External Funding Matters, but Does it Matter Who it Comes from?

Exploring the Differential Effects of Different Funding Types on Swedish Biotech Firms

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Abstract:

The biotechnology field produces astonishing medical innovations with vital transformative potential for modern medicine and society at large. At the same time, biotech is characterized as R&D-intensive, with decade-long product lead times and the need for substantial investment costs. Dedicated biotech firms (DBF) hence depend on interorganizational ties to other actors to access external capital and complementary resources. Different capital providers offer various types of funding that differ in their investment objectives and degrees of engagement. This master thesis seeks to analyze the differential effects of different funding types on DBF performance by empirically investigating the Swedish biotech ecosystem from 2004-2015. The theoretical framework used for analysis combines Entrepreneurial Ecosystem and Entrepreneurial Finance literature. Using an explorative pre-study, we shine light on the dynamic composition of funding along the DBF life cycle. Building on the findings from the pre-study, the main analysis constitutes a series of regression models estimating the effect of the most relevant funding types on performance in terms of growth. We find evidence that the total number of funding ties, funding from the government, and international funding are consistently positively correlated with employee growth. Funding from VCs and corporate alliances only partially show a positive growth impact. We discuss the importance of overcoming the prevalent funding gap and account for different dynamics bringing about the specific capital landscape in Sweden's biotech ecosystem.

Keywords: Biotech; Entrepreneurial Ecosystem; Entrepreneurial Finance; External Funding

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Glossary

Biotech	Biotechnology
DBF	Dedicated Biotech Firm
EE	Entrepreneurial Ecosystem
EMA	European Medicines Agency
FDA	Food and Drug Administration
GVC	Governmental Venture Capital
IPO	Initial Public Offering
IVC	Independent Venture Capital
M&A	Merger & Acquisition
PE	Private Equity
R&D	Research & Development
SWF	Sovereign Wealth Funds
VC	Venture Capital

Table of Contents

1. Introduction

"Our solid financial situation make[s] us a unique biopharma company, not only in Sweden but globally" says Gunilla Osswald, CEO of *BioArctic* (Garcia, 2019, para. 2). *BioArctic* is one of Sweden's greatest success stories in the biotechnology field developing immunotherapies for neurodegenerative disorders and has recently achieved groundbreaking advancements with *lecanemab* – the first disease-modifying drug to prove effective in slowing the progression of Alzheimer's disease (Hodes, 2022). As Gunilla Osswald's statement suggests, external funding plays a crucial role in bridging the gap between scientific discovery and a marketable biotech product. But does it matter who the capital comes from? We seek to answer this question by exploring the differential performance effects of different types of funding in biotech.

The setting of this thesis is the Swedish biotechnology field and its dedicated biotech firms that are or aspire to become, a success story like *BioArctic*. In its broadest sense, biotechnology is defined as "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" (OECD, 2005). Firms operating in the biotech field are referred to as dedicated biotechnology firms (DBF). Although biotechnology is a multidisciplinary field, including agricultural, industrial, marine, food, environmental, and medical biotechnology (Gupta et al., 2017), we restrict the focus of this thesis to medical biotech only. Following the literature, we use the term DBF to refer to firms applying biotechnology techniques to develop, produce, and commercialize goods or services in human therapeutics and diagnostics (Powell et al., 1996). The biotech field is highly interesting to investigate for several reasons. Firstly, the field is producing innovations with significant transformative potential for modern medicine and society at large (Regeringskansliet, 2000). Secondly, biotech positively impacts the economy through job creation, exports and gross value added (Hopkins et al., 2019), making it a key agenda point of policy makers. Globally, the biotech field is projected to grow by almost 18% from 2021 to 2030, reaching a total valuation of US$ 3.44 trillion (Vision Research Reports, 2022). Thirdly, the field is unique in that long development cycles (Pisano, 2006), huge investment costs (Powell et al., 1996), and on top of that low breakthrough rates (Bratic et al., 2014) imply high risk. Hence it is important to understand theoretically and empirically how funding from different sources impacts the performance of DBFs and the biotech field as a whole.

For the theoretical framework guiding our analyses, we employ key concepts from two streams of research. The first is the literature on Entrepreneurial Ecosystem (EE), which suggests that entrepreneurship is not an independent effort, but rather co-created by different actors such as universities, capital providers, public institutions, established firms, as well as new ventures (Wurth et al., 2022). From this perspective, the performance of a DBF is dependent on the interorganizational relationships it forms with other ecosystem actors to access key resources (Feldman et al., 2019). The second stream of literature is on Entrepreneurial Finance, which allows to focus on the role of external capital as one factor of EEs. Entrepreneurial Finance considers both the funding demands of a DBF, as well as the funding options supplied by different capital providers and how these alter along the firm life cycle (Fraser et al., 2015). This literature emphasizes differences between various types of funding and accounts for the realities of market inefficiencies leading to funding gaps (Wilson et al., 2018). Additionally, we address theory on performance measurements in a funding context in general and specific to the biotech field. Given the uniqueness of the industry in terms of long development-cycles and high investment costs the use of traditional performance metrics related to financial indicators alone warrants caution, leading us to evaluate both sales and employee growth.

Applying the synthesized framework to the described setting, we empirically analyze the conceptual explanations of the relationship between funding and DBF performance by theory. A unique dataset is leveraged to extract detailed information about different funding events relating to a sample of 313 DBFs in Sweden between 2004-2013. Further secondary databases are consulted to retrieve financial information on the sample firms. Through an explorative pre-study, we investigate the composition of different types of funding across the study period and along the life cycle of a DBF. The most discussed sources of capital in previous literature are the government, corporate alliances, and venture capital firms (VCs), as well as international funding sources. We estimate the relationships between funding from these sources and DBF performance using a series of regression analyses. We thereby look at performance in terms of sales growth and employment growth.

1.1 Purpose

The purpose of this master thesis is twofold. The main purpose is to untangle the relationship between different funding types and DBF performance in terms of growth. Using statistical tests, this thesis models firm performance as a function of funding ties from different

external capital providers. To operationalize this relationship, we need to first understand the funding landscape of the Swedish biotech sector. Thus, the second purpose, acting as an enabler to the first, is to describe the dynamics of how different funding types are employed in practice through relationships between capital providers and DBFs. Concepts from the Entrepreneurial Ecosystem and Entrepreneurial Finance literature are applied to interpret the observations. The two purposes result in the following research questions:

1) *What is the differential effect of different types of funding on DBF performance?*

2) *What is the dynamic composition of the Swedish biotech funding landscape?*

1.2 Contribution

With this master thesis we contribute to existing literature and furthermore, provide valuable practical insights. We advance the understanding of the relationship between funding and DBF performance by combining concepts from the Entrepreneurial Ecosystem (EE) and Entrepreneurial Finance perspectives. Such combination of these two allows for an explanation of the composition of different types of entrepreneurial capital, influenced by dynamically changing needs of the DBF and the capital providers. Hence, we are able to explain how these two sides come together in an entrepreneurial ecosystem, forming interorganizational relationships that facilitate resource exchange, product development and growth. In addition, these theoretical concepts are tested empirically by evaluating the relationship of external funding and performance. We contribute by untangling and testing the performance effects of different funding types and thereby provide alternative evidence to inconclusive previous studies. Consequently, we add to previous research by employing a combined theoretical lens that offers a holistic explanation for why certain funding types have a greater impact on firm performance, while also acknowledging for the realities of market failure that constrain the biotech field.

Given that biotech products, services and solutions have far-reaching social, economic, and environmental impacts, policy makers have taken great interest in strengthening this field (Lindholm-Dahlstrand & Cetindamar, 2000). The Swedish government recognizes that "biotechnology can, in the future, impact the living situation and development for all the inhabitants of the earth" (Regeringskansliet, 2000, p. 2, English Summary). Biotechnology is understood as a growth engine leading the government to call for increased efforts to fund its development (Regeringskansliet, 2000). Against this backdrop, it is important to understand

the nature and behavior of the financial markets that fund DBFs (A. N. Berger & Udell, 1998) and to ensure that policy actions are effective in achieving the stated public benefits (OECD, 2005). Past research pointed out that Sweden's biotech ecosystem is struggling to achieve growth (Carlsson, 2002). As we measure both sales and employee development in our empirical analysis, we specifically enhance the understanding of how funding relates to growth. These insights hence entail important implications for effective policy making aimed at growing the biotech field through the capital market.

Finally, this thesis provides practical implications for decisionmakers in the industry. Hopkins et al. (2013) argue that funding decisions impact a firm's strategic direction and performance. This thesis can guide the management of DBFs by improving the understanding of the spectrum of available funding and by providing insights on the optimal type of funding in driving growth. Furthermore, this research can benefit capital providers and investors seeking to determine a DBF's market value. Traditional financial indicators have been criticized for not capturing the significant value of high-tech firms invested heavily in R&D and intangible assets (Yang, 2007). An examination of a DBF's existing relationships to external capital providers can offer an alternative, non-financial means to evaluate its value. This evaluation can offer an alternative, non-financial means to evaluate firm value. A non-financial indicator of value is especially useful in the biotech industry, where assets are intangible and products are considered high-risk (Stuart et al., 1999; Yang, 2007). The ability to predict the performance of a new venture, in turn, has the potential to significantly decrease investment risk (Pasayat et al., 2022).

The remainder of the thesis is structured as follows. First, we elaborate more on the peculiarities of the biotech sector (2). A theoretical framework and hypotheses section follows (3), which provides a map of previous studies on the subject and introduces the theoretical concepts used for analysis. In this section we derive hypotheses based on both the theoretical ideas and gaps in previous literature. In the method section (4) we describe and reflect on the chosen methodological approach and describe the empirical setting. We present the results of our explorative pre-study as part of the method chapter as this provides the necessary basis for how we define, measure and test our variables. In the subsequent results (5) and discussion (6) sections, we describe and interpret the outcomes of the performance analysis. We close the

thesis by acknowledging limitations and proposing future areas of research and offer some concluding remarks (7).

2. The Biotech Field

BioArctic's promising Alzheimer drug *lecanemab* is the result of a scientific discovery made by the professor and later founder Lars Lannfelt's in the 1990s. Today *lecanemab* is on its path to becoming the first effective disease-modifying drug against Alzheimer's and is heading for market approval in the US, Japan and EU in early 2023 (Langreth, 2022). More than 30 years have passed from scientific discovery to the achievement of promising late-stage results. Decades in which the product is not commercially sold a single time, yet costs billions in research and development (R&D). The DBF relies on strategic partnerships in accessing important resources including external capital. *BioArctic* is an exemplary case demonstrating the challenges common in the biotech field. Because these peculiarities have important implications for the funding landscape, we wish to clarify them at this stage.

As defined in the introduction, we focus on medical biotechnology and on those DBFs applying biotech techniques to develop, produce, and commercialize goods or services in human therapeutics and diagnostics (Powell et al., 1996). An EY Industry Report summarizes the discovery and development process in biotech (Giovannetti & Morrison, 2000). The first and oftentimes longest stage is the discovery stage, which can range between 2 – 10 years. Here, the DBF focuses on extensive basic research efforts rooted in biology and biochemistry with the aim of reaching a scientific discovery that has potential to become a drug candidate. In the second stage, this lead drug candidate is developed and tested in first pre-clinical trials. Thereafter, the lead candidate is clinically tested in phase I, II, and III trials. Following promising late-stage trial results, the DBF can apply for approval with the respective administrative bodies, such as the *Food and Drug Administration* (FDA) in the US, or the *European Medicines Agency* (EMA) in Europe. These will conduct extensive reviews before granting or declining commercialization approval, which can take approximately 2 years. The approval rate for biotech products by the FDA have been estimated previously to lie at 32% (DiMasi et al., 2010), 25% (Philippidis, 2012) and 15% (Hay et al., 2014). Yet, these rates are only for products already in clinical-trial phase I stages. Many research efforts never even make it that far in the first place (Bratic et al., 2014). After approval, a 2-year period of post-marketing testing follows.

The reason why the development process in biotech is so extensive and heavily regulated is that biotech is based on highly novel and specific knowledge that has only recently emerged. DBFs employ complex methods from a plethora of disciplines in molecular biology, organic chemistry, computer technology, and software development in their research (Deeds et al., 2000). Biotech R&D is capital-intensive and lengthy with development cycles typically ranging between 10-20 years (Pisano, 2006; Westhead & Storey, 1997). In fact, according to the 2020 EU industrial R&D scoreboard by the European Commission, "pharmaceuticals & biotechnology" ranks as the top sector regarding R&D spending, totaling €166.8 billion in 2019 (Grassano et al., 2020). Toth (2013) even goes so far as to claim that while the number of novel therapeutic breakthroughs has not increased, development costs have skyrocketed. The development costs of a single new drug has been estimated to be as high as $4.54 billion (Schlander et al., 2021). High R&D costs coupled with limited operating revenue imply that DBFs often make losses in their first years of existence (Zakrzewska & Kijek, 2016). Given the lack of revenue, a DBF relies on external funding long before a commercial product or service is developed, and in many cases even without ever achieving successful product commercialization (Lazonick & Tulum, 2011).

Apart from funding, other critical resources such as knowledge, human capital, infrastructure, and market access are also necessary for successful commercialization of entrepreneurial biotech products (Feldman et al., 2019). To access these resources, DBFs utilize interorganizational relationships with various actors in their ecosystem more extensively than companies in other fields (Gilding et al., 2020; Lindstrand et al., 2011; Powell et al., 1996, 2005). Given their focus on science, DBFs are often closely associated with universities and academic research projects (Carlsson, 2002). Further, it is common that strategic alliances are formed with established pharma companies, where collaborations can entail licensing or R&D agreements or equity joint ventures (Dushnitsky & Lenox, 2005). Merger & acquisition (M&A) deals are thereby no rarity (Carlsson, 2002). The government takes another key role in the biotech ecosystem. Its role is to strengthen this promising field, recognized as an engine for economic growth (Regeringskansliet, 2000). Moreover, the state has a responsibility to incentivize R&D tackling the global disease burden and to correct market failures such as the funding gap that we will elaborate more on in section 3 (Toth, 2013). Finally, the broader healthcare ecosystem is characterized by a unique set of stakeholders including payers, practitioners, patients, and pharmacists that interact in complex ways. We will not elaborate

more on these stakeholders, however, it is interesting to note that their influence further favors the emergence of interorganizational relationships (Wadman & Hütt, 2004).

In this thesis we want to focus on ecosystem ties that relate to funding. It is a major challenge for a young venture without revenue, collateral or validating track-record to access external capital in this high-risk field. Considering the length of the product development process and the need for a consistent flow of capital, a DBF also requires several, successive rounds of funding (Bonini & Capizzi, 2019). In sourcing external capital, a DBF can access different sources and forms of funding, each with varying degrees of engagement and investment objectives (A. N. Berger & Udell, 1998). Extant literature explores the numerous types of funding available specifically in the biotech field and with a focus on early-stage DBFs (Lazonick & Tulum, 2011; Toth, 2013). The most prominently mentioned sources of funding are government grants or subsidies, venture capital (VC), and alliances with established pharmaceutical or other biotech companies. Yet business angels, philanthropic funds, private equity (PE), commercial banks, the stock market, family and friends, research organizations, and accelerator programs also provide capital. A definition of each of these funding ties is provided in the appendix (9.1).

