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High-Tech Start-ups Spun-off from an Entrepreneurial University in Sweden*

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Abstract

Chalmers University of Technology, situated in Gothenburg, the industrial heart of Sweden, is a renowned entrepreneurial university. By harnessing regional technological innovations and business assets, Chalmers has produced a significant number of successful and enduring spin-offs. This study explores the distinctive entrepreneurial ecosystem in Gothenburg, contrasting it with Silicon Valley, through the lens of "surrogate" and "non-surrogate" start-ups. The "surrogate" model, common among participants of master's entrepreneurship programs, involves student teams commercializing a mix of internally and externally sourced technological innovations into new products and services. Conversely, the "non-surrogate" model sees postdoctoral researchers and scientists capitalizing on business opportunities by commercializing their intellectual property. Chalmers supports these ventures through investments and incubations, complemented by mentoring local business angels, corporate leaders, and alumni. This creates a nurturing environment for both start-up types. Despite limited foreign venture capitalists, lean start-ups maintain disciplined fundraising strategies and judicious resource management. The life science companies introduced in the two case studies demonstrate this approach by collaborating with medical experts as technical advisers to develop groundbreaking therapies alongside technology licensing and custom manufacturing for diverse revenue streams.

Keywords

Academic spinoff, surrogate entrepreneur, Gothenburg, technology seed

I. Introduction

Chalmers University of Technology, located in Gothenburg, is recognized as a leading entrepreneurial university in Europe (Etzkowitz, 2008). The increasing attention on Chalmers stems

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from the notable success of its master's program, the Chalmers School of Entrepreneurship (CSE), launched in 1997. This program has produced numerous technology-based start-ups that have maintained a high survival rate. The survival rate of start-ups (six years since inception) in the U.S. is estimated to be between 36% and 51% (according to data for companies founded in 2005) (Shane, 2010). In comparison, start-ups from the Chalmers University of Technology show a higher survival rate, with data indicating that 80% of start-ups founded between 1997 and 2005 were still in business in 2012 (Lundqvist, 2014). This high survival rate is attributed to various educational programs and entrepreneurial events that filter out business plans with limited growth potential before commercialization.

A key characteristic of start-ups emerging from CSE is the prominent role of surrogate entrepreneurs.

Surrogate entrepreneurs refer to individuals who, on behalf of inventors, take charge of utilizing and commercializing technologies researched and developed at universities or research institutes (Radosevich, 1995; Vohora, Wright & Lockett, 2004, etc.). They are expected to be engaged in the initial stages of formulating a new venture idea and steering the business toward achieving its objectives (e.g., Clarysse & Moray, 2004). Most CSE start-ups focus on commercializing technology seeds sourced from inventors and exemplify a typical surrogate model of entrepreneurship.

Lundqvist (2014) examines the prevalence of surrogate entrepreneurship across various industry sectors. Of the 49 companies incubated at the university from the initiation of CSE in 1997 to 2005, surrogate entrepreneurs led a significant number in the biotech, materials, and medical device sectors and leveraged the university's technology seeds. By contrast, in the ICT sector, the proportion of surrogate entrepreneurs was approximately half. Notably, a sizable proportion of these ICT ventures utilize technological seeds sourced from the private sector.

According to a study examining cases in Sweden and the United States (Lundqvist & Middelton, 2013), inventors do not necessarily need to assume managerial roles. By simply fulfilling the role of inventors, university researchers can contribute significantly to the creation and growth of start-ups.

A study focusing on Sweden and the United States (Lundqvist & Middelton, 2013) suggests that inventors are not required to assume managerial roles. By serving as inventors, university researchers can make substantial contributions to the inception and development of start-ups. Furthermore, at Chalmers University of Technology, entrepreneurship within research entities beyond the CSE is thriving. In these instances, "non-surrogate entrepreneurship," characterized by inventors independently commercializing their technology seeds, is particularly notable. Even within this non-surrogate entrepreneurship framework, the university bolsters ventures through their distinctive intellectual property systems and programs designed to improve management skills.

This study explores academic spin-offs, recognized as university start-ups, located in Gothenburg, Sweden's second-largest city. It focuses on the entrepreneurs of these start-up companies as well as

university systems, the regional community, and national institutional settings, all of which support their growth and development.

The two start-ups analyzed in this study utilize technologies from the biotech and materials sectors, both of which are part of the life science field. One company adopts the surrogate entrepreneurship model, while the other chooses a non-surrogate pathway. The subsequent sections elucidate the background and institutional frameworks supporting the formation of these start-ups and engage in a comparative analysis of managerial resource acquisition and strategic decision-making.

