

Strategic Debt and Product Market Behavior
in
Oligopolistic Markets

Doctoral Thesis

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List of Symbols

| | |
|--------------------|--|
| β^k | decision of the bank to liquidate the firm in state k ($\beta \in [0, 1]$) |
| γ | probability for consumer heterogeneity |
| δ | discount rate |
| μ | innovation success probability |
| θ | probability of the good state |
| $\hat{\theta}_i^k$ | optimal probability of firm i in state k |
| λ | measure of the decrease of variable costs after an innovation |
| Π_i | profit of firm i |
| Π_i^k | profit of firm i in state k |
| $\hat{\Pi}_i^k$ | net profit of firm i in state k in period 1 (after repayment to the bank) |
| $\tilde{\Pi}_i^k$ | net profit of firm i in state k in period 2 (after repayment to the bank) |
| σ_i^H | market share of firm i in the Hotelling model |
| σ_i^S | market share of firm i in the Schmalensee model |
| a | prohibitive price |
| b | price sensitivity |
| c_i | variable costs of firm i |
| C | Cournot equilibrium |
| $D[\cdot]$ | demand function |
| e | equity costs |
| $E[\cdot]$ | expectation |
| F_t | fixed costs in period t |
| f_i | brand awareness of firm i |
| $g_i(\cdot)$ | convex cost function of firm i |
| i, j | firms |
| I | investment costs |
| k | capital costs |
| l | leverage |
| m | monitoring costs |
| n | number of firms in the market |
| p_i | price of firm i |
| p^r | reservation price |
| p_i^* | optimal price of firm i |
| q_i | quantity of firm i |
| q_i^* | optimal quantity of firm i |

| | |
|-----------------|-------------------------------------|
| Q | market quantity |
| r | interest rate |
| R_t | repayment to the bank in period t |
| s_i | product quality of firm i |
| \underline{s} | minimum product quality |
| S, T | equilibria |
| t | period |
| U | utility of a consumer |
| V | payoff of the firm |
| W | payoff of the bank |
| w | constant |
| z^k | market size in state k |
| \bar{z} | expected market size |

1. Introduction

Financial decisions play an important role in the success of a firm. As the recent case of the German automotive supplier Schaeffler Group shows the decision to buy the rival Continental in combination with a strong rise of the own leverage increases the default risk of the firm. Due to the change of the general economic market environment, a bankruptcy of the Schaeffler Group without any financial aid is imminent.

But not only the general economic environment as in the case of Schaeffler makes bankruptcy of a firm more probable. Rivals of the firm can also capitalize on the increased default risk. The change of the capital structure can induce rivals to behave more or less aggressive in the output market. This behavior has a direct impact on firms' own behavior, profit and default probability. And the other way round taking such reactions into account firms are able to signal a specific behavior on the output market by changing their capital structure. Thus, the capital structure has a strategic impact on the behavior of firms in the market: capital structure decisions influence product market decisions.

This proposition was introduced by Brander and Lewis (1986), who integrated the capital structure decision as an additional variable of firms in a Cournot model. Showalter (1995) discusses the financial decision in the Bertrand model. Since then many other papers followed. Those papers distinguish either in the type of capital or the assumed competition environment. The outcome of the models strongly depend on these assumptions. For instance, the optimal behavior of a firm in a market with quantity competition distinguishes from the optimal behavior in a market with price competition. Relevant for the outcome are also the time focus and the kind of uncertainty in the market. Thus, whether a firm should strategically increase its leverage or not, depends on the respective market environment.

These results are also the motivation for this thesis. For market participants, which are current and potential managers, share- or stakeholder of a firm as well as for competition authorities it is of interest, how firms optimal behavior is influenced by changing the capital structure. Hence, this thesis tries to fill the gaps in that part of literature. The effects and influence of further decision

variables beside the price or quantity decision on the optimal behavior of firms will be investigated. These decision variables are:

1. the product quality (vertical differentiation)
2. the marketing expenses (horizontal differentiation)
3. the expenses for research and development (R&D)

The thesis has the following structure: The following chapter gives a short overview on the relevant literature on the one hand of corporate finance and product market competition and on the other hand of the combination of these topics. Herein different models which are the basis for this thesis are presented more extended.

The three subsequent chapters present the three above mentioned models of capital structure decisions under different market environments. In every chapter the focus of the capital structure decision lies in the analysis of self- vs. debt-financing and the effect of both on the market outcome.

The first paper investigates the role of the financial decision in a market with vertical differentiation. Firms can differentiate from their rivals by increasing or decreasing the quality of their product. Assuming Bertrand competition the chosen product quality of a firm determines the intensity of price competition in the market. Without any quality differences products are assumed to be homogenous and prices reduce to marginal costs. The capital structure choice influences the product quality decision and as a consequence the price decision of firms in the market.

In the second paper the financial stage is integrated in a model with horizontal differentiation. Firms in the market compete in prices as in the Hotelling model and invest in marketing to make their product known to consumers. With the amount of marketing firms decide on the intensity of competition. Again, the financial choice influences the intensity of competition in the market.

The third paper integrates the financial decision in a market with R&D and Cournot competition. In the model the investment in R&D possibly reduces marginal costs. Hence, firms have the opportunity to become the cost leader in the industry. Whereas the R&D decision of a firm is mainly driven by the

gain of a cost leadership and the possible bankruptcy, the quantity decision after the innovation stage depends on marginal costs of both firms.

The last chapter concludes and summarizes the general findings of the thesis.

2. Literature review

2.1. Overview

This chapter gives an overview of the relevant literature for this thesis. At first, the literature will be discussed, which serve as a basis for the main topic of this thesis: on the one hand the literature about capital structure decisions and on the other hand about the behavior of a firm under different market environments. The third part of the literature combines these two areas of research: the capital structure decision of a firm and its influence on firms behavior in the product market.

Section 2 deals with the literature about the capital structure decision of a firm. The focus of this area of research lies on the investigation of capital costs and firm value. Following the literature an optimal capital structure is achieved, when capital costs are minimized or the firm value is maximized, respectively. Hence, the key question in this area of research is, whether an optimal capital structure exists and if yes, how it can be achieved. At this, one important issue is the information structure. Uncertainty in the market and asymmetric information about future profits leads to incentive problems of the entrepreneur of a firm. Such problems also play a key role in the different approaches of the fourth section.

Product market competition models will be discussed in section 3. To understand the outcomes of the capital structure and product market models the implications of the different types of competition are important to recall. The literature mainly describes two ways of competition: firms can either compete in quantities or on prices. Furthermore, additional variables like the R&D or marketing decision are integrated in some models. Supposing an oligopolistic market structure with market power of firms the different outcomes of those models are of interest. Firms ability to behave strategically in different market environments will be analyzed. Porter's strategy advice will be discussed.

Section 4 summarizes the literature with respect to strategic capital structure decisions. As described above decisions on the capital structure do not only influence capital costs, but also the outcome on the output market. The capital structure can signal a specific behavior of the firm to the rivals on the output market or changes rivals behavior, respectively. This behavior depends

on the chosen type of capital and the market environment. The intensity of competition is either strengthened or softened.

Concluding remarks will be made in section 5. It summarizes the most important results of the presented literature and gives an outlook to the further chapters.

2.2. Theories of Capital Structure

2.2.1. Costs of Capital and the Irrelevance of Capital Structure

A large part of the corporate finance literature deals with the optimization of the capital structure of a firm. In these theories an optimal capital structure is achieved in case of lowest cost of capital. As a consequence, at this point the value of a firm is maximized. Thus, the literature tries to show whether costs of capital change with different leverages. If this was the case, an optimal capital structure should exist.

The traditional thesis of capital structure argues that there are three effects that primarily influence the costs of capital k (compare Schmidt and Terberger (1997)).

- With increasing leverage l expensive equity (costs of equity: e) is replaced by cheap debt (costs of debt: i).
- The remaining equity, however, is becoming more risky with increasing leverage. The shareholders demand a higher premium at a point which leverage exceeds some predefined boundary.
- At very high rates of leverage creditors also demand a higher premium, because repayment of interest becomes less probable.

Combining these three effects, there exists an optimal capital structure, where the costs of capital have a minimum. With statement one, for lower rates of leverage the capital costs are decreasing with increasing leverage. But with statement two and three at a certain boundary, when rates of leverage are relatively high, the costs of capital are increasing.

Contrary to the traditional thesis Modigliani and Miller (1958) argue that in a perfect capital market no optimal capital structure exists. A perfect capital market has the following characteristics (compare Schmidt and Terberger (1997)):

- All equity and debt is traded on a perfect capital market; that means no transaction costs, all market prices are identical for every market participant and known.
- There is no risk of liquidity or bankruptcy.
- The investment plans, which determine future profits, are known and independent of financing.
- It is possible to classify firms according to their business risk. At least there are two firms in every class of risk.
- Equity and debt underlie the same tax.

Figure 1 shows the results of the theorems of Modigliani and Miller (1958). The costs of debt are equal for every leverage. The costs of equity, however, linearly increase with a higher leverage, because equity becomes riskier. The costs of equity increase in a way that capital costs are equal for every capital structure and correspond the costs of a self-financed firm. As a result, no optimal capital structure exists.

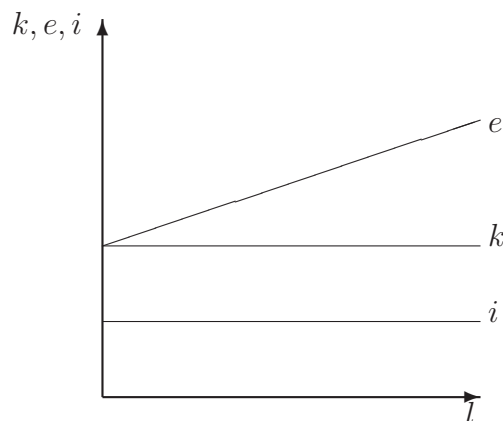


Figure 1: Capital structure according to Modigliani and Miller (1958)

The assumptions of the theorems of Modigliani and Miller (1958) are very strict. The result of a non-existence of an optimal capital structure is there-

fore very unstable against changes of the assumptions. Among others one important arm of literature stresses the assumption of the information allocation between managers and share- and stakeholder of a firm. Contrary to Modigliani and Miller (1958), in this part of literature the allocation of information is assumed to be asymmetrical. Managers are better informed about the firm than capital owners. This arm is called the neo-institutional perception.

2.2.2. Capital structure decisions under the neo-institutional perception

The central thesis of this arm of literature is that managers are able to take advantage of the asymmetric information structure. Managers have the incentive to not behave optimally from the perception of capital owners and/or creditors. Basically, there are two kinds of information problems

- Adverse Selection: Capital owners or creditors cannot differentiate firms with good investment projects from firms with bad investment projects or firms with a good management from firms with a bad management, respectively.
- Moral Hazard: After raising capital, managers of a firm have the incentive to invest in riskier projects or to behave not optimal otherwise (e.g. investing in fringe benefits, striving less).

These two information problems are discussed in the following for debt and equity financing. At this, due to the contents of our research the main focus lies on the role of debt.

Debt financing

Jensen and Meckling (1976) as well as Stiglitz and Weiss (1981) have analyzed the relationship between banks and managers of a firm in their models with asymmetric information. In these one-period models creditors are either confronted with the risk of adverse selection or moral hazard. For simplicity it is assumed that either firms have only two possible investment projects with the same expected return, but different risks (moral hazard case) or there are two

types of firms in the market with two different investment projects, a riskier and a less risky one (adverse selection case).

For the moral hazard problem it is important to analyze the incentive structure of both, the bank and the firm. Figure 2 shows the distribution of the revenues of two investment projects with the same expected return. Furthermore, the calculation of the firm can be seen. After realization of profits the firm has to repay the loan plus the interest rate ($D(1+r)$). If the firm did not earn enough profits to repay that amount, the bank would receive the remaining profits. Additionally, the bank could receive a collateral of C , if this was arranged before. Thus, for a firm all revenues upon the threshold $(D(1+r) - C)$ are of relevance. The profit of the firm is according to the repayment structure of the standard debt contract given by

$$\pi(R, \hat{r}) = \max(R - (1 + \hat{r})D; -C) \quad (2.1)$$

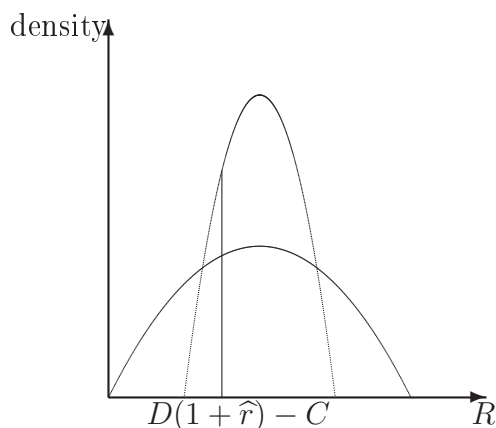


Figure 2: Revenues of two investment projects with different risks

From figure 2 it can be seen that the riskier an investment project is the higher are the expected profits of the firm after repayment of the credit. It is more valuable for a firm to invest in riskier projects than in safer ones. Managers have the incentive to shift risk from shareholders to debtholders. Applying figure 2 also for the case of adverse selection: at a certain interest rate only firms with riskier projects can repay high interest rates.

As a consequence of both problems banks claim a higher premium for their capital. These are additional capital costs for the firm. Moreover, Stiglitz and Weiss (1981) come to the conclusion that it is not valuable for banks to increase interest rates as high as possible. Banks set the interest rate to a

certain value and ration credits. Thus, banks have a safer pool of credits, but firms are possibly not able to finance all of their investment projects.

But financing with debt has not only the before mentioned problems of moral hazard or adverse selection. The literature emphasizes also other problems that arise due to asymmetric information. In the model of Myers (1977) a firm has growth or investment options, respectively. If the firm were only financed with internal capital, the firm would realize all options with a positive net present value. But a partially debt-financed firm would have the incentive, not to invest in all these options, if the owner-manager wanted to maximize the value of equity and not the value of the whole firm. But are some investments disadvantageous from the perception of the shareholders, debt causes underinvestment. Myers (1977) concludes that firms with many growth options should not be financed with debt, but with outside equity. And firms with many physical assets and only some growth options should be financed with debt. This is convenient with the proposition of Ross (1977), who emphasized that debt can be used as a signal. The firm with better prospects can issue more debt than a firm with less prospects. Mostly firms with more physical assets are able to do this.

A solution for the underinvestment problem could be according to Myers (1977) the right contract design. Credit contracts could include renegotiation, shortening of duration, monitoring and covenants, restriction of dividends or mediation.

For one period-problems Gale and Hellwig (1985) show that in a world of asymmetric information the standard debt contract is the optimal contract between a bank and an entrepreneur. This can also be found in Townsend (1979) and Williamson (1987). Gale and Hellwig (1985) assume that an entrepreneur needs external funds to completely finance its investment project ($I = D$). A competitive bank is willing to supply a loan as long as the repayment equals $\rho = (1 + r)D$. The entrepreneur is subject to limited liability. Both players are risk neutral. The projects' return is stochastic and only observable by the entrepreneur. The bank can monitor the entrepreneur, which involves costs of m .

Then the optimal contract is the standard debt contract with the following characteristics (compare Neff (2003)):

- When the firm is solvent, the contract involves a fixed repayment of $(1 + r)D$ to the bank. The bank does not participate in investment profits above $(1 + r)D$.
- If the firm cannot meet its repayment obligations, it declares bankruptcy. In this case, the bank engages in costly state verifications which induces monitoring costs of m .
- In case of bankruptcy, the firm has to transfer all its profits to the bank.

Figure 3 shows the repayment structure to the bank of the standard debt contract.

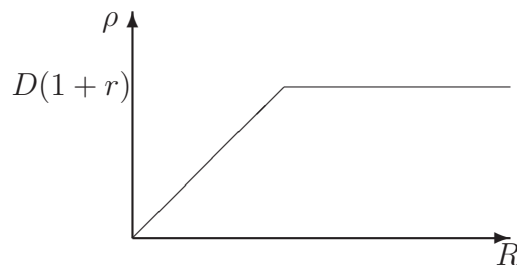


Figure 3: The standard debt contract

Equity financing

Jensen and Meckling (1976) also analyze the incentive problems of managers in case of outside equity financing. Managers of a firm have two investment opportunities: either they invest in value-creating assets or in fringe benefits that only have a personal value.

Jensen and Meckling (1976) assume that managers maximize their utility with respect to these two kinds of assets. If firms are partially financed with outside equity, the investment in fringe benefits has a relatively higher value for managers compared with value creating assets. Hence, managers invest more in fringe benefits when they are financed by outside equity. Anticipating this, outside investors are only willing to pay a lower price for the outstanding shares.

A further problem that according to Myers and Majluf (1984) the emission of new equity implicates is the problem of underinvestment. This problem arises due to the assumption that firms only want to finance new investment

projects with the emission of new equity, when it is advantageous for the old shareholders. In doing so firms try to exploit short-term information asymmetries. Firms only invest and issue new equity when they are overvalued on the market. Thus, with rational expectations after an emission-announcement of a firm investors revalue the firm. Asquith and Mullins (1986) have empirically shown that exactly this is the case, the value of a firm decreases about 2-3% after an announcement. This leads to a situation, where firms with good investment projects only issue new equity, when short-term information asymmetries does not exist. Otherwise these firms never issue new equity with the consequence that the market for new equity equals a market for lemons (compare Akerlof (1970)).

Optimal capital structure and pecking order theory

The analysis of debt and outside equity has shown that in an environment with asymmetric information raising debt or equity involves agency costs. These costs are, however, of a different kind and level. For a given level of outside financing the more a firm is financed with debt relative to outside equity the higher are the agency costs of debt. And the more a firm is financed with outside equity relative to debt the higher are the agency costs of outside equity. Combining the agency costs of debt and outside equity Jensen and Meckling (1976) have shown that for a given level of outside financing there exists an optimal mix of debt and equity, where the combined agency costs have a minimum.

But the agency costs are not only different for a given level of outside financing. Furthermore the agency costs depend on the ratio of debt and outside equity relative to the total capital of the firm. The higher the level of outside financing the higher are the agency costs for the entrepreneur. An optimal capital structure is according to Jensen and Meckling (1976) achieved, when the marginal agency costs equal the marginal value of diversification.

Thus, contrary to the theorem of Modigliani and Miller (1958), which postulates that under a perfect capital market with symmetric information no optimal capital structure exists, Jensen and Meckling (1976) demonstrate that with abolishing the assumption of symmetric information due to agency costs of outside financing an optimal capital structure exists.

Myers and Majluf (1984) come to another conclusion. Due to different agency costs of the different opportunities to finance a firm they derive a pecking-order, what kind of capital firms should use to finance their projects. These are

1. Internal financing (depreciation, restriction of dividends, etc.)
2. debt (bank loans, bonds)
3. hybrids (convertibles, options, etc.)
4. outside equity

An empirical analysis of Schwiete and Weigand (1997) show that the capital structure of companies from important industrial nations in the eighties is structured similar to the pecking-order-theory, mostly with internal capital followed by debt and as a last resort outside equity, except Japan, where the proportion of debt is higher than the proportion of internal capital.

A review of the main corporate finance literature is given by Williamson (1988). Furthermore, he confronts the literature of the agency theory with the transaction theory. He argues that whether a project should be financed by debt or by equity depends principally on the characteristics of the assets.

2.2.3. Interim result

Theories on capital structure were for a long time only driven by the investigation of capital costs. An optimal capital structure is found, where capital costs are minimized and accordingly the firm value is maximized. The literature can be split into the following two directions

- The theorems of Modigliani and Miller (1958): In a perfect capital market capital costs are identical for every capital structure. Hence, no optimal capital structure exists.
- The assumptions of a perfect capital market are too strict. Changing assumption leads to the result of the existence of an optimal capital structure, where capital costs are minimized.

One important line of the latter is the assumption of asymmetric information in the market. Entrepreneurs of a firm have better information than capital owners. This leads to incentive problems of entrepreneurs. In case of debt financing, for instance, to risk-shifting and under investment. In case of outside equity financing, for instance, to empire building or fringe benefits investments. To minimize those problems additional costs for monitoring, bonding etc. (so called agency costs) arise. These costs distinguish for different ways of financing. As a consequence, an optimal capital structure exists, where capital costs (including agency costs) are minimized.

2.3. Oligopoly models and behavior of the firm

Situations, in which decisions have to be made and the own strategy depends upon the strategic choices of others, are called strategic (compare Feess (2000)). Assuming decision-makers behave rational in such situations, these situations are also called games. But strategic decisions can only be made in an environment, where the decision-maker is able to influence the outcome of the game. Hence, strategic behavior in markets implies concentrated markets, where at least one firm has market power.

In contrast to standard-monopoly models without entry or models with perfect competition, in oligopoly models it is possible to assume strategic behavior of firms in the market. In a standard-monopoly with high entry barriers a firm has not to decide strategically, because there are no other actual or possible players in the market. The monopolist just maximizes his profit. Only in models, where market entry is possible, the monopolist can behave strategically. In a market with perfect competition firms cannot behave strategically due to their small size. The market price is given for every firm. Firms can only adjust their quantity according to that given market-price.

Thus, assuming a firm can make strategic decisions implies market power of that firm or the market itself is very concentrated, respectively. Due to the fact that we want to analyze strategic behavior later, only oligopoly models are of interest. For simplification, the analysis focuses on duopoly models. Two different market environments with different time horizons are possible, price or quantity competition. Further, additional exogenous or endogenous variables like R&D, horizontal or vertical differentiation can be integrated in

such models. An overview on a wide range of oligopolistic models can be found in Pfaehler and Wiese (1998).

The different presented models can be classified according to the recommendation of Porter (1980) on the optimal behavior of a firm. To survive in a market in the long run a firm has to aspire one of the following three strategies

- cost leadership
- product differentiation
- time leadership

The advantages of cost leadership can mainly be seen in the Cournot and Bertrand model with homogenous products. The Hotelling and the Bertrand model with heterogenous products as well as models with horizontal or vertical differentiation deal with product differentiation and its advantages. The Stackelberg game explains the advantage of time leadership.

2.3.1. Quantity competition

The classical static one period quantity competition game is called Cournot-competition (according to Cournot (1838)). In the basic Cournot model there are two firms ($i = 1, 2$) in a market competing in a one-shot quantity competition game, where no entry is possible. Both firms are risk-neutral. The quantity of the market is given by $Q = \sum q_i$. The costs c_i of firm i are to simplify matters constant and symmetric ($c_i = c \geq 0 \forall i \in n$, supposing costs are not identical would only change the positions of the best response functions and the equilibrium would not be symmetrical). The products of both firms are homogeneous. Hence, products are perfect substitutes (supposing heterogenous products would also only change the position and slope of the best response function and therefore lead to another position of the equilibrium). The revenues ($R_i = pq_i = (a - bQ)q_i$) are negatively related to the quantity of the market. Firms are faced by fixed costs of F_i . Both competitors are identical and there is perfect information in the market. That means, every variable is common knowledge for every market participant. The game is

static, both firms set their prices simultaneously. The profit-function of firm i in this market is given by

$$\Pi_i = (a - bQ - c)q_i - F_i \quad (2.2)$$

Optimizing 2.2 with regard to the quantity q_i leads to

$$q_i = \frac{a - c - bq_j}{2b} \quad (2.3)$$

The best response functions of both firms can be seen in figure 4. The optimal quantity of firm i (q_i^C) is detected at the point of intersection, which is called the Cournot-Nash equilibrium

$$q_i^C = \frac{a - c}{3b} \quad (2.4)$$

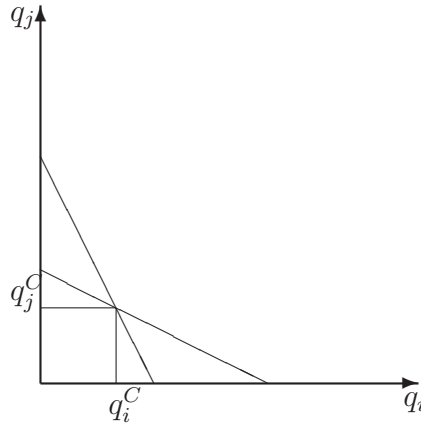


Figure 4: Quantity best response functions of firm i and j in the model of Cournot

With 2.4 the profit of firm i in the Cournot-Nash equilibrium is then

$$\Pi_i^C = \frac{(a - c)^2}{9b} - F_i \quad (2.5)$$

Without fixed costs 2.5 is positive for every $a > c$, which is always assumed. Contrary to a market with perfect competition market power in a Cournot-duopoly leads to positive profits for all firms in the market. The more firms are in an oligopolistic market the less are the individual quantities and profits of every firm in the market. This can be easily seen from the optimal quantity $q^C = \frac{a-c}{(n+1)b}$ and profit $\Pi_i^C = \frac{a-c}{(n+1)^2b}$ in such a situation.

A Cournot market with homogenous goods has the following implications (compare Pfaehler and Wiese (1998)):

- The oligopolistic market structure can only be expected, if there exist either entry barriers with high entry costs or the marginal costs of a further firm is higher than the equilibrium price of the oligopoly.
- All firms in the market have the incentive to decrease marginal costs and to increase the demand of the industry, because both rises the profit of all firms.
- Additionally, every firm has the incentive either to decrease its own marginal cost or to raise rivals marginal costs, respectively. Having lower marginal costs leads at least to higher profits than the rival. For a market price lower than rivals marginal costs it even leads to a monopoly.

The quantity approach of Cournot is basis for many other similar competition models, e.g. models with heterogenous goods or with time leadership of one company (compare Stackelberg (1934)), but these models are not of interest for the own research and therefore neglected.

2.3.2. Price competition

The classical static one shot price game is called Bertrand-Competition game (according to Bertrand (1883)). The setup of the game is similar to the quantity game of Cournot, except the strategic variable is not the quantity, but the price. Interestingly, the outcome of the Bertrand game with homogenous products is very different to the Cournot competition game. Due to the assumption of a perfect market, which includes that the customers have no preferences and there are no transaction costs, the customers always buy from the firm with the lowest price. Hence, for every price the competitor sets, a firm has the incentive to set its own price marginally lower. This is possible as long as $p_i \geq c_i$. Thus, for similar marginal costs in the Bertrand-Nash-equilibrium prices equal marginal costs and both firms earn zero profits. This result, however, is - even compared to the result of Cournot - very strong. Thus, other authors include the fact that markets are normally imperfect or suppose that products are heterogenous (at least from the perspective of the consumer).

One important price competition model with heterogenous products is the approach of Hotelling (compare Hotelling (1929) and with enhancements

D'Aspremont, Gabszewicz, and Thisse (1979), the illustration of the Hotelling model is geared to the analysis of Pfaehler and Wiese (1998)). In his model Hotelling describes the preference of the consumers as a uniformed distribution. The preferences are mapped on the so called Hotelling line, which is an unit line with length one. The location of firm i is marked with a_i , which is a number between 0 and 1. It is assumed that every firm can only have one location. Thus, the locations of two firms can be described by

$$0 \leq a_i \leq a_j \leq 1 \quad (2.6)$$

with $i \neq j$. If both firms have the same location or if the products of both firms are homogenous, respectively, it holds $a_i = a_j$.

Production costs are assumed to be constant and identical for both firms $c_i = c_j = c$. Further costs of product differentiation are neglected. Market entry involves fixed costs of F_i .

Every consumer has different preferences and therefore another location on the Hotelling line. The position of a consumer is marked with $0 \leq h \leq 1$. The distance between a firm and a consumer is therefore $|h - a_i|$ or $|a_j - h|$, respectively. The distance can be either interpreted as the regional distance or the difference between the preference of the consumer and the design of the product of a firm. Independent of the interpretation the difference involves costs for the consumers. These costs depend on the distance to the firms and are assumed to be

$$K_i(h) = t(h - a_i)^2 \quad (2.7)$$

$$K_j(h) = t(a_j - h)^2 \quad (2.8)$$

t can be interpreted as transportation costs or the parameter of heterogeneity, respectively. The higher t , the more weighted is the distance to the firms. For $t = 0$ the location of a firm is irrelevant or the products of both firms are valued as homogenous. The Hotelling line is illustrated in figure 5.

Consumers buy from the firm which guarantees the highest consumer surplus CP_i , which consists of the individual willingness to pay WP for the product less the effective price p_i^{eff} . The price of the product plus the transportation costs build together the effective price.

$$CP_i = WP - p_i^{eff} = WP - (p_i + t(h - a_i)^2) \quad (2.9)$$

$$CP_j = WP - p_j^{eff} = WP - (p_j + t(a_j - h)^2) \quad (2.10)$$

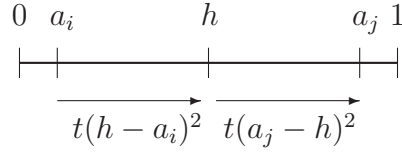


Figure 5: The Hotelling line

Due to the assumption of uniformly distributed consumer preferences on the Hotelling line, for every location of each firm there has to exist a consumer h^* who is indifferent between both products. All consumers left of him buy from firm i and all consumers right of him from firm j . The market share of firm i depends on the prices of both firms and is given by $\sigma_i^H(p_i, p_j) = h^*$. The market share of the other firm is consequently $\sigma_j^H(p_i, p_j) = 1 - h^*$. Both market shares are assumed to be positive.

