



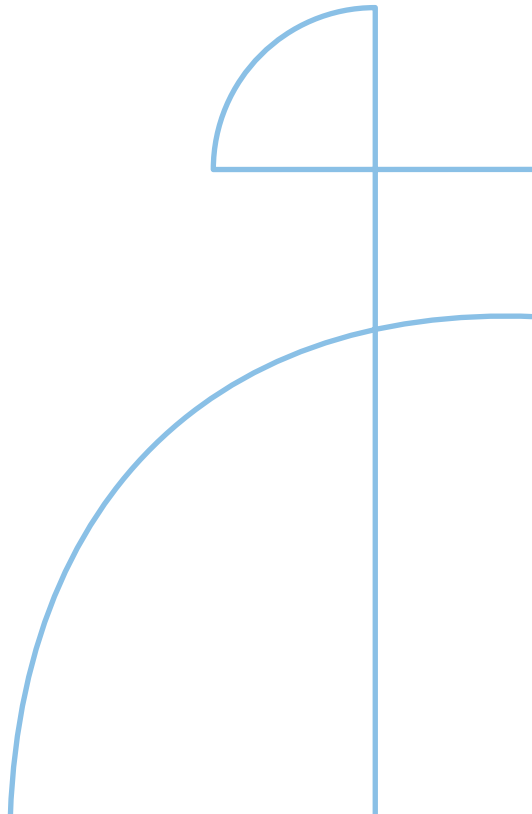
Doctoral Thesis in Business Studies

Navigating resource constraints in biotechnology firms

Financing, incubators and entrepreneurial strategies in
Sweden's clustered innovation environment

KRITTHANA KIMUAM

KTH ROYAL INSTITUTE OF TECHNOLOGY



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Academic Dissertation which, with due permission of the KTH Royal Institute of Technology, is submitted for public defence for the Degree of Doctor of Philosophy on Monday the 15th of June 2026, at 1:00 p.m. in Kollegiesalen, Brinellvägen 8, Stockholm.

Doctoral Thesis in Business Studies
KTH Royal Institute of Technology
Stockholm, Sweden 2026

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TRITA-ABE-DLT- 2622
ISBN 978-91-8106-653-1

Printed by: Universitetservice US-AB, Sweden 2026

Abstract

Biotechnology is a knowledge-intensive industry characterized by long development timelines, high uncertainty, and substantial resource requirements. Firms in this sector often depend heavily on external financial, institutional, and knowledge-based resources to sustain research and development and progress toward commercialization. Despite strong public support, biotechnology firms in Sweden continue to face persistent resource constraints that shape their growth trajectories and strategic choices. This thesis examines how biotechnology firm access, mobilize, and manage critical resources for growth within Sweden's clustered and institutionally structured innovation environment. The thesis comprises four complementary studies that provide a multi-level analysis of biotechnology firm development. The first study quantitatively examines how access to external financing and locating in cluster areas influence firm survival. The second study explores how biotechnology incubators strategically build and manage networks to secure essential resources for early-stage ventures. The third study investigates how biotechnology entrepreneurs perceive and navigate evolving resource constraints and institutional support across different development stages. The fourth study analyzes how intellectual capital and innovation activities shape biotechnology firms' capital structure decisions, particularly their reliance on equity versus debt financing.

The findings show that biotechnology firm development is shaped not only by resource availability but also by how resources are coordinated and strategically mobilized over time. Public funding supports early value creation, incubators

function as active resource coordinators, entrepreneurs adapt strategies as resource needs evolve, and financing decisions reflect pragmatic trade-offs related to innovation and intangible assets. Overall, the thesis contributes to research on biotechnology entrepreneurship by integrating financial, institutional, and strategic perspectives and offers insights for policymakers, incubator managers, and entrepreneurs in science-based industries.

Keywords

Biotechnology entrepreneurship, resource orchestration, innovation clusters, incubators, external funding, firm survival, capital structure, Sweden

Sammanfattning

Bioteknik är en kunskapsintensiv bransch som kännetecknas av långa utvecklingstider, hög osäkerhet och omfattande resursbehov. Företag inom denna sektor är ofta väldigt beroende av externa finansiella, institutionella och kunskapsbaserade resurser för att kunna bedriva forskning och utveckling för att kommersialisera produkter och tjänster. Trots omfattande offentligt stöd fortsätter bioteknikföretag i Sverige att möta resursbegränsningar som påverkar deras tillväxt och strategiska val. Denna avhandling undersöker hur bioteknikföretag får tillgång till, mobiliserar och hanterar kritiska resurser för att skapa tillväxt inom Sveriges klusterbaserade och institutionellt strukturerade innovationsmiljö. Avhandlingen består av fyra kompletterande delstudier som tillsammans ger en flernivåanalys av bioteknikföretags utveckling. Den första studien analyserar kvantitativt hur tillgång till extern finansiering och lokalisering i kluster påverkar företags överlevnad. Den andra studien undersöker hur bioteknikinkubatorer strategiskt bygger upp och hanterar nätverk för att kunna säkra viktiga resurser för företag i tidiga utvecklingskedan. Den tredje studien belyser hur bioteknikentreprenörer uppfattar och hanterar föränderliga resursbegränsningar och institutionellt stöd i olika utvecklingsfaser. Den fjärde studien analyserar hur intellektuellt kapital och innovationsaktiviteter påverkar bioteknikföretags kapitalstruktur, särskilt deras användning av eget kapital respektive skuldfinansiering.

Resultaten visar att bioteknikföretags utveckling inte enbart formas av tillgången till resurser, utan också av hur dessa resurser samordnas och mobiliseras strategiskt över tid. Offentlig finansiering bidrar till tidigt

värdeskapande, inkubatorer fungerar som aktiva resurskoordinatorer, entreprenörer anpassar sina strategier i takt med att resursbehoven förändras, och finansieringsbeslut präglas av pragmatiska avvägningar kopplade till innovation och immateriella tillgångar. Sammantaget bidrar avhandlingen till forskningen om bioteknikentreprenörskap genom att integrera finansiella, institutionella och strategiska perspektiv. Den erbjuder även insikter för beslutsfattare, inkubatorledare och entreprenörer verksamma i kunskapsintensiva och forskningsbaserade industrier.

Nyckelord

Bioteknikentreprenörskap, resursorkestrering, innovationskluster, inkubatorer, extern finansiering, företagsöverlevnad, kapitalstruktur, Sverige

Acknowledgments

I would like to express my sincere gratitude to all the people who have supported me, encouraged me, and stood by me throughout my journey toward becoming a Ph.D. and completing this doctoral thesis. This work would not have been possible without the kindness, guidance, and understanding of many people around me.

First and foremost, I would like to express my deepest and most heartfelt gratitude to my main supervisor, Prof. Björn Berggren. I feel truly fortunate to have been a doctoral student under his supervision. His guidance, patience, and trust have meant a great deal to me throughout my Ph.D. journey. He has continuously supported my academic development while also giving me the freedom to grow as an independent researcher. I still remember the first time I met him at the Education Expo in Thailand in 2019. That meeting marked the beginning of an important chapter in my life, and I am always grateful for the opportunity he gave me to pursue my doctoral studies at KTH.

I would also like to extend my sincere thanks to my co-supervisor, Andreas Fili, for his valuable comments, guidance, and support during my doctoral studies, especially during the interview process of our research paper. His insights and encouragement have contributed greatly to the development of this thesis.

My sincere thanks also go to my co-supervisor, Inga-Lill Söderberg, for her support, thoughtful feedback, and encouragement throughout the research process. I truly appreciate her time, knowledge, and kindness.

A very special thanks goes to my lovely friend, Ida Ayu Agung Faradynawati. Thank you for your friendship, your constant support, and always being there for me through both academic and personal challenges. Your help has meant so much to me, and I am especially grateful for our collaboration as co-author on one of the papers included in this thesis.

I would also like to thank my lovely friend Hui Zhu for the support, encouragement, and kindness shown throughout this journey. Your friendship has been deeply appreciated. The activities and foods we shared with Ida, Hsu-Chi, and Tianmin were so fun and memorable.

My warm thanks also go to Hsu Chi for being such a good friend and office neighbor, sharing conversations during lunch, and everyday moments in the office.

I would like to express my sincere appreciation to Anna Broback, Head of Division, for her support and encouragement. I am grateful for the positive and supportive environment she helped create.

I would also like to express my gratitude to all my colleagues at the Department of Real Estate and Construction Management. In particular, I would like to thank my friendly colleagues in the Division of Real Estate Business and Financial Systems for their support and kindness.

My sincere thanks also go to the opponent at my final seminar for his constructive feedback. His comments were highly valuable and helped me improve this thesis. I would also like to thank my advance reviewer for feedback and improvement of the thesis.

I would also like to thank my doctoral colleagues and friends, including Joakim Fichtel, Kanha Teang, Loi Dang, and Shufan Ma, for sharing this journey with me. My thanks also go to former Ph.D. colleagues, Cinthia Sin Tian Ho, Zisheng Song, Jing Su, and Olli Vigren, for their encouragement and for generously sharing helpful advice and constructive suggestions during my Ph.D. studies.

In addition, I would like to express my sincere gratitude to all administrative staff for their support with practical matters throughout my studies. In particular, I would like to thank Tora Hedenvind and Marie Larsson for all their help with administrative matters, which made everyday academic life much easier.

I would also thank Schwann, my dear friend of over 22 years, for always being there for me throughout so many stages of life. Even while living in the UK, you have always been just a phone call away, ready to listen, give advice, and talk through everything with me. I am deeply grateful for your constant support, understanding, and friendship over the years. I also treasure all the wonderful trips we have shared, including trips to Liverpool, Edinburgh, Glasgow, and France. Those memories, along with your unwavering presence and encouragement, have brought so much warmth and strength to my journey.

I would like to thank Jay, Sujet Phodaphol, for being such a wonderful friend during my first two years in Stockholm. Thank you for the weekends we spent travelling and exploring Stockholm together. From our trips to France and the Dolomites to many other adventures along the way, those moments brought so much joy, excitement, and comfort to my life abroad. Your friendship, companionship, and the many shared experiences made my time in Stockholm much happier.

I would also be deeply thankful to my Thai friends in Stockholm, Ohm, Kla, Ping, Pae, Prem, Dell, Paris, Friend, Firm, Pat, Fah, Mi, Joey, Nont, Phoom, Jeen, and others for their unconditional companionship, encouragement, and support throughout my doctoral journey. Being far from home can be challenging, and your friendship made Stockholm feel warmer and more like home. I am also grateful for the joyful moments, laughter, food, and time shared with you guys.

Our Friday gathering and Saturday badminton brought so much happiness, fun, and positive energy into my life.

I would also like to gratefully acknowledge the Royal Thai Government Scholarship (OCSC) for funding my Ph.D. studies at KTH Royal Institute of Technology. This financial support made my doctoral education possible, and I am deeply thankful for this opportunity.

Finally, I would like to express my deepest love and gratitude to my parents, my relatives, and my friends in Thailand. Thank you for your endless love, belief, understanding, and encouragement. Even from afar, your support has always been my source of strength. Your faith in me has carried me through the most difficult moments and reminded me why I started this journey in the first place.

This thesis is dedicated, with love and gratitude, to everyone who has been part of this journey.

Kritthana Kimuam
Stockholm, May 2026

List of publications

Paper 1 Kritthana, Kimuam., Björn, Berggren. (20xx), Do funding and Cluster Reduce Future Bankruptcy Risk? A Longitudinal Study of Swedish Biotechnology Firms.

This manuscript is going to be submitted to the Journal of Engineering and Technology Management

Paper 2 Kritthana, Kimuam., Andreas, Fili. (20xx), Resource Coordination and Control through Strategic Networking: Insights from Biotechnology Incubators in Sweden.

This manuscript has been submitted to the European Journal of Innovation Management and is currently under the 2nd round review.

Paper 3 Kritthana, Kimuam., Inga-Lill, Söderberg. (2026), Entrepreneurial Perspectives on Support for Biotechnology Firms in Sweden, International Journal of Innovation Science.

This manuscript has been accepted for publication in the international Journal of Innovation Science

Paper 4 Kimuam, K., Berggren, B., & Faradynawati, I. A. A.. Capital Structure Decisions in Swedish Biotechnology Firms: The Role of Intellectual Capital and Innovation Activities. International Journal of Financial Studies, 13(1), 43. <https://doi.org/10.3390/ijfs13010043>

List of abbreviations

R&D	research and development
USD	United States Dollar
UK	United Kingdom
US	United States
VC	venture capital
IC	intellectual capital
VAIC	value added intellectual coefficient
HRs	hazard ratios
PH	proportional hazards

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1 Introduction

This section presents the background and motivation of this thesis, which serves as the foundation of its overall purpose. It also outlines four research questions derived from this purpose and explains how they relate to individual papers included in this thesis. This section concludes with an overview of the thesis structure.

1.1 Background

Biotechnology has emerged as one of the most transformative and strategically significant sectors in the global knowledge economy. Its scientific foundations have advanced at an unprecedented pace, driven by developments in genomics, proteomics, metabolomics, synthetic biology, bioinformatics, and gene-editing tools (Aguilar et al., 2009; Gartland et al., 2017). These technologies have expanded the sector's reach beyond traditional pharmaceuticals to encompass personalized medicine, advanced diagnostics, regenerative therapies, precision agriculture, industrial bioprocess engineering, and sustainable biomaterials. Today, biotechnology plays a central role in addressing global challenges related to human health, food security, demographic pressures, and the transition toward low-carbon and circular forms of production (Dey, 2025). According to global industry estimates, the sector experienced a worldwide growth rate of approximately 1.3% between 2015 and 2020, with projections indicating continued expansion as research and development (R&D) spending rises across regions (Martin et al., 2021). This sustained growth reflects biotechnology's

emergence as a core enabling technology for next-generation therapeutic development, industrial innovation, and sustainable bioproduction.

Despite the sector's dynamism, biotechnology remains a complex and resource-intensive domain, characterized by long development horizons, scientific uncertainty, and exceptionally high capital requirements. Global comparative data show that biotechnology activity is heavily concentrated in high-income countries where scientific excellence, capital availability, and institutional support reinforce one another. The United States, for example, hosts more than 318 large and publicly listed biotechnology companies, commands a market size exceeding USD 100 billion, and invests over USD 20.5 billion annually in biotechnology R&D (Martin et al., 2021). Europe exhibits similar concentrations of activity. Germany, France, and the United Kingdom are consistently ranked among the world's top contributors to biotechnology publications and innovation (Yeung et al., 2019). European biotechnology research spans industries such as pharmaceuticals, food and feed, chemicals, textiles, and environmental protection (Gartland et al., 2013). Figure 1 further illustrates that biotechnology is not a single uniform sector, but a highly diversified field composed of several subdomains. These segments differ in their scientific bases, application contexts, and commercialization pathways. These differences shape firms' resource needs, regulatory demands, and development trajectories. This diversity is particularly important for understanding biotechnology firms, as it helps explain why access to financial, scientific, and institutional support varies across contexts. These patterns highlight both the vast potential of biotechnology and the structural challenges faced by firms, particularly startups. These challenges arise as firms seek to access the financial, scientific, regulatory, and institutional resources required for successful development (Chiaroni & Chiesa, 2006; Pourhamidi, 2012).

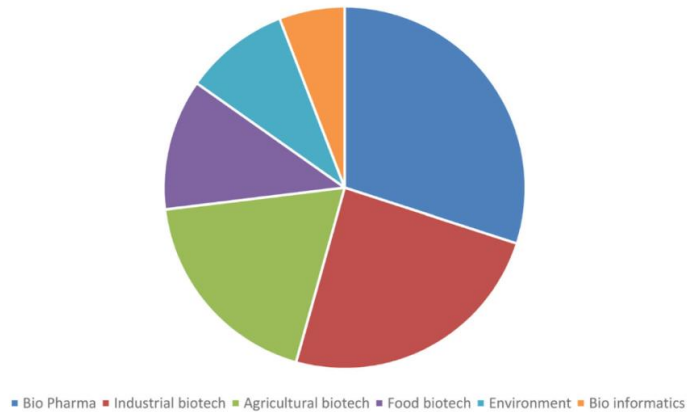


Figure 1: Categories within the global biotechnology industries (Martin et al., 2021).

These obstacles have intensified international discussion about how to strengthen biotechnology development and improve the conditions under which new biotechnology ventures emerge. Biotechnology startups operate under significantly greater uncertainty than firms in many other sectors (Domonkos, 2010). They often require access to specialized laboratory facilities, highly trained scientific personnel, regulatory expertise, and advanced testing environments (Dolgin, 2013; Fruehauf, 2024). Their R&D cycles frequently span a decade or more, during which firms may operate without revenues and with limited tangible assets that can be used as collateral (Kang & Park, 2012). As global investment data demonstrate, biotechnology innovation is strongly shaped by public funding and institutional legitimacy, especially in early stages where private investors perceive high levels of technological and market risk (Shin et al., 2019; Shin et al., 2017). In response, many countries have expanded structured support systems aimed at reducing entry barriers, accelerating scientific translation, and facilitating the resource mobilization needed for firms to progress from research to market.

One influential framework for improving biotechnology development is the concept of regional innovation clusters, geographically concentrated systems that bring together universities, hospitals, research institutes, incubators, science parks, investors, and established firms (Gilding et al., 2020;

Vlaisavljevic et al., 2020). Clusters enhance the efficiency and effectiveness of biotechnology innovation by creating environments in which knowledge flows more quickly and collaboration is more frequent. They also improve resource access through repeated interaction, shared infrastructure, and coordinated support mechanisms. International examples such as Boston, the San Francisco Bay Area, Cambridge (UK), and Munich demonstrate how spatial concentration, network density, and institutional coordination can accelerate firm formation and reduce the structural disadvantages typically faced by early-stage biotechnology ventures (Chiaroni & Chiesa, 2006; Dorocki, 2014; Sopoligová & Pavelková, 2017). These clusters rely not only on physical proximity but also on social, cognitive, and institutional proximity, enabling the exchange of tacit knowledge, trust-based collaboration, and rapid recombination of scientific and commercial expertise.