II. Academic Start-ups in Gothenburg

1. History and Geographical Location of the City of Gothenburg

Before exploring the specifics of Gothenburg, I will provide an overview of Sweden. Located on the Scandinavian Peninsula, Sweden spans 450,000 km. Approximately one-third of Sweden lies within the Arctic Circle, with a population of 10.38 million (National Institute of Social Security and Population Studies, 2021) [1]. Regarding GDP per capita and global rankings, Sweden boasts a high per capita GDP of USD 64,578, ranking 20th (World Bank Survey, 2022) [2]. Sweden ranks fourth in the IMD World Competitiveness Ranking. Sweden's economic growth rate is 2.83% (IMD, 2022) [3]. These figures highlight Sweden's high productivity levels. Renowned for its tuition-free education, Sweden's public education expenditure is 6.68% of its GDP (UNESCO, 2022) [4]. Such investments in education are likely to play a key role in supporting economic growth and fostering productivity.

Gothenburg is Sweden's second-largest city. In contrast to the capital, Stockholm, which faces the Baltic Sea, Gothenburg faces the North Sea and is situated on the northern shore opposite Denmark's Jutland Peninsula. Historically established as a trade hub beyond Europe, Gothenburg flourished as a commercial and industrial city, propelled by the growth of its shipbuilding and machine-building industries. The city itself has a population of 580,000, which increases to approximately one million when the surrounding areas are included. Gothenburg hosts the headquarters of the Volvo Group, known for manufacturing automobiles, trucks, and transportation vehicles and Saab, an aircraft and defense munition supplier. It also houses the sole remaining research and development center of the pharmaceutical giant AstraZeneca in Sweden, along with a branch of the telecommunications equipment manufacturer Ericsson. These corporations are actively engaged in joint research with university researchers and show keen interest in partnerships with university start-ups.

[1] National Institute of Population and Social Security Research, (2021).
[2] Global Note (2024a).
[3] IMD (2022) /
[4] Global Note (2024b).

2. The Entrepreneurial University of Gothenburg

(1) Overview of Entrepreneurship Courses

Chalmers University of Technology in Gothenburg is recognized as a top research and educational institution in Europe. The university was first established in 1829 under the auspices of a donation from William Chalmers, a trading merchant who was the director of the Swedish East India Company. Later, while all Swedish universities became state-owned when the university incorporation system was introduced in 1994, Chalmers University of Technology chose to become the only university corporation in Sweden. The university has a strong independence orientation. Consisting of 17 faculties, including engineering, science, architecture, and life science, the university enrolls approximately 12,000 students. With 1,000 postdocs and researchers, it is a significant research university at both national and European levels.

The major technology universities in these four Nordic countries are Aalto (Finland), Chalmers (Sweden), DTU (Denmark), and NTNU (Norway). Among these, Chalmers University of Technology stands out for its excellence in entrepreneurship education and serves as an active hub for creating university-based start-ups (Warhuus & Basaiawmoit, 2014). It is particularly noteworthy that Chalmers University of Technology has been successful in fostering technology start-ups by incorporating the experience of commercializing technology seeds owned by universities and local companies into its educational programs. There is worldwide interest in how Chalmers has involved itself in the creation of academic start-ups and how the university's approach differs from precedents such as Silicon Valley and Cambridge (Taji, 2014; Taji, 2020).

The CSE, a master's program, is the focal point of entrepreneurship education at Chalmers University of Technology. The program was inaugurated in 1997 to foster pragmatic entrepreneurship with a focus on technology. Over more than 20 years since then, the organizational scheme has undergone incremental changes, and as of 2018, four majors have existed: Tech-Track (technology start-ups, about 20 students), Corp Track (new business development, about 10 students), ICM Track (business design of intellectual properties, about 10 students), and Bio-Track (life science start-ups, about five students).

Of these majors, I would like to introduce the Tech-Track and Bio-Track. The program spans two years, and the curriculum in the second year incorporates the process of developing venture ideas using actual technology seeds through growth. Specifically, the process includes (i) the discovery of technology seeds, (ii) patenting/licensing, (iii) business idea generation, (iv) business plan formulation, (v) launching a business, and (vi) growth. In the second year, the students form teams of three for collaborative learning. On average, 12–13 teams participate in practical training each year. In the second year, the students study in teams of three. They initiate their own businesses as early as around the time of graduation, but it may also extend to six months to a year after graduation. At the time of graduation, approximately six teams have started their own businesses. The bonds among classmates

are strong and involve mutual assistance and consultation during busy periods. There is also a robust vertical connection between seniors and juniors, and instances in which seniors assume leadership roles in companies founded by juniors are common.