Generally, a consumer at location h will buy from firm i , if

$$p_i^{eff} = p_i + t(h - a_i)^2 \leq p_j + t(a_j - h)^2 = p_j^{eff} \quad (2.11)$$

Solving 2.11 for h leads to

$$h \leq \frac{a_i + a_j}{2} + \frac{p_j - p_i}{2t(a_j - a_i)} =: h^* \quad (2.12)$$

All consumers for whom 2.12 holds buy from firm i . h^* is again the position of the indifferent consumer. Hence, the demand function of both firms are

$$\sigma_i^H(p_i, p_j, a_i, a_j) = h^* = \frac{a_i + a_j}{2} + \frac{p_j - p_i}{2t(a_j - a_i)} \quad (2.13)$$

$$\sigma_j^H(p_i, p_j, a_i, a_j) = 1 - h^* = 1 - \frac{a_i + a_j}{2} - \frac{p_j - p_i}{2t(a_j - a_i)} \quad (2.14)$$

Assuming the highest possible product differentiation with one firm at every end of the Hotelling line, $a_i = 0$ and $a_j = 1$ ($\Delta a = 1$), demand functions are reduced to

$$\sigma_i^H(p_i, p_j, 0, 1) = \frac{1}{2} + \frac{p_j - p_i}{2t} \quad (2.15)$$

$$\sigma_j^H(p_i, p_j, 0, 1) = \frac{1}{2} + \frac{p_i - p_j}{2t} \quad (2.16)$$

Given symmetry in the market optimal prices are equal and given by

$$p_i^* = c + t \quad (2.17)$$

Optimal prices correspond to marginal costs and the heterogeneity parameter. Thus, prices are higher than with homogenous goods. Every firm supplies half of the market and makes a profit of $\Pi_i = \frac{t}{2}$. Figure 6 summarizes the results.

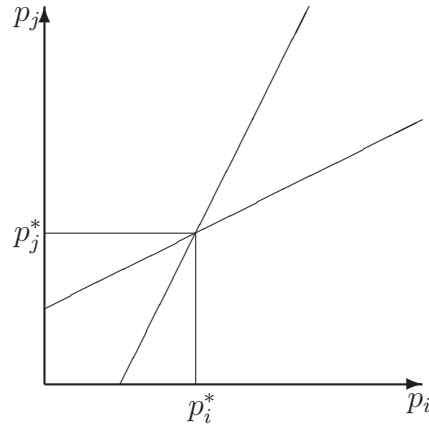


Figure 6: Price best response functions of firm i and j

The Hotelling model has the following implications (compare Pfaehler and Wiese (1998))

- Every firm has a natural customer base (all consumers left of a_i and right of a_j).
- The goods are normal goods. If firm i increases prices, it will lose market share to firm j .
- A price advantage of one firm leads to a bigger market share compared with the other firm.
- Product differentiation decreases the intensity of competition. The higher the transportation costs t or the larger the distance between both firms $\Delta a = a_j - a_i$ is the less important are prices of both firms.

2.3.3. Competition with horizontal and vertical differentiation

Already the Hotelling model includes product differentiation, but only in the expression of consumer preferences. In this chapter models are presented which include a further decision variable. In addition to the price decision firms can

either choose their marketing expenses or their product quality to influence market outcome.

Horizontal or vertical differentiation of a firm normally involves marketing for the differentiated product. Without marketing campaigns potential consumers do not know the advantages and differences of the respective product compared to rivals products. Grossman and Shapiro (1984) integrate therefore the marketing decision into a price competition model. Price competition is based on the Hotelling model. In the model firms will be only able to sell products, if they also invest in marketing to make their product known in the market. But, as the price decision, marketing decisions of firms depend on each other. The more a firm invests in marketing the more it increases its brand awareness f_i but the more it also competes with other firms in the market. Assuming a duopoly with two firms at the respective end of the Hotelling line the profit function of firm i is given by

$$\Pi_i = (p_i - c) \left(f_i(1 - f_j) + f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) \right) - \frac{w}{2} f_i^2 \quad (2.18)$$

From 2.18 for symmetric firms a solution for optimal prices and brand awareness can be easily found. This is

$$p_i^* = c + \sqrt{\frac{2w}{t}} t \quad (2.19)$$

$$f_i^* = \frac{2}{1 + \sqrt{\frac{2w}{t}}} \quad (2.20)$$

with $\sqrt{\frac{2w}{t}} \geq 1$. With the additional marketing variable optimal prices (2.19) are in equilibrium higher than in the standard Hotelling model (2.17). Quantities (market shares) are lower, because firms do not supply the whole market $\sigma^* = \frac{2\sqrt{\frac{2w}{t}}}{(1 + \sqrt{\frac{2w}{t}})^2} \leq \frac{1}{2}$. Optimal profits are $\Pi_i^* = \frac{2w}{(1 + \sqrt{\frac{2w}{t}})^2}$. Interestingly, optimal profits increase with a higher marketing cost parameter w due to less marketing and higher prices in equilibrium.

Gabszewicz and Thisse (1979), Gabszewicz and Thisse (1980), Shaked and Sutton (1982) and Shaked and Sutton (1983) were the first, who developed quality competition models. Price competition in such models is without differentiation as in Bertrand (1883) so fierce that firms earn zero profits. Thus, it is valuable for firms to differentiate their products by incremental quality

improvements. Demand in the markets is supposed to exist for both types of quality (for instance think of the perception of high quality products of industrialized countries vs. the perception of low quality products of low cost countries). The market structure is as follows (the illustration is geared to Tirole (1988)):

Two firms in a market are supposed to supply products to consumers with different qualities s_i . At this, firm 1 is assumed to be the high quality firm and firm 2 the low quality firm ($s_1 > s_2$). Further, production costs of both firms are constant and equal ($c = c_1 = c_2$).

On the demand side the utility of every consumer is positively influenced by the quality of the product and negatively by the price. Hence, the utility function of a consumer is given by

$$U = \theta s - p \tag{2.21}$$

Every consumer buys at most one unit of the product. If a consumer did not purchase a product, his utility would be zero. Let the parameter $\theta \in [\underline{\theta}, \bar{\theta}]$ describe the importance of quality for a certain consumer. Let θ be uniformly distributed over a population of consumers with $\underline{\theta} > 0$ and $\bar{\theta} = \underline{\theta} + 1$. The density is one. It is important to notice that with a higher value of $\underline{\theta}$ the difference between consumer tastes decrease.

For simplification and to let vertical differentiation be valuable, two further assumptions are made.

1. $\bar{\theta} \geq 2\underline{\theta} \Leftrightarrow \underline{\theta} \leq 1$

This assumption guarantees a certain heterogeneity between the consumers. In the case of a lower heterogeneity, supplying different qualities is not valuable.

2. $p_2 \leq \underline{\theta}s_2$

This assumption guarantees that in equilibrium the whole demand is satisfied.

With these two assumptions the whole demand can be divided into the demand of the high quality and the low quality firm. Depending on prices and qualities of both firms, consumers buy either from the high quality or the low quality firm. The critical consumer evaluates both products equally, which means

$\theta s_1 - p_1 = \theta s_2 - p_2$. The demand for both products is given by

$$D_1(p_1, p_2) = \frac{\bar{\theta} - \frac{p_1 - p_2}{s_1 - s_2}}{s_1 - s_2} \quad (2.22)$$

$$D_2(p_1, p_2) = \frac{\frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta}}{s_1 - s_2} \quad (2.23)$$

Profits of both firms are given by $\Pi_i = (p_i - c)D_i(p_i, p_j)$. Optimizing both maximization problems and solving the system of two best response functions leads to the Nash-equilibrium

$$p_1 = c + \frac{2\bar{\theta} - \underline{\theta}}{3}(s_1 - s_2) \quad (2.24)$$

$$p_2 = c + \frac{\bar{\theta} - 2\underline{\theta}}{3}(s_1 - s_2) \quad (2.25)$$

The optimal price of the high quality firm (2.24) is higher than the price of the low quality firm (2.25). This is also true for the profits ($\Pi_1 = \frac{(2\bar{\theta} - \underline{\theta})^2(s_1 - s_2)}{9} > \frac{(\bar{\theta} - 2\underline{\theta})^2(s_1 - s_2)}{9} = \Pi_2$). The quality choice of both firms can be easily determined. Both profits increase with the quality difference of both companies. Consequently, the high quality firm chooses the maximum and the low quality firm the minimum quality.

2.3.4. Interim results

This chapter has summarized different models of product market competition. The models show that market outcomes strongly depend on the type of competition in the market. An intensified competition is for instance boosted by competition in prices, supply of homogenous goods or the same type of quality. Thus, as Porter (1980) recommends, to survive in a market in the long run a firm has to aspire either cost leadership, product differentiation or time leadership. The influence of the market environment can be also seen in the next chapter where models are discussed which combine the capital market and product market decision.

2.4. Capital market decisions and product market behavior

Until now, firms behavior on two different markets were analyzed: on the one hand its activity on the capital market and on the other hand its strategy on

the output market. But the behavior on both markets should not be analyzed separately. The behavior in one market can effect the optimal behavior in the other market. Capital market decisions influence product market decisions and vice versa. The focus of our research and thus of this overview lies on the first, the effects of a firms capital structure on the optimal behavior on the output market. Brander and Lewis (1986) were the first, who analyze this interdependence for firms acting in markets with quantity competition. Since then, many papers followed with modified assumptions. Mainly, models in the literature differ in the following three ways:

- the assumed and analyzed capital structure of a firm (inside vs. outside capital, debt vs equity, etc.)
- the type of competition in the market (quantity, price, R&D, etc.)
- time horizon (static, repeated, etc.)

Most of the oligopoly models are reduced to a duopoly situation due to the easier way of modeling and similar or stronger results than compared to models with more firms in the market. The results of the models differ in accordance with different assumptions. As in the prior section discussed, debt implies other incentive problems than outside equity and, for instance, quantity competition implies other optimal behavior of firms than price competition. The overview of the literature is structured according to the time horizon.

1. static one period models
2. dynamic models with finite horizons
3. dynamic models with infinite horizons

For all cases different models of capital structure and competition are presented. At this, due to own research interests most of the models deal with the effects of debt on product market behavior. A range of models that stress the effects of outside equity also exist, but are neglected in the presentation.

2.4.1. Static models of capital structure and product market competition

Brander and Lewis (1986) and Brander and Lewis (1988) analyze capital structure effects in a Cournot competition environment. Two symmetric firms compete in a market under uncertainty. Uncertainty is described by z and can affect either demand or marginal costs. The structure of the game is as follows: first both firms choose their capital structure and after that their quantity. Finally, nature decides on the realized state of the world. Brander and Lewis (1986) assume that independent of the capital structure, managers behave in the interest of shareholders. As in the first section discussed, in case of debt-financing managers are assumed to be only aware of good states of the world (where demand is high or marginal costs are low). If firms are protected by limited liability, managers will try to shift risk to debt holders. Managers of a partially debt-financed firm optimize the following payoff function

$$V_i = \int_{\hat{z}_i}^{\bar{z}} (\Pi_i(q_i, q_j, z_i) - D_i) f(z_i) dz_i \quad (2.26)$$

with $\Pi_i(q_i, q_j, \hat{z}_i) - D_i = 0$. Note that the critical value \hat{z}_i depends on both, quantities and the amount of the firms own debt. However, the debt level of the rival does not affect the critical value of the firm in focus.

Brander and Lewis (1986) come to the following results: If firms amass debt, equity oriented managers will behave more aggressive on the output market. The output-level of a debt-financed firm is increasing, while the output of the equity financed firm is decreasing. In this case the profit of the debt-financed firm is higher than before. The profit of the equity financed firm is lower. Due to symmetry, however, both firms have the incentive to take up debt. Thus, in equilibrium both firms are strategically financed partly by debt. This reduces the profits of both firms. The situation is comparable to the prisoner's dilemma. Figure 7 summarizes the results and shows best response functions of both firms and the new equilibrium S .

Contrary to the Cournot competition analysis Showalter (1995) models the implications of capital structure in a differentiated Bertrand competition framework. Like Brander and Lewis (1986) he analyzes cost and demand uncertainty. The structure of the game is similar to the game of Brander and Lewis (1986).

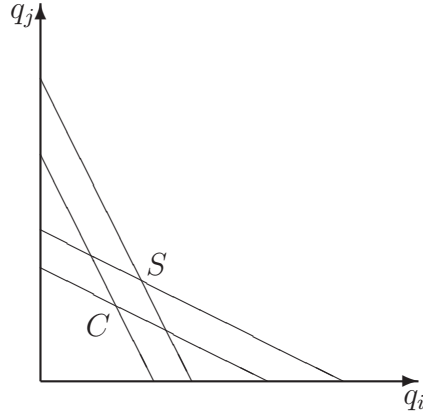


Figure 7: Cournot equilibrium in the model of Brander and Lewis (1986)

In the model of Showalter (1995) managers of a partially debt-financed firm optimize the following payoff function

$$V_i = \int_{\hat{z}_i}^{\bar{z}} (\Pi_i(p_i, p_j, z_i) - D_i) f(z_i) dz_i \quad (2.27)$$

with $\Pi_i(p_i, p_j, \hat{z}_i) - D_i = 0$. Again the critical value \hat{z}_i depends only on both, prices and the amount of the firms own debt. The debt level of the rival does not affect the critical value.

Contrary to the quantity model of Brander and Lewis (1986) the two different kinds of uncertainty lead to two different results of the game. Under cost uncertainty an increase in debt leads to decreasing prices. Thus, in equilibrium firms have no incentive to hold debt strategically and are both purely financed by equity. Under demand uncertainty, however, prices in the market will increase. Hence, firms choose under these circumstances strategically positive debt-levels. Figure 8 summarizes the results in case of demand uncertainty. Best response functions of both firms shift outside. The equilibrium with positive debt-levels induces higher equilibrium prices.

Wanzenried (2003) stresses on capital structure decisions under demand uncertainty in general. She comes to the result that the choice of firms' capital structure depends on specific output market characteristics. The higher the volatility in demand, the higher the firms' leverage. The debt level is highest for the lowest substitutability between varieties. The insights of Wanzenried (2003) are based on the work of Hughes, Kao, and Mukherji (1998) who also investigate capital structure under demand uncertainty. They find out that the consequences of issuing debt are invariant to the level of uncertainty, given

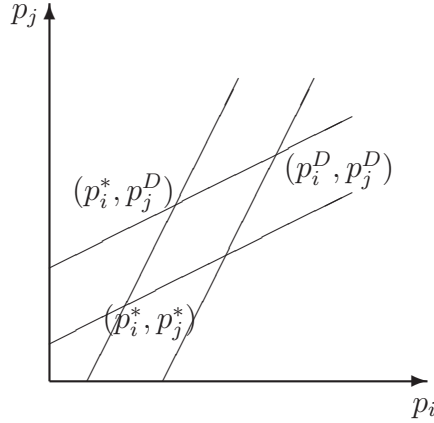


Figure 8: Market equilibrium under demand uncertainty

that firms can recalibrate the terms of debt to achieve the Stackelberg solution. Franck and Pape (2008) and Haan and Toolsema (2008), however, recalculate the models and come to other results. Both argue that chosen debt levels of both firms influence the default risk of a firm and not only their own. With the adjusted assumption Haan and Toolsema (2008) come to the result that the equilibrium debt level decreases as demand becomes more volatile.

Chen (2005) integrates the R&D decision of a firm as an additional variable into a model with Cournot competition. Firms in the market operate in a RJV to decrease marginal costs. The model has three stages: First, firms choose their capital structure, second, the level of R&D and, at last, the quantity. The expected profit of a firm is given by

$$V_i = \int_{\underline{z}}^{\bar{z}} [(a - q - c + z_i + x)q_i - \frac{w}{2}x_i^2]f(z_i)dz_i \quad (2.28)$$

Expected marginal costs are directly influenced by the amount of overall research investment ($x = \sum_{i=1}^n x_i$). However, costs are uncertain due to the parameter z , which is not influenced by research investments. Backward induction leads to optimal quantities and research investments. Under self-financing of both firms in the market these are given by

$$q_i = \frac{3w}{9w - 4}(a - c) \quad (2.29)$$

$$x_i = \frac{2}{9w - 4}(a - c) \quad (2.30)$$

If firms in the market accumulate debt, they will (as without the R&D decision) tend to behave more aggressive in the market. But not only output, also R&D

investment increases. As a consequence, firms profits decline with the level of debt. In case of different capital structures in the market with one self-financed and one debt-financed firm, profits of the debt-financed firm are lowest. The self-financed firm in turn takes advantage of higher R&D investments of the rival. Taking the R&D decision into account in equilibrium both firms are self-financed. This result stays in contrast to the result of Brander and Lewis (1986), where debt-financed firm earns highest profits in asymmetric industries and, as a consequence, firms are in equilibrium debt-financed.

2.4.2. Dynamic models of capital structure and product market competition

The interdependence of capital structure and product market decisions are not only applicable in static frameworks, but also in a more dynamic. In the following three different kind of dynamic models of capital structure and product market competition will be presented. The models can be distinguished in the amount of periods or the market structure, respectively.

1. market entry games
2. two period models
3. n-period models

In market entry games a monopolist is faced by potential entrants in the market. Two period models are characterized by the enlargement of the static one period duopoly framework to a dynamic two period one. In n-period models the one-period game is played over n periods.

1. Market entry games

Showalter (1999a) models market entry in a Bertrand competition environment. After a possible entry the incumbent competes with the entrant in prices. The model is similar to the static Bertrand framework of Showalter (1995). Again, Showalter (1999a) distinguishes between cost and demand uncertainty. The results are similar to the results of Showalter (1995). Under cost uncertainty prices fall with an increase of debt. Hence, the incumbent

takes up debt strategically to deter entry. Under demand uncertainty, however, prices are rising with positive debt levels. The incumbent cannot deter entry, but takes up debt strategically to soften competition afterwards.

Poitevin (1989), however, analyzes a market entry game with Cournot competition. In the model firms can choose between debt financing and external equity financing. The game has three steps: First, the entrant chooses its capital structure and decides whether to enter the market or not. Second, the incumbent chooses its capital structure. At last, firms play a Cournot quantity game. Whereas marginal costs of the incumbent are common knowledge, marginal costs of the entrant are private information. Thus, the capital structure of a firm serves as a signal for outside investors. Poitevin (1989) come to the following results: A low-cost entrant should be partially financed by debt to signal its cost structure to the market. The incumbent, however, should be entirely financed by equity, because due to the positive leverage of the entrant a predatory behavior is valuable. This result stands in contrast to the one-period model of Brander and Lewis (1986), where the leveraged firms behaves more aggressive than the unleveraged firm.

Lambrecht (2001) focuses on the interaction between market entry, company foreclosure, and capital structure in a duopoly. He comes to the result that the order in which firms foreclose is determined not only by differences in firm-specific factors. Common factors, such as the interest rate and the market profit volatility play also an important role. Furthermore, firms with high bankruptcy costs or with prospects of profit improvement can get bigger reductions on their debt repayments. Financial vulnerability of the incumbent induces earlier entry.

2. Two-Period models

In the model of Bolton and Scharfstein (1990) two firms compete in a market over two periods. Both firms have an investment project at the beginning of both periods with investment costs of I_t . The returns of the investment projects are uncertain. In every period both firms can make a high profit with $\Pi^H > I_t$ or a low profit with $\Pi^L < I_t$, which are stochastically independent over the periods. It is common knowledge that the expected profits of both periods are positive ($E(\Pi) = \theta\Pi^H + (1 - \theta)\Pi^L > I_t$), but the realized profits in both periods are not observable by outside investors. Outside investors rely

on reported profits. Firms are subject to limited liability. The discount rate is zero. Demand is not explicitly given.

One firm needs external capital, which is only given by banks. It is assumed that banks have the complete bargaining power. The bank makes the firm a take-it-or-leave-it-offer. The contract maximizes the wealth of the bank with respect to the participation, incentive and limited liability constraints of the firm. It determines the repayments to the bank (R^k) and a possible exit of the bank after the first period (β^k). The bank and the firm are both risk-neutral. Thus, the maximization problem of the bank is given by

$$\max_{\beta^k, R_1^k, R_2^k} W = \theta[R_1^H + \beta^H(R_2^H - I_2)] + (1 - \theta)[R_1^L + \beta^L(R_2^L - I_2)] - I_1 \quad (2.31)$$

subject to the incentive constraint of the firm

$$\Pi_1^H - R_1^H + \beta^H(E(\Pi_2) - R_2) \geq \Pi_1^L - R_1^L + \beta^L(E(\Pi_2) - R_2) \quad (2.32)$$

which ensures a truthful reporting of the firm. The static and intertemporal limited liability are given by

$$\begin{aligned} \Pi_t^k &\geq R_t^k \\ \Pi_1^k + \Pi_2^k &\geq R_1^k + R_2^k \end{aligned} \quad (2.33)$$

At last the participation constraint of the firm is given by

$$\theta[\Pi_1^H - R_1^H + \beta^H(E(\Pi_2) - R_2)] + (1 - \theta)[\Pi_1^L - R_1^L + \beta^L(E(\Pi_2) - R_2)] \geq 0 \quad (2.34)$$

The maximization problem can be solved by backward induction. On the last stage firms have always the incentive to report bad profits due to the non-observability of profits by outside investors and limited liability. Thus, on the last stage banks only receive $R_2 = \Pi^L$. Furthermore, Bolton and Scharfstein (1990) show that the incentive constraint 2.32 is binding. This reduces the maximization problem of the bank 2.31 to

$$\max_{\beta^k, R_1^k} W = \beta^H \theta(E(\Pi_2) - I_2) - \beta^L(\theta E(\Pi_2) - \Pi^L + (1 - \theta)I_2) + R_1^L - I_1 \quad (2.35)$$

It is obvious that financing in the case of a reported low profit is not valuable for the bank. Therefore, banks will always exit financing after the first period,

if the firm reports low profits ($\beta^L = 0$), and continues financing, if the firm reports high profits ($\beta^H = 1$). Taking this into account and the fact that 2.32 has to be binding, the optimal contract in the model of Bolton and Scharfstein (1990) has the following design: The bank invests at date 0 in case of $I_t \leq \frac{\theta E(\Pi) + \Pi^L}{1 + \theta}$. In this case, $R_1^L = \Pi^L$, $\beta^L = 0$, $R_1^H = E(\Pi)$, $\beta^H = 1$. The firm only operates in the second period if its first-period profits are Π^H .

This outcome is inefficient, because the expected profit of the firm in the second period is independent of the first period and positive. But due to the strong assumption that state verification is not possible, it is not valuable for the bank to finance the firm. Bolton and Scharfstein (1990) show in the second part of their paper that such contracts can influence the outcome of the product market competition. If it is possible for the equity financed firm to decrease the probability of the good state (θ) of the debt-financed firm, e.g. by reducing its price or increasing its spending for advertising, it will be rather possible to squeeze the other firm out of the market. If it is valuable, the equity-financed firm will do this and become a monopolist.

Neff (1999) has developed a two-period model with R&D and price competition. The model framework is based on the work of Bolton and Scharfstein (1990), but more concretized with respect to the product market competition stage. Two symmetric firms have the opportunity to become cost leader in case of a successful cost cutting innovation. Hence, in every period both firms invest on the first stage in R&D to potentially reduce their marginal costs. The innovation success is stochastic. θ_i represents the innovation probability of firm i . R&D investments directly influence this probability. R&D costs are assumed to be a convex function $g_i(\theta_i)$. At the second stage price competition is based on the Hotelling model with $\Pi_i = (p_i - c)(\frac{1}{2} + \frac{p_j - p_i}{t})$. Optimal profits during the second stage depend on innovations in the first stage. Thus, either both firms have innovation success or not and share the market equally (Π_i^S) or one of the two firms has a cost advantage and therefore a lower price with higher demand (Π_i^A and Π_j^D). The profit of a firm on the first stage is given by

$$V_i = \theta_i(\theta_j \Pi_i^S + (1 - \theta_j) \Pi_i^A) + (1 - \theta_i)(\theta_j \Pi_i^D + (1 - \theta_j) \Pi_i^S) - g_i(\theta_i) - F_t \quad (2.36)$$

Optimizing 2.36 on the first stage and taking symmetry into account results in

$$\hat{\theta}_i = \frac{(\Pi_i^A - \Pi_i^S)}{\frac{g'(\theta)}{\theta} + (\Pi_i^A - 2\Pi_i^S + \Pi_i^D)} \quad (2.37)$$

Firms optimal R&D investment depends mainly on the differences of the different states. In the analysis over two periods Neff (1999) comes to the result that if one firm has already a cost advantage after period one, this firm will invest more in R&D activities than the cost follower. Moreover, if potential gains from innovation are very high, firms in symmetric market positions will compete more fiercely in the second-period R&D game than firms in asymmetric market positions ($\theta^S > \theta^A > \theta^D$).

The integration of debt in the model occurs in the same way as in Bolton and Scharfstein (1990). Assumptions on the optimal financial contract are identical. The debt-financed firm receives a loan from a bank. The bank tries to maximize its repayment under the participation, incentive, and intertemporal limited liability constraints. Under these conditions Neff (1999) comes to the result that if firm i is externally financed via a long term debt contract, its optimal first-period R&D activities will decrease. The self-financed rival j , on the other hand, will increase its level of first-period R&D activities. Furthermore, if both firms need external debt to finance the fixed production costs, their levels of optimal R&D activities in the first period will decrease. As a consequence of the reduced R&D activities, product prices will increase.

In contrast to the model of Bolton and Scharfstein (1990) and as the model of Neff (1999) the model of Chevalier and Scharfstein (1996) integrates the product market stage more explicit. On the product market stage there is price competition designed as a combination of the Hotelling model and the consumer switching cost model of Klemperer (1995). In the first period consumers have to pay a transportation cost according to their distance to the two firms. In the second period consumers will have to pay a switching cost, if they want to switch to the other firm. The market share σ_i of both firms is also taken from the Hotelling model ($\sigma_i^H(p_i, p_j) = \frac{1}{2} + \frac{p_j - p_i}{2t}$).

For simplicity switching costs are assumed to be such high that customers are loyal and willing to pay the reservation price p^r in the second period. Production costs c are constant and identical for both firms in every period.

Furthermore, firms have to make an initial investment I to be able to start production. The market size in the first period is stochastic and therefore not exactly known by firms in the market. Firms are only aware of the existence of two possible market sizes, a high market size z^H with probability θ or a low market size z^L with probability $1 - \theta$. Hence, the expected market size in the first period is given by $\bar{z} = \theta z^H + (1 - \theta)z^L$. The market size in the second period is normalized to one. For simplicity, firms value future profits similar to current profits. The discount rate is supposed to be one. The profit of firm i over both periods is given by

$$\begin{aligned} \Pi_i &= (p_i - c)\bar{z} \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) - I && \text{period 1} \\ &+ (p^r - c) \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) && \text{period 2} \end{aligned} \quad (2.38)$$

Optimizing 2.38 over both periods with respect to the price in the first period the optimal price is given by

$$p_i^* = c + t - \frac{p^r - c}{\bar{z}} \quad (2.39)$$

Moreover in case of debt-financed firms, the financial contract has another design as in Bolton and Scharfstein (1990). Firms only need money in the first period to cover their initial investment. Therefore, firms have to borrow debt in the amount of I . Assuming asymmetric information in the market, banks cannot verify the true state of the world. The bank calls for a repayment of R^H after the first period. If the firm cannot repay the loan, the bank will have the right to liquidate the firm assets after the second period. It is assumed that firms can repay the loan only in the good state ($\Pi_i(z^L) < R^H \leq \Pi_i(z^H)$). Thus, in the good state of the world firms repay the loan after the first period and receive the whole revenue of the second period. In the bad state of the world the owner-manager keeps the first-period profits by himself and repays nothing. As a consequence, the bank assumes control and the entrepreneur receives nothing in the second period. In this case the bank receives nothing in the first period and full revenues of the second period, which is assumed to have a lower value for the bank ($l \cdot \Pi_{i2}$ with $0 < l < 1$). In conclusion, the bank is willing to lend if its expected payoff is nonnegative

$$V^B = \theta R^H + (1 - \theta)l(p^r - c) \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) - I \geq 0 \quad (2.40)$$

Taking the financial contract into account the expected payoff of entrepreneur i changes to

$$\begin{aligned}\Pi_i^D &= (p_i - c)\bar{z} \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) - \theta R^H && \text{period 1} \\ &+ \theta(p^r - c) \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) && \text{period 2}\end{aligned}\quad (2.41)$$

The design of the contract guarantees a similar profit for the first period except the repayment to the bank, which the entrepreneur only pays in the good state. The profit of the second period accrues correspondingly also only in the good state. Firms optimize 2.41 with regard to the price in the first period. This leads to

$$p_i^D = c + t - \theta \frac{p^r - c}{\bar{z}} \quad (2.42)$$

The optimal price of both firms is higher under debt-financing (2.42) than under self-financing (2.39). If one firm is self-financed and the rival debt-financed, optimal prices change to

$$p_i^* = c + t - \frac{p^r - c}{\bar{z}} + \frac{1}{3}(1 - \theta) \frac{p^r - c}{\bar{z}} \quad (2.43)$$

$$p_j^D = c + t - \frac{p^r - c}{\bar{z}} + \frac{2}{3}(1 - \theta) \frac{p^r - c}{\bar{z}} \quad (2.44)$$

In this case the debt-financed firm demands a higher price (2.44) than the self-financed firm (2.43). Both prices are, however, higher than in the case with two self-financed firms (2.39) and lower than in the case of two debt-financed firms (2.42). The results are similar to the outcome of Showalter (1995) and can also be seen in figure 8.