Within these clusters, multiple actors perform distinct but complementary roles in shaping the innovation landscape. Universities and research hospitals generate new scientific knowledge and serve as platforms for spin-off creation (Chen & Lin, 2017). Incubators and science parks provide laboratory infrastructure, business development support, mentoring, regulatory guidance, and access to scientific networks (Leitão et al., 2022). Investors—including public agencies, venture capital firms, and angel networks—supply financial capital and strategic expertise, often playing a critical role in guiding firms through long and uncertain development cycles. Government agencies and innovation bodies design funding schemes, regulatory frameworks, and policy instruments that can either enable or constrain biotechnology development (Vlaisavljevic et al., 2020). Together, these actors form the backbone of the biotechnology cluster. They influence how firms access, integrate, and leverage resources over time.

Sweden provides an analytically compelling setting for examining these processes. The country hosts over 3,800 life-science and biotechnology firms, employs approximately 50,000 people in the sector, and maintains strong export performance driven by pharmaceuticals and medical technologies (SwedenBIO, 2025). Sweden's major biotechnology clusters, particularly Stockholm–Uppsala, Gothenburg, and the cross-border Medicon Valley region, are anchored by globally recognized universities, specialized incubators, research hospitals, and public funding agencies such as Vinnova and

Tillväxtverket (Government Offices of Sweden, 2020). However, despite its sophisticated scientific base, Sweden exhibits regional variation in capital access, managerial expertise, and institutional support. Biotechnology firms face persistent challenges in securing early-stage financing, obtaining specialized laboratory facilities, navigating regulatory demands, and accessing market-oriented resources as they progress through development stages (Nilsson, 2001; Valentin et al., 2007). These structural features make Sweden a particularly suitable context. This context allows investigation of how resource-constrained biotechnology ventures navigate regional conditions and institutional environments.

Although previous research has addressed various aspects of biotechnology development, several important gaps remain. First, there is limited empirical understanding of how different forms of external financing and locating in cluster area affect biotechnology firms' survival in smaller innovation economies such as Sweden. Second, despite the recognized importance of biotechnology incubators, little is known about how they strategically build and orchestrate networks to secure critical resources for early-stage ventures. Third, biotechnology research often overlooks entrepreneurs' own perspectives, providing limited insight into how founders interpret and respond to evolving resource constraints across different stages of firm development. Finally, although biotechnology is one of the most intangible-asset-intensive industries, relatively few empirical studies examine how intellectual capital and innovation outputs shape firms' financing decisions over time.

To address these gaps, this thesis adopts an empirically oriented and multi-method approach to examine biotechnology firm development in Sweden. The analysis focuses on firm-level financing outcomes, the role of incubators as intermediary organizations, and entrepreneurs' experiences of resource constraints within a clustered and institutionally structured innovation environment. By combining quantitative analyses with qualitative insights, the thesis examines how resources are accessed, coordinated, and managed across different stages of firm development. This framing provides the basis for the research purpose and questions presented in the following section.

1.2 Purpose of the study and research questions

The purpose of this thesis is to provide a comprehensive understanding of how biotechnology firms in Sweden access and manage the resources necessary for growth within a clustered and institutionally structured innovation environment. Sweden's biotechnology sector is organized around strong regional clusters, where firms rely heavily on external financial, institutional, and knowledge-based resources. Through four complementary studies, the thesis investigates (see Figure 2): (1) how external financing and cluster location affect firms' survival; (2) how incubators within these clusters build and orchestrate networks to secure essential resources for early-stage ventures; (3) how entrepreneurs navigate evolving resource constraints across development stages; and (4) how intellectual capital and innovation activity shape firms' financing decisions. Together, these studies provide complementary insights into the financial and institutional mechanisms that enable or constrain firm development within Sweden's biotechnology clusters.

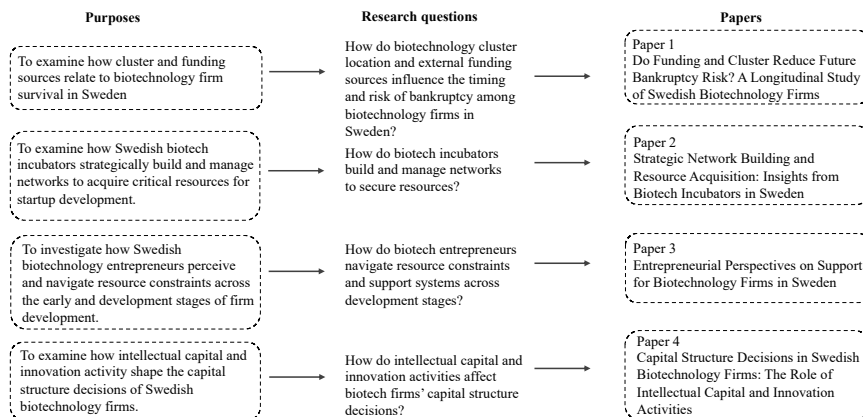


Figure 2: The purposes, research questions, and papers.

This thesis takes the biotechnology firm as the primary unit of analysis and examines how firms navigate resource constraints across development stages in Sweden. The main analytical lens is resource navigation and resource orchestration over time, how firms access, mobilize, and recombine critical financial, knowledge-based, and institutional resources under high uncertainty. Cluster and institutional conditions are treated as contextual structures that

shape resource availability, legitimacy, and constraints, while incubators and inter-organizational networks are conceptualized as intermediary mechanisms through which resources are accessed and coordinated. The thesis connects these contexts and mechanisms to firm-level outcomes, including survival risk, value creation, and financing choices.

The first study examines whether biotechnology cluster location and external funding reduce future bankruptcy risk among Swedish biotechnology firms. The purpose is to assess how cluster and funding sources relate to firm survival by analyzing the timing and likelihood of bankruptcy in the Swedish biotechnology sector.

Biotechnology firms operate under long, expensive, and uncertain R&D cycles. Many ventures spend years in scientific development, validation, and regulatory preparation before generating stable revenues. As a result, biotechnology firms are structurally more exposed to liquidity constraints and external shocks than firms in many other industries. In such settings, understanding the conditions that shape continued operation versus premature exit is central for explaining why some firms persist long enough to reach commercialization while others do not.

External financing is therefore a critical feature of biotechnology firm development, but its implications may vary by funding source. Public funding instruments (e.g., grants and publicly supported schemes) are often designed to support experiments and capability-building under uncertainty, particularly in early development phases. Private investment can provide larger resource injections and strategic support, but may differ in timing, selection criteria, and expectations. Distinguishing between public and private funding helps clarify how different financing environments relate to firm trajectories in a science-based sector.

Beyond finance, the geographic proximity may shape firms' ability to access and mobilize resources. Biotechnology clusters can concentrate specialized infrastructure, skilled labor, research organizations, and intermediaries that facilitate collaboration, knowledge exchange, and legitimacy-building. These

features can influence both the opportunities available to firms and how effectively they can translate resources into progress over time. Because cluster benefits may vary across stages of development, it is important to examine cluster location together with funding conditions rather than treating either factor in isolation.

This question is particularly important in Sweden, where biotechnology is an expanding part of the national innovation system, and the sector is dominated by small and medium-sized firms that often operate for extended periods without stable revenues. With substantial public investment in life-science innovation alongside an increasing presence of private capital, examining how funding sources and cluster context relate to firm trajectories provides relevant insight for entrepreneurs, investors, and policymakers concerned with sustaining science-based ventures through high-uncertainty development periods.

RQ1: How do biotechnology cluster location and external funding sources (public and private) influence the timing and risk of bankruptcy among biotechnology firms in Sweden?

The second study explores how biotechnology incubators build, coordinate, and manage networks to secure critical resources for early-stage firms. The purpose is to understand the mechanisms through which incubators facilitate resource acquisition within the biotechnology ecosystem.

Biotechnology incubators strategically build and manage networks with a variety of stakeholders to acquire essential resources for their incubated firms (Fruehauf, 2024). This interconnectivity facilitates not only access to financial resources but also enhances human, operational, and technical resources that are vital for the growth and success of biotechnology startups (Wu et al., 2022).

One significant way that biotechnology incubators create value is through collaborative relationships with universities. Research indicates that biotechnology firms increasingly depend on the knowledge and capabilities of

academic institutions, as universities provide a fertile ground for innovative ideas and breakthroughs in the biopharmaceutical sector (Triulzi et al., 2013). Close interactions between biotechnology firms and universities can result in the generation and diffusion of new scientific knowledge, thereby promoting a more robust innovation landscape (Triulzi et al., 2013). This relationship is further beneficial as incubators can assist in bridging the gap between fundamental research and commercialization which can enable startups to leverage academic advancements (Alves et al., 2014). The proximity and collaboration with academic partners enhance the legitimacy and credibility of incubated firms, making it easier for them to attract funding from institutional investors and government grants (Bialek-Jaworska & Gabryelczyk, 2016).

Venture capital and business angel networks play a crucial role in the support structures that biotechnology incubators mobilize for their startups. Beyond providing financial backing, these networks also serve as gateways to broader knowledge flows and strategic connections. Research shows that incubators often act as network brokers, linking startups to formal investors and banks, thereby increasing their chances of securing external funding and positioning them to pursue innovative opportunities (Van Rijnsoever et al., 2017). Furthermore, incubators that establish strong linkages with venture capital actors may increase the likelihood of investment flowing into their startups, as such ties create visibility and access to financial backers seeking promising ventures (Guo, 2012). Evidence from biotechnology clusters further highlights that the innovative capacity of startups is not determined by location alone. It is also shaped by the quality and intensity of communication networks. Strong and dynamic ties with universities, large pharmaceutical companies, and peers enhance firms' knowledge sharing and innovative output, particularly when startups are embedded in the communication core of these networks (Allen et al., 2016). In this way, incubators that cultivate both financial and knowledge networks help startups navigate the complexities of the biotechnology sector and strengthen their potential for long-term success.

Government support is another critical element in the network structure of biotechnology incubators. Public policies and funding initiatives often target the biotechnology sector to foster economic development and innovation. This governmental backing can manifest in various forms, such as financial incentives, grants for R&D, and infrastructural support (Curran et al., 2015).

Incubators frequently act as intermediaries with government bodies, facilitating access to programs designed to stimulate enterprise growth and technological advancement (Rachman et al., 2024). The success of incubated firms in securing governmental funding can also be attributed to the incubators' established credibility and track record of supporting startups (Novanda, 2022).

Networking with other incubators further enriches the resource pool available to biotechnology startups. Collaboration among incubators can lead to shared resources and best practices, amplifying the support system for new ventures. This interconnectedness allows incubators to learn from one another and adapt successful strategies, enhancing their operational effectiveness and service offerings (Binsawad et al., 2019; Lasrado et al., 2016). Such collaborative networks facilitate resource-sharing, mentorship opportunities, and combined access to advanced facilities and technologies, which are indispensable for the growth trajectories of biotechnology companies (Loganathan & M H, 2022).

Despite the recognized importance of incubators as intermediary organizations, existing research provides limited empirical insight into how incubators actively build, coordinate, and manage networks to secure critical resources in practice, particularly within science-based sectors such as biotechnology. Most studies emphasize the outcomes of incubation rather than the underlying strategies and mechanisms through which networks are orchestrated. This study addresses this gap by examining the network-building practices of biotechnology incubators in Sweden, focusing on how they mobilize diverse partners to support early-stage firms. Accordingly, the following research question is formulated:

RQ2: How do biotechnology incubators strategically build and manage networks to acquire essential resources?

The third study investigates how biotechnology entrepreneurs navigate shifting resource constraints as their firms progress from early development to later stages. The purpose is to capture how entrepreneurs perceive, respond to, and manage evolving support needs across the firm lifecycle.

Biotechnology entrepreneurship is characterized by high resource intensity, long development timelines, and significant uncertainty. Entrepreneurs in this sector must manage capital-intensive research and development (R&D) projects, navigate complex regulatory processes, and secure pathways to market, all while operating with limited resources (Meramo et al., 2022). These conditions make resource constraints a defining challenge for biotechnology startups, compelling entrepreneurs to seek innovative strategies for survival and growth.

Prior research has identified several mechanisms through which biotechnology firms attempt to mitigate these constraints. Collaborative partnerships with pharmaceutical incumbents, for example, provide access to financial resources, technical expertise, and market credibility that enhance startup legitimacy (Beaudry, 2014; Harada et al., 2021). Financing strategies also vary by development stage. While early-stage ventures often rely on angel investors, government grants, and early-stage venture capital, later-stage firms typically access larger private investments to fund scaling and commercialization (Chen et al., 2011; Ullah et al., 2010). Institutional support mechanisms such as incubators, public funding agencies, and innovation programs further contribute by offering not only financial assistance but also networks, mentoring, and strategic advice (Didoni, 2020; Loganathan & M H, 2022; Tatoud et al., 2024).

Although these studies shed light on specific support mechanisms, they tend to treat resource acquisition as structural or stage-specific processes rather than dynamic practices enacted by entrepreneurs. Less attention has been devoted to how biotechnology entrepreneurs themselves perceive and navigate resource constraints across successive stages of development. This gap is critical because resource challenges evolve over time. Early ventures seek legitimacy and seed funding, whereas later-stage firms must address scaling, regulatory hurdles, and competitive positioning (Ahn et al., 2011; Marrus & Blaho, 2023). Understanding how entrepreneurs perceive, interpret, and navigate resource constraints and support systems across development stages is therefore essential for capturing the lived dynamics of biotechnology entrepreneurship.

While prior studies identify key support mechanisms and resource constraints faced by biotechnology firms, they offer limited insight into how entrepreneurs themselves perceive, interpret, and respond to these challenges as their firms evolve. In particular, little is known about how founders navigate changing support systems and adjust their strategies across different development stages. By foregrounding entrepreneurs' own perspectives, this study seeks to capture the lived dynamics of resource navigation in biotechnology entrepreneurship. Accordingly, the following research question is posed:

RQ3: How do biotechnology entrepreneurs navigate resource constraints and support systems across development stages?

The fourth study analyzes how intellectual capital and innovation activities shape biotechnology firms' capital structure decisions. The purpose is to determine whether intangible assets and innovation intensity influence firms' reliance on equity versus debt financing.

Intellectual capital (IC) is a central driver of competitiveness in knowledge-intensive sectors such as biotechnology. Comprising human, structural, and relational components, IC enhances firm performance and market value while shaping strategic financing decisions (Fadaei et al., 2013; Lv & Han, 2015). However, because intangible assets are difficult to collateralize and carry uncertain returns, creditors perceive them as risky, making debt financing less feasible (Bolek & Lyroudi, 2015). Firms with strong IC therefore tend to rely more on equity financing, as investors are willing to support companies that demonstrate the capacity to leverage intangible resources for growth and innovation (Milijić & Popović, 2021). Structural capital in particular supports independent innovation and long-term expansion strategies, encouraging the use of equity over debt to maintain flexibility for R&D investment (Li et al., 2014; Pylypenko et al., 2022). While IC has been linked to performance and financing choices, its influence on capital structure decisions remains underexplored, particularly in biotechnology firms whose balance sheets are dominated by intangible resources.

Innovation activities represent another critical factor shaping capital structure. R&D and patenting drive firm growth, with patents acting as signals of innovative capacity and correlating positively with profitability and sales growth (Artz et al., 2010; Liu, 2022). Yet the risky and uncertain nature of R&D makes it difficult for biotech firms to obtain debt financing (Golej, 2016). To manage these challenges, many small and medium-sized firms engage in alliances with larger pharmaceutical companies to access resources for commercialization (Fernald et al., 2015; Schoonmaker & Rau, 2014) or turn to venture capital, which aligns with the long-term and high-risk profile of biotechnology innovation (Sohn & Kang, 2015). Equity financing is therefore particularly advantageous, as it avoids fixed repayment obligations and provides flexibility to sustain innovation (Brown & Floros, 2012). Moreover, high levels of patenting signal quality to investors and improve access to equity (Hoenen et al., 2014; Hottenrott et al., 2016). While prior studies link innovation to financing constraints, there is still limited research on how innovation intensity directly shapes the capital structure decisions of biotechnology firms.

Collectively, literature highlighted that both IC and innovation activities can influence whether biotechnology firms rely on equity or debt financing. However, the specific ways in which these resource-based and innovation-driven factors affect capital structure remain insufficiently understood. Addressing this gap is crucial for understanding financial strategy in an industry characterized by intangible assets, high R&D intensity, and uncertain revenue streams.

Although prior research suggests that both intellectual capital and innovation activities influence financing constraints, empirical evidence on how these factors shape capital structure decisions remains limited, particularly in biotechnology firms dominated by intangible assets and long development cycles. Existing studies often examine performance outcomes or financing constraints separately, leaving the relationship between innovation-driven resources and financing choices insufficiently explored. This study addresses this gap by empirically examining how intellectual capital efficiency and innovation activity influence biotechnology firms' reliance on equity versus debt financing. Accordingly, the following research question is formulated:

RQ4: How do intellectual capital and innovation activities affect biotechnology firms' capital structure decisions?