Ensuring a consistent flow of funding to spur product commercialization is consistently identified as one of a DBF's key challenges by several researchers (Bertoni & Randone, 2004; Gilding et al., 2020; Lazonick & Tulum, 2011; McCutchen & Swamidass, 1996; Toth, 2013; Woiceshyn, 1995). The choice of funding impacts the strategic behavior and performance of the DBF (Hopkins et al., 2013). Although it is generally understood that biotechnology calls for a different funding model than other industries, only little is known about the links between the type of funding and firm performance (Ahmed & Cozzarin, 2009). How different types of funding impact DBF growth performance remains an open question, which we aim to address in this thesis.

3. Theory and Hypotheses

This thesis employs concepts from the Entrepreneurial Ecosystem (EE) in conjunction with the Entrepreneurial Finance literature. Brief introductions and key concepts of the theories are outlined below (3.1.1 and 3.1.2), followed by an overview of performance measurements in the biotech context (3.1.3). The theory perspectives are then conceptualized into the analytical

framework (3.1.4). Thereafter, we zoom in on the most relevant types of funding in biotech and hypothesize their effect on DBF performance (3.2).

3.1 Theoretical Framework

3.1.1 Entrepreneurial Ecosystems

The Entrepreneurial Ecosystem (EE) perspective views entrepreneurship not as an independent effort of a single firm, but as a joint effort of multiple, different actors such as universities, capital providers, public institutions, established firms as well as new ventures (Wurth et al., 2022). EEs thus are collective environments for entrepreneurship made up of different actors, processes and culture that contribute to competitive advantage and shape entrepreneurial outcomes for individual firms, industries and nations (Feldman et al., 2019). They can be specific to an industry and geographically bound, which is why they are often referred to as "hubs" or "clusters" (Alaassar et al., 2022; Gilding, 2008; Mason & Brown, 2014). Importantly, EEs affect not only the activity and performance of start-ups in the narrow sense, but the entirety of potential entrepreneurs, start-ups, growth-oriented innovative firms, and larger corporate entities in different institutional, geographic, economic, or industrial contexts (Brown & Mason, 2017).

In a review of previous EE research (Donegan et al., 2019; Qin et al., 2019; Vedula & Kim, 2019) conducted for a special section in *Industrial and Corporate Change,* Feldman et al. (2019) summarize the factors contributing to a successful EE as 1) human capital, 2) knowledge creation, 3) access to finance, 4) market access, and 5) infrastructure relevant to entrepreneurship and innovation. These success factors are also vital in the specific setting of the biotech field. To access these resources related to knowledge, funding, and infrastructure (Gilding et al., 2020), young and innovative DBFs depend on external resources and stakeholders in their environment (Powell et al., 1996, 2005). Further, the path from scientific research to product commercialization is not straightforward and requires the involvement of several stakeholders along the way (Toth, 2013; Wadman & Hütt, 2004). As a result, DBFs depend on the EE and engage in relationships with other ecosystem actors to a greater extent than new ventures in other fields (McKelvey et al., 2003; Stuart et al., 1999). Put simply, in the biotech field several actors, who are not necessarily new ventures, come together in an ecosystem and engage jointly in entrepreneurial activity.

Many studies of EEs focus on identifying different factors or elements in an ecosystem. The World Economic Forum (2013) for instance defines the EE elements as 1) accessible markets, 2) human capital workforce, 3) funding & finance, 4) mentors, advisors, & support systems, 5) regulatory framework & infrastructure, 6) education & training, 7) major universities as catalysts, and 8) cultural support. Among these elements, "funding and finance" has been understood as critical in spurring the entrepreneurial activity and defining for a successful ecosystem cluster (Gilding et al., 2020). It has been pointed out that the complementarity and interdependence among different actors (Jacobides et al., 2018) act as enabling or constraining entrepreneurial outcomes. Skeptics have, however, criticized that the EE literature focuses mainly on identifying elements in an ecosystem without understanding the dynamics of interaction between them (Shwetzer et al., 2019). Hence, more research has strived to develop the conceptual frameworks of the theory and to study the relationships between the main elements of an EE (Brown & Mason, 2017; Shwetzer et al., 2019; Spigel, 2017; Stam, 2015).

3.1.2 Entrepreneurial Finance

Entrepreneurial Finance is a stream of literature that considers how nascent firms access capital to fund their growth and innovation and looks at different investors with varying motives and financing engagements (Block et al., 2018; H. D. Kang, 2018). Entrepreneurial Finance covers venture capital, private equity, trade credit, angel finance, IPOs among others (Cumming & Johan, 2017). Recent research has focused on changes in the landscape of Entrepreneurial Finance as new forms, such as crowdfunding or peer-to-peer lending, emerge. Different forms of funding, distinguished mainly between equity and debt, are also subjects of study in the field (S. Myers, 1984). The perspective further puts an emphasis on the relationship between a firm's access to capital and performance (Fraser et al., 2015).

Entrepreneurial Finance provides theoretical explanations for financial constraints that arise in practice as it looks at supply and demand forces of capital in an entrepreneurial setting (Fraser et al., 2015). On the demand side, the concept of the financial pecking-order (S. Myers, 1984; S. C. Myers & Majluf, 1984) suggests that companies themselves prefer internal funding over external debt or external equity, and short-term debt over long-term debt. This theory has roots in corporate finance literature, but has been applied to the entrepreneurial setting, too (Bonini & Capizzi, 2019). These preferences are driven by the entrepreneur's aversion to risk and cost, which are highest with external equity (Manigart et al., 1997). Further, ownership

considerations influence the funding demand, as entrepreneurs can be reluctant to lose control through ownership dilution or fear the consequences of defaulting on debt (Fraser et al., 2015). Small technology-based firms have hence been found to finance their innovations primarily with internal funds (Revest & Sapio, 2012). These internal sources, however, are often insufficient in meeting the substantial amount of investments typical in high-tech industries (Czarnitzki & Delanote, 2015).

On the supply side, agency theory (Jensen & Meckling, 1976) has been used to explain how information asymmetries and moral hazard lead to a constrain in the supply of external finance (Denis, 2004). This type of market failure leads to allocative inefficiencies (Bonini & Capizzi, 2019), which in turn explain the shortage in the supply of external capital. Young firms that lack a proven track record of the marketability of their products are especially informationally opaque and struggle to attract external funding (Revest & Sapio, 2012). This is aggravated even more for high-tech and R&D-intensive firms that face higher costs of capital than firms in other industries, caused by the uncertainty of the outcome of R&D activities (Hall, 2002). In summary, through the Entrepreneurial Finance lens, mismatches in demand and supply explain the presence of a funding gap, which is defined as the difference between capital that would be invested under perfect information and the actual amount invested (Wilson et al., 2018).

Entrepreneurial Finance uses these constructs of agency and pecking-order theory to additionally explain different funding needs and options along the life cycle of entrepreneurial ventures (Fraser et al., 2015; H. D. Kang, 2018). When a firm is still in its early stage in terms of age and size, it relies more heavily on insider and angel finance. As the firm grows it gains more experience and becomes less informationally opaque, giving it more access to intermediated finance from VCs, banks, or other financing companies (A. N. Berger & Udell, 1998). Entrepreneurial Finance acknowledges that young firms not only seek to access external funding, but also other resources such as human capital, know-how, reputation, and legitimacy (Cumming et al., 2019).

3.1.3 Performance Measurement

The goal of any capital investment is to spur performance that creates value in the investee firm. Performance can be measured in very different ways and is a proxy for a firm's success. Extant entrepreneurial finance literature has pointed out this methodological issue of measuring

performance in young ventures in general (Bonini et al., 2019). In the specific case of DBFs that lack sales and profitability for many years of their existence, this challenge is even greater. The vastly different approaches by previous studies mirrors the complexity of defining success in the biotech field. Bertoni and Tykvová (2015) define performance as inventions and innovations, measured by patent stock of a company and citation-weighted patent stock respectively. Similarly, an investigation of the Swedish and Danish biotech cluster regards performance as firm output measured by active projects and patents per employee, normalizing for different firm size (Valentin et al., 2008). Others measure performance through biotechs' market value, calculated by the product of the firm's outstanding shares and its share price (McCutchen & Swamidass, 1996). Financial performance in terms of revenue and profit is broadly used in evaluating firm performance (Pasayat et al., 2022).

The EE and Entrepreneurial Finance perspective emphasizes entrepreneurial and commercial success, rather than knowledge creation or inventive productivity. Thus, we decide on sales growth and employee growth as performance metrics going forward. We specifically decide against patents for our dependent variable, as they are oftentimes a prerequisite for receiving funding in the first place (Hoenig & Henkel, 2015). A growth metric offers the benefit of being able to compare performance across different firm sizes and is considered a key indicator especially for young firms in an entrepreneurial context. Further it has been found that Sweden, in particular, faces a growth challenge in regards to its biotech sector (Carlsson, 2002), making it all the more important to understand drivers of growth. Finally, we focus on an entrepreneurial framework in which growth is generally a common objective. This measure has further been used in similar studies on regional biotech hubs (Ahmed & Cozzarin, 2009).

Positive sales indicate a firm's ability to produce and commercialize viable products or services. Sales growth is hence broadly accepted as an indicator for a firm's success and remains one of the most important metrics for firm valuation (Barringer et al., 2005; Bratic et al., 2014). It has additionally been claimed to be the most significant estimator for DBF valuation (Hsiang-Ling Chen et al., 2013). Especially for firms lacking a track record of profits and consistent book values, sales are considered an important indicator by investors (Bertoni et al., 2013). Yet, considering the idiosyncrasies of the biotech field, where sales often take substantial time to materialize, sales growth alone does not suffice. We therefore also include the development of the number of employees as a non-financial performance indicator. Extant literature has explored this metric's relationship with funding from different sources in the

high-tech start-up field (Bertoni et al., 2011; Grilli & Murtinu, 2014). Some capital providers, specifically those offering public funding, usually follow less financially driven objectives. Governments for instance strive to strengthen the local economy through job creation (Grilli & Murtinu, 2014; Manigart et al., 2002). These non-financial objectives are thus captured by employee growth. The combination of both sales and employee growth has been studied by Bertoni et al. (2013), who argue that they are positively correlated when transaction costs are high and product-specific skills are required. These conditions apply to the biotech field.

3.1.4 Synthesis of Conceptual Framework

The EE and Entrepreneurial Finance streams are jointly employed to make sense of the funding ties between DBFs and capital providers in the entrepreneurial ecosystem. The EE perspective provides the tool to define the level of analysis – the regionally bound biotech field in Sweden including ties between DBFs and other stakeholders. Adding the Entrepreneurial Finance perspective zooms in on funding and allows for a consideration of the individual capital providers in terms of their motives, engagements, but also limitations. Through this conceptual framework we understand the DBF and the external capital providers as the main actors that interact with one another through a funding tie. With the focus on funding events, this relationship inherently includes the flows of funds. Yet on top of that, the ties differ in the degree of complementary resource exchange. Both the literature on EE and Entrepreneurial Finance account for the importance of complementary resources, including knowledge sharing, access to human capital, funding, a supporting infrastructure and market access (Cumming et al., 2019; Feldman et al., 2019; Vedula & Kim, 2019). The provision of both financial and non-financial resources aims to create value in the target DBF and hence influences the DBF's performance. Reality, however, is more complex. Market inefficiencies and supply and demand dynamics constrain the actual funding landscape. Entrepreneurial Finance allows us to understand these constraints and make sense of why certain funding types are more applicable and hence more successful at different stages of a DBF's life cycle. In summary, we evaluate different funding relationships and their effect on performance measured by sales and employee growth, based on their ability to provide access to complementary resources while considering market inefficiencies leading to financial constraints.

3.2 Literature Review and Hypotheses Formulation

In formulating the hypotheses, we explore what previous studies have found and derive expectations based on the theoretical concepts. As a starting point, we take the overarching relationship between the total number of funding ties and firm performance and then proceed to consider the contingent performance effect of different types of funding. In the biotech context, some specific sources of funding have been studied in more detail than others, yet with frequently mixed and contradicting findings, which we want to examine. These are funding from the government, corporate alliances, and VCs. Further we focus on a comparison of international and domestic ties. Through the following hypotheses we seek to disentangle the actual relationship of funding types and firm performance in terms of growth.

3.2.1 Total Funding Ties and Firm Performance

As stated previously, access to funding is a key success factor for a DBF (Bertoni & Randone, 2004; Gilding et al., 2020; Lazonick & Tulum, 2011). Although through our theoretical perspective, the impact of a tie is influenced by its strength driven by the level of resource exchange, the mere presence of funding ties can have strong signaling power and likely a positive effect on the firm's performance. Entrepreneurial Finance literature has found the number of investors and number of funding rounds to be positively correlated with firm performance (Pasayat et al., 2022). The number of investors is argued to convey to potential investors that the firm has a viable product or service. It is said that the ability to raise capital alone acts as a visible signal of achievement that positively influences later funding rounds, of which young, growth-oriented ventures typically require several (Bonini & Capizzi, 2019). Shane and Cable (2002) argue that ties provide access to information and hence help in overcoming information symmetry. As information asymmetry is one of the major constraints to an optimal funding supply (Fraser et al., 2015), a reduction thereof is advantageous. Consequently, it is believed that overall venture funding into the firm is increased, leading it on a path to success. On the contrary, Sorenson and Stuart (2001) address the common notion that *it is not getting the money, it is who the money comes from*. While we do not expect a negative relationship between funding ties and performance, we do not know how strong a possible positive effect might be. Hence, the first and most general hypothesis postulates that a higher number of funding ties is positively correlated with DBF performance.

H1: DBFs with a higher number of funding ties are more likely to perform better than DBFs with fewer funding ties

3.2.2 Funding from the Government and Firm Performance

Funding from the government is referred to as public finance. Typically, governments provide funding in the form of grants, debt (soft-loans), and increasingly also public equity through government VCs (GVC) (Grilli & Murtinu, 2014). The funding motives of governments are different from private actors and include exploiting public benefits and reducing prevalent equity funding gaps (Manigart et al., 2002). Public entities typically value social returns including job creation, innovation production, and economic growth higher than mere financial return. It is argued that governments are more willing to invest in high-risk, early-stage ventures and hold on to them longer, as they de-prioritize financial return (Grilli & Murtinu, 2014). Public funding can be seen as the required ignition for the emergence and development of highly innovative, future growth sectors. The US with its *National Institutes of Health* (NIH) is often praised as an example of successful government funding. Its public research funding has managed to significantly spur new firm growth, creating an "innovation ecosystem" that makes up the successful biotech sector in the US (Ferguson & Johnson Langer, 2021; Kolympiris et al., 2014).

Generally, public funding strives to compensate the short-term orientation of private funding and aims to strengthen long-term growth (Lindholm-Dahlstrand & Cetindamar, 2000). The government acts to correct the market failure caused by private investors' reluctancy to invest in young and high-risk ventures. Also, governments aim to incentivize the focus on targeting the global disease burden, which might otherwise not be financially or commercially attractive (Toth, 2013). The development of the Covid-19 vaccine has demonstrated how governments act to fill funding gaps when risk is high, where 98% of the investments provided for R&D purposes came from public funding (McCarthy, 2021). Government funding is provided both directly and indirectly (Klofsten & Lindholm-Dahlstrand, 2000; Lindholm-Dahlstrand & Cetindamar, 2000). Direct innovation financing is provided by soft-loans or grants. A study by Hottentott and Richtstein (2020) finds that high-tech manufacturing start-ups in Germany, who received grant funding, showed stronger growth performance compared to non-subsidized firms. Çetindamar and Laage-Hellman (2003) find that different government funds play an important role in providing capital at early stages of new ventures, when other sources of financing, such as equity or debt, fall short. Hence government funds are crucial in

closing the funding gap young DBFs experience in seed and early-stage funding rounds. Public financial backing further has a strong signaling effect to other external investors. Consequently, a DBF with funding from the government may attract subsequent funding from other investors, namely VCs (M. Berger & Hottenrott, 2021). Söderblom (2015) demonstrates that the follow-on access to capital after public funding in the Swedish market has a positive impact on long-term firm performance. Indirect measures from the government can take the form of policy and tax reformations aimed at incentivizing and facilitating the investment into biotech firms by other financial actors (Lindholm-Dahlstrand & Cetindamar, 2000). These indirect measures are not focus of this thesis and are only mentioned for the sake of completeness.

