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THE CAPITAL STRUCTURE OF FINNISH BIOTECHNOLOGY SMEs – an empirical analysis

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ABSTRACT: This empirical study tests three different theoretical frameworks of capital structure choice on a cross-sectional data of 59 Finnish biotechnology SMEs. The theoretical approaches comprehend principal-agent, asymmetric information and trade-off theories. The purpose of the paper is to trial the validity of the theories applied and, more importantly, to deepen and broaden existing knowledge on a young and scarcely studied sector showing great potential, the Finnish biotechnology industry. The results of the empirical study based on regression analysis do not provide unconditional support for any of the frameworks. The evidence presented is only partially supportive. Reasons for this might be inherent in the general nature of the theories themselves as well as some unique characteristics of the biotech industry.

KEYWORDS Biotechnology, capital structure, agency costs, pecking order, asymmetric information, tradeoff theory

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TIIVISTELMÄ: Tämä tutkimus tarkastelee 59 suomalaisen bioteknologia-alalla toimivan pk-yrityksen poikkileikkausaineistoa kolmen eri teoreettisen viitekehyksen näkökulmasta, jotka pyrkivät selittämään rahoitusrakennevalintoja yritysorganisaatiossa. Teoreettiset lähestymistavat käsittävät päämies-agentti-ongelmaa, asymmetrista informaatiota sekä veroetuja. Tutkimuksen tarkoituksena on testata sovellettujen teorioiden validiteettia, mutta erityisesti syventää tietämystä nuoresta, niukasti tutkitusta bioteknologiasektorista. Regressioanalyysiin pohjautuva empiirinen tarkastelu ei tue yhtäkään viitekehystä sellaisenaan. Tulokset ovat vain joiltain osin teorioita tukevia. Tämän voidaan olettaa johtuvan teorioiden yleisluontoisuudesta sekä bioteknologiasektorin erityispiirteistä.

AVAINSANAT Bioteknologia, rahoitusrakenne, agenttikustannukset, pecking order, asymmetrinen informaatio, trade-off teoria

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1 Introduction

1.1 Aims

This paper aims at explaining the capital structure of Finnish biotechnology SMEs at the end of the year 2001. To this end the subject is approached from three different theoretical directions; namely, theories based on agency costs (e.g. the "free cash flow theory"), theories based on asymmetric information (e.g. the "pecking order theory") and those based on interest tax shields (e.g. the "trade off theory"). I justify this choice of theoretical perspectives with the fact that they have represented major targets of economic research for the past thirty years and are widely respected as fundamental frameworks behind capital structure choices [1]. Although the choice of literature this study leans on seems rather old, it still represents the general focus of capital structure research today. As Zingales (2000) puts it: "It is especially noteworthy that, 10 years later, the survey by Harris and Raviv (1991) would not necessitate any dramatic rewriting. Although there have certainly been important contributions afterward, they have been mostly empirical, and they have not undermined the conceptual framework underlying Harris and Raviv's analysis."

1.2 Limitations

Other theories of capital structure than those mentioned above are left beyond the boundaries of this paper for space and focus reasons. Excluded theories include those based on product/input market interactions and corporate control considerations. Also the broad discussion about the theory of the firm is left untouched at this point of time. I further limit the study to biotechnology *SMEs* out of two reasons. Firstly, data on capital structure of biotech divisions of large corporations were next to inextricable. Data that could be extracted were often so aggregate that they could not be utilized for detailed analysis [2]. Secondly, it is in my field of personal interest to study and point out the differences of financing patterns in biotechnology as opposed to other industries. I assumed that larger and more mature companies resemble those in other sectors in terms of capital structure relatively more than small and medium sized companies due to better availability of revenue financing and the consolidated state of business in the eyes of outside investors. In other words, large firms might have overcome the

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[1] The review papers of Harris and Raviv (1991) and Myers (2001) provide an excellent outline of prior research in the field of capital structure choice.

[2] I gratefully acknowledge the efforts of Etlatieto Ltd to provide the access to the research data. I further thank Raine Hermans and Otto Toivanen for tutoring me in the process of the analysis. Insightful comments from Ari Hyytinen are also appreciated.

financial challenges that are discriminatory for R&D intensive companies with a greater probability than small and medium sized ones. Thus, the inclusion of large sized firms might have diluted findings stemming from unique characteristics of the matter of biotechnology. The question whether this assumption holds true stands open for further research and is not answered to in this paper.

1.3 Motivation and contribution

It is not my *explicit* intention to give further empirical support for the validity of any of the above mentioned theories. There is already extensive existing literature on this matter (see section 3 for a brief review of some empirical studies). The primary contribution of this study is related to the target industry itself. The Finnish biotechnology sector is a previously almost uncharted field of research, and the data at hand are at this point of time unique not only in terms of scale but also in terms of scope [3]. Based on the same data this study builds on, two papers have been written on financial structure aspects of Finnish biotechnology companies. Hermans and Luukkonen (2002) is a general survey drawing a picture of the Finnish biotech industry as a whole, including a depiction of its financial structure. Hermans and Tahvanainen (2002) is a descriptive paper focusing on the description of the capital structure in the biotech industry. It provides propositions for more theoretical analysis. The paper at hand picks up this challenge and tries to give explanations to the picture drawn in the foregoing works by applying a more theoretical approach. Thus, with this analysis of the financing structures of Finnish biotech SMEs I hope to extend the knowledge base on an industry that develops technologies with vast potentials capable of changing the ways of living we all have been used to.

1.4 Background [4]

Biotechnology is a hot topic at the beginning of the third millennium. With the recent preliminary completion of the Human Genome Project, many previously unconquerable scourges of mankind have come into the reach of being overcome. Today we are able to alter any living organism and "improve" it. Organisms can be made immune to diseases, resistant against pesticides, they can be cloned, fitted with new foreign characteristics and modified to enhance our health. Even the cure for the most feared diseases like cancer is said to be within sight. Diagnostics become ever more accurate and faster. Materials can be equipped with new traits

[3] For prior research on finnish biotechnology see for example Schienstock and Tulkki (2001)

[4] Parts of this subsection are taken directly from the work of Hermans and Tahvanainen (2002). Permission of the co-author has been requested and granted.

(like conductive plastics or bio-active glass) and existing production processes in almost every industry experience efficiency boosts; not to speak of the array of completely new production processes and products. The possibilities are almost endless. The potential social, economic and not to forget ethical impacts are monumental. With this said, the enhancement of knowledge and understanding on biotechnology becomes an ethical imperative.

This paper is devoted to study financial aspects of biotechnology [5]. Frictionless access to finance is a critical success factor for a business of any kind. It can decide whether a business is started up in the first place, how fast it is able to grow, how vulnerable the business is to economic hardship and whether it is capable of utilizing emerging opportunities touched on above. In order to be functioning and accessible, the financial markets have to offer a repertoire of services that meet the financial needs of businesses. These needs differ from sector to sector and are inherent in the unique characteristics of each of these sectors and the organizations operating within them. If one aims at providing a sound financial environment for a specific sector, it is necessary to acquire a deep understanding of its financial needs first. Only a crisp comprehension of sector specific financial demands stemming from the characteristics of operations within a sector provides the ability to design customized solutions to businesses with challenging financial needs.

With these issues in mind, I try to shed light on the reasons of capital structure choices in the Finnish biotech sector. If it is possible to identify the determinants behind these choices, one is able to characterize financial needs prevalent in the biotech industry and draw implications on the characteristics of biotech companies. Acknowledging that sufficient funding was identified as number one difficulty during the start-up phase among Finnish biotech firms in the ETLA survey, the completion of this task will answer to an acute dilemma of today's biotechnology industry in Finland.

The paper proceeds as follows. Section 2 comprehends a review of the relevant theoretical literature. Testable hypothesis for the empirical part of the paper are derived towards the end of each theory specific sub-section. Section 3 continues with the presentation of the data, the analyses and the results. Section 4 concludes the paper and points directions for future research.

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[5] For a broader overview of the Finnish biotechnology sector refer to Hermans and Luukkonen (2002).

2 Review of theoretical literature

The purpose of this subsection is to derive testable propositions for each of the three theories I deal with in this paper. First, I review the most fundamental works that have promoted the scientific discussion about corporate capital structure choice. As a next step, the implications obtained from these papers are then transformed into propositions that can be tested on the data at hand. By the selection of literature I lean heavily on the works of Harris and Raviv (1991) and Myers (2001).

2.1 Theories based on agency costs

Agency costs emerge in a setting where the interests of a principal and his agent are not perfectly aligned. The principal hires the agent so that this would manage and run a venture owned by the principal. In order to be able to run the venture the agent is delegated decision rights. The principal cannot coordinate the venture by himself, because, say, he owns lots of other ventures and could not possibly coordinate all of them at the same time, or because the principal is not a single entity but a widely dispersed group of owners. In the latter case coordinated management is impossible due to enormous inefficiencies in the decision making process. In a case of conflicting interests the principal applies various control and monitoring mechanisms in order to prevent the agent from deviating from the pursuit of the principal's goals. These measures are costly and are the cause of the "agency costs".

But why do the interests of the parties deviate from another, what kind of control mechanisms are there and how do the agency costs affect capital structure choices? In the following I present works that try to find answers to these questions.

2.1.1 Basic framework

The probably most influential work that proposes a relationship between the principal-agent theory and corporate capital structure was conducted by Jensen and Meckling (1976) laying a foundation for future discussion. Prior research was primarily focused on developing an optimal contract that would solve the dilemma between the principal and the agent by aligning their interests. In their 1976 paper, Jensen and Meckling characterize two generic relationships in which agency costs play such a role that they affect capital structure; one between the management of a firm (i.e. *the agent*) and its shareholders (i.e. *the principal*), the other be-

tween the shareholders (in fact, the *owner*-manager) playing the role of *the agent* this time and debt holders of the company impersonating *the principal*.

Management vs. shareholders - agency costs of outside equity

In the former case, the divergence of interests arises when the management of the company is not in possession of 100 per cent of the company's shares. The 100% manager owned company maximizes its utility derived from monetary and non-monetary returns, the latter including perquisites (luxurious office decoration, company car, etc.), pleasure from charitable activities, good personal relationships at work and so forth. The utility from both types of return is maximized when the marginal utility of monetary returns is equal to the marginal utility of each source of non-monetary returns.

When the ownership share of the management drops below 100 per cent the marginal utility of monetary returns decreases, because now, for every dollar spent on creating monetary returns, the management can appropriate only a fraction of these equal to the fraction of their shares of total equity in the company. The rest of the returns flows to the holders of outside equity. One could also say, the price for a unit of monetary returns has increased relative to the price of one unit of non-monetary returns making the latter relatively cheaper. The logical reaction of the management is to devote a larger share of company wealth towards creating non-monetary returns, which cannot be appropriated by the outside investors *at all*. Thus, every dollar that is not invested into generating monetary returns but "wasted" in non-monetary returns (from the perspective of outside investors) lowers the value of the company on equity markets by the same amount. Therefore, outside investors want as much as possible invested into projects generating monetary returns, whereas the management spends the company resources on producing non-monetary returns until the marginal utility of non-monetary returns decreases relatively down to the (post equity issuance) lower level of monetary returns[6]. Hence, the interests of the two parties clash. This is the answer to why interests deviate as proposed by Jensen and Meckling (1976).

Assumed that investors behave rationally and have sufficient information about the extent the management will deviate from current behavior, they will take this deviation into account when pricing the equity they want to purchase. Knowing that the management will alter its

6 Jensen and Meckling assume a decreasing marginal rate of substitution of non-monetary returns. Therefore, consuming increasing amounts of non-monetary returns lowers their marginal utility relative to that of monetary returns.

behavior after the equity is issued, investors subtract the amount of value that is destroyed by the assumed behavior of the management after the equity is sold from the actual company value. The difference between the actual value of the company and the value investors are ready to pay for is an agency cost of outside equity that Jensen and Meckling (1976) call the "residual loss". This loss is borne solely by the management in form of forgone equity sales revenue. The management will thus issue equity only if the revenue received from it can be used to generate profit that outweighs the residual loss.

In addition to the residual loss being just one type of agency costs, total agency costs comprise also monitoring costs and bonding costs. Monitoring costs are incurred by the shareholders when controlling and limiting the management's opportunities to reap non-monetary returns. These control measures include incentive schemes, audits, IT-based control systems, budget limits, etc. Since every dollar spent on monitoring is subtracted from the company wealth, it reduces firm value by the amount spent on it. On the other side, limiting the generation of non-monetary returns increases firm value. Thus, investors have an incentive to monitor if the marginal increase of firm value is positive for every dollar spent on monitoring. The management is happy to sign a contract allowing for monitoring of the consumption of non-monetary returns since it results in an increase of firm value as compared to the firm value without monitoring. The increase in firm value is captured by the management in form of a higher price for equity [7].

Bonding costs result in an identical effect as monitoring costs. Bonding apprehends efforts of the management to convince investors that it will not engage in excessive consumption of non-monetary returns after the equity is issued. Measures include for example guarantees to audit financial accounts by public accountants and contractual limitations on the decision power of the management. Again, it is in the management's interest to exercise bonding if the costs are less than the rise in firm value due to decreased consumption of non-monetary returns. The rise in firm value is captured again by the management in form of a higher price of equity sold.

Subtracting the net effect of the residual loss, monitoring and bonding from the firm value before the equity issue gives us the value of the firm that investors are ready to pay. The dif-

[7] Assumed that the equity market is competitive.

ference between the original firm value and the value investors would pay can be defined as total agency costs of outside equity.

Shareholders vs. debt holders – agency costs of debt

Since outside equity seems to be adjunctive with agency costs, why does the management not just keep a 100 per cent share in the company and finance investments with debt? The answer is, so Jensen and Meckling (1976) suggest, that debt financing creates agency costs, too.

Let us take the imaginary example of such a highly leveraged firm. The owner-management [8] of this company has the choice between investing in a project that most certainly returns a mediocre pay-off and a project that returns a very high pay-off but with a much lower probability [9]. Although the expected value of both projects is equal [10], the management will always prefer the riskier project to the less risky one. This is because the owner-management will appropriate almost all of the gain in case of success but bear only a fraction of the costs in case of failure. Creditors cannot touch any returns above the sum of debt issued and the contractual interest rate if the project is successful, but loose everything in the opposite case. Thus, by signaling prior to the issue of debt that the less risky project will be chosen but choosing the riskier one after the issue, wealth is transferred from the creditors to the management: The risk of not getting back the capital borrowed to the management is higher with the risky project from the perspective of the creditors. The probability of getting above average returns is higher with the risky project from the perspective of the management.

This hold-up behavior of the owner-management will be anticipated by creditors and taken into account when pricing the debt. The price of debt rises by the amount wealth would be transferred to the owner-management. It follows that no wealth is transferred and no welfare loss occurs. Hence, no agency costs are incurred. The problem of agency costs emerges only when the projects differ not only in the variance of their pay-off distributions but also in their expected value. Jensen and Meckling (1976) assume the riskier project to have the lower one. If the risky project is chosen, debt value will decrease again, but so will the overall value of the firm due to the lower expected value of the project. If the wealth transfer effect[11] is suffi-

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[8] Or a hired management that actually maximizes the value of existing shareholders.

