities[323].

(3) Startup Ecosystem Formation Support Project GTIE Program

Greater Tokyo Innovation Ecosystem (GTIE) is a program funded by MEXT and jointly led by the University of Tokyo, Waseda University, and Tokyo Institute of Technology to foster university spin-off startups that will change the world by supporting entrepreneurial activities, fostering entrepreneurial talent, developing entrepreneurial environment, and creating an ecosystem[324]. Among them, the University of Tokyo GTIE Program provides commercialization feasibility study based on research results with researchers and business developers, and supports their selection for the University of Tokyo's GAP Fund and other accelerator programs. The program is structured into four phases[325]. First, in the 1st phase, participants learn basic methods of applying research results to business and summarize ideas for each theme. Next, in the 2nd phase, participants apply for GAP funds and accelerator programs, and practice making presentations in preparation for the selection process. In the third phase, participants create a business plan based on their hypothesis, conduct interviews with customers, and make a pitch in English. In the 4th phase, participants test their hypotheses[326]. According to Prof. Shigeo Kagami of the University of Tokyo, who heads GTIE at UTokyo, the program also provides mentorship, not only

[322]Yukihiro Murata.
[323]Yukihiro Murata.
[324]"Startup Ecosystem Formation Support Project GTIE Program," The University of Tokyo, Industry-Academia Collaboration Division, accessed May 4, 2023, http://www.ducr.u-tokyo.ac.jp/activity/venture/gtie.html.
[325]"Startup Ecosystem Formation Support Project GTIE Program."
[326]"Startup Ecosystem Formation Support Project GTIE Program."

in Japan, but in UTokyo's case, also through a contract with UC San Diego to provide mentoring from overseas experts. The program even culminates in a pitch at UC San Diego.

(4) Entrepreneurship Courses and their Visualization through an Integrated Database

The University of Tokyo recognized the need for a centralized search system for entrepreneurship courses, as these courses were scattered across different departments and lacked an integrated platform[327]. To address this, they developed a comprehensive search system that enables users to easily search for entrepreneurship courses and extracurricular programs based on various criteria such as semester, academic year, affiliation, field of study, and level. As of May 2023, there are a total of 63 entrepreneurship courses and programs available through this system, providing students with a wide range of options to explore and engage in entrepreneurial education[328].

In addition to the Deep Tech Entrepreneurship Course and GTIE programs discussed earlier, the University of Tokyo offers several other notable initiatives. One such program is the "Entrepreneurship Dojo," which was initiated in 2005 through a collaboration between UTokyo's Industry-Academia Collaboration Division, UTEC, and TLO. Over the years, it has become the university's longest-running entrepreneurship education program, attracting approximately 4,700 students by the end of 2020[329]. The course is structured into beginner, intermediate, and advanced levels, and teams selected from the advanced level have the opportunity to participate in a business plan contest. Each selected team is assigned two mentors, typically venture capitalists or former entrepreneurs. According to Prof. Shigeo Kagami of the University of Tokyo, who has been leading this "Entrepreneurship Dojo," the mentors are basically venture capitalists or former entrepreneurs. Prof. Kagami explains highlights the virtuous cycle at UTokyo, where successful entrepreneurs who have established their own companies serve as mentors, contributing to the growth and development of aspiring entrepreneurs. Another program offered

[327]"List of Courses | The University of Tokyo Faculty of Engineering Industry-University Cooperative Education"; Yukihiro Murata, Interview with the coordinator of the deep-tech course at UTokyo.
[328]"List of Courses | The University of Tokyo Faculty of Engineering Industry-University Cooperative Education."
[329] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*.

by the university is the Spring-Summer Founders Program (SFP), a two-month initiative conducted during the summer and spring vacations. Under this program, students engage in technology projects and product development while receiving activity funds ranging from approximately 30,000 to 300,000 yen [330]. According to Professor Kagami, research-seed type deep tech projects at UTokyo always have a mentor assigned, and in some cases, previous program participants act as mentors in the form of bridging tutors. Depending on the nature and stage of the educational program, mentors can be practitioners if the project is approaching commercialization, or student mentors may be assigned to undergraduate students. In most cases, mentors receive an honorarium for their contributions. The University of Tokyo has made efforts to secure mentors and has achieved a certain level of success, , thanks to the involvement of over 400 companies associated with University of Tokyo-related ventures, which has resulted in a pool of experienced professionals willing to mentor and guide aspiring entrepreneurs.

(5) Summary and Analysis

The University of Tokyo offers about 60 entrepreneurship education programs. The University of Tokyo's GAP Fund Program is an intramural grant program for the commercialization of research results at the University of Tokyo, and researchers and faculty members are eligible to apply. The University of Tokyo offers a career education in entrepreneurship known as the Deep Tech course. There are two classes, one for undergraduates and the other for graduate and PhD students, each with different content. The undergraduate courses focus on future-oriented ideas and fieldwork, while the graduate and PhD student classes provide funding and pitching opportunities to commercialize research findings. The University of Tokyo GTIE Program within GTIE offers commercialization feasibility studies and support for participating researchers and developers, including mentorship from both domestic and overseas experts.

In addition to the Deep Tech courses and the GTIE program, the University of Tokyo has several other programs. The oldest of these programs is the Entrepreneurship Dojo, which was launched in 2005 as a collaboration between the University of Tokyo's Industry-University Collaboration

[330]"List of Courses | The University of Tokyo Faculty of Engineering Industry-University Cooperative Education."

Division, UTEC, and TLO. The program offers beginner, intermediate, and advanced courses, and upon completion of the advanced level, teams are selected to participate in a business plan contest. Selected teams are assigned a venture capitalist or former entrepreneur as a mentor. Due in part to the University of Tokyo's efforts to date, there are more than 400 related venture companies, making it relatively easy to secure mentors compared to other universities in Japan.

6.3. Other University-Related VCs

6.3.1. WERU Investment

(1) Background of Establishment

WERU Investment is an independent asset management firm established in 1998, distinguishes itself as the first venture capital firm in Japan to utilize university resources[331]. Founded primarily by the Waseda University Entrepreneurial Research Association, WERU maintains a strategic distance from the university despite its close ties and contractual affiliation[332]. According to WERU Investment CEO Tadashi Takiguchi, WERU's strategy since its inception has been to maintain a certain distance from the university. Although WERU has a very close relationship with Waseda University and is contractually affiliated with the university, and furthermore, WERU has Waseda University on its board of directors and receives investment from Waseda University, it exists as an organization independent from the university organization and does not operate as a Waseda University organization[333]. This approach aligns with the findings of a comparative study conducted by the Waseda University Entrepreneurial Research Association, highlighting the distinct structure observed in the United States where related VC firms gather at universities where those in charge of university-industry collaboration are working as incubators and accelerators, and the university's role primarily centers on business development rather than fund ownership. According to Takiguchi, the major difference between Japan and the U.S. is the existence of an incubator/accelerator rather than a fund. Therefore, when WERU Investment was first established, the fund was not the first priority, but the role of the incubator was more

[331] "ABOUT US - WERU Investment Co., Ltd.," April 30, 2021, https://www.weruinvest.com/about-us/.
[332] Tadashi Takiguchi, Interview with CEO of WERU Investment, April 12, 2023.
[333] Tadashi Takiguchi.

important in terms of how to commercialize the university's technology. Later, as the size of the fund grew, its significance grew and the fund's role became stronger. According to Takiguchi, it is important to separate investment criteria for each fund when investing in university-related companies.

(2) Investment Policy

To ensure the sustainability of their fund, a fund of up to 5-10 billion yen can manage to invest solely in startups related to Waseda University, but beyond that amount, the fund would not be viable unless it invests in startups outside of Waseda University. Therefore, from the beginning, WERU did not focus exclusively on startups related to Waseda University, but rather targeted universities and research institutes in Japan, and around 2010, the fund shifted its direction to invest in a wide range of overseas research institutes and universities. Currently, WERU manages three funds, each with a focus on achieving financial returns. However, the investment strategies differ depending on whether the fund's objective is centered on the Japanese market or the global landscape. The following is a detailed look at the two funds. The third fund is a 20 billion fund that invests in global growth stage companies that do not involve university spin-off startups, so it falls outside the scope of the subsequent section.

(3) Waseda University-specific Fund

WERU Investment has a close relationship with Waseda University, contributing as an incubator for entrepreneurship education at Waseda University, while also serving as a provider of funding. In 2018, WERU established a Waseda University-specific fund with a size of 1 billion yen, designed to support startups affiliated with Waseda University. This fund operates for a duration of 10 years and typically invests around 30 million yen per company at the early stages before other venture capitals step in. Investments are made in Waseda-related startups that leverage Waseda University patents, engage in joint research, have management ties to Waseda University, or have key management positions held by Waseda alumni. It is important to note that the fund does not limit its investments solely to tech startups; non-tech startups are also eligible as long as they fulfill the aforementioned requirements. This is particularly relevant as some startups

emerge from Waseda University's business school and other educational programs, resulting in approximately half of the investments being allocated to service-oriented startups. Furthermore, in line with their objective of bridging the gap between the university and society, the fund exclusively invests in pre-seed and seed stages, refraining from participating in Series A or Series B rounds. Approximately 80% of the investments are startups with business models targeted at the Japanese market. As a proactive approach, WERU Investment provides additional support to the invested companies, such as offering credit guarantees, participating in the board and offering hands-on supports. They also facilitate introductions to potential human resources. Currently, the fund has invested in 10 companies, with 5 of them belonging to the deep tech sector.

(4) The Early-stage Global Fund

WERU also manages a fund established in 2014 that invests in global technology startups in Japan, the United States, and elsewhere. The early-stage global fund is 10 billion yen with a maximum of 1 billion yen per investment and a 10-year term. The early-stage global fund has invested in 19 companies, two of which are Waseda-related startups and 17 are startups in the deep-tech field. The company invests in startups that can aim for the global market. The reason why the global fund is investing overseas is because in Japan, the only IPO destination is Mothers, and the Exit amount is smaller than if the company were to go public overseas.

A specific example of investment recipients is CoreTissue BioEngineering Inc. It is a medical device company that uses decellularization technology and is based on the research findings of Prof. Kiyotaka Iwasaki, who returned to Waseda University from Harvard. WERU invested in this company in 2019 as the first project from the Waseda University Specialized Fund, followed by a Series A investment from the Global Fund in 2023, and is currently investing in the company as it aims for a global market.

(5) Investment Decision

The decision-making process regarding which fund to invest in and whether or not to proceed with an investment is contingent upon the evaluation of the business model and human

resources. Furthermore, within the realm of deep tech, there are certain technologies that are specifically tailored for the Japanese market. This determination is based on factors such as the number of patents and research papers associated with the technology. If these numbers are limited, it becomes challenging to pursue global market expansion due to the difficulties in securing overseas funding.

To assess the technological aspects, thorough research and analysis are conducted on future technology trends, industry developments, and startup trends. These three types of research form the foundation for creating hypotheses about future social trends. Based on these hypotheses, the investment scope is defined. Once a potential investment candidate is identified, researchers are interviewed, and the artificial intelligence tool "Valuenex," developed by a Waseda University related startup, is utilized to analyze patents and conduct quantitative assessments regarding the feasibility of future technology utilization. As a result, the company tends to seek investment targets based on these hypotheses rather than frequently evaluating incoming projects. In the process of making investment decisions, the company prioritizes technologies that have progressed beyond the research proof-of-concept stage and have at least a prototype available. Additionally, they seek a compelling product-market fit story[334].

(6) Summary and Analysis

WERU Investment is a Waseda University-affiliated venture capital (VC) firm established in 1998. WERU has adopted a strategy of maintaining a certain distance from the university, operating as an independent organization while maintaining close ties with Waseda University. At the time of its establishment, WERU's main activity was as an incubator in the role of commercializing university technologies, and the fund was only a part of its support. However, as the size of the fund grew, the role of the fund was strengthened.

[334] Tadashi Takiguchi.

WERU operates several funds. The Waseda University Specialized Fund mainly targets startups related to Waseda University. This fund invests at an early stage and selects investees based on Waseda University patents, joint research, and Waseda-educated management.
In addition, the Global Fund invests in global technology venture companies, including those in Japan and the United States. The fund invests in early-stage companies and targets startups in Japan and abroad.

WERU Investment conducts technology assessments and analyzes technology and industry trends, as well as venture trends, to determine its investment field. The fund also utilizes the AI to evaluate patents and conduct quantitative analysis of technologies during the assessment process.

6.3.2. Keio Innovation Initiative

(1) Founding History and Portfolio

Keio Innovation Initiative, Inc. (KII) was founded in 2015 as a joint venture between Keio University and Nomura Holdings, with Keio University holding an 80% stake and Nomura Holdings holding a 20% stake[335]. It currently manages two funds: the first fund, established in 2016 with a duration of 10 years, has a total capital of 4.5 billion yen, while the second fund, established in 2020 with a duration of 10 years, has a total capital of 10.3 billion yen[336]. The first fund exclusively focuses on investments in startups related with Keio University and has thus far supported 19 such ventures. Conversely, the second fund has a broader investment scope, targeting a diverse range of companies beyond Keio University, and has successfully invested in 26 startups, with 18 of them being related to Keio University[337]. Among the 45 companies in KII's portfolio, more than 80% operate within the deep tech sector, with approximately half being at the seed or early-stage, and the remaining half at the middle stage of development[338]. The establishment of the venture capital firm was prompted by the emergence of university-affiliated VC firms like UTEC

[335] Keio Innovation Initiative, “Keio Innovation Initiative Company Profile,” April 2023.
[336] Keio Innovation Initiative.
[337] Kotaro Yamagishi, Interview with CEO of Keio Innovation Initiative, May 12, 2023.
[338] Kotaro Yamagishi.

and the creation of public-private funds like UTokyo IPC at that time[339]. Consequently, the first fund initially focused solely on supporting startups related to Keio University.

(2) Investment policy

The Keio Innovation Initiative (KII) is not solely driven by a profit-oriented approach typically associated with venture capital firms[340]. Instead, it operates on a broader social mission of promoting the commercialization of university research outcomes and nurturing startups for the betterment of society. This distinctive vision guided KII's investment strategy, where the initial fund exclusively supported startups related to Keio University, and subsequently, the second fund expanded its scope to include non-Keio University startups. CEO Kotaro Yamagishi provided three reasons to elucidate the rationale behind this policy shift.