Dasgupta and Titman (1998) stresses on a two-period model with price competition and firms capital need in both periods. On the financial stage, banks lend long term debt in the first and short term debt in the second period. Dasgupta and Titman (1998) come to similar results as Chevalier and Scharfstein (1996). If a firm takes up long-term debt and requires additional debt to finance the second period investment, its first-period price increases in the level of existing debt. Rival's first-period price is also increasing with the existing debt level. If one firm unilaterally increases its long-term debt, while the rival is self-financed, first-period price of that firm will be higher than the price of the self-financed rival.

In their previous work, Dasgupta and Titman (1996) integrate product quality in their two-period model. Firm i is the known high quality firm in the market. Firm j can choose between a high and a low quality before both firms set prices. Qualities are not known by consumers. The only signal to the consumers is the offered price of the product. Dasgupta and Titman (1996) come to the following result: If firm i is completely self-financed, while firm j needs external debt financing, both firms will produce high quality and choose lower first-period prices than under complete self financing. The integration of the quality decision into the model makes price competition more intense.

Stadler (1997) combines the before mentioned models. The financial contract is designed as of Bolton and Scharfstein (1990) and the product market stage as of Chevalier and Scharfstein (1996). The outcome is similar to these models. If a firm is debt-financed, price competition will be softened. Product prices are higher than without debt financing.

3. n-period models

Maksimovic (1988) analyzes the effects of capital structure on repeated oligopolies. In every period firms first decide simultaneously on their capital structure and play after that a Cournot competition game, where industries demand and costs are constant over time. Maksimovic (1988) comes to the result that there exist an upper bound on the firm's debt level in the absence of bankruptcy costs. This bound depends on the number of firms in the industry, the discount rate, the elasticity of demand, and other related factors. Debt makes collusion more difficult to sustain.

Damania (1997) also stresses on repeated oligopolies with Cournot competition. In his model he integrates stochastic demand fluctuations. Contrary to Maksimovic (1988) debt facilitates tacit collusion, when perfect collusion is not feasible. Damania (1997) constitutes this finding with the outcome of the static model of Brander and Lewis (1986). Due to the more aggressive behavior of firms in case of debt financing firms have lower payoffs after a defection. Consequently, firms have a lower incentive to deviate from collusion.

2.4.3. Empirical findings of capital structure and product market competition

Most of the before analyzed models are confirmed by empirical studies. In the following a short overview of the existing empirical studies and its links to the theoretical models will be given. The approach of the different empirical works is similar. To investigate effects of capital structure, industries are of interest where the capital structure of firms is already or becomes due to a strong change in capital structure very different, respectively. Thus, most of the studies investigate industries where firms are in financial distress or have a strong change in their capital structure, e.g. by a Leveraged Buyout (LBO). A Leveraged Buyout is a debt-financed takeover transaction, by which the firm's assets serve as collateral for the required bank-loans (compare Neff (2003)).

Opler and Titman (1994) study firms in situations of financial distress. Highly leveraged firms lose market shares to their less leveraged competitors. An increase in debt level - especially in R&D intensive industries - leads to an inferior competitive market position. This confirms to the model of Neff (1999).

Campello and Fluck (2004) investigate the consequences of negative demand shocks in 57 different industries during the recession of 1990/91 in America. They also come to the result that firms with a high leverage significantly lose market shares to firms with a low leverage. Furthermore, the loss of market share of highly debt financed firms is more pronounced in industries where low debt usage is the norm and in industries with high consumer switching costs.

Phillips (1995) investigates four different industries, in which the leverage of firms are strongly changed by a LBO. In three of these industries, namely fiberglass insulation, tractor trailer and polyethylene industry, where barriers to entry are high, output is negatively associated with the average industry debt ratio. Hence, product prices are higher. Thus, highly leveraged firms behave less aggressive in the market. Moreover, they lose market share to their less leveraged competitors. These findings correspond to the models of Glazer (1989), Phillips (1992), Showalter (1995) and Dasgupta and Titman (1998).

In the fourth industry, the gypsum industry, product prices are negatively related to the average debt ratio of the industry. Output is increasing. In this

industry barriers to entry are low, the production technology is simple with small plant sizes (compare Phillips (1995)). Only smaller investments in new plants have to be made. Hence, the result of this industry corresponds to the models of Brander and Lewis (1986) and Maksimovic (1988).

In an analysis of 1641 manufacturing firms Showalter (1999b) supports his theoretical results for industries with price competition. Under demand uncertainty firms increase their debt level and under cost uncertainty they reduce it.

Kovenock and Phillips (1995) and Kovenock and Phillips (1997) also analyze LBO's in different industries and come to the same result as Phillips (1995) that increasing debt levels in the industry lead to higher product prices and less industry output. Stomper and Zulehner (2004) come to similar results for the industry of Austrian ski hotels. Chevalier (1995b) confirms these results, too. She analyzes LBO's in the Supermarket industry. But this result is only valid for industries, in which all players are highly leveraged. If only one firm is highly leveraged, prices will be decreasing, what could be a sign of predatory pricing. In a second study Chevalier (1995a) finds that after a LBO of an incumbent rivals share prices increase. This confirms the strategic effect of a capital structure change. Furthermore, in highly leveraged markets an entry of new firms is more probable.

To the opposite result to the before mentioned comes Zingales (1998) for the American trucking industry, which was deregulated in the mid eighties. After the deregulation highly leveraged firms started to decrease their prices as a consequence of the new regulatory environment.

Campello (2006) discovers that the amount of debt is decisive whether it damages or enhances firms performance. Moderate debt levels yield market share gains. But exceeding a critical value additional indebtedness leads to significant sales underperformance. Furthermore, industry leaders in concentrated industries cannot expand their sales through leverage if their indebtedness already exceeds their industry standard. Furthermore, in a previous empirical study Campello (2003) confirms the results of Chevalier and Scharfstein (1996) with respect to their findings about firms behavior during booms and recessions. During recessions the financing with debt has a negative impact on firms (relative-to industry) sales growth in industries in which rivals are relatively

unlevered. During booms this is not the case. In contrast, for firms competing in high-debt industries no such effects are observed. At the industry level, markups are more countercyclical when industry debt is high.

Kale and Shahrur (2007) investigate the link between a firm's leverage and the characteristics of its suppliers and customers. They find that a firm's leverage is negatively related to the R&D intensities of its suppliers and customers. Furthermore, the degree of concentration in suppliers/customers industries increases with a positive debt level.

The empirical study of De Jong, Nguyen, and van Dijk (2007) brings evidence for the static models of Brander and Lewis (1986) and Showalter (1995). They classify markets according to the prevailed kind of uncertainty. In markets with demand uncertainty positive leverages can be observed in both market scenarios, Bertrand and Cournot competition. In markets with cost uncertainty positive debt levels can be observed only for Cournot competition.

2.4.4. Experimental studies on capital structure and product market competition

In an experimental study Oechssler and Schuhmacher (2004) check the theoretical results of Brander and Lewis (1986) and Showalter (1995). They come to the result that with quantity competition, debt has an effect only on own output and is ignored by opponents. Debt is ineffective as a strategic instrument. Subjects choose much less debt as predicted in Brander and Lewis (1986). Contrary to that result in case of price competition, in the majority subjects choose high debt levels with demand uncertainty and low debt levels with cost uncertainty as predicted by Showalter (1995).

2.5. Conclusion

This chapter has summarized the literature of three different topics: the capital structure decision, the behavior of a firm in the product market, and the effects of the combination of both decisions.

The literature about the capital structure decision of a firm is mainly driven by focussing on capital costs. The traditional thesis of an optimal capital structure is disproved by Modigliani and Miller (1958) for perfect capital markets.

Given perfect capital markets capital costs are equal for every leverage. Capital structure decisions are irrelevant. Given imperfect capital markets, however, the new institutional literature proposes due to asymmetric information between capital lenders and the firm again the existence of an optimal capital structure. Whether firms are financed by debt or outside equity, managers have the incentive to behave in their own interest. Capital owners anticipate this behavior and increase capital costs. Both asymmetric information problems result in different cost increases, which causes the existence of an optimal capital structure (Jensen and Meckling (1976)) and the pecking order theory (Myers and Majluf (1984)). Thus, entrepreneurs can behave strategically by financing their firm.

The literature on product market competition consists mainly of two different types of models, firms either compete in quantities or on prices. Supposing an oligopolistic market structure with market power of firms the outcome of the game is interestingly quite different. Whereas in the quantity game for homogenous goods in equilibrium firms make positive profits, in price competition games despite of having market power, firms tend to attain zero profits. Firms would only make positive profits, if they used Porters strategy (Porter (1980)). Either firms try to become the cost or time leader in the market or differentiate their product. Cost or time leadership can squeeze rivals out of the market. Product differentiation softens competition per se and tries to make use of different consumer tastes. The more products are differentiated higher profits are possible.

Since the propositions of Brander and Lewis (1986) these two approaches are combined, because decisions on the capital structure do not only influence capital costs, but also the outcome on the output market. The capital structure signals a specific behavior of the firm to the rivals on the output market. Hence, firms can also use the capital structure decision strategically in this perspective. For instance, a positive leverage in quantity games signals a more aggressive behavior in the output market. Profits decrease with positive leverage in the market. In price competition games the outcome depends on the kind of uncertainty in the market. Whereas cost uncertainty also induces a more aggressive behavior, demand uncertainty softens competition in the market. Thus, only in the latter case firms hold debt strategically. A wide range of other models expand those ideas and come to similar results. Empirical research

mainly supports the different theories.

The presented literature serves as a basis for our research in the following chapters. It makes use of the ideas and results of the models. The main focus of our research lies on markets in which firms try to behave as predicted by Porter (1980). Either firms try to differentiate their products by vertical or horizontal differentiation or try to decrease their marginal costs by investing in R&D for cost-cutting technologies. Thus, these games have a further step due to one additional strategic variable. The different behavior of equity vs. debt financed firm in such markets will be investigated.

3. Strategic debt in markets with vertical differentiation

Abstract

The literature of capital structure and product market competition mainly emphasizes the effects of capital structure on prices or quantities in the market. Our paper proposes that also other important variables of a firm are influenced by the capital structure decision. If firms hold debt in a duopoly market with price competition and vertical differentiation, an increase of vertical differentiation will positively influence profits of both firms. In equilibrium, the quality-difference between both products in the market is higher. As a consequence, prices of both types of quality increase.

Keywords: product quality, vertical differentiation, capital structure, product market competition

JEL classification: D 43, G 32, L 13

3.1. Introduction

As Bertrand (1883) has shown firms supplying homogenous goods and competing in prices are faced with fierce competition in the market. In the long run such firms make zero profits. One possibility to soften competition in the market is vertical differentiation. Firms have the opportunity to differentiate from their rival by increasing or decreasing their product quality in comparison with their rivals product. Gabszewicz and Thisse (1980), Shaked and Sutton (1982) and Shaked and Sutton (1983) have shown that vertical differentiation results in positive profits for both, low and high quality firms. Prices of both products could be set higher than without vertical differentiation. This result supports also Porter's thesis that if firms wanted to survive in a market, they would have to strive for the cost leadership or differentiation of their product (compare Porter (1980)).

All those models, however, are only analyzing the effects of different product qualities on prices and quantities in the market. But product market decisions of a firm are also influenced by other firm variables. Therefore, our model investigates one additional step. It integrates the financial decision of firms apart from the price and quality decision. This approach stands in line with the literature on capital structure and product market competition, which in turn focuses to a large extent only on the effects of different capital structures on prices and quantities in the market.

The literature on capital structure and product market competition is mainly influenced by the work of Brander and Lewis (1986) and Showalter (1995). In the model of Brander and Lewis (1986) firms compete in quantity. A positive leverage induces firms to behave more aggressively in the market. As both firms have the incentive to be financed by debt profits decrease and the situation is comparable to a prisoner's dilemma. Both firms are worse off. Showalter (1995) build a model in a similar way for markets with price competition. In the model, firm's behavior depends on the kind of uncertainty in the market. In markets with cost uncertainty firms behave more aggressively. As profits decrease with a positive debt-level firms hold no debt in equilibrium. In markets with demand uncertainty, however, firms behave less aggressively. A positive debt-level induces higher prices in the market. Consequently, in equilibrium firms hold debt strategically.

Hughes, Kao, and Mukherji (1998) focus on capital structure decisions under demand uncertainty in general. They come to the result that the level of uncertainty has no influence on the consequences of issuing debt, given that firms can recalibrate the terms of debt to achieve the Stackelberg solution. Wanzenried (2003) also investigates the role of demand uncertainty. She concludes that the capital structure choice of a firm depends on specific output market characteristics. The leverage of a firm is positively influenced by the volatility in demand. Furthermore, the debt level is highest for the lowest substitutability between varieties. In both models, however, only the own debt level influences the default risk of a firm. Franck and Pape (2008) and Haan and Toolsema (2008) argue that the default risk of a firm depends on chosen debt levels of both firms. Taking this into account Haan and Toolsema (2008) conclude that as demand becomes more volatile, the equilibrium debt level decreases.

A wide range of empirical studies as well as an experimental study of Oechssler and Schuhmacher (2004) support the theories on capital structure and product market competition. In their experimental study, Oechssler and Schuhmacher (2004) come to the result that in markets with quantity competition, debt has only an effect on the own output and is ignored by rivals. Subjects choose much less debt as predicted in Brander and Lewis (1986). In markets with price competition, however, subjects behave as predicted in the model of Showalter (1995). Under demand uncertainty the majority of subjects chooses high debt levels whereas under cost uncertainty the majority chooses low debt levels.

The model of Showalter (1995) is also supported by his own empirical study. Showalter (1999b) categorizes 1641 manufacturing firms into different markets with price competition. As he has theoretically shown, market outcomes are different due to different uncertainties in the market. In markets with demand uncertainty Showalter (1999b) observes positive debt-levels of firms whereas in markets with cost uncertainty he observes less debt. To the same result come De Jong, Nguyen, and van Dijk (2007) in their empirical study. As Showalter (1999b) they also classify markets according to the prevailed kind of uncertainty. As a further result they show that in markets with quantity competition positive debt levels can be observed for both kinds of uncertainty. This result supports the theory of Brander and Lewis (1986).

In the empirical study of Phillips (1995) four different industries are investi-

gated, in which the leverage of firms were strongly changed due to a LBO. In three of these industries, where barriers to entry are high, a higher average industry debt ratio correlates with a lower output of firms within the industry. Also product prices are higher. Thus, highly leveraged firms behave less aggressive in the market. Moreover, highly leveraged firms lose market share to their less leveraged rivals. In the fourth industry, a higher average debt ratio correlates with lower product prices. Output is shown to increase. This industry, however, is characterized by low barriers to entry: the production technology is simple and plant sizes are small.

The empirical study of Chevalier (1995b) focuses on LBO's in the supermarket industry in different regions in the US. She came to the result that prices tend to increase with the number of leveraged firms in the market. Tendencies of predatory behavior can be observed, if only one firm in the market is highly leveraged. In this case, self-financed rivals initiate price reductions. In a further study Chevalier (1995a) also analyzes share price reactions. Rivals share prices tend to increase after a LBO of an incumbent firm. This supports the strategic effect of a capital structure change. Kovenock and Phillips (1995) and Kovenock and Phillips (1997) also analyze LBO's in different industries. Higher product prices and less industry output correlate with higher debt levels within the industry. To similar results come Stomper and Zulehner (2004) in their study of the Austrian ski hotel industry.

3.2. The model

Our model aims to show the effects of different capital structures in a market with price competition and vertical differentiation. It makes use of the work of Gabszewicz and Thisse (1979), Gabszewicz and Thisse (1980), Shaked and Sutton (1982) and Shaked and Sutton (1983). Price competition in such models is so fierce that it is valuable for firms to differentiate their products by incremental quality improvements. Demand in the markets is supposed to exist for both types of quality. Thus, this strategy softens competition.

An additional opportunity to influence and possibly soften competition is the strategic use of the capital structure. Suppose there are two firms in the market, one firm that offers high quality products and one firm that offers low quality products. The quality difference is known in the market. Then four

different financing situations are of interest.

- both firms are strictly self financed
- the low quality firm is debt-financed
- the high quality firm is debt-financed
- both firms have a positive leverage

The setup of the whole game is as follows (the basic illustration of vertical differentiation follows Tirole (1988)): Suppose two homogenous firms compete in a market. On the product market firms compete in quality and prices. The whole game consists of one period. The different decisions of firms are assumed to be sequential. The period consists of three different stages:

1. the financial stage, when firms decide on their capital structure
2. the quality stage, when firms decide on the quality of their product
3. the price competition stage, when firms set their prices

The financial stage will be investigated separately in the particular sections. Thus, the further investigation rests on two stages, the quality and the price competition stage. On the different stages firms have to decide simultaneously. After one stage firms can observe the behavior of the rivals in the previous stage. Decisions are sequential, but firms move simultaneously.

Production costs of firm i consist of fixed costs F_i and marginal costs c_i . Assume for simplicity marginal costs are constant and equal for both firms ($c = c_1 = c_2$). Let s_i be the product quality of firm i . Suppose that with marginal costs of c firms produce a product with the lowest possible quality \underline{s} . Firms, however, are able to produce every quality above this level ($\underline{s} \leq s_i \leq \infty$). But, producing this additional quality is not for free. Assume the cost function of quality is convex. The more quality the product has the more expensive it is for firms to increase the quality. For simplicity the cost function is quadratic and identical for both firms $Q_i(s_i) = \frac{w}{2}(s_i - \underline{s})^2$. Q_i stands for the whole costs of quality. w describes the quality-cost parameter of firm i . Further, assume that firm 1 is known to supply the market with high quality and firm 2 to supply the market with low quality ($s_1 > s_2$).

The demand side is structured as follows. Assume the utility of every consumer is influenced positively by the quality of the product and negatively by the price. Thus, the utility function of a consumer is given by

$$U = \theta s - p \quad (3.1)$$

Assume every consumer buys at most one unit of the product. If a consumer did not purchase a product, his utility would be zero. Let the parameter $\theta \in [\underline{\theta}, \bar{\theta}]$ describe the importance of quality for a certain consumer. Let θ be uniformly distributed over a population of consumers with $\underline{\theta} > 0$ and $\bar{\theta} = \underline{\theta} + 1$. The density is one. It is important to notice that with a higher value of $\underline{\theta}$ the difference between consumer tastes decrease.

For simplification and to let vertical differentiation be valuable, two further assumptions have to be made.

1. $\bar{\theta} > 2\underline{\theta} \Leftrightarrow \underline{\theta} < 1$

This assumption guarantees a certain heterogeneity between the consumers. In case of a lower heterogeneity, supplying different qualities is not valuable.

2. $p_2 \leq \underline{\theta} s_2$

This assumption guarantees that in equilibrium the whole demand is satisfied.

With these two assumptions the whole demand can be divided into the demand of the high quality and the low quality firm. Depending on prices and qualities of both firms, consumers buy either from the high quality or the low quality firm. The critical consumer evaluates both products equally, which means $\theta s_1 - p_1 = \theta s_2 - p_2$. The demand for both products is given by

$$D_1(p_1, p_2) = \bar{\theta} - \frac{p_1 - p_2}{s_1 - s_2} = \underline{\theta} + 1 - \frac{p_1 - p_2}{s_1 - s_2} \quad (3.2)$$

$$D_2(p_1, p_2) = \frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta} \quad (3.3)$$

Suppose the degree of heterogeneity is not known by firms. Only due to assumption one $\underline{\theta} \in [0, 1]$ is known. In case of debt financing only two states are relevant for the analysis. Either the firm defaults or does not. The model only considers these two states. Firms are either faced by a less difference in consumer heterogeneity and thus a high value of the quality parameter $\underline{\theta}^H$,

or a high difference in consumer heterogeneity and a low value of the quality parameter $\underline{\theta}^L$. Suppose with probability γ the value of the heterogeneity parameter is $\underline{\theta}^L$ and $\underline{\theta}^H$ with probability $1 - \gamma$. The expected heterogeneity parameter is then $\underline{\theta}^e \equiv \underline{\theta} = \gamma\underline{\theta}^L + (1 - \gamma)\underline{\theta}^H$.

3.3. Price and quality competition with self-financing

Initially, to be able to compare the different cases, the standard situation with two self-financed firms in a duopoly market is considered. In this case no principal agent conflicts arise. The profit (Π_i) of firm i is identical to the payoff of the entrepreneur of firm i (V_i). The payoff depends on prices and quality levels of both firms ($V_i[s_i, s_j, p_i, p_j]$). The profit functions of both firms have the following design.

$$V_1 = (p_1 - c) \left(\underline{\theta} + 1 - \frac{p_1 - p_2}{s_1 - s_2} \right) - \frac{w}{2}(s_1 - \underline{s})^2 - F_1 \quad (3.4)$$

$$V_2 = (p_2 - c) \left(\frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta} \right) - \frac{w}{2}(s_2 - \underline{s})^2 - F_2 \quad (3.5)$$

As explained firms act in two stages, the quality and the price competition stage. Entrepreneurs optimize their profit function with regard to these two variables. Due to the sequential setting firms decide first on their optimal quality before setting the optimal price. Such sequential environments can be solved by backward induction. This leads to the first proposition.

Proposition 1: Assuming two symmetrical self-financed firms in a duopoly market competing in prices and quality, the optimal price of the high quality product is higher than the price of the low quality product. Optimal prices are highest in case of the maximum quality difference between the two products.

Proof 1: On the last stage firms set their prices. Optimizing 3.4 and 3.5 with regard to the price ($\frac{\partial V_i[s_i, s_j, p_i, p_j]}{\partial p_i} = 0$) results in the following price best response functions.

$$p_1 = \frac{(\underline{\theta} + 1)(s_1 - s_2) + c + p_2}{2} \quad (3.6)$$

$$p_2 = \frac{-\underline{\theta}(s_1 - s_2) + c + p_1}{2} \quad (3.7)$$

Prices are strategic complements. Thus, if one firm reduces prices to increase its market share, also the other firm will do so. Moreover, in case of equal quality prices would be competed down to marginal costs. The quality difference results in a higher price of the high quality firm (3.6) compared to the low quality firm (3.7). Solving the system of two best response functions yields the optimal prices of both firms.

$$p_1^* = c + \frac{(\underline{\theta} + 2)(s_1 - s_2)}{3} \quad (3.8)$$

$$p_2^* = c + \frac{(1 - \underline{\theta})(s_1 - s_2)}{3} \quad (3.9)$$

As $\frac{\partial^2 V_i[f_i, f_j, p_i, p_j]}{\partial p_i^2} < 0 \forall p_i$, 3.8 and 3.9 are the profit maximizing prices. The result conforms to the optimal price in the illustration of Tirole (1988). Optimal prices increase with marginal costs and the difference in quality of both products. Hence, optimal prices are highest in case of the highest difference in quality of both products.

Interestingly, the heterogeneity parameter has different effects. For the high quality firm the optimal price increases with a higher heterogeneity parameter. It is better to have a lower difference between consumer tastes. For the low quality firm the reverse is true. The lower the heterogeneity parameter the higher is the optimal price. For the low quality firm it is more valuable to have a high difference between consumer tastes. The best response functions of both firms are drawn in figure 9. The point of intersection marks the optimal prices. \square

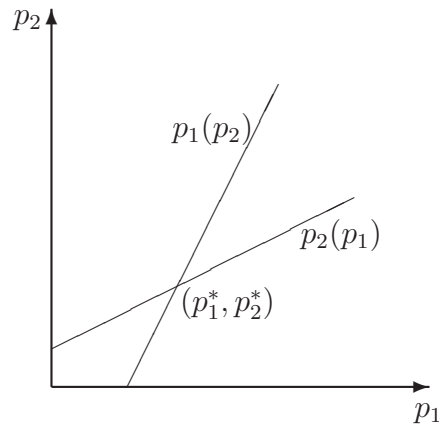


Figure 9: Price best response functions of two self-financed firms

With optimal prices the critical consumer can be determined. The critical

consumer $\hat{\theta}$ is given by

$$\hat{\theta} = \frac{p_1 - p_2}{s_1 - s_2} = \frac{1 + 2\theta}{3} \quad (3.10)$$

The more consumer preferences are similar ($\theta \rightarrow 1$) the higher is the market share of the high quality firm. Supplying the market with low quality products is less valuable. The other way round the less consumer preferences are similar ($\theta \rightarrow 0$) the lower is the market share of the high quality firm. The lowest possible market share of the high quality firm in the model is $\frac{2}{3}$.

Taking optimal prices from 3.8 and 3.9 into account the profit functions ($V_i[s_i, s_j]$) of both firms are reduced to

$$V_1 = \frac{(\theta + 2)^2(s_1 - s_2)}{9} - \frac{w}{2}(s_1 - \underline{s})^2 - F_1 \quad (3.11)$$

$$V_2 = \frac{(1 - \theta)^2(s_1 - s_2)}{9} - \frac{w}{2}(s_2 - \underline{s})^2 - F_2 \quad (3.12)$$

Proposition 2: Assuming two symmetrical self-financed firms in a duopoly market competing in prices and quality, optimal qualities differ as much as it is valuable for both firms. The low quality firm chooses the lowest possible quality and the high quality firm a higher profit maximizing quality.

Proof 2: From 3.11 and 3.12 it is obvious that maximum vertical differentiation is optimal. As any quality above the lowest possible quality involves further costs, the optimal quality of the low quality firm is $s_2 = \underline{s}$. The high quality firm tries to increase its quality as high as it is valuable. Thus, optimizing the profit function of firm i in the first stage (3.11) with respect to the quality ($\frac{\partial V_i[s_i, s_j]}{\partial s_i} = 0$) optimal qualities of both firms are given by

$$s_1^* = \underline{s} + \frac{(\theta + 2)^2}{9w} \quad (3.13)$$

$$s_2^* = \underline{s} \quad (3.14)$$

As $\frac{\partial^2 V_i[s_i, s_j]}{\partial s_i^2} < 0 \forall s_i$, 3.13 describes the profit maximizing quality of the high quality firm. 3.13 depends positively on the heterogeneity parameter. It depends negatively on the costs for quality. \square

Optimal profits of both entrepreneurs are with optimal qualities and prices given by

$$V_1^* = \frac{(\underline{\theta} + 2)^4}{162w} - F_1 \quad (3.15)$$

$$V_2^* = \frac{(1 - \underline{\theta})^2(\underline{\theta} + 2)^2}{81w} - F_2 \quad (3.16)$$

3.15 and 3.16 depend only on the heterogeneity parameter and the costs of quality. The effects of the latter are similar for both firms. With higher costs for quality the profit decreases. This is interesting, because in equilibrium the low quality firm has except of marginal production costs due to $s_2^* = \underline{s}$ no direct costs for quality. Higher costs for quality, however, induce a lower optimal quality for the high quality firm, which has a negative effect on the profit of the low quality firm. The heterogeneity parameter effects the profits in two different ways. Whereas a higher value of the heterogeneity parameter induces higher profits for the high quality firm, it lowers the profits of the low quality firm. Profits decrease due to a lower difference of consumers tastes for higher values of $\underline{\theta}$.

Profits are positive for $\frac{(\underline{\theta}+2)^4}{162w} > F_1$ and $\frac{(1-\underline{\theta})^2(\underline{\theta}+2)^2}{81w} > F_2$. This is assumed in the following.

3.4. Debt-financing of the low quality firm

In the prior section both firms are completely self-financed. In this section the entrepreneur of the low quality firm has the opportunity to finance its firm partly by debt. Suppose the amount of debt covers exactly the fixed costs of the firm. Assume the capital market is competitive and all players in the market are risk neutral. The offered financial contract has the following design.

Assume there is asymmetric information in the market. Banks know ex ante the possible profits of a firm and therefore that the expected profit of a low quality firm is positive. Otherwise banks would not lend any money to such a firm. But ex post the bank does not know exactly the state of the world. Banks, however, have the opportunity to monitor the firm. Let m be the monitoring costs of the bank. As Gale and Hellwig (1985) have shown in such a one-period situation the standard-debt contract is optimal. The repayment to the bank in the good state of the world, where profits are high, is R_i . It is

due to perfect competition so high that banks make zero profits in expectation. In the bad state banks monitor the firm and receive the whole profit of the firm. The expected payoff of the bank is

$$W = \gamma R_2 + (1 - \gamma)(V^H - m) - F_2 = 0 \quad (3.17)$$

In the good state of the world the entrepreneur of the low quality firm receives the profit less the repayment to the bank. In the bad state he receives nothing. The entrepreneur of the high quality firm is not directly effected by the debt contract. Thus, taking the financial contract into account the expected payoff ($V_i[s_i, s_j, p_i, p_j]$) of both entrepreneurs are

$$V_1 = (p_1 - c) \left(\underline{\theta} + 1 - \frac{p_1 - p_2}{s_1 - s_2} \right) - \frac{w}{2}(s_1 - \underline{s})^2 - F_1 \quad (3.18)$$

$$V_2^D = \gamma \left((p_2 - c) \left(\frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta}^L \right) - \frac{w}{2}(s_2 - \underline{s})^2 - R \right) \quad (3.19)$$

Proposition 3: If the low quality firm borrows money from a bank and the debt contract has the above mentioned design, competition in the market will be less intense. Optimal prices of both firms increase and the optimal quality of the high quality firm rises.