[9] Jensen and Meckling assume that the pay-off distributions of both projects are log-normally distributed and that the expected pay-off is in both cases equal. The projects differ only in their variances of the pay-off distributions with the riskier having the greater variance.

[10] Thus, firm value is constant no matter which project is chosen.

[11] The size of the effect is equal to the size of the debt value decrease.

ciently large compared to the decrease in firm value, the value of equity held by the owner-management rises. Thus, choosing the riskier project can pay off even if firm value decreases.

Creditors will anticipate this behavior before pricing the debt. They will raise the price by the amount that compensates for the wealth transfer and, so, no wealth is transferred just like in the case of equal expected values. But no one will compensate the management for the reduction in overall firm value. This reduction in firm value represents the agency costs. The phenomenon is comparable to the residual loss explained above and is called by Jensen and Meckling the "incentive effect". A common expression for it in related literature is also the "asset substitution effect".

As in the case of agency costs of outside equity, the agency costs of debt include monitoring and bonding costs as well. Monitoring can be practiced by imposing constraints on the behavior of the management. Contracts can be written for this purpose. Writing such contracts, controlling for contractual violations and the inflexibility to capture possible opportunities caused by the restrictions are the source of monitoring costs. If these costs are lower than the amount of wealth prevented from being transferred to the management in the absence of a contract, the creditors have an incentive to write it. Since the costs of writing the contract are borne by the management in form of a higher price of debt, it is in the management's interest to keep monitoring costs as low as possible. If the management can produce information required for monitoring at lower cost than creditors (by means of internal accounting, for example), then it would pay to provide such information since it lowers the monitoring costs and, thus, the price of debt. The costs incurred by committing to provide such information are referred to as bonding costs.

A last element of total agency costs of debt financing are bankruptcy and reorganization costs. In the case of bankruptcy, shareholders loose all claims to the company. Debt holders have the prerogative to those claims. If the market value of future returns of the company is bigger than the sum of a piecemeal sale of the company's assets, the company will continue its operations. Otherwise it will be liquidated. If no liquidation occurs, operations are usually reorganized (the management is changed, the organization structure is altered, a new business logic is developed, etc.), which is a rather costly affair. If the company is liquidated then the arrangement of selling the assets and the appointment of a priority order of creditors will generate

costs [12]. These costs are anticipated by the creditors prior to a debt issue. Creditors reflect the danger of bankruptcy and reorganization in the price they are ready to pay for debt claims. The higher the probability of bankruptcy the higher the price of debt.

If outside equity and debt financing give rise to agency costs and sticking to 100 per cent inside equity financing would eliminate them completely, why does the owner-management resort to outside financing in the first place? Jensen and Meckling (1976) argue that outside financing will be demanded if the total wealth of the management is not high enough to finance projects with positive NPVs. If the marginal utility of such a project exceeds the marginal agency costs of outside financing then the management will invest in it by means of reverting to outside financing.

Even if the total wealth of the management (i.e. maximum amount of inside financing) would suffice to invest in positive NPV projects, it can be that the management will go outside for financing them. This happens if the owner-management desires to disperse the risk of investment by spreading the ownership portfolio outside the own company. This reduces the amount of inside equity disposable for investments, and again outside financing is demanded. This phenomenon occurs if the utility of dispersing the investment portfolio is higher than the agency costs of outside financing.

After showing why interests deviate and agency costs arise, Jensen and Meckling argue how this affects the capital structure of a company. It is a rather straight forward affair: The ratio of inside to outside financing is determined by weighing the benefits of additional projects that could not be financed with inside equity and benefits obtained from dispersing the investment portfolio (and risk) against the agency costs of outside financing. The ratio of outside equity and debt is determined by minimizing total agency costs since this will maximize firm value. The agency costs of debt rise with the increasing debt ratio, whereas the agency costs of outside equity fall at the same time and vice versa. It is a matter of finding a balance between the three sources of finance.

Now that the fundamental framework behind the agency cost theory of capital structure is laid out, I will continue to review additional contributions to the discussion.

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[12] If the sale of assets does not cover all of the outstanding debt claims, a pecking order has to be established among the creditors for a just allocation of asset sale returns.

2.1.2 Extensions to the framework

In his later work, Jensen (1986) expands the theory by incorporating the *benefits* of debt financing into the framework creating thereby the "free cash flow theory". He argues that debt payments commit the management to pay out free future cash flows instead of wasting them on organizational inefficiencies or investing them below the cost of capital [13]. In other words, debt restricts the amount of cash available to the management to engage in value decreasing activities as explained in the subsection *Management vs. shareholders* above.

Since debt represents a credible commitment to pay out cash (if payments are not met, creditors would force the company into bankruptcy), leverage is a signal that resources are invested efficiently which results in an increase in firm value and, implicitly, a decline in agency costs (of outside equity, to be exact): Debt signals to potential outside equity investors that the management cannot engage into a higher than optimal spending on non-monetary returns due to the lack of available cash. Thus, investors are ready to pay a higher price for equity. This reduction of agency costs has to be taken into account when optimizing the capital structure of the firm. In addition to just limiting the possibilities of misconduct of the management, the fear of default and bankruptcy serves also as an incentive to run the organization more efficiently. Also tax related incentives to borrow represent benefits of debt financing and are dealt with in section 2.3. Of course, leverage has also its downsides. The increase of leverage incurs all the monitoring and bankruptcy costs discussed earlier.

Jensen limits the positive effects of debt to firms being able to generate large amounts of free cash flow and having a rather small set of growth opportunities. In fast growing companies with limited cash flow generation and numerous growth opportunities the control effects of debt, as Jensen calls them, do not occur. This is for two reasons. Firstly, there can be no free cash flow when there is no cash flow in the first place. Secondly, with a rich set of highly profitable investment projects the marginal utility of a dollar spent on such a project is much higher than in a firm with projects having a lower pay-off, as is often the case when growth opportunities are rare. This has powerful implications on the capital structure of firms in high growth industries as compared to firms in low growth industries. I will deal with implications later when testable propositions are developed.

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[13] Jensen defines "free cash flow" as " […] cash flow in excess of that required to fund all projects that have positive net present values when discounted at the relevant cost of capital." It is assumed that projects financed with debt have positive net present values or at least higher NPVs than projects started due to the shirking behavior of the management.

The work of Stulz (1990) builds directly on Jensen's free cash flow theory and extends it by a few aspects making it more intricate. In his argumentation it is assumed that the amount of perquisites (i.e. non-monetary returns) that managers can consume increases with investment even after all positive NPV investment projects have been realized and only value decreasing projects are left over. This can occur due to compensation packages that encourage investment *per se*. Thus, the management will invest in negative NPV projects instead of paying out cash after all positive NPV projects have been exhausted and, therefore, overinvestment occurs. This is completely in line with Jensen and Meckling's (1976) and Jensen's (1986) frameworks. Stulz also says that debt is an instrument for constraining the unfavorable behavior of the management limiting resources at free disposal.

The new idea Stulz introduces is that since investors cannot perceive cash flows or managerial investment decisions, there will be *underinvestment* when cash flows are truly low. The reason is that the management is not able to convince investors about the inadequacy of funds for realizing all positive NPV projects since it is in the management's interest to say so even if funds were adequate (recall: management benefits from any additional investment). It follows that even in times of low cash flows, the unconvinced investors still use debt to restrict maverick management behavior as if cash flows were high. So, the management has no funds available even for the positive NPV project because it is bound to meet interest payments. This probability of underinvestment can be added to the agency costs of debt. The optimal amount of debt is obtained again by trading off these costs against the benefits of restricting overinvestment. The implications of the threat of underinvestment on the capital structure choice of firms will be shown in association with the propositions later on [14].

Jensen's free cash flow theory and Stulz's extensions are perfect complements to Jensen and Meckling's basis. Another complementary view is provided by Harris and Raviv's (1990) approach. They highlight the informational value of debt and draw implications on capital structure from it. They are in line with Jensen and Meckling's (1976) view that the management not owning 100 per cent of equity will act against the interests of the outside investors. This acting against the interests of investors is to be understood as the will to carry on business even if assets in place are not used in the first best way and liquidation would yield a higher return. Management activities are assumed not to be observable. In order to be able to

[14] Landes and Loistl (1991) examine also the influence of fluctuating cash flows and come to similar implications as Stulz.

evaluate management behavior investors use debt as an instrument to create the required information.

Debt produces this information in two ways. First, when the company curtails debt and settles interest payments, the sheer ability to do so gives a statement on the soundness of business. Thus, if payments are met, investors raise their valuation of the firm. Second, if debt payments are not met, creditors initiate an investigation whether they should force liquidation of the company or continue business. Although the procedure is costly, it reveals lots of information to investors about the financial state of the firm and the attractiveness of the liquidation alternative as compared to carrying on with business.

With that said, debt lowers agency costs by disseminating information from the management to investors. To be more accurate and referring to Jensen and Meckling's (1976) framework, one could argue that the informational nature of debt lowers the monitoring costs of outside financing, since a large part of these costs is generated by obtaining the required information on management behavior in order to control for contractual violations, for example [15]. This is exactly what debt provides according to Harris and Raviv (1990). On the other hand, in case of default, costs are generated due to the investigation explained above. In Jensen and Meckling's framework these investigation costs could be interpreted as the bankruptcy costs of debt.

The optimal amount of debt is calculated by weighing the utility of information created by debt against the probable investigation costs (bankruptcy costs) caused by it: the more debt the better information and, thus, better operating decisions. But this raises the probability of default and, hence, the occurrence of an investigation and increased costs. Harris and Raviv's (1990) theory does not violate against the argumentation of Jensen and Meckling (1976) at any point. It is rather a detail enrichment of another benefit of debt to the comprehensive framework. It certainly has new implications on the capital structure theory which are dealt with later when propositions are derived.

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[15] It has to be remarked that Jensen and Meckling (1976) define monitoring as explicit actions of investors to *further* limit the consumptions of non-monetary returns *after* the *implicit* level of this behavior has been taken into account by lowering the price for outside equity. According to Harris and Raviv's (1990) extension, even this implicit level cannot be predicted without information provided by debt. Thus, the beneficial effect of debt cannot strictly be limited to monitoring costs.

Where the works of Jensen(1986), Harris and Raviv (1990) and Stulz (1990) all deal with the amount of debt as an explicit choice, Diamond (1989) suggests that the price and amount of debt a firm can raise is dependent on its reputation. Because of the asset substitution effect explained above, firms choose to prefer risky over less risky projects. If a firm can convince creditors that it will choose the less risky project, it will receive debt for a lower price. Since creditors cannot observe which projects is chosen in the end directly, they judge the lender firm by its default history. Only a firm with a clean default history, i.e. a "good reputation", is actually convincing and receives debt to a lower price. With this said, it pays an old firm to choose the less risky project so it will not loose the price advantage (its reputation) by defaulting. Young firms with a short track record cannot have built a reputation yet and thus receive more expensive debt. For such a firm it pays to choose the risky project. Only if a young firm survives long enough default free, although choosing the risky projects, can it built a reputation. At that point it pays to switch to the less risky projects.

Additional literature around the principal-agent discussion is provided by Grossman and Hart (1982), Williamson (1988), Hart and Moore (1990), Stulz (1990), Leland (1998) and Myers (2000). Now that a basic theoretical foundation is drawn, I will derive testable propositions for the empirical part of this study.

2.1.4 Proposition development

According to Jensen and Meckling (1976), the asset substitution effect increases the price of debt and thus the residual loss. It follows that firms that are not believed to be able to take advantage of the asset substitution effect, i.e. they are faced with a relatively small set of investment opportunities, receive debt to a lower price. Such firms have lower marginal agency costs of debt and, thus, are expected to display a higher debt-equity ratio. Using growth opportunities as a proxy for asset substitution opportunities it follows:

Proposition I: Firms with higher growth opportunities have a lower debt-equity ratio.

This implication can also be derived from Stulz's work where the optimal capital structure is determined by trading off the benefit of debt in reducing overinvestment against the cost of debt in preventing underinvestment. Proposition one is in accordance with this since firms

with high growth opportunities are concerned with not loosing the precious opportunities of growth and apply lower debt levels.

According to Jensen (1986), free cash flow provides the management with funds to invest into below cost projects and organizational inefficiencies. A firm creates free cash flow when it is profitable. The higher the profitability the more free cash flow is generated. Debt reduces free cash flow, since it commits the management to regular interest payments and is so preferred over capital financing. In order to reduce ever higher levels of free cash flow ever higher debt levels are needed. It follows:

Proposition II: The debt-to-equity ratio increases with relative profitability.

Harris & Raviv (1990) argue that debt is an instrument to retrieve information on the true state of the company. As said before the optimal amount of debt is determined by balancing the informational benefits of debt against the bankruptcy costs incurred by it. Assumed that the informational return on one dollar of debt is fixed it is the amount of bankruptcy costs incurred by one dollar of debt that determines the optimal amount of debt. If the marginal bankruptcy cost of debt is low, more debt is issued to create information. If it is high less debt is issued. There are two aspects that affect the marginal bankruptcy cost of debt: one is the cost incurred by an investigation in case of a default. If it is high the marginal bankruptcy cost is high and vice versa. The second aspect relates to the probability of making the right decision whether to liquidate or continue in the case of a default. If the probability of being able to make the right decision is high, then the marginal bankruptcy cost of debt is lower and more debt is issued. An increase in liquidation value of a company raises the probability that liquidation is the best (right) solution in case of default. This higher probability of choosing the "right strategy" lowers the bankruptcy cost of debt. It follows:

Proposition III: Firms that display a relatively higher tangible assets-over-total assets ratio have a relatively higher debt-equity ratio.

Diamond's argumentation suggests that the reputation of a firm to be default free increases with its age, because the firm chooses ever less risky projects as it matures. This results in a decrease of the marginal cost of debt as compared to the marginal cost of equity. A firm with relatively better reputation will therefore draw relatively more debt. It follows:

Proposition IV: The debt-to-equity ratio increases with firm age.

2.2 Theories based on asymmetric information

In simple words, asymmetric information is the technical term describing the condition when one party among others is better informed about a certain matter than the rest. In the research of capital structure it refers to the situation where insiders of a company, i.e. the management and possibly existing shareholders, have private information about the firms revenue streams and opportunities of investment. For outsiders this information is concealed. This information asymmetry has implications when the firm needs to turn to outsiders for extra financing. What kind of implications occur and why they occur is further examined in this section, at the end of which propositions for the empirical part of the paper are developed.

The study of the influence of asymmetric information on capital structure can be divided into at least three branches. One follows the idea that capital structure is utilized as an instrument to alleviate inefficiencies that emerge when an investment decision is made. These inefficiencies refer to potential under- or overinvestment problems caused by the asymmetry of information and will be explained in the following. Another branch studies capital structure as a signaling device that is used to transmit the information of insiders to outsiders. In other words, on one hand capital structure can be used to mitigate problems arising from information asymmetry, on the other it can be used to dissolve the asymmetry in the first place. The third branch explains capital structure choices referring to managerial risk aversion in a situation where information asymmetries are present. I begin with the firstly mentioned.