1.3 Thesis organization

This thesis contains 6 chapters. The first chapter is the introductory chapter, introducing the background, motivation, and overall purpose of the study. It presents four research questions. Chapter 2 is the literature review of concepts and theories related to the study. This chapter reviews research on biotechnology cluster development, resource acquisition, financing, and incubator support. Chapter 3 provides an overview of the Swedish biotechnology sector and describes the institutional and financial sources. Chapter 4 presents the data sources, methodological choices, and analytical procedures applied across the four studies. The chapter describes the quantitative analyses conducted in Studies 1 and 4. These analyses use firm-level data to examine survival and financing patterns. It then summarizes the qualitative components of Studies 2 and 3. These include interviews with incubators' management team members and biotechnology entrepreneurs, and the analysis procedures used to interpret these data. Chapter 5 synthesizes the key findings from the four research papers and shows how they address the overall purpose of the thesis. This chapter highlights how each study contributes complementary insights into resource acquisition, financing, support mechanisms, and development processes in Swedish biotechnology firms. It also outlines the theoretical and practical contributions of each research paper. Chapter 6 concludes the thesis by presenting the theoretical implications, practical contributions, and policy relevance of the research. It also outlines limitations and provides suggestions for future research avenues in biotechnology entrepreneurship and innovation studies. After six chapters, four research papers will be attached at the end of the thesis.

2 Literature review

This chapter develops the conceptual foundation for examining how biotechnology firms navigate resource constraints over time. The chapter is structured around a resource navigation and orchestration perspective, emphasizing how firms access, mobilize, and coordinate critical resources under uncertainty and across development stages. It then situates these firm-level processes within Sweden's clustered and institutionally structured innovation environment by reviewing (i) cluster and institutional conditions as contextual structures, (ii) incubators and networks as intermediary mechanisms enabling resource access and coordination, and (iii) financing and capital-structure perspectives explaining how resource characteristics (e.g., intangibility and innovation intensity) shape funding choices and firm outcomes.

2.1 Conceptual framework: Resource navigation in clustered institutional environments

Biotechnology ventures operate under persistent resource constraints that are unusually intense compared to many other technology sectors. These constraints are not limited to financial capital but also include access to specialized infrastructure and laboratories, regulatory and clinical expertise, and skilled scientific and managerial talent, as well as, critically, legitimacy in the eyes of investors, partners, and public agencies (Bettanti et al., 2022). In such settings, firm development depends not only on the availability of resources, but also on how firms locate, access, mobilize, and combine resources

over time as uncertainty unfolds and development needs shift across stages (Gurău & Dana, 2020; Maurer & Ebers, 2006).

To capture these dynamics, this thesis adopts resource navigation and resource orchestration as its main analytical lens. Resource navigation refers to the strategies and practices through which firms identify resource gaps, search for support, and engage with external actors to secure critical inputs for development. Resource orchestration emphasizes how firms (and supporting intermediaries) structure, bundle, and leverage resources, financial, knowledge-based, human, and relational resources to facilitate progress from scientific development to validation and commercialization. This lens highlights a process view in which resource constraints are not static. Resource problems, priorities, and solutions evolve as firms move from early development to later-stage scaling.

This thesis further situates these firm-level processes within Sweden's clustered and institutionally structured innovation environment. Clusters provide a context in which key actors such as universities, research hospitals, science parks, investors, public agencies, and established firms are geographically and socially concentrated (Delgado et al., 2016). Such concentration can shape resource access by increasing proximity to specialized knowledge, infrastructure, and collaboration opportunities, while also strengthening legitimacy through association with recognized institutions (Chen et al., 2016; Rychen & Zimmermann, 2008). At the same time, institutional structures such as public funding systems, regulatory regimes, and innovation policies shape which types of resources are available, to whom, and under what conditions. From this perspective, clusters and institutions are treated as contextual structures that influence both resource availability and governing resource mobilization (Bradley et al., 2021).

Within this context, incubators and networks are conceptualized as key intermediary mechanisms through which resource navigation becomes possible in practice. Incubators may act as brokers, coordinators, and translators between scientific entrepreneurs and external resource holders, helping firms access laboratories, mentoring, investor networks, public funding programs, and credibility signals (van Rijnsoever, 2020; Van Rijnsoever et al., 2017).

Networks that link firms to universities, clinical partners, investors, and peer ventures provide relational channels through which information, legitimacy, and resources flow (Gao et al., 2021; Van Rijnsoever et al., 2017). Importantly, intermediaries do not merely provide resources. They can shape how resources are coordinated and matched to stage-specific needs, thereby influencing how efficiently resource constraints are mitigated over time.

Finally, the framework links contextual conditions and intermediary mechanisms to firm-level outcomes and processes. In this thesis, the core observable outcomes are (1) survival-related outcomes, captured as the timing and risk of bankruptcy (RQ1), and (2) financing outcomes, captured through firms' capital structure choices and financing strategy (RQ4). In addition, the thesis examines two key process dimensions through which resources are accessed and mobilized: (3) intermediary mechanisms, focusing on how biotechnology incubators strategically build and manage networks to acquire essential resources (RQ2), and (4) firm-level resource navigation practices, capturing how entrepreneurs perceive and navigate evolving resource constraints and support systems across development stages (RQ3). Thus, these outcomes and mechanisms provide a multi-level explanation of how biotechnology firms progress under uncertainty within Sweden's clustered and institutionally structured innovation environment.

Building on this conceptual framework, the next section reviews biotechnology clusters and cluster development as the contextual conditions shaping resource access and coordination in biotechnology ecosystems.

2.2 Biotechnology cluster and cluster development

2.2.1 Biotechnology cluster

A biotechnology cluster is a geographical concentration of interconnected biotechnology-related companies, research institutions, and other organizations that have vertical or horizontal relationships. The cluster encourages cooperation, innovation, and knowledge sharing among the various biotechnology stakeholders, which fosters the creation of new products and technologies as well as greater effectiveness and competitiveness (Chiaroni & Chiesa, 2005). The biotechnology cluster has a great impact on the local and

regional economy such as the job creation (Mattsson, 2009). There are several biotechnology clusters around the world, but those biotechnology clusters focus on different industries. This is due to the fact that biotechnology is a multidisciplinary science that combines natural sciences and engineering (Dorocki, 2014). Biotechnology is the application of technological processes associated with living organisms or their components for the purpose of modifying or producing useful products ranging from genetic engineering to drug development (Dorocki, 2014). Thus, biotechnology clusters also cover a broad range of industries such as agricultural industries, pharmaceutical industries, medical diagnostics, medical devices, and forestry (Ayrapetyan & Hermans, 2020; Hermans, 2018; Kim, 2015).

2.2.2 Overview of cluster creation and cluster formation

The formation of clusters is influenced by a combination of factors, including government policies, access to finance, research institutions, and entrepreneurial activities (Dorocki, 2014; Dove, 2000). In this section, we will explore how clusters have emerged in the United States (US), the United Kingdom (UK), European countries, and Asia.

Biotechnology clusters in the United States have developed into globally leading centers. The first biotechnology clusters emerged in the 1970s, largely due to the presence of strong science-based organizations. Proximity to universities and research institutions played a pivotal role in this development, as universities contributed to entrepreneurial activity and provided highly skilled researchers (Feldman & Francis, 2002). For example, the Bay Area benefited from the University of California system, with campuses in San Francisco, Berkeley, and Davis supporting early biotechnology initiatives, including the establishment of the first biotechnology company in the late 1970s (Chiaroni & Chiesa, 2006). Similarly, the biotechnology cluster in San Diego was strongly influenced by academic spin-offs from the University of California San Diego and private research institutes (Chiaroni & Chiesa, 2005). In the early 1990s, San Diego's cluster grew rapidly due to two reinforcing dynamics. Firstly, when the large companies were acquired, many of high skilled researchers created new companies leading to a strong entrepreneurial culture. Secondly, the military downsizing in the 1990s forced a great number of highly qualified laborers to search for new jobs. Public-sector initiatives supported this transition through

targeted funds and tax incentives aimed at fostering new biotechnology companies.

In the UK, the Oxbridge region is an example of the success of biotechnology clusters. The clusters are formed by the proximity to universities and research institutions, providing access to skilled labor and new technologies. (Garnsey & Smith, 1998) argued that the proximity of the two leading universities and the complexity of high-tech industries contributed to success in cluster development. Not only facilitating the knowledge transfer, but the presence of leading universities also provided a critical mass of scientific expertise and research infrastructure, which attracted a range of companies and investors to the region (Garnsey & Longhi, 2004; Garnsey & Smith, 1998). In Cambridge, the biotechnology cluster emerged without a strong commitment from public actors in the beginning (Chiaroni & Chiesa, 2005). The central agencies, such as the Bioindustry Association, East Region Biotechnology Initiative, and East Anglia Development Agency, were established later. In Scotland, regional innovation policy played a crucial role in facilitating interactions between actors. For example, policies that support R&D collaborations between firms and academic institutions or that provide funding for new ventures stimulate the growth of biotechnology clusters (Rosiello & Orsenigo, 2008).

European countries have several successful global biotechnology clusters. In Germany, there are several famous biotechnology clusters located in large cities such as Berlin, Munich, and Heidelberg. The study from Dorocki presented the long history of the biotechnology industry in Germany, dating back to the 1970s (Dorocki, 2014). The biotechnology cluster formation in Germany has been driven as a result of the BioRegio contest and the creation of technology parks (Chiaroni & Chiesa, 2006). The BioRegio contest provided the amount of funding to German regions with high potential in the biotechnology sector (Chiaroni & Chiesa, 2005; Cooke, 2007). In Heidelberg, the technology park was found to foster a biotechnology cluster by providing laboratory infrastructure, office space, and services to startups and new companies (Chiaroni & Chiesa, 2006). Thus, biotechnology clusters in Germany were influenced by a range of factors, including state support, strong investment in research and development, and the presence of leading research institutions. In France, biotechnology clusters were driven by a combination of factors, including the concentration of leading research institutions, a supportive policy environment,

and a highly skilled workforce. The cluster of Marseilles has a strong academic environment, allowing the creation of a great number of startups (Chiaroni & Chiesa, 2006). The cluster of Paris-Evry showed how public sector support can catalyze the cluster creation. Government and local organizations played a crucial role in fostering the cluster (Chiaroni & Chiesa, 2006). Policies promoting the cluster at a global level, including funding support are implemented for the growth of biotechnology clusters (Chiaroni & Chiesa, 2005).

In contrast to the US and Europe, biotechnology clusters in Asia were initiated by government policy targeting biotechnology as a key driver for economic growth. In China, the government is deeply involved in the development of the regional biotechnology industry. Several policies were issued to support the development of biotechnology clusters. For example, the Torch program was created to establish science parks in many areas of China. Unlike the US, many clusters in China are policy-driven and have been established without a strong scientific base (Conlé & Taube, 2012). In Singapore, the government implemented various policies attempting to attract foreign direct investment. Biopolis was founded as a research and innovation hub providing the necessary infrastructure and resources for biotechnology companies to conduct research and development activities (Finegold et al., 2004). In line with China and Singapore, biotechnology clusters in Malaysia and India were shaped by government-led policies that provided financial incentives, developed biotechnology parks, strengthened university–industry linkages, and expanded research infrastructure. (Phelps & Dawood, 2014; Subrahmanya, 2017).

2.2.3 Structural conditions shaping biotechnology cluster formation

The previous literature on cluster formation attempted to present major driving forces or success factors that affected the formation of biotechnology clusters. Those articles concentrated on how clusters developed. The biotechnology cluster is developed by a combination of factors, including government policy, scientific base, collaborations between universities and industries, skilled human resources, access to capital, and infrastructures (Ayrapetyan & Hermans, 2020; Huang & Huarng, 2015; Klunko et al., 2020; Sable, 2007). Previous studies presented four main factors in cluster formation (Chiaroni & Chiesa, 2005, 2006).

1. Scientific and knowledge infrastructure

Biotechnology companies are founded on innovation and scientific breakthroughs. Hence, the presence of a strong scientific base is crucial for the cluster's growth and success. Leading universities and research centers are a critical component of the biotechnology cluster. Biotechnology companies require a highly skilled workforce. The presence of life sciences research institutions and universities attracts talented researchers and scientists (Darmody & Bendis, 2021; Efendioglu, 2005; Kim, 2015; Saliceti-Piazza et al., 2003; Tripl & Tödtling, 2007). Beyond generating knowledge, universities also play a central role in commercialization processes. Entrepreneurial cultures within academic institutions facilitate the creation of spin-offs and encourage technology transfer, turning research outputs into marketable innovations (Salazar et al., 2008). Universities and research centers generate knowledge by conducting research. The research outputs from these institutions can be commercialized through the technology transfer process, leading to the development of new products and technologies (Garnsey & Longhi, 2004). Besides the presence of a strong scientific knowledge base, networks and collaborations between universities, industries, and government agencies are also important. Collaboration between these organizations can also facilitate the technology transfer (Lockhart et al., 2012). These partnerships can involve joint research projects, where many agencies share expertise and resources to develop new technology.

2. Industrial structure and firm activity

The presence and composition of biotechnology firms, including startups, dedicated biotechnology firms, and academic spin-offs, shape the industrial structure of a cluster and its innovative capacity. Biotechnology firms play a central role in applying scientific knowledge and transforming it into commercial products and technologies. (Cooke, 2002a). Industrial companies can also facilitate collaboration and networking with other stakeholders in the ecosystem, including research institutions, large companies, and other biotechnology companies (Chiaroni & Chiesa, 2005).

Besides small and medium companies, large companies also have a significant impact on cluster development. For example, multinational pharmaceutical

companies help to distribute and market therapeutic products as well as encourage industrial spin-offs from their companies and provide a financial resource for research activities (Cooke, 2001; Putri & Fujiwara, 2015). Likewise, entrepreneurial actors play an important role in shaping the industrial dynamics of a cluster. The previous study compared entrepreneurial activity in Taiwan and the United States, showing that Taiwan faced constraints in attracting skilled entrepreneurs due to restrictive regulations on foreign experts. The study suggests that policy reforms are necessary to strengthen the conditions for entrepreneurial formation. (Efendioglu, 2005). Another study further examined internal and external influences on the decision to become an entrepreneur, showing that local environments matter by providing access to networks, research institutions, and market opportunities, while government programs, such as funding schemes, training initiatives, and regulatory support, create concrete conditions that enable individuals to initiate new ventures. (Feldman et al., 2005).

3. Financing and capital access

Financing and capital access play a pivotal role in the growth of the biotechnology industry, as firms require substantial resources to support long and uncertain research and development cycles (Darmody & Bendis, 2021). Access to external funding is therefore essential for enabling firms to develop and commercialize new products (Depret & Hamdouch, 2010). Within biotechnology clusters, financing typically comes from private capital and public funding.

Private capital includes seed funding, angel investment, and venture capital. Seed funding provides small but critical early-stage resources that allow biotechnology firms to begin proof-of-concept activities and initial R&D (Cooke, 2002a; Darmody & Bendis, 2021; Finegold et al., 2004). Angel investors and early-stage venture capital often supply these funds when firms have limited revenue and high scientific uncertainty. Venture capital plays an increasingly important role as firms move into later development phases, offering larger investments in exchange for equity and providing strategic guidance that can support scaling, commercialization, and managerial professionalization (Chiaroni & Chiesa, 2005; Cooke, 2002a; Feldman & Francis, 2003; Valentin et al., 2008).

Public funding constitutes the second major source of financial support within biotechnology clusters. Governments provide research grants, subsidies, and targeted innovation programs that help firms undertake high-risk scientific activities and build foundational technological capabilities (Cooke, 2008; Miller et al., 2011; Salazar et al., 2008). Public funds may also support the development of infrastructure such as laboratories, research institutes, and technology parks which is the resources that are essential for enabling biotechnology research and firm formation.

4. Institutional and infrastructure support

Institutional and infrastructure support shape the broader conditions under which biotechnology clusters develop. Regulatory environments play a central role, as policies related to tax incentives, laboratory standards, clinical trial procedures, and financial support directly influence firms' ability to operate and innovate. Although many regulations are determined at the national level, some policies can be adjusted regionally (Cooke, 2002a). Intellectual property protection is particularly important in biotechnology, where strong patent laws and effective enforcement mechanisms are essential to safeguard research outcomes and attract investment. The revision of India's patent regime, for instance, demonstrates how policy changes can stimulate activity within the biotechnology sector despite the dominance of multinational patent holders (Miller et al., 2011). Supportive physical and organizational infrastructures further contribute to cluster development. Science parks provide foundational facilities such as incubation spaces, laboratory environments, tax incentives, and seed funding opportunities that reduce entry barriers for new firms (Vaidyanathan, 2008).

Incubators complement these functions by offering specialized laboratory equipment, technical assistance, and professional services that enable startups to conduct research and early experimentation (Feldman & Francis, 2003). These forms of infrastructure are often designed to promote commercialization, as illustrated by Technology Park Malaysia, which was established to support technical innovation, research collaboration, and the market deployment of new technologies (Phelps & Dawood, 2014).

Organizational spaces that facilitate interaction also play an important role. Meeting places, such as shared offices, networking platforms, and collaborative forums, may encourage knowledge exchange and strengthen the social and professional ties necessary for cluster development (Lundequist & Power, 2002). In addition, branding and international promotion contribute to long-term competitiveness by enhancing global visibility and attracting skilled human capital and investment. Leading biotechnology clusters often benefit from strong brand recognition, which reinforces their ability to draw venture capital and specialized talent (Darmody & Bendis, 2021; Lundequist & Power, 2002).

2.2.4 Geographical proximity

Geographical proximity refers to the physical closeness of actors and its influence on coordination, interaction, and collective action (Kasabov, 2010). In high-technology sectors, such as biotechnology, which is characterized by multi-technology processes and highly specialized skills, spatial concentration can facilitate collaboration, knowledge sharing, and network formation among firms, universities, and research institutions (Chiaroni & Chiesa, 2005). Well-known cases such as the Cambridge biotechnology cluster illustrate how proximity supports rapid knowledge diffusion and innovation (Garnsey & Smith, 1998). Empirical studies further show that geographically concentrated clusters tend to experience faster knowledge flows and higher innovation output than dispersed locations (Erden & von Krogh, 2011; Rosiello & Orsenigo, 2008). In addition, some forms of informal interaction, such as tacit knowledge exchange, are influenced by spatial proximity (Cooke, 2002a, 2002b).