"One reason is that when raising funds, especially when considering increasing the size of the fund, it benefits limited partners (LPs) to have a larger universe of investment targets than just Keio University."

By increasing the investment universe, LPs gain access to a more diverse set of opportunities, maximizing their potential returns.

"Another reason is that, after all, investing in startups has an aspect of investing in relatively good ones, so investing in startups enables the accumulation of valuable know-how. Basically, we invest in Japanese startups, but as a VC, if we only look at opportunities coming from Keio University, we lose a sense of relativity and a sense of the market."

By engaging with a variety of ventures, including those outside Keio University, they enhance their expertise and understanding of the startup ecosystem. This broader perspective is crucial for maintaining relativity and staying attuned to market dynamics.

[339] Kotaro Yamagishi.
[340] Kotaro Yamagishi.

"Third, there is a request or an opportunity. Tokyo Medical and Dental University and Osaka University have officially requested us to take care of them. We have not yet invested startups from Tokyo Medical and Dental University, but they have disclosed information to us from the seed stage, and we have opportunities."

These requests and engagements highlight their expanding network and the potential for future collaborations beyond Keio University.

Furthermore, more than 80% of KII's investments are directed towards deep tech ventures, with a specific focus on life sciences, medical, and digital sectors encompassing IT and AI. [341]. Yamagishi expounded that these two areas within deep tech exhibit higher potential for profitable exits. Notably, drug discovery holds promise for generating returns through M&A activities during the developmental phase. Conversely, Yamagishi acknowledged the challenges in attaining substantial returns within the manufacturing, materials, and energy sectors.

Consequently, investment decisions are anchored on this exit-oriented approach. Yamagishi also clarified the rationale behind the balanced distribution of investments, with half allocated to the seed to early stage and the other half to the middle stage.

Regarding investment policies, they are contingent upon the fund's size and the number of companies to be invested in. For a fund with a 10-year duration, new investments typically conclude within three to four years, necessitating an exit strategy within six to seven years at the shortest to realize returns[342]. Consequently, investment decisions are anchored on this exit-oriented approach. Yamagishi also clarified the rationale behind the balanced distribution of investments, with half allocated to the seed to early stage and the other half to the middle stage.

[341] Keio Innovation Initiative, "Keio Innovation Initiative Company Profile"; Kotaro Yamagishi, Interview with CEO of Keio Innovation Initiative.
[342] Kotaro Yamagishi, Interview with CEO of Keio Innovation Initiative.

“There are two reasons for this, though it is not so much risk diversification. One is that our main investment strategy is to go hands-on from the seed/early stage, but if we do everything from the seed/early stage, we will run out of resources, which is a supply-side problem for us. The other is that there will be startups that we were not able to invest in during the seed/early stage, but that have already begun to show signs of success, so we will invest in them later. As a result, we cannot expect a very high return on middle or late-stage investment, but we can expect a reasonably solid 3X or 4X return on our investment. On the other hand, those who start from seed can expect a return of 30x if they do well."

Furthermore, a mere 20% of investment prospects related to Keio University originate from official channels like the Technology Licensing Organization (TLO), as the majority of opportunities are identified through alternative channels coinciding with their arrival via the official route [343]. Notably, they often approach renowned professors who have secured substantial research grants even before their research becomes widely recognized.
When making investment decisions, various factors are taken into consideration, including the customer value proposition, technological advantage, market conditions, business model, and founding team.

(3) Summary and Analysis

Keio Innovation Initiative, Inc. (KII) was established in 2015 as a collaborative effort between Keio University and Nomura Holdings. KII currently oversees the management of two funds. Fund 1, established with a 10-year timeframe, focuses on investing in startups affiliated with Keio University. On the other hand, Fund 2, established in 2020, aims to support startups outside the realm of Keio University.

KII's investment endeavors primarily center around the deep tech sector, with particular emphasis on fields such as life sciences, healthcare, and digital technologies (IT and AI). The core principle driving KII's investment policy is the pursuit of commercializing research outcomes from

[343] Kotaro Yamagishi.

the university and nurturing startups that bring societal benefits. Consequently, investment decisions are carefully made, taking into account essential factors such as the customer value proposition, technological advantages, prevailing market conditions, business models, and the capabilities of the founding team.

In line with their commitment to maximize returns, KII places significant emphasis on exit strategies for the startups they invest in. This entails completing new investments within a span of three to four years for a 10-year fund, with a target of recouping returns within six to seven years, at the earliest. To diversify their investment portfolio, KII engages in both seed or early-stage investments and middle-stage investments. Given their limited resources for hands-on support in the seed and early stage, KII also considers investing in successful startups at the middle stage.

6.3.3. Tokyo University of Science Innovation Capital

(1) History

Tokyo University of Science Innovation Capital (TUSIC) was established in November 2018 as an officially accredited venture capital firm affiliated with Tokyo University of Science. n 2014, Tokyo University of Science Investment Management (TUSIM) was established as a university business company to provide comprehensive support for entrepreneurship events, startup consultations, and the management of incubation facilities. By integrating Tokyo University of Science's Industry-University Collaboration Organization, TUSIC, and TUSIM, the university has established a seamless support system spanning from startup to exit[344]. As of April 2023, Tokyo University of Science's incubation facilities, known as Cross Point, have been home to 216 resident companies, with 107 of them participating in venture pitches. Tokyo University of Science has authorized several venture funds, including the No. 1 fund established in 2016 with a size of 4 billion yen, the No. 2 fund established in 2019 with a size of 7.5 billion yen, and the upcoming No. 3 fund, currently in the preparatory phase, to be established in 2023. The No. 1 fund is fully owned by the university and operates under its auspices, while the No. 2 fund is a limited

[344]Yuichi Katayori, Interview with CEO of Tokyo University of Science Innovation Capital.

partnership funded by the Tokyo University of Science and private institutional investors. [345]. Two funds diversifies its investments by supporting a wide range of startups, including those associated with Tokyo University of Science, although not limited to them. To date, the No. 1 fund has invested in 21 companies, with 13 of them being lead investments, while the No. 2 fund has invested in 17 companies, with 14 of them being lead investments. Approximately half of the total investment projects are related to Tokyo University of Science, while around 30% of the investments focus on deep-tech ventures.

According to CEO Yuichi Katayori, he described the founding of the company as follows

"In 2015, I joined Tokyo University of Science. At that time, the university did not have any rules or regulations in place regarding venture capital. However, with the support of Prof. Michael A. Cusumano, who was serving as the vice president, President, Prof. Cusumano, and I managed to establish a venture capital firm. In Japan, universities, in particular, were known for their rigidness and reluctance to venture into uncharted territories. Fortunately, I was given the opportunity to initiate the venture capital endeavor due to my background at Goldman Sachs and the trust placed in me to take full responsibility. "

During our search process, they annually interview and conduct initial screenings of approximately 200 companies from a pool of around 300 potential candidates[346]. Out of these, they carry out a comprehensive review and due diligence process for approximately 100 companies each year. As a result, they have successfully invested in a total of 38 companies thus far. However, investing in deep tech presents unique challenges for venture capitalists who are focused on generating returns. Katayori explains as follows:

“Deep-tech startups present unique challenges when it comes to going public within the fund's designated timeframe, and significant investment is required to monetize these ventures. For

[345]Yuichi Katayori.
[346] Yuichi Katayori.

instance, in the case of a semiconductor startup, it may take approximately 1 billion yen before sales can commence. Determining the necessary capital for product launch poses difficulties as well. Essentially, venture capitalists face a mismatch between the time it takes for a solid performance to materialize and the time it takes for research findings to commercialize, making this a particularly challenging aspect."

On the other hand, Katayori emphasizes the importance of a one-stop system in creating university spinoffs.

"University-affiliated venture capital firms are poised to play a pivotal role as deep-tech prospects continue to emerge from within the university ecosystem, seeking guidance for commercialization. To enhance the likelihood of success, the presence of an incubation facility becomes crucial. I firmly believe that the probability of success is elevated when a pre-company formation consultation framework is in place, coupled with a meticulous evaluation of the time and capital required for successful commercialization prior to the initial investment. By establishing such a system, the chances of achieving favorable outcomes can be significantly increased."

In addition, when making investments, "it is difficult to control technology-based startups unless they are lead investments," he said. In addition, he said that the venture capitalists needed to increase the number of university spinoffs are "venture capitalists with solid experience in growing companies," but the problem is that there are not enough of them.

(2) Incubation Facilities Cross Point

Cross Point, the incubation facility of Tokyo University of Science, is unique in that it is not named after the university like The Engine, which was built by MIT.

According to Katayori, This choice of name was influenced by advice from Prof. Cusumano, who served as the specially appointed vice president of Tokyo University of Science at the time. Katayori says the use of the university's name could deter external stakeholders from

participating, limiting the diverse interactions that could take place within the facility. Katayori elucidates the significance of Crosspoint by stating:

"Prof. Cusumano enlightened us about the core essence of an incubation facility, emphasizing that mere consultation, investment, or cherry-picking of promising ventures is insufficient. Instead, it is imperative to establish a supportive environment that identifies the intrinsic value of technology and its corresponding market. Thus, we established Cross Point—a space dedicated to nurturing and assisting startups at the pre-seed and seed stages. Furthermore, we have implemented a system that enables immediate investment when appropriate. Additionally, such a facility should have the capacity to assess the projected timeframe for reaching the early and growth stage. This can be accomplished by fostering a collaborative environment where close consultation with startups occurs within the same location and we take a first look at them. Tokyo University of Science serves as a tangible embodiment of this concept."

Shinsuke Matsumoto, the Incubation Manager, highlights the array of complimentary services available to residents of the facility. These services encompass refining business plans, facilitating company incorporation, providing referrals to legal and intellectual property experts, and offering guidance on government subsidies[347]. Additionally, Matsumoto acknowledges the current absence of a laboratory within the premises but acknowledges its necessity and indicates that it is under consideration. He further notes that approximately 20% of the tenants represent deep tech ventures[348].

(3) Summary and Analysis

Tokyo University of Science Innovation Capital (TUSIC) was founded in 2018 as an accredited venture capital firm affiliated with Tokyo University of Science. Operating since 2014, Tokyo University of Science Investment Management (TUSIM) serves as a university-operated company responsible for managing entrepreneurial events and incubation facilities. By integrating TUSIC,

[347] Shinsuke Matsumoto, Interview with General Manager, Incubation Division, Tokyo University of Science Investment Management Co., April 3, 2023.
[348] Shinsuke Matsumoto.

TUSIM, and the Industry-University Collaboration Organization, Tokyo University of Science has developed a comprehensive, all-in-one support system that accompanies startups on their journey from inception to achievement. Currently, the first fund is wholly owned by Tokyo University of Science, while the second fund includes LP participation from private institutional investors. Approximately half of the investments made are directly related to Tokyo University of Science, with roughly 30% dedicated to deep tech enterprises.

It is worth noting that investing in deep tech ventures presents challenges in terms of both time frame and the required amount of funding. The process of taking a deep tech startup exit necessitates significant time and capital investment. Venture capitalists encounter a fundamental discrepancy between the duration of their investment funds and the optimal timeframe for achieving successful exits. This misalignment poses a fundamental challenge for VCs as they strive to strike a balance between maximizing returns and meeting the predetermined time constraints of their funds. Consequently, the percentage of investments allocated to deep tech is perceived to be somewhat limited.

Conversely, the importance of incubation facilities and meticulous planning in terms of timing and funding for commercialization cannot be understated in ensuring the success of university spin-off companies. University venture capital plays a pivotal role in this regard. Additionally, lead investment assumes a crucial position for technology-based ventures, yet the availability of experienced venture capitalists remains insufficient in Japan.

Cross Point, the incubation facility at Tokyo University of Science, was intentionally established without explicitly incorporating the university's name. This deliberate choice enables students from various universities to engage with and benefit from the facility's resources and support.

7. UTokyo Spin-off Startup Short Case Study

7.1. Overall

This section presents case studies of six UTokyo spinoff startups, based on interviews and literature review. The six startups are deep tech in the fields of bio/life sciences, climate change/energy, and AI/IT. In addition, three of the interviewees are CEOs who started their own companies based on their own research results in graduate or PhD programs, one is a UTokyo alumnus CEO who was successfully matched as an outside industry management talent, and one is also a UTokyo alumnus CEO who is a venture capitalist as well.

The primary focus of the interviews revolved around the funding trajectory, encompassing both pre and post-company founding phases. By delving into the funding experiences of these startups, we aim to shed light on the challenges, strategies, and successes encountered during their fundraising endeavors. The interviews were supplemented by a literature review, which constitutes the short case study as a whole.

This chapter also analyzes the case study keeping in mind the Brad Feld et al.'s key elements of VC Funding as described in "Chapter 5 MIT Spin-off Startup Short Case Study".

7.2. GIRASOL ENERGY

(1) Founding History

Girasol Energy Corporation, founded in February 2017, uses a new communication technology invented by Associate Professor Hideya Ochiai of the University of Tokyo's Graduate School of Information Science and Technology to improve the operating rate of solar power plants, to determine the causes of declining power generation capacity of solar panels, and to take measures to restore power generation capacity to regenerate power plants[349]. CEO and Co-

[349]University of Tokyo, "University of Tokyo Intellectual Property Report 2022."

Founder Li Min was working at the University of Tokyo's Industry-Academia Collaboration Division at the time and had contacts with many research laboratories, when he met Associate Professor Ochiai and his research results[350]. Three people including Li Min and Hiroyuki Ikegami, a PhD student at the University of Tokyo's Graduate School of Information Science and Technology, started the company, and the other two were concurrently working[351]. Shortly after its founding, Girasol Energy moved into the Entrepreneur Plaza, an incubation facility operated by the University of Tokyo's Industry-University Cooperative Creation Promotion Division[352]. By moving into the incubation facility, the company had the advantage of receiving various types of support for commercialization, including introductions to accounting, tax, legal, and other professionals, networking opportunities, and introductions to investors and other companies.[353] In addition, the fact that the company is registered on the premises of the University of Tokyo has greatly increased the credibility of the company with external parties, such as business partners[354]. In addition, Girasol Energy received several million yen in funding for its activities and hands-on management support through the Accelerator Program (the predecessor to the current "1st Round" support program) by the University of Tokyo IPC prior to starting the company[355]. Specifically, Girasol Energy conducted market validation and research, negotiated for the transfer of intellectual property from the University of Tokyo's TLO, licensed the technology, and created prototypes[356].