CSE entrants are predominantly individuals with technical majors in their undergraduate studies. Aged primarily between 22 and 27, with an average of only three years of work experience, they seldom have their own technological seeds. These students grow into surrogate entrepreneurs by leveraging the inventors' technological seeds.

Incidentally, the University of Gothenburg hosts a medical faculty member and an affiliated hospital. Bio-Track collaborates with the Sahlgrenska Academy of the University of Gothenburg, a comprehensive university located in the city. Sahlgrenska Academy, which provides education in medicine, pharmacy, nursing, and life science, also includes entrepreneurship education. Students in the entrepreneurship program followed the same curriculum as the CSE students during the first year of their master's degree. Unfortunately, partly because of the impact of the COVID-19 pandemic, the program at Sahlgrenska Academy has been suspended (as of 2023).

(2) Curriculum for Cultivating Surrogate Entrepreneurs

CSE students have abundant opportunities to engage with technological seeds. Technical information is gathered from research laboratories across all disciplines within the university during the second half of the first year of the master's program. Moreover, students are introduced to various technologies not only by local companies, such as Volvo, Saab, Ericsson, and AstraZeneca but also from outside the region. Underutilized or unpatented intellectual property that lies untapped within companies is also discussed. Students collaborate in teams to discuss and select technology seeds. The selection of technology seeds and team formation are crucial determinants of the success or failure of activities throughout the program.

Entrepreneurial ventures in which technology seeds are sourced from external providers are categorized as a surrogate type. If a start-up aims to commercialize a student's original idea or expired patent technology, it falls into the category of non-surrogate type. As mentioned earlier, 80% of start-ups founded within eight years of the inception of the CSE in 1997 were still operational as of 2012. Among the six companies that succeeded in exits, such as initial public offering (IPO) or M&As, five were led by surrogate entrepreneurs who had been involved in the start-up and managed the company from its inception (Lundqvist, 2014).

The CSE program, designed to foster surrogate entrepreneurship, has evolved over the past 20 years through trial and error and involves repeated organizational adjustments and content improvements. To enrich the surrounding environment, CSE has actively worked on the selection and introduction of external mentors who support teams alongside university researchers and educators.

Students initially confirm their team members and enter into contracts with inventors to secure

licenses for technology use. They then focus on creating new businesses. From their second year onward, students have more frequent discussions with team and faculty members in the university's project rooms. In the same building, an organization called Chalmers Ventures serves two functions: venture capital for start-up investments and business incubation, including educational support. While Chalmers Ventures is originally an organization that helps incorporate start-ups, it provides advice to student teams from the stage of refining business ideas and connects them with professionals, such as engineers, as needed.

In the second year, the student teams expand their activities beyond campus, engage in fieldwork for market research, and seek partners. Occasionally, unforeseen challenges may arise, such as receiving notices of discontinuation from intellectual property holders, encountering significant hurdles in the commercialization process, or experiencing team disputes. Only teams that successfully address and overcome unexpected situations proceed to the incorporation stage. During the intensive preparation period spanning a full year, plans with limited growth prospects are filtered out. In other words, when a start-up launches, both its business plan and management team are already quite well-honed (Igarashi, 2018).

III. Schemes for Promoting Academic Start-ups

1. Background of Encouraging Non-Surrogate Entrepreneurship

Chalmers University of Technology encourages entrepreneurship among not only CSE students but also graduate students and faculty from other departments. In an awareness-raising program launched in 2019, faculty members were instructed on the significance and expertise required for start-up creation. Chalmers University of Technology maintained a stable budget to finance such programs, soliciting donations from local family business owners in addition to government funds. Two full-time staff members serving on a fixed-term basis were employed at all times to organize a variety of programs. For instance, they invited start-up support personnel from U.S. universities to conduct seminars and provide guidance on patent registration and usage consent procedures. The staff in charge made efforts to persuade busy faculty members to participate, contributing to increased participation rates.

The intellectual property system at Swedish universities operates on a model that is markedly different from the Bayh–Dole Act style system applied in the United States and Japan. Under the Bayh-Dole Act or similar systems, intellectual property emanating from university research labs is vested in the university, and licensing procedures are orchestrated through the university's technology transfer office. Inventors, including faculty members and researchers, are entitled to share licensing fees. In contrast, the Swedish system attributes intellectual property to inventors, offering substantial revenue potential to teaching staff and researchers engaged in commercialization. The Swedish system refrains

from mandating Bayh–Dole-Act-style practices, leaving the choice of IP management in the hands of researchers who are rightful owners. In essence, researchers have the option to either adopt Bayh-Dole-style practices by entrusting their intellectual property to Chalmers Ventures or independently pursue its exploitation. Self-exploitation provides significant financial incentives. Such an institutional framework can provide a robust boost to university-launched start-ups. In interviews with approximately 30 start-ups between 2014 and 2019, the author discovered that individuals who completed research-oriented graduate programs often cited "recommendations from professors or senior colleagues" as the primary motivation for starting a business. The exploration of entrepreneurship usually intensifies during doctoral or postdoctoral programs. Professors rarely venture into entrepreneurship and often prefer to assume the role of technical advisers.