Proximity also influences access to financing. For example, biotechnology startups located near the Bay Area and Silicon Valley benefit from easier access to private investors, including venture capitalists, angel investors, and specialized financial institutions (Chiaroni & Chiesa, 2005). These financial advantages reinforce the attractiveness of geographically concentrated clusters.

However, the importance of geographical proximity has been contested. Several studies argue that the requirement for strict co-location of biotechnology firms is relatively weak and that spatial proximity alone is insufficient for sustaining

cluster development (Depret & Hamdouch, 2010; Wilde & Hermans, 2021). What matters more is the presence of interaction, trust, and social embeddedness among actors, which enable collaboration beyond mere physical closeness. Consequently, other forms of proximity, such as cognitive, organizational, and strategic proximity, often play a more decisive role in shaping long-term collaboration and cluster performance (Depret & Hamdouch, 2010).

2.2.5 Lifecycle of the biotechnology cluster

The development of biotechnology clusters is often described using a life-cycle perspective that highlights how clusters evolve through different stages over time, typically including emergence, growth, maturity, and possible decline (Auerswald & Dani, 2017; Lazzeretti et al., 2019; Subrahmanya, 2017).

The emergence stage is the beginning of the cluster's development. At this stage, the cluster is still small and new, with a limited number of firms and institutions (Feldman et al., 2005). Most firms in the cluster are startups, and there is little in the way of established processes or infrastructure. Entrepreneurial activity is high, but the ecosystem is largely disconnected from external sources of funding and expertise (Feldman et al., 2005). The focus at this stage is on creating the basic infrastructure and attracting new firms to the cluster (Auerswald & Dani, 2017).

The second stage is the growth stage. In this stage, the biotechnology cluster experiences rapid expansion in size and complexity as new companies and institutions continue to join the cluster (Dawidko & Micek, 2015; Feldman et al., 2005). This phase is characterized by increased investment in research and development, the emergence of specialized service providers, and the establishment of supportive infrastructure such as incubators, accelerators, and networking groups (Auerswald & Dani, 2017).

The third stage is the maturity stage. In this phase, the biotechnology cluster has reached a stable level of growth and has established a reputation as a hub for biotechnology innovation (Feldman & Francis, 2003). This phase has a more diverse range of companies and institutions, as well as increased collaboration

and partnerships among cluster members (Feldman et al., 2005). The focus may shift towards commercialization and scale-up of innovative products and services.

Next, the decline stage occurs when the biotechnology cluster experiences a decrease in activity due to various factors such as market saturation, lack of investment, or regulatory impediments (Auerswald & Dani, 2017). Companies and institutions may relocate or go out of business, and the cluster may experience a loss of talent and infrastructure. However, some clusters are able to undergo renewal, drawing on existing capabilities to develop new technological specializations or attract new firms. Renewal may involve establishing new research centers, investing in emerging technologies, or strengthening support structures to reposition the cluster strategically (Auerswald & Dani, 2017). Across different stages, cluster dynamics are shaped by interacting factors such as government policy, investment patterns, technological change, and market demand. As a result, different phases require different forms of support and intervention to sustain cluster development.

2.2.6 Challenges in developing biotechnology clusters

Developing a biotechnology cluster is associated with a range of structural and contextual challenges, and not all cluster initiatives result in sustained success. One major challenge concerns access to finance. In many regions, particularly in emerging economies, biotechnology firms face difficulties in securing private investment due to the high risk, long development timelines, and scientific uncertainty inherent in the industry (Conlé & Taube, 2012; Cooke, 2002a). In several Asian countries, venture capitalists are new investors in the biotechnology industry. They do not have sufficient experience in this specific industry (Conlé & Taube, 2012; Finegold et al., 2004). Moreover, there are a few venture capitalists who invest in biotechnology startups because of the high risk and long timelines for product development. As a result, biotechnology startups often rely heavily on public funding, while struggling to attract private capital at later stages of development (Miller et al., 2011; Molloy, 2021). A second challenge relates to human capital. Biotechnology clusters require a highly skilled workforce in scientific research and development, and commercialization (Putri & Fujiwara, 2015). Beyond scientific expertise, biotechnology clusters often face shortages of managerial and

commercialization-related skills within the local labor market (Dawidko & Micek, 2015; Kasabov, 2011). Thirdly, biotechnology companies rely heavily on intellectual property to protect their innovations and discoveries (Orsenigo, 2001). In some countries, however, weak or inconsistently enforced IP frameworks create uncertainty for firms and investors, limiting incentives for innovation and commercialization (Efendioglu, 2005). Furthermore, building infrastructure is another challenge in developing a biotechnology cluster. Biotechnology companies require specialized facilities and equipment. Building infrastructure and access to the necessary facilities may be limited in some regions (Conlé & Taube, 2012; Putri & Fujiwara, 2015). Moreover, cultural differences can impede cluster development. Biotechnology industries attract foreign investors and foreign scientists who have different backgrounds and cultures. For example, BioValley faced cultural differences issues across French, Swiss, and German (Fuhrer, 2004). Finally, the shift in focus on a particular industry impedes the development of the biotechnology cluster. One example is that there is a shift from a focus on the biopharmaceutical industry to the agricultural industry due to the high demand for sustainable development (Hoffman, 2014). Another example is the case of the Indian cluster. In India, the software cluster's success hindered the biotechnology cluster development (Vaidyanathan, 2008).

The literature on biotechnology clusters highlights that cluster development is shaped by a combination of scientific resources, firm structures, financing conditions, institutional support, spatial proximity, and evolutionary dynamics. While these structural conditions provide an important foundation, they do not operate automatically. The effectiveness with which resources are mobilized and connections are formed depends on the presence of intermediary actors and organized networks that link firms, research institutions, investors, and public organizations. In biotechnology clusters, incubators and network-based support structures play a central role in coordinating these interactions, particularly for early-stage ventures. The following section, therefore, turns to the role of incubators and networks within biotechnology clusters.

2.3 Incubators and networks in biotechnology clusters

2.3.1 Role of biotechnology incubators

Biotechnology incubators play a pivotal role in transforming early-stage scientific ideas into viable commercial ventures within knowledge-intensive environments (Wu et al., 2022). Unlike general business incubators, biotechnology incubators are specifically designed to address the distinctive needs of life-science startups, which are characterized by long research and development (R&D) cycles, high technical and complex regulatory processes, uncertainty, and high capital intensity (Mian, 2014; Pauwels et al., 2016). These organizations not only provide shared physical infrastructure such as laboratories and specialized equipment but also provide access to managerial, legal, and technical expertise that lower entry barriers for early-stage firms (Holzwarth, 2019; Leitão et al., 2022; Wu et al., 2022). Beyond cost reduction, biotechnology incubators also foster knowledge exchange and technological learning through structured mentorship and close linkages with universities, research hospitals, and pharmaceutical companies (Bøllingtoft & Ulhøi, 2005; Holzwarth, 2019). By embedding entrepreneurs in dense scientific and industrial networks, biotechnology incubators act as network orchestrators that facilitate the recombination of scientific, financial, and relational capital critical to venture development.

The role of biotechnology incubators has evolved significantly over time. Early models emphasized facility provision and basic administrative assistance, but modern biotechnology incubators function as complex innovation intermediaries that combine managerial support, scientific mentoring, and ecosystem coordination (Indiran et al., 2021; Mulyasasmita et al., 2024). They operate at the intersection of academia, industry, and policy, mediating between the production of scientific knowledge and its commercial application. This evolution reflects a broader shift toward what (Mian et al., 2016) terms the second generation of incubation, in which incubators act as ecosystem catalysts rather than simple service providers.

In this sense, their role extends beyond organizational support to encompass strategic system-building. Incubators bridge the “valley of death” between scientific discovery and market adoption, ensuring that promising technologies

do not stagnate in research laboratories but instead progress toward validation and commercialization (Alves et al., 2014; Cheng et al., 2022). The incubators also contribute to regional economic development by nurturing clusters of high-value scientific activity and attracting investment from both public and private sources (Gazieva et al., 2023; Porumboiu, 2021). Consequently, biotechnology incubators are increasingly viewed as institutional entrepreneurs that shape local and national innovation trajectories, rather than as peripheral support organizations.

2.3.2 Network of biotechnology incubators

Network theory provides a powerful framework for understanding how biotechnology incubators generate value. In network-theoretic terms, incubators occupy strategic brokerage positions that connect otherwise disconnected actors within the biotechnology ecosystem, such as scientists, investors, policymakers, clinicians, and large pharmaceutical companies (Powell et al., 2005). These brokerage roles enable them to mediate the flow of resources, information, and legitimacy across organizational boundaries. In doing so, they bridge structural holes in the innovation system. Through these relationships, incubators strengthen the relational and cognitive proximity among diverse actors. This facilitates more efficient knowledge diffusion and collective problem-solving in the life-science sector.

The relational function of incubators can be observed in three interrelated dimensions. First, incubators act as knowledge intermediaries by facilitating tacit knowledge transfer between academic institutions and industry. The proximity of startups to university research groups, clinical partners, and experienced mentors allows for the rapid exchange of technical insights, intellectual property strategies, and market intelligence (Du & Wang, 2019; Villani et al., 2017). This process enhances learning dynamics and accelerates the transformation of research outputs into commercially viable innovations. Second, incubators function as network orchestrators that coordinate multilateral collaborations among firms, investors, and public agencies. As ecosystems become more complex, the incubator's capacity to align stakeholders' incentives and integrate external partners becomes crucial for success. Studies show that strong ties with regional universities, hospitals, and venture funds are positively correlated with incubator performance and startup

outcomes (Alves et al., 2014; Pettersen et al., 2016). Incubators that effectively manage these relationships can secure early-stage funding, form public–private research alliances, and open international market channels for their tenants (Fithri et al., 2024). Third, incubators reinforce cluster-based network structures by geographically concentrating talent and resources. Biotechnology clusters illustrate how incubators act as anchoring institutions that sustain network density and trust among regional actors (Casper, 2007; Teigland et al., 2005). Embedded within these ecosystems, incubators both benefit from and contribute to agglomeration effects, leading to cumulative advantages in innovation and investment attraction. In this context, incubators actively shape networks by fostering collaboration, lowering coordination costs, and creating the relational infrastructure necessary for sustained knowledge exchange.

Moreover, network theory suggests that incubators enhance both the centrality and visibility of emerging ventures. Startups affiliated with prominent incubators gain access to established networks, improving their reputational capital and their ability to attract strategic partners and investors (Loganathan & M H, 2022; Shih & Aaboen, 2019). At the same time, the incubator itself benefits from maintaining relationships with successful alumni firms, creating a virtuous cycle of reputation and resource flow. As biotechnology ventures increasingly internationalize, incubators play an additional role as transnational connectors, linking domestic innovation ecosystems to global research and investment networks (Didoni, 2020). This role underscores the importance of network orchestration as a defining feature of contemporary biotechnology incubation.

2.3.3 Resource mobilization and strategic effects of biotechnology incubators

Biotechnology incubators generate value not only through networks but also by mobilizing critical resources, both tangible and intangible, that underpin innovation performance. Incubators provide startups with access to specialized laboratories, shared scientific equipment, and regulatory compliance systems that would otherwise be prohibitively expensive to establish independently (Alves et al., 2014; Kuryan et al., 2018). This resource-sharing model reduces fixed costs and facilitates experimentation, enabling entrepreneurs to focus on product validation and proof-of-concept activities (Kuryan et al., 2018). In addition to physical resources, biotechnology incubators offer mentoring and

networking opportunities. The guidance from experienced entrepreneurs and industry experts can significantly influence the strategic decisions of startups, thereby enhancing their likelihood of survival and growth. Networking within the incubator environment contributes to building business relationships and accessing vital external resources, which are often necessary for achieving competitive advantages in the biotechnology field (Shih & Aaboen, 2019; Vanderstraeten et al., 2016)

From a resource-based view perspective, incubators enhance the resource endowment of tenant firms by providing valuable, rare, and often inimitable assets, such as scientific expertise, institutional legitimacy, and access to investor networks, that strengthen competitive advantage (Cheng et al., 2022). These facilities can significantly bolster a firm's resource essential for innovation and growth. Alves et al. further emphasize that the relationship between an incubator and a biotech company is paramount for the successful development of biotechnology activities, demonstrating how tailored support systems can facilitate effective resource integration (Alves et al., 2014). The outcomes of these resources and network mechanisms are visible at multiple levels. At the venture level, incubators enhance survival rates, accelerate time-to-market, and improve innovation output by aligning scientific and commercial processes (Gardner, 2021). At the regional level, they contribute to employment, knowledge spillovers, and investment inflows, thereby enhancing the competitiveness of local biotechnology clusters (Gardner, 2021; Gazieva et al., 2023).

Ultimately, biotechnology incubators can be understood as dynamic networked resource orchestrators. They integrate tangible assets, knowledge, and relationships into a coherent system that supports entrepreneurial experimentation and industrial renewal. Their strategic outcomes extend beyond venture success to encompass regional innovation capacity, global visibility, and institutional legitimacy. As ecosystems evolve, incubators that maintain adaptive governance, strong network centrality, and resource diversity are most likely to sustain their relevance and impact.

2.4 Institutional support and resources across development stages in biotechnology industries

2.4.1 Resource scarcity in the early stage

Resource scarcity is a significant challenge that early-stage biotechnology firms face. Early-stage biotechnology firms face prolonged, capital-intensive research and development (R&D) phases, which often span from discovery to early clinical trials without generating revenue or market validation (Baeyens et al., 2006; Lo & Thakor, 2022). Scarcity is multidimensional, encompassing not only financial constraints but also shortages in infrastructure, regulatory expertise, and managerial capacity (Bruneo et al., 2024; Polidoro Jr & Yang, 2021).

One major constraint for biotechnology firms is financial resource scarcity because of the reliance on external funding sources, such as venture capital, and the absence of early revenue-generating activities. Unlike firms in sectors such as ICT, biotechnology ventures must commit substantial upfront investment to laboratory infrastructure, clinical trials, and regulatory approval, often over long development timelines with uncertain outcomes (Baeyens et al., 2006; Harada et al., 2021). As these firms typically lack internal cash flow, they rely heavily on external funding sources including public grants, venture capital, and strategic alliances with large pharmaceutical companies, to sustain R&D activity through early development stages (Lo & Thakor, 2022; Ullah et al., 2010). However, traditional financing channels are often inaccessible because biotechnology assets are intangible and cannot be easily collateralized, while the high probability of failure throughout drug development increases investor risk perception (Polidoro Jr & Yang, 2021).

Besides financial capital, the importance of human resources in biotechnology firms cannot be overstated because their success relies on highly specialized scientific and managerial expertise that is difficult to find, attract, and retain. Unlike other sectors, biotechnology firms require individuals with deep knowledge in areas such as clinical research, regulatory approval, intellectual property, and commercialization, making human capital a strategic resource that directly influences innovation outcomes, investment attraction, and the ability to navigate uncertainty (Harada et al., 2021; Zajřrtova & Maresova, 2025). As a result, human capital is not a generic labor input, it is a strategic resource that directly shapes a firm's survival and competitiveness. When

qualified personnel are scarce, firms become more vulnerable to delays, increased costs, and failure to secure funding. The ability to build and retain an effective team, therefore, determines whether a biotech firm can manage uncertainty and move its products through the development pipeline. In this context, external support structures, particularly incubators and accelerators, help mitigate human capital constraints by providing access to expert mentorship, temporary leadership, and professional training (Brown III & Paul, 2025; Chakma et al., 2010; Mitchell et al., 2020). These mechanisms enable biotech firms to gain capabilities they cannot afford to build internally, reinforcing the view that human capital is a dynamic, scarce, and strategically essential resource in the biotechnology sector.

Technology infrastructure is considered as one of the critical resources constraining the development of biotechnology startups. This infrastructure scarcity significantly impedes the translation of scientific research into viable product concepts and weakens firms' capacity to attract subsequent funding or strategic partners. Prior studies highlight that inadequate R&D infrastructure elevates marginal costs and prolongs development timelines, thereby constraining the early-stage innovation pipeline and limiting the execution of proof-of-concept demonstrations essential for investor confidence and validation (Oudouard et al., 2025; Segers, 2015). The resource-based view conceptualizes laboratory infrastructure as a distinctive, firm-specific resource embedded within a startup's knowledge base and operational routines, enabling the transformation of scientific capabilities into unique products and processes (Oudouard et al., 2025; Segers, 2015). When such infrastructure is rare, non-substitutable, and difficult to imitate, it can confer sustained competitive advantage. However, many biotechnology startups lack comprehensive in-house facilities and rely on external laboratories or contract research organizations to fill these gaps. In these cases, advantage derives less from internal ownership of physical assets and more from the firm's ability to orchestrate collaborations, manage alliances, and establish effective access routines that leverage external R&D capabilities (Oudouard et al., 2025; Segers, 2015).

Market knowledge and legitimacy are interdependent intangible resources whose scarcity constrains the commercialization and growth of biotechnology startups. Limited market knowledge restricts startups' ability to sense customer

needs, validate value propositions, and absorb external information critical for navigating regulatory and intellectual property environments. Evidence from open innovation studies showed that firms lacking strong market intelligence underperform in market entry and value capture compared with peers that effectively acquire and exploit external knowledge (Centobelli et al., 2017; Eftekhari & Bogers, 2015; Hashai & Markovich, 2017). In the biotechnology sector, where success depends on understanding complex clinical and regulatory, insufficient market knowledge leads to misalignment between R&D and market requirements, thereby slowing absorption and higher commercialization risk (Rijssegem & Andries, 2025; Yu et al., 2023). This misalignment also weakens firms' legitimacy in the eyes of investors, partners, and regulatory stakeholders, further constraining access to external resources.