Proof 3: Optimizing on the second stage 3.18 and 3.19 with regard to prices ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$) the best response function of the low quality firm changes. The best response function of the high quality firm remains unchanged.

$$p_1 = \frac{(\underline{\theta} + 1)(s_1 - s_2) + c + p_2}{2} \quad (3.20)$$

$$p_2 = \frac{-\underline{\theta}^L(s_1 - s_2) + c + p_1}{2} \quad (3.21)$$

Due to the lower value of the heterogeneity parameter $\underline{\theta}^L$ the best response function of entrepreneur i shifts outward . Solving the system of two best response functions (3.20 and 3.21) yields the equilibrium prices under debt-financing of the low quality firm.

$$p_1^* = c + \frac{(2 + 2\underline{\theta} - \underline{\theta}^L)(s_1 - s_2)}{3} \quad (3.22)$$

$$p_2^D = c + \frac{(1 + \underline{\theta} - 2\underline{\theta}^L)(s_1 - s_2)}{3} \quad (3.23)$$

Optimal prices of both firms under debt-financing of the low quality firm (3.22 and 3.23) are higher than under self-financing of both firms (3.8 and 3.9). Thus, if the low quality firm is borrowing money from a bank, this will be a fat-cat strategy in the terminology of Fudenberg and Tirole (1984). Debt financing increases prices in the market. Figure 10 summarizes these results.

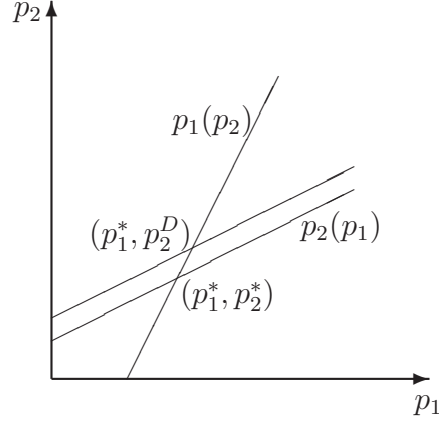


Figure 10: Price best response functions under debt-financing of the low quality firm

Taking 3.22 and 3.23 into account, payoff functions ($V_i[s_i, s_j]$) on the first stage are given by

$$V_1 = \frac{(2 + 2\underline{\theta} - \underline{\theta}^L)^2(s_1 - s_2)}{9} - \frac{w}{2}(s_1 - \underline{s})^2 - F_1 \quad (3.24)$$

$$V_2^D = \gamma \left(\frac{(1 + \underline{\theta} - 2\underline{\theta}^L)^2(s_1 - s_2)}{9} - \frac{w}{2}(s_2 - \underline{s})^2 - R_2 \right) \quad (3.25)$$

Again in the first stage entrepreneurs have to set the optimal quality ($\frac{\partial V_i[s_i, s_j]}{\partial s_i} = 0$). It is obvious that the maximum difference between both qualities is optimal. Hence, the low quality firm again chooses the lowest possible quality and the high quality firm adjusts its quality to the new market environment.

$$s_1^* = \underline{s} + \frac{(2 + 2\underline{\theta} - \underline{\theta}^L)^2}{9w} \quad (3.26)$$

$$s_2^D = \underline{s} \quad (3.27)$$

Comparing optimal qualities of the high quality firm in both cases (3.26 and 3.13), reveals that the quality has increased. The low quality firm still offers

the product with the lowest possible quality. Taking optimal qualities into account, optimal payoffs of both entrepreneurs are given by

$$V_1^* = \frac{(2 + 2\theta - \underline{\theta}^L)^4}{162w} - F_1 \quad (3.28)$$

$$V_2^D = \gamma \left(\frac{(1 + \underline{\theta} - 2\underline{\theta}^L)^2 (2 + 2\theta - \underline{\theta}^L)^2}{81w} - R_2 \right) \quad (3.29)$$

In case of debt-financing of the low quality firm the profit of the high quality firm (3.28) is higher than under self-financing (3.15). The revenues of the low quality firm are due the quality increase of the rival higher than under the self-financing scenario. \square

3.5. Debt-financing of the high quality firm

In the prior section the low quality firm was debt-financed. In this section the high quality firm is debt-financed and the low quality firm self-financed. Let again the amount of debt exactly cover the fixed costs. The assumptions about the capital market as well as the offered financial contract have the same design as before. Interestingly, the valuation of the two states are changing. For the high quality firm the bad state occurs for a low heterogeneity parameter of consumer tastes. Assume the heterogeneity parameter is so low that the high quality firm cannot repay the loan in the bad state. Therefore the expected payoff of the bank changes to

$$W = \gamma(V^L - m) + (1 - \gamma)R_1 - F_1 = 0 \quad (3.30)$$

The entrepreneur of the high quality firm in the good state receives the profit less the repayment to the bank and nothing in the bad state. Again, the entrepreneur of the low quality firm is not directly effected by the debt contract. Thus, taking the financial contract into account the expected payoff ($V_i[s_i, s_j, p_i, p_j]$) of both entrepreneurs changes to

$$V_1^D = (1 - \gamma) \left((p_1 - c) \left(\underline{\theta}^H + 1 - \frac{p_1 - p_2}{s_1 - s_2} \right) - \frac{w}{2}(s_1 - \underline{s})^2 - R_1 \right) \quad (3.31)$$

$$V_2 = (p_2 - c) \left(\frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta} \right) - \frac{w}{2}(s_2 - \underline{s})^2 - F_2 \quad (3.32)$$

Proposition 4: *If the high quality firm borrows money from a bank and the debt contract has the above mentioned design, again competition in the market will be less intense. Optimal prices of both firms increase and the optimal quality of the high quality firm rises.*

Proof 4: Following the same analysis as before and optimizing in the second stage the profit function of both firms (3.31 and 3.32) with regard to prices ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$) the best response function of the high quality firm changes. The best response function of the low quality firm is identical to the self-financing case.

$$p_1 = \frac{(\underline{\theta}^H + 1)(s_1 - s_2) + c + p_2}{2} \quad (3.33)$$

$$p_2 = \frac{-\underline{\theta}(s_1 - s_2) + c + p_1}{2} \quad (3.34)$$

Due to the higher value of the heterogeneity parameter $\underline{\theta}^H$ the best response function of the high quality firm shifts outward. Solving the system of two best response functions yields the equilibrium prices under debt-financing of the high quality firm.

$$p_1^D = c + \frac{(2 + 2\underline{\theta}^H - \underline{\theta})(s_1 - s_2)}{3} \quad (3.35)$$

$$p_2^* = c + \frac{(1 + \underline{\theta}^H - 2\underline{\theta})(s_1 - s_2)}{3} \quad (3.36)$$

Optimal prices of both firms under debt-financing of the high quality firm (3.35 and 3.36) are higher than under self-financing of both firms (3.8 and 3.9). Thus, debt-financing of the high quality firm is also a fat-cat strategy in the terminology of Fudenberg and Tirole (1984). A positive debt level increases prices. Figure 11 summarizes these results.

Taking 3.35 and 3.36 into account, profit functions ($V_i[s_i, s_j]$) in the first stage are given by

$$V_1^D = (1 - \gamma) \left(\frac{(2 + 2\underline{\theta}^H - \underline{\theta})^2 (s_1 - s_2)}{9} - \frac{w}{2} (s_1 - \underline{s})^2 - R_1 \right) \quad (3.37)$$

$$V_2 = \frac{(1 + \underline{\theta}^H - 2\underline{\theta}^L)^2 (s_1 - s_2)}{9} - \frac{w}{2} (s_2 - \underline{s})^2 - F_2 \quad (3.38)$$

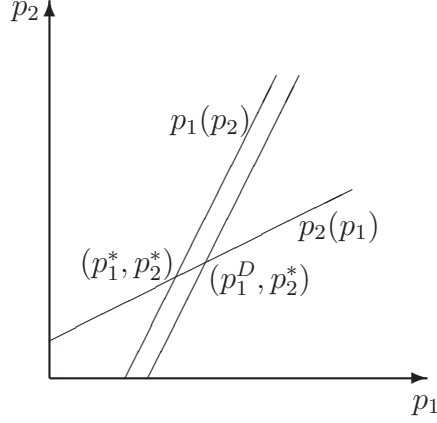


Figure 11: Price best response functions under debt-financing of the high quality firm

On the first stage firms determine the optimal product quality ($\frac{\partial V_i[s_i, s_j]}{\partial s_i} = 0$). Again the low quality firm chooses the lowest possible quality and the high quality firm adjusts its quality accordingly.

$$s_1^D = \underline{s} + \frac{(2 + 2\underline{\theta}^H - \underline{\theta})^2}{9w} \quad (3.39)$$

$$s_2^* = \underline{s} \quad (3.40)$$

Comparing optimal qualities of the high quality firm under self- and debt-financing of the high quality firm (3.13 and 3.39), the quality has increased. Whether the optimal quality is higher or lower than in case of debt-financing of the low quality firm depends on the values of the variables. Taking 3.39 and 3.40 into account, optimal payoffs of both entrepreneurs are given by:

$$V_1^D = (1 - \gamma) \left(\frac{(2 + 2\underline{\theta}^H - \underline{\theta})^4}{162w} - R_1 \right) \quad (3.41)$$

$$V_2^* = \frac{(1 + \underline{\theta}^H - 2\underline{\theta})^2 (2 + 2\underline{\theta}^H - \underline{\theta})^2}{81w} - F_2 \quad (3.42)$$

In case of debt-financing of the high quality firm revenues of the high quality firm are higher than under self-financing. The profit of the low quality firm (3.42) is due the quality increase of the rival also higher than under self-financing (3.16). \square

3.6. Debt-financing of both firms

Lastly this section presents the assumption of both firms to be debt-financed. In the prior sections debt-financing of one firm is a soft commitment and results

in higher prices and quality in the market. This should also be the case, if both firms were financed by debt. Interestingly the strength of the earlier investigated effects depend on the heterogeneity parameter. It was already mentioned that both firms could go bankrupt in two different states of the world. The high quality firm for small values and the low quality firm for high values of the heterogeneity parameter. In the prior sections it could be automatically assumed that the heterogeneity parameter is above or below a critical value. But in case of two debt-financed firms this is very decisive for the outcome of the game.

The possible values of the heterogeneity parameter and the fixed costs of both firms determine the outcome of the game.

- The range of the heterogeneity parameter and the fixed costs can adopt values such that none of the firm goes bankrupt. Consequently debt has in this case no effect on the outcome of the game. Firms behave as they were self-financed. But this case was also excluded in the two sections with one debt-financed firm.
- The range of the heterogeneity parameter can be either so high or so low that one of the firms could go bankrupt. Then the outcome of the game equals one of the outcomes with one debt-financed firm.
- The range of the heterogeneity parameter and the fixed costs can adopt values that both firms could go bankrupt. Then debt effects both firms directly in the following way.

Suppose the low quality firm defaults in case of $\underline{\theta}^H$ with probability γ and the high quality firm in case of $\underline{\theta}^L$ with probability $1 - \gamma$. This assumption is very restrictive, but simplifies the analysis without changing the effects.

Suppose that both firms are financed by two different banks. The expected payoffs of the banks are as before

$$W_1 = \gamma(V_1^L - m) + (1 - \gamma)R_1 - F_1 = 0 \quad (3.43)$$

$$W_2 = \gamma R_2 + (1 - \gamma)(V_2^H - m) - F_2 = 0 \quad (3.44)$$

Taking the financial contracts into account the expected payoffs of both entrepreneurs ($V_i[s_i, s_j, p_i, p_j]$) are

$$V_1^D = (1 - \gamma) \left((p_1 - c) \left(\underline{\theta}^H + 1 - \frac{p_1 - p_2}{s_1 - s_2} \right) - \frac{w}{2}(s_1 - \underline{s})^2 - R_1 \right) \quad (3.45)$$

$$V_2^D = \gamma \left((p_2 - c) \left(\frac{p_1 - p_2}{s_1 - s_2} - \underline{\theta}^L \right) - \frac{w}{2}(s_2 - \underline{s})^2 - R \right) \quad (3.46)$$

Proposition 5: *If both firms borrow money from a bank and the debt contracts have the above mentioned design, competition in the market will be less intense. Optimal prices of both firms increase and the optimal quality of the high quality firm does as well.*

Proof 5: Following the same analysis as before and optimizing on the second stage the profit function of both firms (3.45 and 3.46) with regard to prices ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$), best response functions are as above. Equilibrium prices under debt-financing of both firms are given by

$$p_1^D = c + \frac{(2 + 2\underline{\theta}^H - \underline{\theta}^L)(s_1 - s_2)}{3} \quad (3.47)$$

$$p_2^D = c + \frac{(1 + \underline{\theta}^H - 2\underline{\theta}^L)(s_1 - s_2)}{3} \quad (3.48)$$

If both firms were debt-financed, optimal prices of both firms are higher than in all other cases. Figure 12 summarizes these results.

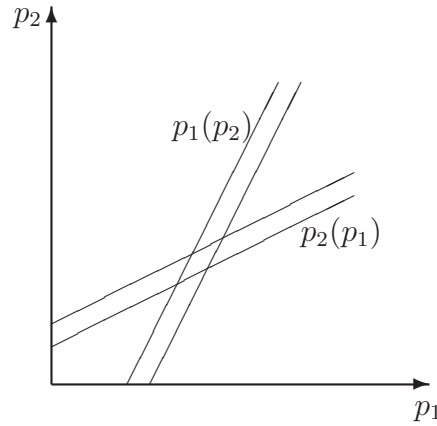


Figure 12: Price best response functions under debt-financing of both firms

Taking 3.47 and 3.48 into account, profit functions ($V_i[s_i, s_j]$) on the first stage are given by

$$V_1^D = (1 - \gamma) \left(\frac{(2 + 2\underline{\theta}^H - \underline{\theta}^L)^2 (s_1 - s_2)}{9} - \frac{w}{2} (s_1 - \underline{s})^2 - R_1 \right) \quad (3.49)$$

$$V_2^D = \gamma \left(\frac{(1 + \underline{\theta}^H - 2\underline{\theta}^L)^2 (s_1 - s_2)}{9} - \frac{w}{2} (s_2 - \underline{s})^2 - R_2 \right) \quad (3.50)$$

Optimal qualities change to

$$s_1^D = \underline{s} + \frac{(2 + 2\underline{\theta}^H - \underline{\theta}^L)^2}{9w} \quad (3.51)$$

$$s_2^D = \underline{s} \quad (3.52)$$

The optimal quality of the high quality firm (3.51) increases. The quality in this case is highest. Taking optimal qualities into account optimal payoffs of both entrepreneurs are given by

$$V_1^D = (1 - \gamma) \left(\frac{(2 + 2\underline{\theta}^H - \underline{\theta}^L)^4}{162w} - R_1 \right) \quad (3.53)$$

$$V_2^D = \gamma \left(\frac{(1 + \underline{\theta}^H - 2\underline{\theta}^L)^2 (2 + 2\underline{\theta}^H - \underline{\theta}^L)^2}{81w} - R_2 \right) \quad (3.54)$$

The revenues of both firms are higher than in all other cases. \square

3.7. Conclusion

Our paper has shown that financial decisions influence not only prices and quantities in the market but also other important variables of a firm. The model has investigated markets with price competition and vertical differentiation. Firms that are supplying homogenous goods and are faced by price competition have the incentive to vertically differentiate their products to soften competition. But as shown also the adjustment of the capital structure can be used for further softening of competition. Debt increases prices in the market as in Showalter (1995). It also induces high quality firms to increase their quality. The low quality firm always supplies the lowest possible quality. Thus, a higher quality of the high quality firm means a stronger differentiation of both products. Consequently, both firms can increase their prices. As in the literature with price competition a positive leverage is advantageous for both firms. Hence, in equilibrium both types of firms have a positive leverage.

Optimal prices in the model are also in line with the empirical literature on capital structure and product market competition. Further empirical research could focus on the findings on the quality decision of a firm. In markets with vertical differentiation the model predicts that product qualities would be higher, if more leveraged firms were in the market.

A possible extension of the model could be the integration of advertising. Vertical differentiation of products should normally increase marketing activity of firms, because without any advertising consumers are not aware of the quality differences of the products in the market. Firms have to advertise their product to make the quality advantages of their product known by consumers. High quality firms should have the incentive to advertise more than their low quality rivals (compare for instance Tremblay and Polansky (2002)). Although persuasive advertising could also be used only for establishing a brand and thus high prices (compare Tremblay and Martins-Filho (2001)).

Empirical results differ by proving this thesis. Tremblay and Polansky (2002) show with examples for different markets that in most of them the high quality firm advertises more. In their analysis of 200 products evaluated by Consumer Reports, Caves and Greene (1996) find in fact that prices and qualities of products correlate. But quality and advertising are typically uncorrelated among brands. Integrating the financial decision in those models should not only effect prices and qualities, but additionally the advertising behavior of firms.

Moreover, an enlargement of the model to more than one period could be interesting. Taking into account that either the low or the high quality firm could go bankrupt and allowing no entry and exit of other firms, incumbents could potentially become monopolists. Then, further adjustments of prices and qualities seems to be reasonable. Furthermore, the quality decision of a firm could be modeled endogenous. Dasgupta and Titman (1996) investigate this in a two-period model. One firm in the market is known as the high quality firm. The rival of that firm can choose between a high and a low quality before both firms set prices. Qualities are not known by consumers. The only signal to the consumers is the offered price of the product. Dasgupta and Titman (1996) come to the following result: If the known high quality firm is completely self-financed, while its rival needs external debt financing, both firms will produce high quality and choose lower first-period prices than

under complete self financing.

4. The Influence of Capital Structure Decisions on Marketing and Price Competition

Abstract

The literature of capital structure and product market competition mainly focuses on the effects of capital structure on prices or quantities in a market. This paper proposes that also other important variables of a firm are influenced by the capital structure decision of a firm. For horizontal differentiated firms acting in markets with price and marketing competition the adjustment of the capital structure positively influences their profits. A positive leverage softens competition in the market. Leveraged firms behave less aggressive than their self-financed rivals. Prices increase and marketing expenses decrease.

Keywords: Marketing, horizontal differentiation, capital structure, product market competition

JEL classification: D 43, G 32, L 13

4.1. Introduction

As Bertrand (1883) has shown firms supplying homogenous goods and competing in prices are faced with fierce competition in the market. Horizontal differentiation is an opportunity to soften competition in such a market environment. Porter (1980) sees horizontal differentiation as one of the only strategies to survive in the long run. In case of horizontal differentiation, however, investments in marketing are necessary to educate and to convince consumers of the advantages of the differentiated product.

Our paper aims to show that firms have a further possibility to soften competition in horizontal differentiated markets. The adjustment of the capital structure can positively influence the outcome of the competition game. This approach will be in line with the literature of capital structure and product market competition. It tries to fill the gap that the capital structure decision not only influences prices and quantities in the market, but also other important decision variables of a firm.

The literature on capital structure and product market competition is mainly influenced by the work of Brander and Lewis (1986) and Showalter (1995) for static models. Brander and Lewis (1986) show for markets with quantity competition that leveraged firms behave more aggressively in the market. Due to a prisoner's dilemma situation in equilibrium, all firms have a positive leverage and are worse off. Contrary to the results for quantity competition Showalter (1995) shows that in markets with price competition the optimal behavior of a firm depends on the kind of uncertainty. In markets with cost uncertainty firms also behave more aggressively. Hence, in equilibrium firms hold no strategic debt. In markets with demand uncertainty, however, firms behave less aggressively. Prices increase with a positive debt-level. In equilibrium firms have a positive leverage.

Wanzenried (2003) focuses on capital structure decisions under demand uncertainty in general. She finds that the choice of firms' capital structure depends on specific output market characteristics. The higher the volatility in demand, the higher the firms' leverage. The debt level is highest for the lowest substitutability between varieties. The insights of Wanzenried (2003) are based on the work of Hughes, Kao, and Mukherji (1998) who also investigate capital structure under demand uncertainty. They find out that the consequences of

issuing debt are invariant to the level of uncertainty, given that firms can recalibrate the terms of debt to achieve the Stackelberg solution. Franck and Pape (2008) and Haan and Toolsema (2008), however, employ the models and come to other results. Both argue that chosen debt levels of both firms influence the default risk of a firm and not only their own. With the adjusted assumption, Haan and Toolsema (2008) conclude that the equilibrium debt level decreases as demand becomes more volatile.

The static results also hold in a more dynamic framework. In the two-period models of Bolton and Scharfstein (1996) and Chevalier and Scharfstein (1996) prices of debt-financed firms are higher than those of their self-financed counterparts.

The theoretical propositions on capital structure and product market competition are supported to the greatest possible extent by an experimental study of Oechssler and Schuhmacher (2004) as well as a wide range of empirical studies. In an analysis of 1641 manufacturing firms Showalter (1999b) supports his theoretical results for industries with price competition. Under demand uncertainty firms increase their debt level and under cost uncertainty they reduce it.

The empirical study of De Jong, Nguyen, and van Dijk (2007) brings evidence for the static models of Brander and Lewis (1986) and Showalter (1995). They classify markets according to the prevailed kind of uncertainty. In markets with demand uncertainty positive leverages can be observed in both market scenarios, Bertrand and Cournot competition. In markets with cost uncertainty positive debt levels can be observed only for Cournot competition.

Campello and Fluck (2004) investigate the consequences of negative demand shocks in 57 different industries during the recession of 1990/91 in America. Firms with a high leverage significantly lose market shares to firms with a low leverage. Furthermore, the loss of market share of highly debt financed firms is more pronounced in industries where low debt usage is the norm and moreover in industries with high consumer switching costs.

Phillips (1995) investigates four different industries, in which the leverage of firms was strongly changed by a LBO. In three of these industries, namely fiberglass insulation, tractor trailer and polyethylene industry, where barriers to entry are high, output is negatively associated with the average industry

debt ratio. Product prices are higher. Consequently, highly leveraged firms behave less aggressive in the market. Moreover, they lose market share to their less leveraged competitors. In the fourth industry, the gypsum industry, product prices are negatively related to the average debt ratio of the industry. Output is increasing. This industry is characterized by low barriers to entry and simple production technology with small plant sizes. Only smaller investments in new plants have to be made.

Chevalier (1995b) investigates LBO's in the supermarket industry in different regions in the US. If almost or even all firms in the specific market were highly leveraged, prices would increase in the market. If, however, only one firm in the market is highly leveraged, price reductions can be observed. These are initiated from the self-financed rivals. In a second study Chevalier (1995a) finds that after a LBO of an incumbent rivals share prices increase. This confirms the strategic effect of a capital structure change. Kovenock and Phillips (1995) and Kovenock and Phillips (1997) also analyze LBO's in different industries and come to the result that increasing debt levels in the industry lead to higher product prices and less industry output. Stomper and Zulehner (2004) come to similar results for the industry of Austrian ski hotels.

As stated our paper wants to focus on markets with differentiated products and price competition, where also marketing is highly relevant. Grullon, Kanatas, and Kumar (2006) investigate capital structure changes of firms in different industries, which are not financially distressed, and its impact on their advertising behavior. They show that an increase in a firms' leverage results in a decrease of advertising of the leveraged firm and an increase of the relatively less leveraged rivals. Conversely a decrease in leverage leads to the opposite behavior of the leveraged firm and its rivals.

4.2. The model

The following model wants to analyze optimal capital structure decisions for firms, which operate in a market with marketing and price competition. On the one hand it includes elements of the model of Chevalier and Scharfstein (1996), who designed a two-period duopoly model, where both firms compete in prices. Mainly the design of the financial contract is adopted. On the other hand it includes elements of the model of Grossman and Shapiro (1984),

who integrated marketing competition as an additional step in the decision process of a company, which competes in prices. The integration of that model, however, is designed similar to the illustration of Tirole (1988).

To keep the environment preferably simple the assumptions of the model are very strict. But this does not limit the propositions. The analysis is focused on different types of capital structure. Firms can either be self-financed by the entrepreneur or can borrow money from a bank. A positive share of debt leads to a positive leverage of the firm. Thus, three different situation are of interest:

- two strictly self financed firms
- two similar positively leveraged firms
- two different leveraged firms (for simplicity the leverage of one firm is zero)

These three situations will be discussed in the following chapters separately. It will be shown that different financing decisions result in different outcomes of the marketing and price competition game.

The setup of the whole game is as follows: Suppose two symmetric firms compete in a market. On the product market firms compete in marketing and prices. The game has two periods. The different decisions of firms are assumed to be sequential. The focus of the analysis lies on the behavior of the firms in the first period. Thus, whereas the second period consists only of one stage, namely the price competition stage, the first period consists of three different stages.

1. the financial stage, when firms decide on their capital structure
2. the marketing stage, when firms decide on their marketing outlay
3. the price competition stage, when firms set their prices

As already explained the financial stage will be investigated separately in the particular sections. Hence, the further investigation rests on two stages, the marketing and the price competition stage. On the different stages firms have

to decide simultaneously. After each stage firms can observe the behavior of the rivals in the previous stage. Thus, decisions for individual firms are sequential, however firms move simultaneously within the industry.

First, firms have to decide on the level of their marketing expenses. Without any marketing firms will not make any profit, because the products of the firms are not known by the consumers. To make the products known to the consumers firms have to invest money for marketing. The cost function of marketing is assumed to be convex. The more people already know the product the more expensive it is for firms to reach (or convince) the residual consumers. For simplicity the cost function is quadratic and identical for both firms $M_i(f_i) = \frac{1}{2}wf_i^2$, where M_i are the total marketing costs, w the marketing-cost parameter and f_i the brand awareness of firm i ($0 \leq f_i \leq 1$). As higher the brand awareness of a firm the more its product is known by consumers. For simplicity it is assumed that firms not only know their own brand awareness, but can also observe the marketing activity and the brand awareness of the rival. Thus, firms supply two different customer groups. One group knows both firms and the other only the respective firm. Consequently, the profit of a firm depends not only on the own brand awareness, but also on the brand awareness of the rival.

Assume that all consumers who know the product also buy one unit of the product. For all consumers that know both products, firms will be led to compete in prices. This fraction of consumers is described by the product of both brand awareness parameters $f_i f_j$. This part of the market is called common market in the following. Further, assume products are heterogenous. The integrated model of heterogenous price competition is based on Hotelling (1929) and D'Aspremont, Gabszewicz, and Thisse (1979) with the modification that both firms are positioned at the ends of the Hotelling line. Thus, the market share σ_i of firm i in the common market is given by

$$\sigma_i^H(p_i, p_j) = \frac{1}{2} + \frac{p_j - p_i}{2t} \quad (4.1)$$

where p_i describes the first-period price of firm i ($i \neq j$ and $i, j \in \{1, 2\}$). t stands classically for the parameter of heterogeneity of the two products.

The fraction of consumers who only know one firm is described by $f_i(1 - f_j)$. Assume that in this part of the market firms can behave as a monopolist. Firms

charge the reservation price p^r for this customer group. Thus, marketing of a firm has a positive effect on its own profit and a negative effect on the profit of the other firm. The remaining group of consumers is not being advertised. This fraction of the uninformed and therefore potential consumers is given by $(1 - f_i)(1 - f_j)$.

Imagine, for instance, two firms, which are supplying heterogenous products and sell these products at two different locations. Firms advertise first in their neighborhood. In this area they can act as a monopolist, because customers are only aware of this firm. The greater their marketing expenses or the larger the advertising area is, respectively, the more overlap of the advertised areas will there be between the two firms. In the overlap area both firms compete in prices. The only difference is the heterogeneity of their products.

Another interpretation could be to imagine the price differential as buyer power. If consumers knew both companies they could ask for a discount. If consumers received no discount, they could opt to buy from the rival.

Furthermore, assume consumers have switching costs (compare Klemperer (1987)). Suppose switching costs are so high that it is not valuable for consumers to switch to another firm in the second period. Therefore it can be assumed that consumers are loyal. This assumption will not be the reason for later results, but intensifies them as Campello and Fluck (2004) found. Additionally, firms can not advertise for new customers. The loyal customers are willing to pay the reservation price p^r in the second period. Thus, in order to optimize their profit firms demand the reservation price in the second period, while market shares are determined in the first period.

The cost function of both firms consists of the described marketing costs M_i and marginal costs of production c . Assume c is constant and identical for both firms. Furthermore, firms have to make an initial investment of I .

Assume the demand for the product is not exactly known by the firms in the market. The market size in the first period is stochastic. This assumption is necessary to account for risk in case of debt-financing. Firms only know the possible distribution of demand. To keep it simple, suppose there are only two possible market sizes, a large market z^H with probability θ ($0 < \theta < 1$) or a small market z^L with probability $1 - \theta$. This assumption can be made due to the fact that for a given debt-contract only two states are of interest. Either the

firm can repay the loan or it goes bankrupt. Then, z^k is the expected market size in the respective state. As Franck and Pape (2008) show the probability of the good state θ decreases with a higher debt level of both firms. Thus, for simplifying the analysis debt levels are seen as exogenous. The expected market size over both states in the first period is given by $\bar{z} = \theta z^H + (1 - \theta)z^L$. The market size in the second period is normalized to one. For simplicity firms value future profits similar to current profits. Therefore, the discount rate is assumed to be one.