Unlike CSE students, researchers typically lack the specialized knowledge and skills required to start a business. Chalmers Ventures, as previously mentioned, steps in to support these aspiring entrepreneurs with limited business management expertise. Researchers reaching out to Chalmers Ventures are encouraged to participate in the Start-up Summer, a five-week intensive program aimed at developing robust business models. This program is free of charge and open to external participants, providing opportunities to compete with individuals from outside the organization.

2. Frameworks for Fostering Young Entrepreneurs

Chalmers Ventures was formed through the merger of two entities: Encubator, focused on mentoring, and Chalmers Innovation, responsible for investments. Encubator was founded to redirect the CSE education program toward more hands-on entrepreneurship. Although the composition of start-ups may change, Chalmers Ventures consistently manages a roster of approximately 100 start-ups in its investment portfolios.

Chalmers Ventures employs over 20 full-time staff. Apart from a few management staff members, most are business coaches (mentors). In cases where it is not feasible to offer salaries matching top-tier talent, the organization seeks part-time collaboration to obtain advice. Each mentor typically supervises four start-ups and reviews each company's progress weekly. It is common for mentors to become members of start-up boards. Occasionally, they even participate as dedicated executives in start-ups. Each mentor is assigned a specific industry and area of expertise. Particularly in the realm of life science business, where specialized knowledge and unique personal networks are crucial, it has been observed over time that some individuals serve as mentors for multiple start-ups. With the presence of major companies in the automotive, IT, life science, and chemical sectors, Gothenburg benefits from being able to tap into mentors from the ranks of alumni or current professionals in these companies. Even seasoned entrepreneurs who have stepped back from the frontlines after growing their start-ups can become valuable mentors.

Over the 20 years since the establishment of the CSE, a cycle has developed wherein intangible management resources, such as experience and networks accumulated by alumni and seasoned

entrepreneurs, are passed on to the younger generation, underpinning their growth. This cycle, known as “entrepreneurial know-how recycling” (Mason & Harrison, 2006; Spigel & Harrison, 2018), has invigorated the region’s entrepreneurial ecosystems. Both successful cases and failed entrepreneurial experiences can be drawn from this cycle.

Once start-ups embark on the process of commercialization, they begin searching for a place to operate. At this phase, the university provides incubator facilities and financial support. During this phase, called the pre-seed stage, start-ups receive an investment of 300,000 SEK (approximately 4.25 million JPY) and can stay in the incubator for up to one and a half years. Upon advancing to the seed stage, they can secure investments ranging from 1 to 3 million SEK, aiming for further growth. The maximum investment limit is set at 12 million SEK for the entire period (as of 2019). In addition to the university fund, there is a government-backed fund, ALMI Invest. However, because of its regulations that prohibit standalone investments, ALMI investment capital must be deployed in conjunction with university funds.

Government loans, also known as soft loans, are also available for financial assistance. In the event of closing a business without making a profit, borrowers are not required to repay loans. Moreover, entrepreneurs were allowed to appropriate part of the loan funds for their living expenses. When interviewing young entrepreneurs, they often express the sentiment that “given the absence of financial risks, refraining from starting a business while young would be like missing out on valuable opportunities.”

Up to this point, I have discussed start-ups originating from the Chalmers University of Technology, classifying them into surrogate and non-surrogate types. The mechanisms supporting inexperienced young founders are not limited to mentoring by Chalmers Ventures or financial support from the university or governments. Business elites, seasoned professionals, and owners of family businesses residing in Gothenburg, a representative industrial city in Sweden, also contribute to young founders’ entrepreneurial endeavors.

In surrogate-type start-ups emerging from the CSE program, members of the management team are typically in their twenties and fresh out of graduate school. Individuals lacking work experience are around 24 years old, while those with some prior work backgrounds are approximately 28. Despite holding titles such as CEO, COO (Chief Operating Officer), CMO (Chief Marketing Officer), or CTO (Chief Technology Officer), most have little management experience and lack professional networks to access potential partners or customers. To support them, the board of directors includes experienced specialists with titles of Chairperson or President. Such setups are commonly observed, with alumni of leading local companies supporting the start-up as non-executive directors. For instance, in the life science field, former executives from AstraZeneca can be found on the board. The IT sector features Ericsson executives with similar advisory roles. Inventors providing technological seeds often assume technical advisers roles.