2.2.1 Using debt to cope with under- and overinvestment

Myers and Majluf (1984) argue that the information asymmetry between insiders of a company and potential investors results in a decrease of equity value when equity is issued in some cases or a rejection of positive NPV investments in others. The latter is a clear case of underinvestment by definition. The chain of argumentation leading to these hypotheses goes as follows.

For simplicity, firms are divided into high value (H) and low value (L) companies. Reality is not as simple, of course, but if the terms “high” and “low” describe the relative values of companies under comparison, not absolute values, this simplified setting can be transferred to

describe any two firms. For investors it is not possible to determine whether the firm they are about to invest in is of type H or L since asset value and revenue streams are not observable before the issue. Thus, we have the case of information asymmetry described above. For the argumentation to hold, Myers and Majluf (1984) assume that the management maximizes the value of existing shareholders and that investors are rational.

Consider a project that needs outside financing. The outside financing comes in the form of an equity issue and finances 100 per cent of the project. In the moment of the issue, investors cannot observe whether the issuing firm is of type H or L due to the information asymmetry, as explained before. All they know is that if the equity is valued according to the true value of the H type firm and the firm turns out to be of type L after the issue, stakeholders of the L type would gain supernormal pay-offs and investors would pay too much for their claims due to the overpricing. It is not in the interest of a L type firm management to identify themselves as such, because they maximize the wealth of current shareholders. Pretending to be of type H just might work out and the equity is overpriced earning the current shareholders supernormal wealth gains in the amount of the overpriced margin. Anticipating this behavior and being unable to verify the true value of the firm, investors adjust the price offer for the equity downwards accordingly. The result for the L type firm is that its equity is priced fairly. Current shareholders let go of a fraction of their claims equal to the fraction of the investment of total firm value including the added NPV of the project and gain the net present value of the project.

For a H type firm the situation looks worse. Since the firm cannot credibly verify its true type, the equity to be issued is underpriced by the investors. If the resulting wealth loss incurred to the current shareholders of the firm does not exceed the value created by the investment (i.e. the NPV of the project), then the project will be still accepted if and only if the project cannot be financed by any other means. But if undercutting the real equity price is severe enough, i.e. the difference of the true value of the H type firm and the value predicted by the investors is sufficiently large, the loss incurred is greater than the value created by the project and current shareholders experience a net wealth decrease. Existing shareholders end up with less than prior to the issue. In this case the project will be rejected although it has a positive net present value and no equity is issued.

The argumentation implies that, in equilibrium, type H firms never issue equity, and if they do, only as a last resort. L type firms, on the other hand, are always eager to issue equity since they have nothing to loose. Thus, the issue of equity is a signal that the firm is of type L. In case of an equity issue announcement, investors therefore always lower their assumption of the firm value, no matter of what type the firm is, leading to a fall in the value of *existing* shares.

Myers (1984) baptizes the implications of the argumentation for financial behavior the "pecking order theory". He argues that investments of a firm are financed according to this pecking order: First, a firm in need of finance draws on internal financing. Since information asymmetry does not appear among insiders, there is no wealth destroying aspect to it. Company shares will not be downgraded. Also, internal financing does not involve fixed or variable issue costs and is therefore preferred to any kind of outside financing, even if terms would resemble those of internal funding otherwise. Issue costs include items like administrative and underwriting costs. Myers (1984) adds that managers are reluctant to turn outside the company because they want to dodge the "discipline of the capital market". Second, only if internally generated cash flows are insufficient to fund all positive NPV projects do managers consider issuing securities of any kind. This can happen, for example, if in times of fluctuating cash flows a sticky dividend policy inhibits the flexible use of cash (i.e. canceling dividend payments and redirecting funds to investments). If this is the case, firms issue always debt before equity. Debt is issued first, because its value is independent of asymmetric information. The single debt security is worth the same no matter whether the firm is of type L or H assuming that the investment target itself is known to the investors [16]. Thus, debt is priced fairly and is cheaper than equity. At the bottom of the pecking order locates outside equity since its issue incurs the depreciation of firm value on top of the usual issue costs, which are more expensive for equity than debt. Brealey and Myers (1991) introduce a more psychological reason why managers avoid going public. They argue that managers maximize comfort and are therefore reluctant to "face the glare of publicity and public attention" (see p. 447). Implications of the pecking order on the capital structure are discussed when further propositions are developed at the end of this subsection.

Extensions to the framework

Krasker (1986) extends Myers and Majluf's framework by allowing the size of the investment, and thus, the size of the issue vary. This alteration does not affect the basic findings of

[16] Otherwise the same hold-up problem arises as discussed in subsection 2.1.1 "Shareholders vs. debt holders – Agency costs of debt".

Myers and Majluf (1984), but adds a rather intuitive one to them. Krasker finds that the amount of equity issued correlates positively to the decrease in share price. That is, the bigger the issue announcement the bigger the fall in share price.

Where Krasker follows the concept of Myers and Majluf (1984) closely, Narayanan (1988) approaches the matter in a more complicated manner. There are two major differences to Myers and Majluf. First, the information asymmetry concerns only the single investment project, not the assets-in-place as well. This entails that Narayanan's findings hold for newly floated companies that do not have assets-in-place yet, mature and stable firms that do not show information asymmetries for the assets-in-place anymore since they have become less opaque and for spin-off projects. Second, the investment decision is risky resulting in risky debt, if debt is issued to finance the project. This complicates the analysis, since risky debt, as opposed to risk-free debt, can be undervalued by the market, too. Thus, it is more difficult to tell whether equity or debt should be preferred in case of outside financing. With these alterations Narayanan takes a step further towards a more realistic setting.

Despite the differences in the underlying assumptions, Narayanan (1988) obtains very similar results as Myers and Majluf (1984). His findings support the pecking order theory. The intuition behind his model is based on the assumption that investors do not evaluate the quality [17] of a firm for each company separately. Instead, investors pool firms operating in the market and value *all* of them at the *average* quality. Now, supposed that equity is the only way to raise capital. Given that all firms are valued at the average market quality, firms with even negative investment NPVs stay in the market. This is because high quality firms with highly positive investment NPVs raise the average quality level of all firms in the market so high that this level compensates for the losses incurred by investing in a negative NPV project. On the other hand, high quality firms are undervalued by the average pricing method.

Supposed that debt is the only way to finance the investment. Since debt is risky in Narayanan's (1988) model, it can be misprized in the same way equity is misprized due to the information asymmetry concerning the investment. Again, firms with negative NPVs can stay in the market if the average price of all firms in the market is high enough to compensate for the negative NPV and again, high quality firms bear the losses because they are undervalued by the average pricing method. The question arises why firms should prefer debt over equity if

both lead to the same result? The answer according to Narayanan (1988) is that debt financing results in higher average market value for firms than equity financing. This is because with debt financing there are fewer "lemons" (negative NPV firms) on the market than with equity financing. With fewer lemons on the market the average value of firms rises and undervaluation of high quality firms is less severe. The reason for the lower presence of lemons in the market lies in the nature of debt itself. Debt is a fixed claim. Thus, as Narayanan (1988) puts it: "In states of bankruptcy, the fact that it [i.e. debt] is being overvalued is of no consequence to the firm because the equity holders get nothing." If equity is overvalued, equity holders profit from it in every state of the company, even in case of bankruptcy. It is obvious that lemons prefer equity before debt, because for them the probability of bankruptcy is relatively higher at a given debt ratio.

As a result, firms prefer to use debt as number one outside financing source in order to keep lemons from entering the market and keep the undervaluation at its minimum. These findings support those of Myers and Majluf (1984) and the pecking order theory, although based on dissimilar argumentation. Narayanan (1988) enriches the implication set by showing that even (some) negative NPV projects will be accepted in equilibrium. This is the case of overinvestment.

A similar approach to that of Narayanan (1988) is followed by Heinkel and Zechner (1990) and takes another step further towards a more realistic comprehension about the complexity of the environment. This is achieved through the introduction of time. Capital structure, so Heinkel and Zechner (1990) argue, can be chosen at a time *prior* to the investment and the existence of the information asymmetry. This is additional to the option to issue debt or equity at the time of the investment itself. While debt issued at the latter moment functions in the same way as Narayanan (1988) describes, senior debt issued prior to the investment and the existence of the information asymmetry creates incentives to underinvest. This amplifies the soothing effect of junior debt on the overinvestment problem. To be precise, Heinkel and Zechner (1990) argue that the effect of senior debt precisely counterbalances the overinvestment incentives of an all-equity financed case so that non-negative NPV projects are accepted only.

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[17] The quality of the firm refers in Narayanan's (1988) paper only to the NPV of the single investment that is supposed to be financed, *not* the value of the firm as understood in Myers and Majluf's (1984)theories.

The review until now has dealt with perspectives where capital structure is used to overcome the problems of over- and underinvestment which arise from asymmetric information. Next, I turn to approaches where capital structure is used to signal information from insiders to outsiders so that the asymmetric information itself can be vanquished.

2.2.2 Debt as a signaling instrument

Ross (1977) contributes an elementary study examining managers' incentives to signal the firm's quality to outside investors. He applies a two-period framework, in which managers have private information about the quality of the firm approximated by firm returns. The difference to the approaches treated until now is that the management does not maximize the wealth or utility of existing shareholders but its own benefit defined by the compensation function

$$M = (1 + r)\gamma_0 V_0 + \gamma_1 \begin{Bmatrix} V_1 \text{ if } V_1 \geq F \\ V_1 - L \text{ if } V_1 < F \end{Bmatrix},$$

where M represents the compensation to the management for its efforts, V_0 and V_1 are firm values at time zero and one respectively, and F is the face value of debt issued at time zero to finance a fixed investment. L is a penalty imposed on the management if at time one firm value is less than the face value of debt and the firm is bankrupt, because it cannot repay the debt. γ is a weight assigning a certain share of firm value to the management at the two different points of time. Thus, the maximization of firm value at any given time is in the best interest of the management [18]. The only variable the manager can make decisions on is the amount of debt issued at time zero and, thus, he chooses F so as to maximize M, his compensation.

My intention is to present just the basic intuition of Ross' (1977) framework. Given that there are the two now familiar types of firms L and H with these letters representing the respective firm value at time one, i.e. V_1. By definition L< H. Again, investors cannot perceive the type of the firm due to the information asymmetry. For a manager of the H type firm it pays to reveal the identity of the company he is working for since his pay-off increases with the perceived value of the firm. One way to signal the type to the outside is the amount of debt issued at time zero. It is assumed there exists a "critical level of financing" F^* with

[18] It is assumed that γ is strictly positive.

$$L \leq F^{*} < H.$$

H type firms will choose F so that $F^{*} < F \leq H$, because L type firms cannot choose such a high F without risking bankruptcy. The firm is recognized as a type H firm and both V values in the compensation function are maximized yielding maximum pay-off to the management. The reason why the V_0 value depends on firm type is that the issuance of a large enough debt in time zero is already the signal of firm quality. If a L type firm would want to imitate an H type firm by choosing F so that $F > F^{*} \geq L$, then the V_1 value for the firm would be less than F and the firm goes bankrupt imposing the penalty L on the management. The bankruptcy would not occur until time one, of course, and one could argue that if imitating a type H firm by choosing $F > F^{*}$ yielded a high enough value for V_0, it could offset the bankruptcy costs (L) in time one. If this is the case, it pays off to imitate a type H firm. Ross deals with this dilemma by assuming that L is sufficiently large so that the gain in a "false" V_0 value never offsets the costs incurred by bankruptcy.

The logic can be easily transferred into a world with multiple firms. A superior firm will always issue debt so large that the next inferior firm cannot match it without incurring bankruptcy. The inferior firm, again, will issue a larger amount of debt than the next inferior firm and so forth. The implication is rather straight forward. Higher quality firms have a higher debt-to-equity ratio than inferior ones. Let me get back to that when deriving testable propositions at the end of the subsection. There are a few extensions and alternative approaches that analyze the role of debt as a signaling instrument. Admittedly, these works derive very similar implications with respect to effects on capital structure and are therefore left unexplored by this study. For the interested, refer to Heinkel (1982), Poitevin (1989) and Glazer and Israel (1990), for example.

2.2.3 Information asymmetry and managerial risk aversion

I conclude the examination of the effects of information asymmetry on capital structure choice by introducing Leland and Pyle's (1977) argumentation how entrepreneurs (i.e. owner-managers) signal the quality of the firm to outsiders by "choosing" the level of equity they retain for themselves. Leland and Pyle (1977) derive diverse implications from their argumentation. I will concentrate the presentation on those parts of their work that are essential to show the effects on capital structure. The rest is not covered in this paper. Again, the presenta-

tion is a strong simplification of the original work aiming at highlighting the intuition behind the argumentation of Leland and Pyle (1977).

In their model, the owner-manager has private information about the expected end-of-period value of a project he wants to invest in, whereas investors have not. It is in the manager's intention to retain a certain fraction of equity that is put into the project for himself and finance the rest of the project with outside financing. The fraction of equity is the only variable the manager can determine. It is in his interest to retain a high equity share if he expects the project to be of high value and return much, because he can appropriate them due to the large equity share. If the manager expects the project to be of inferior value, he does not retain such a large equity share but invests into an alternative market portfolio and finances the inferior project to a larger extent with outside funds (i.e. riskless debt and equity).

The choice for the manager is not as simple as it seems. An increasing level of managerially owned equity lowers the total utility of the manager due to risk aversion, since the returns of the project are not assumed to be certain but volatile to some degree. Thus, concentrating wealth on one specific, uncertain project increases the risk that the investment deteriorates managerial utility.

The probability of project success is higher when that project is of relatively higher quality or, in other words, the decrease in managerial utility is smaller for managers of higher quality projects. It follows that managers knowing their project to be of higher quality are also willing to retain an even higher fraction of equity in that certain project, whereas managers investing into a relatively inferior project retain a smaller fraction of equity. Thus, the fraction of equity retained by the owner-manager can be taken as a signal of project quality by potential outside investors. This implies that the price investors are ready to pay for a fixed amount of equity is a function of the equity fraction retained by the manager.

One implication is that firms engaging in high quality projects display a higher fraction of equity owned by insiders. Another intuitive implication is that if insiders retain increasing fractions of equity (i.e. less equity is issued to finance the project in total terms), the amount of debt issued must rise accordingly so that the project can be sufficiently financed. It follows that the debt-to-equity ratio is higher for firms with higher quality projects. This is an implication that does not necessarily hold since equity value is dependent of the equity fraction re-

tained by insiders. If this fraction increases then the price investors are ready to pay for a fixed amount of equity rises, as argued above. When the *price* rises high enough, it can compensate for the loss of funds incurred by the decreasing fraction in the *amount* of outside equity issued and no additional debt is needed.

With a sufficient theoretical background drawn, I will derive testable propositions for the empirical analyses next.

2.2.4 Proposition development

According to Myers and Majluf (1984), underpricing of equity is a result of outside investors' compensation for the information asymmetry. The bigger the informational asymmetry is the more investors downgrade the value of equity and the more firms lean on debt financing. Now, R&D is generally regarded to be very knowledge intensive. This knowledge is said to be very tacit of nature and to be restricted to the minds of the very people conducting R&D. One could therefore argue that the R&D intensity of a firm can be used to approximate the intensity of the information asymmetry. It follows:

Proposition V: Leverage increases with R&D intensity.