2.4.2 Institutional support and public funding

Institutional support and public capital play a pivotal role in shaping the innovation trajectories of biotechnology startups as they navigate resource-intensive early stages, complex regulations, and uncertain commercialization paths. The interaction between public institutions, venture capital, and entrepreneurial actors forms an ecosystem that enables these firms to overcome early financial constraints and sustain innovation. Public funding often acts as a financial resource and a credibility signal. Previous research shows that government backing reduces perceived investor risk by signaling institutional endorsement, thereby facilitating access to venture capital (Thys et al., 2025). This signaling effect is particularly important for academic spin-offs, where scientific uncertainty and long development timelines deter private investment. In such contexts, institutional legitimacy enhances credibility and encourages external funding. Another study conducted a focused analysis of R&D investments specifically in biotechnology innovations developed by the US biotechnology startups from 2017 to 2023. The results indicated that understanding funding dynamics and investment requirements is vital for these startups to achieve successful product development, as they often rely on significant initial public investment to navigate the stages of drug development. The correlation between institutional support and the financing landscape emphasizes the critical role of public capital in establishing a foundation for these innovative ventures (Oudouard et al., 2025).

While institutional support and public capital provide essential external resources and legitimacy, their impact ultimately depends on how biotechnology firms internalize and leverage these inputs. Drawing on the Dynamic Capabilities (Grandclément, 2015) framework, it explains firms' adaptability through three core activities, including sensing, seizing, and reconfiguring, that enable growth and innovation. Studies argue that sensing opportunities and threats, mobilizing resources to seize them, and reconfiguring asset bases are critical for biotechnology startups navigating complex regulatory, scientific, and funding ecosystems (Kindström et al., 2013; Teixeira et al., 2021). These capabilities illustrate the mechanisms through which institutional support (e.g., government programs, venture funding, regulatory clarity) and public capital foster startups' ability to sense opportunities, acquire resources, and reconfigure them to deliver biotech innovations to the market (Devarakonda & Liu, 2024).

In addition, social capital, the networks, trust, and relational ties that link startups with external actors, plays a mediating role in transforming institutional resources into dynamic capabilities and innovation outcomes. Structural, relational, and cognitive dimensions of social capital facilitate access to knowledge, resources, and legitimacy, which are essential for science-based entrepreneurship (Huggins, 2010; Zheng, 2010). Empirical studies show that relational capital and cognitive alignment promote collaboration and knowledge sharing within biotechnology ecosystems, accelerating innovation and market entry (Carey et al., 2011; Mura et al., 2016; Zhang et al., 2019). The literature on social capital in industry clusters also shows that well-connected networks interacting with institutional environments promote startup growth and innovation by enabling knowledge spillovers, collaboration, and joint problem-solving. Previous study indicates that local clusters leverage relational resources and trust networks to support the development of biotech startups within regional ecosystems (Presutti & Boari, 2011).

2.5 Capital structure and intellectual capital in biotechnology firms

2.5.1 Intellectual capital and innovation activity

Intellectual capital plays a pivotal role in the biotechnology sector, serving as a critical determinant of firm performance, innovation capacity, and sustainable

competitive advantage. It encompasses human, structural, and relational capital that collectively contribute to firms' value creation and strategic positioning (Harrison & Sullivan, 2000; Pulic, 2004; Tovstiga & Tulugurova, 2009). Human capital refers to the expertise, skills, and experience of scientists and technical staff, which drive R&D productivity and knowledge creation. Structural capital represents the internal systems, patents, databases, R&D infrastructure, and organizational routines that allow firms to retain and apply knowledge effectively. Relational capital includes collaborative networks, partnerships, licensing relationships, and links with research institutions, all of which are critical in biotechnology due to the sector's high interdependence and regulatory complexity (Agostini et al., 2017; Darvish et al., 2013). In biotechnology and pharmaceuticals, where R&D intensity and innovation outputs dominate firm value, intellectual capital indicators often explain variations in market valuation more effectively than traditional tangible assets (Anghel et al., 2018; Chen et al., 2005). Consequently, Intellectual capital is not only a source of operational advantage but also a critical determinant of how biotech firms are perceived by investors and creditors.

Intellectual capital influences capital structure decisions through signaling to creditor and investors about future earning potential, risk, and growth capacity. In biotechnology sector, where tangible collateral is often limited and R&D milestones dominate valuation, intellectual capital becomes a critical component of collateralizable value and forward-looking leverage calculations. The literature on intellectual capital and market value, financial performance supports the notion that higher intellectual capital generally associates with stronger market perceptions of value, which can translate into more favorable debt/equity terms (Ardiansari et al., 2021; Nimtrakoon, 2015). However, another study has investigated the implications of intellectual capital on capital structure and profitability (D'Amato, 2021). The study found a negative correlation between high levels of intellectual capital and financial leverage, suggesting that firms with strong intellectual assets tend to adopt conservative financing policies, which can further enhance their stability and performance (D'Amato, 2021). Similarly, another study has assessed the risk-return dynamics within biotech companies, discussing how their intangible assets and associated high-risk profiles can affect access to funding, thereby influencing innovation capacity (Bruneo et al., 2024).

Innovation is a critical driver of firm growth, primarily through its role in product development and technological advancement. Firms that continuously invest in research and development (R&D) and actively pursue patenting tend to achieve more sustainable and long-term growth. In the pharmaceutical industry, for instance, patenting has been shown to significantly enhance firm growth by enabling companies to capture the returns on their R&D investments and strengthen their competitive advantage (Guarascio & Tamagni, 2019). Research showed that strategic patent management, such as the systematic development, maintenance, and exploitation of patent portfolios, enhances innovative performance by supporting knowledge protection, coordination of R&D activities, and commercialization efforts in biotechnology firms (Narayan & Hungund, 2022; Stezano & Oliver Espinoza, 2019). These patents not only protect proprietary knowledge but also act as valuable intangible assets that underpin firm valuation and attract investors. The relationship between innovation activities and firm characteristics demonstrates that certain internal factors, such as R&D intensity, significantly influence the patenting behavior of biotechnology firms. The study has suggested that firms exhibiting high levels of R&D investment tend to produce more patents, thereby ensuring the continuity of their innovative activities (Guo & Zhou, 2016). Conversely, firms facing budget constraints may rely on patent analytics as a strategic tool to identify valuable patents for monetization or strategic abandonment (Guderian et al., 2021).

The high uncertainty, long development timelines, and intangible asset base of biotechnology firms strongly shape their financing strategies and capital structure choices. Many biotechnology firms build alliances with larger pharmaceutical companies to access funding, distribution networks, and technical expertise, allowing them to focus on their core R&D activities while reducing financial pressure (Fernald et al., 2015; Schoonmaker & Rau, 2014). Venture capital is another key source of funding that supports long-term innovation in this high-risk sector (Sohn & Kang, 2015). Because of uncertain returns and long development timelines, traditional debt financing is often avoided, as fixed repayment obligations can strain limited cash flows (Bruneo et al., 2024). Instead, equity financing is typically preferred, since it offers greater flexibility and fits the long-term nature of biotech innovation (Brown & Floros, 2012). Firms with stronger patent portfolios also tend to attract more equity investors, as patents signal technological capability and future growth potential

(Hottenrott et al., 2016; Hsu & Ziedonis, 2013). Conversely, empirical studies have argued that the presence of patents, which can serve as valuable intangible assets, can lead firms to adopt more favorable debt strategies. These strategies often involve an increase in leverage since secured debt can be more easily justified by patented innovations, which serve as collateral (Ahmed Sheikh & Wang, 2013; Baker & Wurgler, 2002).

2.5.2 Capital structure choices in biotechnology firms

Capital structure decisions in biotechnology firms are shaped by the distinctive characteristics of the sector, which include high R&D intensity, long product development cycles, and limited tangible assets that can serve as collateral. These conditions increase uncertainty and complicate access to traditional debt markets, prompting many biotechnology firms to rely heavily on equity financing to sustain operations and innovation. An empirical study has revealed that biotechnology firms often lean towards equity financing to mitigate the risks associated with high leverage and to maintain flexibility in their investment strategies (Power et al., 2022). Another study has demonstrated that while debt can offer temporary liquidity, excessive leverage reduces profitability and restricts strategic flexibility (Zhang & Nik Azman, 2023). Moreover, a previous study has highlighted a significant correlation between market development and capital structure decisions, emphasizing that as financial markets become more developed, firms tend to prefer equity over debt due to declining costs of equity issuance and increasing availability of venture capital (Doku et al., 2011). This trend is particularly pronounced in the biotechnology sector, where investor appetite for equity can provide not only capital but also strategic partnerships and credibility.

The financing decisions of biotechnology firms can be explained through a combination of established capital structure theories and underlying informational mechanisms. In particular, prior research draws on pecking order theory, signaling theory, and agency theory to explain how firms choose between equity and debt, while information asymmetry plays a central role in shaping these decisions. The pecking order theory posits that companies prioritize their sources of financing according to the principle of least effort, starting with internal funding, followed by debt issuance, and finally resorting to equity as a last option (Alan & Gaur, 2018; Myers & Majluf, 1984). In scenarios where

companies perceive higher risks in issuing debt, especially in innovative sectors like biotechnology where project uncertainty is relatively high, firms are inclined to seek equity financing first (Fourati & Affes, 2013). As firms within this sector typically rely on consistent innovation and development, they tend to prioritize internal funds and external equity to mitigate risks associated with external debt financing (Fourati & Affes, 2013; Sony & Bhaduri, 2018). Empirical evidence further suggested that the ability to issue equity in response to fluctuating operational capabilities and technological breakthroughs can buffer biotechnology firms against the adverse effects of leverage, reinforcing their inclination toward equity-based financing (Rahman & Arifuzzaman, 2014).

Information asymmetry provides an additional explanation for capital structure choices in biotechnology firms. Information asymmetry refers to the disparity between information held by firm insiders and external investors, which increases the cost of external financing and influences capital structure strategies (Klein et al., 2002). In the biotechnology sector, firms with substantial intellectual capital often face heightened information asymmetry, which increases financing costs because investors perceive intangible and innovation-driven resources as uncertain and risky (Orens et al., 2009; Prabowo, 2017). In biotechnology firms, patents, R&D intensity, and equity financing decisions act as signals that reduce information asymmetry and shape investor perceptions of firm quality and growth potential. These signals are particularly important in high-risk innovation contexts, where external investors rely on observable indicators to evaluate future returns and financing risk.

From an agency theory perspective, biotechnology firms also face elevated agency costs due to uncertainty in future cash flows and the experimental nature of R&D activities. This uncertainty elevates agency costs when managerial actions diverge from shareholder interests. The study has suggested that firms with high agency costs should adopt governance mechanisms and financing strategies that mitigate such conflicts (Mande et al., 2012). To mitigate these conflicts, innovation-oriented firms are often expected to favor equity financing, as equity avoids fixed repayment commitments and reduces agency problems associated with excessive debt (Power et al., 2022).

Despite facing high innovation uncertainty and pronounced information asymmetry, some studies find that biotechnology firms do not exhibit a strong preference for equity financing. Instead, a positive relationship between R&D intensity and leverage has been observed, indicating that biotechnology firms may continue to rely on debt financing to secure stable funding for essential R&D activities (Lee & Lee, 2019). This finding implied that, unlike other innovation-driven firms that favor equity for financial flexibility, biotechnology firms view debt financing as a practical mechanism to secure continuous funding for long-term innovation despite heightened risk and agency concerns.

3 The biotechnology sector in Sweden

3.1 Historical development of Sweden's biotechnology clusters

3.1.1 Early scientific roots (1930s – 1970s)

The foundations of Sweden's biotechnology industry can be traced back to early twentieth-century advances in life-science research, particularly in Uppsala. Pioneering work in protein chemistry and separation science by Nobel laureates during the 1930s and 1940s established a world-leading scientific knowledge base. These advances laid the groundwork for later developments in industrial biotechnology and biomedical applications (Waxell, 2009).

Industrialization followed when the pharmaceutical company Pharmacia relocated from Stockholm to Uppsala in the 1950s in order to collaborate closely with these academic research groups. This relocation established a long-lasting academia–industry collaboration that became a defining feature of the region's subsequent development and helped anchor biotechnology-related activities locally (Waxell, 2009). By the mid-1980s, biotechnology had been formally recognized as a strategic technology in Sweden. Leading technical universities, including KTH, Lund Institute of Technology, and Chalmers University of Technology, had already established advanced biotechnology research programs, further strengthening the national scientific base.

3.1.2 Formation of biotechnology clusters (1980s – 2000s)

From the 1980s onward, biotechnology activities in Sweden became increasingly concentrated around major university cities, resulting in the emergence of distinct regional clusters (McKelvey et al., 2003; Waxell, 2009). Among these, the Uppsala and Stockholm–Uppsala region developed into the most prominent biotechnology concentration.

Uppsala evolved into a specialized cluster focusing on biotechnology supplies, diagnostics, and scientific instruments (Waxell, 2009). By the early 2000s, the Uppsala cluster comprised approximately 80 biotechnology firms employing around 5,000 people, while the broader regional ecosystem included around 160 related organizations with a total workforce of roughly 8,000 employees. The university and the legacy of Pharmacia functioned as key anchor organizations supporting firm formation, knowledge spillovers, and labor mobility (Waxell, 2009).

Although firms in the Uppsala cluster maintain strongly globalized relationships in terms of markets and research collaborations, several critical resources remain locally embedded. Capital sourcing, labor markets, and informal social networks are predominantly regional, creating a distinctive local milieu that continues to support cluster cohesion despite extensive international linkages (Waxell & Malmberg, 2007). Importantly, research shows that the success of the Uppsala cluster cannot be attributed to a single critical event, such as Pharmacia's restructuring, but rather to the long-term interaction between stable academic and industrial units that gradually accumulated complementary capabilities over time (Waluszewski, 2004; Waxell, 2009).

3.1.3 Regions of biotechnology clusters

The Stockholm–Uppsala region represents one of the earliest and most prominent biotechnology clusters in Sweden. Anchored by Karolinska Institutet, Uppsala University, and major healthcare institutions, the region benefited from dense academic–industrial linkages and a long tradition of biomedical research. In Uppsala, the historical presence of Pharmacia and its successors acted as an anchor organization, supporting the emergence of a broader network of biotechnology firms, specialized service providers, and

research-oriented startups. Studies of the Uppsala cluster highlight the importance of anchor firms and complementary agents in shaping local cluster dynamics and sustaining competitiveness over time

In southern Sweden, biotechnology development is closely associated with the Medicon Valley cluster, which spans the Skåne region and eastern Denmark (see Figure 3). Unlike many US biotechnology clusters that emerged primarily through entrepreneurial dynamics, Medicon Valley developed from a strong university-driven research base, with entrepreneurial activity entering at a later stage (Braunerhjelm & Helgesson, 2006). Lund University has played a particularly central role, functioning as a key source of scientific knowledge, spin-offs, and human capital. Since the 1980s, biotechnology development in Skåne has been supported by substantial public investments in research infrastructure, regionalized innovation policy, and the formal recognition of universities' "third mission" of commercialization and societal engagement (Angelakis & Galanakis, 2017). National and regional programs, including competence centers, Vinnova and SSF-funded initiatives, as well as science parks such as IDEON, contributed to long-term capability building and the formation of new firms. These coordinated policy efforts enabled sustained development rather than short-term project-based growth (Angelakis & Galanakis, 2017).

Gothenburg and western Sweden represent a more heterogeneous biotechnology region. Rather than specializing narrowly, this region developed capabilities across a range of biotechnology-related activities, including pharmaceuticals, medical technologies, agriculture, and industrial biotechnology during the late 1990s and early 2000s (Brink et al., 2007). The co-location of different segments of the biotechnology value chain created positive feedback effects for learning and capability development. This diversification allowed the region to build resilience, even though it lacked the same degree of specialization observed in Uppsala or Medicon Valley (Brink et al., 2007).

Overall, Sweden's biotechnology clusters have emerged through long-term interactions between scientific institutions, industrial actors, and public policy rather than through short-term entrepreneurial booms. This historical

trajectory has shaped the institutional structure of the sector, influencing how firms access resources, how incubators operate, and how financing and support mechanisms are organized across regions. These characteristics provide the contextual foundation for the empirical analyses presented in the following sections.



Figure 3: Regions of biotechnology in Sweden (Government Offices of Sweden, 2020).

3.2 Swedish biotechnology

The biotechnology and life science sector in Sweden is characterized by strong interconnections between innovation, advanced scientific research, and a well-established institutional support structure. Sweden’s commitment to fostering biotechnology is evident in its impressive number of firms, growing employment in the sector, and substantial contribution to the national economy. As of the latest data from (SwedenBIO, 2025), there are over 3,800 companies within the biotechnology and life science sector in 2022, with approximately 50,000 employees engaged in biotechnology-related fields (see Figure 4). These key metrics underscore the pivotal role of Sweden’s biotechnology sector. Furthermore, gender representation within these companies reflects wider societal trends in Sweden, with women making up 50% of the labor workforce

in the biotechnology sector, and over a quarter of the CEOs in this sector are women (SwedenBIO, 2025).

The significance of Sweden's biotechnology sector extends beyond employment figures. It also plays a critical role in international trade. The export share of the biotechnology products made up approximately 9.4% of Sweden's total exports in 2022. Remarkably, this share was ten times higher than the export share of the gaming industry, which is a key part of the tech sector. Pharmaceuticals dominate the life science export category, representing approximately 75% of its total export value (SwedenBIO, 2025).

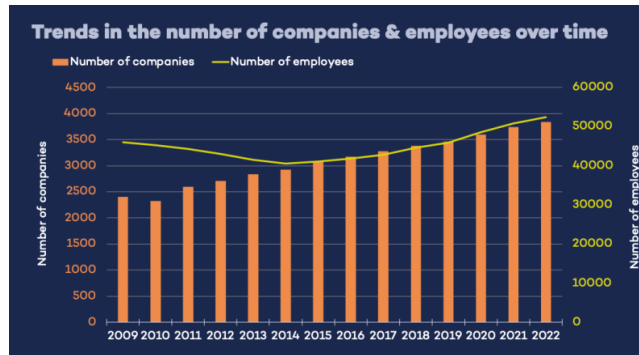


Figure 4: Trend in the number of companies and employees over time (SwedenBIO, 2025).