4.3. Price and marketing competition with self-financing

Three different financing situations of the two firms in the market are of interest. The standard financing situation, which serves as a comparison with the other situation later on, are two completely self-financed firms. In this case the profit (Π_i) of firm i is identical to the payoff of the entrepreneur of firm i (V_i). The payoff depends on prices and brand awareness of both firms ($V_i[f_i, f_j, p_i, p_j]$). Over both periods the payoff of entrepreneur i is given by

$$\begin{aligned}
V_i &= \Pi_{i1} + \Pi_{i2} \\
&= (p_i - c)\bar{z}f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c)\bar{z}f_i(1 - f_j) - \frac{w}{2}f_i^2 - I \\
&+ (p^r - c)f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c)f_i(1 - f_j)
\end{aligned} \tag{4.2}$$

Firms act in two stages, the marketing and the price competition stage. Thus, firms have to optimize the profit function (4.2) with regard to these two variables. Due to the assumption that firms can set the price in the part of the market, where they act as a monopolist, only the optimal price for the common market has to be determined. Due to the sequential setting, firms decide first on their optimal marketing expenses and afterwards on the optimal price. Such sequential environments can be solved by backward induction. This leads to the first proposition.

Proposition 1: Assuming two symmetrical self-financed firms in a duopoly market competing in prices and brand awareness, optimal prices are independent of marketing expenses. Furthermore, the optimal price of a firm depends neg-

atively on the reservation price in the second period.

Proof 1: On the last stage firms have to set prices. Optimizing 4.2 with regard to the price ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$) results in the following price best response function.

$$p_i = \frac{p_j + c + t}{2} - \frac{p^r - c}{2\bar{z}} \quad (4.3)$$

Prices are strategic complements. If one firm reduced its price to increase market share, also the other firm would do so. Moreover, prices are independent of the brand awareness of both firms. An increase or decrease in marketing expenses has no effect on prices.

Inserting the price best response function of firm j , which is identical due to symmetry, the resulting equilibrium price is

$$p_i^* = c + t - \frac{p^r - c}{\bar{z}} \quad (4.4)$$

As $\frac{\partial^2 V_i[f_i, f_j, p_i, p_j]}{\partial p_i^2} < 0 \forall p_i$ 4.4 describes the profit maximizing price. The optimal price increases with marginal costs, the heterogeneity parameter and the expected size of the market. It decreases with the level of the reservation price. The best response functions of both firms are drawn in figure 13. To exclude subsidizing the product in the first period, $p^r < (t + c)\bar{z} + c$ is assumed in the following. The reservation price has an upper bound. The point of intersection marks the optimal prices of both firms. \square

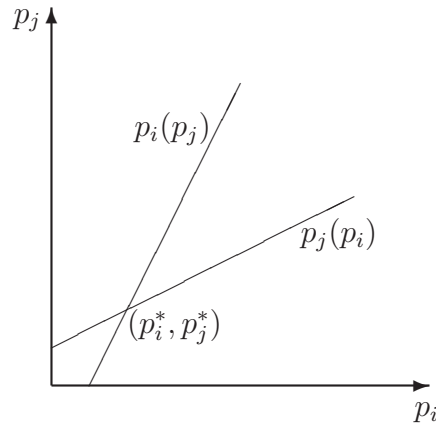


Figure 13: Price best response functions of two self-financed firms

Proposition 2: Assuming two symmetrical self-financed firms in a duopoly market competing in prices and brand awareness, brand awareness parameters are

strategic substitutes. Furthermore, the optimal brand awareness of a firm depends positively on the reservation price in the second period.

Proof 2: On the first stage firms have to choose optimal marketing expenses. Generally, optimizing 4.2 the payoff function of the entrepreneur ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial f_i} = 0$) without taking into account optimal prices the optimal brand awareness of firm i is given by:

$$f_i = \frac{(p^r - c)(\bar{z} + 1)}{w} - \left(\frac{(p_i - p_j)((p_i - c)\bar{z} + p^r - c) + t((p^r - p_i)\bar{z} + (p^r - c)(\bar{z} + 1))}{2tw} \right) f_j \quad (4.5)$$

The slope of the best response function is negative. Marketing activities of firms are strategic substitutes. The more the rival invests in marketing the less valuable is the own investment in marketing ($\frac{\partial f_i}{\partial f_j} < 0$). Furthermore, it is obvious that with price increases of the rival, a firm's marketing activity increases ($\frac{\partial f_i}{\partial p_j} > 0$). A stronger activity in the common market is valuable. The behavior during its own price increase, however, depends on the values of the parameters. No general proposition can be made.

Taking into account optimal prices on the first stage and then optimizing with respect to the marketing expenses ($\frac{\partial V_i[f_i, f_j]}{\partial f_i} = 0$) results in the following brand awareness best response function.

$$f_i = \frac{(p^r - c)(\bar{z} + 1)}{w} - \left(\frac{2(p^r - c)(\bar{z} + 1) - t\bar{z}}{2w} \right) f_j \quad (4.6)$$

Let $p^r > c + \frac{\bar{z}t}{2(\bar{z}+1)}$ be the lower bound of the reservation price. Again it can be seen that brand awareness is a strategic substitute. This is assumed in the following. Inserting the brand awareness best response function of the rival leads to the optimal brand awareness of firm i .

$$f_i^* = \frac{2(p^r - c)(\bar{z} + 1)}{2w - \bar{z}t + 2(p^r - c)(\bar{z} + 1)} \quad (4.7)$$

As $\frac{\partial^2 V_i[f_i, f_j]}{\partial f_i^2} < 0 \forall f_i$, f_i^* is the profit maximizing brand awareness. The optimal brand awareness of a firm depends positively on the expected market size and the parameter of heterogeneity. It depends negatively on the costs for marketing. Figure 14 summarizes these results. To satisfy the assumption

$0 \leq f_i \leq 1$ it must hold $w \geq (p^r - c)(\bar{z} + 1)$, which is assumed in the following. The point of intersection marks the optimal brand awareness of both firms. \square

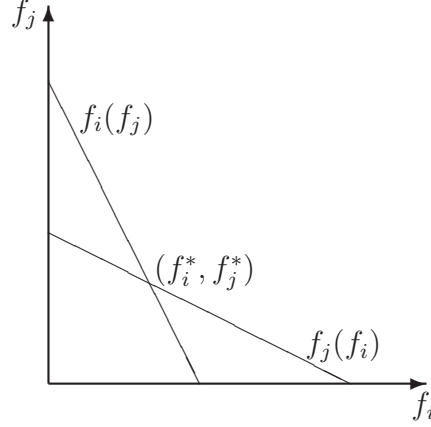


Figure 14: Brand awareness best response functions of two self-financed firms

Taking 4.7 into account the expected payoff of entrepreneur i is given by

$$V_i^* = \frac{2w((p^r - c)(\bar{z} + 1))^2}{(\bar{z}t - 2w - 2(p^r - c)(\bar{z} + 1))^2} - I \quad (4.8)$$

The optimal profit of a self-financed firm depends mainly on the reservation price firms can charge from the uninformed consumers in the first and of all consumers in the second period. Due to $w > (p^r - c)(\bar{z} + 1)$ the profit of a firm depends negatively on the marketing cost parameter. Furthermore, the more heterogenous the products are (t increases) or the higher the expected market share is (\bar{z}) the higher is the profit of a firm. Table 1 summarizes these results.

| $\frac{\partial V_i^*}{\partial p^r}$ | $\frac{\partial V_i^*}{\partial c}$ | $\frac{\partial V_i^*}{\partial w}$ | $\frac{\partial V_i^*}{\partial t}$ | $\frac{\partial V_i^*}{\partial \bar{z}}$ |
|---------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---|
| > 0 | < 0 | < 0 | > 0 | > 0 |

Table 1: Comparative statics

In sum, the investment is advantageous over both periods as long as $\frac{2w((p^r - c)(\bar{z} + 1))^2}{(\bar{z}t - 2w - 2(p^r - c)(\bar{z} + 1))^2} \geq I$. This is assumed in the following.

4.4. Debt-financing of both firms in the market

In the prior section both firms were completely self-financed. We now turn to the case of both firms having positive leverage. To keep it simple and

symmetric assume that both firms have the same debt-financing conditions and borrow the same amount of debt. The offered financial contract is adopted from the debt contract in Chevalier and Scharfstein (1996). Their contract design is based on the work of Bolton and Scharfstein (1996) and Hart and Moore (1998). The contract design is as follows.

Assume firms only need money in the first period to cover their initial investment. Thus, firms have to borrow debt in the amount of I . Furthermore, assume asymmetric information in the market. Banks cannot verify the true state of the world. The bank calls for a repayment of $R^H > I$ after the first period. If the firm cannot repay the loan, the bank will have the right to liquidate the firm after the second period. Demand is uncertain. Let good states of the world be described by a high demand and bad states of the world by a low demand. Assume that in the latter state revenues are too low to cover the loan. Only in the good state of the world, firms are able to repay the loan ($\Pi_i(z^L) < R^H \leq \Pi_i(z^H)$). Thus in the good state of the world the entrepreneur repays the loan after the first period and receives the whole revenue of the second period. In the bad state of the world the entrepreneur keeps the first-period profits by himself and repays nothing. Consequently the bank assumes control and the entrepreneur receives nothing in the second period. In this case, the bank receives nothing in the first period and full revenues of the second period, which are assumed to have a lower value for the bank ($l \cdot \Pi_{i2}$ with $0 < l < 1$). The design of the contract guarantees that the rival is not directly influenced by it. The firm operates in both periods. In conclusion, the bank would be willing to lend money, if its expected repayment was nonnegative.

$$W = \theta R^H + (1 - \theta)l(p^r - c)f_i \left(f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (1 - f_j) \right) - I \geq 0 \quad (4.9)$$

Taking the financial contract into account the expected payoff of entrepreneur i changes to

$$\begin{aligned} V_i^D &= \Pi_{i1}^D + \Pi_{i2}^D \\ &= (p_i - c)\bar{z}f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c)\bar{z}f_i(1 - f_j) - \frac{w}{2}f_i^2 - \theta R^H \\ &+ \theta(p^r - c)f_i \left(f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (1 - f_j) \right) \end{aligned} \quad (4.10)$$

The design of the contract guarantees a similar profit for the first period except the repayment to the bank, which the entrepreneur only pays in the good state. The profit of the second period accrues correspondingly also only in the good state.

Proposition 3: If firms borrow money from a bank and the debt contract has the above mentioned design competition in the market is less intense. Optimal prices increase and optimal brand awareness of both firms decrease.

Proof 3: Firms again have to optimize the profit function with regard to the optimal price and the optimal marketing intensity. Optimizing 4.10 with regard to the price ($\frac{\partial V_i^D[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$) leads to a new price best response function.

$$p_i = \frac{p_j + c + t}{2} - \theta \frac{p^r - c}{2\bar{z}} \quad (4.11)$$

Compared to the self-financing case (4.3) the best response function of entrepreneur i (4.11) shifts outward due to the lower expected profit in the second period. The entrepreneur receives profits in period two only with probability θ . Due to symmetry this is also the case for entrepreneur j . Solving the system of two price best response functions leads to the equilibrium price under debt-financing.

$$p_i^D = c + t - \theta \frac{p^r - c}{\bar{z}} \quad (4.12)$$

The optimal price of both firms i under debt-financing is higher than under self-financing. Thus, borrowing money from a bank is a fat-cat strategy in the terminology of Fudenberg and Tirole (1984). It increases prices. Figure 15 summarizes these results.

Taking 4.12 into account on the first stage the profit function has to be optimized regarding to the optimal marketing expenses ($\frac{\partial V_i^D[f_i, f_j]}{\partial f_i} = 0$). This results also in a new brand awareness best response function.

$$f_i = \frac{(p^r - c)(\bar{z} + \theta)}{w} - \left(\frac{2(p^r - c)(\bar{z} + \theta) - t\bar{z}}{2w} \right) f_j \quad (4.13)$$

Due to $0 < \theta < 1$ the best response function shifts inward with a flatter slope in case of two debt-financed firms. Due to symmetry the best response function

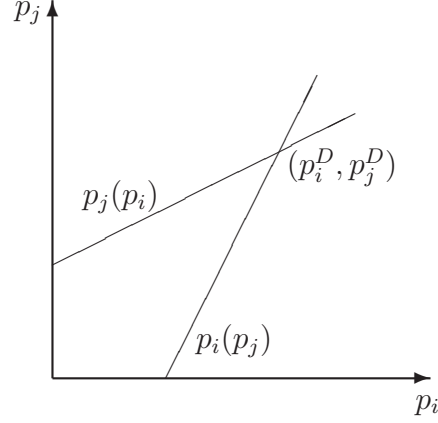


Figure 15: Price best response functions of two debt-financed firms

of the rival firm is identical. Solving the system of two best response functions yields the optimal brand awareness of firm i .

$$f_i^D = \frac{2(p^r - c)(\bar{z} + \theta)}{2w - \bar{z}t + 2(p^r - c)(\bar{z} + \theta)} \quad (4.14)$$

The optimal brand awareness under debt-financing (4.14) is lower than under self-financing (4.7). Debt is a soft commitment not only for the optimal price, but also for the optimal brand awareness. Debt-financed firms invest less in marketing. Figure 16 summarizes these results.

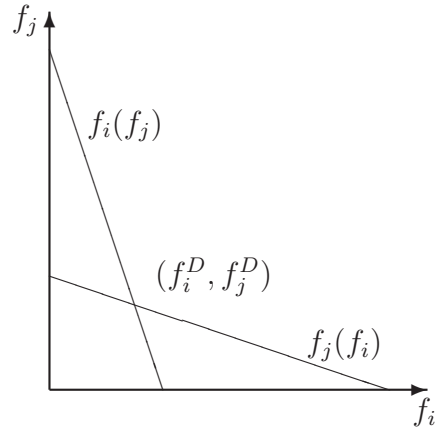


Figure 16: Brand awareness best response functions of two debt-financed firms

Taking 4.14 into account the optimal payoff of entrepreneur i is given by

$$V_i^D = \frac{2w((p^r - c)(\bar{z} + \theta))^2}{(\bar{z}t - 2w - 2(p^r - c)(\bar{z} + \theta))^2} - \theta R^H \quad (4.15)$$

In case of debt-financing the expected revenues of the entrepreneur are due to $\frac{\partial \Pi_i^D}{\partial \theta} > 0$ and $0 < \theta < 1$ lower than in case of self-financing. \square

4.5. Debt-financing of one firm in the market

After considering the symmetric cases in this last section the effects of two firms with a different leverage will be analyzed. For simplicity assume that one firm is completely self-financed and the other firm is debt-financed. The design of the debt contract is identical to the contract above. The advantage of this contract is that the profit function of the self-financed firm remains unchanged. The debt-financed firm stays in the market in every state. In the first period both firms operate. In the second period either the entrepreneur or the bank controls the firm. Therefore, the debt-financed firm also operates in the second period in every state. Thus the contract of the debt-financed firm has no direct effect on the profit function of the self-financed firm. All changes in the behavior of the self-financed firm must be strategic. Assuming firm i is the self-financed firm and firm j is the debt-financed-firm the payoffs of both entrepreneurs are as above.

$$\begin{aligned}
V_i &= \Pi_{i1} + \Pi_{i2} \\
&= (p_i - c)\bar{z}f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c)\bar{z}f_i(1 - f_j) - \frac{w}{2}f_i^2 - I \\
&+ (p^r - c)f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c)f_i(1 - f_j) \tag{4.16}
\end{aligned}$$

$$\begin{aligned}
V_j^D &= \Pi_{j1}^D + \Pi_{j2}^D \\
&= (p_j - c)\bar{z}f_j f_i \left(\frac{1}{2} + \frac{p_i - p_j}{2t} \right) + (p^r - c)\bar{z}f_j(1 - f_i) - \frac{w}{2}f_j^2 - \theta R^H \\
&+ \theta(p^r - c)f_j \left(f_i \left(\frac{1}{2} + \frac{p_i - p_j}{2t} \right) + (1 - f_i) \right) \tag{4.17}
\end{aligned}$$

Proposition 4: If one firm is self-financed and the other firm debt-financed optimal prices and firms' optimal brand awareness are different. The debt-financed firm behaves less aggressive. The optimal price is higher and the optimal brand awareness lower than of the self-financed firm.

Proof 4: The structure of the analysis is as before. Optimizing 4.16 and 4.17 with regard to firms prices ($\frac{\partial V_i[f_i, f_j, p_i, p_j]}{\partial p_i} = 0$ and $\frac{\partial V_j^D[f_i, f_j, p_i, p_j]}{\partial p_j} = 0$) lead to the

above mentioned price best response functions (4.3 and 4.11). Solving the set of best response functions yields the optimal prices of both firms

$$p_i^* = c + t - \frac{p^r - c}{\bar{z}} + \frac{1}{3}(1 - \theta)\frac{p^r - c}{\bar{z}} \quad (4.18)$$

$$p_j^D = c + t - \frac{p^r - c}{\bar{z}} + \frac{2}{3}(1 - \theta)\frac{p^r - c}{\bar{z}} \quad (4.19)$$

The price of the positively leveraged firm (4.19) is $\frac{1}{3}(1 - \theta)\frac{p^r - c}{\bar{z}}$ higher than the price of the self-financed firm (4.18). Hence, due to the unchanged profit function, this price differential is purely strategic. In order to have high profits in the good state, debt-financed firms try to increase prices. The self-financed firm also increases prices, but less than the debt-financed firms. As a consequence, self-financed firms have higher market shares in the common market. Figure 17 summarizes these results and shows the equilibria for the different cases.

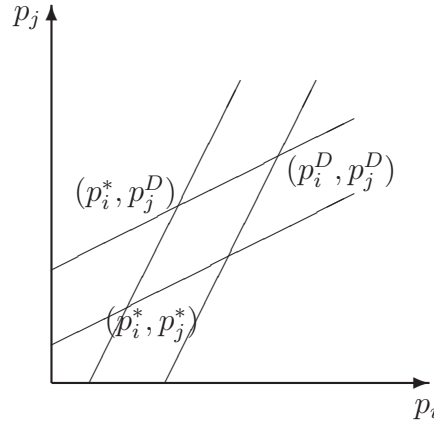


Figure 17: Price best response functions of two different leveraged firms

Inserting 4.18 and 4.19 and optimizing the payoff function of both entrepreneurs regarding to the marketing activity parameter the best response functions are given by

$$f_i = \frac{(p^r - c)(\bar{z} + 1)}{w} - \left(\frac{6\bar{z}t(p^r - c)(3\bar{z} + \theta + 2) - 9\bar{z}^2t^2 - (p^r - c)^2(1 - \theta)^2}{18\bar{z}tw} \right) f_j \quad (4.20)$$

$$f_j = \frac{(p^r - c)(\bar{z} + \theta)}{w} - \left(\frac{6\bar{z}t(p^r - c)(3\bar{z} + 2\theta + 1) - 9\bar{z}^2t^2 - (p^r - c)^2(1 - \theta)^2}{18\bar{z}tw} \right) f_i \quad (4.21)$$

The axis intercept of the debt-financed firm is lower than the one of the self-financed-firm. Also the slope of the brand awareness best response function is flatter with respect to the self-financed firm. The values of the self-financed firm are $(1 - \theta)\frac{(p^r - c)}{w}$ for the axis intercept and $(1 - \theta)\frac{(p^r - c)}{3w}$ for the slope higher than for the debt-financed firm. Figure 18 illustrates the best-response functions of both firms and shows the equilibrium for that case.

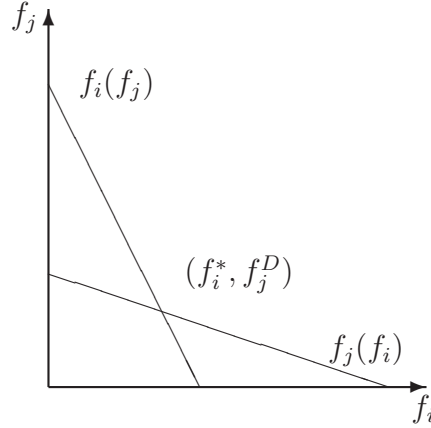


Figure 18: Brand awareness best response functions of two different leveraged firms

Comparing this situation with the two above mentioned situations the following can be concluded. Interestingly, the best response functions are changing compared to the respective situations. The slope of the best-response function of the self-financed firm becomes less steep compared to the first situation. The best response function of the debt-financed firm shifts inward in the same way as in the second case. The slope also becomes more flat. Therefore, in equilibrium the marketing activity parameter of the self-financed firm is higher than the parameter of the debt-financed firm. \square

4.6. Discussion

In this section welfare effects and critical assumptions of the model will be discussed. It also serves as a link for future research. Furthermore, some extensions will be conducted to make the propositions of the model more robust. The focus of this section lies on:

- Welfare effects

- n firms: Extension of the duopoly model to an oligopoly model with more than two firms.
- Discounting future profits: Future profits are normally less important than current profits.
- Consumer discrimination: perfect price discrimination in different markets is mostly not possible.
- Long-term bank relationships: Entrepreneurs normally operate several periods in a market and have the opportunity to sign long-term debt contracts.

4.6.1. Welfare effects

The welfare effects of our model are relatively straightforward. Every consumer would have a positive utility, if he bought one unit of the product at a price lower than the reservation price. This means as more consumers are reached by the firms and the cheaper the products are the higher is consumer welfare. Thus, consumer welfare is maximized when both firms are completely self-financed. In all other cases firms decrease their marketing expenses and increase prices.

Independent of the capital structure firm's profits are maximized when they behave as in the self-financing case. Hence, adding up consumer and producer surplus welfare is maximized in case of self-financing.

4.6.2. n firms

An extension to n firms in the market changes two important assumptions, respectively the market share of a firm in the common market and the opportunity of price discrimination in different markets. Regarding market share the theory of Hotelling (1929) is only applicable for two firms. A possible extension would be the integration of the circular city model of Schmalensee (compare Schmalensee and Willig (1989)). The market share in the common market can thus be found. Generally, according to the circular city model of Schmalensee

the market share of a firm in a market with n firms for the common market is given by

$$\sigma_i^S(p_i, p_j) = \frac{1}{n} + n \frac{\sum_{j=1, j \neq i}^n p_j - (n-1)p_i}{2t} \quad (4.22)$$

The definition of the common market, however, is more difficult. It has to be determined, which companies compete in which market and in which markets firms can apply price discrimination.

The general assumptions are changed in the following way: For simplicity assume there is only a third firm in the market. The effects which can be seen as more firms enter the market are almost identical. The market share of a firm in the case of three competing firms is

$$\sigma_i^S(p_i, p_j) = \frac{1}{3} + 3 \frac{\sum_{j=1}^2 p_j - 2p_i}{2t} \quad (4.23)$$

As assumed due to firms brand awareness in the market they are able to price discriminate. Consumers who only know one firm have to pay a different price from consumers who know more firms. This assumption is very restrictive, because it implies complete information of all firms, but it is also very helpful. It simplifies the analysis without changing the general propositions. Furthermore, the different prices can also be interpreted as a discount that firms have to give well informed consumers. If this is not done, then consumers can easily switch to the competitor.

Due to this insight the assumption will be maintained also for three firms. Thus, there are four different types of consumers possible, either a consumer knows none of the firms, one, two or all. The fraction of consumers for the different cases are determined as above. The first case can be neglected. For the other cases firms can charge different prices dependent on consumers knowledge about the amount of firms in the market. For the cases of one and two known firms, the model remains the same. For the new case of three known firms the above mentioned approach of Schmalensee will be adopted. Different markets result from the assumptions on consumers knowledge. The allocation is similar to the case of two firms in the market. The expected profit of an entrepreneur

in case of three firms in the market is

$$\begin{aligned}
V_i = & (p_i^1 - c)\bar{z}f_i f_j f_k \left(\frac{1}{3} + 3\frac{p_j^1 + p_k^1 - 2p_i^1}{2t} \right) \\
& + (p_i^2 - c)\bar{z}f_i f_j (1 - f_k) \left(\frac{1}{2} + \frac{p_j^2 - p_i^2}{2t} \right) \\
& + (p_i^3 - c)\bar{z}f_i (1 - f_j) f_k \left(\frac{1}{2} + \frac{p_k^3 - p_i^3}{2t} \right) \\
& + (p^r - c)\bar{z}f_i (1 - f_j)(1 - f_k) - \frac{w}{2}f_i^2 - I \\
& + (p^r - c)f_i f_j f_k \left(\frac{1}{3} + 3\frac{p_j^1 + p_k^1 - 2p_i^1}{2t} \right) \\
& + (p^r - c)f_i f_j (1 - f_k) \left(\frac{1}{2} + \frac{p_j^2 - p_i^2}{2t} \right) \\
& + (p^r - c)f_i (1 - f_j) f_k \left(\frac{1}{2} + \frac{p_k^3 - p_i^3}{2t} \right) \\
& + (p^r - c)f_i (1 - f_j)(1 - f_k)
\end{aligned} \tag{4.24}$$

Proposition 5: *Under the new environment with more than two firms in the market the general propositions of the model remain unaffected. A positive leverage of some of the firms softens competition within the market. However, the more firms are in the market the less can be softened competition by a positive leverage of one firm.*

Proof 5: The entrepreneur has to set prices for the different markets. Optimizing 4.24 regarding to the different prices leads to

$$p_i^1 = c + \frac{t}{9} - \frac{p^r - c}{z} \tag{4.25}$$

$$p_i^2 = p_i^3 = c + t - \frac{p^r - c}{\bar{z}} \tag{4.26}$$

The optimal prices in the markets, in which consumers know two firms, remain the same. In the market, where all firms are known, competition is more fierce. The optimal price is lower than in the other markets. This is also the case, if one or more of these firms are financed by debt. As more firms in the market are financed by debt, the higher are the prices in the market (see Appendix 1).

In a similar way the optimal brand awareness of firms changes. As shown the lower the price of a firm the higher is its marketing activity. Thus, the marketing activity of all firms increases. As a consequence of an additional firm in the market, more consumers know about additional options and prices decrease. \square

4.6.3. Discounting future profits

In the original model it was assumed that future profits have the same value for the entrepreneur as current profits. This assumption is very restrictive. In reality this is not always the case. Current profits are more valuable. Future profits are discounted. Therefore, assume the entrepreneur has a discount rate for future profits of δ with $\delta = \frac{1}{1+r}$. Hereby, r can describe either the general interest rate or the entrepreneurs interest rate. To keep it simple and symmetric assume first. For $r = 0$ the future is as important as today $\delta = 1$. For $0 < r \leq 1$, which is the normal range of the interest rate, future profits are valued lower than current profits. $\delta = \frac{1}{2}$ is within this range the minimum discount rate.

Integrating the discount rate has similar effects in all scenarios. Therefore, it will be analyzed only for the first scenario with two self-financed firms. The profit function of a firm changes to

$$\begin{aligned}
V_i &= \Pi_{i1} + \delta \Pi_{i2} \\
&= (p_i - c) \bar{z} f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c) \bar{z} f_i (1 - f_j) - \frac{w}{2} f_i^2 - I \\
&+ \delta \left((p^r - c) f_i f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) + (p^r - c) f_i (1 - f_j) \right) \quad (4.27)
\end{aligned}$$

It is obvious that for $r > 0$ the payoff of entrepreneur i is lower than before. But of more interest are the effects for the optimal prices and brand awareness. This leads to the following proposition.

Proposition 6: If future profits are discounted, in the first period optimal prices will increase and optimal firms brand awareness will decrease.

Proof 6: The optimal price in this scenario is given by

$$p_i^* = c + t - \delta \frac{p^r - c}{\bar{z}} \quad (4.28)$$

The lower the discount rate δ the more are current profits of interest. This also reflects the optimal price. The optimal price is low in the first scenario because firms try to increase their market share in the first period to gain from the profit margin of $p^r - c$ in the second period. If future profits are valued less, firms will increase their prices to have a higher profit in the first period. Interestingly, if symmetric firms and hence symmetric prices are assumed in both scenarios, profits won't decrease in the second period, because the common market is still shared equally. Thus, higher interest rates guarantee higher profits in the common market.

Similarly the optimal marketing behavior is changed. Taking discount rates into account the optimal brand awareness is now given by

$$f_i^* = \frac{2(p^r - c)(\bar{z} + \delta)}{2w - \bar{z}t + 2(p^r - c)(\bar{z} + \delta)} \quad (4.29)$$

A higher brand awareness guarantees higher future profits. If the future is valued less, firms will invest less in their own brand. This can be derived from $\frac{\partial f_i^*}{\partial \delta} > 0$. \square

The discounting of future profits leads to higher prices and less brand awareness. Thus, higher interest rates induce less competitive behavior of firms. The optimal payoff of entrepreneur i changes to

$$V_i^* = \frac{2w((p^r - c)(\bar{z} + \delta))^2}{(\bar{z}t - 2w - 2(p^r - c)(\bar{z} + \delta))^2} - I \quad (4.30)$$

Thus, as mentioned above, for $r > 0$ the optimal payoff for entrepreneur i decreases.