As a downside, governments lack the industrial experience and cannot provide managerial support to DBFs (Lindholm-Dahlstrand & Cetindamar, 2000). Comparisons of GVCs with IVCs show that GVC backed DBFs do not perform better in terms of innovation (Bertoni & Tykvová, 2015) or growth (Grilli & Murtinu, 2014). Yet the same studies find the combined effect of both GVC and IVC to have a positive performance impact, indicating governmental finance is an effective complement to IVCs, but not a substitute. A study on DBF survival rates finds that firms backed by larger, more reputable GVCs are more likely to survive than their counterparts backed by IVCs (Manigart et al., 2002). However, firms backed by smaller, less-established GVCs are less likely to survive. The study argues that the role of acquired expertise helps the older GVCs in their tasks of selecting, supporting, and monitoring DBFs. Others have suggested that the government as a capital provider lacks efficiency and business performance incentives (Colombo et al., 2016) that could have negative impacts for a firm's success.

It is true that government funding does not provide the same level of resource access or managerial support as VCs or corporate alliances do. However, it acts as a signal and as a complement to other ecosystem actors and plays a crucial role in overcoming the funding gap in early venture stages. The second hypothesis aims to test the strength of the relationship between government funding and DBF performance.

H2: DBFs funded by the government are more likely to perform better than DBFs that are not

3.2.3 Funding from Corporate Alliances and Firm Performance

Many DBFs engage in various arrangements of strategic alliances with established companies in the EE that are not primarily financial institutions. There are different types of

partner constellations, namely biotech-biotech and biotech-pharma alliances (Gay & Dousset, 2005). The former has been less significant, but is becoming more prominent (Filson & Morales, 2006). Most of the discussion has focused on the alliances with bigger, more established pharmaceutical firms. These firms usually invest into younger, promising DBFs for strategic reasons and the opportunity to access technological assets (Hellmann, 2002; Röhm et al., 2018). Moreover, the forms of alliance arrangements between companies range from informal relationships to various licensing, marketing, and supply chain relationships as well as equity joint ventures (Dushnitsky & Lenox, 2005; Zidorn & Wagner, 2013).

Corporate Venture Capital (CVC) is a commonly explored type of corporate alliance funding, which involves a larger, more established company taking a minority equity stake in a new venture. CVC investors seek financial returns through IPOs or sales of the ventures they are invested in (P. Gompers & Lerner, 1998). McCutchen et al. (1996) highlight collaborative research revenue as an important R&D funding source for DBFs. This type of funding is based on a long-term strategic agreement between an emerging biotech company and a more established, bigger pharmaceutical company. These corporate investors contribute additional commercialization capabilities in the form of know-how on product development and marketing campaigning, as well as experience with the application processes to the regulatory agencies (Bratic et al., 2014).

Gilding et al. (2020) state that collaborative ties with other network actors provide access to complementary resources and sources for organizational learning. Powell et al. (1996) also claim that DBFs use ties to access knowledge and resources, finding a positive link between R&D alliances and growth. Investments from holding companies similarly provide access to complementary resources, increasing chances of survival and success (Park & Steensma, 2013). In comparing CVC investments to independent VC (IVC) investments, several researchers find that DBFs backed by CVCs are more successful (Alvarez-Garrido & Dushnitsky, 2016; Shuwaikh & Dubocage, 2022). The provided reasoning for this result is that corporate investors hold important domain expertise and provide a DBF with access to important complementary resources that are relevant to the development of biotech solutions. Stuart et al. (1999) claim that young DBFs affiliated with established companies within their ecosystem are perceived to be endorsed and expected to perform better. Their results show that privately held DBFs with strategic partnerships and organizational equity investors go to IPO faster and are valued higher. In other words, interorganizational alliances offer external

legitimacy to young DBFs, which signals value to other investors. The overwhelming evidence points to a positive relationship between funding through collaborative alliances with corporates and firm performance.

H3: DBFs funded by corporate alliances are more likely to perform better than DBFs without

3.2.4 Funding from VCs and Firm Performance

Venture Capital (VC) funds are oftentimes limited partnerships that pool capital from funds or wealthy individuals (Dushnitsky & Shapira, 2010) and invest in high-risk ventures with the goal of achieving financial return (Shuwaikh & Dubocage, 2022). VCs are actively involved in firm management, set up complex financing contracts and often define their exit pathways already at the point of investment (P. A. Gompers & Lerner, 1999). Venture capital is thought to be an expensive form of finance with required rates of return between 15 - 45% (Manigart et al., 1997). VCs add value by providing complementary resources such as coaching, mentoring, and access to third parties (Brinster & Tykvová, 2021). Typically, VCs target mid-stage to late-stage deals (Drover et al., 2017). In the EU the average VC deal size into biotech and pharma in 2021 was at €8.3 billion (PitchBook Data, Inc., 2022). What is more, VC-backing is perceived as a strong signal of endorsement to other investors, given VC firms' extensive screening and monitoring efforts (Grilli & Murtinu, 2014).

VC funding is one of the most examined sources of external finance. The presence of dedicated VC funds has been shown to be a prerequisite for biotech industry growth (Arantes-Oliveira, 2007). The nature of VCs and their active engagement in the management of the invested firm in particular is believed to have a positive impact on firm survival (Bertoni & Randone, 2004). A study by Sapienza (1992) found that VCs add the most value to an entrepreneurial venture when contact between the two actors is frequent and open. Many other researchers argue similarly that a VC's effort to help its portfolio firm solve managerial challenges is the essence of its distinct contribution to firm success (Çetindamar & Laage-Hellman, 2003; Klofsten & Lindholm-Dahlstrand, 2000). In contrast, Manigart et al. (2002) find that VC backed firms in the Belgian biotech sector have a lower probability of survival than non VC backed firms. The researchers explain that this might be due to the adverse selection problem in which successful companies are already financed by other, less expensive types of funding. Moreover, a VC's objective to maximize value in high growth settings across

their entire portfolio also implies high levels of risk, which in turn entails higher likelihood of bankruptcy of individual firms (Manigart et al., 2002). A potentially negative performance effect might, in other words, result from VC's placing riskier investments. Another research finds that UK-based DBFs with VC funding are less successful than those funded through the stock market (Hopkins et al., 2013). While pointing out that these results do not infer superiority of funding through IPOs over funding from VCs, the researchers argue that this result may be explained by VC's lack in selectivity of their investments. To sum up, previous studies have shown different degrees of impacts of VC funding in the biotech setting. To reach more clarity on the effect we test for the hypothesis that VC funding is associated with increased DBF performance.

H4: DBFs funded by VCs are more likely to perform better than DBFs that are not

3.2.5 Funding from International Capital Providers and Firm Performance

With our last hypothesis, we want to evaluate the effect of funding ties that transcend national borders. Literature thereby commonly examines the mere fact that funding comes from abroad and does not distinguish between the type of capital provider. Generally, geographic proximity is thought to spur the transfer of tacit knowledge, which warrants ecosystem positions close to other important actors as more favorable (DeCarolis & Deeds, 1999). DBFs historically locate themselves in proximity to public research organizations to reap benefits from *knowledge-spillovers*, which foster the build-up of regionally concentrated clusters (Gilding, 2008). The inherently high information asymmetries and monitoring costs can be minimized by investors in focusing on local investments. Some research has empirically supported the superiority of a regional focus regarding funding access. Powell et al. (2002) find a strong geographic concentration of DBFs and VC funding in the US. Specifically in the case of funding from CVCs, there is evidence that geographic proximity facilitates access to complementary resources which has a positive effect on innovative production of the DBF (Shuwaikh & Dubocage, 2022). Kolympiris et al. (2011) argue that DBFs can reap performance benefits in regional clusters through access to scarce specialized labor markets, knowledge diffusion, and network effects. Another study finds that foreign VC funding decreases the likelihood of success given that distance hampers effective communication and information sharing (Humphery-Jenner & Suchard, 2013). The setting of this study is China, a country in which social connection matters, which could explain the amplified effect.

Opposingly, a study on the Korean biotechnology market finds that those firms with international ties achieve better performance in terms of innovation than firms with domestic ties only (K.-N. Kang & Park, 2012). The authors note that this may apply especially to regions with less advanced private investment options, where it is advantageous to seek funding abroad. Similarly, a study on young high-tech firms shows that foreign equity ownership through VCs and PEs from abroad can facilitate access to external finance (Corsi & Prencipe, 2017). It is argued that foreign investors may reduce information asymmetries and provide a signal of endorsement, with a positive impact on further funding and a means to closing the funding gap (Harrison & McMillan, 2003). Especially for high-tech clusters it is additionally argued that non-local collaborations represent an important source of production and commercialization resources, as well as know-how that is lacking locally (Oinas & Malecki, 2002; Rees, 2005). A study looking at the Swedish biotech sector similarly reports that DBFs employ a mix of local, national, and international collaborative ties (McKelvey et al., 2003). This study, however, does not investigate the performance effect of these ties but rather takes a descriptive approach. In summary, both the limited insight into the local conditions of the Swedish biotech ecosystem and the contradicting results previously reported warrant further investigation of the relationship between international ties and performance. The fifth hypothesis tests whether international funding ties are associated with a higher likelihood of better performance.

H5: DBFs funded by international capital providers are more likely to perform better than DBFs without

4. Method

In this section we describe the research method chosen for this thesis. First, we describe the reasoning behind the selection of the approach and discuss the fit to the purpose and research question (4.1). Next, we elaborate on the empirical setting (4.2) and elaborate on the data (4.3) and the sample (4.4). We then report the findings from the pre-study (4.5), which are required to define the variables and their measurements (4.6) and our analytical methods (4.7).

4.1 Methodological Fit

The purpose of this thesis is to study the effect of different funding types on DBF performance. The funding landscape in the context of biotech is a previously studied topic. We

use a deductive approach in testing a combination of developed concepts from theory on EE and Entrepreneurial Finance. As the state of prior research can be described as mature, a focused hypothesis testing approach is appropriate (Edmondson & Mcmanus, 2007). Using a comparative and quantitative approach based on secondary data, we statistically test the correlation relationship between different funding types and DBF performance. We conduct our examination both at the biotechnology ecosystem-level as well as the firm-level and take a longitudinal approach.

4.2 Empirical Setting

Following Feldman et al. (2019), this thesis conceives of EEs as specific to a geographic context (Sweden) and industry (medical biotechnology). Thus, our setting is defined as the Swedish biotech field. Analyses of other fields, such as real estate (Vigren, 2022) or fintech (Alaassar et al., 2022), and university campuses (Miller & Acs, 2017; Siegel & Wright, 2015), through this perspective validate the approach. Several previous studies have similarly set out to examine the distinct geographic ecosystem of the biotech field (Casper, 2007; McKelvey et al., 2003; Rees, 2005; Trippl & Tödtling, 2007).

Sweden's biotech field is internationally renowned and has been recently ranked second in the *Worldview national ranking of health biotech sectors*, following Switzerland and preceding the United States (Hodgson & Schreiber-Gregory, 2022). Sweden is home to many successful DBFs. In terms of the number of biotech or pharma companies among the leading 1,000 companies among the EU countries, Sweden ranks 4th (Grassano et al., 2020). Regional clusters of DBFs have grown in proximity to universities, namely the Stockholm-Uppsala region, Gothenburg, Lund, Linköping and Umeå (Carlsson, 2002). Historically, the local bio-pharmaceutical field was dominated by *Astra* and *Pharmacia*. While the merger of *Astra* with *Zeneca* and the acquisition of *Pharmacia* by *Pfizer* meant that Sweden lost two important headquarters, these developments also positioned Sweden well in the global arena (Garcia, 2019).

Previously, it has been pointed out that while Sweden has a high firm birth rate, the country struggles to achieve growth (Carlsson, 2002). The main reason for this has been the lack of competent and specialized investors, constraining DBFs in their growth potential. In a rection to that, the funding landscape has become increasingly sophisticated. The last decade has seen the capital market for high-technology firms such as DBFs become more mature. Especially

since the early 2000s, new financial actors have entered and shaped the market, providing more volumes of diversified forms of capital (Karaomerlioglu & Jacobsson, 2000). The Swedish government recognizes biotechnology as a growth engine and calls for increased efforts of funding its development (Regeringskansliet, 2000). Substantial investments made into research, infrastructure, and innovation programs by the government show its continued commitment to the development of the field (SwedenBIO, 2020). Hence, we believe this setting to be highly interesting to investigate further.

4.3 Data

4.3.1 Event Dataset

This thesis leverages an existing dataset compiled throughout a parallel research project funded by *Vinnova* (Sweden's innovation agency) on the topic of *financing biotech to meet challenges similar to Covid*. The dataset has been collected by a dedicated research team over the course of five years. It contains a unique and proprietary collection of transactional event data covering the period between 2004 and 2013. Event data is defined as an interaction between any of the 353 DBFs in the total sample and another actor in the ecosystem. Actors can be other DBFs, biomedical or pharmaceutical firms, universities, institutional investors, regulatory institutions, or commercial actors, located both in Sweden and abroad. The events are pre-categorized into several different layers of ties. These layers include financial, commercial, organizational, regulatory, as well as R&D, marketing, & licensing ties. There are in total 3,458 partners and 8,966 ties captured. This dataset is rich in detail and offers granular data on the different capital providers and types of funding.

This dataset is leveraged as it offers unique documentation of all occurred financial transactions of Swedish DBFs between 2004-2013 in great detail. We acknowledge that using secondary data has the disadvantage of a lack of guarantee of data quality and an outdatedness of the data (Bryman, 2012). This dataset is limited in terms of the timespan over which the data points were collected. On the one hand, we lack more recent data capturing the period from 2013 up until today. Entrepreneurial Finance literature has repeatedly highlighted that the capital market has recently seen a number of new players entering the field (Block et al., 2018). These more recent developments and potential new dynamics are not captured in the dataset. As part of the original research project, these more recent data points will be collected to include events up to 2019. However, this work has not been completed yet and the lengthy data

collection process did not allow for a primary data collection for this thesis. On the other hand, we lack the funding events that occurred before 2004, which might still have an influence on performance in subsequent years. Nevertheless, we see great value in investigating the available information as it offers a cost and time efficient opportunity to look at the longitudinal evolvement of funding in the Swedish biotech ecosystem (Bryman, 2012). Further, this dataset provides data, to the best of our knowledge, not previously or otherwise available for analysis. Given the official backing by *Vinnova*, the capabilities of a qualified, full-time research team that gathered the data, and having received thorough explanations of the entire data collection process, we believe the quality of the data to be of the highest quality.

4.3.2 Financial Data

We further sourced a range of public databases for financial information on the DBFs in the sample. The main source of information is the *SERRANO*[1] database by the Swedish House of Finance. Additionally, the databases *Retriever Business*[2], *Bisnode*[3], and *Valu8*[4] were accessed to cross-check and complete the data. This data-triangulation adds to the overall reliability (Bryman, 2012). Finally, the Swedish Companies Registration Office, *Bolagsverket*[5], was accessed to retrieve information on firm registration and deregistration date, as well as the reasons for deregistration. The collected data was pooled, cleaned, and normalized to retrieve all DBF related information in terms of age, exit pathways, and employee and sales numbers. We include datapoints over the period of 2004 to 2015 to represent performance developments with a two-year time lag after the final year of funding tie observations in 2013.