In non-surrogate start-ups, the inventor-turned-founder typically assumes the CTO position, launching their companies in their late 20s or early 30s after completing their postdocs. These founders, often lacking business experience, are paired with invited CEOs, typically seasoned professionals with more experience than the CTO. They are expected to assist the CTO in acquiring lead users and opening new markets. The success of a non-surrogate start-up depends on the CEO's management skills and networks. Consequently, university faculty, Chalmers Ventures, and business angels actively collaborate to recruit qualified CEOs.

Within the landscape of business angel investors, owners of family-run companies often exert greater influence than alumni of prominent local corporations. Many run real estate businesses or long-established enterprises whose names seldom appear publicly. Young entrepreneurs leverage personal networks to connect with these business angels, securing stable funding streams for their ventures.

IV. Case Study in Surrogate Entrepreneurship

1. Stayble Therapeutics: Overview

Stayble Therapeutics originated as a CSE project. It was initiated based on an injection-based back pain therapy created by a professor at the University of Gothenburg Medical School. This makes Stayble Therapeutics a typical example of surrogate entrepreneurship in life science. The following is an overview of the company:

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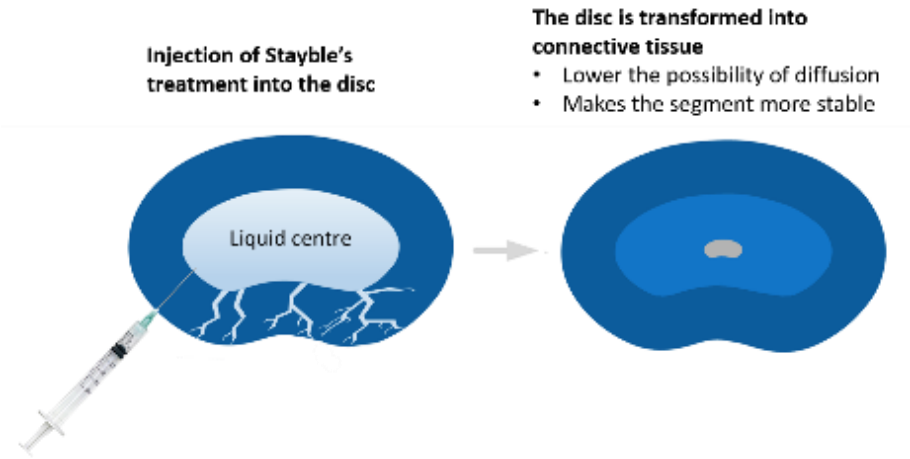
- Company name: Stayble Therapeutics.
- Origin: Founded in 2014 by students who graduated from an entrepreneurship program at Chalmers University of Technology.
- Technology seeds: Injections to relieve back pain invented by a professor at the University of Gothenburg Medical School.
- Main investors: European Commission grants, university and governmental funds, business angels.
- Exit: Publicly listed on Nasdaq First North Growth in 2020, raising SEK35M ($4.92M).

Stayble Therapeutics has developed a novel treatment for chronic lumbar discogenic pain. I will now briefly explain it. Healthy human intervertebral discs contain a gel-like fluid called nucleus pulposus. From 30s to 50s , the disc may become unstable and gradually lose its water-binding capacity, causing the fluid to start to leak, leading to pain. Their treatment involves injecting a substance into the intervertebral disc to solidify it, reducing fluid leakage and alleviating pain. Importantly, this treatment is minimally invasive. The professor who developed the technology refers to it as a "reverse-thinking" approach. As illustrated in Figure 1, injections into the intervertebral disc transform the disc

material into a connective tissue that restricts spinal fluid diffusion, which in turn stabilizes symptoms.

Figure 1. Stayble Therapeutic's Technology



Source: Publicly available documents

Stayble Therapeutics has advanced through two phases of clinical trials: Phase 1b in 2017 and Phase 2b in 2020. In 2020, the company conducted an IPO to secure funding for the upcoming phase of clinical trials.

2. Management Team

Kjell Olmarker, the inventor of Stayble Therapeutic's technology, founded the company with a surrogate entrepreneur and served as a board member. This marked his fourth start-up venture. Following his first project, which faced managerial challenges, he chose to contribute technology seeds to Chalmers University of Technology and entrusted management to the surrogate entrepreneurs. His two subsequent projects, involving inflammation and surgical drugs, were successful and sold. It can be inferred that trust and collaboration between the inventor and entrepreneurship training course officers were established over time, given the inventor's continued provision of technology seeds. After Stayble Therapeutics went public, Olmarker stepped down from the board, feeling that his role as an inventor was fulfilled as the company transitioned to accelerated commercialization.