Following Narayanan (1988) and Heinkel and Zechner (1990), firms of higher quality have the incentive to drive lesser quality firms out of the market if investors value firms at the average firm quality, because the exit of firms of lesser quality raises the average valuation of firm staying on the markets. As explained earlier (p. 30-33), debt serves as an instrument for this strategy. It follows:

Proposition VI: Firms of higher quality employ higher debt-to-equity ratios.

This proposition can be derived also from the work of Ross (1977), although by way of different argumentation. In his work higher debt levels signal a higher quality of the firm. Since firm value at any given point of time determines the value of the management's compensation package, managers are motivated to maximize firm value by signaling with high debt ratios.

Since a relatively higher fraction of equity retained by insiders signals a relatively higher project value in Leland and Pyle (1977), it follows:

Proposition VII: Firms of higher quality employ higher ratios of inside equity.

2.3 Theories based on interest tax shields

Up until now the theories reviewed have been applied to a world without taxes. In this subsection I will examine the effects that taxes impose on the optimal capital structure. The financial world refers to this branch of study as the "trade-off theory". Compared to the prior two theoretical branches, this tax based approach will be dealt with rather shortly. This is due to three reasons. First, the chain of argumentation is fairly straight forward as compared to the more intricate agency theory of capital structure or the pecking order theory with its abstract framework. Second, despite its simple logic, the trade-off theory is probably the most disputed among the three discussed in this paper. Citing Myers' (1984) review paper: "[…there was] no study clearly demonstrating that a firm's tax status has a predictable, material effect on its debt policy." Almost twenty years later he still does not reverse this statement in Myers (2001). Third, the cross-sectional data at hand does not provide the possibilities to conduct a time series analyses, which would yield definitely more interesting and fundamental findings than an analyses based on a cross-section. Thus, the primary reason for the inclusion of the trade-off theory in this study is the strive to paint a complete theoretical background covering all the major approaches.

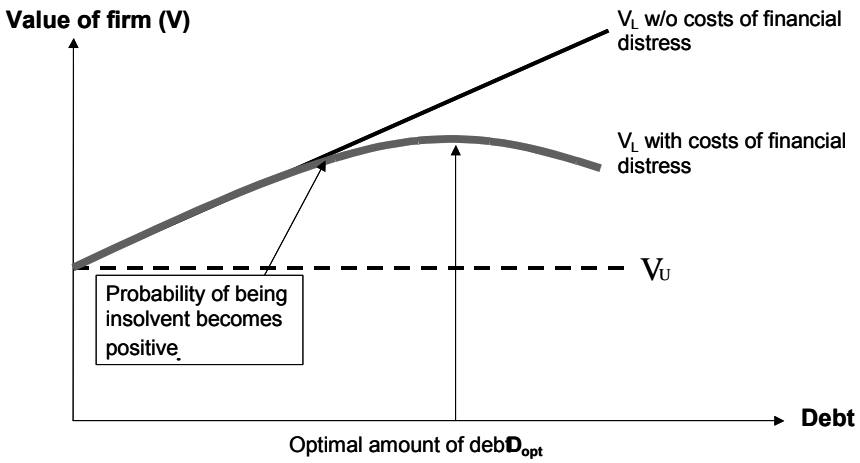
The trade-off theory has probably existed as long as interest payments on debt have been deductible from the income tax burden of a company. I could not trace back the life-line to the originator of the theory so I lean on a brief and simple illustration by Brealey and Myers (1991) and Myers (2001) to introduce the basic framework. Unlike the pecking order theory that cannot designate an optimal debt ratio to a firm, the trade-off theory predicts such a ratio that is obtained by trading off debt interest tax shields and bankruptcy costs that increase with the amount of debt issued.

When the income tax for a firm is calculated, the firm is allowed to deduct the interest it pays for outstanding debt from the amount of pre-tax earnings. Now that the pre-tax income is lower, the total amount of taxes due is lower as well [19]. The difference in taxes actually paid and taxes calculated without the deduction of interest is called the interest tax shield. In other words, for every dollar of debt issued the firm retains a certain fraction of taxes due. Debt

[19] Assumed that the corporate tax rate is fixed and independent of the level of earnings.

financing increases the total after-tax dollar return to debt and equity and, thus, increases firm value. With this said, it is intuitive that a firm should always prefer debt over equity, since equity does not provide any tax shields. Unfortunately, the story is not that simple. With every additional dollar of debt the firm also increases its probability to default. In case of default the firm is bankrupt and incurs bankruptcy costs defined as above. It can be argued that the firm borrows up to the point where the marginal value of tax shields on additional debt is just offset by the increase in the present value of bankruptcy and reorganization costs. Figure 2.1 illustrates this graphically. The black monotonically inclining line displays the increasing value of a firm taking increasing amounts of debt when no bankruptcy or reorganization costs exist. The gray line displays the value of the firm when these costs do exist. At first the two lines coincide. This is intuitive if one assumes that the firm has a given debt capacity. If the amount of debt issued stays within the boundaries of the debt capacity, it is riskless and default free (i.e. at least the interest payments can be met). Not until the debt capacity is exceeded will the probability of bankruptcy be positive. The marginal present value of bankruptcy and reorganization costs increases from that point on counterweighing the (here constant) marginal value of tax shields until they are equal at point $\mathbf{D_{opt}}$.

Figure 2.1: Deriving the optimal amount of debt



After that point the present value of bankruptcy costs exceeds that of the tax shield and firm value decreases again. The optimal level of debt, designated $\mathbf{D_{opt}}$, implies also the optimal debt-equity ratio and , thus, the optimal capital structure of the firm. With this said, the trade-off theory predicts a moderate level of borrowing as opposed to the pecking order. The segmented black line represents just the reference value level of an unlevered firm. The implications on capital structure are derived again at the end of the subsection.

2.3.1 Extensions to the framework

The triviality of the argumentation above can be defended in an environment with no transaction costs. If it is costless for firms to adopt the optimal debt-equity ratio, then one could expect to observe every firm to have such a ratio at any given time. In reality the adoption is not costless due to transaction costs. Therefore, one expects to observe a constant adjustment behavior of firms, whose capital structure hovers somewhere around the optimal debt-equity ratio, aiming at their optimal target ratio. In order to capture this behavior, a student of the matter must monitor the adjustment activities over several periods. As discussed earlier, this is the core problem of the cross-sectional data that is available for this paper. It is impossible to catch temporal shifts in the capital structures of sample firms.

Transaction costs are not the only complication to the framework. The size of the gain from tax deductibility is not constant in the real world, of course. In figure 2.1 this was assumed for simplicity reasons. In reality tax shields are risky. Firstly, because future profitability of the firm is never guaranteed. A firm must be profitable in order to be able to deduct anything from earnings. An unprofitable firm can take no advantage of interest deduction. Secondly, because debt capacity depends on profitability and firm value as well. A less valuable firm has a lower debt capacity and faces potential bankruptcy earlier or is not able to maintain nor establish a large debt ratio. Thus, the size and duration of tax shields is unknown.

Another major objection to the theory is introduced by Miller (1977). In his seminal work Miller defends the renowned theorem established together with his colleague Modigliani [see Miller and Modigliani (1958)] that the capital structure choice of the firm does not affect its value. He argues that tax shield benefits are offset by rising costs of debt since investors roll over their tax liabilities from debt interest income into the price of debt. Miller concludes that, given this behavior, there will be an optimal debt-equity ratio on the industry level but no such ratio existed on the individual firm level. The more complete chain of argumentation flows as follows: The basis for Miller's (1977) argumentation is the fact that interest income is taxable according to the personal income tax rate. This means that when a firm issues debt the interest rate on it must be high enough to compensate for the taxes on interest income of creditors under the personal income tax. It follows that an initial debt issue by the firm first attracts investors for whom the given interest rate on the debt is just high enough to make it worth investing. This means that the investors' tax bracket must be low enough so that the interest income on the investment (i.e. the debt) will outweigh the corresponding taxes. But if

the firm wants to issue more debt it has to attract investors in ever higher personal income tax brackets who in turn must receive ever higher interest payments to be compensated for the higher tax rate. Thus, the costs of debt rise with the amount of debt issued. The required interest rate keeps rising and incurring increasing costs of debt financing until the tax shield benefits are offset.

This would imply that the optimal amount of debt is issued at the point where the marginal tax shield utility is just offset by the rising marginal cost of debt. This holds true if competitors did not accompany the firm. Assuming a perfect market for investments the industry level interest rate and the industry level amount of debt are fixed in equilibrium: If firms issue debt in excess of the industry level equilibrium quantity, then the interest rate is driven up and some levered firms find leverage a bad solution. On the other hand, if firms issue a smaller quantity of debt than dictated by the equilibrium, then some unlevered firms find it advantageous to borrow. Firms that opt for high leverage attract investors in low tax brackets and firms aiming at low leverage strategies find investors in high tax brackets. Firms can choose between lots of debt to a low price and little debt to a high price. Thus, firm value on individual firm level is independent of capital structure choices.

DeAngelo and Masulis (1980) expand Miller's (1977) new irrelevancy theorem to defend the trade-off theory from being abandoned as irrelevant. They show that Miller's theorem does not hold in a more realistic setting, especially referring to the major effects of non-debt tax shields such as depreciation deductions and investment tax credits. They conclude that taking further variables of the real world into account an optimal capital structure on the individual firm level does exist [20]. One implication regarding capital structure must be highlighted here. Non-debt tax shields do not require existent debt in order to be effective by definition. Since a firm does not have to issue debt in order to be able to enjoy tax shields, it does not have to suffer from the costs of debt imposed by the personal interest income taxation as discussed in Miller (1977). This makes the use of debt less favorable for a firm with non-debt tax shields than for a firm without them. It follows that firms with relatively more non-debt tax shields have a lower debt-equity ratio than firms with relatively less non-debt tax shields. A more detailed review of the work of DeAngelo and Masulis (1980) is disregarded. With the data at disposal it is not possible to test the validity of DeAngelo's and Masulis' findings. It is my

[20] These variables include agency, bankruptcy and other leverage-related costs, a more intricate tax regulation, tax loss carry-backs and carry-forwards and the already mentioned non-debt tax shields.

sole intention to show the relevant turns taken in the scientific discussion regarding the relevance of the trade-off theory.

Now that the core of the theory is explained, I turn to the development of testable propositions for a last time.

2.3.2 Proposition development

Profitable firms have relatively more taxable income than firms that are not as profitable. Therefore, they also have a larger tax bill to pay. The tax bill in turn lowers company value. It is intuitive that larger firms have a bigger incentive to protect their income from taxes by issuing debt and creating thereby tax shields. Profitable firms also have a bigger debt capacity since they can handle a larger debt burden without risking default. This lowers the probability of bankruptcy and the marginal bankruptcy costs. In figure 2.1 this translates into a shift of the optimal amount of debt D_{opt} to the right, which means that the firm issues relatively more debt in equilibrium. It follows:

Proposition VIII: Relatively more profitable firms have a higher debt-to-equity ratio.

Unfortunately, the data at hand does not provide me with a time series, which could help to observe firms' adjustment to an optimal target level of debt as the theory predicts. Now, it is time to turn to the empirical part of this study.

3 Analysis

Before describing the data, which the empirical analysis is based upon, I briefly review some of the relevant empirical literature that tests the theories dealt with above. In the search for prior empirical work that deals with testing capital structure theories I did not encounter any that extended to test more than two of these within the framework of one single paper. In this sense the paper at hand differs from existing literature. A simple reason for this lies in the aim of this particular research. While prior literature is interested in the validity of the theories as such, the motivation of this paper is to deepen the understanding of capital structure choices in the particular industry that provides the data. For this goal, I need a set of theories that approach the matter from different perspectives and deal with very different aspects that might

serve as motivators for capital structure choices. The review will provide a benchmark for my own empirical analysis and help position this paper among the existing literature. The field of prior work in this context is fairly large and the approaches taken vary a lot.

In their empirical study Shyam-Sunder and Myers (1999) test the static trade-off theory against the pecking order model. They apply models of both frameworks on Industrial Compustat time series data from 1971 to 1989 comprising 157 firms in the final sample with a requirement for continuous data on flow of funds. This biases the sample in favor of relatively larger firms, which might have an effect on results concerning the trade-off theory (see the actual study for more details). The models applied are theory specific and take details like dividend payments, capital expenditures, increases in working capital and the differentiation between long and short term debt into account. Shyam-Sunder and Myers find that both models have excellent explanatory power when tested separately. They still perform well when tested jointly although the power of the trade-off model diminishes somewhat relatively to the pecking order model. The authors run additional simulation experiments, which lead to results that speak relatively in favor of the pecking order theory. The availability of the time series data is a clear advantage over the study at hand in terms of a better testability of the trade-off framework. Only with such data it is possible to observe possible movements towards a target debt ratio over time. Also the application of separate framework specific models enhances the ability to make more precise statements about the validity of results in contrast to this study since here only a generic regression model is used (see section 3.2 for a detailed model description). The inclusion of relatively smaller firms on the other hand is the strength of this paper as opposed to that of Shyam-Sunder and Myers (1999).

Ang, Rebel and Cole (2000) examine empirically the role of agency costs in determining the capital structure of 1708 firms from the FRB/NSSBF (National Survey of Small Business Finances) database of which many are 100 per cent owned by a sole owner-manager (they serve as a perfect zero level agency-cost base). Measuring agency costs directly (standardized excessive expenses relative to the zero agency cost case firms) and indirectly (ratio of annual sales to total assets, an efficiency measure) they find evidence in favor of the existence of agency costs within the sample that are higher for firms that are not directed by sole owners and rise with a decreasing ownership share of the management. The paper of Ang, Rebel and Cole (2000) is comparable to this study in so far that it does not rely on framework specific models but uses a generic approach relating the expense structures to according ownership

structures. Their study also uses cross-sectional data on small, non-public businesses as is done in this paper making a comparison of results between the papers easier. The strength as opposed to the paper at hand is the use of direct measures of agency costs. As will be presented later, this study relies very much on proxies.

The work of Bradley, Jarrell and Kim (1984) tests a joined model of the trade-off, agency cost, personal tax rate and non-debt tax shield frameworks on the cross-section of 821 firms from the Compustat file. The paper examines the performance of 20-year average firm leverage ratios for these firms covering 25 two-digit SIC industries. The results for the custom-built joined model are supportive in respect to the theory of optimal capital structure. Asymmetric information issues are not dealt with explicitly in the paper. Its strengths over this study are again the minute details of the model that capture the real-world environment better than a generic model as used in this study.

Another empirical study concerning the relationship of information asymmetries and capital structure choices is conducted by Himmelberg and Petersen (1994). They relate internal finance with R&D investments in a Compustat panel data comprising 179 firms active in four different high-tech industries: chemicals and drugs, machinery, electrical equipment and communications and instruments between 1983 and 1987. The size of firms is limited to small firms with capital stocks lower than 10 million dollars. Consistent with the logic of the pecking order, Himmelberg and Petersen (1994) find that R&D is substantially positively correlated with internal finance, a result that is at least partially supported also by this study as presented in section 3.4. The study of Himmelberg and Petersen is an interesting benchmark for this paper for the same reason as the paper by Hyytinen and Pajarinen (2002) is for the benchmarking of the data in the next section: the firms in the sample are high-tech firms from diverse sectors with relatively high R&D intensities just as biotech companies are. The advantage of Himmelberg and Petersen's (1994) work is that the analysis is based on a panel allowing the observation of behavior over time.