4.6.4. Price discrimination

In our model perfect price discrimination with respect to the different markets is assumed. Firms act in one market as a monopolist and in the other market competitively as in a duopoly. Uninformed consumers pay more for the product than informed consumers. Firms are able to accomplish this due to the assumptions that consumers would only know and buy the product, if they were influenced by marketing of the firm and moreover that firms have perfect information about the fraction of informed consumers.

In reality, however, in most markets this is not possible. There are other mechanisms that provide for the diffusion of information about a product and its suppliers. Consumers, for instance, inform themselves about alternative suppliers of a product. Moreover, several marketing channels, for example, advertising on TV, in newspapers or the internet are not personalized. Only some marketing channels like advertising by mail can be personalized. But also here it is not guaranteed that the receiver reads it or is inclined to buy the product. Thus, firms are not able to distinguish between well informed and less informed consumers. Either there is no price discrimination or the fraction of well informed consumers is higher and the price difference between both markets smaller.

Assume for the extreme case that price discrimination between well and less informed consumers is impossible. Then marketing activity can be modeled similar to the model of Grossman and Shapiro (1984). The profit of a self-financed firm changes to

$$\begin{aligned}
V_i &= \Pi_{i1} + \Pi_{i2} \\
&= (p_i - c)z f_i \left(1 - f_j + f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) \right) - \frac{w}{2} f_i^2 - I \\
&+ (p^r - c) f_i \left(1 - f_j + f_j \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) \right)
\end{aligned} \tag{4.31}$$

In this environment optimal prices depend negatively on the marketing activity of both firms. Optimal prices are given by

$$p_i^* = c - \frac{(p^r - c)(2f_i + f_j)}{3f_i f_j z} + t \left(\frac{2f_j + 2f_i}{3f_i f_j} - 1 \right) \tag{4.32}$$

Comparing 4.32 with the situation in the basic model (4.4), prices are only equal in case of perfect information in the market, where all consumers are informed by marketing ($f_i = f_j = 1$). In the case of less marketing, prices are due to $\frac{\partial p_i^*}{\partial f_i} < 0$ and $\frac{\partial p_i^*}{\partial f_j} < 0$ higher. Thus, if perfect price discrimination is not possible, common prices will lie between the duopoly and the reservation price of the basic model. In case of debt financing results are similar to the basic model. Prices in the market are higher. Moreover, debt-financed firms charge higher prices than self-financed firms. For instance, the optimal price in case of two debt-financed firms is given by

$$p_i^D = c - \frac{\theta(p^r - c)(2f_i + f_j)}{3f_i f_j z} + t \left(\frac{2f_j + 2f_i}{3f_i f_j} - 1 \right) \tag{4.33}$$

For the brand awareness of a firm the outcome is not obvious. Optimizing on the first stage (the analysis follows Pfaehler and Wiese (1998), p.284ff) results in

$$\frac{\partial V_i(f_i, f_j)}{\partial f_i} = \underbrace{\frac{\partial V_i}{\partial f_i}}_{?} + \underbrace{\frac{\partial V_i}{\partial p_j} \frac{\partial p_j^*}{\partial f_i}}_{<0} + \underbrace{\frac{\partial V_i}{\partial p_i} \frac{\partial p_i^*}{\partial f_i}}_{=0} \quad (4.34)$$

The first term, the direct effect, consists of a revenue and a cost term. With increased marketing, demand and revenue as well as cost increase. It depends on the absolute value of f_i , which term is larger. The second term, the strategic effect, is due to $\frac{\partial V_i}{\partial p_j} > 0$ and $\frac{\partial p_j^*}{\partial f_j} < 0$ negative. The last term is zero due to $\frac{\partial V_i}{\partial p_i} = 0$, the Envelope-theorem. Thus, the total effect depends on the absolute value of f_i . For smaller values of f_i marketing pays off as long as the total effect is zero.

In case of debt-financing the direct effect results in a smaller optimal brand awareness. Due to the weaker strategic effect, however, it is not clear which effect prevails. But as prices are higher, the best guess is that the optimal brand awareness is lower as in the basic model. Thus, all in all, the propositions of the basic model would also be valid, if no price discrimination were possible.

4.6.5. Long-term bank relationships

The model concentrates on the short term. As there are only two periods it is therefore rather static. This seems to be only realistic for investment projects with a one-period return or for projects with myopic managers. Supposing firms operate more than two periods in the market and managers are long-term oriented banks also lend money for more than two periods. Between banks and firms can occur a housebank relationship like in Germany, where banks have more insights into a firm. Dependent on future profit expectations banks do not compulsory liquidate firms in case of low profits. Then repayments are delayed into later periods. If firms act in such an environment, the effects suggested by the model might be mitigated.

4.7. Conclusion

The literature of capital structure and product market competition mainly focuses only on the effects of capital structure on prices or quantities. Our

paper proposes that also other important variables of a firm are influenced by the capital structure decision of a firm. The model analyzes markets with price competition and horizontal differentiation, where marketing expenses are relevant. Our main result is that the marketing decision is also influenced by the capital structure of the firms in the market. If all firms in the market had a positive leverage, optimal prices would increase and firms marketing activity decrease. If only one firm was debt-financed, optimal prices and firms marketing activity would be different. The debt-financed firm behaves less aggressively. The optimal price is higher and the marketing activity is lower than of the debt-financed firm. Thus, debt can be strategically held by firms, because it softens marketing and price competition.

As optimal prices in the model are independent of firms' optimal marketing activity optimal prices are similar to those in the model of Chevalier and Scharfstein (1996). Prices would be lowest, if all firms in the market were purely self-financed. The more debt-financed firms are in the market, the higher are the prices of the individual firms. Furthermore, optimal prices of debt-financed firms are always higher than those of self-financed firms. These results are supported by the empirical findings of Chevalier (1995a) and Kovenock and Phillips (1995), except that in the case of differently financed firms, price cuts of self-financed firms could be observed. In the theoretical model, optimal prices are only lower than those of debt-financed firms, but not lower than without any debt-financed firm in the market.

The theoretical outcome for the marketing activity corresponds largely to the empirical findings of Grullon, Kanatas, and Kumar (2006). A positive leverage of some firms in the market softens marketing competition. The marketing activity of self-financed firms in our model, however, also decreases. But marketing activities of those firms are higher than those of debt-financed firms. Thus, effects are similar, but weaker than suggested by empirical findings. The lowest marketing activity in the market should be observed, if all firms were debt-financed. This result agrees with the empirical findings.

Appendix

(1) Table 2 and 3 summarize the optimal prices in the different situations for common markets with two and three firms:

| self- / debt-financed firms | price of self-financed firm | price of debt-financed firm |
|-----------------------------|---|--|
| 2 / 0 | $c + t - \frac{p^r - c}{z}$ | — |
| 1 / 1 | $c + t - \frac{p^r - c}{z} + (1 - \theta) \frac{p^r - c}{3z}$ | $c + t - \frac{p^r - c}{z} + (1 - \theta) \frac{2(p^r - c)}{3z}$ |
| 0 / 2 | — | $c + t - \theta \frac{p^r - c}{z}$ |

Table 2: The optimal prices of self- and debt-financed firms in case of two firms in the market

| self- / debt-financed firms | price of self-financed firm | price of debt-financed firm |
|-----------------------------|--|--|
| 3 / 0 | $c + \frac{t}{9} - \frac{p^r - c}{z}$ | — |
| 2 / 1 | $c + \frac{t}{9} - \frac{p^r - c}{z} + (1 - \theta) \frac{p^r - c}{5z}$ | $c + \frac{t}{9} - \frac{p^r - c}{z} + (1 - \theta) \frac{3(p^r - c)}{5z}$ |
| 1 / 2 | $c + \frac{t}{9} - \frac{p^r - c}{z} + (1 - \theta) \frac{2(p^r - c)}{5z}$ | $c + \frac{t}{9} - \frac{p^r - c}{z} + (1 - \theta) \frac{4(p^r - c)}{5z}$ |
| 0 / 3 | — | $c + \frac{t}{9} - \theta \frac{p^r - c}{z}$ |

Table 3: The optimal prices of self- and debt-financed firms in case of three firms in the market

5. Strategic debt in markets with R&D and Cournot competition

Abstract

The literature on capital structure and product market competition has shown that the market behavior of a firm is influenced by its and rivals capital structure. This paper investigates not only the influence of the capital structure on market quantities and prices, but also on R&D investment decisions. Firms have the opportunity to spend R&D expenditures in technologies that elicits a cheaper production process. The model shows that debt-financing of all firms in the market intensifies R&D competition. If just one firm in the market is debt-financed, this firm will decrease its R&D expenditures. The self-financed firms on the other hand behave predatorily and increase their R&D expenditures. In equilibrium no firm in the market is financed by debt.

Keywords: R&D activity, capital structure, product market competition

JEL classification: D 43, G 32, L 13

5.1. Introduction

Capital structure decisions of a firm are influenced by different factors. Beside the availability of financial resources one main argument for debt or equity are the investment decisions of a firm. Transaction cost and agency theory already gives advice as to how to finance specific investments.

Transaction costs theories argue that the capital structure of a firm is not only influenced by financial reasons, but rather by strategic and control reasons. Whether a project should be financed by debt or by equity depends principally on the characteristics of the assets (Williamson (1988)). Whereas tangible assets should be financed by debt, intangible assets should be financed by equity.

Agency theory supports this thesis. In the model of Myers (1977) a firm has growth or investment options, respectively. If a firm is only financed with internal capital, the firm would realize all options with a positive net present value. But a partially debt-financed firm would have the incentive, not to invest in all these options, if the owner-manager of that firm tried to maximize the value of equity and not the value of the whole firm. But due to the fact that some investments are disadvantageous from the perception of the shareholders, debt causes underinvestment. Myers (1977) concludes that firms with many growth options should not be financed with debt, but with outside equity. And firms with many physical assets and only some growth options should be financed with debt.

Empirical studies supports the arguments. Balakrishnan and Fox (1993) show in their study of 295 mining and manufacturing firms that unique firm-specific assets and skills are by far the most important determinants of capital structure. As formulated in their hypothesis a firm's leverage is positively related to the redeployability of its existing assets and to its investments in tangible assets. Further Balakrishnan and Fox (1993) argue that firms that tend to invest heavily in R&D which potentially creates intangible and firm specific knowhow will find it more difficult to fund such investments with debt.

Opler and Titman (1994) study firms in situations of financial distress. Highly leveraged firms lose market share to their less leveraged competitors. An increase in debt level - especially in R&D intensive industries - leads to an inferior competitive market position.

Our paper wants to take on those empirical findings and wants to investigate capital structure decisions of a firm while being engaged in R&D investments. As Kamien, Muller, and Zang (1992) state R&D competition can take place in four different ways. Basically, either firms fully compete in R&D expenses or cooperate via a Research Joint Venture (RJV). Additionally, in both cases firms can either determine the common amount of research expenses (cartelization) or decide for themselves on their own amount. Kamien, Muller, and Zang (1992) investigate these four situations in markets with Cournot and Bertrand competition. In markets with RJV competition R&D expenses are lower and product prices higher than in markets, where firms compete in R&D. A RJV with coordinated R&D, however, yields the highest consumer and producer surplus among all other cases.

Neff (1999) and Chen (2005) additionally integrate the capital structure decision of a firm into models with R&D competition. In both papers, firms invest in R&D to search for a cost-cutting technology. Whereas in the model of Neff (1999) firms are faced by R&D and price competition, in the model of Chen (2005) firms are faced by RJV and quantity competition. The latter model is based on the RJV model of D'Aspremont and Jacquemin (1988). In the model of Neff (1999) debt-financing of a firm decrease their R&D investment. Self-financed rivals, however, increase R&D investment. Are all firms in a market debt-financed, equilibrium R&D investment decreases. Consequently, equilibrium prices are higher. In the model of Chen (2005) debt-financed firms behave more aggressive. R&D investments as well as quantities increase. Profits, however, are highest in case of self-financing. Thus, in equilibrium, all firms in the market are self-financed.

Our model is based on the work of Neff (1999) and Chen (2005). As in the model of Neff (1999) R&D competition is assumed. Firms, however, compete, as in Chen (2005), in quantities. The theoretical approach stands in line with the literature on capital structure and product market competition, which is mainly influenced by the work of Brander and Lewis (1986) and Showalter (1995) for static models. Brander and Lewis (1986) show for markets with quantity competition that leveraged firms behave more aggressive in the market. Due to a prisoners dilemma situation in equilibrium all firms have a positive leverage and are worse off. Contrary to markets with quantity competition, Showalter (1995) shows that in markets with price competition the

optimal behavior of a firm depends on the kind of uncertainty. In markets with cost uncertainty firms behave more aggressive. Thus, in equilibrium firms hold no strategic debt. In markets with demand uncertainty, however, firms behave less aggressive. Prices increase with a positive debt-level. In equilibrium firms have a positive leverage.

The theoretical propositions on capital structure and product market competition are confirmed as far as possible by an experimental study of Oechssler and Schuhmacher (2004) as well as a wide range of empirical studies. In an analysis of 1641 manufacturing firms Showalter (1999b) supports his theoretical results for industries with price competition. Under demand uncertainty firms increase their debt level and under cost uncertainty they reduce it.

The empirical study of De Jong, Nguyen, and van Dijk (2007) brings evidence for the static models of Brander and Lewis (1986) and Showalter (1995). They classify markets according to the prevailed kind of uncertainty. In markets with demand uncertainty positive leverages can be observed in both market scenarios, Bertrand and Cournot competition. In markets with cost uncertainty positive debt levels can be observed only for Cournot competition.

Campello and Fluck (2004) investigate the consequences of negative demand shocks in 57 different industries during the recession of 1990/91 in America. Firms with a high leverage significantly lose market shares to firms with a low leverage. Furthermore, the loss of market share of highly debt financed firms is more pronounced in industries where low debt usage is the norm and in industries with high consumer switching costs.

Phillips (1995) investigates four different industries, in which the leverage of firms were strongly changed due to a LBO. In three of these industries, namely fiberglass insulation, tractor trailer and polyethylene industry, where barriers to entry are high, output is negatively associated with the average industry debt ratio. also product prices are higher. Thus, highly leveraged firms behave less aggressive in the market. Moreover, they lose market share to their less leveraged competitors. In the fourth industry, the gypsum industry, product prices are negatively related to the average debt ratio of the industry. Output is shown to increase. The industry is characterized by low barriers to entry and a simple production technology with small plant sizes. Only smaller investments in new plants have to be made.

Chevalier (1995b) investigates LBO's in the supermarket industry in different regions in the US. If many or even all firms in the specific market were highly leveraged, prices tend to increase. However, when only one firm in the market is highly leveraged, price reductions can be observed. These are initiated from the self-financed rivals. In a second study Chevalier (1995a) finds that after a LBO of an incumbent rivals share prices increase. This confirms the strategic effect of a capital structure change. Kovenock and Phillips (1995) and Kovenock and Phillips (1997) also analyze LBO's in different industries and come to the result that increasing debt levels in the industry lead to higher product prices and less industry output. Stomper and Zulehner (2004) come to similar results for the industry of Austrian ski hotels.

5.2. R&D and Cournot competition - The basic one period model

As mentioned above, our work is based on Neff (1999) and Chen (2005). Whereas Chen (2005) considers a one period model, firms in the model of Neff (1999) compete over two periods. As the latter our model also consists of two periods. Furthermore, the kind of uncertainty in both models is different. In the model of Chen (2005) uncertainty is independent of R&D expenses. Higher expenses decrease expected marginal costs, but uncertainty still exists. In the model of Neff (1999) the decrease in costs is fixed, but the probability of an innovation is directly influenced by the amount of R&D expenses. With higher research costs an innovation is more probable. The risk of no success decreases. From our point of view the latter assumption seems to be more realistic, because a successful innovation is automatically connected with a decrease in marginal costs.

Thus, basic elements of our model are geared to the two-period model of Neff (1999) (for an illustration see also Neff (2003)). As mentioned above, in her model she analyzes capital structure decisions of two firms in a duopoly that could invest in R&D and compete in prices on the product market. Our model, however, has little modifications. On the output market firms do not directly compete in prices, but first in quantities. Kreps and Scheinkmann (1983) have shown that under these circumstances the results are similar to the quantity competition game of Cournot (1838). Thus, the product market stage will be

modeled as a Cournot competition game. Furthermore, Neff (2003) assumes that the innovation in a cost reducing technology results in the same cost saving in every period. Allowing more than two periods this assumption seems not very realistic due to the lower bound of zero for marginal costs. In our model marginal costs are reduced by a certain percentage of marginal costs of the respective period. For simplicity this percentage is fixed and similar in every period.

But before analyzing the case of more than one period we present the setup of the basic one-period model. This setup is identical in every period. The financial stage at the beginning of the whole game and with it debt as a financial instrument is omitted for the time being. The setup of the basic model is as follows: Consider a market with two firms $i = 1, 2$ acting in a Cournot-competition game. Firms can invest in R&D, which possibly yield to a successful innovation cutting their marginal costs.

The structure of every period is as follows: First firms decide to invest in R&D. The amount of money g_i a firm spends in R&D does not guarantee a successful innovation. Suppose the effect of R&D expenses are to increase the probability θ_i of a successful innovation. Further, suppose the function for R&D expenses is convex. Then it is twice continuously differentiable and the second derivative is positive. For simplicity assume in the following that the function is quadratic $g_i(\theta_i) = w\theta_i^2$ with $w > 0$. Figure 19 illustrates the R&D function.

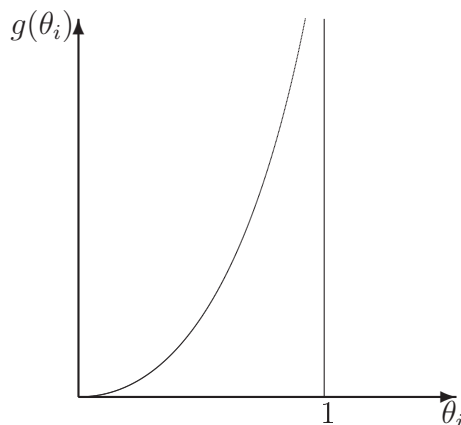


Figure 19: The R&D function of firm i

After investing in R&D, nature decides whether R&D is successful or not. As supposed the success probability is influenced by the amount of money a firm

has invested in R&D. In the new market environment firms play a Cournot Competition game. The outcome of the game depends on the cost structure of both firms. Either there is a cost advantage of one firm, which yields to a higher market share with respect to the other firm, or both firms have the same cost structure, which yields in a symmetric market share. To sum up every period consists of three different stages:

1. Both firms invest in R&D.
2. Nature decides whether the firms will innovate or not.
3. Firms play a Cournot competition game.

For simplicity assume that marginal costs c are constant and identical for both firms in the first period. After a successful innovation marginal costs are supposed to decrease to λc in every period with $0 < \lambda < 1$. Thus, marginal costs of a firm will never be zero, but will decrease to almost zero after several successful innovations, if further investment in R&D is valuable for firms. It is obvious that the innovation activity of a firm depends very strong on the value of λ . If λ was close to 1, spending money in R&D activity would not be very valuable. The lower the value of λ the more effective are expenditures in R&D. Another consequence of this assumption is that the cost advantage of a successful innovation is decreasing with every further successful innovation, which is sensible due to the fact that there exists a lower bound of marginal costs, namely zero.

The profit function of firm i (the analysis for the other firm is symmetrical) in every period can take shape of four different types dependent on the innovation success of firm i and j ($j \neq i$). The profit function consists of revenues and costs. The revenues are $p(Q) \cdot q$ with a demand function $p(Q)$ which is supposed to be linear decreasing and equal in every period $p(Q) = a - bQ$ ($Q = \sum_{i=1}^2 q_i$). No new demand will be generated. Costs are on the one hand costs of production $C(q_i) = cq_i$ and on the other hand costs for R&D $g_i(\theta_i)$. Additionally, a firm is faced by fixed costs of F_t in every period t . Neglecting research and fixed costs on the second stage, the profit function of firm i on that stage has the following shape

$$\Pi_i = (a - bQ - c)q_i \tag{5.1}$$

At first, it is due to the assumption that every period is similar enough to analyze the one period game to be able to draw conclusions for the n-period game. The outcome of the one period game can be found by backward induction. On the last stage both firms play a Cournot competition game. Optimal quantity and profit of firm i on the last stage supposing different marginal costs are given by

$$q_i = \frac{a - 2c_i + c_j}{3b} \quad (5.2)$$

$$\Pi_i = \frac{(a - 2c_i + c_j)^2}{9b} \quad (5.3)$$

As assumed nature decides, whether the R&D expenditures of a firm yield in a successful innovation or not. Thus, on the last stage there are four different situations possible: either one of both firms has innovation success, both or none of them. Excluding fixed and research costs which are identical in every case and therefore not relevant for the decision and remembering that $c = c_i = c_j$, then four different profits for firm i are conceivable at the end of the game. Table 4 illustrates those different profits.

| (firm i \ firm j) | innovation success | no innovation |
|------------------------|---|---|
| innovation success | $\Pi_i^I = \frac{(a-\lambda c)^2}{9b}$ | $\Pi_i^A = \frac{(a-2\lambda c+c)^2}{9b}$ |
| no innovation | $\Pi_i^D = \frac{(a-2c+\lambda c)^2}{9b}$ | $\Pi_i^N = \frac{(a-c)^2}{9b}$ |

Table 4: The profits of firm i in the four different innovation situations

Without taking research costs into account a successful innovation is due to the assumption of $0 < \lambda < 1$ always better for firm i . The most advantageous situation for that firm is a sole innovation (Π_i^A). The worst (disadvantageous) situation is a sole innovation of the rival (Π_i^D). Furthermore, it is always better for firm i that firm j has no innovation success. Hence, the order of the profits from the perception of firm i is $\Pi_i^A > \Pi_i^I > \Pi_i^N > \Pi_i^D$.

Due to symmetry of the game, it is better for both firms to have a successful innovation than no innovation. Consequently, both firms have the incentive to invest in R&D as long as the possible gain outweighs expenses. Remembering that θ describes the success probability of a firm the profit function V_i of firm i on the first stage is

$$V_i = \theta_i(\theta_j\Pi_i^I + (1 - \theta_j)\Pi_i^A) + (1 - \theta_i)(\theta_j\Pi_i^D + (1 - \theta_j)\Pi_i^N) - g_i(\theta_i) - F_t \quad (5.4)$$

On the first stage firm i has to determine its optimal R&D expenditures. Due to the assumption that the level of R&D expenditures determine directly the innovation success probability 5.4 has to be optimized regarding to the innovation success probability θ . With $0 \leq \theta_i \leq 1$ and the fact that V_i is continuous the extreme value theorem of Weierstrass guarantees that the function has a maximum. Remembering that $g_i(\theta_i) = w\theta_i^2$, the best response function of firm i is

$$\begin{aligned}\theta_i &= \frac{\Pi_i^A - \Pi_i^N}{2w} - \left(\frac{\Pi_i^A + \Pi_i^D - \Pi_i^I - \Pi_i^N}{2w} \right) \theta_j \\ &= \frac{2c(a - \lambda c)(1 - \lambda)}{9bw} - \frac{2c^2(\lambda - 1)^2}{9bw} \theta_j\end{aligned}\quad (5.5)$$

Due to $\frac{2c^2(1-\lambda)^2}{9bw} > 0$ the slope of 5.5 is always negative. To hold the condition $0 < \theta_i < 1$ it is necessary that $\Pi_i^A > \Pi_i^N$, which holds for every w . Furthermore, $w \geq \frac{\Pi_i^A - \Pi_i^N}{2}$ has to be true. If w was lower an optimal innovation probability of $\theta_i^* > 1$ would be possible. Then, it is always valuable for a firm to invest as much in R&D as an innovation becomes certain. A further analysis would be inconsequential. Thus, $w \geq \frac{\Pi_i^A - \Pi_i^N}{2}$ is assumed in the following. With this assumption axis intercept and slope of the best response function are between zero and one.

From $\frac{\partial \theta_i}{\partial \theta_j} = \frac{-2c^2(\lambda-1)^2}{9bw} < 0$ it is obvious that both innovation success probabilities are strategic substitutes. An increase in the innovation success probability of firm j induces a decrease in the optimal innovation success probability of firm i . Figure 20 shows the best response functions of both firms.

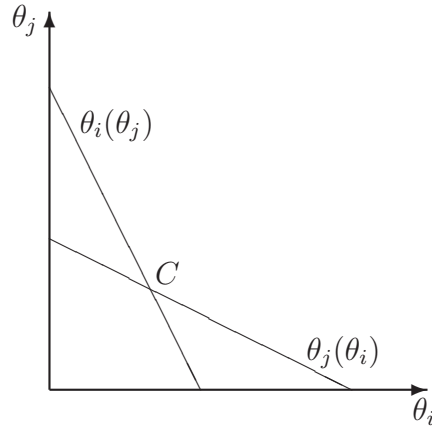


Figure 20: Best response functions of firm i and j in the duopoly situation

The axis intercept of 5.5 on the θ_j axis is due to $\theta_j = \frac{\Pi_i^A - \Pi_i^N}{\Pi_i^A - \Pi_i^N + \Pi_i^D - \Pi_i^I} = \frac{a - \lambda c}{(1 - \lambda)c} > 1 \geq \frac{\Pi_i^A - \Pi_i^N}{2w} = \theta_i$ higher than on the θ_i axis. Hence, the slope is between -1 and

zero. The reverse is also true for the best response function of firm j . Due to symmetry both R&D functions are identical and it can be set $\theta_i = \theta_j$. This leads to the Cournot equilibrium C

$$\begin{aligned}\hat{\theta}_i &= \frac{(\Pi_i^A - \Pi_i^N)}{2w + (\Pi_i^A - \Pi_i^N + \Pi_i^D - \Pi_i^I)} \\ &= \frac{2c(a - \lambda c)(1 - \lambda)}{9bw + 2c^2(\lambda - 1)^2} \\ &\leq \frac{a - \lambda c}{a - 2\lambda c + c} \leq 1\end{aligned}\tag{5.6}$$

In equilibrium, the optimal innovation probability is due to $w \geq \frac{\Pi_i^A - \Pi_i^N}{2}$ and $(\Pi_i^A - \Pi_i^N + \Pi_i^D - \Pi_i^I) > 0$ always lower than one. The higher research costs are the lower is the optimal innovation probability of firm i ($\frac{\partial \hat{\theta}_i}{\partial w} < 0$). Further, the more marginal costs can be saved the higher is the optimal innovation probability ($\frac{\partial \hat{\theta}_i}{\partial \lambda} < 0$) for $\lambda \in \mathbb{R}$. Similar results hold for the profits in the different situations. Table 5 summarizes these results. In equilibrium firm i invests the more in R&D the higher Π_i^A or Π_i^I and the lower Π_i^N or Π_i^D .

| $\frac{\partial \hat{\theta}_i}{\partial w}$ | $\frac{\partial \hat{\theta}_i}{\partial \lambda}$ | $\frac{\partial \hat{\theta}_i}{\partial \Pi_i^A}$ | $\frac{\partial \hat{\theta}_i}{\partial \Pi_i^I}$ | $\frac{\partial \hat{\theta}_i}{\partial \Pi_i^N}$ | $\frac{\partial \hat{\theta}_i}{\partial \Pi_i^D}$ |
|--|--|--|--|--|--|
| < 0 | < 0 | > 0 | > 0 | < 0 | < 0 |

Table 5: Comparative statics

To conclude, in the one period case depending on the investment decision of the rival firms invest in R&D as long as the expected marginal revenues equal the marginal expenditures. The expected profit of a firm depends on the different market structures evoked by the innovation success or failure of the firms. The higher the possible gain of an innovation the more invests a firm in R&D et vice versa.

5.3. The basic two period model with self-financing

After considering the one-period case the time horizon in this section is extended to more than one period. In the second period there are as a consequence of the results from the first period four possible initial situations. In two of them both companies have an equal market share due to equal marginal costs in the first period. In the two other situations either firm i starts with a

higher market share due to lower marginal costs in the first period or with a lower market share due to higher marginal costs in the first period.

It is now of interest whether and how the behavior of the firms changes due to the outcome of the first period. The two cases, where the market shares are equal in the second period would be either identical to the analysis of the first period, if both firms did not innovate in the first period, or at least firms would behave in a similar way, respectively. A different behavior can be expected in the two cases, where firm i has either an advantageous position or a disadvantageous position.