(2) Initial VC Funding and Public Grants, then Series A Round

Then, in October 2017, they executed a pre-seed fundraising of tens of millions of yen in total from ANRI, a private VC in the deep-tech domain, and two angel investors[357]. At that time, Girasol Energy was short of resources and needed to collaborate with others, but this led to a

[350]Li Min, Interview with CEO of Girasol Energy, April 22, 2023.
[351]Li Min.
[352]University of Tokyo, "University of Tokyo Intellectual Property Report 2022."
[353]University of Tokyo.
[354]Tadashi Senbo, Interview with CFO of Girasol Energy, April 19, 2023; Li Min, Interview with CEO of Girasol Energy.
[355]University of Tokyo, "University of Tokyo Intellectual Property Report 2022."
[356]Li Min, Interview with CEO of Girasol Energy.
[357]"PitchBook Profile - Girasol Energy," accessed April 27, 2023, https://my-pitchbook-com.libproxy.mit.edu/profile/300323-35/company/profile; Li Min, Interview with CEO of Girasol Energy.

relationship with Yamanashi Prefecture, which led to the start of a large-scale joint demonstration project between Yamanashi Prefecture and Girasol Energy in October 2019, as well as investment by Yamanashi Prefecture in 2020 and 2021[358]. In parallel, Li Min and their team participated in pitch events organized by several VCs, etc. In May 2018, Girasol was awarded a grant by the New Energy and Industrial Technology Development Organization (NEDO) as Phase B of the "New Energy Technology Innovation Support Project by Venture Companies, etc.," under the theme of "Technological development of IoT systems using next-generation power line communication technology to make solar power generation sustainable"[359]. The company was one of 13 companies selected from 65 applications after a selection screening by external experts and an internal review by NEDO[360]. In November 2018, the company also won third place in the Asian Entrepreneurship Award sponsored by Mitsui Fudosan (a real estate company), winning prize money of 450,000 yen[361]. According to Li Min, the relationship with Mitsui Fudosan, from which they would later get investment, was built through this event, which was much more helpful than the prize money gained from this event. Furthermore, in 2019, they were selected for Phase C of NEDO's "New Energy Technology Innovation Support Project by Venture Companies, etc." under the theme of "Practical demonstration of an IoT system that contributes to making solar power generation a sustainable main power source." In Phase B in 2018, the project conducted basic technology development and from 2019, practical application development was conducted from the results obtained in 2018.[362] In 2019, the project was also adopted by NEDO's "Research and Development Project for Early Social Implementation of AI

[358]"Yamanashi Prefecture Demonstrates 'Panel-by-Panel Monitoring' of Solar Power Generation with University of Tokyo Venture - News - Mega Solar Business : Nikkei Business Publications," Mega Solar Business, accessed May 6, 2023, https://project.nikkeibp.co.jp/ms/atcl/19/news/00001/00271/?ST=msb; Li Min, Interview with CEO of Girasol Energy.

[359]"Determination of the Implementation Structure for the FY 2008 'New Energy Technology Innovation Support Project by Venture Businesses, Etc.' | Public Offering | NEDO," accessed April 27, 2023, https://www.nedo.go.jp/koubo/CA3_100176.html.

[360]"Determination of the Implementation Structure for the FY 2008 'New Energy Technology Innovation Support Project by Venture Businesses, Etc.' | Public Offering | NEDO."

[361]"PitchBook Profile - Girasol Energy"; "Girasol Energy, a solar panel maintenance automation company, raises over 500 million yen in Series A -- from the University of Tokyo IPC and others - BRIDGE Technology & Startup Information," August 31, 2021, https://thebridge.jp/2021/08/girasol-energy-series-a-round-funding, https://thebridge.jp/2021/08/girasol-energy-series-a-round-funding.

[362]NEDO, "Technology Research and Development Project for Discovery and Commercialization of New Energy Seeds (Interim Evaluation)," https://www.nedo.go.jp/content/100924372.pdf.

Technology" under the theme of "Technological Development of AI Engine and Repowering Module Using Solar Panel Data"[363]. And in 2020, the company received tens of millions of yen in seed investment from K4 Venture, a CVC of Kansai Electric Power, and Fuyo General Lease Company, a major Japanese general leasing company[364]. In the same year, it also received an investment of approximately 30 million yen from Yamanashi Prefecture[365]. In August 2021, led by UTokyo IPC, which invested 190 million yen, along with K4 Ventures, Tokyu Corporation, 31VENTURES, a CVC of Mitsui Fudosan, and Yamanashi Chuo Bank SDGs Fund, which is jointly managed by the Yamanashi Chuo Bank and the Yamanashi Chuo Bank Management Consulting, and ANRI, Girasol Energy raised a total of over 500 million yen in Series A funding[366].

(3) Importance of Using Private and Public Funds Accordingly

Girasol provides valuable insights on the distinction between public and private funds. Li Min emphasizes the significance of utilizing these funds differently as public and private funds are distinct categories of financial resources, each with its own unique characteristics and implications, based on his personal experience.

“What makes public funds different than private funds is that they have a clear sense of purpose. The use of money is also quite strongly determined. On the other hand, with public funds, as long as you produce results, they are not involved in management's participation regarding equity, so in that sense, there is a degree of freedom on the part of management, while on the development side, you are subject to strong restrictions. In terms of private financing, at the time we were not sure how far we could go with the bank loan, and also, since the loan is debt after all, even if they said that we did not have to repay the loan, it would become the credit issue. As for the loan, I

[363]“Seven New Projects Selected for Research and Development Project for Early Social Implementation of AI Technology | Press Release | NEDO,” accessed May 6, 2023, https://www.nedo.go.jp/news/press/AA5_101115.html.
[364]“PitchBook Profile - Girasol Energy”; Li Min, Interview with CEO of Girasol Energy.
[365]“Yamanashi Prefecture Invests in University of Tokyo Startup in Renewable Energy Technology - Nihon Keizai Shimbun,” accessed May 6, 2023, https://www.nikkei.com/article/DGXMZO59459690S0A520C2L83000/.
[366]“Girasol Energy, a solar panel maintenance automation company, raises over 500 million yen in Series A -- from the University of Tokyo IPC and others - BRIDGE Technology & Startup Information”; University of Tokyo, “University of Tokyo Intellectual Property Report 2022.”

am a foreigner, so I did not know whether I would be able to get a loan so easily. As for private funding, the use of funds is relatively free. But on the other hand, it is a form of partial transfer of management rights, so I think it will have a long-term impact. I think that for tech university spin-off startups, it would be better to use both public and private in a well-balanced manner for the future."

(4) Private Capital (VC vs. CVC vs. Angel Investors)

Furthermore, Girasol Energy has successfully secured a diverse range of private funding to support its growth trajectory. The initial pre-seed stage witnessed investment from ANRI, a private venture capital, and angel investors, showcasing their confidence in the company's potential. Subsequently, the company attracted investments from corporate venture capitalists (CVCs) and provincial entities, further bolstering its financial backing. Li Min elaborates on this background, providing insights into the funding landscape.

"In our case, if we consider VC as a firm that is strongly seeking financial returns, I think it is probably true that a larger portion of the money we receive is strategic investments. The current shareholders include two VC firms, while in terms of the number of business companies (CVC), there are at least five or more. From this perspective, the reason why CVC invested in Girasol is because Girasol has a direction and vision to solve problems in the future of renewable energy in Japan, especially solar power, and is capable of creating something interesting on a continuous basis."

In addition, Girasol Energy was funded by two entrepreneurial angel investors. Matching resources was critical in receiving angel investment, and there was no substitute for support, especially from angel investors with successful entrepreneurial experience in the business[367]. In addition, they also served as Girasol's CFO for a time, and their contribution as human resources was significant.

[367]Li Min, Interview with CEO of Girasol Energy.

According to Li Min, while there was also an element of coincidence in the decision of which VC's money to accept, they resulted in a situation in which Girasol decided to proceed with ANRI, which was hands-off VC, rather than hands-on VC. He explains the situation as follows.

“We were not a luxury startup (that can have many options), so it may have been a coincidence that we ended up working with ANRI, which is a hands-off VC, rather than a hands-on VC. The relationship is a bit complicated, but while I was a graduate student at the University of Tokyo's Graduate School of Engineering (Master of Technology Management), I did summer internship at UTEC. I had been building a good relationship with one UTEC partner I met at that time for a long time. That UTEC partner is also a member of our board of directors, and in the early stages of the program, I invited him to join us, not as a board member but as a mentor. After ANRI joined, I raised the issue of forming a board of directors. At the time, CTO Ikegami was still working for the company with which he had collaborated on his doctoral thesis. On the other hand, I separately invited the mentor from UTEC and an engineer to join Girasol's management team, and we established a board of directors and began to operate the company.”

(5) Amount of VC Fundraising

As for the amount of funding, Li Min himself was a first-time entrepreneur and had to learn how to use money step by step, and he recalls that the initial millions and tens of millions of yen were suitable for that.

“It's a question of management ability, and I think the answer will depend on the caliber of the CEO, but I myself am not such a strong CEO with strong experience, so I rather had to start learning how to use the money step by step. We exactly raised funds step by step now in the order of million yen units, ten million yen units, and hundred million yen units. Thanks to that, I had not yet made a big slip (failure) at this stage, and I was able to study the world like this. At that time, if I had suddenly received several hundred million yen, I would have been in trouble”.

Also, from a technical point of view, a few million yen or tens of millions of yen would have sufficed.

“In our case, it's not just pure energy, it's energy x IT, or digital data. I myself, of course, initially planned to make a lot of IoT devices and distribute them around, but they were not an energy device itself and the plan was to make them in a relatively light manner for a few thousand yen each In that context, tens of millions of yen meant that we could make tens of thousands of units, so it was a good opportunity for us to verify our initial business.”

(6) Summary and Analysis

In this case, we can see the journey of a start-up company that has raised public and private funds- private funds are from VC, CVC, and angel investors, in a well-balanced manner. Girasol Energy is a company that has grown by successfully combining public and private funding according to its objectives. As for public funding, since they are in the energy sector, they are using a grant from NEDO, which is under METI for technology development. The fact that Girasol's business area is renewable energy, a priority policy area for the Japanese government, suggests that NEDO's public funds were easy to use, which also influenced Girasol's success in obtaining a large amount of public funds. While the use of public funds is restricted to technology development, the advantages they provide to management as non-dilutive funds are also indicated. With regard to private funding, the most notable feature is a large number of strategic investments from CVCs of electric power companies, real estate companies, and leasing companies that have business ties to renewable energy. The investments from these CVCs seek not only financial returns but also strategic synergies between the technologies developed by Girasol Energy and the business of the parent company of the CVC, providing Girasol Energy with the potential pathway for non-financial outcomes. Quaise Energy, also in the energy sector, has received a number of investments from CVCs, demonstrating the importance of seeking strategic synergies with operating companies while raising capital. While it was important for Girasol Energy to conduct a demonstration project due to the nature of its business, the fact that it found a partner in Yamanashi Prefecture at an early stage and succeeded in obtaining investment at

the same time can be read as having a positive impact on its subsequent Series A. The case study also points out the importance of the role of angel investors in terms of human resources, as was pointed out in the Kytopen case as well. In particular, angel investors who already have entrepreneurial experience are much more valuable to early-stage startups for the advice and human support they provide than for the amount of money they invest.

Throughout, there is a very clear market fit story of increasing solar power utilization given the global rapid trend of decarbonization and innovation needed to increase the renewable energy in the Japanese energy mix. Also, they started demonstration projects with the Yamanashi Prefectural Government at an early stage, which contributed to gaining trust.
Doing a demonstration project with a local government shows credibility to the market. In terms of the team, CEO Li Min has a background in technology management, and CTO Ikegami is a researcher, making for a well-balanced team. From the VC's point of view, it was suggested that Li Min raised only the necessary amount, starting with a small investment at first on a step-by-step basis and raising the necessary amount each time, which is in line with Brad Feld et al.'s point of not asking for more than the necessary amount.

7.3. PROVIGATE

(1) Founding History

PROVIGATE is a startup company founded in March 2015 to commercialize the research breakthroughs of Associate Professor Toshiya Sakata of the Department of Materials Science and Engineering, Graduate School of Engineering, The University of Tokyo [368]. Focusing on glycoalbumin (GA), PROVIGATE directs its efforts towards the development of a blood glucose monitoring service catered to individuals afflicted with diabetes and pre-diabetes[369].

[368]"The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)," accessed May 6, 2023, https://foundx.jp/interview/koshin_sekimizu/; "New tools for diabetes care from 'accidental entrepreneurs,'" UTokyo, accessed May 6, 2023, https://www.u-tokyo.ac.jp/focus/ja/features/entrepreneurs11.html.
[369]"Provigate, Inc. Dev Blood Glucose Monitoring Devices & Services," accessed May 6, 2023, https://provigate.com/en/.

The genesis of PROVIGATE traces back to the year 2012 when Associate Professor Toshiya Sakata applied for the Japan Science and Technology Agency (JST)'s "Program for Creating STart-ups from Advanced Research and Technology (START)" (project promotion type entrepreneurship demonstration support). There, with the guidance and support of the project promoter from the VC, he was aiming to start a business in the development of a tear sugar sensor[370]. Under this program, a grant of up to 30 million yen per year is provided[371]. CEO and Co-Founder Koshin Sekimizu met Associate Professor Sakata in 2014[372]. Sekimizu, an accomplished individual with a PhD in biology and extensive experience in the consultancy sector, was working for a private equity (PE) firm in Hong Kong when he serendipitously encountered the groundbreaking technology. The momentous occasion took place during his consultation session with Prof. Sakata, where he provided valuable insights on launching a tear-based glucose sensor venture. [373]. Enamored by the technology's potential, Sekimizu and Prof. Sakata joined forces, ultimately becoming co-founders of the company[374]. Their shared passion and expertise laid a solid foundation for their entrepreneurial journey. Following the establishment of the company, Sekimizu and Prof. Sakata embarked on a dedicated journey to develop a tear sugar sensor. From 2015 to 2017, they diligently pursued this goal, leveraging seed funding and series A investments from private venture capitals as well as NEDO's "R&D Startup Support Program/Commercialization Support for R&D Startups in the Seed Phase" (STS)[375].