Beyond its economic weight, Sweden is an analytically interesting case for analyzing a biotechnology cluster for several reasons. Firstly, Sweden possesses a strong science base and academic infrastructure, including world-class universities, including Karolinska Institutet, Uppsala University, Lund University, and University of Gothenburg, and specialized research hospitals that continuously generate intellectual capital and biotechnology spin-offs (Taji & Igarashi, 2025; Waxell & Malmberg, 2007). Secondly, Sweden's innovation system is highly institutionalized, with coordinated public agencies, e.g., Vinnova, Tillväxtverket, and regional cluster programs. Vinnova, Sweden's innovation agency, plays a pivotal role, funding initiatives that enhance the connectivity between research institutions and biotech firms, thus enabling quick adaptation to global market demands (Lundgren, 2025). Such a

structured approach not only bolsters the sector's global competitiveness but also fosters an export-oriented culture, attracting international partnerships and investments.

3.3 Collaborative communities in the Swedish biotechnology sector

Sweden's biotechnology and life science industry exemplifies a collaborative and networked innovation system where knowledge sharing, spin-off creation, and collaboration across academia and industry drive innovation. Cluster formation and close collaboration within specialized communities underpin the biotechnology sector's ability to translate scientific advances into commercial outcomes, particularly among young and small firms. The empirical data highlighted the strong academic and institutional roots of Swedish biotechnology and life science entrepreneurship. Approximately 50% of companies are spin-offs, of which 36% originated from academia and research institutions, while 13% spun off from existing life science companies (SwedenBIO, 2025).

For the Swedish biotechnology cluster, science parks, co-working spaces, and incubators play a crucial role in supporting dynamic industries. Besides specific benefits offered by certain communities, sharing knowledge, experience, and premises is crucial for small businesses. Overall, 52% of the firms surveyed are part of such communities. Among companies aged 0-4 years, 78% are engaged in a community (SwedenBIO, 2025). In addition to institutional and spatial collaboration, external expertise and consulting networks represent another essential pillar of the Swedish biotechnology ecosystem.

3.4 Financial structure and sources of capital

The Swedish biotechnology industry is characterized by its capital-intensive nature and heavy reliance on external funding, particularly during the early R&D stages before commercialization. The pathway from discovery to market in biotechnology typically involves long development timelines, regulatory hurdles, and substantial upfront investment. At the broader industry level, the biotechnology and life sciences sector ranked as the third-largest recipient of VC investment in Sweden in 2024, accounting for SEK 1,401 million, or 20% of total

VC investments, which indicates continued investor interest in science-based ventures (Tillväxtanalys, 2026).

Survey data also revealed clear age-related differences in funding composition. Younger companies (0-4 years) predominantly depend on investors and public or private share issues (approximately 49%) and grants, reflecting their early-stage need for venture capital and institutional support (SwedenBIO, 2025). These firms often operate in pre-revenue phases where external funding substitutes for sales income. In contrast, mature firms reported a growing reliance on sales revenues and licensing income, indicating successful translation toward commercial viability. Overall, 51% of companies generate revenue from sales, encompassing both products and services, while 15% of established companies cite licensing agreements as a supplementary income source (SwedenBIO, 2025). As firms age, their financial model evolves from equity-based to revenue-based funding. Among companies older than 15 years, sales and licensing dominate, whereas investor dependency gradually declines. Conversely, grants and loans play a diminishing role as companies scale and diversify their income streams (SwedenBIO, 2025).

3.5 Temporal context and industrial transformation

The empirical period covered in this thesis spans a decade during which the life-science and biotechnology industries underwent substantial changes. In addition to ongoing scientific advances and shifting commercialization pathways, the period includes major systemic events that plausibly affected resource availability, risk perceptions, and the functioning of innovation support systems. These developments may influence both (i) the baseline conditions under which biotechnology firms operate (e.g., access to capital, collaboration opportunities, and institutional priorities) and (ii) the effectiveness of specific mechanisms such as public funding, incubator support, and network-based resource mobilization.

This thesis does not assume that the biotechnology field is temporally static. Instead, it treats the observed firm and ecosystem dynamics as embedded in a changing environment. The four studies capture different aspects of these dynamics. The quantitative studies examine firm-level outcomes across the full

period while accounting for year-to-year differences, whereas the qualitative studies provide a process-oriented perspective on how actors navigate evolving constraints and support systems. Taken together, the thesis aims to develop an integrated understanding of resource navigation in biotechnology that remains attentive to temporal context, while acknowledging that some transformation mechanisms are difficult to isolate within the scope of the current empirical designs.

4 Research design, data, and methodology

This chapter outlines the research design, data sources, and methodological approaches employed across the four studies that constitute this thesis. In line with the overall purpose of the thesis, to understand how biotechnology firms in Sweden access and manage critical resources for growth within a clustered and institutionally structured innovation environment. The research adopts a mixed-methods design that integrates quantitative and qualitative approaches.

The mixed-methods design reflects the multi-dimensional nature of resource access and firm development in the biotechnology sector. Quantitative methods are used to examine structural and measurable relationships between resource conditions and firm-level outcomes (Ferreira & Fernandes, 2017), addressing research questions 1 and 4. Specifically, quantitative analyses assess how external financing, intellectual capital, and innovation activities relate to biotechnology firms' growth, value added, and capital structure decisions across Sweden's life-science regions.

Qualitative methods are employed to examine how biotechnology incubators and entrepreneurs access, coordinate, and manage resources, and how these processes evolve over the course of firm development, thereby addressing research questions 2 and 3. Through interviews with incubator representatives and biotechnology entrepreneurs, the qualitative studies investigate how networks are built and coordinated, how support mechanisms operate in

practice, and how entrepreneurs navigate shifting resource constraints as their firms move from early to later development stages.

By combining quantitative and qualitative approaches, the thesis adopts a mixed-methods design that supports a complementary understanding of biotechnology firm development. Quantitative analyses provide generalizable evidence of patterns in financing, growth, and capital structure (Abughniem et al., 2020; Polit & Beck, 2010), while qualitative analyses offer in-depth insights into the strategies and institutional interactions through which resources are accessed and mobilized (Kalbarczyk et al., 2021; Lim, 2025). Together, these approaches enable a more comprehensive examination of the financial, institutional, and organizational processes shaping biotechnology firm development within Sweden's clustered innovation environment.

4.1 Quantitative research design

This section describes the quantitative research design applied in Paper 1 and Paper 4. The quantitative approach focuses on firm-level data to analyze how measurable resource conditions influence biotechnology firm growth and financing behavior. The quantitative method is grounded in the operationalization of theoretical concepts into measurable variables, enabling the statistical assessment of whether relationships between variables are consistent, significant, and generalizable from the sample to the broader population (Creswell & Creswell, 2017). By applying quantitative techniques, this approach allows the exploration of broader patterns, comparison across firms and regions, and evaluation of how strongly specific factors contribute to observable outcomes. This method, therefore, strengthens the explanatory power of the research by generating empirical evidence that can either support or challenge assumptions (Bryman, 2016).

The quantitative method is particularly valuable in contexts where researchers aim to establish generalizable findings and examine multiple influences simultaneously. This method also offers several advantages, such as detecting overall patterns, estimating the strength of relationships between variables, allowing results to be tested for consistency, and checked with statistical confidence (Balnaves & Caputi, 2001). However, these benefits come with

limitations. The quantitative analysis may underrepresent contextual nuances, experience-based interpretation, and informal mechanisms that shape organizational behavior (Dunwoodie et al., 2023).

In this thesis, Paper 1 and Paper 4 employ a quantitative approach. By operationalizing theoretical constructs such as intellectual capital, innovation activity, and regional support infrastructure into numerical indicators, the analysis provides the empirical testing of how these constructs relate to biotechnology firm growth and firms' capital structure. In Paper 1, this study investigates how variation in regional resource infrastructures, including access to public and private capital and geographical proximity, relates to the growth of biotechnology firms across Sweden's life science regions. This approach enables a better understanding of how differences in innovation geography shape firm-level opportunities. In Paper 4, the study statistically examines how intellectual capital and innovation activities influence biotechnology firms' capital structure decisions, specifically whether they are more likely to rely on equity or debt financing.

4.1.1 Data sources

For Paper 1, the data have been gathered from Tillväxtanalys to capture regional differences in innovation growth, institutional support, and financial accessibility. These regional indicators include the number of biotechnology firms and public funding availability over the period 2010-2020. Compiling these data enables an examination of how geographical variations and institutional support relate to biotechnology firm survival outcomes (bankruptcy risk) across Sweden's life science regions.

For Paper 4, all data were retrieved from Retriever Business, covering 1,528 biotechnology firms from 2012 to 2022. The dependent variable measures a firm's capital structure decision. The independent variables include value added intellectual coefficient (VAIC) and innovation activity, measured by the patent value. The control variables are profitability, size, firm age, and growth. This dataset enables the examination of how biotechnology firms mobilize financial resources under conditions of high technology risk and heavy reliance on intangible assets.

4.1.2 Variables and measurement

This section describes the operationalization and measurement of variables employed in the quantitative analyses presented in Paper 1 and Paper 4. In both studies, theoretical constructs are translated into observable indicators using firm-level and regional-level data to enable statistical testing of the proposed research questions.

Paper 1 examines how cluster location and access to external financing relate to biotechnology firm survival (bankruptcy risk) over time. The unit of analysis is the firm, while key explanatory variables capture differences in regional financial infrastructure.

Dependent Variable: The dependent variable is bankruptcy, defined as the first observed year in which a firm enters bankruptcy during the study period. Firms are coded bankruptcy = 1 in the event year and right-censored at their last observed year if no bankruptcy occurs. Analysis time is measured in years since entry (or an equivalent firm-time measure), allowing estimation of the hazard (instantaneous risk) of bankruptcy over the firm's observed life.

Independent variable: The main independent variables capture cluster location and external funding. Cluster location is a binary indicator for whether the firm is located in a biotechnology cluster, based on geographic identifiers (municipality/county). External funding is measured using one-year lagged indicators for funding receipt. Models use two funding specifications: (i) an indicator for any external funding, and (ii) separate indicators for public and private funding. To assess whether cluster context conditions the funding-survival relationship, an interaction term (cluster × funding) is included.

Control Variables: All models include one-year lagged, time-varying financial controls. Firm size is measured as $\ln(\text{total assets})$ to capture differences in scale and resource capacity. Capital structure is included to reflect financing profiles and balance-sheet conditions associated with financial distress. These controls help isolate the associations of cluster location and funding with bankruptcy hazard.

Table 1: Summary of variables used in Paper 1.

Variable type	Variable	Measurement	Data source
Dependent variable	Bankruptcy	Bankruptcy event	Tillväxtanalys
Independent variable	Clusters	Firms locating in clusters	Tillväxtanalys
Independent variable	Funding type	Public funding, private funding	Tillväxtanalys
Control variable	Firm size	Total asset (ln)	Tillväxtanalys
Control variable	Capital structure	Debt equity ratio	Tillväxtanalys

Paper 4 investigates how intellectual capital and innovation activity influence biotechnology firms' capital structure decisions. The analysis is based on a panel of Swedish biotechnology firms observed between 2012 and 2022.

Dependent Variable: Capital structure decision is modeled as a binary variable indicating whether a firm relies primarily on equity financing or debt financing. Following prior research, the dependent variable is coded as: 1 if net equity issuance exceeds net debt issuance, and 0 otherwise. This binary operationalization allows the use of logistic regression to estimate the probability that a firm chooses equity over debt as its dominant financing strategy

Independent Variables

- Intellectual Capital (IC): Intellectual capital is measured using the VAIC, which captures the efficiency with which firms utilize human, structural, and capital-employed resources to generate value. VAIC is widely applied in studies of intangible assets and financial strategy and provides an indirect but standardized proxy for intellectual capital efficiency.
- Innovation Activity: Innovation is measured as the natural logarithm of the nominal value of patents and licenses reported by the firm in a given

year. This measure reflects both the intensity and economic relevance of innovation outputs and is commonly used to proxy innovation activity in knowledge-intensive industries.

Control Variables: To control for firm-specific characteristics that may influence financing decisions, the following variables are included: Profitability, measured as EBITDA divided by total assets; Growth opportunities, measured as year-to-year sales growth; Asset tangibility, defined as tangible assets divided by total assets; Firm size, measured as the natural logarithm of total assets; Firm age, calculated as the number of years since establishment. These controls account for differences in risk, maturity, and asset structure that may independently affect capital structure choices.

Table 2: Summary of variables used in Paper 4.

Variable type	Variable	Measurement	Data source
Dependent variable	Capital structure decision	1= Equity financing 0= Debt financing	Retriever Business
Independent variable	Intellectual capital	VAIC	Retriever Business
Independent variable	Innovation activity	Patent value	Retriever Business
Control variable	Profitability	EBITDA/total assets	Retriever Business
Control variable	Firm size	Total asset (ln)	Retriever Business
Control variable	Firm age	Year since firm establishment	Retriever Business
Control variable	Growth	Annual sale growth rate	Retriever Business
Control variable	Asset tangibility	Tangible asset/total assets	Retriever Business

4.1.3 Statistical analysis

Cox hazard model

To examine how cluster location and external funding relate to bankruptcy risk over time, the study applies event-history (survival) analysis using Cox proportional hazards models. Survival analysis is appropriate because it models time to event (bankruptcy) while accounting for right-censoring (firms that do not go bankrupt within the observation window). The unit of analysis is a firm-year spell, and firms are followed annually until bankruptcy occurs or until they exit observation.

The Cox model specifies the bankruptcy hazard for firm i at time t as:

$$h_t(t | X_{i,t-1}) = h_0(t) \exp(X'_{i,t-1}\beta)$$

where $h_i(t)$ is the instantaneous risk of bankruptcy, $h_0(t)$ is the baseline hazard, and $X_{i,t-1}$ is a vector of covariates measured one year earlier. Coefficients are reported as hazard ratios (HRs); values below 1 indicate lower bankruptcy risk and values above 1 indicate higher risk.

All explanatory variables are lagged by one year to strengthen temporal ordering and reduce simultaneity concerns. The empirical analysis follows a structured model sequence aligned with the hypotheses: a baseline model includes financial controls; subsequent models add (i) cluster location, (ii) external funding, (iii) separate public and private funding indicators, and (iv) an interaction term between cluster location and funding to test whether the funding–bankruptcy association differs between cluster and non-cluster firms.

To account for time-specific shocks and macroeconomic conditions, models are stratified by calendar year, allowing the baseline hazard to vary flexibly across years. Because the data are measured annually, ties are handled using the Breslow method. Statistical inference is based on robust standard errors clustered at the firm level to account for within-firm dependence across repeated observations.

The proportional hazards (PH) assumption is assessed using Schoenfeld residual tests (global and covariate-specific). When diagnostics indicate non-proportionality for selected covariates, an additional specification relaxes the PH assumption by estimating a time-varying coefficient model in which the effect of those covariates is allowed to change with time (modelled as a function of $\ln(t+1)$), while retaining proportional effects for covariates that satisfy the assumption. All models are estimated in Stata using partial likelihood.

In Paper 1, a Cox proportional hazards model is employed to examine the relationship between cluster locations, external funding, and the risk of bankruptcy.

Logistic regression

Logistic regression is a commonly used statistical technique to examine the relationship between a dependent variable and one or more independent variables (Smith, 2015). Logistic regression is a type of regression model specifically designed for use when the variable is binary, representing two possible outcomes, such as whether a firm issues equity financing or debt financing (Smith, 2015). This makes logistic regression particularly appropriate for analyzing strategic financing decisions where the outcome reflects a choice between two distinct alternatives.

Logistic regression estimates the probability that an observation belongs to a particular category of the dependent variable, where the predicted probability ranges between 0 and 1 (Smith, 2015). The logistic regression model can include multiple independent variables, such as intellectual capital efficiency, innovation activity, and firm characteristics. The estimated probability for each firm i issuing equity financing (\hat{Y}_i) is calculated using the following logistic function:

$$\hat{Y}_i = \frac{e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i}}{1 + e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i}}$$

where $e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i}$ represents the linear combination of independent variables that determine the log-odds of the outcome. The transformation of predicted probabilities into log-odds results in the following linear relationship:

$$\ln \frac{\hat{Y}}{1 - \hat{Y}} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i.$$

The form enables direct interpretation of the coefficients in terms of their influence on the likelihood of choosing equity financing. One advantage of logistic regression is its use of odds ratios, which provide a clear interpretation of how changes in an independent variable increase or decrease the probability of the strategic outcome.

In Paper 4, logistic regression is used to estimate how intellectual capital and innovation activity influence firms' capital structure decisions, specifically whether they choose equity rather than debt financing. This analysis draws from a panel dataset of Swedish biotechnology firms from 2012 to 2022.

4.2 Qualitative research design

The methodological choice is guided by the study's objectives to explore and understand the complexity of interactions and interdependencies among incubators, entrepreneurs, and supporting institutions. A qualitative approach enables researchers to capture the contextual and relational dynamics of these processes, revealing how actors interpret and respond to constraints, opportunities, and institutional environments within Sweden's biotechnology clusters (Bryman, 2016; Lim, 2025; Waxell, 2009). Paper 2 and Paper 3 are grounded in a qualitative research methodology designed to uncover 1.) how biotechnology incubators coordinate, access, and manage critical resources within the innovation ecosystem. 2.) how Swedish biotechnology entrepreneurs perceive and navigate resource challenges across the early and development stages, and how the role of incubator and other support actors within the innovation ecosystem evolves over time. These phenomena are social and continuously evolving, shaped by processes of collaboration, negotiation, and adaptation. Understanding them, therefore, requires methods that allow detailed, interpretive, and context-sensitive exploration rather than statistical measurement.