In the following analysis this study tests the above developed propositions on a cross-section of Finnish biotech SMEs that is briefly presented in the next section.

3.1 Data [21]

The empirical evidence in this paper is based on new cross-sectional data originating from a recently conducted private survey and hand-collected data from the National Board of Patents and Registration of Finland (PRH). Primarily the survey data serves as a basis for the analysis. Only in cases of controversial, inaccurate, missing or misleading data is the data from PRH used. No data from PRH is used that originates from periods prior to the year 2000. The survey covers the majority of companies operating in the Finnish biotechnology sector. Out of 120 active biotech companies at the end of 2001 the sample includes 84 companies of which 72 are small or medium-sized.

The sample is somewhat smaller than the population for the following reasons. The existence of a number of companies was unknown prior to the execution of the survey so that 116 companies were initially contacted. The contacts were based on the member list of the Finnish Bioindustries Association that tracks the development of and serves as a central organization for the Finnish biotech sector. One of the companies was tracked from the Internet. Out of these 116 companies, one was untraceable, 13 refused to respond, eight were operating in an irrelevant sector, three were not in operation, two had merged with another company and five could not be included due to other reasons. Altogether 9 companies were further excluded since they were too large to fit the definition of SMEs. Three companies were excluded because no sensible data was available on them. They were subsidiaries of bigger corporations and could not be properly separated from these in terms of equity and debt issues. 72 is the number of firms that form the sample used for data description in this section. The number of firms that made it into the sample in the final empirical analysis is still less, namely 59. This is due to incoherent data.

The companies in the sample are either independent businesses, partnerships or subsidiaries of bigger corporations. In the latter two cases the businesses had to be independently responsible business units in order to be included in the sample. If the criteria were not fulfilled, the data were collected from the parent company. No companies being 25 years of age or older met the criteria for inclusion. It has to be pointed out that the majority of firms excluded for their large size belonged to this age category and the remaining three "old" firms could not be included due to the lack of coherent data. Therefore the final sample consists of SMEs that are younger than 25 years of age. There are no severe outliers in terms of data on equity, capital loans or debt.

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[21] This section is taken to a large extent directly from Hermans and Tahvanainen (2002).

In the following tables I briefly sum up the actual sources of finance which the biotech SMEs draw funds from. This serves the single purpose to deepen the understanding of what is hidden behind the extremely aggregate and abstract terms "equity" and "debt" that have been used incessantly in this paper. It also facilitates the positioning of the biotech SMEs among the forces of the financial markets and helps to identify patterns that are not captured by the actual variables used to estimate the model described in section 3.2. The major role of capital loans in the total funding of the sector definitely constitutes such a pattern, as will be presented in this section and discussed in the concluding part of this study. *For a complete version of this data description refer to Hermans and Tahvanainen (2002)*.

In the tables firm size is split into two categories, small and large. A firm is small when the total labor force remains below 20 and the annual revenue stays below EUR 1 million. If one or more criteria are exceeded, the firm belongs to the category "large". The firm age is divided into four categories out of which only the three youngest are effectively in use. If a firm is established before 1977 (25 years of age and older), it is considered old. There are no Finnish biotech SMEs belonging to that category. Firms founded between 1977 and 1992 are labeled middle-aged (9 to 24 years of age). The category adolescent consists of firms established between 1993 and 1996 (5 to 8 years of age) and the remainder of the sample, firms started between 1997 and 2001 (0 to 4 years of age), belong to the category infant.

Table 3.1 Estimated distribution of aggregate equity, capital loans and debt by firm size and age

	Equity	Capital loans	Debt	Total
A: All (N=72)				
%	43.6 %	31.5 %	24.9 %	100.0 %
(amount, mill.€)				305.3
B: Breakdown by size of SME				
Small	-6.9%	70.9 %	36.0%	100.0 %
(amount, mill.€)				32.7
Large	49.3 %	27.1 %	23.6 %	100.0 %
(amount, mill.€)				274.7
C: Breakdown by age of SME				
Infant	39.5 %	46.2 %	14.3 %	100.0 %
(amount, mill.€)				162.7
Adolescent	41.0 %	27.0 %	32.0 %	100.0 %
(amount, mill.€)				64.1
Middle-aged	54.4 %	4.6 %	41.0 %	100.0 %
(amount, mill.€)				78.4
Old	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)				n.a.

Table 3.2 Estimated distribution of equity by firm size and age

	Individuals		Institutions					
	Active in business	Other individ.	Public VC	Private VC	Financial instit.	Other firms	Other equity	Total sources of equity
A: All (N=72)								
%	22.8 %	5.2 %	19.4 %	24.3 %	2.2 %	22.0 %	4.2 %	100.0 %
(amount, mill.€)								215.0
B: Breakdown by size of SME								
Small	32.1 %	2.8 %	27.1 %	7.3 %	1.8 %	24.9 %	4.0 %	100.0 %
(amount, mill.€)								14.4
Large	22.1 %	5.3 %	18.8 %	25.5 %	2.2 %	21.8 %	4.2 %	100.0 %
(amount, mill.€)								200.7
C: Breakdown by age of SME								
Infant	28.9 %	6.1 %	24.0 %	37.8 %	0.5 %	2.4 %	0.3 %	100.0 %
(amount, mill.€)								116.1
Adolescent	22.7 %	7.7 %	25.8 %	14.2 %	7.6 %	18.1 %	3.7 %	100.0 %
(amount, mill.€)								50.8
Middle-aged	8.2 %	0.2 %	1.3 %	2.3 %	0.5 %	73.3 %	14.2 %	100.0 %
(amount, mill.€)								48.2
Old	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)								n.a.

Table 3.3 Estimated distribution of debt by firm size and age

	Financial institutions				Non-financial business and government							
	Domestic banks	Domestic finance firms	Other dom. fin. instit.	Foreign financial instit.	Trade credit	Other non-fin. Business	Finnvera	Tekes	Other govt.	CPs and bonds	Other debt	Total sources of debt
A: All (N=72)												
%	14.5 %	3.2 %	0.0 %	0.0 %	31.8 %	5.5 %	6.5 %	13.3 %	4.4 %	0.4 %	20.4 %	100.0 %
(amount, mill.€)												75.9
B: Breakdown by size of SME												
Small	9.8 %	9.0 %	0.0 %	0.0 %	13.7 %	8.1 %	14.3 %	11.8 %	12.3 %	0.0 %	21.1 %	100.0 %
(amount, mill.€)												11.0
Large	15.3 %	2.2 %	0.0 %	0.0 %	34.9 %	5.0 %	5.2 %	13.5 %	3.1 %	0.5 %	20.3 %	100.0 %
(amount, mill.€)												64.9
C: Breakdown by age of SME												
Infant	14.0 %	6.6 %	0.0 %	0.0 %	19.4 %	3.4 %	7.7 %	17.1 %	1.3 %	0.0 %	30.5 %	100.0 %
(amount, mill.€)												23.3
Adolescent	2.0 %	0.0 %	0.0 %	0.0 %	45.6 %	2.4 %	9.5 %	23.4 %	10.6 %	0.0 %	6.4 %	100.0 %
(amount, mill.€)												20.5
Middle-aged	22.8 %	2.7 %	0.1 %	0.0 %	31.9 %	9.0 %	3.6 %	4.0 %	2.8 %	1.1 %	22.1 %	100.0 %
(amount, mill.€)												32.1
Old	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)												n.a.

Table 3.4 Distribution of capital loans by firm size and age

	Private				Public						
	Dom. fin. instit.	Foreign fin. instit.	Foreign VC	Private VC	Public VC	Sitra	Finnvera	Tekes	Other governm. & public	Other	Total
A: All (N=72)											
%	0.6 %	0.0 %	4.0 %	18.1 %	0.4 %	13.7 %	0.3 %	53.4 %	0.0 %	9.6 %	100.0 %
(amount, mill.€)											96.2
B: Breakdown by size of SME											
Small	2.5 %	0.0 %	16.9 %	18.4 %	0.0 %	37.7 %	1.4 %	19.2 %	0.0 %	4.0 %	100.0 %
(amount, mill.€)											21.7
Large	0.0 %	0.0 %	0.3 %	18.0 %	0.6 %	6.7 %	0.0 %	63.3 %	0.0 %	11.2 %	100.0 %
(amount, mill.€)											74.5
C: Breakdown by age of SME											
Infant	0.7 %	0.0 %	5.1 %	22.5 %	0.6 %	11.4 %	0.2 %	48.0 %	0.0 %	11.4 %	100.0 %
(amount, mill.€)											75.2
Adolescent	0.0 %	0.0 %	0.0 %	1.4 %	0.0 %	20.1 %	0.7 %	76.1 %	0.0 %	1.7 %	100.0 %
(amount, mill.€)											17.3
Middle-aged	0.0 %	0.0 %	0.0 %	5.4 %	0.0 %	29.9 %	0.0 %	55.4 %	0.0 %	9.3 %	100.0 %
(amount, mill.€)											3.6
Old	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)											n.a.

3.2 Model

For the purposes of testing the validity of the research propositions I use a simple linear regression model twice. I use it once to test hypothesis I to VI and VIII and a second time to test hypothesis VII. Hypothesis VII must be tested separately since the dependent variable is different from that in the other propositions. Where hypothesis I to VI and VIII employ the debt-equity ratio as the dependent variable, hypothesis VII employs the inside equity-to-total equity ratio. In section 3.4, the results for both regressions are presented in the tables 3.6 and 3.7 accordingly. The formal expression of the model takes the following form:

$$D_i = c + \alpha I_i + \beta C_i + \varepsilon_i$$

D represents the dependent variable, which is the debt-equity ratio for all hypothesis except number VII, as explained above. The constant is represented by the lowercase *c* in the formula. The independent variables that are supposed to explain the dependent variable according to the theories are incorporated into the model by the vector *I*. The content of the vector is examined more closely in section 3.2.2 where the independent variables are introduced one by one in more detail. α is the coefficient of the vector *I*. *C* is the control vector representing control dummies and other control. Section 3.2.3 discusses all the elements of the control vector.

β is the coefficient of the vector C. ε is the error term and the subscript index i serves as the firm index.

Certainly, the use of this basic regression prohibits the explicit regard of intricate details of the individual works that the propositions are derived from. I would have to test the data with all the original, proposition specific models that the authors developed in the papers referred to in the theoretical part of this study in order to be able to make more robust estimations on the validity of the theories. This would clearly exceed the boundaries of this paper if one takes into account that the theory base applied is rather large ranged. Thus, I content myself with observing more basic patterns of the data, for the purpose of which a simple linear regression model is sufficient.

Before describing the process of the analysis and the measures applied during it, I briefly introduce the variables used in the model.

3.2.1 Dependent variables

Before turning to actual process of the analysis, I will introduce the individual variables and elaborate in more detail on how they are operationalized. As already mentioned, the dependent variable for hypothesis I to VI and VIII is the debt-equity ratio of the firms in the sample. Here, equity is defined differently and more straightforward than that employed in the data description. Since simple disaggregate information on the distribution of equity over different sources is not needed nor in focus any longer, it is neither necessary nor appropriate to correct it for past losses. In reality financing decisions are made in realistic circumstances, which in turn are affected by profits and losses of past and present periods. A correction of equity for past losses would therefore distort the picture and contaminate the results.

Here, the figures for equity and debt are taken directly from the balance sheet of the companies without correcting them at all. The debt-equity ratio is calculated by dividing total debt by total equity. It must to be strongly pointed out that capital loans are part of equity as it is officially treated as such by law, although it has many common characteristics with debt. As can be observed in the data capital loans constitute a major source of finance, far more important than debt, for Finnish biotech SMEs. Thus, results of this study might heavily depend on how outsiders perceive the role of capital loans and how it is treated on financial markets. This matter will be discussed in further detail in the concluding section of this paper. Other-

wise capital loans are treated as equity from this point on. In the final run of the model the debt-equity ratio undergoes a logarithmic modification making a linear estimation more suitable. In more formal terms one can express the debt-equity ratio as follows: ln (total debt / total equity). The logarithmic modification has the disadvantage that one of the firms in the sample is discarded due to the fact that its debt-to-equity ratio is negative. Thus, the final sample consists of 59 firms, as touched on in section 3.1 earlier. Fortunately, this does not introduce distortions into the analysis, since a negative equity ratio means the firm is out of business and out of existence. The firm should be excluded anyway.

The dependent variable for testing hypothesis VII is the ratio of inside equity to total equity of a company. Inside equity is defined as what is commonly understood as "broad" inside equity. This means that it consists of equity owned by individuals that are actively participating in the daily business of the company and equity owned by the principal owner as defined above. I include the principal owner's share of equity into the definition of inside equity because it can be argued by definition that the principal owner has an influential saying in the financial decision making of the company and can be expected to have inside knowledge about the firm quality as defined by the theory earlier. Again, equity is taken directly from the balance sheet without modifications or corrections. Thus, the inside equity ratio is calculated by dividing the amount of inside equity by total equity.

3.2.2 Independent variables

Growth opportunities

The choice of independent variables is dictated by the research propositions. In proposition I the dependent variable is explained by growth opportunities. The data provide an excellent proxy describing these opportunities by the expected annual growth rate of turnover for the next five-year period. One can argue that a sustained growth in turnover stems from investments into diverse projects. A higher growth rate, therefore, requires more investments and more investments on their part require more investment opportunities, exactly what is supposed to be measured. So far the proxy works well.

The problem is that the growth rate expresses only percentages in turnover growth. For a small firm it is much easier to grow by huge percentage figures than for a firm with an already high turnover level. This means that a project rendering a fixed absolute return, or in other words a "unit of growth opportunities", would increase the turnover of a small firm by a lar-

ger fraction than the turnover of a large firm. Thus, it is not sensible to measure investment opportunities by using turnover growth rates as a proxy. The growth rates must be transformed into absolute monetary values so that the scale differences in turnover can be controlled for. In order to do so, the absolute monetary value of turnover at the end of the next five-year period is calculated based on the expected growth rates and the present turnover figures. As a next step, the present turnover value is subtracted from the calculated end-of-five-year-period value. The difference gives an absolute value for the growth opportunities in monetary terms that is free of the scale problem that cannot be coped with using simple growth rates. Some of the companies report zero level turnovers. For these firms it is not possible to calculate absolute end-of-five-year period turnover values since the multiplication of the zero level present turnover with any expected growth rate, no matter how high, would result in a zero. This does not capture the growth opportunities in a realistic way. In these cases I assume a fixed present annual turnover of 100.000 € so that the future turnover can be calculated. This procedure causes some minor distortions regarding the estimations, but gives a more realistic picture of the growth opportunities of zero turnover companies.

Relative profitability

In proposition II and VIII the dependent variables are explained by relative profitability. In the light of the theories, profitability is a proxy for the amount of free cash flow that is available to the management for investments on the one hand (proposition II) and target to interest tax shield operations on the other (proposition VIII).