[370]"The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)"; "Project Promotion Type - Support for Demonstration of Entrepreneurship|START | Program for the Creation of New University-Driven Industries," accessed May 6, 2023, https://www.jst.go.jp/start/.
[371]"National Science and Technology Agency, Japan Science and Technology Agency, New Industry Creation Fund for Universities Project," accessed May 6, 2023, https://www.jst.go.jp/program/startupkikin/#koubo_02.
[372]"The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)."
[373]"The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)."
[374]"New tools for diabetes care from 'accidental entrepreneurs.'"
[375]"The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)"; "New tools for diabetes care from 'accidental entrepreneurs'"; Koshin Sekimizu, Interview with CEO and founder of PROVIGATE, April 10, 2023.

(2) The Big Pivot

However, given the highly competitive nature of the blood glucose measurement market, PROVIGATE swiftly embarked on a quest for alternative biomarkers “beyond tear sugar” underwater shortly after its establishment, and one biomarker in particular caught their attention: glycoalbumin (GA).[376] GA offered a unique advantage by effectively reflecting changes in average blood glucose levels and postprandial hyperglycemia over the preceding one to two weeks , and thus it is not necessary to draw blood from a fingertip every few hours as in general blood glucose self-monitoring, but GA measurements could be conducted only using large clinical laboratories, and challenges remained in terms of making it smaller and cheaper[377]. While PROVIGATE had already secured funding from VCs, they encountered difficulty in gaining understanding from existing investors about parallel development efforts, as VCs typically advocate for ventures to concentrate resources on a single pipeline[378]. Consequently, funding for GA research and development (R&D) was secured through the aforementioned NEDO grant, prompting PROVIGATE's official pivot in December 2017[379]. Such a substantial pivot, unlike the norm in IT companies, often signifies a precarious situation for manufacturing-focused companies like PROVIGATE, which faced a prolonged period of severe funding crises[380]. Over the course of approximately a year and a half following the pivot, the company grappled with severe funding shortages[381]. However, in June 2018, PROVIGATE managed to navigate the funding shortfall by being selected in June 2018 by the Japan Agency for Medical Research and Development (AMED) for the "FY 2018 Medical Field Research Results Deployment Project/Program for Development of Advanced Measurement and Analysis Technology and Equipment”. This provided a crucial lifeline. Subsequently, the company emerged from its predicament through angel investments from alumni company managers at the University of

[376]“The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007).”
[377] “Glycoalbumin (GA) as a Potential Indicator of Weekly Average Blood Glucose Aiming to Realize Blood Glucose Control by Weekly GA Measurement for Prevention of Severe Diabetes Mellitus Provigate,” Diabetes Resource Guide, accessed May 10, 2023, https://dm-rg.net/news/e20f9802-45b2-4c16-b2be-30a179896e06.
[378]“The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007).”
[379]“The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007).”
[380]“The University of Tokyo FoundX | PROVIGATE Corporation Mr. Koshin Sekimizu (Ph.D. 2007)”; “New tools for diabetes care from ‘accidental entrepreneurs.’”
[381]Koshin Sekimizu, Interview with CEO and founder of PROVIGATE.

Tokyo, whom they fortuitously encountered through the FoundX startup support program for graduates of the University of Tokyo, and an investment from the "Industry-Academia Collaborative Agreement " that Daikin Industries, Ltd. has with the University of Tokyo[382].

(3) Fundraising after Overcoming the Financial Crisis

Subsequently, in October 2019, PROVIGATE achieved another milestone by being selected for NEDO's "Research and Development Venture Support Project / Commercialization Support for Startups in Cooperation with Companies" (SCA). Building on this progress, the company successfully secured a total of 370 million yen in funding in April 2020. ANRI, Coral Capital, JST, and angel investors contributed to this funding round, elevating the total equity funding raised since the company's inception to 840 million yen[383]. The company's funding journey continued in August 2020 when it was selected for NEDO's "Product Commercialization Alliance (PCA)," and in July 2021, it was selected for AMED's "Fiscal 2021 Project for Strengthening Advanced R&D and Development Systems in Medical Devices, etc.: Development of Health". In September 2021, Sparx Group, ANRI, and Coral Capital invested 910 million yen, and in January 2022, Toyoda Gosei's CVC invested another 100 million yen, bringing the total amount of equity financing since its founding to 1.85 billion yen.

Behind the success of PROVIGATE's pivot, a pivotal factor was the successful recruitment of Narifumi Ito, a highly skilled biosensor engineer, as Chief Technology Officer (CTO)[384]. Given the scarcity of biosensor engineers globally, CEO Sekimizu meticulously reviewed pertinent literature and patent information to identify and ultimately hire Ito, who had been instrumental in the development of a urine glucose meter at Tanita, a renowned Japanese medical device

[382]"New tools for diabetes care from 'accidental entrepreneurs.'"
[383]"Daikin, ANRI, Coral Capital, JST, and angel investors raised a total of 370 million yen. This brings the total amount of equity financing since the company's founding to 840 million yen. | Provigate, Inc.," April 8, 2020, https://provigate.com/news/a-total-of-jpy-370-million-was-raised-from-daikin-anri-coral-capital-jst-and-angel-investors-this-brings-the-total-amount-of-equity-funding-raised-since-the-companys-foundation-to-jpy-840-million/.
[384]"Deep Tech Provigate Pivots to the World with a Rise and Fall," INITIAL, accessed May 6, 2023, https://initial.inc/articles/briefing43.

company[385]. With Ito's wealth of experience in medical device development, mass production, and sales expansion, he became a catalyst for attracting other talented individuals to join the team[386]. As a result, PROVIGATE seamlessly transitioned into smooth research and development operations following the pivotal moment[387].

While PROVIGATE encountered challenges in securing funds, CEO Sekimizu emphasized the significance of public funding, especially in the deep-tech sector, as the amount of private VC funding for startups in Japan reached only 800 billion yen in 2022[388]. He states that public funding is "still very important in terms of initial funding, especially in the deep-tech area"[389] . The company has received grants from organizations such as AMED, JST, NEDO, and the Tokyo Metropolitan Government, which have played a pivotal role in their progress.

(4) Summary and Analysis

The PROVIGATE case, similar to the Kytopen case discussed in the MIT case study, is a case of a major pivot in the early stages of its founding. Both were successful in the pivot itself, but PROVIGATE struggled with fundraising in the wake of the pivot. This implies the difficulty of gaining understanding and support from existing investors in the deep tech sector, as the pivot not only changes the business plan but also affects the timing of the company's exit strategy. Due in part to its background of overcoming its fundraising struggles, PROVIGATE extensively utilized a wide range of grants from various ministries. This indicates that grants are dispersed across multiple government entities, necessitating careful identification of available grants for each phase of technology development. It is worth noting that PROVIGATE has continued to leverage NEDO funds for research in the areas where it pivoted. This demonstrates the adaptability and flexibility of public funding in supporting technological advancements.

[385]"Deep Tech Provigate Pivots to the World with a Rise and Fall."
[386]"Deep Tech Provigate Pivots to the World with a Rise and Fall."
[387]"Deep Tech Provigate Pivots to the World with a Rise and Fall."
[388]"Domestic Startups Raise Over 800 Billion Yen, Looking Back with Investors, Investment Trends for 2021," DIAMOND SIGNAL, April 28, 2023, https://signal.diamond.jp/articles/-/989; Koshin Sekimizu, Interview with CEO and founder of PROVIGATE.
[389]"Domestic Startups Raise Over 800 Billion Yen, Looking Back with Investors, Investment Trends for 2021"; Koshin Sekimizu, Interview with CEO and founder of PROVIGATE.

Furthermore, this case underscores the importance of angel investors in fundraising, as their investment played a crucial role in helping PROVIGATE overcome financial challenges. Additionally, similar to Quaise Energy, PROVIGATE was founded by successfully matching industry talent from outside the laboratory to assume a leadership position, rather than having a person from within the lab become the CEO. Sekimizu's background, with a PhD in biology, research understanding, and experience in the financial and healthcare industries through consulting and private equity, similar background with that of Quaise Energy's CEO.
Moreover, the strategic recruitment of CTO Ito, an accomplished engineer identified through careful review of his dissertation, has contributed to the formation of a highly competent team. These efforts have been instrumental in PROVIGATE's team-building success.

Moreover, the strategic recruitment of CTO Ito, an accomplished engineer identified through careful review of his dissertation, has contributed to the formation of a highly competent team. These efforts have been instrumental in PROVIGATE's team-building success.

7.4. Urban X Technologies

(1) Founding History

Urban X Technologies, founded in April 2020, utilizes artificial intelligence (AI) to analyze image data captured by smartphones and drive recorders, thereby enhancing the efficiency of road inspections. [390]. The company's inception was made possible by leveraging the research findings of Hiroya Maeda, CEO and Founder of Urban X Technologies, at Yoshihide Sekimoto's lab at the Institute of Industrial Science, University of Tokyo. Maeda, after completing his master's degree at the University of Tokyo, embarked on a full-time position at a large corporation while concurrently pursuing research at Sekimoto Lab on a part-time basis. During the process of gathering information to embark on his entrepreneurial journey, Maeda discovered the

[390]"Aiming to Solve Aging Infrastructure by Building Digital Twins and Utilizing AI, Driving next-Generation Urban Development Urban X Technologies Co., Ltd.," *UTokyo IPC* (blog), accessed April 27, 2023, https://www.utokyo-ipc.co.jp/story/urbanx/.

University of Tokyo's Industry-University Collaboration webpage and learned about UTokyo IPC. Through direct communication with the CEO of Mantra, a startup that had already been selected for the UTokyo IPC's 1st Round, Maeda received a recommendation for the program, acknowledging its merits. Subsequently, he applied to the UTokyo IPC's 1st Round and was accepted in January 2020[391] . Building upon his thesis, patent, and prototype, Maeda founded Urban X Technologies in April 2020, establishing a solid foundation for the company's operations[392].

(2) Initial Fundraising from VCs

Hiroya Maeda was chosen as an individual participant in the Information-technology Promotion Agency Exploratory Project, organized by METI[393] This opportunity further propelled Urban X Technologies' progress, and in October of the same year, the company initiated a demonstration experiment with Mitsui Sumitomo Insurance, marking a significant milestone[394].

Additionally, Urban X Technologies successfully raised 80 million yen in a seed round held in October 2020[395]. The investment was led by UTokyo IPC, with ANRI also participating[396]. This funding round provided the company with the opportunity to select the most suitable venture capital firm to receive investment. Ultimately, CEO Maeda's decision was influenced by the large size of the fund and its extended time horizon of 15 years. He also valued the trust and rapport built with UTokyo IPC since their participation in the 1st Round accelerator program. Considering the early stage of their startup, Maeda took into account the risk of premature exit demands that could arise from a short-term fund.

[391]"Aiming to Solve Aging Infrastructure by Building Digital Twins and Utilizing AI, Driving next-Generation Urban Development Urban X Technologies Co., Ltd."
[392]Hiroya Maeda, Interview with CEO of Urban X Technologies, April 25, 2023.
[393]Nikkei, "Urban-X Technologies and Mitsui Sumitomo Insurance Begin Demonstration Experiment to Support Social Infrastructure Maintenance," October 27, 2020, https://www.nikkei.com/article/DGXLRSP542344_X21C20A0000000/.
[394]Nikkei.
[395]"Notice of Fund Raising," *UrbanX Technologies* (blog), October 3, 2022, https://urbanx-tech.com/news/385.
[396]"Notice of Fund Raising."

At that stage, they were developing the product with 4-5 engineers only, and to strengthen their business operations, Urban X Technologies hired a Chief Operating Officer (COO) with a business background in April 2021[397]. The process of identifying suitable candidates for the COO role was facilitated through referrals from UTokyo IPC and ANRI. Subsequently, in September, the company was selected for the "Urban Innovation Toyonaka" public-private collaborative project, forging a partnership with the local government. In December 2021, they commenced commercial service under the name "DRA RECO (Drive Recorder) Road Manager.",[398].

Continuing their growth trajectory, Urban X Technologies secured additional funding of 400 million yen in 2022[399]. UTokyo IPC and Mitsui Sumitomo Insurance Capital were among the investors, with ANRI leading the investment. Reflecting on the previous fundraising rounds, especially the seed round, Maeda recalled that investors placed significant emphasis on evaluating him as CEO and the overall team, rather than solely focusing on the technology or business strategy while he emphasized that in the subsequent fundraising stages, the evaluation focus would primarily shift towards the business itself.

Concurrently, in August 2022, the company secured public funds through its selection for the NEDO STS "R&D Startup Support Project / Commercialization Support for R&D Startups in Seed Phase." These grants were primarily designated for technology development purposes and could not be utilized for business-related expenses[400].

(3) Summary and Analysis

In this particular case, Urban X Technologies achieved the objective of selecting the lead venture capital from a pool of multiple VCs, aligning with the funding goals outlined by Brad Feld et al. This case offers valuable insights into the criteria that entrepreneurs can consider when determining which VC's capital to accept, such as the time horizon. Specifically, a short fund duration carries the risk of premature exit demands. Furthermore, the case highlights the

[397]Hiroya Maeda, Interview with CEO of Urban X Technologies.
[398]"NEWS," *UrbanX Technologies* (blog), accessed April 27, 2023, https://urbanx-tech.com/news.
[399]"NEWS."
[400]"NEWS."

significance of VCs assessing the management team as a crucial factor in seed funding decisions during the early stages of a startup. It should be noted that the relative importance of these decision-making factors may vary at different stages of funding, with a higher emphasis on the business during Series A funding rounds.

Regarding the team, it is noteworthy that Urban X Technologies proactively hired a Chief Operating Officer (COO) early in the startup's initial phases, emphasizing the significance of building a strong team from the outset. Additionally, the company's product market fit story is indicated as compelling right from its inception. The application of AI and IT technology to streamline road inspections, which were traditionally conducted manually, resonated well with stakeholders. Early on, the company engaged in demonstration tests with insurance companies swiftly transformed those insights into marketable products and started selling, demonstrating promising growth potential and profitability at an early stage.

One thing to note about this case study is that although Urban X Technologies operates in the realm of AI and IT technologies, the development process entails relatively lower costs, like you can develop it almost only with PCs, and time requirements compared to fields like biotechnology and energy. This is why the products can be marketed at a fairly early stage. Therefore, it is crucial to pay attention to this distinguishing characteristic. It is generally more challenging for deep tech startups in fields such as biotechnology, energy, and space to demonstrate early growth and profit potential.