4.4 Sample

The sample investigated for this thesis consists of 313 DBFs. These 313 DBFs represent the share of the entire population of 353 DBFs in Sweden as of 2011 that have funding ties to other stakeholders during the period of 2004-2013. The entire population of Swedish DBFs was defined for the *Vinnova*-funded project team at the start of the data collection process in 2011 and DBFs that were founded after 2011 are therefore not part of the sample. Compared

[1] https://www.hhs.se/en/houseoffinance/data-center/serrano/
[2] www.retrievergroup.com/sv/business-suite
[3] Now part of Dun & Bradstreet: www.dnb.com/sv-se/
[4] www.valu8group.com
[5] www.bolagsverket.se

to many other studies in the field of biotech, which examine only publicly listed companies (Bertoni & Randone, 2004; Stuart et al., 2007), the analyses in this thesis are based on a sample of Swedish DBFs that includes both publicly listed and private companies. This provides the advantage of giving a more holistic picture of the industry, as well as gathering insights on early life cycle stages of the firms which are especially sensitive to funding.

Based on average sales and employee data over the entire period from 2004 to 2015 and age at the year of 2015, the DBFs are categorized into "small" (employees < 10; sales < SEK 1 million), "medium" (employees 10–50; sales SEK 1 million – SEK 10 million) or "large" (employees > 50; sales > SEK 10 million), and into "start-up" (0-5 years), "early-stage" (6-10 years), "middle-stage" (11-15 years), "late-stage" (16-20 years) and "matured" (20+ years). The classification was chosen based on discussions with the project leader of the original *Vinnova*-funded project with the goal to be most representative of the underlying sample. Over the period between 2004-2015, 68 DBFs changed their status from active to inactive. Of these, 42 are exits due to liquidations or bankruptcies, which we consider failed firms. 26 DBFs have been involved in M&A deals, which are seen as an indication of success. Table 1 provides a summary of the DBFs in terms of age and size.

	DBF Count
AGE	
Start-up	1
Early-stage	81
Middle-stage	105
Late-stage	55
Mature	71
SIZE	
Small	110
Medium	112
Large	91
Grand Total	**313**

Table 1 – Size and Age Distribution of Sample

4.5 Pre-Study

This pre-study has both a methodological and a theoretical argument. In order to define the measures and variables needed for this thesis' purpose of evaluating the performance effects of different funding types, we first need to investigate which funding ties make up the Swedish

biotech capital market. Previous literature proposes that the most discussed sources of funding in biotech are the government, VCs, corporate alliances, and foreign investors. Hence, we want to verify whether the event dataset confirms these ties to be the most relevant in this setting too. Further, as we sourced a secondary dataset which was initially collected for other purposes, it is necessary to study the dataset extensively to be able to correctly extract the required information for the sake of this research. In the following we offer a definition of funding ties that fits the conceptual framework of this thesis and outline how we recoded the data accordingly (4.5.1). Thereafter we provide an overview of the funding ties across the period of study (4.5.2), as well as a more detailed examination of the funding composition for different firm ages and sizes (4.5.3). Descriptive statistics and graphical representation of the data are generated using Microsoft Excel and illustrate patterns and trends.

4.5.1 Definition of Funding Ties

The chosen theoretical framework puts an emphasis on the relationship between actors in an ecosystem (EE) and the motives and traits of different capital providers (Entrepreneurial Finance). Thus, our level of analysis entails the funding tie between a DBF and an external capital provider. We define funding ties as external funding provided from a capital provider to a DBF with the general purpose of product development and commercialization. The initial dataset is based on a broader definition and further includes other non-funding related ties. We thus recoded the data to map the funding ties onto our definition. Through regular interviews with the members of the original research project, specifically with the data analyst, we ensured full understanding and correct interpretation of the data. For each of the data entries relevant to our understanding of a funding event, we extracted information on the DBF, the capital provider, as well as the form of finance (equity, debt, grant, or royalty & milestone payments). Capital providers were further recoded into categories that match the required granularity and common practice employed in previous research.

As there are slightly different definitions as to what constitutes a funding relationship, we want to comment on the boundaries we draw. Initial public offerings (IPOs) and merger & acquisitions (M&A) have been previously interpreted both as exit routes (Lazonick & Tulum, 2011), or funding types. While arguably M&A deals are a type of funding, the capital is not directly provided for product development and commercialization, but rather for the acquirer's goal of strategically accessing biotech competences or resources (McCutchen & Swamidass, 1996). There are differences in the size of ownership stakes acquired, the nature of the take-

over (friendly or hostile), and the degree of integration into the acquiring firm. We acknowledge that a DBF could undergo an M&A deal solely for the purpose of financing its core business, while operating as independently as before (Lindholm-Dahlstrand, 2000; Lindholm-Dahlstrand & Cetindamar, 2000). Yet as these cases are occasional, we will regard all M&A deals as a successful exit route and not as a source of funding. On the other hand, an IPO is here classified as a type of funding, in that capital is provided from the stock market for the ongoing operations as an independent DBF. We accordingly side with Hopkins et al. (2013) in classifying stock market funding through IPOs as a funding tie and M&A deals as an exit. After these data transformations, 1,349 funding ties remain, enacted between 313 DBFs and 474 distinct partners from a total of 13 types of funding.

4.5.2 Overview of Funding Landscape

We begin by introducing the entirety of types of funding employed in the Swedish biotech ecosystem. From the dataset we have information on each funding event, which reveals information on the specific form of finance employed (equity, debt, grants, or royalty & milestone payments). In table 2 we demonstrate the classification of funding ties according to both capital providers and form of finance. This chart reveals that each capital provider focuses on certain forms of finance. The count of ties shows that three sources of funding make up two thirds of all ties, each employing a major form of finance. These are 1) government funding in the form of grants, 2) corporate alliances in the form of royalty & milestone payments, and 3) VCs in the form of equity. These ties are also those most frequently discussed in research, as highlighted in the foregoing literature review and hypotheses formulation. The smallest contributors are founder, family & friends, banks, holding companies and the stock market. Business angels, accelerators, private equity (PE), and investment funds make up the middle field. A complete set of definitions of each funding type is provided in the appendix (9.1).

Capital Provider	***Equity***	***Grant***	***Debt***	***Royalty & Milestone Payments***	***Total***
Government	2%	87%	12%	0%	**434**
Corporate Alliance	31%	5%	5%	59%	**287**
VC	78%	0%	22%	0%	**185**
Research Organization	53%	32%	14%	2%	**66**
Investment Fund	78%	5%	14%	3%	**59**
PE	64%	2%	34%	0%	**59**
Accelerators	33%	46%	19%	2%	**54**
Other	63%	4%	21%	12%	**52**

Business Angel	87%	0%	13%	0%	**47**
Holding Company	79%	3%	15%	3%	**33**
Stock Market	100%	0%	0%	0%	**33**
Bank	16%	4%	80%	0%	**25**
Founder, Family & Friends	67%	0%	27%	7%	**15**
					1349

Table 2 – Funding Ties per Capital Provider and their Employed Form of Finance

We continue by examining the development of the total number of funding ties over the entire period of investigation from 2004 to 2013. Figure 1 visualizes the ties by different capital providers. Looking at the entirety of ties, an interruption of the previously strong growth trend in total number of ties can be observed following the financial crisis in 2008. In the following years, the total number of ties stays rather constant yet at lower levels than seen in the years preceding the crisis. Changes in government funding are thereby the driving force of the overall development.

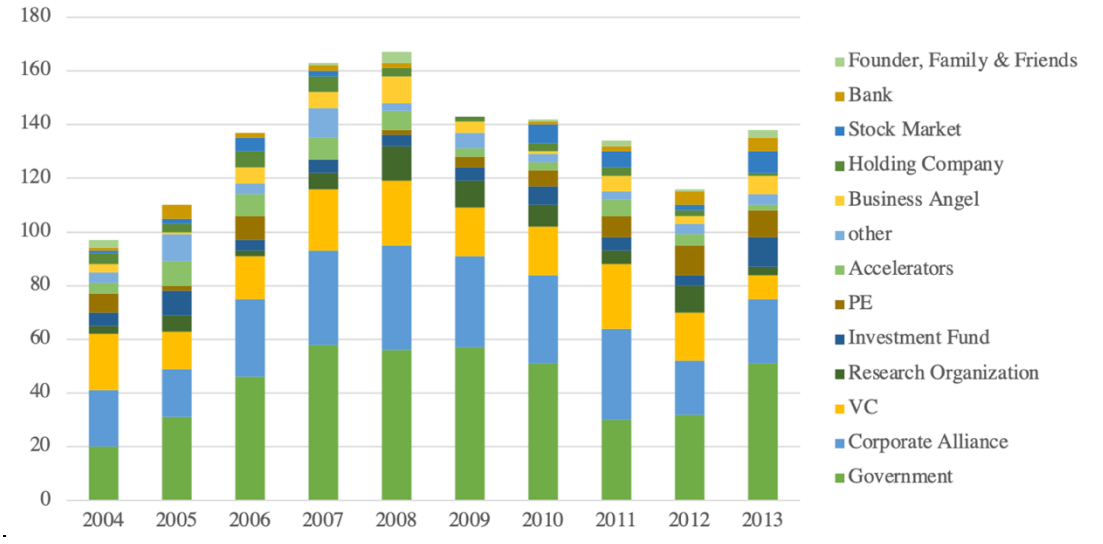

Figure 1 – Total Count of Funding Ties by Capital Provider

Figure 2 shows the ties distinguished by form of finance (equity, debt, grant, royalty & milestone payments). The chart quantifies that equity and grant financing are the two biggest forms of finance. They fluctuate throughout the period and contribute on average 39% (equity) and 33% (grant) of total funding ties. Interestingly, these two forms of finance show opposite development trends especially in times of crisis. Debt and licensing payments make up each only around 15% of total funding ties.

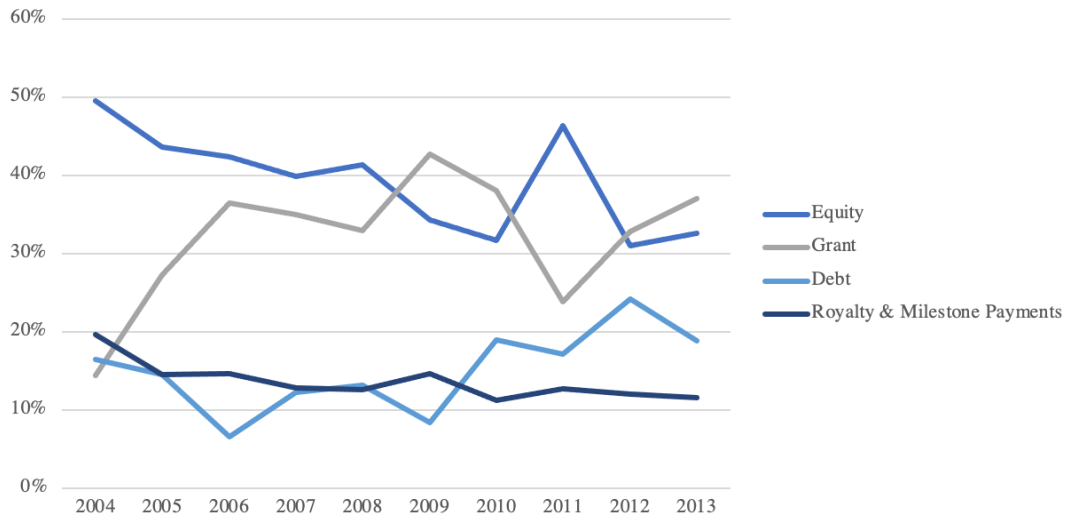

Figure 2 – Relative Contribution of Different Forms of Finance

4.5.3 Funding Ties of the Sample DBFs

Among the sample of 313 DBFs, 123 (39%) have leveraged 1-5 funding ties over the period from 2004-2013. Another 54 (17%) have enacted 6-10 ties, 20 (6%) DBFs count 11-15 ties, while only 17 (5%) count more than 15 ties. The highest number of ties observed for one DBF is 32 funding ties. There are 99 (32%) DBFs with no funding events captured in the period of observation. Figure 3 visualizes the frequency of ties among the sample in a histogram.

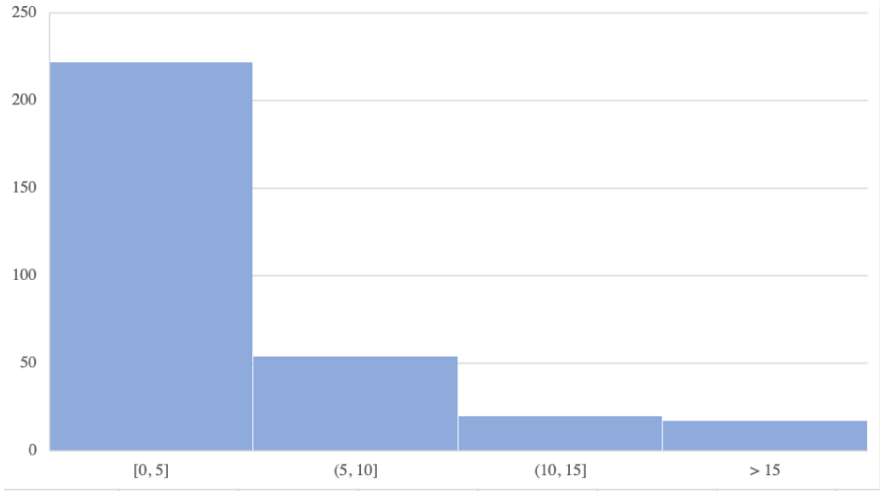

Figure 3 – Histogram of Frequency of the Count of Total Funding Ties

Table 3 provides an overview of the distribution of different funding ties among the DBFs in the Swedish biotech ecosystem. We employ the approach used by Berger & Udell (1998) to distinguish the various DBFs in terms of size and age. We employ the same age and size

definitions as in the description of the sample, using the age at year 2015 and average sales and employee numbers over the entire period from 2004–2015.

