INVESTMENT, PRODUCTION AND INDEBTEDNESS IN A DUOPOLY WITH UNCERTAIN DEMAND

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ABSTRACT

The paper builds a dynamic and stochastic simulation model to analyse how players' behaviour changes as the number of competitors increases in the market. Our major contribution is to parallelly use the classic terms of corporate finance and microeconomic models to calculate the necessary quantities for business valuation and the effect of competition on the market. Our general results show that, for several firms, the optimal leverage ratio increases with the number of firms. This is due to the declining cash flows from operations and, in parallel, to the relatively increasing importance of the tax shield effect arising from the capital structure. This paper highlights the importance of considering market structure in financial analysis and modelling. While a monopoly can shape the market individually, firms are constrained to a higher output than the socially optimal in the presence of a competitor. This essentially limits their freedom to make decisions about the capital structure.

INTRODUCTION

Most models in neoclassical economics aim to describe the equilibrium, conditions and stability of a market, mainly in a highly formalised framework. Microeconomics deduces in great detail that all economic phenomena (e.g., the relative prices of products, demand-supply function) are based on the profit-maximising behaviour of people. The detail usually starts to fade in the area of corporate operations. It is a common assumption that corporate technology is a black box and the value to be maximised is the *profit*, which is the difference between the revenue and the costs associated with production. In our paper, we present a model that fills in the gaps in these details from corporate finance. Firms must make an investment and choose the capital structure behind that. The concept of profit maximization is clarified, focusing on ownership wealth maximization using practical firm valuation methods.

The introduction of the paper could have been started from the other direction. The literature on standard corporate finance is very diverse and covers a wide range of issues. For example, if we take the textbook by Brealey and Myers (2005), we can find chapters on investment valuation, equities, bonds, financing and risk. The focus of this paper is on companies that make decisions about investments and their financing. In the simplest models, investments are usually listed with their future cash flows. More sophisticated models link the cash flow to the evolution of events. The most common case is that cash flow depends on how the company performs. However, the role of competitors in the size of the cash flows is less frequently present. In practice, companies must also look outwards and take decisions not only in a model of their own but also taking into account the market as a whole. This is where game theory comes into play, which examines the interaction of players (in this case, companies) and the strategies that can be developed on this basis. In this paper, I would like to present a model that draws heavily on game theory and microeconomics in the interaction of firms. The decisions of competitors directly affect the performance of the firm, so the design of investment and financing strategies must consider what others are doing.

In summary, we want to combine neoclassical economics based on microeconomics and game theory with corporate finance. We use the model to answer questions that would not arise without linking the two fields. In particular, we are investigating the impact of the intensity of market competition on the optimal level of leverage and the probability of default.

LITERATURE OVERVIEW

About oligopolies in general

An oligopoly is a market model situated between monopoly and perfect competition, where there are several firms on the supply side of the market, but not so many that they would have to behave in a price-accepting way. The first oligopoly model was introduced by Cournot (1838), initially with only two firms (duopoly). In the model, firms make a simultaneous decision on the quantities brought to market, where based on a demand curve, the price is determined.

In this situation, we look for the so-called Nash equilibrium known from game theory, where each firm acts optimally in response to the other firm's production. Under the most general conditions (the demand function

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is decreasing, the variable-cost function is increasing), the Nash equilibrium is not Pareto-efficient. The Pareto-efficient condition can be reached by firms colluding to maximize the sum of their profits. In this case, the cartel of firms behaves as a monopoly in the market, which, however, is not sustainable, as by deviating positively from it, the deviant actor can skim the market, increasing its individual profits and reducing the profit her counterpart. That is why the general assumption in an oligopoly market is that firms overproduce relative to the Pareto-efficient state.