7.5. ORLIB

(1) Founding History

ORLIB, a startup focused on high-energy rechargeable batteries and related technologies, was established in May 2020. It has experienced growth by leveraging a combination of public funding and contracted technology development projects, without relying on private investments. ORLIB develops a rechargeable battery with the potential to significantly increase the operating

duration of existing lithium-ion batteries and other battery types by approximately 1.7 times. For example, for commercial purpose, the current primary objective is to extend the flight time of small drones and various vehicles, particularly for applications such as infrastructure inspections. Moreover, their goal is to develop lithium batteries that do not use critical minerals like nickel, cobalt, manganese, and others.

In 2017, Sato, along with Professor Hiroshi Nishihara from the Graduate School of Science at the University of Tokyo, applied for the Japan Science and Technology Agency's (JST) Project Promotion Type Entrepreneurship Demonstration Support program, known as START. This collaborative project spanned from October 2017 to March 2020. START is a program designed to foster the establishment of startups and provides a grant of approximately 30 million yen per year. Leveraging their patents, Sato and Nishihara utilized the support from the START program to advance their commercialization efforts.

The CEO and Co-Founder of ORLIB, Masaharu Sato, brings approximately 20 years of experience in the lithium-ion battery industry from his tenure at a private company's research institute. In 2017, Sato, along with Professor Hiroshi Nishihara from the Graduate School of Science at the University of Tokyo, applied for the Japan Science and Technology Agency's (JST) Project Promotion Type Entrepreneurship Demonstration Support program, known as START[401] This collaborative project spanned from October 2017 to March 2020. START is a program designed to foster the establishment of startups and provides a grant of approximately 30 million yen per year. Leveraging their patents, Sato and Nishihara utilized the support from the START program to advance their commercialization efforts[402]. During this program, the team received support from a management consultancy that acted as a business promoter. The company initially had its headquarters at the Entrepreneur Lab of the University of Tokyo and a laboratory located at the National Museum of Emerging Science and Innovation (Miraikan). The laboratory at Miraikan

[401]UTokyo IPC, "Development of new materials to realize a sustainable and prosperous society with an eye toward the practical application of safe and inexpensive high-energy rechargeable batteries," *UTokyo IPC* (blog), accessed May 6, 2023, https://www.utokyo-ipc.co.jp/story/orlib/; "Project Promotion Type - Support for Demonstration of Entrepreneurship|START | Program for the Creation of New University-Driven Industries."
[402]Masaharu Sato, Interview with CEO and co-founder of ORLIB, April 7, 2023.

was accessible free of charge, with the exception of utilities, under specific conditions. Following the completion of the project, ORLIB occupied this laboratory space for a duration of two years[403]. Subsequently, with the assistance of the UTokyo IPC, the company relocated its laboratory to the Yokohama Hardtech Hub in April 2022[404]. This co-creation space, established by Mitsubishi Heavy Industries in the Honmoku district of Yokohama, provided a conducive environment for ORLIB's ongoing activities. It is currently operated by seven people, mostly researchers.

(2) Accelerator Programs and Public Grants

The establishment of ORLIB in 2020 opened doors for the company to apply to and participate in various accelerator programs, and their applications were mostly accepted. Through these programs, ORLIB secured funding and support, including 3 million yen from HAX TOKYO, a hardware accelerator originally from Silicon Valley in the U.S., and 3 million yen from the Mitsubishi UFJ Technology Development Foundation's R&D grant program. IN addition to fundings, they received assistance such as business plan revisions. The U Tokyo IPC's "1st Round" in 2020 provided further support with 500,000 yen and training on business plan formulation,[405]. Concurrently, ORLIB obtained a grant from the NEDO R&D Start-up Support Program (NEP) for "Development of High Energy Battery Technology for Large Drones by Continuous Electrolysis Pre-Doping Technology". This grant awarded them 30 million yen for the period from October 2020 to September 2021. While these accelerator programs proved valuable, a challenge arose when the operating capitals began to deplete before the programs' completion[406]. To secure additional funding, ORLIB engaged in fundraising with various VCs and participated in pitch events. However, they encountered difficulties in finding lead investors. Some VCs pointed out that their expected sales were relatively small. Fundraising and pitching required them to

[403]Masaharu Sato.
[404]UTokyo IPC, "Development of new materials to realize a sustainable and prosperous society with an eye toward the practical application of safe and inexpensive high-energy rechargeable batteries."
[405]Masaharu Sato, Interview with CEO and co-founder of ORLIB; UTokyo IPC, "Development of new materials to realize a sustainable and prosperous society with an eye toward the practical application of safe and inexpensive high-energy rechargeable batteries."
[406]Masaharu Sato, Interview with CEO and co-founder of ORLIB.

emphasize their story and talk big, which they found difficult. Consequently, ORLIB decided to shift its strategy and pursue growth through contracted technology development projects and government commissions and grants. In 2021, the company was selected for the “NEDO Technology R&D Project for Discovery and Commercialization of Seeds of New Energy, etc.”, Phase B "Technological Development of High Energy Battery for Large Drones by Continuous Electrolytic Predoping Technology" from October 2021 to September 2022[407]. Moreover, ORLIB was also adopted by NEDO for Phase C, a technology research and development project aimed at discovering and commercializing seeds of new energy sources, focusing on "Technological Development of High Energy Battery for Large Drones by Continuous Electrolytic Pre-Doping Technology," , which will take place from December 2022 to November 2024. Furthermore, in 2023, ORLIB became part of a consortium led by Softbank, a leading Japanese telecommunications company, as a new research project under the Defense Equipment Agency's "Security Technology Research Promotion Program" for the fiscal year 2022.

Currently, ORLIB is involved in battery development while undertaking projects commissioned by both the private sector and the national government. For instance, the company analyzes the internal workings of imported batteries when a burnt smell emanates from them, as contract services to the private sector. While this diversification may slow down the development of their core technology, CEO Sato acknowledges its significance in ensuring the company's financial sustainability.

(3) Summary and Analysis

This case exemplifies the rigors of the path associated with securing private funding from accelerator programs. It presents an alternative approach when private funding proves difficult to obtain: pursuing contracted projects and leveraging public funds. In other words, the strategy involves conducting research and development while generating operational cash flow through contracted projects and accessing public funding. Regarding public grants, PROVIGATE also utilized a public grant when they struggled with getting private funding. While this approach

[407]Masaharu Sato.

ensures financial stability, it also introduces a trade-off by potentially slowing down the pace of technological advancement due to parallel business activities.

ORLIB has demonstrated success in securing public funds since its establishment in 2020. This testifies, among other things, ORLIB's technical capabilities and technological possibilities that ORLIB is developing. This suggests the potential for future private fundraising given its relatively short operating history of about three years. However, ORLIB acknowledges the challenges associated with private financing. Their commercial product focuses on developing batteries for small drones primarily used in infrastructure inspections. It is worth considering that the product's market fit may be weak, given concerns raised by venture capitalists regarding the small projected revenue. Also, the 1.7 times increase in drone flight time, which may not be compelling enough for infrastructure inspection businesses. Consequently, while the battery industry itself offers a vast market, there is a possibility that the market for this specific use case remains limited. Regarding the team composition, since the core members are primarily researchers, augmenting the team with a business-oriented member could contribute to a more balanced skill set.

7.6. Z2One

(1) Founding History

Z2One, founded in 2016 by Hiromichi Tsuji, a former PhD student at the University of Tokyo, is an AI-based software startup. Tsuji's entrepreneurial journey began by filing patent applications in Japan, the US, and Europe and securing licensing agreements for the research outcomes through TLO[408]. In contrast to startups that rely on venture capital investments, Z2One has pursued a steady growth trajectory using its own capital, supplemented by loans from banks and revenues generated from a technology development consulting business. In 2016, Tsuji established Z2One and set up its operations in the University of Tokyo's Entrepreneur Plaza, an incubation facility. At that time, Tsuji's vision involved refining the technology and business plan

[408]Hiromichi Tsuji, Interview with CEO and founder of Z2One, April 19, 2023.

during the early stages and subsequently pursuing rapid expansion through investment opportunities[409].

(2) Change of Route from the Original Plan

However, during the initial stages of Z2One's journey, he encountered challenges in the progression of his technological development, which did not meet his initial expectations[410]. Concurrently, he invested two years engaging in extensive interviews with potential customer companies to determine the key factors that would motivate them to purchase Z2One's product. By the end of the second year, the company faced financial difficulties, and in the third year, the urgency to generate revenue became critical. Although the possibility of securing investment existed if they could establish a viable business, immediate prospects for achieving this goal remained uncertain.

Furthermore, Z2One operates in the business-to-business sector, catering to large corporations as their primary customer base. As a result, they faced fierce competition in a market where numerous competitors already existed. Even if Z2One's product surpassed existing offerings in terms of quality, the company struggled to establish the necessary level of trust with potential customers and lacked a clear path to enter established markets, as indicated by their market research interviews.

Consequently, Z2One opted to change its strategic approach. Instead of pursuing rapid expansion through investment, it shifted its focus towards undertaking technical development contracts and consulting services for Japanese automobile companies, construction machinery manufacturers, and home appliance manufacturers. By generating operating capital through consulting engagements, Z2One not only secured financial stability but also gained the trust and credibility necessary to thrive in their industry. They also leveraged the knowledge acquired through consulting to enhance their software development capabilities. As a result, Z2One has

[409]Hiromichi Tsuji.
[410]Hiromichi Tsuji.

now entered its seventh year of operation, maintaining a lean team of fewer than five members at any given time. Remarkably, they achieved profitability in their fourth year. Through continuous technology accumulation facilitated by consulting projects and integration into their software, Z2One has finally reached the significant milestone of releasing their software this year[411].

(3) Choosing not to Raise Private Financing in the Early Years

Tsuji has more than 10 years of experience at Nissan Motor Co. and also has business experience as a researcher[412]. He said that he was originally a bit cautious about accepting investments at the time of establishment, although he engaged in information exchanges with VCs. He witnessed instances where startups failed due to easily accepting investments and relinquishing significant management control for minimal financial support.

Particularly, Tsuji highlighted the risk of small investments, such as a mere 5 million yen, quickly dissipating without substantial progress in establishing or projecting the future establishment of the business. Consequently, securing subsequent rounds of investment would become challenging, rendering the initial investment essentially futile.

Moreover, in the company's third year of operation, Z2One received an acquisition offer from a foreign company. However, Tsuji decided to decline the offer, partially due to his perception that the acquirer's intent was primarily to acquire the entirety of the company's technology and human resources for developing a new business in Japan. Tsuji believed that this approach did not align with Z2One's long-term vision and strategic goals.

Conversely, Z2One achieved success in securing public funds from local governments. In 2021, they received a partial subsidy amounting to 12 million yen for new product and technology development from the Tokyo Metropolitan Government. Additionally, the company obtained a

[411]Hiromichi Tsuji.
[412]Hiromichi Tsuji.

local government subsidy of 1 million yen from Bunkyo Ward specifically designated for technological development initiatives[413].

(4) Decision to Revoke Patents

While Z2One has been dedicated to software development since 2016, the company faced the challenge of the high cost of maintaining patents (approximately 3 million yen per year in Japan, the U.S., and Europe) compared to the period of software development and the period of earning returns from sales[414]. Consequently, Z2One made the strategic decision to relinquish their patents. Several factors contributed to this choice. First, the software development process involved a small team without significant personnel turnover, ensuring minimal risk of technology leakage, which diminished the necessity for patent protection. Second, the landscape of the industry witnessed a shift towards open-sourcing codes, exemplified by initiatives like Open AI and H2O, which influenced Z2One's perception of the diminishing technical significance of patents in the field. Tsuji noted that while patents could still serve as valuable decision-making tools for investors and customers, their relevance in terms of technical importance was gradually diminishing[415].

(5) Summary and Analysis

This case study serves as an additional testament to the inherent risks associated with early-stage start-ups when it comes to seeking private funding, mirroring the findings from the VulcanForms case study. Z2One's approach during its early years, particularly the first two years, shares similarities with VulcanForms, as observed in the MIT case study. Both companies adopted a strategy of using their own capital to develop the technology to a certain extent before seeking external investment. While VulcanForms and Z2One diverged in their subsequent funding paths, VMS rightly points out that the necessity of seeking funding in the early stages must be carefully evaluated. Possessing a solid technological foundation and identifying potential clients are key prerequisites for initiating the funding process.

[413]Hiromichi Tsuji.
[414]Hiromichi Tsuji.
[415]Hiromichi Tsuji.

Furthermore, this case underscores the significance of engaging in interviews with potential customers. It exemplifies how comprehending customer needs through interviews and consulting endeavors led to the development of a product that effectively addressed those needs. Although the University of Tokyo lacks a program akin to MIT I-Corps, this analogous efforts can be viewed as an indication that a program like MIT I-Corps is also valuable in the Japanese context.

Additionally, this case study reveals that Z2One altered its course due to an inability to gain customer trust and confidence in the viability of transitioning from existing products to their own offerings. During the initial two years of research, Tsuji's analysis of the situation indicated that, given the company's business-to-business nature, it was challenging to persuade customers to switch to their own products without establishing a foundation of trust. Consequently, even if Z2One's product outperformed existing alternatives, customers could still opt to continue using the familiar options, which presented a less-than-compelling proposition for proceeding.

This thoughtful self-analysis enabled the company to pivot, gradually accumulating trust and knowledge, completing software development, and charting a path towards sales. This case study exemplifies an alternative approach when initial assumptions deviate from expectations.

Moreover, the strategy of methodically advancing technology development while generating operational revenue through contracting and consulting is shared by ORLIB, underscoring that this approach offers one way of avoiding reliance on venture capital and other funding sources.

7.7. ReverSASP Therapeutics

(1) Founding History

ReverSASP Therapeutics is a bio-venture founded in 2022 by Makoto Ohori and Takashi Futami, two venture capitalists of UTokyo IPC and Fast Track Initiative, to create innovative new drugs

for various aging-related diseases based on the aging biology research by Prof. Makoto Nakanishi at Institute of Medical Science, The University of Tokyo[416]. It is imperative to acknowledge that due to the stealth nature of this startup, the extent of information that can be divulged is restricted. Consequently, this case study was crafted by drawing upon interviews and publicly accessible data, considering the aforementioned circumstances.