	Govern-ment	Corporate Alliance	VC	Research Org.	Investment Fund	PE	Acceler-ator	Business Angel	Stock Market	Holding Company	Bank	Founder, Family & Friends	Other	Total
AGE														
Start-up	35	3	28	11	9	9	4	6	0	0	3	1	2	**111**
	32%	*3%*	*25%*	*10%*	*8%*	*8%*	*4%*	*5%*	*0%*	*0%*	*3%*	*1%*	*2%*	
Early-stage	217	76	92	35	10	17	28	14	5	14	6	8	14	**536**
	40%	*14%*	*17%*	*7%*	*2%*	*3%*	*5%*	*3%*	*1%*	*3%*	*1%*	*1%*	*3%*	
Middle-stage	108	49	55	19	31	15	16	22	13	11	9	3	21	**372**
	29%	*13%*	*15%*	*5%*	*8%*	*4%*	*4%*	*6%*	*3%*	*3%*	*2%*	*1%*	*6%*	
Late-stage	36	68	5	0	4	7	4	4	2	2	5	1	11	**149**
	24%	*46%*	*3%*	*0%*	*3%*	*5%*	*3%*	*3%*	*1%*	*1%*	*3%*	*1%*	*7%*	
Mature	38	91	5	1	5	11	2	1	13	6	2	2	4	**181**
	21%	*50%*	*3%*	*1%*	*3%*	*6%*	*1%*	*1%*	*7%*	*3%*	*1%*	*1%*	*2%*	
SIZE														
Small	176	54	107	43	18	40	22	25	8	14	5	8	30	**634**
	34%	*10%*	*21%*	*8%*	*3%*	*8%*	*4%*	*5%*	*2%*	*3%*	*1%*	*2%*	*5%*	
Medium	177	59	68	17	21	13	26	14	14	12	10	5	12	**347**
	41%	*14%*	*16%*	*4%*	*5%*	*3%*	*6%*	*3%*	*3%*	*3%*	*2%*	*1%*	*3%*	
Large	81	174	10	6	20	6	6	8	11	7	10	2	10	**368**
	24%	*51%*	*3%*	*2%*	*6%*	*2%*	*2%*	*2%*	*3%*	*2%*	*3%*	*1%*	*3%*	
Grand Total	**434**	**287**	**185**	**66**	**59**	**59**	**54**	**47**	**33**	**33**	**25**	**15**	**52**	**1349**

Table 3 – DBF Age & Size per Capital Provider

Age categorization: “small” (employees < 10; revenue < SEK 1 million), “medium” (employees 10-50; revenue SEK 1 million – SEK 10 mil.); size categorization: “large” (employees > 50; revenue > SEK 10 million), and to “start-up” (0-5 years), “early-stage” (6-10 years), “middle-stage” (11-15 years), “late-stage” (16-20 years) and “matured” (20+ years).

The following figures visualize the data from table 4, beginning with a focus on different age and then size groups. Figure 4 shows the relative split of funding ties per capital provider in the different age categories of the DBFs. This shows that government funding is more heavily used when a firm is younger. As government funding decreases with firm age, funding from corporate alliances grows. Once a firm is matured, this is the most important source of capital, making up 50% of funding ties. VC funding, like government funding, weighs more heavily in early phases of the company’s life cycle. Stock market funding through IPOs only come into play when the firm is around 10 years old. Comparable patterns can be observed when distinguishing between firm sizes, as shown in figure 5.

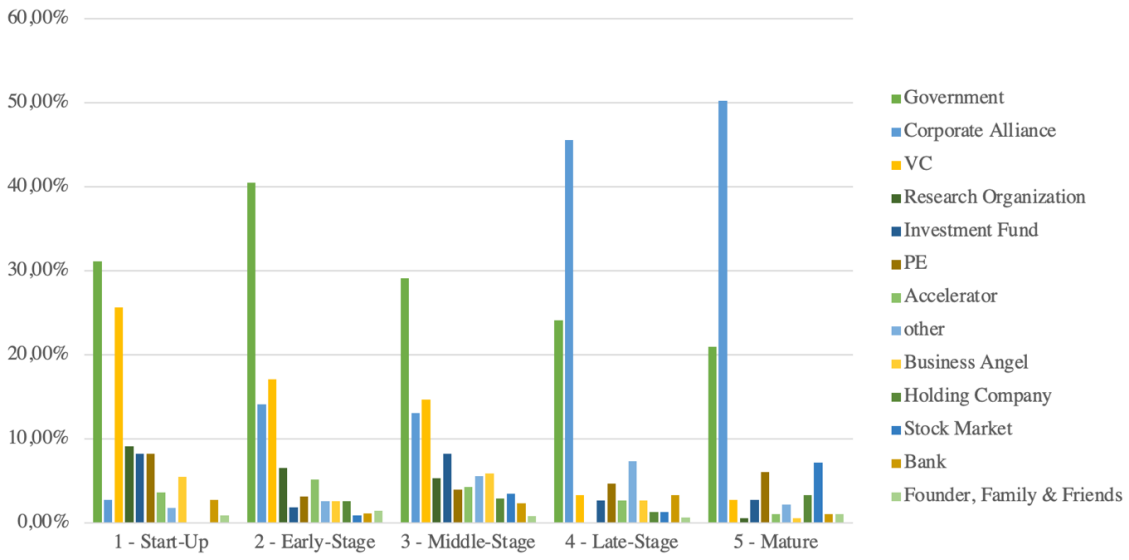

Figure 4 – Funding Ties per Capital Provider at Different Firm Ages

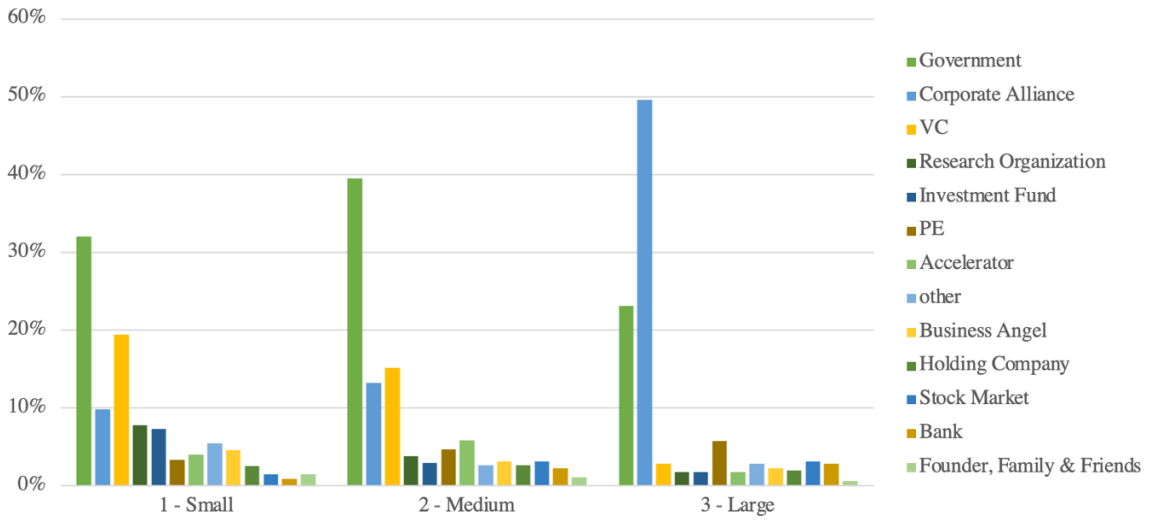

Figure 5 – Funding Ties per Capital Provider at Different Firm Sizes

In a similar manner we look at the composition of forms of finance in each age and size group of the DBFs. Table 4 provides the tabular summarization of the split and figures 6 and 7 picture the relative distribution. Royalty and milestone payments clearly increase in relative contribution to total funding both with DBF age and size. Equity is very important in younger and smaller DBFs and shows a decreasing trend with growing maturity. Regarding age, we see a spark in the relative contribution of equity for middle-aged DBFs, where this form of finance accounts for 52% of all funding ties. Grants play a consistently important role with slight fluctuations around 30-40% for both age and size observations. Debt is interestingly a relevant contributor already from early stages on, yet only makes up 10-20% of overall funding.

	Equity	Grant	Debt	Royalty & Milestone Payments	Total
AGE					
Start-up	51	34	23	1	**109**
	47%	*31%*	*21%*	*1%*	
Early-stage	199	231	85	21	**536**
	37%	*43%*	*16%*	*4%*	
Middle-stage	194	106	51	23	**374**
	52%	*28%*	*14%*	*6%*	
Late-stage	46	28	23	52	**149**
	31%	*19%*	*15%*	*35%*	
Mature	35	45	17	84	**181**
	19%	*25%*	*9%*	*46%*	
SIZE					
Small	281	165	91	13	**550**
	51%	*30%*	*17%*	*2%*	
Medium	149	196	72	31	**448**
	33%	*44%*	*16%*	*7%*	
Large	95	83	36	137	**351**
	27%	*24%*	*10%*	*39%*	
Grand Total	**525**	**444**	**199**	**181**	**1349**

Table 4 – DBF Age & Size Distribution per Form of Finance

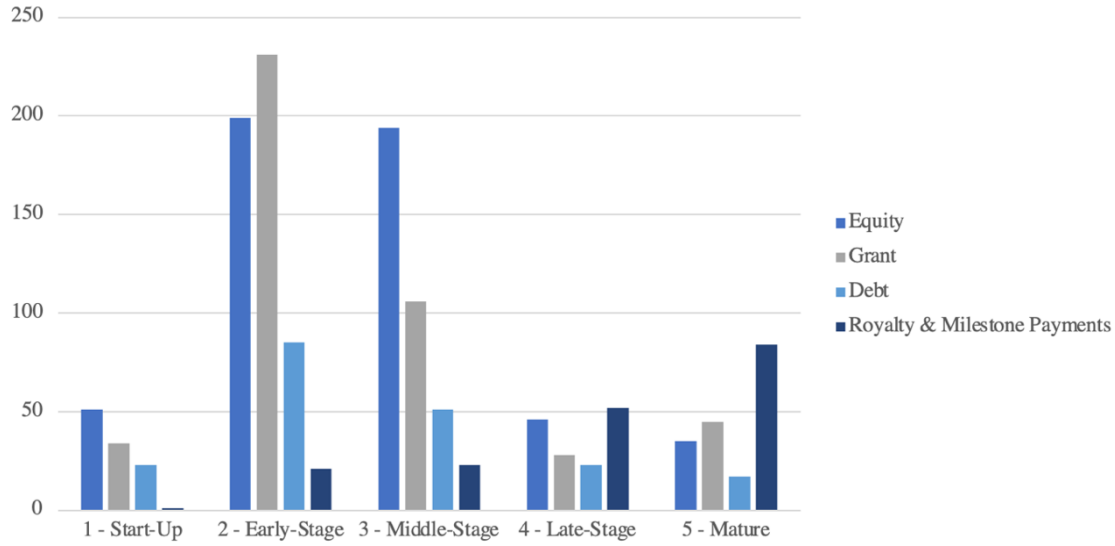

Figure 6 – Funding Ties per Form of Finance at Different Firm Ages

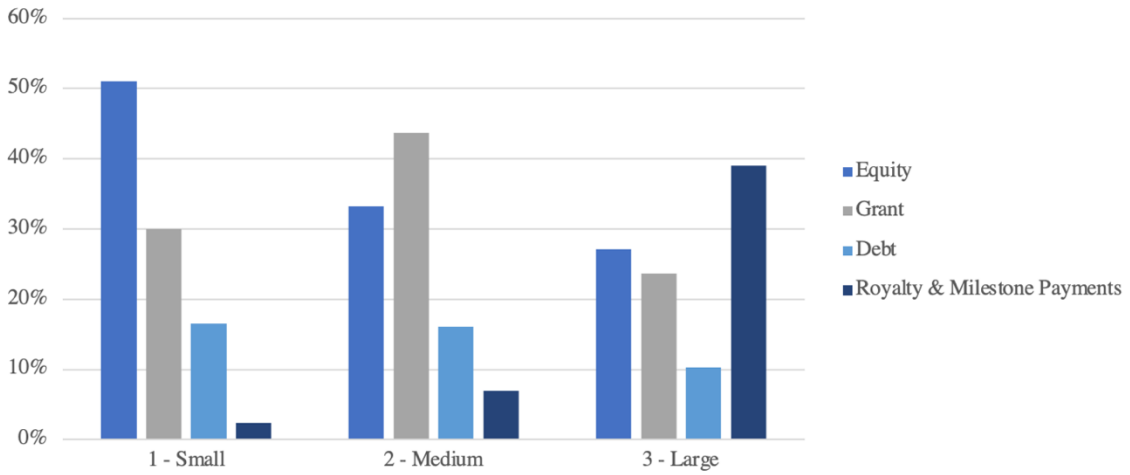

Figure 7 – Funding Ties per Form of Finance at Different Firm Sizes

Table 5 shows the split of international and domestic ties in the dataset, differentiated according to capital provider. We see that in total domestic ties are employed almost three times as often as international ties. Among the three biggest capital providers, VC ties are the least international (6%). Government funding has an international footprint of 33%. Funding through corporate alliances shows a split of approximately 50/50 between domestic and international ties.

Capital Provider	***Domestic***	***International***	***Grand Total***
Government	293	141	434
Corporate Alliance	146	141	287
VC	174	11	185
Research Organization	60	6	66
Investment Fund	51	8	59
PE	53	6	59
Accelerator	52	2	54
Other	40	12	52
Business Angel	42	5	47
Stock Market	32	1	33
Holding Company	32	1	33
Bank	24	1	25
Founder, Family & Friends	15	0	15
Grand Total	**1014**	**335**	**1349**

Table 5 - Split of International and Domestic Ties per Capital Provider

In conclusion, the pre-study confirms the most prevalent types of funding to be provided from the government, corporate alliances, and VCs. We also see foreign funding to play an

important role. Therefore, we now proceed to defining our variables and analytical procedures for the focus of this research project – the performance evaluation.

4.6 Measures & Variables

4.6.1 Dependent Variables

The dependent variable is the performance of DBFs. As our performance indicators, we measure the growth of the firm's sales figures and the growth of the number of employees. Considering this thesis' conceptual framework of EE and Entrepreneurial Finance, we are interested in entrepreneurial and commercial success, rather than knowledge creation or inventive productivity.

In assessing sales growth, this thesis employs the compounded annual growth rate of sales (CAGR) similar to a comparative study on the Australian biotech sector (Molloy et al., 2021). CAGR is calculated as the annualized growth rate of sales, using the formula below. EB is the ending balance, and BB is the beginning balance. These are measured within the respective study periods over the period of positive sales generation. The number of years over which CAGR is measured is indicated by n.

$$CAGR = \left(\frac{EB}{BB}\right)^{\frac{1}{n}} - 1$$

For the employee growth metric, we calculate the annual average growth rate (AAGR). AAGR takes the average of a series of year-on-year growth rates, using the formula below.

$$AAGR = \left[(Growth\ Rate)_y + (Growth\ Rate)_{y+1} + \ (Growth\ Rate)_{y+n} + \cdots\right]/n$$

$$Growth\ Rate = \left[\left(\frac{EB}{BB}\right) - 1\right] x\ 100$$

We use CAGR for the sales data as the high variance in the figures over the period would impact the AAGR significantly. In practice this approach is also commonly used in evaluating financial performance as it considers compounding effects (CFI, 2022). The employee figures develop more stable and hence the AAGR suffices. Both employee and sales growth are only calculated for those DBFs that show positive sales or employee numbers in 3 or more years in each of the periods. Fewer data points would not produce insightful growth indications. For a

comparison of different groups of DBFs in relation to average sales, we use the logarithm of sales to reduce the heteroscedasticity and hence variance in the data (Ermini & Hendry, 2008).

In general, we split the time horizon in two five-year-long periods (2004-2008; 2009-2013). This is done with the intention to measure performance effects more accurately. Further, the financial crisis occurred in 2008, which could impact the development of both funding events and performance in the second half of the period. 34 DBFs were founded only after 2006. For period 1, these were excluded, as we aim for at least 2 years of activity in the respective periods. For period 2 we exclude 18 DBFs that exited the market before 2011 and hence would not pass the threshold of 2 years of datapoints required. We calculate growth metrics over the 5 years per period plus two subsequent years. Including figures two years beyond the cut-off period allows for the time lag of performance effects to materialize. If, for instance, a DBF enacted a funding tie in 2013, it is expected to show in sales or employee growth only in the subsequent years and not immediately. The chosen duration is based on a study on the Swedish VC landscape, which found that investments take effect on sales growth 2-3 years after they were made (Tillväxtanalys, 2017). This lagged analysis approach has also been previously employed in other studies of similar settings (Ahmed & Cozzarin, 2009; Hottenrott & Richstein, 2020; Zidorn & Wagner, 2013).