From a practical point of view, out of all the oligopoly markets, the airline industry is certainly the most inquisitive. The effect of non-Pareto-efficient operations can be seen, for example, in flight delays. Airlines operate with higher than optimal leverage, build more than optimal capacity, and launch more flights, which leads to a deterioration in quality (Oum, Zhang and Zhang, 2000). They take competitors into account in their pricing strategies. For example, in the case of a potential new entrant, more leveraged airlines should lower their prices more to reduce the risk of bankruptcy in order to realize a lower but more secure revenue (Ma, 2019). Higher leverage also implies higher risk, which is explicitly true for air transport. Demand-side shocks can be caused by several factors. In recent years, for example, many airlines have had to declare bankruptcy as a result of the demand slump caused by the COVID-19 pandemic (Buckley, 2023).

About capital structure in general

A company can finance its investments from two main sources: equity and debt. The proportion of these is known as the capital structure. There is a large literature on the impact of capital structure on firm value. The pioneering paper on this topic is Modigliani and Miller (1958). The main finding of their work is that in a *perfect capital market, the corporate capital structure has no effect on the value of the firm*. This is commonly referred to as Modigliani and Miller's Theorem I. In reality, of course, the composition of finance plays a very important role, so the keyword in the theorem is the perfect capital market. A perfect capital market is where there is perfect market competition, there are no transactional costs, taxes, or costs of financial distress, the interest rate is constant, and the players have perfect information and are rational.

It is an important question from both a theoretical and a practical point of view, what happens when the conditions for a perfect capital market are not present. In the case of this paper oligopoly, information uncertainty due to stochastic demand, tax and bankruptcy risk. In general, tax has an impact on the capital structure decision as in most countries the result of financial operations is not included in the tax base, i.e. the loan and the resulting interest payment liability reduce the tax base. This is known as the tax shield effect, which thus encourages companies to go into debt in order to save more tax. On the other hand, this high exposure makes the company vulnerable and potential financial difficulties come at a cost. The theory describing the decision taking into account the above effects is the so-called *trade-off theory*, according to which *the financing decision is a choice between the gains from tax saving and the costs from potential financial distress* (Kraus and Litzenberger, 1973). The theory has been questioned empirically by several studies (e.g. Fama and French, 1998), but it is still the dominant starting point for the study of capital structure decisions. The tax shield effect also appears in the model of this paper. On the other hand, the cost of financial distress is represented by the risk of bankruptcy and, in the event of bankruptcy, by the loss of future cash flows.

Capital structure in an oligopoly market

A relatively less researched but very interesting question is the impact of market structure on borrowing i.e. how market competition affects indebtedness. A general pioneer model was created by Brander and Lewis (1986) on this topic. The authors used a duopolistic model consisting of two subgames. First, both firms decide on the amount of debt they are borrowing, and then, also knowing the other firm's debt decision, they decide on the quantities brought to market. Here each firm has a $q_i(D_1, D_2)$ production function and an $R_i(q_1(D_1, D_2), q_2(D_1, D_2), z)$ profit function, where z is a random variable, reflecting the market conditions. From the profit made, they have to repay debt, otherwise, they go bankrupt. Under general conditions, the authors show that it is worthwhile for firm i to increase the size of its debt for a while, as it can produce more and will force firm j to produce less. However, after some point, the marginal loss to bondholders (i.e., the risk that the firm goes bankrupt) becomes so large that it is no longer worthwhile to increase the leverage. Thus, we obtain an interior point solution and there will be an optimal debt amount.

Firm valuation

Essentially, a company has value because it can generate cash flows from the capital invested. The value depends on the cash flow relative to the capital invested (i.e. the rate of return) and how fast it grows. The size of the cash flow depends on an important factor that is often not taken into account in conventional microeconomic models: the tax shield effect, which is the tax saved that results from the financing structure. In most countries, the liability to pay interest is deductible from the tax base, i.e., out of two identical firms (with the same revenues and operating costs), the one with higher leverage will pay less tax because it will have a smaller tax base. The so-called adjusted present value (*APV*) method breaks down the value of a company's operations into two components: the cash flow that would result if the company financed itself purely from equity and the tax savings resulting from the financing structure. In other words, the method separates the value from operations and the value from the capital structure (Copeland, Koller and Murrin, 2000, Chapter 8).