Andreas Gerward, the surrogate entrepreneur, studied business design at Chalmers University of Technology. He then gained experience in B2B sales as an intern before enrolling in the CSE. After graduating, he initiated a pre-clinical therapeutic project that he was working on during his studies. However, he eventually decided to abandon it because of its lack of efficacy in pre-clinical development. He then moved on to Stayble Therapeutics as CEO. At that time, the company's original project manager joined another venture. In a challenging situation, he took over as CEO, succeeding

his classmate, at the invitation of inventors and mentors.

Mattias Münnich, who served as a mentor at Chalmers Ventures, was involved in launching life science projects. After being appointed board member of Stayble Therapeutics, Münnich committed himself to establishing connections with government-backed venture capitalists and medical experts. During the company's initial three years, the management team comprised seven members, including clinical physicians, with the CEO in a full-time position.

3. Management Resources and Strategies

The company initially operated within an incubator at the University of Gothenburg's Medical Faculty, as this was convenient for meeting inventors and cost-effective. Despite facing significant fundraising challenges, the company followed established practices in life science entrepreneurship and successfully secured research funds from the European Commission and the Swedish government. External investments were obtained not only from the university and government-backed funds but also from business angels associated with the university. Additionally, the company proactively approached clinical physicians in the life science industry for their support.

The operational team initially comprised a CEO and an engaged board of directors. In 2015, a researcher from the neighboring AstraZeneca joined the team on a part-time basis (50% commitment). Since its inception, the company has consistently pursued a strategy of minimizing personnel and costs and collaborating with partner companies for commercialization. They specified injection ingredients and outsourced production, thereby avoiding the need for in-house manufacturing facilities. Establishing a production process for licensing was also a part of their plan.

In 2017, the company conducted a Phase I clinical trial with 15 patients in Sweden. However, securing participants for the subsequent Phase II trial was extremely challenging owing to the COVID-19 pandemic. Consequently, the company expanded its recruitment efforts to hospitals in Europe and Russia and presented its research to physicians through an online community. Facebook announcements effectively recruited patients from Sweden. Clinical trials conducted between 2021 and 2023 targeted 110 patients in Spain, the Netherlands, and Russia. As of 2023, the list of part-time directors and technical advisors includes 10 individuals, including hospital personnel, who have cooperated in clinical trials.

Starting in 2023, the company plans to seek FDA approval in the United States upon completing Phase III clinical trial. Recognizing the importance of partnerships in global expansion, this company is in contact with pharmaceutical companies in Europe, the United States, Japan, and South Korea. Notably, the operational team of the business has remained consistent with around five individuals since 2017.

V. Case Study in Non-Surrogate Entrepreneurship

1. Promimic: Overview

Promimic is a startup that was spun off from the materials chemistry laboratory at Chalmers University of Technology. It was founded by a postdoctoral researcher who leveraged the technological innovations of the laboratory with which he was affiliated. The following is an overview of the company:

- Company Name: Promimic.
- Origin: Founded in 2006 by a postdoctoral researcher in the materials chemistry laboratory at Chalmers University of Technology.
- Technology Seeds: Dental and orthopedic implant coatings developed in the founder's laboratory.
- Main Funding Sources: University and government funds, business angels, and Swedish venture capital.
- Exit: Went public with an IPO on Nasdaq First North Growth in 2022.

Promimic offers a nanocoating solution for dental and orthopedic implants that caters to implant manufacturers (Figure 2). As Gothenburg is the birthplace of implants, there are potential customers in and around the city. Furthermore, the company strategically expanded into North American and Brazilian markets, securing FDA approval in the United States.

Figure 2 Promimic's Technology

Source: company data

2. Management Team

Per Kjellin, the company's founder and CTO, was inspired by hydroxyapatite, a substance studied by a colleague in the same laboratory, during his postdoctoral research. This substance forms a thin layer of 20 nanometers and can bond bones to implant materials. With promising applications in dentistry and orthopedics, Per Kjellin, along with his colleague and professor, filed a patent and set up

a company with the colleague. The professor's encouragement for postdocs to pursue entrepreneurship reflected the laboratory's enthusiasm for innovative ventures.

Later, a colleague departed to launch a new venture, leaving Per Kjellin as the sole executive. Subsequently, Kjell chose to relocate the office to the university's incubator facility, where the company stayed for seven years. During this time, Chalmers Ventures offered valuable management guidance and networking support.

Mattias Münnich was a mentor sent by Chalmers Ventures and was also involved in Stayble Therapeutics. After assuming the role of the Director of Business Development at Promimic, Münnich additionally took on the position of COO at Stayble.