4.6.2 Independent Variables

Based on the pre-study we have seen the entire range of funding types present in the Swedish setting. However, for the performance analysis we focus only on the most relevant external funding types, namely government funding, corporate alliance funding, and VC funding, as well as international funding. In classifying a tie to the relevant categories of inquiry, we focus on the different capital providers as the decisive characteristic. That means, that even if a capital provider (e.g., government) offers different forms of finance (e.g., both grants and debt), we count all ties with the government towards our independent variable (e.g., government funding).

Generally, in measuring the funding ties, dummy variables can be employed to capture whether a DBF has enacted a certain tie of interest or not. However, if and when a firm has a mix of multiple different ties over the period, a count of ties offers a more precise indication of the relative role a given type of funding may play. Through the ecosystem perspective, we believe this approach further to be more suitable as a higher number of funding ties also implies

more potential for resource and knowledge access, with a subsequent impact on performance. Each variable is evaluated on the DBF-level and at an aggregate sum over each of the two sub-periods from 2004-2008 and 2009-2013, as well as overall.

The independent variable government funding includes public funding from both Swedish, European, and foreign public institutions. In Sweden, some of the biggest providers are *Vinnova*[6] and *Almi*[7]. The European Union also strongly engages in biotech funding through numerous framework programs[8] (FPs) for research. Corporate Alliance Funding covers both biotech-biotech and biotech-pharma relationships. The types of capital providers involved in this category are other DBFs from within and outside the sample, as well as biomedical, big pharma, and life-science companies. VC funding includes all ties with independent VCs. International funding ties are those where the capital provider is based outside of Sweden. We thereby do not distinguish between capital providers.

4.6.3 Control Variables

It is important to account for the size and age of the firm in the regression models predicting firm performance. These two control variables we believe will also impact our performance metrics. Older and bigger DBFs will likely be perceived as more attractive investments from capital providers' point of view. To limit their influence on the dependent variable, we account for them in our regression models and hence improve internal validity (Bryman, 2012). We measure age from the year of registration of the DBF until the end of the respective study period and assign a categorical rank according to the thresholds used in the description of the sample (4.4): (1 – start-up, to 5 – mature). Size is operationalized as an ordered categorization ranging from 1 – smallest to 3 – biggest, also based on previously defined measures of average sales and employee count. As acknowledged in the introduction of the event dataset, we do not have a complete picture of the funding history of those DBFs that were founded prior to 2004. Controlling for age in our regression analysis helps us account for this limitation.

Table 6 provides a summary of our dependent, independent, and control variables.

Variable Name	***Measurement***	***Hypothesis***
DV-Sales-Growth	CAGR of yearly sales volumes when sales > 0 for more than 2 years	-

[6] https://www.vinnova.se
[7] https://www.almi.se
[8] https://ec.europa.eu/eurostat/cros/content/research-projects-under-framework-programmes-0_en

DV-Employee-Growth	AAGR of yearly employee count when employee > 0 for more than 2 years	-
IV-AllTies	Count of all funding ties	H1
IV-Gov	Count of funding ties with the government	H2
IV-Corp	Count of funding ties with corporate alliances	H3
IV-VC	Count of funding ties with VCs	H4
IV-Intl	Count of international funding ties	H5
SizeRank	Ordered rank from 1-3 based on employee and sales thresholds	-
AgeRank	Ordered rank from 1-5 based on DBF age	-

Table 6 – Measures and Definitions of Variables

4.7 Analytical Procedures

We initiate the performance evaluation by demonstrating some descriptive statistics and correlations among the variables. We then conduct a difference-in-means test on DBFs with and DBFs without financial ties. To test whether the differences in means between the variables under investigation between the two groups are statistically significant we conduct a two-sample or independent T-test. Both sales and employee growth are normally distributed and the variance between the two groups is similar, making this test an applicable one.

Finally, we run several ordinary-least-squares (OLS) regressions to estimate the effect of different types of funding on performance. The linear regression aims to predict the dependent variable (performance) as a linear function of the independent variable (funding type). The formula is provided below, where Y is the dependent variable, β_0 the intercept, β_1 the slope of the independent variable X_i, and ϵ the random error (Montgomery et al., 2021).

$$Y = \beta_0 + \beta_1 X_i + \epsilon$$

As derived from the literature review, funding from the government, corporate alliances, VCs, as well as international funding are the most prominent ties. These are the focus of the performance analysis. As the goal is not to compare the funding types directly to one another, we run separate regression models, each focusing on the presence of one funding type at a time. This approach also avoids issues of multi-collinearity (Montgomery et al., 2021). We further estimate different models for our two performance indicators: sales growth and employee growth. We add our control variables to each model to increase the accuracy of the explanatory power of the different variables. When running the regression analyses, we exclude those DBFs

that exited the market due to bankruptcy and liquidation as these are understood as firm failure. M&A cases are seen as a success and are included. We accept our hypotheses when the p-value is lower than 0.05, indicating a significant result. The coefficient estimate thereby indicates how strong a relationship between funding type and performance is, as well as in which direction (positive or negative) the variables correlate. The entire statistical analysis is conducted using the statistical program R-Studio.

5. Results

In this section we report the results of our performance analysis. This includes the descriptive statistics of variables (5.1) and the regression outcomes of the performance evaluation (5.2).

5.1 Descriptive Statistics of Variables

Table 7 shows the descriptive statistics including mean and standard deviation for all the employed variables as well as the correlation matrix. On average the DBFs in the sample achieve an overall growth in sales of 11.6% at a standard deviation of 35.3%. However, between period 1 and 2 these numbers differ substantially. Period 1 sees a sales growth of 21.7% and period 2 only of 3.1%. The realized employee growth is overall on average 1.9% with a variance of 28.8%. In period 1 employee numbers grow on average by 8.3%, while in period 2 they shrink by 8.3%. The sample has a mean number of 4.3 total ties and a standard deviation of 5.9 overall. The means of the specific types of funding range from 0.6 (VC) to 1.4 (government). Their standard deviation is between 2.1 (VC) and 2.8 (corporate alliance). Another difference between the study periods stands out in regards to the correlation of sales growth and the different funding types. Namely, that for period 1 the funding ties and sales growth have consistently negative correlations, while period 2 has positive ones.

We further look at the correlation of our control variables with the dependent and independent variables. Across the time periods the direction and approximate strength of correlations is similar. We hence refer to the findings of the overall period for the sake of simplicity. AgeRank thereby shows a comparatively strong negative correlation with sales growth (-0.29) and employee growth (-0.27). This indicates that the older the DBF, the lower the respective growth rates. For SizeRank we report the opposite, namely positive and slightly weaker correlations with sales growth (0.17) and employee growth (0.09). Hence, larger DBFs

achieve higher growth rates. Interestingly, the correlation directions of age and size are the same within each type of funding yet change signs among the different types. For both size and age, the correlation with total ties is rather small and negative (-0.05 and -0.06 respectively). The same is true for the correlations with VC (age: -0.11; size: -0.16) and government ties (age: -0.20; size: -0.13), while they are positive for international (age: 0.12; size: 0.15) and corporate alliance (age: 0.21; size: 0.23) ties.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1. *DV-Sales-Growth*	11.62%^{ALL}	35.32%^{ALL}									
	21.71%^{1}	56.57%^{1}	-								
	3.1%^{2}	32.62%^{2}									
2. *DV-Employee-Growth*	1.9%^{ALL}	28.76%^{ALL}	0.41^{ALL}								
	8.26%^{1}	43.26%^{1}	0.28^{1}	-							
	-8.3%^{2}	40.36%^{2}	0.14^{2}								
3. *IV-AllTies*	4.30^{ALL}	5.91^{ALL}	0.08^{ALL}	0.27^{ALL}							
	2.40^{1}	3.82^{1}	-0.03^{1}	0.33^{1}	-						
	2.28^{2}	2.72^{2}	0.12^{2}	0.16^{2}							
4. *IV-Gov*	1.38^{ALL}	2.38^{ALL}	0.15^{ALL}	0.30^{ALL}	0.58^{ALL}						
	0.71^{1}	1.62^{1}	-0.03^{1}	0.30^{1}	0.63^{1}	-					
	0.75^{2}	1.45^{2}	0.18^{2}	0.12^{2}	0.60^{2}						
5. *IV-Corp.*	0.91^{ALL}	2.75^{ALL}	0.03^{ALL}	0.06^{ALL}	0.55^{ALL}	0.05^{ALL}					
	0.52^{1}	1.62^{1}	-0.06^{1}	0.12^{1}	0.57^{1}	0.12^{1}	-				
	0.49^{2}	1.55^{2}	0.08^{2}	0.07^{2}	0.63^{2}	-0.01^{2}					
6. *IV-VC*	0.59^{ALL}	2.10^{ALL}	-0.01^{ALL}	0.08^{ALL}	0.52^{ALL}	0.04^{ALL}	-0.02^{ALL}				
	0.36^{1}	1.12^{1}	-0.02^{1}	0.13^{1}	0.48^{1}	0.04^{1}	0.02^{1}	-			
	0.29^{2}	1.54^{2}	0.04^{2}	-0.03^{2}	0.25^{2}	0.12^{2}	0.07^{2}				
7. *IV-Intl*	1.07^{ALL}	2.68^{ALL}	-0.03^{ALL}	0.14^{ALL}	0.66^{ALL}	0.41^{ALL}	0.80^{ALL}	0.01^{ALL}			
	0.58^{1}	1.71^{1}	-0.11^{1}	0.19^{1}	0.67^{1}	0.42^{1}	0.87^{1}	0.02^{1}	-		
	0.59^{2}	1.53^{2}	0.06^{2}	0.20^{2}	0.74^{2}	0.46^{2}	0.63^{2}	0.06^{2}			
8. *SizeRank*	1.94^{ALL}	0.80^{ALL}	0.17^{ALL}	0.09^{ALL}	-0.05^{ALL}	-0.13^{ALL}	0.23^{ALL}	-0.16^{ALL}	0.15^{ALL}		
	1.96^{1}	0.81^{1}	0.03^{1}	-0.02^{1}	-0.09^{1}	-0.14^{1}	0.19^{1}	-0.19^{1}	0.15^{1}	-	
	1.94^{2}	0.80^{2}	0.02^{2}	0.24^{2}	0.08^{2}	-0.10^{2}	0.19^{2}	-0.07^{2}	0.12^{2}		
9. *AgeRank*	3.36^{ALL}	1.11^{ALL}	-0.29^{ALL}	-0.27^{ALL}	-0.06^{ALL}	-0.20^{ALL}	0.21^{ALL}	-0.11^{ALL}	0.12^{ALL}	0.32^{ALL}	
	2.77^{1}	1.31^{1}	-0.26^{1}	-0.18^{1}	-0.10^{1}	-0.17^{1}	0.17^{1}	-0.16^{1}	0.11^{1}	0.32^{1}	-
	3.36^{2}	1.11^{2}	-0.11^{2}	-0.06^{2}	-0.02^{2}	-0.19^{2}	0.17^{2}	-0.14^{2}	0.05^{2}	0.24^{2}	

Table 7 - Descriptive Statistics and Correlation Matrix

(ALL = overall; 1 = period 1; 2 = period 2)

5.2 Result of the Performance Evaluation

Before testing for hypothesis 1, with its focus on understanding the impact of total funding ties on performance, we take a closer look at those DBFs without any funding ties. We compare this group of DBFs without funding ties to the one with funding ties in terms of their average sales and employee growth. Results of the T-test are reported in table 8. Both sales and employee growth rates are higher in the group with funding ties. Yet, only the latter is significant according to the T-test. The differences are quite substantial as DBFs with funding ties grow by 5.29% (overall), whereas those DBFs without funding ties shrink by -5.56% (overall). We further note that for both growth rates we observe a higher rate in period 1 compared to period 2 (sales growth, with ties, period 1: 24%; period 2: 6.5%; sales growth, without ties, period 1: 19%; period 2: -0.7%; employee growth, with ties, period 1: 14.4%; period 2: -2.8%; employee growth, without ties, period 1: 0.6%; period 2: -15.5%). To provide more insight, we further show the number of DBFs in each group, their average age, and average logarithmic sales. While the group without ties is older on average, the difference is only around 2-3 years and not significant according to the T-test. However, average sales are significantly higher for the no-funding-ties group.

Table 9 reports the estimations of the relationship between the independent variables (types of funding) and the dependent variable (DBF performance). We begin with looking at high-level outcomes across the different regression models. We see that for employee growth most of the models report statistically significant results. On the contrary, sales growth, as a dependent variable, is not statistically correlated in any but two of the models. Periods 1 and 2 differ in their strength and direction of the relationships between funding and growth. Firstly, for sales growth, period 1 shows negative correlations while period 2 shows positive ones. The results for employee growth are consistent in all periods and further achieve similar significance levels. The coefficients are, however, higher in period 2 for employee growth.

	With financial ties	***Without financial ties***	**T-Test** t(df) = t; p<0.05
Count DBFs			
Overall (04-15)	214	99	-
P1 (04-10)	148	122	-
P2 (09-15)	160	135	-
Age			
Overall (04-15)	15.98	17.9	t(311) = 1.5875, p = 0.1134
P1 (04-10)	11.86	14.56	t(268) = 2.2227, p = 0.02707
P2 (09-15)	15.31	17.95	t(293) = 2.2504, p = 0.02516
Survival			
Overall (04-15)	184 survivors (30 failures) 85%	87 survivors (12 failures) 88%	-
P1 (04-10)	142 survivors (6 failures) 96%	118 survivors (4 failures) 97%	-
P2 (09-15)	147 survivors (13 failures) 91%	116 survivors (19 failures) 86%	-
Average Sales (log(Sales))			
Overall (04-15)	4.66	5.72	t(269) = 3.6431, p = 0.0003***
P1 (04-10)	4.48	5.35	t(258) = 2.9079, p = 0.00395*
P2 (09-15)	4.79	5.19	t(261) = 1.2895, p = 0.1984
Sales Growth			
Overall (04-15)	13.4%	8.3%	t(241) = -1.072, p = 0.2848
P1 (04-10)	24%	19%	t(206) = -0.6691, p = 0.5042
P2 (09-15)	6.5%	-0.7%	t(164) = -1.4227, p = 0.1567
Employee Growth			
Overall (04-15)	5.29%	-5.56%	t(309) = -3.1319, p = 0.0019*
P1 (04-10)	14.4%	0.6%	t(265) = -2.6318, p = 0.008992**
P2 (09-15)	-2.8%	-15.5%	t(273) = -2.6185, p = 0.009326**

Table 8 – T-test Comparison between DBFs With and Without Funding Ties

(Signif. codes: * < 0.05; ** < 0.01; *** < 0.001)

	Sales Growth (+ AgeRank + SizeRank)		Employee Growth (+ AgeRank + SizeRank)	
	Coefficient	Adj. R-Squared	Coefficient	Adj. R-Squared
Total (H1)				
Overall (04-15)	0.004140	0.152	0.01307***	0.1232
P1 (04-10)	-0.008009	0.06842	0.031128***	0.08143
P2 (09-15)	0.012423	0.01274	0.024945***	0.1199
Government (H2)				
Overall (04-15)	0.01687	0.1605	0.027534***	0.102
P1 (04-10)	-0.02370	0.07006	0.05867***	0.05373
P2 (09-15)	0.03469*	0.02669	0.04353**	0.09005
Corporate Alliance (H3)				
Overall (04-15)	0.004764	0.1485	0.009468	0.05893
P1 (04-10)	-0.01117	0.06691	0.035934*	0.02376
P2 (09-15)	0.01582	0.005268	0.01495	0.06833
VC (H4)				
Overall (04-15)	-0.001259	0.147	0.013842	0.06113
P1 (04-10)	-0.03360	0.06751	0.05038*	0.02251
P2 (09-15)	0.02891	-0.002042	0.01910	0.07049
International (H5)				
Overall (04-15)	-0.003985	0.148	0.020387***	0.08678
P1 (04-10)	-0.02813	0.07436	0.04269**	0.03453
P2 (09-15)	0.01272	0.001267	0.06437***	0.1282
DF				
Overall (04-15)	239		307	
P1 (04-10)	204		263	
P2 (09-15)	162		271	

Table 9 – Regression Results Performance Analysis

Reporting Coefficient Estimates & Adjusted R-Squared (Signif. codes: * < 0.05; ** < 0.01; *** < 0.001)

Looking at our first regression model, the estimation coefficient for the total number of ties (hypothesis 1) on sales growth across all time periods is low and insignificant (overall: 0.004; period 1: -0.008; period 2: 0.012). For the relationship between total ties an employee growth we find slightly positive and significant correlations (overall: 0.013***; period 1: 0.03***; period 2: 0.02***). The adjusted R-squared for the model based on the overall data indicates that 12.3% of the variance in employee growth can be explained by the combination of the independent and control variables. R-squared for employee growth in period 1 is 8.1% and in period 2 12%. These outcomes show the models including the control variables. R-squared increased in all cases when adding the controls, indicating that the models can explain more variance in the data when accounting for age and size. Generally, hypothesis 1 regarding sales growth cannot be confirmed. However, we confirm hypothesis 1 in that DBFs with a higher number of total funding ties are associated with higher employee growth.