(2) Speedy Fundraising from VCs

Regarding funding, ReverSASP Therapeutics achieved a significant milestone in April 2022 when it was chosen to participate in the 1st Round of UTokyo IPC's accelerator program. This granted them free access to invaluable guidance from seasoned professionals, including laborers and lawyers, along with millions of yen in funding with no strings attached and non-dilutive funds[417]. According to Ohori, a partner of UTokyo IPC, the pass rate for the subsequent round of investment for startups that progress past the 1st Round reaches almost 90%, so being selected for the 1st Round was a significant factor for them. The funding received undeniably proved advantageous; however, the invaluable support provided by the program's expert professionals including lawyers emerged as an even more significant asset in establishing the company[418]. Three months later, in July, UTokyo IPC and Fast Track Initiative assumed the roles of co-lead investors, collectively contributing a pre-seed investment totaling 600 million yen.[419] The company's decision as a science-based enterprise to exclusively negotiate with the above two venture capital firms at the pre-seed stage was because they possessed a profound understanding of the scientific intricacies, according to Ohori[420]. As of April 2023, ReverSASP Therapeutics had already recruited two scientists who are leading the charge in technological advancement and development within the company's ranks[421].

[416]Fast Track Initiative Co., Ltd., "Invested in establishment of reverSASP Therapeutics, which is working on drug discovery based on new elucidation of aging biology," July 7, 2022, https://www.fti-jp.com/blog/2022/07/07/post-1062/; UTokyoIPC, "Invests in reverSASP Therapeutics, Inc.," *UTokyo IPC* (blog), July 7, 2022, https://www.utokyo-ipc.co.jp/2022/07/reversasp-therapeutics/.
[417]Makoto Ohori, Interview with Co-Founder of ReverSASP Therapeutics, April 26, 2023.
[418]Makoto Ohori.
[419]UTokyoIPC, "Invests in reverSASP Therapeutics, Inc."
[420]Makoto Ohori, Interview with Co-Founder of ReverSASP Therapeutics.
[421]Makoto Ohori.

(3) Summary and Analysis

In this case, we observe the establishment of businesses by venture capitalists who successfully secured funding from their respective VC firms; MIT spinoff Quaise Energy is a similar example, as its CEO previously worked for The Engine before starting his own company, and subsequently received funding from The Engine. Another illustrative example can be found in VEDANTA BIOSCIENCES, a Cambridge-based life science startup founded by the VC which leverages intellectual property sourced from the University of Tokyo [422]. It is worth noting that they achieved a remarkably swift attainment of pre-seed funding, a mere three months subsequent to their participation in the 1st Round, for example to compared to the case of Urban X Technologies. When a VC member takes the initiative to establish a company, it is it is reasonable to assume that they possess familiarity with VC operations and have cultivated a relationship of trust with the enrolled VCs from the outset. Consequently, in the presence of a robust technology and a compelling product-market fit, it can be inferred that the venture capitalist side expedites its evaluation of the team, thus leading to a more streamlined and expeditious fundraising process.

7.8. Conclusion on How UTokyo Spin-off Startups Made Fundraising Choices

(1) Implications from the Short Case Studies

The implications derived from the aforementioned six case studies can be summarized as follows: Firstly, it is important for startups to actively seek investment offers from multiple VCs. This notion was emphasized in the MIT case study, and UrbanX Technologies reiterated the significance of diversifying funding sources.

[422]"What is the flow of commercializing 'new technology from the University of Tokyo'?," CNET Japan, March 24, 2023, https://japan.cnet.com/article/35201221/.

Secondly, the significance of UTokyo and VCs offering or introducing laboratory and office facilities was highlighted by Girasol and ORLIB. This underscores the importance of such resources in supporting startup growth and development.

Thirdly, investment from angel investors brings the advantage of not only financial support but also valuable human expertise. As exemplified by the case of Girasol, many angel investors possess more time and extensive experience than VCs, so they can provide business advice and even assume roles such as Chief Financial Officer. This human resource contribution is of significant value alongside financial backing. While certain cases, like Provigate, emphasize substantial financial contributions, the human support aspect still remains significant.

Fourthly, the importance of leveraging university support programs commencing a business endeavor became evident. Girasol, Urban X Technologies, ORLIB, and ReverSASP Therapeutics participated in UTokyo's 1st Round accelerator program, where they received guidance from legal experts and other professionals on starting a business.

Lastly, potentially strong management and a cohesive team play a crucial role in securing capital from VCs, particularly for seed-stage companies This emphasizes the significance of demonstrating strong leadership skills and assembling a skilled and motivated team to instill confidence and attract support from VCs.

(2) Use of Public and Private Funds

Girasol Energy and Provigate strategically leverage a combination of both public and private funds, while ORLIB relies on public funds and Urban X Technologies and ReverSASP Therapeutics rely on private funds. In particular, both Provigate and ORLIB make effective use of JST's START program prior to initiating their entrepreneurial ventures. This SBIR program offers grants that facilitate research and development (R&D) activities, as well as commercialization support with the premise of launching a business. Following the establishment of their respective enterprises, Girasol Energy, Provigate, and ORLIB successfully secure and utilize SBIR grants for startup support from NEDO, respectively. In addition to the SBIR, some of them also utilized technology

development grants. Provigate and ORLIB also benefited from grants from AMED and the Defense Acquisition Agency, respectively.

The funding sources of the six UTokyo spin-off startups and the corresponding services provided by UTokyo are listed in the Table presented below.

Table 7.1 Summary of UTokyo Spin-off Startups Short Case Studies

Company		GIRASOL ENERGY	Provigate	Urban X Technologies	ORLIB	Z2one	ReverSASP Therapeutics
Founded Year		2017	2015	2020	2020	2016	2022
Industry		Energy	Biotech & Life Sciences	AI/Software	Energy	AI/Software	Biotech & Life Sciences
Interviewee		CEO and Co-Founder/ CFO	CEO and Co-Founder	CEO and Founder	CEO and Co-Founder	CEO and Founder	Board Member and Co-Founder
UTokyo IPC		✓		✓			✓
VC		✓	✓	✓			
CVC		✓	✓	✓			
Angel Funding		✓	✓				
Accelerator Program		✓		✓	✓		✓
Grant	JST(MEXT)		✓(START)		✓(START)		
	NEDO(METI)	✓(NEP and others)	✓(STS,SCA, PCA)		✓(NEP)		
	AMED(MHLW)		✓				
	ATLA (MOD)				✓		
	Others		Tokyo Metropolitan City		HAX TOKYO, IPA Mito PJT	Tokyo Metropolitan city/Bunkyo-ku	
Other financial service						Bank Loan	
Contract work					✓	✓	
UT Entreprenership Plaza		✓	✓	✓	✓	✓	
Other UT Service		*CEO and Founder did summer internship at UTEC *A partner from UTEC was an advisor for the company *UTokyo IPC 1st Round			*UTokyo IPC 1st Round		*UTokyo IPC 1st Round

8. Discussion

In the preceding chapters, we provided an overview of the ecosystem associated with each university and venture capital related to the creation of university spin-off startups in the deep tech field. Specifically, we focused on MIT in the United States, the University of Tokyo in Japan, and three private universities. Building upon this overview, we conducted brief case studies on the funding journeys of spin-off startups originating from each university. We highlighted key findings respectively.

In this chapter, we extract insights from the aforementioned findings to examine the success factors related to university-related VCs, university spin-off startups, and the overall university ecosystems involved in the creation of deep tech ventures. Firstly, in Section 8.1., we analyze university-related VCs in both Japan and the United States to gain a deeper understanding of the strategies that contribute to their success. Subsequently, Section 8.2. explores insights derived from case studies of university spin-off startups, focusing on specific solutions and factors that address the funding gap and the "valley of death" entrepreneurs encounter during the commercialization of their research.

Conversely, Section 8.3. examines the ecosystem aspect. Drawing from the case studies of university VCs and startups, as well as a comparative analysis of the ecosystems at MIT and the University of Tokyo, we seek to identify key considerations for establishing and cultivating a university ecosystem that promotes the successful launch of ventures in Japan.

8.1. Analysis of University-Related VCs

In this study, we provide an overview of the objectives of their establishment, and investment policies of university-related venture capital (VC) entities, including The Engine (for MIT), UTEC and UTokyo IPC (for the University of Tokyo), WERU (for Waseda University), Keio Innovation

Initiative (for Keio University), and TUSIC (for Tokyo University of Science). We extract several key elements necessary for the establishment and operation of university-related VCs.

First, we discuss the roles and objectives of university-related VCs.

(1) Role and Purpose of University-related VCs

Commercializing research outcomes in research universities often poses challenges due to the significant funding and time required for development, making it difficult for private funds to invest in the early stages that involve high levels of uncertainty. Public funds have historically been utilized to support the development of deep tech technologies and early-stage deep tech startups. However, these public funds did not always fully bridge the financial gap due to usage restrictions, cost-sharing schemes, and prepayment requirements. The research done by MIT also found that "finding the sustained support to develop complex Tough Tech (Deep-Tech) ideas was nearly impossible". The Engine was founded to address this identified challenge. Similarly, UTEC in Japan was founded with the aim of actively promoting the dissemination of excellent research outcomes and talent from the University of Tokyo. The Engine predominantly invests in startups based on technologies from research universities such as MIT and Harvard. UTEC has also invested in startups based on technologies from various universities and research institutions, resulting in successful examples like PeptiDream, indicating its role in bridging the funding gap. Therefore, university-related VCs play a significant role in overcoming the financial gap faced by deep tech startups in their early stages.

Secondly, our analysis reveals that university-related VCs play a substantial role not only in funding but also as accelerators. The Engine provides access to labs, offices, and hands-on support with a public mission. Japanese university VCs, including UTEC, have a basic policy of providing hands-on support such as business development. These initiatives enable startups to utilize the funds invested by VCs more efficiently and experience accelerated growth. Thus, another role of university VCs is acting as accelerators.

Furthermore, our findings indicate a strong correlation between the role of university-related venture capital (VC) entities and their original founding purposes.

There are differences among VCs regarding whether they support startups outside the deep tech field that emerged from university entrepreneurial education. The Engine exclusively invests in deep tech ventures based on its founding purpose. Conversely, UTokyo IPC and WERU explicitly consider startups emerging from entrepreneurial education as their targets. Therefore, this aspect is likely determined by the purpose for which university-related VCs are established.

Lastly, the increasing number of university-launched startups in institutions like the University of Tokyo suggests a significant role of university-related VCs in providing a successful example to aspiring entrepreneurs in developing innovative technologies. Although quantitative data and exits from The Engine's portfolio companies are yet to be observed, the substantial investment in many MIT-spawned startups indicates The Engine's influential role in producing role models.

Next, a study of MIT and Japanese university-related VC shows that several common characteristics make VC successful.

(2) Close Collaboration between a University and a VC

While there are minor variations in terms of capital connections with universities and government funding among these six venture capital firms, they all share a common feature: close collaboration with university Technology Licensing Offices (TLOs) and industry-academia collaboration headquarters, enabling them to access technological innovations through these entities. Prof. Shigeo Kagami, who led the creation of a university spin-off startup ecosystem at the University of Tokyo for nearly two decades, also points out that the University of Tokyo has been the top runner in Japan in the creation of university spin-off startups because it has incorporated TLO and UTEC into its overall organizational structure since the early stages of the incorporation of national universities in 2004[423]. Moreover, many university-related VCs actively engage in entrepreneurship education within their respective universities and also serve as

[423] *Hitotsubashi Business Review 2021 Win.Vol. 69, No. 3 - The Future Changed by Startups*.

incubators. In terms of physical presence, VCs strategically position their offices in close proximity to universities. UTEC and UTokyo IPC, for instance, are located at the University of Tokyo, while TUSIC operates from the Tokyo University of Science. The Engine, WERU, and Keio Innovation Initiative are not situated on campus, but they have offices within walking distance of the university.

While there are minor variations in terms of capital connections with universities and government funding among these six venture capital firms (VCs), they all share a common feature: close collaboration with university Technology Licensing Offices (TLOs) and industry-academia collaboration headquarters, enabling them to access technological innovations through these entities. Professor Shigeo Kagami, who has played a leading role in fostering the university spin-off startup ecosystem at the University of Tokyo for nearly two decades, highlights that the university has been at the forefront of university spin-off startup creation in Japan, which is partly attributed to the integration of TLO and UTEC into the university's organizational structure from the early stages of incorporating national universities in 2004.

Moreover, many university-related VCs actively engage in entrepreneurship education within their respective universities and also serve as incubators. In terms of physical presence, VCs strategically position their offices in close proximity to universities. UTEC and UTokyo IPC, for instance, are located at the University of Tokyo, while TUSIC operates from the Tokyo University of Science. The Engine, WERU, and Keio Innovation Initiative are not situated on campus, but they have offices within walking distance of the university.

(3) Independence from the University and Investment Targets Beyond its Own University

All venture capital firms (excluding UTokyo IPC, as it is a public-private fund)) operate as fully independent entities from universities, aiming to pursue returns as VCs at the time of their establishment. This signifies that investment decisions are made completely autonomously, without any influence from the affiliated university. Moreover, in order to maintain returns as a fund, it is challenging to solely rely on ventures associated with their own university. Therefore,

these VCs do not restrict their investment targets to their own university at present. UTEC's initial fund targeted venture companies originating from the University of Tokyo, but from its No. 2 fund it has clearly expanded the scope of its support to include venture companies that utilize technology and human resources that have synergies with the University of Tokyo. Consequently, they now invest at both the national and global scale. Similarly, the Keio Innovation Initiative limited its No. 1 fund to Keio University, but has broadened the scope of its support with subsequent funds.

WERU has a dedicated fund for Waseda University, tailored to adequately support startups originating from the university with a fund size of 1 billion yen. However, its main fund does not impose restrictions on investment targets. In regard to this aspect, since UTokyo IPC is mainly allowed to invest in UTokyo-related startups, UTokyo IPC has a broader definition of UTokyo-related startups. They hold the view that such restrictions on investment targets could be a hindrance in order to achieve stable returns. Thus, both VCs ultimately share the same perspective. In other words, in order to serve the public purpose of making university research outcomes accessible to society while ensuring their viability as funds and continuing to attract investments from private institutional investors, it is essential, in terms of portfolio construction, not to confine investment targets to a single university, although it depends on the fund size. This is evident from the fact that the number of opportunities considered before making a single investment can range from 100 to 150. It is evident that a single university alone is insufficient to support enough investments in multiple opportunities.

(4) Investment Strategies for Deep Tech VCs to Achieve High Returns

There are several options for strategies available for achieving high returns when investing in deep tech ventures .