Within this methodological design, this study uses qualitative interviews, semi-structured and structured interviews to investigate the perspectives of biotechnology incubators and entrepreneurs in Sweden. These interviews are particularly effective for exploring the practices, experiences, and interactions through which actors coordinate and access resources within the innovation ecosystem. They enable participants to describe their activities, perceptions, and strategies in their own words, providing rich and in-depth insights (DeJonckheere & Vaughn, 2019; Dunwoodie et al., 2023).

4.2.1 Data collection

In Paper 2, semi-structured interviews were conducted with representatives of biotechnology incubators across Sweden. The organizational sample, presented in Table 3, includes both university-affiliated incubators and independent regional incubators that play important roles in connecting early-stage ventures to knowledge, capital, and networks. The sampling strategy was purposive, selecting incubators that vary in size, ownership, and regional location in order to capture different institutional contexts within the Swedish biotechnology innovation ecosystem.

Table 3: Incubators participating in the study.

Organization	Type of Incubator	Region	Founded
Medeon	Regional incubator	Malmö	1985
GU Venture	University incubator	Gothenburg	1995
KI Innovation	University incubator	Stockholm	1996
Uppsala Innovation Center	University incubator	Uppsala	1999
Sting	Regional incubator	Stockholm	2002
Umeå Biotech Incubator	University incubator	Umeå	2003
Smile	Regional incubator	Lund	2007

Building on this organization sample, Table 4 presents the profile of the respondents interviewed from these incubators. The respondents occupied senior roles, including CEOs, board members, and an investment director, and had substantial professional experience. Their positions made them well placed to provide informed accounts of incubator strategy, resource coordination, and support mechanisms for biotechnology ventures.

Table 4: Profile of the respondents of the study.

Participants	Title	Relevant experience (Years)	Gender	Date
P1	CEO	5-10	Man	Dec 8 th 2023
P2	Board member	5-10	Woman	Jan 31 st 2024
P3	CEO	5-10	Man	Oct 23 rd 2023
P4	CEO	>10	Woman	Jan 30 th 2024
P5	CEO	>10	Man	Oct 30 th 2023
P6	Investment director	>10	Man	Feb 1 st 2024
P7	CEO	>10	Man	Jan 15 th 2024
P8	Board member	>10	Woman	April 19 th 2024
P9	CEO	>10	Man	April 22 nd 2024

The interviews followed a guide consisting of thematic sections on network formation, resource acquisition, financial intermediation, and managerial support. This design provided a balance between structure and flexibility. It ensured comparability across interviews while allowing respondents to elaborate on specific practices, experiences, and challenges. Each interview

lasted approximately 60 minutes, was audio-recorded with permission, and transcribed verbatim for analysis. The objective of this semi-structured design was to identify how incubators mobilize and reconfigure networks and resources in support of biotechnology startups. The data provided insight into the mechanisms that underpin resource flows and institutional collaboration, thereby complementing the quantitative findings on financing and growth.

In Paper 3, structured interviews were carried out with biotechnology entrepreneurs and firm founders. The goal was to provide systematic, comparable insights into the entrepreneurs' experiences of resource constraints, financing, and institutional support across different phases of firm growth. A set of structured interview questions was developed, covering four key domains, including company characteristics and background, early-stage development and challenges, relationship with incubators and support organizations, and financing experiences and capital acquisition. The questions were adapted from previous Swedish studies of early-stage technology ventures to ensure relevance and comparability. Participants were selected using criterion-based sampling, focusing on firms listed under the biotechnology SNI codes and affiliated with national associations such as SwedenBIO. In total, sixteen interviews were completed, eight with early-stage firms and eight with development-phase firms.

4.2.2 Data analysis methods

Content analysis

The data collected from interviews were analyzed using content analysis. The content analysis is particularly suitable for exploring complex social phenomena that involve multiple actors, contexts and interactions, as it enables the researcher to systematically organize and interpret extensive qualitative material into meaningful patterns and relationships while maintaining closeness to the original data (Bryman, 2016; Elo & Kyngäs, 2008; Harwood & Garry, 2003). Qualitative content analysis also enables both descriptive and interpretive understanding of textual material. It does not rely on quantifying words or phrases but instead focuses on the underlying meanings, processes, and relationships expressed in participants' narratives (Bryman, 2016; Graneheim & Lundman, 2004). Through this method, the researcher can

identify how interviewees communicate their experiences of collaboration, institutional interaction, and strategic adaptation.

In Paper 2, content analysis was employed to identify and interpret patterns in incubators' strategies, focusing on how networks were used for resource coordination and control. Analysis began deductively with predefined categories informed by theoretical constructs such as human, financial, technological, and relational resources, guided by theoretical constructs from the resource-based view and resource dependence theory. This deductive stage helped structure the data around the incubators' strategic coordination mechanisms. As coding progressed, an inductive phase was introduced to capture insights into key partners of the incubator and how they coordinate. This inductive stage also extended beyond the initial framework, including trust-based coordination, reputation effects, and geographical proximity.

In Paper 3, content analysis was applied to entrepreneurial narratives to identify key categories corresponding to the four sections of the interview guide. Coding focused on identifying how entrepreneurs described their resource challenges, experiences with institutional support, and evolving relationships with incubators and funding organizations. These patterns were later clustered around broader themes such as access to finance, technical expertise, legitimacy, and stage-specific support dynamics. Comparing these findings between early-stage and development-phase firms revealed how resource needs and the perceived value of institutional support change over time.

4.3 Ethical consideration

This thesis follows ethical standards for academic research, particularly those applicable to studies involving human participants and secondary data analysis (ALLEA, 2023). The four papers included in this thesis involve different type of data, therefore ethical considerations are tailored to the characteristics and risk associated with each methodological approach.

Paper 1 and Paper 4 rely exclusively on secondary data publicly available or institutionally provided datasets containing aggregated business information.

All data used in Paper 1 do not contain personal or individually identifiable data. The firm-level analysis in Paper 4 uses financial records sourced from Retriever Business (annual report data collected under Swedish disclosure regulations), and the data were analyzed at the organizational level without processing personal identifiers. Because these papers do not involve human subjects or sensitive personal data, they pose no ethical risks to individuals.

Papers 2 and 3 involve qualitative interviews with CEOs and board members of incubators and biotechnology entrepreneurs in Sweden. Prior to each interview, participants were informed about the aims of the study and their right to withdraw at any point without consequence. In Paper 2, informed consent was obtained before conducting semi-structured interviews. In Paper 3, structured interviews were carried out with sixteen biotechnology entrepreneurs, all of whom agreed to participate in this study. The interviews focused exclusively on experiences, resource needs, and organizational relationships and did not collect any sensitive personal information. To ensure confidentiality, identifying details such as names of individuals and companies were removed during transcription and analysis (Kang & Hwang, 2021).

Across all components of the thesis, ethical practices were ensured through secure data handling, and the anonymization of interview responses. No incentives were offered, and no form of deception or manipulation was used. As the research did not involve vulnerable populations, sensitive biological information, or experimental interventions, the overall risk level was assessed as minimal. Ethical guidelines regarding integrity, data protection, and participant autonomy were upheld throughout the research process (ALLEA, 2023; Kang & Hwang, 2021).

4.4 Use of AI-assisted tools

Generative AI tools were used in a limited and supportive role during the writing process of this thesis, primarily for language editing, grammar correction, and improving readability. In some cases, draft sentences written by the author were reorganized into coherent paragraphs to improve structure and flow. AI tools were not used to generate data, fabricate sources, or conduct statistical analyses. All empirical analyses, interpretations, and conclusions were developed and

verified by the author. The author reviewed and edited AI-assisted outputs and takes full responsibility for the final content of the thesis.

4.5 Author contributions

This section outlines the author’s contributions for each of the four papers included in the dissertation. Table 5 shows that although the specific distribution of tasks differed across papers, the author was consistently involved in the core stages of the research process. The table is intended to provide transparency regarding the division of responsibilities across co-authored publications.

Table 5: Author contributions for each research paper.

Contributions	Paper 1	Paper 2	Paper 3	Paper 4
Conceptualization	Kritthana, Björn	Kritthana, Andreas	Kritthana	Kritthana, Björn, Ida
Methodology	Kritthana	Kritthana, Andreas	Kritthana, Inga-Lill	Kritthana, Ida
Formal analysis	Kritthana	Kritthana	Kritthana, Inga-Lill	Kritthana, Ida
Investigation	Kritthana	Kritthana	Kritthana, Inga-Lill	Kritthana, Ida
Writing- original draft preparation	Kritthana, Björn	Kritthana, Andreas	Kritthana, Inga-Lill	Kritthana, Björn, Ida
Writing – review and editing	Björn	Kritthana, Andreas	Kritthana, Inga-Lill	Kritthana, Björn, Ida

5 Results

This chapter synthesizes the findings from the four research papers included in this thesis. It begins with a cross-paper synthesis (as seen in 5.1) that integrates results across studies to highlight how resource constraints evolve across development stages, how intermediary mechanisms such as incubators and networks facilitate resource access, and how financing logics shape observable firm outcomes in the Swedish biotechnology context. Section 5.2 then provides summaries of each paper, outlining their objectives, methodological approaches, key findings, and contributions.

5.1 Results

While each research paper addresses a distinct research question and uses different data and methods, the four studies speak to a shared underlying phenomenon, which is that biotechnology firms in Sweden develop under persistent resource constraints, and their trajectories depend not only on whether resources exist in the environment but on how resources are accessed, coordinated, and strategically mobilized over time. This thesis has framed these dynamics through the lens of resource navigation and resource orchestration, where cluster and institutional conditions represent the broader context, incubators and networks function as intermediary mechanisms, and firm outcomes become visible in patterns of survival, value creation, and financing choices.

The studies suggest that the Swedish biotechnology ecosystem is best understood as a structured and stage-sensitive support environment. Resource constraints do not appear as a single gap that can be filled once and for all. Instead, constraints shift across development stages, and effective support depends on the timing and fit between a firm's needs and the resources it can credibly mobilize. The qualitative studies provide a close view of how entrepreneurs and incubators experience these constraints and how they work through them, while the quantitative studies show how these processes are reflected in observable outcomes at scale, such as bankruptcy hazard and the balance between equity and debt financing.

5.1.1 A stage-based view of resource constraints

A first integrative insight concerns the stage-specific nature of resource constraints. The interviews with entrepreneurs show a clear pattern. Early-stage biotechnology firms rely heavily on incubators, universities, and public funding agencies, particularly Vinnova, for technical expertise, legitimacy, early network building, and initial funding. This reliance is not simply a preference. It reflects the liabilities of newness that characterize science-based ventures, where firms must signal credibility before they can access broader markets and investors. However, even with strong institutional support, early-stage firms repeatedly describe persistent gaps in managerial expertise and early-stage capital. In this early period, business angels are perceived as more impactful than banks or venture capitalists, suggesting that financial access is shaped by both firm stage and the risk tolerance embedded in different financing actors.

As firms progress into a development phase, the profile of constraints changes rather than disappears. Development-phase firms report greater clarity in market orientation, improved managerial capacity, and a more diversified financing landscape, including Almi, business angels, and follow-on public support. In other words, later-stage firms do not merely "have more resources". Instead, they operate with a different configuration of needs and capabilities, where commercialization and scaling place heavier demands on market-oriented resources, and where external support becomes more selective and strategic. This transition implies that the central challenge is not only resource scarcity, but also the alignment between stage-specific needs and the institutional and financial instruments available in the ecosystem.

Importantly, incubators structure their support around multiple resource categories such as human, financial, operational, and technological and they rely on external partnerships to sustain these resource flows. Technological resources, in particular, are not uniformly required. Pharmaceutical and biotechnology ventures often depend strongly on laboratory infrastructure and specialized equipment, whereas MedTech and e-health ventures may not require the same degree of physical infrastructure. This variation matters because it implies that the “resource problem” is partly sectoral and partly stage-specific, and therefore difficult to address through standardized support models.

5.1.2 Intermediary mechanisms and networked resource orchestration

A second synthesis concerns how resources become accessible in practice through intermediary mechanisms, especially incubators and networks. The incubator study provides a detailed account of how Swedish biotechnology incubators strategically build and manage networks in order to acquire resources that are essential for early-stage venture development. The findings indicate that incubators treat network management as a core strategic task rather than a peripheral activity. They mobilize key partners such as universities, science parks, investors, service providers, and public actors and they sustain resource flows through trust-based partnerships, organized interaction mechanisms, specialization, and the leveraging of geographical proximity.

According to two qualitative studies, incubators appear not only as service providers but as orchestrators that shape how resources are sequenced and coordinated. At the ecosystem level, incubators build legitimacy linkages with universities and science parks, manage investor relationships through pitch events and tailored matchmaking, and invest in longer-term capacity through dedicated investor relations functions and international collaborations. At the firm level, entrepreneurs experience this orchestration as highly valuable in early stages, where incubators act as high-intensity collaborators and increasingly as a more selective and strategic partnership in later stages as firms develop internal capacity and external networks. In this sense, incubators are not merely support organizations; they function as intermediaries that translate institutional structures into concrete access channels for entrepreneurs navigating uncertainty.

This intermediary mechanism perspective also helps interpret the broader claim that cluster environments do not automatically generate benefits. Even in clustered settings, resources must be mobilized and coordinated, and this coordination is often mediated through organized networks. The thesis, therefore, suggests that cluster advantages are partly conditional on the presence of effective intermediaries and the ability of firms to engage with them at the right time and with the right signals of credibility.

5.1.3 Financing logics under uncertainty: public vs private

A third synthesis links the ecosystem and intermediary mechanisms to observed survival patterns. The survival study examines how biotechnology clusters' location and external funding relate to bankruptcy risk over time among Swedish biotechnology firms. The results indicate that firms located in biotechnology clusters exhibit lower bankruptcy hazard than comparable firms outside clusters. External funding is also associated with lower bankruptcy risk; however, this association is primarily driven by public funding, while private funding is not statistically distinguishable from zero in the baseline specifications. Furthermore, the interaction tests do not provide evidence that funding is more protective inside clusters, suggesting that the protective association of external funding does not depend simply on whether a firm is located in a cluster. Diagnostics also suggest that the cluster effect is time-dependent, implying that cluster-related advantages may vary across the firm life course.

The qualitative evidence offers a plausible ecosystem-level interpretation of these patterns. Entrepreneurs describe public funding agencies, particularly Vinnova, as pillars across stages, while simultaneously pointing to persistent early-stage financing gaps and the uneven availability of private capital at the earliest and most uncertain phases. Incubators, in turn, rely heavily on public funding sources such as Vinnova, municipalities, and EU programs, while also cultivating relationships with private investors and, in some cases, taking equity in startups to diversify their income streams. This combination suggests a financing logic in which public actors provide risk-sharing and legitimacy mechanisms that stabilize firms through long pre-revenue development periods,

whereas private financing appears more selective and less uniformly connected to survival outcomes at the population level.

This does not imply that private capital is unimportant. Rather, the thesis-level implication is more nuanced. In a science-based sector characterized by uncertainty and intangibility, public support may provide the continuity and credibility that enables firms to survive long enough to become investable for later-stage private investors. In this sense, public funding can be interpreted not only as financial input but also as part of the institutional scaffolding that supports early resource navigation.

5.1.4 Financing choices and the nature of intangibles

A fourth synthesis addresses how the nature of knowledge-based resources shapes financing behavior. The capital structure study examines Swedish biotechnology firms from 2012 to 2022 and finds that intellectual capital significantly increases the likelihood of equity issuance. This pattern is consistent with the idea that firms with stronger intangible resource efficiency are better positioned to attract equity investors, because intellectual capital can signal growth potential and lower perceived risk. At the same time, innovation activity, proxied by patent value, shows a significant negative association with equity issuance. This suggests that highly innovative firms may prefer debt financing, potentially to retain control, avoid ownership dilution, and use patents as collateral.

This result becomes particularly valuable at the thesis level because it complicates simple claims that biotechnology firms are uniformly equity dependent. Instead, it points to heterogeneity within the category of intangibles. Intellectual capital and patent-based innovation do not appear to push firms in the same financing direction. When these findings are considered alongside the survival evidence, they suggest that financing strategies in Swedish biotech may reflect pragmatic trade-offs that combine stage-specific resource needs, legitimacy dynamics, and the distinct properties of different intangible assets. In practical terms, the thesis indicates that capital structure decisions are not only a matter of the availability of funding sources; they are also shaped by what

kinds of knowledge assets a firm holds and how these assets can be interpreted by financiers.

Overall, the results indicate that at the top level, cluster and institutional conditions shape the opportunity structure for resource access by influencing proximity to specialized actors, legitimacy signals, and the availability of structured support instruments. Within this context, incubators and networks operate as intermediary mechanisms that broker, coordinate, and orchestrate access to human, financial, operational, and technological resources. At the firm level, entrepreneurs engage in resource navigation practices that evolve across development stages, initially emphasizing legitimacy-building and broad support mobilization, and later shifting toward more selective partnerships and commercialization-oriented strategies. These processes are reflected in observable outcomes, including survival risk, value creation, and capital structure choices.

5.2 Summary of papers

Paper 1 examines whether biotechnology cluster location and external funding are associated with lower bankruptcy risk among Swedish biotechnology firms.

Table 6: Summary of Paper 1.