Ulf Brogren was another mentor sent. With the company lacking personnel with management expertise, Brogren, experienced in leading small- and medium-sized enterprises, was well suited to the CEO role. In response to CTO Kjell's request, Brogren assumed the position in 2008, two years after the company was founded. Recognizing the importance of expanding into North America and Brazil for the growth of orthopedic operations, he relocated to the United States to focus on sales to implant manufacturers.

When the business gained traction, a decision was made to appoint a CEO in Sweden. In 2017, Magnus Larsson, an experienced sales representative in the life science industry working for an implant manufacturer in Gothenburg, joined as the new CEO.

3. Management Resources and Strategies

The company originally operated within the university's incubator facility. In 2016, it moved to an incubator within the city's AstraZeneca facility. This incubator aimed to expand AstraZeneca employees' life science knowledge beyond the pharmaceutical field. Promimic qualified for tenancy in the incubator as a provider of implant materials. Resident companies were not only granted access to AstraZeneca's facilities and equipment but also gained the advantage of connecting with experts experienced in FDA applications. Promimic effectively utilized these benefits.

External investment initially consisted of joint contributions from government and university funding. In addition to funding from Chalmers University of Technology, the Karolinska Institute in Stockholm also provided financial support. Business angels are frequently aligned with government funds invested in companies. Additionally, it succeeded in raising capital from domestic venture capitalists.

Until the IPO, the company maintained a lean staff comprising just two full-time employees who were former postdoctoral fellows from the Chalmers University of Technology and the University of Gothenburg. They are likely to progress from internships to full-time roles.

Promimic's customers of the mimic are implant manufacturers. Following successful global expansion into the U.S. and Brazil, the company expanded to Germany, France, and Switzerland. The

company's business encompasses three main areas: licensing finished recipes, supporting clients' R&D on an uptime basis, and providing customized products to meet clients' needs. The third area is managed through a joint venture (JV) established with investment from the U.S. partner company Danco Medical. The JV helped Promimic establish a foothold in the U.S., and Brogren returned to Sweden in 2022 after a long stint there.

Following the 2022 IPO, the company bolstered its organizational structure by hiring 10 technical personnel and 4 staff members in management and sales. While contemplating potential expansion into Japan and China, the company's primary focus remains on solidifying its presence in the U.S. market. Promimic's significant advantage lies in its extensive intellectual property portfolio related to the solvent recipes. Here is a concise overview of its IP acquisitions.

- 2005: First patent application (2 founders: postdoc and professor)
- 2008: Second patent (1 founder: postdoc)
- 2015–16: Strategic partnerships with implant manufacturers in Brazil and the U.S. are believed to have begun
- 2017: Dental implant material receives FDA approval in the U.S.
- 2019: Spinal implant material receives FDA approval in the U.S.
- 2020: Modified spinal implant material receives FDA approval in the U.S.

As of 2022, Promimic has obtained FDA approval for 10 products, with ongoing clinical trials aiming to achieve 16 FDA approvals in the coming years.

VI. Conclusion

In conclusion, I would like to summarize how start-ups are created through entrepreneurial education at the University of Gothenburg and highlight the start-ups' management characteristics.

1. Mechanisms Underlying the Creation of Surrogate and Non-surrogate Entrepreneurship

By comparing Stayble Therapeutics and Promimic, I summarize the mechanisms that foster these two types of start-ups.

(1) CSE's Approach to Building Surrogate Entrepreneurship

CSE's entrepreneurship program has led to numerous start-ups spanning various fields, such as cleantech products and services, measurement and precision instruments for niche areas, and materials not limited to life science. Young entrepreneurs have ventured into diverse areas.

The program, developed and refined over two decades, imparts crucial entrepreneurial knowledge before students progress to practical business launches. In the first year, students undergo

entrepreneurial simulation training, choose technology seeds, and form management teams. The second year encourages students to launch their start-ups swiftly with support from the university's incubator and mentoring programs. In cases where major obstacles to the market launch arise, students are guided to either change direction or discontinue the project. Thus, the program filters out low-viability plans early.

Upon graduation, or shortly thereafter, student-founded corporations transition from the university's project room to incubators while securing funding from university and government venture capitalists. Beyond this institutional support, they benefit from robust backing from business angels operating family-run enterprises, former executives from local companies, and CSE alumni. Mentorship accumulated over many years forms a crucial backbone for young entrepreneurs.

The involvement of inventors and IP holders in the technology seeds of start-ups is limited. They lend a hand when technical guidance or explanations to sales partners are necessary, but in principle, leave management to surrogate entrepreneurs. Management advice is provided by the mentors.