One approach involves extending the time horizon for funds, such as the 18-year term of The Engine and the 15-year term of UTokyo IPC, in contrast to the typical 10-year horizon of other venture capitals. This adjustment recognizes that deep tech startups require more time to reach

exit stages compared to regular startups. The strategy involves lengthening the fund's duration and investing from the seed or early stage, ensuring that the fund's closure aligns with the timing of potential exits. TUSIC's Katayori also highlights this time horizon gap and suggests that, if extending the fund term is challenging, limiting the deep tech portfolio to 20-30% can mitigate the risks associated with longer investment periods. To mitigate risks, TUSIC limits its investment percentage in deep tech to around 30% to secure returns effectively.

Another option is to combine the fund with an accelerator, as demonstrated by The Engine. This strategy involves providing patient and substantial capital from the fund while integrating it with an accelerator to expedite the startup's growth by accelerating the experiment cadence and to achieve higher returns upon exit. The synergy between the fund's capital and the accelerator aims to accelerate growth rates.

Similarly, a third option involves getting involved with the company even before its establishment, providing hands-on support in various aspects, from securing management personnel to company formation. This approach includes making lead investments in the pre-seed, seed, and early stages and participating on the board of directors, aiming for high returns by achieving company growth together. UTEC adopts this strategy and it has proven successful, as exemplified by Peptidream, a company listed on the First Section of the Tokyo Stock Exchange. UTEC has guided numerous startups to IPOs and M&A transactions using this approach and has achieved very high returns among Japanese VC firms, including a 34% IRR for its No. 4 fund. Keio Innovation Initiative also offers hands-on support, with half of its investments originating from the seed and early stages. Similarly, WERU Investment invests from the seed and early stages as well with the needed business development supports. TUSIC, along with other organizations, is also striving for high returns by leveraging the integrated structure of its Industry-Academia Collaboration Division, incubation facility, and fund similar to the University of Tokyo.

The fourth option emphasizes risk diversification by allocating only a portion of investments to deep tech, meaning tech startups that require substantial time and investment until exit. TUSIC

employs this strategy. In the case of UTokyo IPC, their portfolio is predominantly focused on deep tech but not 100%. Investments outside the IT and services sector (excluding AI), account for over 70% of the first fund and over 60% of the second fund. This allocation is also the case with the overall UTEC portfolio, including exited investments. WERU designates the proportion of deep tech investments at 50% for the Waseda specialized Fund and 87% for its Global Fund. Keio Innovation Initiative has over 80% of deep tech. While the precise percentages may vary due to counting methods and other factors, the overall funds' deep tech allocation is not 100%. In contrast, The Engine exclusively invests in "tough tech" ventures that require long-term development and does not invest in the IT and services sectors (excluding AI), making it a 100% deep tech fund. Consequently, The Engine has formulated strategies to manage this risk over an extended fund term. The fund also engages in seed and early-stage participation and provides hands-on support, including accelerator programs. It is important to acknowledge that The Engine is currently in a phase of assessing the effectiveness of its strategies, as its portfolio companies have not yet completed any exits. On the other hand, UTEC has successfully achieved multiple positive exits and is generating returns as a fund, validating the efficacy of the strategies implemented by UTEC.

The fifth option involves focusing on investments in deep tech areas known for their potential high returns. The Keio Innovation Initiative, for instance, allocates significant investments to two fields of bio and digital including AI and IT, anticipating substantial returns in these domains. Similarly, The Engine exclusively invests in startups with significant exit prospects with investment rate of less than 1%.

Lastly, the sixth option involves making a certain number of investments in the middle stage, where returns may not be as high, but solid returns can still be expected. Keio Innovation Initiative takes this approach.

Each venture capital combines these strategies to achieve the desired high returns for their respective funds.

(5) Investment Decision Criteria

All venture capital firms generally follow the common practice of evaluating and reviewing team members, with product market fit and technology and science as the initial criteria. However, each VC has its own unique approach in evaluating these factors and placing varying degrees of emphasis on them.

First and foremost, all VCs consider technology and science as essential requirements for investing in deep tech ventures. The CEO of WERU described this as a situation where there is a proof of concept (POC) as research and a prototype. Different VCs employ various methods to evaluate technology, including quantitative analysis such as AI and big data. UTEC utilizes a proprietary algorithm for analyzing and assessing researchers through big data analysis, while WERU employs AI to evaluate patents. Other VCs rely on their in-house research teams to analyze technology from multiple perspectives. Additionally, all VCs seek the guidance of expert advisors and consult with industry specialists to form their opinions.

When it comes to evaluating the management team, all VCs consider it crucial, albeit with different levels of emphasis. The Engine, for instance, recognizes the potential of first-time entrepreneurs and places significant focus on the potential of the team members. This perspective is shared by Quaise Energy's CEO, a former employee of The Engine, who emphasized the importance of building a strong team before seeking VC funding. UTEC, on the other hand, places importance on the management team but also considers the possibility of matching a management team with a researcher after the company is founded, initiating conversations with the researcher even before a management team is established.

The existence of an attractive market is recognized as a minimum requirement for all VCs. In terms of assessing market attractiveness, The Engine's research team examines industry trends to determine market potential, while WERU evaluates market attractiveness when deciding which areas to invest in beforehand.

A strong product fit story is also recognized as a fundamental requirement. WERU, for example, highlights the importance of a compelling product fit story, even if they may not require a proof of concept as a business. Kano Therapeutic, an investment recipient of The Engine, also attributes part of its successful investment to effectively conveying a strong product fit story for its developing products.

Based on the aforementioned observations, it can be broadly concluded that deep-tech university-related VCs, particularly for seed and early-stage investments, place significant emphasis on the management team, assuming the presence of technology and a product market fit.

(6) Complementary Relationship between VC Fund and Accelerator

The Engine operates as both a venture capital fund with a mandate and an accelerator with a public mission. These dual aspects, not only capital investment, synergistically contribute to the growth acceleration of startups and facilitate substantial returns. Hence, apart from funding, active involvement in business development is of great importance. As part of its accelerator function, The Engine offers dedicated shared labs and offices, including wet labs. This distinguishes it from the Japanese context where university-related VCs do not typically provide their own shared lab or office spaces, but rather the university itself offers certain facilities. For instance, the University of Tokyo provides shared labs and offices, including wet labs, which are utilized by numerous companies in the portfolios of UTEC and UTokyo IPC.

Similarly, Tokyo University of Science offers shared office spaces and is exploring the possibility of offering labs as well. Waseda University operates the Waseda Entrepreneurship Center, which also provides shared office spaces. Keio University has established a shared office in partnership with Kanagawa Prefecture, and other incubation facilities, including shared offices, are under consideration by the university.

(7) Conclusion

As described above, there is a difference between the U.S. and Japan in terms of the purpose of university-related VC in terms of whether it should be limited to deep tech or include other startups in the field of not deep tech that have emerged from university entrepreneurship education. The Engine and Japanese VCs confirmed the common policy that VCs should be independent from universities while working closely with universities, and that they should not limit their investment targets to their own universities. As for strategies for earning returns, as seen above, we confirmed that each VC has various strategies, but the major difference between The Engine and Japanese VCs is the time horizon. In terms of investment decisions, we found that the points to consider are generally the same, but the weight of each factor differs from VC to VC. Based on these findings, we can summarize the following tips for successful university-related VC.

(1) Foster a close working relationship between the university and the VC.
(2) Ensure the VC operates independently from the university and does not limit investments solely to the university itself
(3) Develop an investment strategy and investment decision criteria for deep tech VC that aims to achieve high returns
(4) Facilitate access to accelerator facilities, such as laboratories and shared offices

8.2. Fundraising Decisions of University Spin-off Startups

In our study, we conducted brief case studies on five companies spun off from MIT and six companies from the University of Tokyo, examining their fundraising experiences and the impact of the university ecosystem on startup growth including fundraising, As noted in the Methodology, there is a bias or deviation in the industry sector and the VCs investing in the interviewed companies. It should also be emphasized that the following conclusions are based on interviews with a total of 11 firms and a literature review.

Based on this analysis, we have identified several common characteristics of successful funding choices made by Japanese and U.S. university spin-off startups that contribute to their entrepreneurial fundraising success.

Some of the findings are reinforced by existing literature and interviews with university-related VCs and on-campus services.

(1) Aim to Attract Investment Offers from Multiple VCs

As highlighted by Brad Feld et al. in their book, multiple co-founders have emphasized the importance of not relying on a single VC during the fundraising process. Instead, seeking investment offers from multiple VCs is crucial to obtain more favorable terms. Moreover, having offers(term sheets) from multiple VCs allows startups to select VCs based on considerations such as their potential contributions to the Board, which is also related to the next point.

(2) Important Criterion in Choosing a VC: Who is Coming to the Board

Just as VCs place importance on the management team when deciding which startups to invest in, startups also attach importance to who will join the Board. The individuals joining the Board hold great significance, as evidenced by examples where the final decision is influenced by who becomes a board member from the VC, even if the investment amount offered is relatively smaller.

(3) Human Support from Angel Investors Holds Greater Value than the Investment Amount

One notable advantage of angel investors is their availability of time and experience, surpassing that of VCs. Consequently, their contributions often take the form of human resources rather than just financial resources. Angel investors provide valuable advice on business strategies and may even take on the role of a Chief Financial Officer (CFO) in certain instances. While angel investors tend to invest smaller amounts compared to VCs, their impact on startups can be significant. In some cases, as in the case of Quaise Energy and Provigate, the contribution from

the financial side is also significant. However, managing a large number of investors can be challenging for startups.

(4) Balancing Public and Private Funds

Many startups leverage a combination of public and private funds, each offering distinct advantages. Public funds, which are non-dilutive, are ideal for managing operations but are typically limited to technology development. On the other hand, private funds offer flexibility and ease of use. It is crucial to understand the differences between the two types of funds and strike a balance in their utilization.

In the United States, startups commonly access public funds such as NSF I-Corps for customer discovery, followed by small grants from NSF SBIR Phase 1 and Phase 2, and then proceed with technology development. Alongside these options, startups also have the option to secure pre-seed investments from VCs. Depending on the industry, some startups may forego SBIR grants, considering them insufficient due to the small amount of money involved, and instead opt for private investments from the outset. Later stages may involve securing substantial grants, such as receiving a million-digit-dollar grant from DOE's ARPA-E in the case of energy startups. It should be noted that, both in Japan and the U.S., large government grants often require cost-sharing and prepayment and reimbursement systems, making it challenging for cash-strapped startups to solely rely on them. In Japan, there have been several cases where SBIR grants were initially combined with VC investment for technology development; grants including JST's START, NEDO, AMED, and other SBIR grants were selected in many cases.

(5) Importance of Fundraising Choices: Differentiating between VC and CVC

Startups have highlighted the distinctions between VCs and corporate venture capitals (CVCs) in their fundraising endeavors. Notably, raising funds from CVCs offers advantages beyond mere financial success, providing an alternative path to success. However, the interviewee has also acknowledged that inconsistencies may arise due to differences in policies between the CVC's

parent company and the startup's stage of development. In contrast, VCs typically prioritize strong financial returns.

Previous research has shown that the prioritization of financial versus strategic returns can vary among CVCs, with some acting similarly to VCs[424]. Moreover, the commitment of top management in Japanese CVCs may be unstable due to unique personnel rotations within Japanese firms, influencing investment policies. Additionally, some CVCs may face pressure to achieve short-term returns through collaboration with the parent company[425]. Therefore, it is crucial for startups to develop a financial strategy that aligns with the priorities of CVCs regarding financial or strategic returns, rather than solely dividing investments between VCs and CVCs.

(6) Perceived Risks of Early-Stage Investments

Certain startups opted to self-fund their development until reaching a certain degree of technological advancement, indicating the perceived risks associated with receiving investments from VCs and other sources. MIT's VMS also highlights the importance of timing when raising funds, as funding may not be immediately necessary.

Moreover, as emphasized by Brad Feld et al. in their book, it is essential to have a clear understanding of the funding amount needed and avoid seeking excessive funding. Successful startups have demonstrated a clear grasp of their funding requirements and have been proactive in securing funds.

(7) Key Decision Criteria for VCs: CEO and Team

During the pre-seed and seed rounds of funding from VCs and angel investors, assuming the availability of technology and a good product market fit, the startup's ability to showcase a strong

[424] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*; Tomohisa Okamoto, "Comparative Analysis of Japanese and Western Corporate Venture Capital" (Massachusetts Institute of Technology, 2021).

[425] Hitotsubashi University Innovation Research Center, *Hitotsubashi Business Review 2021 WIN.Vol. 69, No. 3 - The Future Changed by Startups*; Tomohisa Okamoto, "Comparative Analysis of Japanese and Western Corporate Venture Capital."

management team becomes crucial in determining whether funding will be granted. This observation aligns with the findings derived from VC interviews.

(8) Conclusion

In light of the aforementioned points, the following considerations are summarized for entrepreneurs to bear in mind when contemplating fundraising:

(1) Receive investment offers from multiple VC firms. The selection of a VC firm should consider the value they bring beyond just capital; an important criterion in selecting a VC firm is who will come on board.
(2) In the initial investment, the VC's decision is based on the technology and market fit with a strong management team being a crucial factor
(3) Clearly articulate funding needs and the required amount. Understand the risks associated with early-stage investments from investors.
(4) Raise funds considering the characteristics of public funds and private funds (VC, corporate venture capital, and angel investors).

8.3. Comparison of MIT and UTokyo Ecosystems

The case studies conducted at MIT and the University of Tokyo shed light on the support mechanisms provided by their respective university ecosystems to university spin-off startups. These studies revealed both similarities and differences, offering valuable insights into effective strategies.