It must be highlighted that one has to use *relative* profitability instead of absolute profit levels as the measure. The reason for this can be traced back to size effects. According to the free cash flow theory a fixed absolute profit must be offset by an equivalent sized debt to prevent the management from investing into below cost projects. But a fixed size debt has stronger implications on the debt-equity ratio of a small firm with a small balance sheet total than on the debt-equity ratio of a large firm with a large balance sheet total. Issuing debt of an equal amount results in a higher debt-equity ratio for the small firm. This means that two different sized firms making the same absolute profit would experience differing effects on their capital structure. This is not acceptable in the framework of this analysis. Thus, the size of the firm has to be taken into account when approximating profitability. The same argumentation applies to the profitability measure of proposition VIII. The problem is solved by dividing profits by the number of staff employed by the firms.

Another problem is related to the definition of profits. The annual profit figure includes financial items like interest payments, taxes and tax deductions. This creates distortions in the analysis since the debt level, and therefore the size of interest payments and tax deductions, are influential factors of the dependent variable in both propositions, propositions II and VIII. Thus, the dependent and independent variables are not independent from another. To cope with this problem, I use the operating profit as the measure for absolute profit levels. Operating profits do not include any financial items nor is it influenced by tax deductions and the loop to the dependent variables is broken. In table 3.6 the variables is named simply "Profitability".

Tangible asset ratio

Although proposition III uses the *tangible*-assets-over-total-assets ratio to capture the amount of tangible assets in a firm, I use the *intangible* asset ratio in the analysis. It was easier to extract the figures for intangible assets from the data. This does not change the framework of the analysis. The only implication is that the sign of the coefficient for the variable is expected to be the opposite as compared to the original variable of the proposition. One could also rephrase the propositions as follows: Firms that display a relatively higher *intangible* assets over total assets ratio have a relatively *lower* debt-equity ratio. In the results table 3.6 the variable is titled "Intangible asset ratio".

Age

This variable is rather self-explanatory. It is measured in years.

R&D intensity

In proposition V R&D intensity measures the asymmetry of information. Since R&D is highly tacit in nature, R&D intensity comes as a rather natural choice to depict the intensity of the information asymmetry between the insiders owning tacit knowledge and outside investors. Since many of the firms are still in the research phase displaying zero level turnovers despite immense R&D efforts, it is not sensible to calculate the R&D intensity figure by relating R&D expenses to turnover figures. Turnover simply does not capture the volume of operations in these young and R&D intensive firms. Instead I use total costs as a measure of volume. Thus, R&D intensity is calculated by dividing R&D expenses by total costs.

Quality of the firm

Quality of the firm, in case of both propositions VI and VII, is defined by theory as the ability to invest into positive NPV projects. In other words, the higher the NPV of projects, the higher firm quality. Of course, the data cannot provide any objective and accurate forecasts of future project returns. Thus, the best approximation for future returns is the expected growth rate of turnover being subject to subjective estimations and opinions of people actively participating in the business of firms in the sample, the same people that are the source of the data. As already argued above, one does well in using absolute level figures as the operationalized proxy for growth of turnover in order to correct for scale effects. Thus, I use the same variable for approximating firm quality as I use for growth opportunities for testing both, propositions VI and VII.

Other possible quality measures that are not as straightforward as the expected growth rates are the share of personnel with a doctor's degree of total personnel and the R&D intensity. The share of doctors as a measure of quality can be defended by arguing that it reflects the knowledge base and the state-of-art expert skills employed in the company. It is intuitive that these factors lead to a higher success probability of R&D projects in the long run and, thus, higher returns on R&D spending in average. Doctors per personnel is the more substantial and definitely more objective measure for firm quality, too. It is more substantial because it is based on factual reality. One can count the number of personnel and that of doctors reliably and indisputably with proof. This is not possible in case of the growth rate measure, which is based on pure assumptive estimations of individuals. It is also more objective since it is not based on subjective and possibly biased estimations and opinions of individuals that might have an interest in giving overoptimistic predictions about the expected growth rate of turnover to outsiders (here the institution collecting the data). This subjectivity can introduce random distortions to the data and diminish the validity of the growth rate measure. This speaks in favor of the doctors-per-personnel measure. I benchmark the two firm quality measures by including both into the regression analysis of testing propositions one to six and eight. The measure based on absolute turnover growth is titled "Growth opportunities / Firm quality 1" in the results table 3.6, whereas the doctors per personnel measure can be found under the name of "Firm quality (Doctors/personnel)" in the same table.

A higher R&D intensity that can be argued to approximate effort put into a project also raises the probability of successful project completion. Nevertheless, it does not comment on

whether this happens efficiently or how skillfully it is conducted. R&D intensity is therefore intuitively the worst measure of firm quality among the three.

Table 3.7 displays the results for proposition VII. I benchmarked four different types of quality measures, the results of which are separately listed in the columns titled "Model 1-4". In model 1 firm quality is measured by "growth opportunities" as defined above. In model 2 the quality is measured by the expected annual growth rate of turnover. That is, the variable is not expressed in absolute values and is therefore not scale corrected. In model 3 firm quality is proxied by the already presented "doctors per personnel" –measure. Model 4 tries to explain the inside equity ratio by using R&D intensity as a measure of firm quality.

3.2.3 Control variables

There is a vast range of different variables available for control purposes in the data including discrete and continuous variables. For the control vectors of this analysis variables are chosen primarily based on a combination of intuitive reasoning and systematic iteration. I will elaborate on this further in the next subsection where the process of the analysis is depicted. The final versions of the control vectors include the following variables:

Sector dummies

In both results tables, 3.6 and 3.7, sector dummies control for sector specific characteristics that might have an effect on capital structure. Agricultural, biomaterials and food sectors are controlled for. In the survey, sample firms were given the opportunity to count themselves to be active in several sectors simultaneously. This might constitute a problem since the characteristic effects of being active in one sector might mitigate the effects of being active in another. As the results show, some sector specific effects apparently still dominate, which insinuates that the firms might have a focus on one sector although they are active in another at the same time.

Location dummies

Again, both results tables display the results for dummies that control for location effects. The idea is to check whether the capital structure is affected by effects inherent in certain geographical areas.

Difficulties obtaining skilled labor -dummy

There were several dummies available for controlling for certain types of difficulties experienced by the sample firms during their start-up phase. This is the only one that made it into the control vector through the process described in the following section. The intention was to test whether initial difficulties have an effect on capital structure.

Dominant customer dummy

This dummy controls for the effects that the presence of a dominant customer may have on the capital structure of sample firms. A customer is considered to be dominant if its share of total sales represent over one third.

Export ratio

The export ratio is a discrete variable and controls for effects of the share of revenue originating from exports.

Dominant board ownership dummy

This dummy tests for the effects of a dominant ownership share of the board in the company. I argue that through its non-trivial ownership share the board is motivated to practice active decision making on the capital structure. The ownership share of the board is considered dominant if it is larger than fifty per cent of total shares.

Immaterial property rights dummy

This dummy controls for effects that the ownership of rights to produce products/services developed by other companies has on the capital structure. It can be argued that the ownership of IPRs provide a rather direct source of revenues to the owner. Many of the sample firms are still in the R&D phase of their initial products and cannot generate revenue based on products/services developed in-house. Thus, firms that have acquired IPRs from other firms can cover their costs by the revenue based on the acquired IPRs and are expected show higher profitability than firms without IPRs. The dummy should therefore have the same fore sign as the profitability variable.

Number of staff

In table 3.7 this variable controls for the size of firms and is discrete.

Plans to sell the company

This dummy controls for effects that a planned future sale of operations might have on the capital structure choice of the sample firms. Unfortunately, it is not eminent in the data for how long these plans have been existing. It is assumable that a longer period of existence provides a longer window for adjusting the capital structure. Thus, it might be the case that a company that just decided to sell operations did not have the time to adjust its capital structure towards a more attractive one from the perspective of the buyer. This can dilute the significance of the dummy.

Plans to bring an innovation to the market

The future launch of an innovation and the revenues created by it might serve as an incentive to keep equity inside the company so that a larger portion of these revenues can be appropriated. The dummy controls for this effect on the inside equity –ratio.

CEO is chairman of the board

This dummy controls for effects that the close proximity of control and ownership has on the inside equity ratio. Assumed that the board represents ultimately the interests of shareholders, then it can be argued that ownership and control are closer to each other, if the CEO representing the management is active in the board.

3.3 Process of analysis

The course of the analysis progressed in two major phases. First propositions I through VI and VIII were scrutinized. As proper results for these propositions were obtained, proposition VII was analyzed separately, because the dependent variable differed from that of the other propositions (see section 3.2 for details). As a result two separate results tables 3.6 and 3.7 are presented in the results section 3.4.

3.3.1 Testing propositions I through VI and VIII

To begin with, I first ran a regression with completely unaltered variables that are portrayed in section 3.2.2. This means that no logarithmic or exponential alterations were applied on the independent variables. Since the dependent variable, debt-equity ratio, is logarithmically corrected as explained above I used for all runs that are to be depicted in the following a simple OLS regression model and did not have to resort to probit or logit models. Moreover, all

model runs were robust regressions in order to correct for heteroscedasticity in the sample. The results for this initial run were basically the same as presented in the "Model 1" -column of table 3.6 with the exception that there was no result for a squared intangible asset ratio, of course. Annoyed by the fact that all of the statistically significant variables had the wrong sign in the light of the underlying theories, I conducted a run with all of the significant variables additionally squared to see if the distributions of the debt-equity ratio over the independent variables were parable shaped. If they were, this would mean that one side of the parable dominated the regression, in this case the one with the wrong sign, and there was a chance that the less dominant side might be in line with the theories. The results of this second (squared) run are displayed in table 3.6 in the column titled "Model 2". As can be seen, for the intangible assets –variable the hypothesis of an inverted U shaped distribution held true. For the profitability and R&D intensity variables the hypothesis did not hold. Model 1 – column of table 3.6 exhibits the results for the third run, for which I excluded the squared variables of profitability and R&D intensity that were not significant. It is the results of model 1 that I interpret as the actual ones in the results section.

Additional robustness checks were conducted in model 3 and 4. For the run of model 3 I included a "Positive profitability" –variable that conforms to the conventional profitability measure but is corrected for all negative values by replacing them with a zero. It was my intention to check whether negative profits that are characteristic to the yet young biotech sector dilute the effects that a growing profitability might have in the positive range. Apparently this is not the case. In model 4 I tested whether logarithmically altered variables suit the linear regression model better. For this purpose I had to include also dummies for zero level observations to avoid their complete exclusion through the logarithmic operations. The alterations did have no effect except for the age variable that became statistically significant for both, squared and non-squared, variables.

Last, I ran the regression without the control vector to test for its significance. I compared it to model 1 with the result that it is highly significant ($F= 5{,}4269$, $p<0{,}001$).

The final version of the control vector as seen in table 3.6 is the outcome of an extensive process of iteration and intuitive reasoning. First, variables that ran the risk of having a implicitly determined relationship to the dependent variable were eliminated. Then all possible candidate variables that were left over and could be extracted from the data were tested for

correlation. Based on the correlation matrix significant correlation pairs were examined more closely, whereby the variable that was intuitively less important from the perspective of theory was excluded to avoid multicollinearity at a later stage. After that the residual variables were all included in the regression. Through iterative runs of the model variables were excluded from the regression one by one based on their statistical significance. In each run the variable with the worst statistical significance was eliminated. With each elimination the adjusted R^2 value increased. I ended the iteration process as this value started to drop again as an additional variable was excluded. The variables included in the final control vector might not be intuitively the most interesting ones, someone could argue, but they award the model with the best explanatory power in terms of the adjusted R^2 value. I wanted to be sure that none of the excluded variables that seemed intuitively very important really had any statistical significance. To this end I iterated the model again by including these variables one by one in the control vector replacing each of these variables with the next one in each iteration. The composed results of the runs are presented in table 1 of the appendix. One can clearly see that none of the intuitively interesting variables have explanatory power.

3.3.2 Testing proposition VII

For the testing of proposition VII, I conducted four different model runs, the results of which are depicted in table 3.7. The difference between the separate models 1 through 4 is the proxy used for firm quality. As discussed earlier the proxies in the according order are growth opportunities, expected annual growth rate of turnover, doctors per personnel and R&D intensity. All of the four runs were again robust OLS regressions. The motivation for testing different proxies for firm quality is clearly inherent in the difficulty to find a simple and non-controversial measure for that quality. It was my intention to benchmark different measures against each other. As it turned out none of the proxies were statistically significant. Thus, I did not conduct any detailed analysis through logarithmic or exponential alterations of the firm quality measures as in the case of propositions I to VI and VIII.

The control vector was attained trough an identical process as described above. Again, table 2 of the appendix shows the non-existent statistical significances of otherwise interesting variables that were excluded during the iteration process of the control vector. I conducted test runs of all four models without the control vector. Looking at the F –test results it turned out that the control vector was statistically significant at the 0.001 level in all four models with F values of 5.3007, 5.8673, 6,6697 and 5,9906 accordingly. It is time to move on to the results.

3.4 Results

The results of the analysis are presented in tables 3.6 and 3.7. Table 3.6 displays the outcome of testing propositions I to VI and VIII. Table 3.7 shows the results for proposition VII.

3.4.1 Results for propositions I to VI and VIII

Proposition I

As for proposition I, it seems that the data does not support the theory of Jensen and Meckling (1976). The coefficient for the proxy describing growth opportunities in model 1 is not statistically significant. Nor do any of the other three model runs give any better results. The violation against the expectance constituted by Jensen and Meckling's theory is intuitively explainable. Recalling the theory, investment opportunities give rise to asset substitution effects. Investors are assumed to be rational and compensate the effect by raising the price for debt, which in turn results in less debt issued. This requires that investors have the ability to estimate or to observe the investment opportunities of a firm relative to others.