As assumed in case of an advantageous position, firm i is the only firm with a successful innovation in period 1 and therefore has lower marginal costs. From this starting position in period two the different profits on the last stage (excluding the costs of R&D) are summarized in table 6.

| (firm i \ firm j) | innovation success | no innovation |
|------------------------|---|--|
| innovation success | $\Pi_i^{AI} = \frac{(a-2\lambda^2c+\lambda c)^2}{9b}$ | $\Pi_i^{AA} = \frac{(a-2\lambda^2c+c)^2}{9b}$ |
| no innovation | $\Pi_i^{AD} = \Pi_i^I = \frac{(a-\lambda c)^2}{9b}$ | $\Pi_i^{AN} = \Pi_i^A = \frac{(a-2\lambda c+c)^2}{9b}$ |

Table 6: The profits of firm i in period 2 in case of an advantageous position

The other way around in case of a disadvantageous position firm i is the only firm that has no successful innovation in period 1 and therefore higher marginal costs. From that starting position the profits in period two on the last stage (excluding the costs of R&D) are summarized in table 7.

| (firm i \ firm j) | innovation success | no innovation |
|------------------------|---|--|
| innovation success | $\Pi_i^{DI} = \frac{(a-2\lambda c+\lambda^2c)^2}{9b}$ | $\Pi_i^{DA} = \Pi_i^I = \frac{(a-\lambda c)^2}{9b}$ |
| no innovation | $\Pi_i^{DD} = \frac{(a-2c+\lambda^2c)^2}{9b}$ | $\Pi_i^{DN} = \Pi_i^D = \frac{(a-2c+\lambda c)^2}{9b}$ |

Table 7: The profits of firm i in period 2 in case of a disadvantageous position

In the advantageous position two different effects are influencing the profits of firm i . On the one hand, firm i starts with a higher market share. The profit will further increase, if firm i is again the only firm with innovation success. On the other hand independent of rivals technology profit increases become smaller with every innovation.

First, the different starting positions will be analyzed. The best response function of firm i in the advantageous position is given by

$$\theta_i^A = \frac{\theta_j(\Pi_i^{AI} + \Pi_i^A - \Pi_i^{AA} - \Pi_i^I) + (\Pi_i^{AA} - \Pi_i^A)}{2w} \quad (5.7)$$

and the best response function of firm i in the disadvantageous position is given by

$$\theta_i^D = \frac{\theta_j(\Pi_i^{DI} + \Pi_i^D - \Pi_i^I - \Pi_i^{DD}) + (\Pi_i^I - \Pi_i^D)}{2w} \quad (5.8)$$

Comparing 5.5 with 5.7 and 5.8 it can be seen that the two new functions have a different slope and intercept (see Appendix 1). The best response function in 5.8 shifts inside. The intercept in 5.7 depends on the values. The slope of both functions is equal and more steep. Figure 21 illustrates the different best response functions supposing firm i is the cost-follower and firm j the cost-leader.

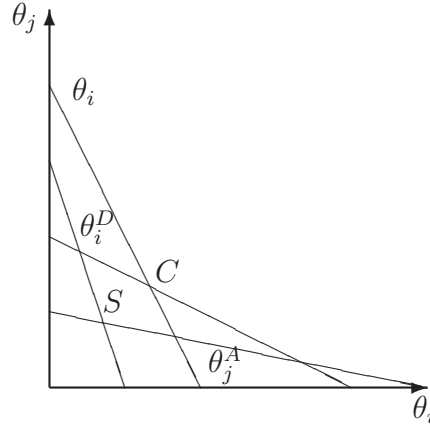


Figure 21: Best response functions of firm i and j in both situations

Due to the shift inside of both best response functions a new equilibrium S arises. In this equilibrium both companies invest less in R&D than before. The degree of R&D competition is much lower. This is logical due to the fact that for the cost-leader only a lower cost advantage is achievable. By the decrease of its R&D expenses also the rival follows, which increases the chance that none of the firms innovate in the next period and market shares keep unchanged. But it is not quite clear which firm invests more or less in R&D. This has to be analyzed by comparing the optimal probabilities in the second period of the cost-leader and follower. The optimal probability of the cost-leader is given by

$$\hat{\theta}_j^A = \frac{(\Pi^{AD} - \Pi^D)(\Pi^{AI} - \Pi^{AD} + \Pi^A - \Pi^{AA}) + 2w(\Pi^{AA} - \Pi^A)}{4w^2 + (\Pi^{AI} - \Pi^{AD} + \Pi^A - \Pi^{AA})(\Pi^{DD} - \Pi^{DI} + \Pi^{AD} - \Pi^D)} \quad (5.9)$$

and the optimal probability of the cost-follower is given by

$$\hat{\theta}_i^D = \frac{(\Pi^{AA} - \Pi^A)(\Pi^{AI} - \Pi^{DD} + \Pi^D - \Pi^{AD}) + 2w(\Pi^{AD} - \Pi^D)}{4w^2 + (\Pi^{AI} - \Pi^{AD} + \Pi^A - \Pi^{AA})(\Pi^{DD} - \Pi^{DI} + \Pi^{AD} - \Pi^D)} \quad (5.10)$$

The difference of the optimal innovation-probabilities (5.9 - 5.10) is given by

$$\hat{\theta}_i^A - \hat{\theta}_i^D = -\frac{2c(\lambda - 1)^2(a - c(1 + \lambda)^2)}{9wb - 2c^2\lambda(1 - \lambda)^2} \quad (5.11)$$

The denominator is positive for $w > \frac{2\lambda c^2(1-\lambda)^2}{9b}$. From the last section we know that w must hold $w > \frac{\Pi_i^A - \Pi_i^N}{2} = \frac{2c(1-\lambda)(a-\lambda c)}{9b}$. This implies $a > c(2\lambda - \lambda^2)$. This is true for all λ . Thus the denominator is always positive.

Then the algebraic sign of the term depends only on the numerator. For $a > c(1 + \lambda)^2$ the numerator is positive and with it the whole term always negative. The optimal innovation probability of the cost follower is higher than the optimal innovation probability of the cost leader ($\theta_i^D > \theta_i^A$). The cost follower invests in equilibrium more in R&D than the cost-leader in the second period. This increases the probability that the cost follower catches up with the cost leader. Thus there is always a tendency for equal market shares in the market.

In turn for $a < c(1 + \lambda)^2$ the numerator is negative and with it the whole term positive. This means it is more probable that the cost-leader has a further innovation and the cost-leader keeps or enlarges its position.

Second, as mentioned before, the possible gain of lower marginal costs is with every successful innovation decreasing. This can be easily seen from table 6. Comparing the profits of a further successful and a non-successful situation independent of the innovation success of the other player, the difference is

$$\begin{aligned} \Pi_i^A - \Pi_i^N &= \frac{(a - 2\lambda^{n+1}c + \lambda^m c)^2}{9b} - \frac{(a - 2\lambda^n c + \lambda^m c)^2}{9b} \\ &= \frac{4c\lambda^n(a(1 - \lambda) + c(\lambda^m - \lambda^{m+1} + \lambda^{n+2} - \lambda^n))}{9b} \end{aligned} \quad (5.12)$$

For infinite periods this means

$$\lim_{t \rightarrow \infty} (\Pi_i^A - \Pi_i^N) = 0 \quad (5.13)$$

Again the effects can also be shown by comparing best response functions of both situations. The axis intercept in case of no innovation is for $a > \lambda c(1 + \lambda)$

higher than in the case where both firms have already innovated. Furthermore, the slope in case of no innovation is more steep. Figure 22 illustrates these effects.

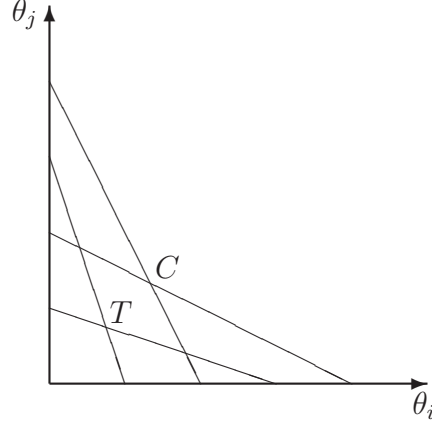


Figure 22: Best response functions of firm i and j when both firms have innovated in period 1

In the new equilibrium T both firms invest less in R&D. Due to symmetry again the optimal innovation success probability for both firms is identical. Hence, the more innovations are already made the less will be invested in future research.

In the first period firms anticipate the outcome of the game and with it the profits of the second period. Firms take future profits into account. Let μ_i^k be the innovation success probability in period 2 and θ_i again the innovation success probability in period 1. Furthermore, let $E[\Pi_i^k]$ be the expected profit less research costs of firm i for the different cases k in the second period. Then the optimal innovation probability of a firm in the first period changes to

$$\hat{\theta}_i = \frac{\Pi_i^A + E[\Pi_i^A] - \Pi_i^N - E[\Pi_i^N]}{2w + (\Pi_i^A + E[\Pi_i^A] - \Pi_i^N - E[\Pi_i^N]) + \Pi_i^D + E[\Pi_i^D] - \Pi_i^I - E[\Pi_i^I]} \quad (5.14)$$

Taking second period profits into account the numerator increases stronger than the denominator. Thus, the optimal innovation probability increases. An early innovation is more profitable than a later one. Firms therefore invests more in R&D in the first period than in the second. Note that in case of two periods research costs have to fulfil a higher bound to hold $0 \leq \theta \leq 1$ ($w \geq \frac{\Pi_i^A - \Pi_i^N + \tilde{\Pi}_i^A - \tilde{\Pi}_i^N}{2}$).

To conclude: The demand function mainly influences the strength of the possible innovation and how the market will be structured in the future. In markets with a high difference between the prohibitive price a and marginal costs c or in markets with a high possible cost cut there is a tendency that the market is shared equally between a stronger firm (cost-leader) that has early innovated and a weaker firm (cost-follower) that has yet to innovate during the first periods. Under this circumstances the cost follower invests more in R&D than the cost leader. Furthermore, the greater the realization of successful innovations in the past the less both firms have the incentive to invest in R&D today. Competition decreases in later periods.

The other way round in a market with a low difference between the prohibitive price a and marginal costs c or in markets with only a small possible cost cut there is a tendency that the market is shared unequally between the cost-leader and the cost-follower. Under this circumstances the cost follower invests less in R&D than the cost leader. The cost-leader tends to maintain its position in the market. But also in this case competition decreases in later periods. There is a tendency to invest much in the beginning, when marginal costs are very high. The more innovations are made and the lower marginal costs already are the less firms invest in R&D. In later periods R&D competition decreases.

5.4. Asymmetric debt-financing with one leveraged firm in the market

In the prior sections two completely self-financed firms were assumed. In this situation no principal-agent conflicts arise. This assumption is withdrawn in the following. Financing by debt is possible for firms. Assuming first that only one entrepreneur takes this opportunity the principal agent conflict between the entrepreneur of this firm and the lending bank will be investigated. Furthermore, the effects on output and research expenses will be analyzed.

The modified assumptions of the game are as follows. Assume the game still consists of two periods and every period is structured as above. At the beginning of every period firms have to make an initial investment of F_t . Whereas firm j is completely self-financed the entrepreneur of firm i borrows a loan from a bank.

The design of the debt contract is geared to the model of Bolton and Scharfstein

(1990) with costly state verification. Assume there is asymmetric information in the market. Banks only know the initial investments by the firms and that firms have the opportunity to invest in R&D in every period, which possibly results in an innovation of a cost cutting technology. R&D investments as well as firms quantities and profits can only be observed by firms in the industry, not by banks. Furthermore, banks do not have any possibility to monitor the firm or monitoring is too expensive, respectively. Suppose firms are also subject to limited liability. Banks cannot request any collateral. Thus, in the first period short-term debt contracts are not offered by banks.

Assume the capital market is competitive. For simplicity, however, suppose banks have all the bargaining power. In the first period a bank offers a firm a take-it-or-leave-it-offer of a long-term debt contract over both periods. This contract is offered by all banks. Thus, either a firm accepts this contract and acts as one of two firms in the market or stays out of the market. Assume all players are risk-neutral.

Suppose firms need money to cover their fixed costs in both periods. Thus, the two period contract contains the borrowing of F_1 in period 1 and of F_2 in period 2. Repayments of the loans have to be done after the respective period. Suppose the profits less the expenditures for R&D are at least as high as the fixed costs of the respective period $\Pi^k - g(\theta_i) \geq F_t$ except for the disadvantageous states Π^D and Π^{DD} . Hence, in the first period only in the disadvantageous case the firm cannot repay the loan $\Pi^D - g(\theta_i) < F_1$.

Due to costly state verification the contract is based on reported profits of firm i . For every reported profit in the first period the bank has the possibility to terminate the contract and to stop financing the firm.

The optimal financial contract of a bank has the following design. For the different states of the world k the bank can claim different repayments R_1^k in the first period. Additionally, the decision to stop financing the firm after period one is marked with β^k . Assume for simplicity there are only two possibilities: For $\beta^k = 0$ the bank stops financing the firm and for $\beta^k = 1$ the bank continues financing the firm in the first period. In the second period the firm due to asymmetric information and costly state verification has the incentive to report only the worst possible profit. Hence, the bank receives in the second period

in every state only R_2 . The bank has the following maximization problem

$$\begin{aligned}
\max_{R_1^k \beta^k} W &= \theta_i(\theta_j(R_1^I + \beta^I(R_2 - F_2)) + (1 - \theta_j)(R_1^A + \beta^A(R_2 - F_2))) \\
&+ (1 - \theta_i)(\theta_j(R_1^D + \beta^D(R_2 - F_2))) \\
&+ (1 - \theta_j)(R_1^N + \beta^N(R_2 - F_2)) - F_1
\end{aligned} \tag{5.15}$$

The optimal contract is bounded to different constraints. First of all, the firm has to be induced to a truthful reporting. For every profit in period 1 the manager of firm i must have the incentive to report the true profit of the respective state and not a lower one. Let μ_i^k be again the innovation success probability in period 2 and θ_i the innovation success probability in period 1. Furthermore, let $E[\Pi_i^k]$ again be the expected profit less research costs of firm i in the second period. Omitting the expenditures for R&D in the first period, which accrue in every case, the different incentive constraints are given by

$$\begin{aligned}
\Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - R_2) &\geq \Pi_i^A - R_1^I + \beta^I(E[\Pi_i^A] - R_2) \\
\Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - R_2) &\geq \Pi_i^A - R_1^N + \beta^N(E[\Pi_i^A] - R_2) \\
\Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - R_2) &\geq \Pi_i^A - R_1^D + \beta^D(E[\Pi_i^A] - R_2) \\
\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - R_2) &\geq \Pi_i^I - R_1^N + \beta^N(E[\Pi_i^I] - R_2) \\
\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - R_2) &\geq \Pi_i^I - R_1^D + \beta^D(E[\Pi_i^I] - R_2) \\
\Pi_i^N - R_1^N + \beta^N(E[\Pi_i^N] - R_2) &\geq \Pi_i^N - R_1^D + \beta^D(E[\Pi_i^N] - R_2)
\end{aligned} \tag{5.16}$$

Three incentive constraints of 5.16, however, are redundant due to other constraints that are stronger (see Appendix (2)). The second one due to the combination of the first and the fourth one, the third one due to the combination of the first and the fifth one and the fifth one due to the combination of the fourth and the last one.

Moreover, the static and intertemporal limited liability constraints have to be fulfilled. On the one hand the net profits of a firm in one period have to be higher than the repayment to the bank in the respective period and on the other hand the sum of the net profits of both periods have to be higher than

the sum of repayments.

$$\begin{aligned}
\Pi_i^k - g(\theta_i) &\geq R_1^k \\
\Pi_i^k - g(\mu_i^k) &\geq R_2 \\
\Pi_i^k - g(\theta_i) + \Pi_i^l - g(\mu_i^l) &\geq R_1^k + R_2
\end{aligned} \tag{5.17}$$

Finally, the contract has to guarantee that the firm chooses the optimal level of R&D activity. At the optimum marginal revenues have to equal marginal costs of R&D.

$$\begin{aligned}
2w\theta_i &= \theta_j[(\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - R_2)) - (\Pi_i^D - R_1^D + \beta^D(E[\Pi_i^D] - R_2))] \\
&+ (1 - \theta_j)[(\Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - R_2)) \\
&- (\Pi_i^N - R_1^N + \beta^N(E[\Pi_i^N] - R_2))]
\end{aligned} \tag{5.18}$$

Taking the constraints of 5.16, 5.17 and 5.18 into account the optimal financial contract can be solved by backward induction. In the second period the bank due to asymmetric information and costly state verification has to assume that the firm declares only the lowest possible profits. In case of reported low profits (Π_1^D) in the first period the bank therefore stops financing the firm ($\beta^D = 0$). The expected reported profits in the second period are lower than the liquidation value. Then, the repayment to the bank in the worst case is $R_1^D = \Pi^D - g_i(\theta)$.

Taking $\beta^D = 0$ into account the lowest repayment to the bank in the second period is $R_2 = \Pi_i^D - g(\mu_i^N)$. Inserting R_2 into the intertemporal limited liability constraint the maximal repayment the bank can expect from firm i in the adjusted worst state is $R_1^N = \Pi^N - g_i(\theta)$. Simplifying the residual incentive constraints, it must hold $R_1^A \leq R_1^I \leq R_1^N$. Thus, it is $R_1^A = R_1^I = R_1^N = \Pi^N - g_i(\theta)$. Suppose that banks make at least zero profits with that type of financial contract. If this was not the case, banks would either not lend any money or as long as it is valuable change the financial contract. A possible adjustment would be to stop financing also in the no innovation case with the profit Π_i^N . Then, the repayment structure changes a little bit. Table 8 summarizes the results.

With the optimal financial contract the optimal investment behavior in R&D can be analyzed. The optimal level of R&D activity of firm i as depicted above

| repayments t_1 | repayments t_2 |
|---|-----------------------------|
| $R_i^D = \Pi_i^D - g(\theta)$ | - |
| $R_1^A = R_1^I = R_i^N = \Pi_i^N - g(\theta)$ | $R_2 = \Pi_i^D - g(\theta)$ |

Table 8: Repayment structure of the optimal financial contract

is influenced by the level of R&D activity of the rival. Firm j takes the optimal financial contract of firm i with a possible exit of the market after period 1 into account. An exit of the market in period 1 permits monopoly profits in period 2. Inserting monopoly profits the best response function of firm j shifts outside and becomes steeper. Let Π_j^M be the monopoly profit. Remembering the adjusted best response function with anticipation of future profits of firm j in period 1 the new best response function is given by

$$\begin{aligned} \theta_j &= \frac{\Pi_j^I + E[\Pi_j^I] + \Pi_j^N + E[\Pi_j^N] - \Pi_j^A - E[\Pi_j^M] - \Pi_j^D - E[\Pi_j^D]}{2w} \theta_i \\ &+ \frac{\Pi_j^A + E[\Pi_j^M] - \Pi_j^N - E[\Pi_j^N]}{2w} \end{aligned} \quad (5.19)$$

The best response function of firm i in turn changes in another way. Let $\widehat{\Pi}_i^k = \Pi_i^k - R^k$ the net profit of firm i in the first period and $\widetilde{\Pi}_i^k = E[\Pi_i^k] - R_2$ the net profit in the second period. Taking the optimal financial contract and the possible exit into account for every θ_j the slope of the best response function of firm i becomes steeper (due to $E[\Pi_i^D] < R^N = \Pi^N - g(\theta)$). The intercept remains unchanged. The new best response function of firm i is given by

$$\begin{aligned} \theta_i &= \frac{\widehat{\Pi}_i^I + \widetilde{\Pi}_i^I + \widehat{\Pi}_i^N + \widetilde{\Pi}_i^N - \widehat{\Pi}_i^A - \widetilde{\Pi}_i^A - \widehat{\Pi}_i^D}{2w} \theta_j + \frac{\widehat{\Pi}_i^A + \widetilde{\Pi}_i^A - \widehat{\Pi}_i^N - \widetilde{\Pi}_i^N}{2w} \\ &= \frac{\Pi_i^I + E[\Pi_i^I] + \Pi_i^N + E[\Pi_i^N] - \Pi_i^A - E[\Pi_i^A] - \Pi_i^D - R^N}{2w} \theta_j \\ &+ \frac{\Pi_i^A + E[\Pi_i^A] - \Pi_i^N - E[\Pi_i^N]}{2w} \end{aligned} \quad (5.20)$$

Figure 23 illustrates both best response functions 5.19 and 5.20. The point of intersection marks the new equilibrium S .

Compared with the old equilibrium C in the new equilibrium S the optimal R&D activities of firm i decreases and of firm j increases. The debt-financed firm tries to lower competition in the market. This would increase the probability to survive after the first period. Firm j in turn tries to prey on firm

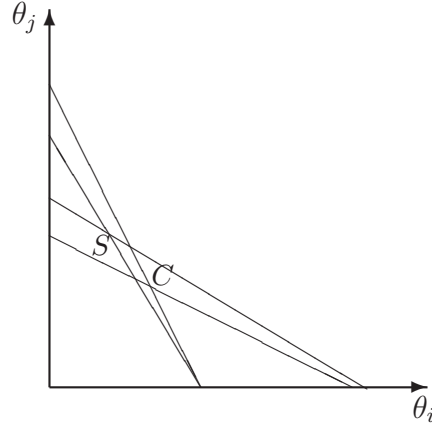


Figure 23: The influence of the optimal financial contract on the best response functions of firm i and j

i , because an innovation success of firm j , whereas firm i has no success, guarantees monopoly profits. As a consequence, the expected profit of the debt-financed firm decreases and of the self-financed firm increases compared with the symmetric self-financing situation.

5.5. Symmetric debt-financing of both firms in the market

Contrary to the asymmetric case with one debt-financed firm, assume now both owner-managers obtain credit from a bank. To exclude additional effects firms borrow the credit from two different banks. Except this, the assumptions are completely identical to the asymmetric case.

Again in case of an innovation of only one firm both banks have the opportunity to stop financing the respective firm. For simplification and to have symmetry assume both firms borrow the same amount of money. The contract covers the whole fixed costs of the respective firm. Having symmetry it is enough to analyze one financial contract and the behavior of one firm. The results are also true for the other bank and firm. The financial contract of a bank has the following design.

For the different states of the world in the first period the bank can again claim different repayments R_1^k . Additionally, the bank has the opportunity to stop financing the firm after the first period. Again this decision of the bank is marked with β^k . The analysis of the contract is carried out in the same way as in the asymmetric case. Only one element changes. Firm i earns in

case of an exit of the rival monopoly profits, which does not directly effect the maximization problem of the bank.

As in the asymmetric case the optimal contract is bounded to different constraints. First, firms have to be induced to a truthful reporting. The contract design is identical to the asymmetric case, except for one state. Let Π^M be the monopoly profit in the second period after one innovation. Let $E[\Pi_i^M]$ be the expected monopoly profit less R&D expenses in the second period. Omitting expenditures for R&D in the first period, which accrue in every case, the three binding incentive constraints are given by

$$\begin{aligned}
\Pi_i^A - R_1^A + \beta^A(E[\Pi^M] - R_2) &\geq \Pi_i^A - R_1^I + \beta^I(E[\Pi^M] - R_2) \\
\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - R_2) &\geq \Pi_i^I - R_1^N + \beta^N(E[\Pi_i^I] - R_2) \\
\Pi_i^N - R_1^N + \beta^N(E[\Pi_i^N] - R_2) &\geq \Pi_i^N - R_1^D + \beta^D(E[\Pi_i^N] - R_2)
\end{aligned} \tag{5.21}$$

Moreover, the static and intertemporal limited liability constraints have to be fulfilled. These constraints remain the same. Finally, the contract has to guarantee that the firm chooses the optimal level of R&D activity. At the optimum marginal revenues have to equal marginal costs of R&D. Due to the possible monopoly situation the profit function of firm i changes for that state. The constraint is now given by

$$\begin{aligned}
2w\theta_i &= \theta_j[(\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - R_2)) - (\Pi_i^D - R_1^D + \beta^D(E[\Pi_i^D] - R_2))] \\
&+ (1 - \theta_j)[(\Pi_i^A - R_1^A + \beta^A(E[\Pi_i^M] - R_2^M)) \\
&- (\Pi_i^N - R_1^N + \beta^N(E[\Pi_i^N] - R_2))]
\end{aligned} \tag{5.22}$$

Taking this three types of constraints into account the optimal financial contract for the symmetric case can be solved by backward induction. Comparing the optimal financial contract in the symmetric case with the contract in the asymmetric case one could argue that the bank receives another repayment in case of a monopoly. But, after an exit of the rival the monopoly profits situation is observable in the market. As the capital market is competitive other banks would offer short-term contracts to the monopolist. Thus, the optimal contract of the symmetric case corresponds to the optimal contract of the asymmetric case.

The second financial contract has also consequences for the optimal level of R&D. Let $\widehat{\Pi}_i^k = \Pi_i^k - R^k$ be again the net profit in the first period and $\widetilde{\Pi}_i^k = E[\Pi_i^k] - R_2$ the net profit in the second period. Again, it is obvious that the optimal level of R&D activity of firm i is influenced by the level of R&D activity of the rival. Firm i takes the optimal financial contract of firm j and a possible exit of the market after period 1 into account. This would permit monopoly profits in the second period. Inserting expected monopoly profits for every θ_i the best response function of firm j shifts due to $E[\Pi_i^M] \geq E[\Pi_i^A]$ outside. Due to that circumstance the best response function also becomes steeper compared to the situation as the only debt-financed firm. Compared with the situation of self-financing, however, the difference of the slopes depends on the values. Remembering the adjusted best response function with anticipation of future profits of firm j in period 1 the new best response function is given by

$$\begin{aligned} \theta_i &= \frac{\widehat{\Pi}_i^I + \widetilde{\Pi}_i^I + \widehat{\Pi}_i^N + \widetilde{\Pi}_i^N - \widehat{\Pi}_i^A - \widetilde{\Pi}_i^M - \widehat{\Pi}_i^D}{2w} \theta_j + \frac{(\widehat{\Pi}_i^A + \widetilde{\Pi}_i^M - \widehat{\Pi}_i^N - \widetilde{\Pi}_i^N)}{2w} \\ &= \frac{\Pi_i^I + E[\Pi_i^I] + \Pi_i^N + E[\Pi_i^N] - \Pi_i^A - E[\Pi_i^M] - \Pi_i^D - R^N}{2w} \theta_j \\ &+ \frac{\Pi_i^A + E[\Pi_i^M] - \Pi_i^N - E[\Pi_i^N]}{2w} \end{aligned} \quad (5.23)$$

Due to symmetry $\theta_i = \theta_j$ the optimal R&D investment of both firms $\hat{\theta}_i$ is

$$\begin{aligned} \hat{\theta}_i &= \frac{\widehat{\Pi}_i^A + \widetilde{\Pi}_i^M - \widehat{\Pi}_i^N - \widetilde{\Pi}_i^N}{2w + (\widehat{\Pi}_i^A + \widetilde{\Pi}_i^M - \widehat{\Pi}_i^N - \widetilde{\Pi}_i^N + \widehat{\Pi}_i^D - \widehat{\Pi}_i^I - \widetilde{\Pi}_i^I)} \\ &= \frac{\Pi_i^A + E[\Pi_i^M] - \Pi_i^N - E[\Pi_i^N]}{2w + (\Pi_i^A + E[\Pi_i^M] - \Pi_i^N - E[\Pi_i^N] + \Pi_i^D + R^N - \Pi_i^I - E[\Pi_i^I])} \end{aligned} \quad (5.24)$$

Comparing 5.24 with 5.14, the position of the optimal innovation probability depends on the values (see Appendix 4). Dependent on marginal costs there exist a critical level $\underline{\lambda}(c)$, where optimal innovation probabilities are identical. For non-drastic innovations ($\underline{\lambda}(c) \leq \lambda < 1$), the optimal innovation probability in case of debt-financing is higher. In turn, for drastic innovations ($0 < \lambda \leq \underline{\lambda}(c)$) the optimal innovation probability in case of self-financing is higher. Figure 24 shows both new best response functions resulting in a new equilibrium T .

For non-drastic innovations ($\underline{\lambda}(c) \leq \lambda < 1$) in the new equilibrium T optimal R&D activities of both firms are higher than in the old equilibrium C . Competition in the market is more fierce. Indeed both firms could be squeezed

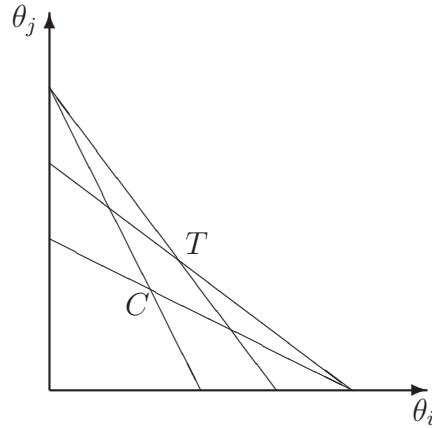


Figure 24: The influence of debt-financing on the best response functions of firm i and j

out of the market. But this is outweighed by the advantage of the monopoly position in period two in case of a bankruptcy of the rival.

Profits behave in a similar way as the optimal innovation probability, but the other way round. For non-drastic innovations debt-financing increases competition in the market. Thus, profits decrease. For drastic innovations, profits are higher in case of debt-financing (see Appendix 5).

5.6. Discussion

In this section critical assumptions of the model and its effects on the outcome of the game as well as welfare effects will be discussed. The focus lies on the following topics:

- Welfare effects
- n firms: Enlargement of the duopoly model to an oligopoly model with more than two firms.
- Preservation of knowledge: Research starts not at zero in every period.
- Infinite periods and long-term bank relationships: Firms operate in a market for more than two periods. Allowing this firms have the opportunity to sign long-term debt contracts over several periods.
- Bank concentration: The structure of the capital market can influence the outcome of the game.

5.6.1. Welfare effects

So far we have not analyzed any welfare effects in the model. Basically, social welfare is defined as the sum of producer and consumer surplus. The latter is easy to determine in the model. For the consumers it is always better to have an innovation, because lower costs induce lower prices and thus a higher surplus. Furthermore, it is always better to have competition in the market. A monopoly situation is worse due to higher market prices. The producer surplus is defined by the profit of the whole firm.