Government funding is the focus of hypothesis 2. Its relationship with sales growth is significant in period 2 (0.03*) yet insignificant overall (0.02) and in period 1 (-0.02). All three periods with regards to employee growth are significant with a positive relationship (overall: 0.03***; period 1: 0.06***; period 2: 0.04**). The adjusted R-squared shows that overall 10.2% of the variance in employee growth can be explained by government funding while accounting for age and size. In period 1 we explain 5.3% and in period 2 9% of the variance. The significant model predicting sales growth for period 2 has an adjusted R-squared of only 2.7%. We consequently accept hypothesis 2 in that government funding is positively correlated with employee growth in all periods, as well as with sales growth between 2009 and 2015. Yet, we remain cautious in assigning too much explanatory power to government funding regarding the latter.

The models testing hypothesis 3 regress funding from corporate alliances on DBF performance. Sales growth as a dependent variable finds no significant support for a relationship with this type of funding (overall: 0.005; period 1: -0.01; period 2: 0.02). Whereas employee growth is significantly positively estimated by corporate funding alliances only in period 1 (0.04*). Overall (0.009) and period 2 (0.01) show no significant results. In period 1, with the significant outcome, we can explain 2.3% of the variance in employee growth. We subsequently can only accept hypothesis 3 suggesting a positive relationship between corporate alliance funding and performance in terms of employee growth between 2004 – 2010. In all other scenarios we reject hypothesis 3.

Hypothesis 4 focuses on funding from VCs as an independent variable. In estimating sales growth our models do not offer significant results in any of the periods (overall: -0.001; period 1: -0.03; period 2: 0.03). The models estimating employee growth show positive coefficients, where only period 1 has a significant relationship (overall: 0.01; period 1: 0.05*; period 2: 0.02). We report an adjusted R-squared of 2.3% in the period in which we find a significant result (period 1). We hence only confirm hypothesis 4 in the case of employee growth in the first period from 2004-2010. In all other scenarios we reject H4.

Hypothesis 5 tests whether international funding ties are positively correlated with DBF performance. For sales growth we find no significant results (overall: -0.004; period 1: -0.03; period 2: 0.01). Conversely, for employee growth our models estimate consistently positive and significant coefficients (overall: 0.02***; period 1: 0.04**; period 2: 0.06***). Adjusted R-squared measures 8.7% overall, 3.4% in period 1 and 12.8% in period 2. Hypothesis 5 must be rejected when estimating sales growth yet can be accepted for employee growth in all periods.

A summary of our hypotheses and their outcomes for each period is provided in table 10.

	Definition	*Sales Growth*	*Employee Growth*
H1	All ties	All: reject P1: reject P2: reject	All: accept P1: accept P2: accept
H2	Government ties	All: reject P1: reject P2: accept	All: accept P1: accept P2: accept
H3	Corporate alliance ties	All: reject P1: reject P2: reject	All: reject P1: accept P2: reject
H4	VC ties	All: reject P1: reject P2: reject	All: reject P1: accept P2: reject
H5	International ties	All: reject P1: reject P2: reject	All: accept P1: accept P2: accept

Table 10 – Summary of Hypothesis Results

6. Discussion

In this section we answer the 2 guiding research questions of this thesis through the employed theoretical framework based on EE and Entrepreneurial Finance. The main research question addresses the differential effect of different funding ties on the performance of DBFs and is answered in the performance analysis (6.2). Precedingly, we discuss the findings from the pre-study (6.1), which seeks to explore the dynamic composition of different types of funding and how they are employed in the Swedish biotech sector. We end this chapter by reflecting upon limitations and areas for future research (6.3).

6.1 Discussion of Pre-Study

Even though the pre-study served as an enabler to the main analysis of the performance evaluation, a discussion of its results on the composition of funding ties offers explanations for the constraining and enabling factors of the effect on performance. In general, we observe a heterogeneous capital market with many actors and forms of finance employed. Coupled with the observation that many DBFs employ a mix of funding ties, we interpret these landscape characteristics as a sign for the extensive and complex funding needs of the biotech field. We see that each capital provider revealed to have one or at most two very distinct forms of finance employed in their funding relationships with DBFs. Governments focus on grant funding, VCs on equity, and corporate alliances mainly employ royalty & milestone payments. This finding confirms the viewpoint in Entrepreneurial Finance that different funding sources have different motives and offer different forms of engagement to the firms they invest in (Block et al., 2018).

In the overall development trend of the form of finance the data showed how equity and grant financing follow opposite movements. A possible explanation is that grant activity, which are only provided by government funding, purposefully counteracts contractions in equity supply during tense economic times, such as the financial crisis. In line with the funding gap concept proposed in Entrepreneurial Finance literature (Cumming et al., 2019), it is plausible that the supply of government grants is increased intently to fill the gap, which is supposed to be especially prevalent in the biotech industry. Grant funding is further the most heavily employed source of funding. DBFs are thought to leverage this funding source when they require seed and early-stage R&D funding (Çetindamar & Laage-Hellman, 2003). Consequently, it is likely that the high presence of government ties is driven by the fact that every DBF in its early stage requires this source of funding to overcome capital constraints at

times where no other investor is yet willing to take the high risks. In looking at the funding sources along the life cycle stages of DBFs, we find further evidence for this. Government funding is clearly the most utilized by younger and smaller firms. In short, our findings strongly support previous research in their notion of government funding playing a crucial role in bridging funding gaps.

VC funding follows the same pattern in that it is most common in younger and smaller DBFs. Interestingly, the fact that funding from VCs is most present in early stages is in opposition to literature that claims VCs are focused more on mid- to late-stage investments (Drover et al., 2017). The likelihood of future financial return is very difficult to assess in early-stage DBFs (Janney et al., 2021). This is a challenge for VCs that, while seeking high-risk investments, expect a substantial upside (Shuwaikh & Dubocage, 2022). It could be that VCs are driven to target these early stage ventures to avoid the alternative risk of being left behind as the capital flow from corporate alliances grows with the DBF's maturity – a phenomenon known as adverse-selection problem (Manigart et al., 2002). This could very well be the case if a DBF prefers grant and milestone payments which, according to the pecking-order theory, are less expensive and more attractive (S. Myers, 1984). Furthermore, a DBF could see more value in funding ties through corporate alliances, even if they take the form of equity, as these offer substantial access to complementary resources and vital domain expertise (Bratic et al., 2014). These reasons are likely explanations for VC's early engagement in biotech.

With growing age and size, government and VC funding become successively replaced by other types of funding. Our findings hence seem to indicate that the presence of both public investors (M. Berger & Hottenrott, 2021) and VCs (Grilli & Murtinu, 2014) entails a positive signaling effect of endorsement. This legitimizes the DBF and increases the likelihood of follow-on funding from other providers, especially from corporate investors (Janney et al., 2021). We have seen that corporate alliances become more employed with increasing age and size of the DBFs. A DBF in later stages of its life cycle is likely perceived to have more advanced biotech products in its pipeline with higher chances of successful commercialization, which ultimately attracts corporate investors. Thus, our findings can further be explained by the argument that established companies seek to strategically acquire biotech resources and capabilities through collaborations (Röhm et al., 2018), which become more attractive with greater maturity.

The data showed that bank funding is one of the smallest in terms of relative contribution to the total amount of funding ties. Regarding the relative importance of different forms of finance, we have also seen that debt, which is the main form of finance through banks, is often less important than equity and grants. It is generally not surprising that commercial loans from banks are rather insignificant sources of funding. It is understood that high-risk firms with intangible assets more frequently access external equity, while low-risk firms with tangible assets tend to source external debt (A. N. Berger & Udell, 1998). Young, high-risk firms, such as our DBF sample, simply lack the track record and collateral required for debt financing. However, debt funding is still employed at noteworthy levels throughout all age and size groups. In trying to explain the presence of debt already in early stages is the theory we can again make use of the pecking-order theory (S. Myers, 1984; S. C. Myers & Majluf, 1984). The pecking-order suggests that from the entrepreneurial venture's perspective, debt is more attractive than equity. This could explain the early utilization of debt finance from banks.

Generally, we find intersing evidence of the interplays of supply and demand in the capital market for biotech, where there are mismatches between preferences of DBFs and requirements from capital providers. These forces constrain one another and explain the emergent composition of funding ties.

6.2 Discussion of Performance Evaluation

At a high-level we reported that our models estimate significant correlation relationships for employee growth, yet not for sales growth. It is commonly discussed in the biotech field that young DBFs often do not have a commercialized product or service that would earn them revenue (Pisano, 2006). Consequently, sales growth is likely not achieved for the first years of existence. Sales numbers are also highly volatile across the years, which adds to the difficulty of robustly assessing sales growth. As employee growth does show significant relationships in some of the models, this performance metric seems to be more telling for the biotech field where many DBFs are still in their early stages. We believe that funding may often be used to spur firm growth in terms of employee count, which indicates increased efforts and resource allocation towards promising product or service development. The weak results for sales growth are, however, an important finding in itself. This implies that funding ties – across the types we tested – do not translate into sales growth. This has implications for investors in evaluating their potential return on investment, especially for equity investors. Potentially investors will only see returns once certain milestones such as IPOs or M&As occur (P.

Gompers & Lerner, 1998). This highlights the notion that biotech funding requires a long-term approach to gain attractive returns (Toth, 2013).

We first discuss the comparison of DBFs with funding ties and DBFs without funding ties in the studied periods. It is important to recall that we do not have the complete picture of funding for DBFs prior to 2004. DBFs without funding events are on average older, which explains why they have higher average sales as well. Most likely these DBFs will have had funding events prior to our study period. It remains interesting though, that these older and bigger DBFs without funding ties grow at a slower rate, specifically in terms of number of employees. Generally, this leaves us to conclude that growth as a performance metric is likely driven by the presence of funding relationships. To which degree and for which types of funding is explored through the regression analysis, which we discuss next.

Our hypotheses tests reveal support for a positive relationship between the total number of funding ties, government funding ties and international funding ties with employee growth. The positive correlation between total funding ties and DBF performance in terms of employee growth supports the premise of the signaling power of funding ties, leading to increased follow-on finance (Bonini & Capizzi, 2019; Janney et al., 2021). However, not all funding types investigated are positively linked to performance. This finding leads us to side with the conviction that *it is not getting the money; it is who the money comes from* (Sorenson & Stuart, 2001).

Government funding as a specific source of capital shows the strongest performance impact. Public funding strives to strengthen the economy, where job creation is often a major goal (Manigart et al., 2002). Seeing as funding from the government is positively linked with employee growth, it seems that this policy objective is successfully achieved. It is also noteworthy that this type of funding is the only one achieving a significant result for the effect on sales growth. However, the low R-squared value indicates that only very little in the variance of sales growth can be explained by government ties. Which is why we remain cautious in concluding a positive effect on sales growth. Previous researchers have argued that governments lack the domain expertise to support their target DBFs to the same degree as VCs or corporate investors can (Lindholm-Dahlstrand & Cetindamar, 2000). We provide evidence that government funding nevertheless shows a more significant impact on DBF growth than these other two types of funding. It is possible that the importance of overcoming the funding gap (Çetindamar & Laage-Hellman, 2003) is so pressing that the effects of public funding in

spurring growth outweigh the advantages of other sources of capital. A statement by Gunilla Oswald on *BioArctic*'s funding situation confirms that *"Support from public authorities has been a decisive factor in our success. . . . Although the amounts were relatively small, they came at critical times in the company's development,"* (Garcia, 2019, para. 10). We summarize the effect of government funding on DBF performance in terms of employee growth as significant and positive.

It is curious that VC and corporate alliances – the two funding ties that are thought to offer substantial access to complementary resources – do not achieve consistent supportive results regarding their impact on performance. Our results hence cannot entirely confirm previous research that has found a positive impact of VC and corporate alliances on DBF performance (Fraser et al., 2015; Park & Steensma, 2013). Only in the period prior to the financial crisis can we report supporting findings of these two funding sources. As growth figures are generally greatly curbed in the second period, it could be that these negative developments interfere with potential performance effects. Yet R-squared values of these periods indicate that only relatively little of the variance in employee growth can be explained by VC funding and corporate alliance funding. We remain careful in concluding these funding types to impact employee growth in a significant manner. As mentioned, these two funding sources have in common that they offer complementary resources, especially access to human capital and knowledge, as well as mentoring and managerial support (Brinster & Tykvová, 2021; Powell et al., 1996). These are resources that in fact might reduce the DBF's need to invest in additional personnel internally. This represents a possible explanation for why funding from VCs and corporates do not show an as high as expected impact on DBF employment. We therefore stress that our results do not necessarily mean that funding from VC and corporates do not have a positive impact on performance. In fact, the high relative importance of both forms of finance as seen in the pre-study suggests that they offer benefits in other ways.

We want to further explore possible reasons for the weak performance impact specifically of VC funding. Foregoing research provides some explanatory arguments. Adverse-selection problems, for instance, postulate that VCs miss out on successful investment targets as equity is perceived as too risky and expensive from the DBF's point of view (Manigart et al., 2002). An argument against this explanation is that the demand for capital in biotech is high and that such high-tech industries are typically struggling with a shortage in capital supply (Cumming et al., 2019). Also, our pre-study results revealed that VC funding is most present in early-stage

DBFs, second to government funding. Hence, there is no indication that DBFs receive funding from other sources prior to VC investments that would constitute a sufficient substitute. As noted by Bertoni & Tykvová (2015), government funding does not suffice as an effective substitute to VC. We do think it is likely though that VCs are pressured to invest earlier into DBFs as they otherwise would prefer to avoid the adverse-selection problem, propelled by corporate investors increasing their funding efforts in mid- to late-stage DBFs. Potentially then, the fact that VCs invest in young DBFs, where risk and uncertainty are higher, could explain the lower performance results of this type of funding. It could further be that VCs prioritize performance of their overall portfolio, while accepting poorer performance of individual DBFs (Manigart et al., 2002).