Table 3.6 Results for testing propositions I to VI and VIII

	Model 1	Model 2	Model 3	Model 4	Model 5
Dependent variable: Debt-equity ratio (ln debt/equity)					
Coefficients					
Constant					
B	.5119***	.6487***	.5151***	.7422***	.9778***
Std. Error	.1762	.2007	.1789	.2683	.1361
Growth opportunities / Firm quality 1					
B	-.0026	-.0036	-.0024	-.0004	.0014
Std. Error	.0019	.0030	.0028	.0034	.0016
Profitability					
B	-1.05e-06*	-1.33e-06**	-9.92e-07	-4.40e-07	-1.39e-07
Std. Error	5.37e-07	6.05e-07	8.33e-07	1.06e-06	1.82e-07
Profitability squared					
B		3.27e-13			
Std. Error		8.84e-13			
Positive profitability					
B			-1.00e-07	-9.78e-07	
Std. Error			1.24e-06	1.30e-06	
Intangible asset ratio					
B	2.9483***	3.1027***	2.9310***		2.7333***
Std. Error	.9116	1.0330	.9938		.9973
Intang. as. ratio squared					
B	-4.2601***	-4.6479***	-4.2286**		-4.1590***
Std. Error	1.4675	1.671368	1.6059		1.4943
Zero intang. assets					
B				.2513	
Std. Error				.4216	
Ln intangible asset ratio					
B				.0791	
Std. Error				.1233	
Ln intang. as. ratio squared					
B				.0008	
Std. Error				.0144	
Age					
B	.0132	.0077	.0130		.0144
Std. Error	.0120	.0116	.0122		.0110
Ln age					
B				-.2366**	
Std. Error				.1070	
Ln age squared					
B				.0859*	
Std. Error				.0490	
R&D intensity					
B	-.3158***	-.5952**	-.3133**		-.1787
Std. Error	.1125	.2766	.1227		.1010
R&D intensity squared					
B		.1034			
Std. Error		.0990			
Zero R&D intensity					
B				.1498	
Std. Error				.8098	
Ln R&D intensity					
B				-.1976*	
Std. Error				.1119	
Ln R&D intensity squared					
B				-.0187	
Std. Error				.0195	
Firm quality 2 (Doctors/personnel)					
B	-.1026	-.1289	-.1027	-.0419	-.1437
Std. Error	.1859	.1860	.1872	.1995	.1970
Control vector					
Active in food sector					
B	.3010**	.2846**	.3016**	.3144**	
Std. Error	.1439	.1361	.1457	.1347	
Active in agricult. sector					
B	1.0964*	1.1214**	1.1035*	1.037*	
Std. Error	.5488	.5425	.6056	.5407	
Located in Helsinki					
B	.1493	.1594	.1470	.1120	
Std. Error	.1384	.1469	.1465	.1814	
Difficulties obtaining skilled labour					
B	.0603	.0489	.0642	.1780	
Std. Error	.1207	.1211	.1243	.1464	
One customer constitutes >1/3 of demand					
B	.1516	.1546	.1505	.2036	
Std. Error	.1005	.1035	.1034	.1456	
Export ratio					
B	.0041***	.0040***	.0041***	.0046***	
Std. Error	.0013	.0014	.0014	.0016	
Board owns >50%					
B	.2797**	.2641**	.2802**	.2451*	
Std. Error	.1107	.1158	.1114	.1219	
Has rights to produce products developed by others					
B	-.2381**	-.2365**	-.2352*	-.1954	
Std. Error	.1091	.1157	.1237	.1516	
Model summary					
F	2.87	-	2.77	2.49	2.18
N	59	59	59	59	59
R^2	0.5992	0.6129	0.5993	0.5701	0.1946

The problem at hand could be that all the data is gathered from a very homogeneous sector, not in terms of *actual* growth opportunities since these differ probably radically from firm to firm, but rather in terms of observable characteristics that could lead to *assumptions about possible* growth opportunities by outside investors. It is easy to tell that the mature oil industry, for example, cannot come up with as many growth opportunities as the young and R&D intensive biotech industry, but it is a whole different story to tell which of the biotech firms face opportunities to grow and which do not. In order for proposition I to hold it must be possible to observe or at least to estimate the differences in growth opportunities among highly R&D intensive and young firms to an extent that it actually affects the price of debt on the firm-to-firm level. I doubt this is possible to an outsider. It would be interesting to compare the biotech industry as a whole to other sectors. It might be that on the industry level incentive effects have an effect on the price of debt after all. This argumentation is supported by the works of Bowen et al. (1982) and Bradley et al. (1984) who find that companies within an industry resemble each other more than companies in different industries and that these industries have a tendency to retain their relative leverage ratio rankings over time. If one takes a look at the data description above it is striking to observe how low the aggregate debt ratio of the whole industry is. With 24,9% it is significantly lower than the ratio of the benchmark data (51,9). This insinuates that on industry level proposition I might very well hold, since firms in the biotech industry can be expected to have relatively more growth opportunities than those in the benchmark sample if measured by expected growth ratios of turnover.

Propositions II and VIII

Propositions II and VIII can also be rejected. The coefficient of the profitability measure is statistically significant at the ten per cent level in model 1 and at the five per cent level in model 2, but displays the wrong sign according to both propositions; it is negative. Three explanations could give an answer to the question why the propositions are rejected. First, profit is technically a balance sheet item that is a component of equity. Thus, profits affect the debt-equity ratio directly. Implicitly, the higher profits are the lower the debt-equity ratio. This effect is supported by the results at hand. Another explanation is provided by the pecking order theory, which Myers (1984) introduced. The theory says that a firm turns to the outside financial markets for funding, preferably debt, only if the internal financing is inadequate to finance projects. Internal financing is provided by profits. If profits are large enough to finance all projects there is no need or motive to turn to outside financing and issue debt. This is exactly what the results seem to back up. The higher the profits the lower the debt-equity

ratio. And last, it seems that Jensen prediction concerning the invalidity of the free cash flow theory with respect to high-growth industries (discussed on page 19) has found empirical proof. The compound effect of these three alternative explanations seem to overweigh the compound effect of tax shield motifs and Jensen's (1984) free cash flow theory.

Proposition III

Results for Proposition III are ambiguous. As discussed earlier, the additional inclusion of an exponentially altered intangible asset ratio variable reveals that the distribution under scrutiny indeed takes the form of an inverted U. Both branches of the inverted U are statistically significant at the one per cent level. A quick calculation of the critical intangible asset ratio at which the negative correlation begins to outweigh the positive one [22] discloses that up to an intangible asset ratio of 0.69 leverage increases with the share of intangible assets of total assets. With ratios over 0.69 leverage decreases again. This finding is obtained in all model runs that do not draw on logarithmically altered variables (models 1,2,3 and 5). For ratios below that critical point it seems that the pure liquidation value of the company does not influence the use of debt as an instrument to produce information as proposed by the theory of Harris and Raviv (1990).

This seems to be intuitively understandable if one considers the nature of the R&D intensive biotech sector. Harris and Raviv (1990) argue that a large share of tangible assets of the balance sheet total make liquidation the best strategy in the case of default. Thus, in case of high tangible asset shares it pays off to create information on the company with the help of debt, because the probability of choosing the truly right strategy based on the information obtained is higher. The problem here might be that due to the extremely R&D intensive nature of biotechnology the right decision in case of default is not as trivially made as suggested by the theory. Even if the firm displays high tangible asset ratios it might very well be that future returns on current R&D projects outweigh the returns created by liquidation by far rendering liquidation the second best strategy in case of a default. Since R&D projects include tacit knowledge and experimentation in uncharted territories by definition, their outcomes are unpredictable. Consequently the decision whether to liquidate or not involves a much higher uncertainty than assumed in the theory. This uncertainty translates into a lower probability of choosing the right strategy at a given level of tangible assets. Furthermore, the information

[22] $\alpha x + \beta x^2 = 0 \Leftrightarrow x = -\alpha/\beta$, where α is the coefficient of the non-squared intangible asset ratio variable and β is the coefficient of the squared intangible asset ratio variable.

created by debt to assess and mitigate the degree of this uncertainty has no value, because it cannot reveal the net present value of current R&D projects that could be realized in the distant future. It can only tell something about the firm's capability to pay back debt in a very proximate time frame, which does not suit the typical case in biotechnology where development phases can take years to bear fruits in the form of revenues from which debt could be paid back. It follows that the amount of tangible assets does not provide useful information on the probability of making the right decision in case of a default. Thus, the theory might not apply to an R&D intensive sector like biotechnology.

It is rather difficult to explain why the debt-equity ratio correlates negatively with the intangible asset ratio beyond the critical ratio of 0.69 and not until 0.69, a fairly high ratio considering that it is the book value. It would be convenient to say that from that point on the theory explains the finding. But the contradicting discussion above throws too big a shadow upon this interpretation to be able to rely on it. Also other alternative interpretations like a diminishing asset base that could work as a collateral for debt fail to explain why there is a significant positive correlation up to the critical point. Clearly, there are forces at work that are not captured by any of the theories that are touched upon in this study. The matter requires in-depth analysis and is left open for future research.

Proposition IV

Age seems to have no bearing on the debt-equity ratio of firms in the sample. Only in the logarithmically and exponentially altered model 4 age becomes significant. Model 4 further discloses that the distribution of the debt-equity ratio over age is U-shaped, non-linear. The validity of model 4 in respect to the age variables is rather questionable since the exclusive use of logarithmic variables in the model seems to dilute all further, otherwise robust results of models one to three. The age variable of model 4 might have absorbed effects from the other variables rendering them insignificant. Thus, I discard the results of model 4. A reason for the insignificance of age in respect to the debt-equity ratio could be that the incremental variations in the age of firms in the sample are not large enough to make any differences in the reputational value of it [23]. Since Diamond's theory makes the price of debt dependent of a

[23] Over 50 per cent of firms in the sample are founded after 1995. A difference of a few years in age does probably not provide a distinctive advantage in terms of reputation.

firms reputation to be default free, it is clear that this age wise homogeneous sample cannot provide a solid empirical proof for proposition IV.

Proposition V

Proposition V must be rejected on the basis of the results. The coefficient of the R&D intensity variable is statistically significant at the one per cent level but has the wrong fore sign. In contrast to Myers and Majluf's (1984) theory, the debt-equity ratio correlates negatively with the extent of the information asymmetry, which is approximated by R&D intensity in this analysis. Several hypotheses can be drawn upon to explain the empirical deviation from theory. First, one could argue that in the eyes of outside investors, who do not have any inside information upon true growth opportunities, take the R&D intensity of a firm instead as a substitute measure for its investment and growth opportunities. If this is the case then Jensen and Meckling's (1976) theory about the incentive effect would be supported by the findings of this study after all: With increasing investment opportunities and in the presence of a threat of default the management acts in the interest of existing shareholders and always chooses to proceed with the riskier project having the largest up-side in case of success. Investors react rationally and increase the price of debt with increasing growth/investment opportunities (here approximated by the R&D intensity) of the investment target.

This interpretation has an important implication on the reason for the failure of the growth opportunity proxy used to test proposition I earlier. It seems that the price of debt in Jensen and Meckling's (1976) context is not determined by the amount of true growth opportunities as perceived and actually faced by insiders, but by the opportunities as perceived and assumed by outsiders, namely investors. True growth opportunities cannot be recognized by outsiders, proxies like the R&D intensity can.

Second, with growing R&D expenses less and less debt might be issued in order to avoid underinvestment. This interpretation is in line with the principal-agent framework.

Another interpretation of the finding can be related to the trade-off theory. As the portion of R&D of total operations increases it can be argued that parallel to that the business risk of a firm increases. This translates into a rise of bankruptcy costs in the trade-off theory framework. As bankruptcy costs rise relatively to a fixed amount of debt the tax shield created by that debt decreases and the company is less motivated to use leverage.

Last, future returns on R&D projects are extremely risky and are consequently a miserable collateral. The more R&D intensive a firm is the less it can put forth as tangible collateral and, as a result, receives less and less debt.

Proposition VI

Proposition VI has to be rejected. The coefficients of neither quality measures (firm quality 1 and 2) are statistically significant. This holds for all runs of the model, one to five. Again, it is difficult to point at a certain or plausible reason why the theory of Heinkel and Zechner (1990) does not hold in this case. It might be everything between a bad proxy for firm quality and the presence of a force that interferes with the logic of their theory. It can just as well be that firms do not act rationally or believe in the pooling mechanism of market pricing, as explained in the theory. The belief in this mechanism is a requirement for the theory to work in practice. I have to delay a more robust explanation until further research is conducted.

Table 3.7 Results for testing proposition VII

	Model 1	Model 2	Model 3	Model 4
Coefficients				
Constant				
B	.2449	.2849	-.3951	.3293
Std. Error	.5867	.4648	.6785	.4717
Firm quality				
B	.0007	.0018	1.187	-.1316
Std. Error	.0023	.0043	.7282	.3056
Control vector				
Number of staff				
B	.0184	.0182	.0226*	.0185
Std. Error	.0122	.0121	.0128	.0123
Plans to sell company				
B	-1.0357	-1.0321	-.9627	-1.0016
Std. Error	.6409	.6306	.5925	.6726
Plans to bring innovation to market				
B	-1.3927***	-1.4036***	-1.3161**	-1.3598**
Std. Error	.5103	.5150	.6280	.5410
Active in biomaterials sector				
B	-1.0848*	-1.1197*	-.9747*	-1.0810*
Std. Error	.5794	.6244	.5165	.5703
Active in foods sector				
B	1.1511	1.1532	1.1902	1.1335
Std. Error	.9203	.9193	.8810	.8955
Active in agricult. sector				
B	5.5899*	5.5648*	5.6136*	5.5596*
Std. Error	3.0168	3.0012	2.9974	2.9981
Age				
B	.0773*	.0768*	.0951**	.0738*
Std. Error	.0416	.0402	.0395	.0388
CEO is president of board				
B	1.5475***	1.5491***	1.3137**	1.5488***
Std. Error	.4540	.4539	.5045	.4487
Located in Kuopio				
B	.8243	.8197***	.7734**	.8478***
Std. Error	.3193	.3073	.3227	.3144
Model summary				
F	2.76	2.61	3.07	2.16
N	61	61	60	61
R^2	0.5270	0.5272	0.5577	0.5278

3.4.2 Results for proposition VII

For the results for proposition VII we have to take a look at table 3.7. Again, I have conducted four model runs; this time to see how sensitive the model is to the definition of the independ-

ent variable, here firm quality as defined in sections 3.2.2 and 3.3.1. The dependent variable is the inside equity-to-total equity ratio. As can be seen, the results do not support the proposition. None of the quality measures is statistically significant.

With this said one has to state that proposition VII has to be rejected in the light of the empirical evidence. Firm quality seems to have no bearing on the inside equity ratio. It is hard to explain this result intuitively since it was one that seemed very realistic. Would not everyone who is expecting large returns from projects want to keep as large of a share of them as possible for himself? One possible explanation is that the amount of inside equity simply is not enough to finance the intended projects and firms have to turn to outside investors for further funding. The theory predicts in such cases that the particular projects are financed by debt to the extent that inside equity is not sufficient. This does not influence the inside equity ratio at all. But if debt is too expensive either due to agency cost or bankruptcy cost considerations, for example, then the firm has to turn to outside equity financing, which has direct implications on the inside equity ratio. Taking into account that a large part of the companies in the sample are research spin-offs founded by individual researches without large financial resources and that biotechnology often requires vast investments over long periods without proximate returns the explanation does not seem to be irrational. Further research is required to obtain profound and legitimate results.

3.4.3 Results for control vectors

As can be seen in the results tables the control vectors include various variables that possess significant explanatory power and add to the significance of both models. From table 3.6 one can infer that biotech firms active in the sectors food and agriculture have obviously high leverage ratios. The fact that some sectors do have a certain capital structure and others have another is anticipated. Firms within a specific sector can be assumed to resemble each other more than firms in different sectors just as capital structures in different industries deviate from another. Thus, the positive correlation of the two sectors and the debt ratio can be traced back to sector characteristics.

The export ratio correlates positively with the debt-equity ratio. The independent variable is statistically significant. The argumentative base for this finding is hard to tie to the theoretical frameworks surveyed in this paper and is left open as a target of further discussion.