From the social welfare point of view it is of interest, which capital structure decision maximizes social welfare. Thus, the three different possible situations have to be compared. Let the situation with two self-financed firms be the basis of the investigation. The paper has shown that a change in the capital structure of a firm changes the optimal behavior of the firm from the shareholders point of view. But the optimal behavior of a firm as a whole remains unchanged. Whichever capital structure the firm employs it should always behave as in the situation of self-financing.

In the asymmetric case there are mainly three effects observable:

1. The self-financed firm invests more in R&D than in the symmetric situation. This increases the probability of an innovation. This increases producer as well as consumer welfare.
2. The firm with the higher leverage invests less in R&D. The innovation probability decreases. Expected consumer welfare decreases.
3. In one state of the world a monopoly is possible, which is bad for overall welfare.

All in all in the asymmetric case the self-financed firm has an advantage. But this advantage is outweighed by the disadvantages of the other firm and consumers. Hence, the overall welfare effect is negative compared to the self-financed case.

Similar to the asymmetric case in the symmetric case there are mainly three effects observable:

1. Both firms invest more in R&D. This increases the probability of an innovation. Expected consumer welfare increases.
2. Expected profits of both firms decrease. A possible monopoly situation is outweighed by higher costs and the possible liquidation.
3. In two states of the world a monopoly is possible, which is positive for the respective firm, but negative for consumers. The overall welfare effect is negative.

Also in the symmetric case positive effects of a possible monopoly are outweighed by negative effects for consumers. Overall welfare is negative compared to the self-financed case.

5.6.2. n firms

The enlargement of the duopoly model to an oligopoly model with more than two firms weakens the illustrated effects. Without going into analytical detail it is relatively obvious that best response functions are effected by the amount of firms in the market due to $\frac{\partial \Pi}{\partial n} < 0$ for every possible profit. Moreover, not only profits decrease with every further rival in the market, but also probabilities of different states. The most obvious one is the second period profit in case of the advantageous position. In case of debt-financing a firm could only receive monopoly profits in the second period, if it was the only firm that has innovated. The probability of this state decreases with every further rival in the market. Thus, described effects still exist, but only with a smaller characteristic, which depends on the amount of players in and the size of the market. With simplifications (different positive and negative states are at a time combined to one good or negative state) the best response function of firm i in the one period case for instance changes from $\theta_i = \frac{\theta_j(\Pi_i^I + \Pi_i^N - \Pi_i^A - \Pi_i^D) + (\Pi_i^A - \Pi_i^N)}{2w}$ to

$$\theta_i = \frac{(\theta_j + \theta_k - \theta_j\theta_k)(\Pi_i^I + \Pi_i^N - \Pi_i^A - \Pi_i^D) + (\Pi_i^A - \Pi_i^N)}{2w} \quad (5.25)$$

As mentioned it has to be noticed that the different profits (Π_i^l) of a firm in a market with three firms are smaller than in a market with only two firms. This applies also to the differences between the different profits, for instance between Π_i^A and Π_i^N . Thus axis intercept and slope of the best response

function decrease the more firms are in the market. Best response functions shift inside. This effect is intensified by the research decision of the third firm. In equilibrium optimal research expenses of a firm are smaller than in a market environment with only two firms. This again applies also to the size of the described effects in case of different capital structures. Nevertheless, effects are indeed weaker as more firms are in the market, but still exist.

5.6.3. Preservation of knowledge

In our model the assumption is made that research in every period starts at zero. This assumption is very strict. Indeed one can think of research projects that lead to no result and are rejected. But many projects take only a longer time than one period. Firms take on research results of the former period and go ahead with that research. Integrating this in the model would give firms the possibility to renegotiate with banks in case of the bad state. But, as supposed, a new innovation takes at least one period of time. Thus, in a world with only two-periods banks would also liquidate the firm in case of the bad state, because due to moral hazard behavior at the end of period two no positive returns can be expected. In a world with more than two periods, however, the preservation of knowledge plays indeed an important role. But the model seems to be useful anyhow, because the adjustment to a new favorable production process may be only possible at the beginning of a period. Moreover, firms possibly cannot adjust their quantities to a new equilibrium during a period.

The effects of debt in a model with preservation of knowledge is investigated by Jensen and Showalter (2004). The model focusses on patent races. Basis of the model is the work of Loury (1979) and Lee and Wilde (1980). The time until the next innovation can vary. It also depends on the amount of money firms spent on research. Research accumulates over periods, however, it is potentially threatened by patents of rival firms in future periods. The innovative firm receives a patent and further research for that project is useless. Research expenses in that model are also influenced by the capital structure of firms. In the model with variable research costs, debt induces lower R&D expenditure from its rival and thus increases its expected profit. Firms in this case are partially debt-financed in equilibrium. In a fixed cost model, debt has

no strategic value in a symmetric equilibrium. In this case debt induces higher R&D expenditure from its rival and thus decreases its expected profit. Firms in this case use no strategic debt.

5.6.4. Infinite periods and long-term bank relationships

The results of the two period case imply that in the long run in an environment of equity- and debt-financed firms doing research in cost-reducing technologies only the equity-financed firms survive. Debt should not be strategically held by firms. But in reality this is sometimes not the case. Apart from the focus of the model only on cost-reducing technologies, there are two other possible explanations for this.

Allowing firms to operate in a market for more than two periods, firms may have the opportunity to sign long-term debt contracts over several periods. Then, firms and banks stay in a longer relationship. A bank receives more information about the firm and can also support the firm in bad states. Basically, this opportunity of signing long-term debt contracts depends on the capital market, on which firms have access.

David, O'Brien, and Yoshikawa (2007) argue that debt can be classified in transactional debt and relational debt. The latter is a long term debt contract with the so called housebank of a company. Housebanks have more insights into a company than other banks. Thus, in distress situations housebanks are more likely to become involved in workout activities (Elsas and Krahnert (2004)). A housebank financing system can be observed for instance in countries like Germany (see Elsas and Krahnert (1998) and Elsas and Krahnert (2004)) and Japan (in the so called keiretsu system). Empirical studies of the interdependence of the financial system, the capital structure of a firm and its R&D behavior come to interesting conclusions.

Lee and O'Neill (2003) investigate U.S. and Japanese firms in seven different industries. They conclude that stock concentration is positively related to investments in R&D. This result is supported by the investigation of Hansen and Hill (1991), who find a weak correlation between institutional investors and firm investment in R&D. A correlation of these variables, but a negative however, is also found by Graves (1988). Furthermore Lee and O'Neill (2003) find out that Japanese firms invest more in R&D than their U.S. counterparts.

The latter result is interesting due to the different financial systems of Japan and USA. While the ownership structure of U.S. firms is more market-based, the Japanese firms are more relationship oriented. Apparently different financial systems result in different investment behaviors in R&D. Furthermore, David, O'Brien, and Yoshikawa (2007) show a positive relationship of R&D intensity to the ratio of relational debt to total debt.

But not only the opportunity of long-term debt contracts mitigates the described effects. Also the model itself implies that in a world with more than two periods firms without an innovation in the first period may survive. This is the case, because a firm that has already innovated several times has a lower incentive to invest in R&D. In the model as well as in reality possible cost reduction is finite. Whereas the cost-follower still invest in R&D the cost-leader stops or reduces this as further cost-reduction is not possible or not valuable anymore, respectively. Let t be the amount of innovations. Remember that

$$\begin{aligned}\lim_{t \rightarrow \infty} (\Pi_i^A - \Pi_i^N) &= 0 \\ \lim_{t \rightarrow \infty} (\Pi_i^I - \Pi_i^D) &= 0\end{aligned}\tag{5.26}$$

Banks take this limited profit increase in later periods into account. Cost-followers will invest more in R&D than cost-leaders in later periods. Thus a cost follower has only a temporary disadvantage. Consequently, banks do not liquidate firms in bad states in early periods. The equity-financed firm anticipate this and behave as in the situation where both firms are completely self-financed. The best-response function of both firms in a specific period is then

$$\begin{aligned}\theta_i &= \frac{\Pi_i^I + \tilde{\Pi}_i^I + \Pi_i^N + \tilde{\Pi}_i^N - \Pi_i^A - \tilde{\Pi}_i^A - \Pi_i^D - \tilde{\Pi}_i^D}{2w} \theta_j \\ &+ \frac{\Pi_i^A + \tilde{\Pi}_i^A - \Pi_i^N - \tilde{\Pi}_i^N}{2w}\end{aligned}\tag{5.27}$$

From 5.27 can easily be seen that with every innovation the best response functions of both firms shift inside, because, as already shown, the difference of current as well as future profits decreases. Every innovation results in a new equilibrium where at least one of both firms invest less in R&D than in the equilibrium before.

Concluding the model is less applicable for firms that have access to capital markets where banks sign long-term contracts over several periods. Moreover,

it is less applicable in markets where a significant decrease in marginal costs is not possible (any more) or a cost leadership of the rival has no strong effect on own profits, respectively.

But the other way round the analysis also shows where the model is highly relevant. For instance in markets where firms have no access to long-term debt-contracts or in markets where significant cost decreases and with it a strong move of market shares are possible.

5.6.5. Bank concentration

In our model firms are effected by the debt contract of the bank. The structure of the capital market, however, was given. But the structure of the capital market can also influence the outcome of the game. This imply the results of Spagnolo (2003). If the banking sector was concentrated or collusive and, moreover, if banks controlled borrowers' choice of managers and managerial incentives, banks could implement collusion in the product market. This can also be the case in competitive capital markets, when firms have common lenders or independent lenders with interlocking directors.

The results of Spagnolo (2003) also have an impact on the R&D behavior of firms in a market. More competitive credit markets imply more competitive product markets and a heightened fierce R&D competition. Large banks, by financing firms in a particular industry can influence the profits in that industry to the higher end as well as indirectly goad firms in commit to lower R&D. Firms in such markets will behave more conservatively.

5.7. Conclusion

Capital structure decisions of a firm are not only driven by capital costs. The capital structure also influences the behavior of a firm and its rivals on the output market. This paper has shown that the capital structure not only influences market quantities and prices, but also other important decision variables of a firm, namely here the research investment decision. In the model firms invest in research to possibly reduce marginal costs of production.

In the asymmetric case with only one debt-financed firm in the market firms behavior is also asymmetric. The debt-financed firm tries to soften competition

by decreasing its research expenses. Self-financed rivals, however, have the incentive to tighten competition by increasing their research expenses. This strategy is predatory, because it increases the probability to squeeze debt-financed firms out of the market. Thus, if firms are not financially restricted, research projects should be financed by equity. Taking up debt places the firm in a disadvantageous position. This result confirms to the results of transaction cost and agency theory that tangible assets should be financed by debt. It also confirms to the results of Neff (2003) and Bolton and Scharfstein (1990), where debt-financing of the rival induces predatory behavior of the self-financed firm.

In the symmetric case with debt-financing of all firms in the market, firms behave dependent on the market environment. In case of non-drastic innovations, debt-financing intensifies competition in the market. Profits are lower than in the symmetric self-financing case. In this case firms are better off of self-financing. Moreover, self-financing is the dominant strategy. In equilibrium, both firms are not financed by debt. For drastic innovations the other way round is true. Indeed, in this case self-financing is not the dominant strategy anymore, but in equilibrium, both firms are self-financed.

Taking asymmetric profits into account, in equilibrium, in both cases firms are self-financed. These results are contrary to the analysis of Neff (2003). In her model with price competition, R&D competition is softened in case of debt-financing of both firms. But the results confirm to the analysis of Chen (2005) where debt-financing results in a more fierce competition in the market. In his focal equilibrium, both firms are self-financed. Furthermore, the outcome of the model confirms to the empirical results of Opler and Titman (1994).

The model, however, is limited to technologies that enables producing at lower marginal costs. In the model the cost leader is automatically the market leader. Further investigation could focus on models where this is not the case. Products do not necessarily have to be homogenous. Beside cost leadership Porter (1980) emphasizes different market strategies like time leadership or product differentiation. Possibly time leadership intensifies or product differentiation weakens the effects. Further models could also focus on research by firms for new or differentiated products. Maybe the effects go partly into another direction as in the model of Jensen and Showalter (2004) for patent races, where the effects are contrary for variable or fixed investments in R&D.

Appendix

(1) The best response function of firm i in period 1 or in case of no innovation, respectively, is given by

$$\begin{aligned}\theta_i^N &= \frac{\theta_j(\Pi_i^I + \Pi_i^N - \Pi_i^A - \Pi_i^D) + (\Pi_i^A - \Pi_i^N)}{2w} \\ &= \frac{2c(a - \lambda c)(1 - \lambda)}{9bw} - \frac{2c^2(\lambda - 1)^2}{9bw}\theta_j\end{aligned}$$

The best response function of firm i in an advantageous position is given by

$$\begin{aligned}\theta_i^A &= \frac{\theta_j(\Pi_i^{AI} + \Pi_i^A - \Pi_i^{AA} - \Pi_i^I) + (\Pi_i^{AA} - \Pi_i^A)}{2w} \\ &= \frac{2\lambda c(a - (\lambda^2 + \lambda - 1)c)(1 - \lambda)}{9bw} - \frac{2\lambda c^2(\lambda - 1)^2}{9bw}\theta_j\end{aligned}$$

The best response function of firm i in a disadvantageous position is given by

$$\begin{aligned}\theta_i^D &= \frac{\theta_j(\Pi_i^{DI} + \Pi_i^D - \Pi_i^{II} - \Pi_i^{DD}) + (\Pi_i^{II} - \Pi_i^D)}{2w} \\ &= \frac{2c(a - c)(1 - \lambda)}{9bw} - \frac{2\lambda c^2(\lambda - 1)^2}{9bw}\theta_j\end{aligned}$$

The best response function of firm i in the case of an innovation of both firms is given by

$$\begin{aligned}\theta_i^I &= \frac{\theta_j(\Pi_i^{II} + \Pi_i^I - \Pi_i^{AI} - \Pi_i^{DI}) + (\Pi_i^{AI} - \Pi_i^I)}{2w} \\ &= \frac{2\lambda c(a - \lambda^2 c)(1 - \lambda)}{9bw} - \frac{2\lambda^2 c^2(\lambda - 1)^2}{9bw}\theta_j\end{aligned}$$

The axis intercept of $\theta_i(\theta_j)$ is due to $(\Pi_i^A - \Pi_i^N) > (\Pi_i^I - \Pi_i^D)$ higher than the one of $\theta_i^D(\theta_j)$. For $a > \lambda c(1 + 2\lambda)$ the axis intercept of $\theta_i^A(\theta_j)$ is due to $(\Pi_i^{AA} - \Pi_i^A) > (\Pi_i^A - \Pi_i^N)$ higher than the one of $\theta_i(\theta_j)$. Thus, for the axis intercept it holds $\theta_i^A(\theta_j) > \theta_i(\theta_j) > \theta_i^D(\theta_j)$. The slope of $\theta_i^A(\theta_j)$ and $\theta_i^D(\theta_j)$ are equal and more flat than the slope of $\theta_i(\theta_j)$.

(2) Example of the first proposition:

Proposition: The combination of the first and the fourth constraint is stronger than the second one.

Proof: The first and the second constraint are

$$\begin{aligned}
& \Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - g(\mu_i^A) - R_2) \\
\geq & \Pi_i^A - R_1^I + \beta^I(E[\Pi_i^A] - g(\mu_i^A) - R_2) \\
& \Pi_i^A - R_1^A + \beta^A(E[\Pi_i^A] - g(\mu_i^A) - R_2) \\
\geq & \Pi_i^A - R_1^N + \beta^N(E[\Pi_i^A] - g(\mu_i^A) - R_2)
\end{aligned}$$

In order that the first constraint is stronger it has to be shown that

$$\Pi_i^A - R_1^I + \beta^I(E[\Pi_i^A] - g(\mu_i^A) - R_2) \geq \Pi_i^A - R_1^N + \beta^N(E[\Pi_i^A] - g(\mu_i^A) - R_2)$$

The fourth constraint is given by

$$\Pi_i^I - R_1^I + \beta^I(E[\Pi_i^I] - g(\mu_i^I) - R_2) \geq \Pi_i^I - R_1^N + \beta^N(E[\Pi_i^I] - g(\mu_i^I) - R_2)$$

which is equivalent to

$$R_1^N \geq R_1^I + (\beta^N - \beta^I)(E[\Pi_i^I] - g(\mu_i^I) - R_2)$$

Inserting this into the before mentioned condition yields to

$$\begin{aligned}
& -R_1^I + \beta^I(E[\Pi_i^A] - g(\mu_i^A) - R_2) \\
\geq & -(R_1^I + (\beta^N - \beta^I)(E[\Pi_i^I] - g(\mu_i^I) - R_2)) + \beta^N(E[\Pi_i^A] - g(\mu_i^A) - R_2)
\end{aligned}$$

which is equivalent to

$$E[\Pi_i^A] - g(\mu_i^A) - R_2 \geq E[\Pi_i^I] - g(\mu_i^I) - R_2$$

This is true due to $E[\Pi_i^A] > E[\Pi_i^I]$ and $g(\mu_i^A) < g(\mu_i^I)$. \square

(3) Due to symmetry in this case $\theta_i = \theta_j$ is essential

$$E[\Pi_i^N] - \Pi_i^N = \frac{2(1 - \lambda)\theta_i(((2\theta_i - \frac{5}{2})\lambda + \frac{3}{2} - 2\theta_i)c + a)c}{9b} > 0$$

(4) The equilibrium innovation probability in case of debt financing is given by

$$\begin{aligned} \hat{\theta}_i &= \frac{\hat{\Pi}_i^A + \tilde{\Pi}_i^M - \hat{\Pi}_i^N - \tilde{\Pi}_i^N}{2w + (\hat{\Pi}_i^A + \tilde{\Pi}_i^M - \hat{\Pi}_i^N - \tilde{\Pi}_i^N + \hat{\Pi}_i^D - \hat{\Pi}_i^I - \tilde{\Pi}_i^I)} \\ &= \frac{\Pi_i^A + E[\Pi_i^M] - \Pi_i^N - E[\Pi_i^N]}{2w + \Pi_i^A + E[\Pi_i^M] - \Pi_i^N - E[\Pi_i^N] + \Pi_i^D + R^N - \Pi_i^I - E[\Pi_i^I]} \end{aligned}$$

As in the case of self-financing, repayments or fixed costs, respectively, are mainly reduced. Due to the fact that in the worst case no second period profit exist, one repayment remains. Figure 25 gives an example for the optimal innovation probability in case of debt-financing dependent on c and λ (Assumption: $a = 100$, $w = \frac{10000}{b}$, $R^N = \Pi^N$ and $E[\Pi^k] = \Pi^k$).

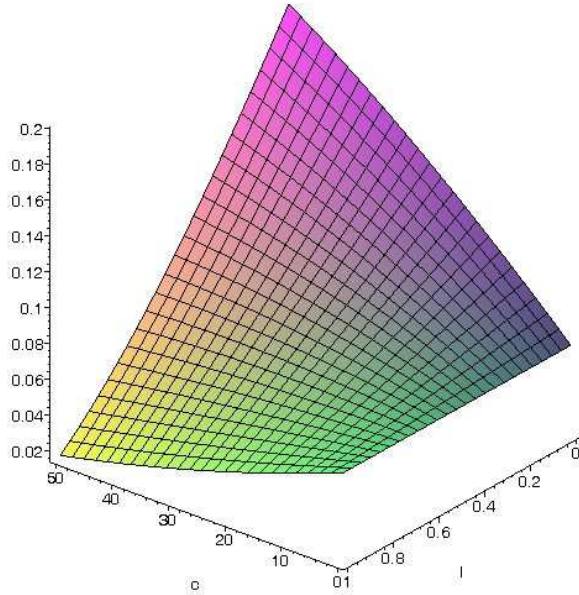


Figure 25: Optimal innovation probability in case of debt-financing of both firms dependent on c and λ

Due to $q_i^* = \frac{a-2c_i+c_j}{3b}$ it must hold $a \geq 2c_i$. The graphic shows that low values of c combined with high values of λ result in the lowest optimal innovation

activity. The higher c and the lower λ the more it is valuable to have an innovation.

For the case of self-financing a similar analysis is true. Remember that the equilibrium innovation probability in case of self-financing is given by

$$\hat{\theta}_i = \frac{\Pi_i^A + E[\Pi_i^A] - \Pi_i^N - E[\Pi_i^N]}{2w + (\Pi_i^A + E[\Pi_i^A] - \Pi_i^N - E[\Pi_i^N]) + \Pi_i^D + E[\Pi_i^D] - \Pi_i^I - E[\Pi_i^I]}$$

Figure 26 gives an impression of the optimal innovation probability in case of self-financing.

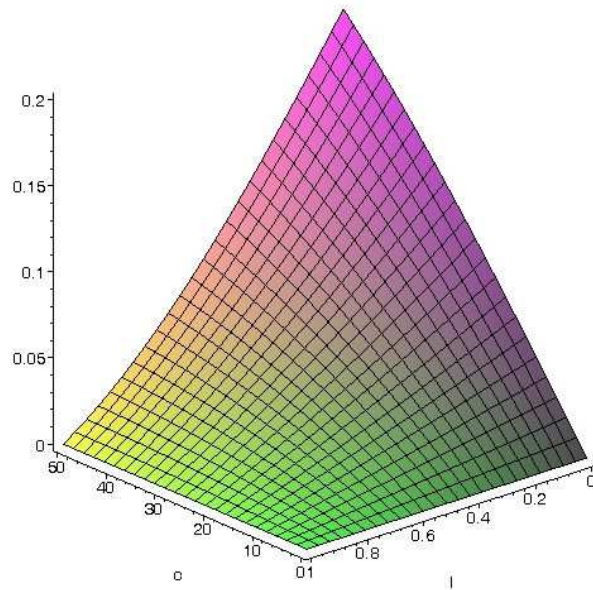


Figure 26: Optimal innovation probability in case of self-financing of both firms dependent on c and λ

As from the equation can be easily seen, the numerator as well as the denominator in case of debt-financing is higher. Which optimal innovation probability is higher depends on the values. Figure 27 shows for the given example the difference of both optimal innovation probabilities.

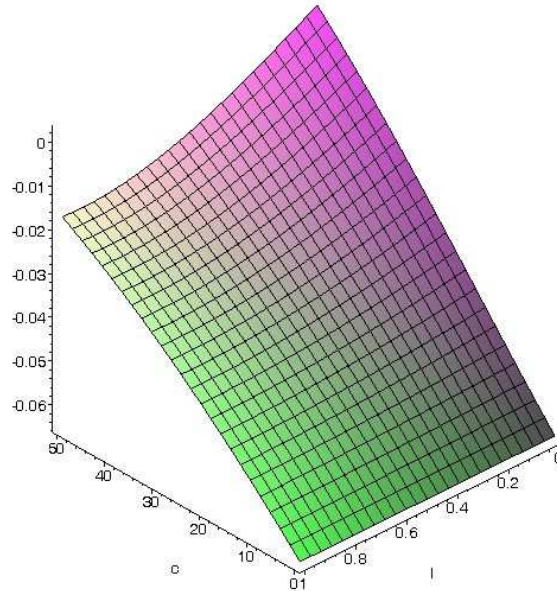


Figure 27: Difference of the optimal innovation probabilities between self- and debt-financed firms dependent on c and λ

For relatively high marginal costs compared with the reservation price and low values of λ the optimal innovation probability of the self-financed case is higher. The other way round, for relatively low marginal costs and a low cost-cut the optimal innovation probability of the debt-financed case is higher.

(5) The profits behave similar to the optimal innovation probability. For non-drastic innovations competition in the market is more fierce in case of debt-financing. Thus, the profits of both firms are lower than in case of self-financing. The opposite is true for drastic innovations. Figure 28 shows the difference between the profits of self- and debt-financing for the above mentioned example. (Assumption: $a = 100$, $w = \frac{10000}{b}$, $R^N = \Pi^N$ and $E[\Pi^k] = \Pi^k$).

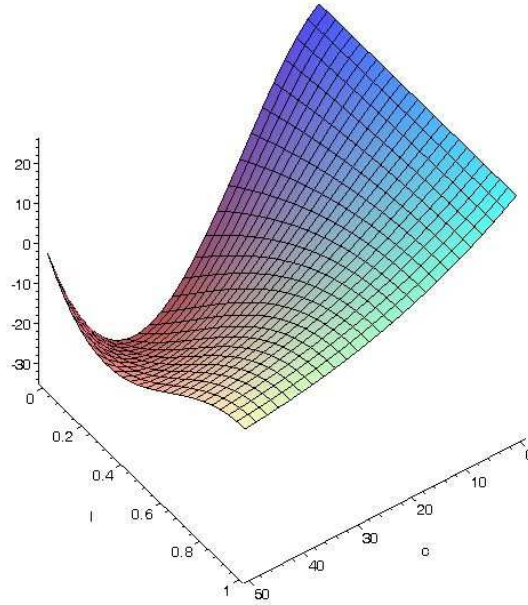


Figure 28: Optimal profit in case of debt-financing of both firms dependent on c and λ

6. Conclusion

Along with reflecting on the means by which a firm is financed as well as the managing of capital costs, the capital structure of a firm has another important strategic function. It can be used to signal rivals a specific behavior on the product market. Since the work of Brander and Lewis (1986), who integrated first the capital structure decision as an additional variable of firms in a Cournot model, and Showalter (1995) (the same for Bertrand models), many other articles dealt with this topic. The outcome of the models strongly depend on the assumed market environment. For instance, markets with quantity competition results in other optimal behavior than in markets with price competition. Relevant for the outcome are also the time focus and the kind of uncertainty in the market. Thus, whether a firm should strategically increase its leverage or not, depends on the respective market environment.

This thesis has also analyzed capital structure decisions of a firm under different market environments. The effects of additional decision variables of firms beside the quantity or price decision were pointed out. The focus of the capital structure decision in each paper was based upon the analysis of self- vs. debt-financing and their effects on the market outcome. In every paper a comparison was made between the outcome in case of symmetric firms, which are either purely self- or debt-financed, and asymmetric firms with one self-financed and one debt-financed firm. Furthermore, an outlook was suggested as to how firms should behave in equilibrium.

The first paper has dealt with the product quality decisions of firms. The chosen product quality of a firm determines the intensity of price competition in the market. The main outcome of the model is that an adjustment of the capital structure can be used to further soften competition. Debt increases prices in the market. It also induces high quality firms to increase their product quality. The low quality firm always supplies the lowest possible quality. Thus, a higher quality of the high quality firm means a stronger differentiation of both products. Consequently, both firms can increase their prices. As in the literature with price competition a positive leverage is advantageous for both firms. Hence, in equilibrium both types of firms have a positive leverage. This increases quality and prices due to the two described effects.

In the second paper the marketing stage was integrated in a market with hor-

horizontal differentiation based on the Hotelling model. In the model, marketing has the decisive task to make a firm's product known to consumers. With the amount of marketing firms decided on the intensity of competition. Our main result is that the marketing decision is also influenced by the capital structure of the firms in the market. If all firms in the market had a positive leverage, optimal prices would increase and firms' marketing activity decrease. If only one firm was debt-financed, optimal prices and firms' marketing activity would be different. The debt-financed firm behaves less aggressively. The optimal price is higher and the marketing activity is lower than of the debt-financed firm. Thus, debt can be strategically held by firms, because it softens competition in the market.

The third paper has analyzed the R&D decisions of firms in markets with Cournot competition. An investment in R&D would possibly reduce marginal costs. Then, firms could become the cost leader in their industry. The R&D decision of a firm was mainly driven by the gain of a cost leadership and the bankruptcy probability. The quantity decision after the innovation stage, however, depends upon the marginal costs of both firms. In the asymmetric case with one self-financed and one debt-financed firm in the market, firms' behavior is also asymmetric. The debt-financed firm tries to soften competition by decreasing its research expenses. Self-financed rivals, however, have the incentive to tighten competition by increasing their research expenses. This strategy is predatory, because it increases the probability to squeeze debt-financed firms out of the market. Thus, if firms are not financially restricted, research projects should be financed by equity. Taking up debt places the firm in a disadvantageous position. In the symmetric case with debt-financing of all firms in the market, firms behave dependent on the market environment. In case of non-drastic innovations, debt-financing intensifies competition in the market. Profits are lower than in the symmetric self-financing case. In this case, firms are better off of self-financing. Moreover, self-financing is the dominant strategy. In equilibrium, both firms are not financed by debt. For drastic innovations the other way round is true. Indeed, in this case self-financing is not the dominant strategy anymore, but in equilibrium, both firms are self-financed.

All three papers have the common ground that they confirm to the existing literature that capital structure decisions influence product market decisions

and can be used to signal a specific behavior. Furthermore, the papers also show that the optimal strategic behavior of a firm is not identical in every case. It strongly depends on the market environment. Whereas in the last paper with R&D and quantity competition debt under certain circumstances has intensified competition, in each of the other papers with price competition and horizontal or vertical differentiation competition has been softened. This should be also the motivation for further research in that area. Managers of firms as well as share- and stakeholders and competition authorities should obtain a clear picture, which kind of capital structure in a specific market environment signals and, in the end, results in a more or less competitive behavior of firms in the market.

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