(2) Frameworks for Fostering Non-surrogate Entrepreneurship

The ownership of intellectual property by individuals rather than the university is a characteristic feature of Sweden. With the option for individuals to manage their IPs, commercializing intellectual property can generate significant returns for faculty members and researchers. In non-surrogate entrepreneurship, young PhD students and postdocs are highly motivated to start businesses using their technologies. If start-ups from the same laboratory grow and reach milestones, such as acquisitions or IPOs, they become role models. Encouraged by such success stories, young researchers begin to heed the advice of their teachers and seniors and embarked on entrepreneurship. Upon starting a business, they assume the role of a Chief Technology Officer (CTO) and recruit suitable individuals for CEO positions. The management selection process involves the participation of university incubators and mentors. Undoubtedly, mentorship plays a crucial role.

2. Resource-Efficient Start-up Management

Both surrogate and non-surrogate start-ups are resource-efficient, relying on funding from university and government-affiliated VCs, as well as investments from local business angels.

(1) Minimal Organizational Structure

Both companies have adopted a lean organizational structure with a minimal number of personnel. Directors also hold concurrent positions in other companies. Non-executive directors are selected from among individuals holding positions in hospitals and universities. Local university graduates are brought in as interns or part-time workers.

(2) Utilization of External Expertise

In the life science sector, obtaining FDA approval is just a critical first milestone. To disseminate new treatments or formulations successfully, recommendations or endorsements of medical doctors and professionals remain essential. Therefore, both companies have established dedicated technical advisory boards separate from their management boards (boards of directors). These boards comprise physicians from collaborating medical institutions involved in clinical trials alongside international researchers and executives from global corporations. These non-executive directors actively promote the adoption of new therapeutic technologies and formulations. They also leverage their professional connections to support start-ups. Notably, physicians and researchers from international hospitals, as well as executives from global corporations, strongly back start-ups in their endeavors to expand global sales channels.

(3) Profit Model for Businesses with Limited Management Resources

Both companies specialize in R&D without manufacturing capabilities. They own patents specifying ingredients and materials and establish manufacturing methods. Their revenues are generated by selling finished products to clients through manufacturing outsourcing or licensing recipes. In addition to out-licensing, Promimic's revenue model includes consulting services to assist clients with development as well as crafting bespoke products for companies seeking tailor-made solutions. Securing U.S. FDA approval in 2017 allowed the company to establish three pillars of business, all of which are low-risk and consistently generate steady returns.

Obtaining FDA approval enables Stayble Therapeutics to explore diverse revenue models. The expertise and network of non-executive directors acquired through Promimic's success will also prove valuable in the concurrent management of Stayble Therapeutics supported by a parallel management team.

(4) Limited Overseas Resources

Although Sweden has a population of about 10 million, some readers might expect a significant influx of foreign students and VC investment because of its membership in the EU.｜ However, the number of international students in Gothenburg is not as high as in other major hubs such as the United States or the United Kingdom. Securing funding abroad is also a challenge. While the CSE actively welcomes students from Asia and Africa, many entrepreneurs who establish start-ups after graduation are Swedish, particularly those from the Gothenburg area. This is in contrast to Stockholm, where a significant number of foreign talent are present, both in management and among start-up employees. It can be said that in Gothenburg, homegrown local talent generally drives the entrepreneurial scene within start-ups. Gothenburg start-ups often struggle to attract overseas VC funding, as evidenced by our two case studies, neither of which raised funding from overseas VCs. In some cases, Gothenburg

start-ups even choose to relocate to Stockholm to gain better access to international VC investments.

(5) Implications

In conclusion, let us consider the implications of establishing and growing academic start-ups. First, for products and services with high scientific and technological standards, it is advisable to form a management team that combines young entrepreneurs with experienced executives, regardless of whether they follow a surrogate or non-surrogate type. In the case study discussed in this paper, a mentor assigned by a venture capital company assumed the role of CEO to support young surrogate entrepreneurs and postdoctoral researchers in bringing their technologies to the market. Additionally, for the surrogate type, it is essential to clearly define the scope and duration of inventors' involvement in providing technology seeds for management.

Limited access to overseas funding is a common challenge shared by other countries, such as Japan. Consequently, maximizing the potential of local human resources and domestic venture capital is an essential priority. Furthermore, adopting a lean organizational structure is important for achieving a diversified revenue model with a minimum organizational setup. This strategy can be strengthened by utilizing dual- or part-time appointments and providing expert advisors. The entrepreneurship model developed in Gothenburg stands in stark contrast to the Silicon Valley model of achieving rapid market realization fueled by substantial VC funding and the recruitment of top talent. These management strategies may offer relevant insights for start-ups worldwide.

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