We reported positive links between international funding and employee growth. These findings contradict previous conclusions that have found geographic proximity to lead to increased performance, argued by facilitated resource access (Powell et al., 2002; Shuwaikh & Dubocage, 2022). The analysis of international funding can provide insights into the relative strength of the Swedish capital market. The US has long acted as a role model regarding the strength of its biotech sector, while Europe has been lacking behind (Arantes-Oliveira, 2007). Looking at the split of international and domestic ties among the funding types reported in the pre-study results, we saw that funding from corporate investors has the greatest international footprint. The strong presence of international funding may on the one hand indicate that the local market is not sufficient in providing the required funds (K.-N. Kang & Park, 2012), which would indicate development needs for the Swedish capital market. On the other hand, this observation can also point to a relative strength of the Swedish biotech field. As incumbent companies often strive to strategically access biotech through collaborations (Röhm et al., 2018), their investment efforts into Sweden may indicate a high sophistication and perceived quality of Swedish DBFs. This side of the argument is supported by Helena Strigård, former CEO of *SwedenBIO*, Sweden's biotech industry association: *"Foreign multinationals and national champions eager to access innovation have understood what Sweden has to offer and are actively building bridges with the local ecosystem"* (Garcia, 2019, para. 1). Finally, access to funding has been identified in theory as a sign of a strong EE (Vedula & Kim, 2019). It can be argued that the Swedish biotech EE is stronger the more funding accessibility – whether domestic or foreign – is facilitated. For policy makers, these findings imply that their efforts in strengthening the local biotech field also ought to consider openness to global capital markets.

Our pre-study has shown that VC funding is heavily domestic. Efforts to make Swedish DBFs more attractive specifically to foreign VCs should hence be considered.

6.3 Limitations & Future Research

6.3.1 Limitations

While our results provide several interesting insights and implications, we also want to critically reflect upon some limiting factors. We have accounted for the fact that apart from funding, other factors determine a DBF's success, namely human capital, knowledge creation, market access, and infrastructure relevant to entrepreneurship and innovation (Feldman et al., 2019). In our study we assume that different types of capital providers and their funding agreements entail various degrees of access to these resources. Yet the degree of resource access is only approximated as we are not measuring the complementary resources. What is more, due to the limited scope of this master thesis, we did not empirically test for the systemic interactions between different funding ties employed simultaneously (Hopkins et al., 2013). Further, as with any regression analysis, we need to acknowledge that correlation is not causation. In this thesis we statistically estimate the linear relationship between different funding ties and performance measured as firm growth. While we do find significant correlation coefficients between our dependent and independent variables and have accounted for covariates, we cannot infer that a certain funding type *causes* sales or employee growth.

It is important to note that we did not look at precise volumes of the funding deals in this thesis. It is possible that the relative importance of certain ties varies if the capital volume differs among the types of funding. For example, government grants usually have a lesser scope than VC ticket sizes. A current funding round on medical technology innovation by *Vinnova* offers up to SEK 500,000 to an individual project, or SEK 1 million if projects are co-financed[9]. In comparison, VC ticket sizes within life science in Sweden are typically around SEK 50 million (Jendi & Sklarsky, 2020). Finally, royalty and milestone payments with corporate investors can in some cases take the form of smaller but recurring sums. Hence, the funding ties differ in the amount of external capital provided, which could impact performance. However, as we utilize the EE perspective and evaluate a tie's strength not only through access

[9] https://www.vinnova.se/en/calls-for-proposals/medtech4health-innovators-in-the-healthcare-sector/medtech4health-innovators-in-healthcare-2022/

to capital, but equally through access to complementary resources, we believe the volume of funding to be less significant.

The occurrence of the financial crisis in the middle of our observation period is another limitation. Sales and employee growth are both significantly lower in the second period from 2009 onwards. While we seek to remain cautious of the effects of the economic downturn, we did not specifically account for it in our models. The years following the crisis for sure impaired levels of employment and sales as well as the supply of capital. We cannot quantify the impact of the crisis fully. However, we do believe that our examination of both periods before and after the crash improve transparency on this manner.

Our findings and thereupon drawn implications are not generalizable to other industries that differ in regards to R&D intensity, product development cycles and capital needs. The peculiarities of the biotech field influence the composition of funding and the presence of funding constraints. However, industries that are characterized as high-tech and R&D intensive will show very similar funding requirements and challenges. The literature often refers to the more broader collectives of high-technology (Corsi & Prencipe, 2017) or technology-based firms (During et al., 2000). To firms associated with these definitions, we believe our findings are very well applicable. Generalizability of the results on the Swedish biotech field to other geographic ecosystems is similarly only partially warranted. There are certain characteristics of our specific setting that influence the funding composition and limit transferability of conclusions. Mainly the maturity of the capital market, influencing the role of direct and indirect governmental funding and the availability of domestic capital, plays a role. But also, the strength of regional research organizations and the regulatory framework regarding intellectual property rights and approval pathways influence the growth dynamics of a biotech ecosystem.

6.3.2 Future Research

Future research has the potential to expand the boundaries of this thesis. First, newly emerged sources of Entrepreneurial Finance, such as crowdfunding, peer-to-peer lending or supply-chain-funding (Fraser et al., 2015) influence the financial landscape of the biotech field and offer additional ways to close the funding gap and potentially drive DBF performance. It would be interesting to investigate whether more recent data would confirm the presence of such new forms of entrepreneurial capital in the Swedish biotech field. Subsequently, these

new forms would also benefit from an analysis of their effect on DBF performance. Especially the impact of new forms on the relative importance of government, VC and corporate alliance funding would demand an evaluation. As mentioned in the limitations section, an analysis of the systemic interactions of different types of funding would be of great interest and ought to include new sources of capital, too (Hopkins et al., 2013).

Second, this thesis has investigated whether ties, that per definition are thought to provide complementary resource access beyond the provision of capital, have a positive impact on firm growth. However, there are several different aspects to complementary resources, as for example managerial support, knowledge sharing, infrastructure, market access, and marketing and commercialization capabilities. Future research should investigate which of these complementary aspects of a funding relationship impact DBF performance and in what way. This would enhance the understanding of which attributes of a funding tie determine its success, to which degree, and under which circumstances. Ultimately this approach would require regarding funding more as an evolving process, considering how complementary resources are accessed and absorbed. Such findings have the potential to add to the life cycle theory of an entrepreneurial venture and guide investment strategies of capital providers, as well as funding decisions of DBFs.

Third, future research on the differential performance effects of international funding from different capital providers would offer great value. As we have seen different performance effects by type of funding, it is likely that the international factor also has varied influences for each of these types. For Swedish policy makers it will be important to know exactly which type of funding to try to attract from abroad. Specifically, we believe it would be interesting to take a closer look at foreign state funding. Other political and strategic dimensions are at play when foreign governments decide to invest into biotech ecosystems. A nation investing into biotech in another country is often motivated by the access to technological capabilities and innovation (Shan & Song, 1997). Sovereign wealth funds (SWF), often clustered in the Middle East, Africa and Asia (Megginson & Gao, 2020), thereby play an increasingly influential role as they are growing in size and sophistication (López, 2022). We believe there are substantial risks involved in allowing too much foreign state influence in critical sectors, which would warrant future research on this topic.

7. Conclusion

The Swedish DBF *BioArctic* demonstrates how funding ties to various capital providers create a solid financial situation, which is critical for firm performance. *BioArctic*'s strong corporate alliances with strategic partners such as *Eisai* and *AbbVie*, public funding support through grants provided for instance by *Vinnova* (Garcia, 2019), and successful VC funding rounds from *Karolinska Development* (2018) have been the cornerstones of the company's success[10].

In this master thesis we evaluate the differential effects of different funding types on DBF performance. As a groundwork for this analysis, we explore the dynamic composition of external funding in the Swedish biotech field through a pre-study. In hypothesizing the relationship between DBF and capital providers we combine theoretical concepts from the Entrepreneurial Ecosystem and Entrepreneurial Finance perspectives. In essence, this framework suggests that several actors come together in an ecosystem to engage in entrepreneurial activity (Wurth et al., 2022). These interorganizational relationships enable a DBF to access financial and complementary resources essential to its success. However, biotechnology is profoundly risky, which in practice implies that funding is constrained (Wilson et al., 2018).

Our explorative pre-study finds a heterogenous capital landscape with changing compositions of funding types, driven by dynamic tensions between capital demand and supply along the life cycle of a DBF. We find that public funding from the government is the most heavily utilized source of funding, especially in early-stage DBFs. We believe grants to be of fundamental importance in bridging the funding gap prevalent in the biotech field. Funding from VCs is similarly most received by younger and smaller DBFs. Corporate alliances fund the biotech field more heavily with growing maturity of the DBF as these established companies strategically seek to access biotech competencies. Employing the adverse-selection problem concept while considering the dynamic funding landscape, we postulate that VCs face the dilemma of balancing their need to minimize investment risk and avoiding being left behind by corporate alliances investing in the most promising DBFs ahead of VCs. To put it differently, VCs are faced with different tensions that influence the optimal time to invest in

[10] See Appendix (9.2) for *BioArctic's* funding history

biotech. Our results support theories on agency cost and information asymmetry and the importance of signaling by funding relationships.

The results from the performance analysis show that the total number of funding ties, government ties and international ties are significantly positively correlated with employee growth. Both public and foreign capital play important roles in growing the biotech field by increasing the availability of capital and in closing the funding gap. Strong international presence of investors potentially indicates the Swedish biotech ecosystem to be perceived as attractive in the global arena. VC and corporate alliance funding are only associated with higher employee growth in the period preceding the financial crisis. These forms of finance provide access to valuable complementary resources that steer the success of a DBF. The relationship between funding ties and sales growth is found to be very weak in our models. Sales are not only rare in biotech, but also highly volatile. Hence, we warrant caution in the use of sales data as a performance indicator for the biotech ecosystem. Overall, we conclude that external funding affects DBF performance and that the provider of capital matters for a DBF's success.

7.1 Contributions

7.1.1 Theoretical Contributions

The findings of this thesis offer theoretical contributions by employing a combined theoretical lens that offers a holistic explanation of why certain funding types have a greater impact on firm performance, while also accounting for the realities of market failure that constrain the biotech field. Entrepreneurial Finance literature alone does not fully explain the need for interorganizational relationships and the complex ecosystem that evolves around dedicated biotech firms. While this stream of literature considers different funding engagements, it is the combination with EE theory that fully accounts for factors strengthening funding ties. EE alone, however, fails to account for the funding gap caused by mismatches between preferences of the DBF and requirements of external capital providers. By inspecting tensions between DBF and investor, we respond to the call by Shwetzer et al. (2019) to consider the dynamic interactions between ecosystem actors rather than merely identifying them. The two theoretical perspectives, EE and Entrepreneurial Finance, complement each other and enable us to paint a cohesive picture of the observed reality.

With our empirical results we untangle some of the performance relationships of a bigger range of funding ties than most previous studies. The unique event dataset, capturing detailed

funding events over several years, even enables us to explore the entire capital landscape as it is employed in Sweden. Further the data allows for a longitudinal study on both public and private DBFs. Our findings thus add to the existing understanding of the entire biotech capital market in Sweden and empirically test funding and performance relationships, while adding a long-term dimension that enables the analysis of growth trends.

7.1.2 Practical Implications

Our findings have valuable practical implications for policy makers aiming to strengthen the local biotech field. We find that government funding is successful in spurring employment growth in the Swedish biotech ecosystem. An increase in the number of employees implies job creation in a promising field with a positive influence on the broader economy and society. These results should be interpreted as a confirmatory sign that efforts result in economic benefits and that this trajectory ought to be sustained. It will remain imperative that governments provide grants that close the prevalent funding gap. Further, governments should incentivize R&D efforts that tackle the actual disease burden. In other words, public funding should be used for the right causes that add to social welfare. Apart from grants, efforts should aim to facilitate the access to external capital from multiple sources, including international funding. Especially VC funding from abroad could be increased with the right incentivization: Reduction in red tape, strengthening of international collaboration on state level, supporting research institutions and tax regulation are all potential measures to improve the investment attractiveness of the Swedish biotech ecosystem.

Other investors, especially aiming for financial return, can also derive practical conclusions from our insights. Our data analysis supports the view that VCs need to balance risk management and timing of investment to be able to target the most promising DBFs. These investors should pay close attention to the funding activities of established corporates. Syndicated investments, where different capital providers pool their funds to invest, presents a possible way to mitigate the adverse-selection problem. Additionally, our findings question the value of sales growth as a performance indicator for young DBFs. Hence, in valuing DBFs and defining investment targets, investors should be cautious of utilizing a sales metric for these purposes. Our results on employment growth, however, offer an interesting non-financial alternative that can also support in efforts of DBF valuation. In general, we want to highlight the general challenge of valuing the performance of DBFs due to the idiosyncrasies of their R&D intensive business model.

From the point of view of a DBF we offer insight on the different dynamics at play that influence the availability of external funding at different life cycle stages. Understanding the forces that constrain and enable funding can help a DBF in strategically overcoming them and leveraging the appropriate capital sources at the right time. Further, our results add to the understanding of which funding types are the most effective in achieving growth, which can guide management of DBFs in intentionally seeking those specific funding ties. Finally, our thesis explains the importance of interorganizational relationships and taking part in the entrepreneurial ecosystem. Knowing how these relationships to various types of capital providers differ in their relative strength can help DBF management purposefully building ties to access complementary resources.

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9. Appendix

9.1 Appendix 1 – Definition of Funding Types

Definitions based on the capital provider's classification in the *Vinnova*-funded event dataset

Capital Provider	***Definition***
Government	Governments fund direct and indirectly (Lindholm-Dahlstrand & Cetindamar, 2000); typically public funds provided as grants, soft loans or governmental VC (GVC); the entity can be national, European or international
Corporate Alliance	Collaborative agreements between a DBF and another DBF, or an established pharma, life science, biomedical company; agreement can be an informal relationships, various licensing, marketing, and supply chain relationships, equity joint ventures (Dushnitsky & Lenox, 2005; Zidorn & Wagner, 2013)
Venture Capital (VC)	Professional asset management entity that invests capital pooled from institutional investors or wealthy individuals (Clayton et al., 2018); usually actively involved in firm management, with complex financing contracts and pre-defined exit pathways (P. A. Gompers & Lerner, 1999)
Research Organization	Universities or dedicated research foundations that fund specific research efforts
Investment Fund	Various specialized funds providing different forms of finance (debt, equity, royalty & milestone payments)
Private Equity (PE)	Professional investment firm that pools capital from investors and strives to realize financial return through leveraged buyouts, entailing active involvement in the target's business to increase its value (McGrath & Nerkar, 2023)
Accelerator	Accelerators or incubators provide support services such as access to infrastructure, mentorship, network access, as well as funding (Block et al., 2018)
Business Angel	Individual and independent investors who invest in early-stage ventures (Clayton et al., 2018); a form of direct and informal finance (A. N. Berger & Udell, 1998)
Stock Market	Funding through the listing of stocks on the stock market through an IPO
Holding Company	Funding provided by the holding company of the DBF
Bank	Commercial banks with debt funding in the form of loans
Founder, Family & Friends	Form of insider finance especially leveraged in seed-financing (A. N. Berger & Udell, 1998)

9.2 Appendix 2 – BioArctic's Funding History[11]

Investor Name	***Funding Type***
AbbVie	Corporate Alliance
HBM Healthcare Investments	VC
Horizon 2020 SME Instrument	Government
European Union Seventh Framework Programme	Government
Vinnova	Government
Karolinska Development	VC
UU Invest	VC

[11] Extracted from Pitchbook: https://pitchbook.com