In order to obtain the tax base, the costs of goods sold and other expenses related to the sale must be deducted from the revenue (*EBITDA*), followed by depreciation (*EBIT*) and finally interest expenses (*EBT*). After deducting the tax, we obtain the net income, to which we need to add back the non-cash items that we have taken into account to calculate the tax base (for our purposes, the only relevant factor for this model is depreciation). Finally, we need to deduct the investment expenditure. In short, this gives the so-called *free cash flow*. As mentioned above, for the APV method, we are interested in the cash flow that would be obtained if the company were financed purely by equity. To do this, we do not deduct interest expense and use EBIT as a basis for calculating a "what if" amount of tax. This gives us the NOPAT (*Net Operating Profit After Tax*), which is a financial indicator that can be reconciled with net income. It has the advantage of better expressing the company's financial result from production since it does not take into account the benefits of the capital structure. This is precisely what we need now. From here, the cash flow calculation is similar: adjust for non-cash items and deduct capital expenditure to get the so-called *free cash flow to firm* (*FCFF*).

The other part of the valuation is the quantification of the benefits of the capital structure. Following the previous logic, this involves calculating the amount of tax the company pays and what it would pay if it were financed purely from equity. The tax actually paid is certainly lower (at least not higher), since interest expenses are deducted there, and the tax base is therefore lower. We call the difference between this notional tax calculated from EBIT and the actual tax a *tax shield*. This can be seen as a kind of tax saving that the company has achieved due to the capital structure.

Estimating the above two components for the future gives a cash flow which, when discounted, gives the intrinsic value of the company. Although, we are interested in the intrinsic value of equity. To obtain this, we still need to subtract the market value of loans, which is the discounted present value of the funds flowing to creditors (interest payments and principal repayments), where the discount factor is derived from the market interest rate on loans (Copeland, Koller and Murrin, 2000, Chapter 8).

We now turn to the issue of optimization. What does the owner want to maximise? Obviously, the intrinsic value of equity. However, it is also worth considering how much of this intrinsic value is generated by the initial capital. The market value added (*MVA*) measure captures this idea as that is the difference between the intrinsic value of the firm and the capital invested (or equivalently, the difference between the intrinsic and book value of equity) (Copeland, Koller and Murrin, 2000, Chapter 4).

THE FRAMEWORK OF OUR MODEL

To put it simple enough, in corporate finance we think of a company as investing, borrowing money, paying interest and repayments, producing and generating revenue. In microeconomics, it is common to simplify this even further, that the company produces and generates profit. We would like to leave this further simplification out of our model and keep the basic corporate steps. In the other direction, we would like to incorporate the interdependence of firms from game theory into the model, which we will do through the market demand function.

We suppose that there are (maximum) three firms and all firms produce a product for which they need a special kind of *machine*. Production capacity is proportional to the number of machines. It is not certain that the firms use this capacity every year. The use of materials (energy, wages, etc.) is strictly proportional to the production each year. The variable cost per unit (c) is constant.

Investment is made by the firm in the form of *machinery purchases*. The machines cost p_g euros, operate for m years and have capacity k (i.e. they can produce k products in a year). The accountants depreciate the machines on a linear basis over their lifetime. In parallel with the investment decision, the company also decides how much debt to borrow for this investment. This loan has a maturity of n years, the principal is to be repaid at the end of year t and the interest is to be paid annually at an interest rate of r_D.

The firms then meet in the market, where the price is determined by a linear inverse demand function $p=A-B\cdot Q$. Here, Q is the total output that firms bring to market, i.e., the model assumes a Cournot duopoly market ($Q = \sum q_i$). Parameter A performs a random walk on a *standard trinomial tree*.

Our investigation thus generalises the traditional Cournot problem, familiar from microeconomics courses, in at least two aspects:

- there are several periods, so the model is *dynamic*: decisions must be taken not only for production but also for a series of purchases, taking into account the expected demand;
- due to the demand uncertainty, the model variants are also *stochastic*.