Aspect	Summary
Purpose	To examine whether biotechnology cluster location and external funding (public and private) are associated with lower bankruptcy risk among Swedish biotechnology firms.
Methodology/Design	Quantitative longitudinal study using firm-level register data (firm-year panel, 2010–2020). Survival analysis is applied using stratified Cox proportional hazards models with one-year lagged covariates, robust standard errors clustered at the firm level, and proportional-hazards diagnostics.
Findings	Cluster-based firms exhibit lower bankruptcy hazard than non-cluster firms. Receiving external funding is associated with lower bankruptcy risk, and this relationship is primarily driven by public funding, while private funding is not statistically distinguishable from zero in baseline models. The cluster × funding interaction does not indicate that funding is more protective inside clusters.
Research Implications	Shifts attention from performance-only outcomes to a failure-risk (survival) perspective in biotechnology. Integrates clusters and funding sources within an event-history framework, highlighting how financing and location relate to downside risk under high uncertainty.
Practical Implications	For policymakers, the results support the importance of public funding instruments that sustain firms through long pre-revenue development periods. For clusters, the analysis underscores the relevance of cluster environments as part of survival-oriented support strategies, alongside financing access.

Paper 2 examines how Swedish biotechnology incubators build and manage networks to acquire critical resources for startup development.

Table 7: Summary of Paper 2.

Aspect	Summary
Purpose	This study examines how Swedish biotechnology incubators strategically build and manage networks to acquire critical resources for startup development. It aims to identify the resource categories most essential for incubators and clarify the mechanisms they use to connect with key partners.
Methodology/Design	A qualitative case study based on semi-structured interviews with CEOs and managers from Swedish biotechnology incubators. Content analysis was used to examine resource strategies, partnerships, and support mechanisms.
Findings	The analysis reveals four core categories of resources including human, financial, operational, and technological resources acquired through diverse network alliances. Universities, science parks, investors, government agencies, and service providers emerge as key partners in resource acquisition. Incubators employ trust-based relationships, organized interaction mechanisms, specialization strategies, and geographical proximity to sustain and expand these networks. The findings also show variation in incubator business models and highlight how proximity to universities and science parks enhances credibility, resource access, and collaborative opportunities.
Research Implications	This study contributes to the literature on incubator management by integrating resource-based view and resource dependence theory to explain how incubators orchestrate internal and external resources. Future research could extend this analysis to international comparisons or investigate long-term outcomes of different incubator models.
Practical Implications	The findings offer actionable insights for incubator managers and policymakers. Managers can strengthen support for biotech startups by cultivating trust-based networks, offering flexible mentorship models, and leveraging specialized service providers. Policymakers can enhance ecosystem effectiveness by incentivizing partnerships among universities, incubators, and science parks, as well as by sustaining public funding

Paper 3 examines how Swedish biotechnology entrepreneurs perceive and navigate resource constraints across different stages of firm development.

Table 8: Summary of Paper 3.

Aspect	Summary
Purpose	This study investigates how Swedish biotechnology entrepreneurs perceive and navigate resource constraints across the early and development stages of firm development. It focuses on the dynamic role of incubators and other support actors in shaping innovation, financing and long-term sustainability in biotechnology sector.
Methodology/Design	Structured interviews were conducted with 16 Swedish biotechnology entrepreneurs, equally divided between early-stage and development-stage firms. The interviews were analyzed thematically to identify patterns in resource constraints, financing experience, institutional support, and incubator engagement across the biotechnology firms' lifecycle.
Findings	Early-stage firms rely more on incubators, universities, and public support, while development-stage firms depend more on internal capabilities and broader networks. Funding challenges persist throughout the lifecycle, with Vinnova and business angels highlighted as the most influential actors. The role of incubators is shown to be dynamic, evolving from high-intensity collaborators in early stages to occasional strategic partners in the development phase, offering more targeted support as firms gain internal capabilities and networks.
Research Implications	This study extends the resource-based view, dynamic capabilities, and social capital theory by illustrating how biotechnology entrepreneurs reconfigure resources and relationships across development stages. It highlights the need for longitudinal and comparative studies to further examine stage-sensitive support dynamics in science-based sectors.
Practical Implications	The findings suggest that incubators and policymakers should design differentiated, stage-specific support mechanisms. Early-stage ventures benefit most from broad, foundational services, while development-phase firms require targeted support such as internationalization, advanced commercialization, and access to growth capital.

Paper 4 examines how intellectual capital and innovation activity influence financing choices in Swedish biotechnology firms.

Table 9: Summary of Paper 4.

Aspect	Summary
Purpose	This paper examines how intellectual capital and innovation activity shape the capital structure decisions of Swedish biotechnology firms. Given the sector’s high reliance on intangible assets and long development cycles, the study aims to uncover whether these two factors drive firms to favor equity or debt financing.
Methodology/Design	The study uses a longitudinal panel dataset of 1,528 Swedish biotechnology firms from 2012–2022 retrieved from the Retriever Business database. The study applies logistic regression modeling to examine the relationship between intellectual capital, innovation activities, and firms’ financing choices. Intellectual capital is measured by the Value-Added Intellectual Coefficient (VAIC), while innovation is proxied through patent and license valuation.
Findings	Results reveal that firms with higher intellectual capital are significantly more likely to issue equity, reflecting the challenges of using intangible assets as collateral but their attractiveness to investors. In contrast, firms with higher innovation activity tend to rely more on debt financing, likely due to patents serving as collateral and the desire to avoid ownership dilution.
Research Implications	This study extends theoretical frameworks on capital structure by integrating the role of intellectual capital and innovation in a knowledge-intensive industry. Future research could explore cross-country comparisons, incorporate macroeconomic variables, or examine managerial and governance factors shaping financing decisions.
Practical Implications	Managers in biotechnology firms should adopt flexible financing strategies that balance equity and debt, considering how intellectual capital and innovation pipelines affect investor perception and financing access. For policymakers, the findings underscore the importance of not only facilitating equity markets but also ensuring access to debt financing.

6 Implications and future research

The thesis shows that it is not only resource availability, but how resources are orchestrated through intermediaries and navigated across stages that shape survival and financing outcomes

6.1 Theoretical implications

This thesis contributes to the literature on biotechnology entrepreneurship, innovation clusters, and firm financing by integrating multiple theoretical perspectives across different levels of analysis. By combining quantitative and qualitative evidence, the thesis advances understanding of how biotechnology firms access, mobilize, and manage critical resources within a clustered and institutionally structured environment.

First, the findings extend research on external financing and firm survival in science-based industries. While prior studies have emphasized that access to capital is critical for biotechnology development, the results of Paper 1 show that the type and structure of external funding are associated with firms' ability to remain viable over time, reflected in differences in bankruptcy hazard. By distinguishing between public and private funding sources, the study highlights that financing should not be treated as a purely volume-based input. Rather, it functions as a form of risk-sharing and legitimacy that can influence whether firms endure long and uncertain pre-revenue development periods. In addition, the findings contribute to cluster and innovation research by linking cluster location and the institutional configuration of funding to survival outcomes at

the firm level, rather than assuming that clusters provide uniform advantages. Overall, the results suggest that the survival implications of both funding and cluster context are conditional and time-sensitive, reinforcing the need to theorize science-based entrepreneurship as a process shaped by institutional support structures and evolving risk profiles. The analysis identifies associations rather than causal effects, but it provides evidence consistent with the view that public support mechanisms can stabilize firm survival under high uncertainty.

Second, the thesis advances resource-based and resource dependence perspectives by shifting attention from firms to intermediary organizations. Paper 2 shows that biotechnology incubators are not passive support structures but active resource coordinators that strategically manage networks to secure human, financial, operational, and technological resources. By conceptualizing incubators as organizations that orchestrate external resources through trust-based partnerships, specialization, and proximity, the thesis extends the resource-based view and resource dependent theory to account for inter-organizational resource mobilization in highly specialized industries. This contributes to incubator research by clarifying how networking strategies translate into concrete resource flows rather than simply whether networks exist.

Third, the thesis contributes to entrepreneurship research by foregrounding entrepreneurs' lived experiences of resource constraints across development stages. Paper 3 demonstrates that resource challenges are dynamic rather than static, evolving as firms move from early scientific validation toward commercialization and scale-up. The findings challenge stage-based models that treat support needs as fixed, instead highlighting how entrepreneurs continuously renegotiate relationships with incubators, investors, and public agencies. This adds a process-oriented perspective to biotechnology entrepreneurship literature and emphasizes the role of perception, learning, and adaptation in navigating uncertainty.

Finally, the thesis contributes to capital structure theory in knowledge-intensive sectors by integrating intellectual capital and innovation activity into analyses of financing decisions. Paper 4 shows that intangible resources, such as intellectual capital efficiency and patent activity, influence firms' reliance on

equity versus debt, but not always in ways predicted by conventional theories. The findings nuance pecking order and agency-based explanations by showing that biotechnology firms may continue to use debt even under high uncertainty when it supports continuity in R&D. This contributes to financial economics by demonstrating that capital structure behavior in biotechnology reflects pragmatic trade-offs shaped by intangible assets, innovation intensity, and institutional context.

6.2 Practical implications for policymakers and entrepreneurs

The findings of this thesis offer several practical implications for policymakers, incubator managers, and biotechnology entrepreneurs.

For policymakers, the results highlight the importance of maintaining a balanced funding landscape that combines public support with mechanisms that facilitate private investment. Paper 1 shows that public funding plays a stabilizing role, particularly in early stages, but that private capital is crucial for scaling and value creation. Policies that encourage coordination between public funding schemes and private investment, such as co-investment schemes or public guarantees, can help reduce financing gaps and support firm progression.

For incubator managers, the thesis underscores that effective incubation depends on strategic network management rather than standardized service provision. Paper 2 demonstrates that human capital, particularly industry-specific business coaching, is a critical resource, and that trust-based relationships with universities, investors, and public agencies are central to sustaining resource flows. Incubators may therefore benefit from investing in specialized staff, dedicated investor relations functions, and long-term partnerships rather than expanding services indiscriminately. Participation in national and international networks can further extend resource access beyond regional boundaries.

For biotechnology entrepreneurs, the findings highlight the importance of actively managing relationships with support organizations and investors as firms evolve. Paper 3 shows that entrepreneurs who adapt their engagement

strategies over time, shifting focus from legitimacy and seed funding toward market access and scaling, are better positioned to navigate resource constraints. Understanding how intellectual capital and innovation outputs signal firm quality to investors, as shown in Paper 4, can also help entrepreneurs make more informed financing decisions and align funding strategies with long-term innovation goals.

6.3 Limitations

Despite its contributions, this thesis has several limitations that should be acknowledged. First, the empirical focus on Sweden limits the generalizability of the findings. Sweden represents a mature but relatively small innovation economy with strong public support and well-developed institutions. While this context provides valuable insights, financing dynamics, incubator roles, and entrepreneurial strategies may differ in larger economies or regions with weaker institutional frameworks. Second, the quantitative analyses rely on secondary data, which constrains the range of variables that can be observed. Measures of innovation and intellectual capital, while carefully operationalized, cannot fully capture qualitative aspects such as managerial competence, strategic intent, or informal learning processes. Third, the qualitative studies draw on a limited number of interviews, reflecting the depth-oriented nature of the research design. Although this approach provides rich insights into processes and perceptions, it does not aim for statistical representativeness. Entrepreneurial experiences may vary across subsectors and firm types in ways not fully captured here. Finally, the thesis examines firms and support structures at specific points in time. While development stages are addressed conceptually, fully longitudinal qualitative data would be required to trace resource dynamics over longer periods. While year adjustments account for common annual shocks, the thesis does not fully identify structural breaks or causal mechanisms of industrial transformation. Future research could combine policy/event-specific designs or richer time-varying measures of ecosystem change to examine how the effects of funding, clusters, and intermediaries evolve across different transformation phases.

6.4 Future research avenues

Building on these limitations, several avenues for future research emerge. First, comparative studies across different national or regional contexts could examine how variations in institutional frameworks and capital markets shape biotechnology development. Such research would help assess the transferability of the findings beyond Sweden. Second, future work could adopt longitudinal qualitative designs to follow biotechnology firms and incubators over extended periods. This would allow deeper analysis of how resource strategies evolve in response to success, failure, or external shocks. Third, further research could explore interactions between incubators and investors, examining how evaluation criteria, signaling mechanisms, and risk perceptions co-evolve in science-based industries. Finally, future studies could integrate micro-level measures of managerial cognition and decision-making to better understand how entrepreneurs interpret uncertainty and translate resource availability into strategic action.

7 Appendix

This appendix presents examples of the interview questions used in Paper 2. The questions are grouped by theme and sub-theme to illustrate the structure of the interview guide.

Themes	Sub-theme	Examples of questions
Incubator's objective and strategies	Goals	Could you tell me about an overview of your incubator, your mission, and goals?
	Strategies	What are your key strategies to achieve these goals?
	Changes in strategy	How your goals and strategies have been changed over time (Maybe the last 10 years)?
		What specific changes have you observed in the biotech startup in recent years, and how these changes influence your goals and strategies?
Resources	Key resources	What are the key resources you seek for your incubator?
		What kind of resources you provide to your incubatees (startups)?
	Collaboration	How do you cooperate with other institutions in order to acquire these resources?
		How do you identify potential partners?
		Whom do you consider to be the most important partner?

Network development	Network	Could you provide examples of how your incubator has leveraged the network?
		How important is building and expanding network in your incubator?
		Do you have any international collaborations or partnerships?
University collaboration	Role	What is the role of the university?
		How this role has been changed over time?
	Collaboration	How do you connect to the university?
	Advantages	How do partnerships with universities benefit you and startups in your program? (Give specific examples)
Investor collaboration	Role	What is the role of investors?
		How this role has been changed over time?
	Collaboration	How do you connect to investors?
	Advantages	How do partnerships with investors benefit you and startups in your program? (Give specific examples)
Government agency collaboration	Collaboration	Do you have a collaboration with some government agencies?
	Role	What is the role of that agency?
		How this role has been changed over time?
	Collaboration	How do you connect to them?
	Advantages	How do partnerships with government agencies benefit you and startups in your program? (Give specific examples)
Startup collaboration	Role	What is the role of startups?
	Collaboration	Could you describe the strategies that you use to attract and support biotech startups in your network?
		How do you facilitate collaboration among startups?
		What strategies do you use to connect startups with other supportive institutions?

		Could you give examples of biotech startups that have benefited from your network?
Other incubators	Collaboration	Do you collaborate with other incubators?
	Role	What is the role of that incubator?
	Collaboration	How do you connect to them?
	Advantages	How do partnerships with other incubators benefit you and startups in your program? (Give specific examples)
Success factors and challenges	Success and challenge factors	What are the key success factors and challenges of your incubators?
	Success in network	What are critical success factors for building and expanding your network?
	Challenge in network	What are your challenges or obstacles you have encountered when trying to expand your network?

The table below presents examples of the interview questions used in Paper 3.

Themes	Questions
Basic information	In what year was the company started (in its current form)?
	Number of full-time employees?
	Number of part-time employees?
	Company turnover (per year)? (Maybe number for 3 years)
	How would you characterize the company's level of technology?
	What is the company's main origin environment?
	Could you describe the ownership structure of your company? Who are the current owners, and which groups play the largest role in ownership?
	Which phase of development is the company in today?
	Would you say that finding interested customers in the early stage was easy, somewhat difficult, or very difficult?
	Did you find it difficult to decide which market to direct your early development toward?

	Would you say you had a clear idea of customer needs when development began, or was this something that evolved later?
	Has your company experienced significant difficulties in obtaining technical or scientific expertise?
	Has your company had problems obtaining management expertise?
	Has it been difficult for your company to obtain the financial resources needed during development? How would you describe the level of difficulty—low, moderate, or high?
	Are you currently experiencing significant challenges in raising capital for the company? Would you say these challenges are minor, moderate, or major?
	Thinking about the period until your company reached commercial viability — did that phase take longer than expected, proceed as expected, or move faster than expected?
	When you began developing the technology, how certain were you that it would succeed? Would you say the outcome was close to what you initially expected, or did it change significantly during development?
	Is the market segment you are targeting today the same one you originally identified, or has it changed over time?
	Looking at the company's development up to this point, would you say things have gone worse than expected or better than expected?
Early stage and development stage	How would you describe the state of the market when you first began developing your product or technology? Would you say it was a new and unprocessed market, a market in early expansion, one experiencing strong growth, a market entering maturity, or a fully mature and slow-growth market?
	Thinking about this stage, did any external actors play a role in helping you refine or develop your project idea, for example, making the idea clearer, easier to communicate, or more market-ready?
	At this stage, did any external actors help you identify or choose your market or market segment, for example by helping you find customers, compare different segments, or build early customer relationships?
	Thinking about this stage, did any external actors help you solve technical or research-related problems, for example by providing expertise, connecting you with technical partners, or offering important scientific or technical information?
	Thinking about this stage, did any external actors help you address challenges related to raising capital?

	Thinking about this stage, did any external actors help make your company or its technology visible or well-known within important networks or industry circles?
	Thinking about the early stage and development phase of your company, how important were these actors for your overall development? (Business angels, VCs, Vinnova, Almi, Bank, Customer suppliers, University, Incubator, RISE, etc)
Incubator	How often does your company interact with the incubator?
	Does your incubator have significant expertise and/or training in sales?
	Does your incubator have significant expertise and/or education in technology or science?
	How many new contacts have the incubator offered your company?
	When your company was working with the incubator, were there specific areas of buyer or customer preferences that you wanted to learn more about? (Follow up: Integration with other products or systems, product features, Maintenance requirements – yes or no?)
	Thinking about your experience with the incubator, how important were the different services they offered for the success of your business? (services, supports...)
	Are there any other services that the company would have wanted/needed but were not offered?
Concluding questions	I'd like to ask about the different actors your company has interacted with for financial support.
	To what extent have customers contributed to financing your company's development?
	To what extent have suppliers contributed to financing your company's development?
	How would you describe the current situation for financing a new company in Sweden? Would you say it is difficult?
	In your view, how important is Vinnova for the development of the biotechnology and life science sector in Sweden? If Vinnova did not exist, do you think the level of development would be much lower than today?
	What are your overall views about how well different actors—public actors, private investors, and venture capital firms—support young biotechnology companies?
	Is there anything else you would like to add about your company's development and role of incubators that we haven't covered yet?

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