The debt-equity ratio is higher if the board of the firm controls more than fifty per cent of equity. The finding can be explained since it is accordance with the intuition of Jensen and Meckling's (1976) agency theory. If control and ownership do not go hand-in-hand there is a need to prevent the management from engaging in opportunistic behavior by issuing debt so that the interests of shareholders are protected. The board has the ultimate saying about the issuance of new debt and equity. Now that the members of the board do not only represent the shareholders but *are* the majority of shareholders they have all the incentives to protect their own interests from the management by issuing debt. On the other hand one could argue that a board that has a significant ownership share in the firm is strongly motivated to control the management directly through close personal contact (i.e. regular meetings, monitoring of figures, direct reports, on-site visits, phone calls, etc.) instead of reverting to indirect and potentially less efficient means as the use of debt. A board with a small ownership share might not be motivated to invest such personal monitoring effort and might be motivated to use the more convenient debt monitor. Following this argumentation the finding is actually in contrast to the agency theory. I leave the matter open for discussion since neither argumentation can be determined to be either right or wrong without further analysis at this point of time.

Also the ownership of rights to produce products developed by other companies has an effect on the capital structure. Firms that own such rights tend to be less leveraged. Again, there is no direct link to the underlying theories.

Concerning the inside equity ratio several of the control vector variables have explanatory power. Again, industry specific and geographical effects come into play. Also the fact that a company has plans to bring an innovation to the market in the near future affects the relative amount of inside equity retained in the company, namely negatively. This might insinuate that during the R&D phase of the near marketable innovation the firms were forced to turn to outside equity financing due to the lack of internal financing, for example. This is in contradiction to the pecking order theory since a company would be expected to turn to debt financing in such a case leaving the inside equity ratio untouched. But if debt was not available, say due to the lack of collaterals, outside equity is the only source of financing if internal funds are insufficient.

Age is positively correlated with the inside equity ratio. This finding can be explained simply by profits that an aging company accumulates over the years of operation.

If the CEO of a firm holds also the seat of the president of the board the firm displays a relatively higher share of inside equity to total equity. Also this finding is in accordance with the principal-agent framework. If the management impersonated by the CEO has the power to decide upon capital structure issues through a dominant board representation it will not restrict its own options by issuing debt.

Table 3.8 summarizes the findings and according argumentation for each proposition.

Table 3.8 Summary of results and argumentation

Proposition	Empirical support	Reasoning
Principal-agent framework		
Management vs. shareholders		
Free cash flow theory	no / yes	**No:** firms prefer internal finance over debt; profits increase equity **Yes:** CEO as president of board decides against use of debt; board as principal owner uses debt to curb opportunistic behavior
Informational role of debt	no	R&D intensive operations render informational value of debt low
Shareholders vs. creditors		
Asset substitution effect	no / yes	**No:** growth opportunities (as estimated by insiders) not observable by outside investors. **Yes:** growth opportunities as proxied by outside investors (R&D intensity) affect price of debt positively
Reputation effects	no	sample too homogeneous in terms of age
Information asymmetry framework		
Pecking order related		
Pecking order theory	no / yes	**No:** threat of asset substitution effect dominates; with increasing R&D less debt used to avoid underinvestment; R&D increases bankruptcy costs of debt; large R&D share of operations a lousy collateral. **Yes:** firms prefer internal finance over debt
High quality firms drive out low quality firms	no	mistrust in pooling mechanism of markets; poor proxy for firm quality (?)
Other		
High quality firms retain larger inside equity share	no	?
Tax related framework		
Trade-off theory	no / yes	**No:** firms prefer internal finance over debt. **Yes:** R&D intensive firms use less debt due to increasing bankruptcy costs

4 Conclusions

A glance at table 3.8 exposes that for a large part of the theoretical background there is no empirical support. The free cash flow theory can be rejected in the light of the evidence presented. Although a board acting simultaneously as the principal owner is associated with higher debt ratios, a finding that is in line with the free cash flow theory, it is not free cash flow that the principal owner is protecting against overinvestment. Also the informational role of debt does seemingly play no role in capital structure choices among Finnish biotech SMEs. Reputation effects do not affect capital structures, neither do high quality firms resort to the

use of debt in order to drive lemons out of the market. Moreover, existing shareholders of high quality firms seem not to be interested in appropriating future returns by retaining a high share of equity inside the firm.

The pecking order theory and the trade-off theory are only partially supported. The results for both are ambiguous since they seem to interfere with each other. The finding that firms seem to use less debt with increasing profits backs up the pecking order theory but torpedoes the trade-off theory. Conversely, the observation that R&D intensive firms facing a higher business risk display lower debt ratios supports the trade-off theory but works against the intuition of the pecking order theory. This contradiction dilutes the validity of the supportive findings.

It is only the asset substitution effect, a subcomponent of the more deliberate agency cost framework, that seems to obtain solid proof from the analysis. Assuming that it is the outsiders' estimation of growth opportunities that affects the price of debt firms with more investment opportunities really seem to face a higher price for debt.

The most interesting question at this point is why the majority of frameworks fail in the light of the evidence. The search for the answer to this question can be commenced from two directions. Firstly, as in every empirical analysis weaknesses in technicalities (e.g. invalidity of proxies) and the logics of the framework (i.e. the theories as such are invalid) can render an otherwise plausible setup worthless. Secondly, and more interestingly, certain characteristics of small and medium sized biotech companies might cause the theories at hand to be unsuitable for grasping real determinants of capital structure choices.

As to the former approach, Myers (2001) concludes his review of all the theoretical settings used also in this paper - taxes, information and agency costs – by stating that none of them provide a universal explanation of financing strategy. Myers argues that this is due to the fact that the theories are not designed to be universal, but very specific and conditional. Each of the theories stresses certain advantages and costs of alternative financing strategies. The lack of generality might effect empirical tests on broad and heterogeneous samples of firms to be uninformative. This means that one might receive results consistent with a theory or two, because they work for a subsample. It could also happen that one receives a consistent result for one theory although they are generated by another. This can be the case when real variables are not quantifiable and proxies or indirect measures are used instead. Myers (2001) further

argues that a certain proxy might very well react to more than one theory. In such a case a significant β has no unambiguous interpretation. It only reveals that numerous theories are simultaneously at work. Knowing that each theory works only in special circumstances dilutes the interpretation in such a case even further.

Considering the substance of the sample in this study, all the matters just discussed do apply: First, asked directly, one would probably first say the biotech sector is very homogenous as compared to other sectors. This picture is provoked by the high R&D intensity throughout the sector as well as the common matter the companies are engaged in, the manipulation and application of biological processes. This perception is deceitful and crumbles when having a closer look. In reality, the sample is truly heterogeneous in terms of operations considering that biotech firms are active in numerous sectors ranging from foods to forestry, from textiles to enzymes and from pharmaceuticals to biomaterials. Moreover, many firms are active in several sectors simultaneously. This translates into heterogeneous business logics, fluctuating R&D phase lengths, deviating asset intensities and so forth. The evidenced significance of sector dummies supports this argumentation. Second, although I tried to find as valid measures and proxies as possible in order to operationalize the theories, they still are only proxies. The interdependence of the trade-off and the pecking order theory is a good example where one significant variable affects both theories at once making interpretation difficult. It is especially hard to tell, which of the two dominates the other. In the face of Myers' (2001) argumentation also the empirically supported role of the asset substitution effect begins to shake. Is it really the principal-agent setting that explains the finding, as assumed until now, or can it be that it is actually the trade-off theory that grasps here? Nobody can tell for sure without digging deeper into the matter.

Now, to turn to a discussion about biotech sector specific characteristics that might render the theories unsuitable, there are indeed some facts that require acknowledgement. First, as already argued biotechnology is an umbrella term for a sector that is extremely homogeneous in terms of operation environment and substance of business. Moreover, the Finnish biotech sector is very small in terms of the number of firms. This combination gives rise to the problem that even the theory consistencies of subsamples (which by themselves were identified as a problem above) are diluted, because those subsamples are simply too small to show statistically significant patterns. Second, over one third of the firms in the sample are active in the pharma sector. The pharmaceutical business as such is already fairly special due to extremely

long development phases that might exceed a decade and strict medical approval processes. The matter is further complicated by the fact that the pharma companies of the SME sample are extremely young as compared to their incumbent competitors that were excluded from the sample and in a much earlier phase in the life-cycle of a typical pharma company. Many do not even have a product on the market. It follows that these firms do not show the typical characteristics of a pharma industry specimen showing much higher R&D intensities, for example, or strictly negative profits in the absence of turnover. These features might introduce critical disturbances into the strongly conditional environments that the capital structure theories work in. For example, assumptions about the rationality of investors or their ability to observe or not observe might not apply or might even be amplified resulting in inconsistencies with the theories.

At this point a few words must be shed on the question about the role capital loans play in the capital structure choices of biotech SMEs. It is significant. As already brought up in section 3.2.1 the share of capital loans of total financing is in fact so large that the results might stand or fall with how the financial markets interpret its characteristics, irrespective of its legal definition, since it displays some characteristics of equity and some of debt. Also the fact that the lion's share of capital loans stems from public sources emphasizes the feeling that there is something special about capital loans that relates somehow to the characteristics of the biotech sector. There is one explanation to this setting that surfaces when taking a close look at the financial statements of single firms in the sample: The majority of firms still display heavy losses caused by the lack of revenues and heavy R&D spending. Ongoing negative profits consume equity rather quickly and would soon render businesses bankrupt in legal terms. The question is how these firms are able to survive. The rescue might be provided by capital loans. They are part of equity, thus, with sufficient reception of capital loans the losses can be technically offset on the balance sheet preventing firms to have to file for bankruptcy. But who would be interested to support a financially fragile and equity consuming sector so patiently that it has the needed time to develop marketable products or services that can lay the foundation for the autarkic existence and sustainable growth of the sector? Private risk equity investors surely not in on a sufficient scale since they have to display returns on investment quicker than possible for the young biotech sector. Thus, it is the public sources that are the only viable source of patient equity financing with TEKES being the largest provider of public funding to high-technology firms. Problem is that TEKES does not make any equity investments, it supplies only loans and capital loans. It is exactly this setting that might pro-

vide an answer to the underlying question why capital loans constitute such a large share of total funding in the biotech SME sector. Since TEKES cannot invest conventional equity into the firms in order to keep them alive it has to support them with providing capital loans. This would mean that the public sector sees such a great potential in biotechnology that it is ready to support it artificially, to keep it on life support. But what does this imply on the questions targeted by this study? What implications does it have on the interpretation of results at hand? Is the true reason for the high equity intensity of biotech firms really that without it there simply would be no biotech sector? Are debt-equity ratios in reality determined simply by cumulative past losses compensated by governmental sources, namely TEKES? This is such a vital question that it has to be answered to before it makes any sense to try to unknot the empirical inconsistencies in respect to the theories applied in this paper.

At the end of the day it must be admitted that based on this study profound statements about forces affecting capital structure choices in the Finnish biotech SME sector cannot be justified. In this sense the paper fails to answer to the quest it initially embarked on trying to deepen the existing knowledge about the sector. Nevertheless, the study is far from worthless. It forms a valuable basis for further study and clearly points at the weaknesses that have to be overcome. It shows why the theories probably failed and thereby reveals some specialties of the biotech sector that have to be taken into account before a throughout successful application of theories comes into reach. A few concrete measures can be proposed based on the findings. Besides the question of the role of capital loans at least these matters have to be shed thoughts on:

First, due to the heterogeneity of sectors grouped together under the umbrella of the biotech industry it is not feasible to apply general theories of capital structure. It might be far more informative to apply them on subsectors and piece together the bigger picture based on these disaggregate findings. Why try to fit everything under one roof if it simply does not comply with its nature? Second, this study focuses on the analysis of firms within the biotech sector only. Really useful information can be expected from benchmarking the biotech sector against other industries. Profound understanding of the differences of industries promote the customization of tools with the help of which their prosperity can be enhanced. Last and most boldly, one could try to forge completely new theories or alter the existing ones that take the oddities and characteristics of biotechnological companies and the local financial sector explicitly into account. Here the small size of the Finnish biotech industry surely comes in handy. With only

about 120 active firms in the field qualitative research that comprehends the whole population is a very feasible possibility that might save immense amounts of time and effort that would have to be put forth to reach the same end through methods of purely quantitative research only. It also might reveal interdependencies and forces that simply cannot be disclosed through empirics. Fact is that the results clearly reveal some significant associations although they cannot be explained by existing literature. It calls for further investigation; if not for science's sake then for the sake of ethical humanity.

Appendix

Table 1: Results for testing alternative control vector variables (Prop. I-VI and VIII)

Variables	Coef.	Std. Err.	P>|t|	N	F	R^2
Number of staff	.0021	.0026	.435	59	F(16,42) = 2.80	.6062
Company is a academic research spinn-off	-.0377	.0868	.667	58	F(16,41) = 2.74	.5966
Company is a corporate spinn-off	.0941	.1000	.353	59	F(16,42) = 2.72	.6049
Company had financial difficulties in start-up phase	-.0944	.1001	.351	59	F(16,42) = 2.80	.6046
Principal owner participates actively in business	.1191	.1300	.365	59	F(16,42) = 2.71	.6051
Company has foreign owners	-.0809	.1216	.510	59	F(16,42) = 2.71	.6042
Principal owner is the founder of company	.1191	.1300	.365	59	F(16,42) = 2.71	.6051
The board has foreign members	-.1806	.1332	.182	59	F(16,42) = 3.27	.6176
CEO is the president of the board	.0053	.1492	.972	58	F(16,41) = 2.70	.6015
Company is located in a science center	-.1278	.1106	.254	59	F(16,42) = 3.04	.6116
Company collaborates with other firms	-.0047	.1800	.979	59	F(16,42) = 2.63	.5992
Company has innovated in past 3 years	.0261	.1206	.830	59	F(16,42) = 2.73	.5996
Company has plans to sell operations	.0761	.1419	.594	59	F(16,42) = 2.76	.6029

Table 2: Results for testing alternative control vector variables (Prop. VII)

Variables	Coef.	Std. Err.	P>|t|	N	F	R^2
Company is a subsidiary	.0950	.5380	.861	60	F(11,48) = 2.80	.5579
Company is a academic research spinn-off	.1470	.3883	.707	59	F(11,47) = 2.74	.5747
Company is a corporate spinn-off	.1252	.5180	.810	60	F(11,48) = 2.81	.5582
Company had financial difficulties in start-up phase	.1503	.5218	.775	60	F(11,48) = 2.74	.5583
Company has foreign owners	.3547	.4191	.402	60	F(11,48) = 3.57	.5616
The board has foreign members	.5482	.3618	.136	60	F(11,48) = 3.14	.5659
Company is located in a science center	.5604	.4192	.188	60	F(11,48) = 3.02	.5688
Company collaborates with other firms	-.2845	.6440	.661	60	F(11,48) = 2.77	.5584
Company has innovated in past 3 years	.4941	.4958	.324	60	F(11,48) = 2.81	.5647
Company will bring an innovation to market	**dropped**					
Company has rights to produce products developed by others	-.6568	.7021	.354	60	F(11,48) = 2.82	.5665
Company was founded during the depression of early 90s	-.6590	.4675	.165	60	F(11,48) = 2.85	.5724
Company located in Turku	-.1745	.4128	.674	60	F(11,48) = 2.83	.5587

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