(1) Implications from VCs and Spin-off Startups

Implications from the case studies of university-related VCs and spin-off startups
emphasize the significance of providing accessible offices and labs to startups right from their inception, as well as the importance of on-campus services in the pre-startup phase. In particular,

the availability of well-equipped labs emerged as a crucial factor Startups highlighted the immediate access to labs as a catalyst for their research and development endeavors.

i. Importance of Access to Labs

Given the paramount importance of technology development in deep tech, immediate access to labs after founding or fundraising is crucial, as highlighted by numerous startups. The notable case is The Engine, where a venture capital firm offers its own dedicated lab facilities to startups. Similarly, in the case of UTEC and UTokyo IPC, although the VCs themselves may not provide labs, startups receiving investments from these entities often leverage the existing lab resources provided by the university. Tokyo University of Science also acknowledges the significance of labs, but recognizes the financial hurdles involved in establishing them. Consequently, granting startups access to labs remains a challenging task for many university-related venture capital firms and universities.

ii. Significance of On-Campus Services during the Pre-startup Phase

Numerous startups extensively leverage on-campus university support programs as a vital part of their journey from research outcomes to the decision to embark on entrepreneurial ventures, with an eye toward post-startup financing. At MIT, notable examples include the CEO of Kytopen participating in a commercialization program and the CEO of Via Separation conducting further research for commercialization with the aid of a grant from the Deshpande Center. Additionally, four companies (Kytopen, Via Separation, Kano Therapeutics, and VulcanForms) have benefitted from mentoring services provided by VMS, while three of them (Kytopen, Via Separation, and Kano Therapeutics) have utilized Startup Exchange. Moreover, MIT nurtures individuals who learn about entrepreneurship in classrooms and subsequently assume leadership roles, grooming them for entrepreneurial endeavors. Consequently, many startups take advantage of expert mentoring services, customer discovery and other commercialization programs, research and development grants, and opportunities to forge industry connections. There are clearly typical examples of service use by deep tech startups for these support programs, and the impact they have had on future funding for deep tech startups is significant.

On the other hand, in Japan, companies such as Girasol, Urban X Technologies, ORLIB, and ReverSASP Therapeutics participated in UTokyo IPC's accelerator program, 1st Round, where they receive guidance from legal professionals and other experts to kickstart their ventures. However, among the case study subjects, no participants were found to have availed themselves of the on-campus programs offered by the University of Tokyo. This disparity could be attributed to the fact that many of the founders in the case studies conducted at MIT were either post-doctoral fellows or PhD students affiliated with professors (i.e., individuals within the laboratory setting) who subsequently assumed CEO positions. In contrast, approximately half of the CEOs in the Japanese context were external personnel not associated with the laboratories. Hence, it is plausible that the subjects of this case study simply did not happen to utilize the on-campus program offered by the university. It is also possible that this is due to the fact that there are not many users of on-campus programs yet. However, this also raises the possibility that entrepreneurial and intramural support services for researchers have not been fully established at the University of Tokyo, unlike the robust ecosystem at MIT, thereby warranting further examination.

(2) Implications from University Ecosystems

A comparison of the MIT and UTokyo ecosystems reveals the following differences and similarities. In addition, Table 8.1 provides a graphical comparison of the on-campus services to support startups provided by MIT and UTokyo.

i. Importance of an Ecosystem with Diverse Services: Diverse Services Are Distributed at MIT, While Those at UTokyo Tend to Be More Integrated

As demonstrated in Table 8-1, a thorough comparison of the startup support services provided at MIT and UTokyo reveals no significant disparities in the actual content of these services. However, notable distinctions arise in terms of the quantity (types) and quality of the services offered.

Regarding the programs and services available on the MIT campus to support startups, as described earlier in Chapter 4, a wide array of programs are scattered across the campus, often with overlapping elements. Students and researchers must choose the most suitable program from this extensive selection, creating a competitive environment where these programs vie for the attention and participation of students and researchers. Consequently, a good virtuous cycle ensues, driving improvements in the multitude of programs.

To begin with, in terms of the number of entrepreneurial courses offered, the University of Tokyo provides approximately 60, whereas MIT offers around 120, almost double the amount offered by the University of Tokyo. MIT also presents a diverse range of options, including numerous hands-on practical classes. Moreover, even within the realm of on-campus pitch contests, MIT stands out with its interdisciplinary pitch contest, the MIT $100K Entrepreneurship Competition, alongside industry-specific pitch contests (such as healthcare, energy, and water resources). Hackathons are regularly held throughout the campus, providing additional opportunities.

Furthermore, MIT offers several avenues for pursuing entrepreneurial ideas while securing funding, such as grants to professors through the Deshpande Center, the Sandbox program, which provides a small grant with a streamlined selection process, and Delta V, an accelerator program. VMS serves as a prominent mentoring resource, focusing primarily on mentorship, while mentoring services are also available at the Deshpande Center, Sandbox, and Delta V, each offering a variety of mentoring options. Nevertheless, as highlighted in an interview with an entrepreneur, the fragmented distribution of these services within the university can present a disadvantage, as it may hinder service recipients' access to information and potentially result in missed opportunities to find services that precisely match their needs.

In terms of facilities, the University of Tokyo boasts an exceptionally robust support system for spin-off startups. It provides offices at three campuses specifically for use by UTokyo-related startups, along with access to various laboratories, including wet labs, at two additional facilities.

Table 8.1 Comparison of the Startup Support Services

Services	MIT	UTokyo
University Related VC	The Engine, E14 Fund	UTEC, UTokyo IPC
TLO	MIT TLO	UTokyo TLO
Shared Office and Lab for Spin-offs	The Engine provides offices and labs *MIT does not provide offices and labs	UTokyo Provides offices and labs at four incubation centers (Entrepreneur Plaza, Incubation Room at Komaba Cooperative Research Building, South Building of Entrepreneur Plaza, and Kashiwa II Entrepreneur Hub)
Workspace for Student Entrepreneurs	MIT InnovationHQ, Martin Trust Center	Part of the above (Entrepreneur Plaza, etc.)
Maker Space	Hobby Shop, ProtoWorks Makerspace, START Studio, Architecture Shop	Hongo Tech Garage
Gap Funding for Researchers	Deshpande Center	UTokyo Gap Fund Program
Mentoring	VMS	*Incorporated into entrepreneurship programs*
Customer Discovery	MIT I-Corps	*Partly Incorporated into entrepreneurship programs*
Deep-tech Venture Course	Climate & Energy Ventures, Mobility Ventures, Healthcare Ventures, Venture Engineering, AI for Impact, Revolutionary Ventures etc.	Deep-tech course, GTIE, UTokyo EDGE NEXT Program(2017~2021)
Overall Entrepreneurship Courses	120+ courses (New Enterprises etc.)	60+ courses (Innovation and Entrepreneurship etc.)
Business Competition and Hackathon	MIT $100K Entrepreneurship Competition, MIT Climate and Energy Prize, MIT Sloan Healthcare Innovation Prize, MIT Water Innovation Prize, MIT Sports Analytics Conference Startup Competition, MIT Sloan Africa Innovate Conference Pitch Competition, MIT Enterprise Forum Arab Startup Competition etc.	UTokyo 1000k
Connecting Startups with Industry	MIT Startup Exchange	N/A
Hackathon	The MIT EnergyHack, MIT iQuHACK (quantum computers), MIT Generative AI Hackathon, MIT Sloan Product Management Hackathon, MIT FinTech Hackathon, MIT Bitcoin Hackathon, Future of Wellbeing Hackathon, MIT COVID Hack community competition, MIT AI for Filmmaking Hackathon, MIT Policy Hackathon etc.	UTokyo Girls Hackathon (Coding), Data Hackathon, Blockchain Hackathon for Students
Other Entrepreneurship Supporting Programs	MIT Sandbox, MIT Delta V, Smart MIT, MIT Fuse, MIT SHIP, orbit, t=0 etc.	Entrepreneurship Dojo, UTokyo FoundX, Todai to Texas

ii. Generous Mentoring Services and the Maintenance of a Mentoring Community Are Key

MIT offers a diverse range of services, many of which include mentoring services. These services are provided by mentors who generously offer their guidance free of charge, while the administration focuses on fostering a strong mentor community to ensure the retention of mentors and maintain a high standard of mentorship. To ensure the selection of exceptional mentors, referrals from existing mentors are utilized, followed by a rigorous process of selection and training. This approach cultivates a sense of belonging within the mentor community and has successfully established a thriving community. Additionally, MIT has implemented numerous innovations to deliver truly high-quality mentoring services, with one of the most crucial elements being the strict guidelines that mentors must adhere to. Notably, mentors maintain complete independence from investment activities and job placements, creating a secure environment for mentees.

As the pool of entrepreneurs with successful experiences remains relatively small compared to MIT, UTokyo maintains its mentors by providing financial incentives, recognizing the importance of cultivating a high-caliber mentor base as an ongoing challenge for the future. This task becomes increasingly challenging not only for UTokyo but also for regional universities in securing mentors.

iii. GAP Funding is Valuable When Combined with Business Development Support

Although they started at different times, both MIT and UTokyo have Gap Funding Programs that provide small grants to researchers to bridge the funding gap between research and commercialization. The amount of funding at MIT and UTokyo is about the same, and both provide grants to faculty members. The biggest difference is that UTokyo's program is as close to only funding, while MIT's program is combined with hands-on support. In addition, MIT has a very selective pool of mentors and mandatory participation in a customer discovery program (I-Corps) that combines research and development with business development in parallel. UTokyo provides advice from TLOs and other organizations, but does not provide hands-on support. In

addition, while MIT provides funding for up to three years, UTokyo's funding is generally limited to one year.

iv. Importance of Education on Customer Discovery

The usefulness of MIT I-Corps has been demonstrated in case studies, and the extremely practical nature of the program, including mandatory interviews with 12 people, is beneficial. In fact, feedback from participants in the case studies has proven that the program has been extremely useful in pivoting and building business skills, as they found that there was no product market fit in their area of focus after listening to customers in the I-Corps. In addition, MIT I-Corps is aligned with many entrepreneurship programs within MIT and is embedded in various programs; at UTokyo, education on customer discovery, such as that provided by I-Corps, is part of the program, but not established. I-Corps is a nationally established NSF-funded program that was established in recognition of the fact that the U.S. federal government provides substantial funding for research annually, yet too little of it is actually put into practice. And the program is designed to solve the business problem that the reason it did not work was not a technical problem, but rather that what the researchers created was something that no one wanted to buy.

v. The Importance of Shared Offices and Labs within the University

In comparison to MIT, the University of Tokyo showed that the benefits to startups from shared offices and labs operated by the University of Tokyo are enormous. MIT itself does not provide any, possibly because the Greater Boston area provides many shared offices and labs. However, The Engine offers shared offices or labs. Many of the companies in the case studies had experience moving into entrepreneurial plazas run by the University of Tokyo, and pointed to the benefits of trust, access to experts, and inexpensive environments that can be gained from these facilities.

(3) Conclusion

From the above, the following points can be summarized for Japanese research universities to keep in mind when building an ecosystem to increase the number of university spin-off startups in the deep tech field.

(1) Foster an ecosystem that provides diverse and high-quality services through iterative trials of various services, without getting overly caught up in duplication, demarcation, etc. On the other hand, organize an integrated window for entrepreneurs.
(2) Cultivate a pool of mentors by expanding their numbers and creating a mentor community. Implement stringent guidelines for mentors to ensure a secure consultation environment for entrepreneurs.
(3) Establish a well-defined Customer Discovery program to prevent entrepreneurs from developing products that lack a market fit.
(4) Develop a Gap Funding Program that offers not only funding but also hands-on support
(5) Facilitate access to shared offices and laboratories within and around the university.

9. Conclusion and Future Work

9.1. Conclusion

In this study, we conducted an analysis of the university ecosystem and university-related VC firms' impact on the creation of university spin-off companies in the deep tech sector. Additionally, we conducted short case studies on the fundraising journey of university spin-off startups during their initial stages. The results obtained offer valuable insights into the success of university-related VCs, university spin-off startups, and the university ecosystem, which are summarized below.

As discussed in the Chapter 8 Discussion section, we were able to identify similarities and differences among university-related VCs, university spin-off startups, and university ecosystems, and draw implications for Japan.

The key considerations for establishing university-related VCs in Japan can be summarized as follows:

(1) Foster a close working relationship between the university and the VC.
(2) Ensure the VC operates independently from the university and does not limit investments solely to the university itself
(3) Develop an investment strategy and investment decision criteria for deep tech VC that aims to achieve high returns
(4) Facilitate access to accelerator facilities, such as laboratories and shared offices

Furthermore, the following points should be considered by entrepreneurs when seeking funding:

(1) Receive investment offers from multiple VC firms. The selection of a VC firm should consider the value they bring beyond just capital; an important criterion in selecting a VC firm is who will come on board.
(2) In the initial investment, the VC's decision is based on the technology and market fit with a strong management team being a crucial factor
(3) Clearly articulate funding needs and the required amount. Understand the risks associated with early-stage investments from investors.
(4) Raise funds considering the characteristics of public funds and private funds (VC, corporate venture capital, and angel investors).

Lastly, the following points should be taken into account when establishing an ecosystem to promote the growth of university spin-off startups in the deep tech field at Japanese research-based universities:

(1) Foster an ecosystem that provides diverse and high-quality services through iterative trials of various services, without getting overly caught up in duplication, demarcation, etc. On the other hand, organize an integrated window for entrepreneurs.
(2) Cultivate a pool of mentors by expanding their numbers and creating a mentor community. Implement stringent guidelines for mentors to ensure a secure consultation environment for entrepreneurs.
(3) Establish a well-defined Customer Discovery program to prevent entrepreneurs from developing products that lack a market fit.
(4) Develop a Gap Funding Program that offers not only funding but also hands-on support
(5) Facilitate access to shared offices and laboratories within and around the university.

9.2. Future Work

First and foremost, in this study, we focused on startups established through licensing via Technology Licensing Offices. However, it was pointed that there is a growing trend in recent company creation for venture capitals to identify talented researchers and create a startup, particularly in the life sciences sector[426]. Additionally, a shift towards open-source practices and non-patenting has been noted in the fields of AI and IT. These observations suggest the emergence of a new trend that structurally differs from the conventional approach of licensing from TLOs. In future research, it is essential to expand the scope of the investigation to include cases where VCs are involved in partnering with researchers and establishing new companies.

Furthermore, as there is little disparity in the number of patents between the United States and Japan, this study assumes that there is no significant difference in patent quality between the two countries. However, given the substantial difference in the number of startups based on research outcomes between the United States and Japan, despite the comparable number of

[426] Toshiya Watanabe, Interview with Director of Industry-Academia Collaboration Division, The University of Tokyo.

patents resulting from research, our study focused on the phase of bridging the gap between research and commercialization. Therefore, we did not investigate potential disparities in patent quality between the United States and Japan. Additionally, we did not delve into the question of how the level of research outcomes that lead to entrepreneurship differs between the two countries, such as variations in the number of notable research results published in prestigious journals. Hence, this aspect requires further investigation, and future work should also consider approaches to enhance the level of research in these areas.