There is a third aspect, in which our approach differs from the simple one-period *profit maximisation* exercise. We take into account *taxes*, the *effects of borrowing* (tax shield from interest payments, the benefits of earlier expansion in an expanding market, etc.), and by presenting the accounting details (*balance sheet, income statement, cash flow statement*), the *maximisation of the owner's wealth* becomes the optimisation criterion.

It is not usual to combine *business valuation* methods and *microeconomic* optimisation procedures. The complexity of the matter makes the use of *Monte Carlo simulation* obvious. The presentation of the various simulation techniques usually focuses on the mathematical technicalities, e.g. efficient random number generation methods, and variance reduction procedures (e.g. the use of antithetic variables). We will help the reader in any further investigations of his own by elaborating on the financial details and formulating financial model variants and analysing the parameters those represent.

THE SIMULATIONAL METHODOLOGY

Companies always plan the next *n* years at the end of the given year and decide on three variables:

1. Production for the following year (q_i)
2. The planned annual linear increase in production (g_i)
3. The percentage of debt in the investment at the end of the year (d_i)

Together, q_i and g_i determine the planned production for the next *T* years (and realised in the first year), from which it is possible to break down on an annual basis how many machines are needed and hence how many machines will have to be purchased in each of the years (planned). This, together with the d_is, determines the planned balance sheets of the companies for the years-end. In the following year, production takes place and the (planned) price is determined based on the inverse demand function in the market. From that, the (planned) income and cash flow statements for each year can be prepared based on the companies' revenues and costs (we assume the same variable costs for each company). For simplicity, it is also assumed that all cash flows occur at the end of the year. We assume that owners can not offer additional capital to the firm thus a company goes bankrupt when it cannot pay the interest for the year.

We assume that firms know the dynamics of the parameter *A* of the inverse demand function, i.e. they can use it to calculate for each year the minimum revenue they need to not go bankrupt (as a function of output). From this, they can obtain, as a function of the other firm's output, the minimum parameter y that will prevent them from going bankrupt. Thus, they obtain a monotonically decreasing survival probability vector, and the expected prices and the resulting expected cash flows are calculated as conditional expected values. This is how the trade-off is incorporated into the model for borrowing since if they did not calculate bankruptcy, they would plan to finance each year with 100% debt due to the tax shield effect.

The intrinsic value of the firm is obtained from the above methodology (*APV method*). Ultimately, companies maximise the (expected) value added of equity, which is the difference between the intrinsic value of equity and its book value (*Market Value Added – MVA*).

Overall, one firm's added value is a function of its own decisions and the decisions of others. Here, we are looking for a fixed point of this equation system, i.e., decision-vectors that no firms want to modify. In this equilibrium *each* firm's decision vector is the optimal decision, taking into consideration the others' decisions. This is the Nash equilibrium of the system.

Parameters

The model parameters were selected to keep it realistic, but "exciting" at the same time, meaning that the default has to be considered as a possible scenario. The crucial points can be summarised with the following.

First, we selected the parameter *B* of the price function to be low, in order to prevent the firms to be able to change the price (and so the revenues) significantly, so they cannot "run away" from close-to-default scenarios. Second, we selected the A_0 (starting point of the trinomial tree) and *c* (variable cost) parameters to have a big enough market with relatively high costs. We also selected the price and capacity of the machines to be relatively high in order to give investments an important role. The other parameters were selected either to help the speed of the simulation or to reflect real life conditions. Table 1. summarises our selections.

Table 1.: The default parameters used in the model

Planned periods (T)	6
Changes on tr. tree in % ([u, m, d])	[+5, 0, -5]
Probabilities on tr. tree ([p_u, p_m, p_d])	[1/3, 1/3, 1/3]
Init. point of inv. demand func. (A_0)	120
Slope of inv. demand function (B)	0.01
Industry expected return (r_A)	12%
Tax rate (TR)	15%
Debt maturity in years (n)	3
Debt interest rate (rD)	10%
Machine price in euros (p_g)	3000
Machine lifespan in years (m)	3
Machine capacity (k)	100
Variable cost in euros (per prod.) (c)	75

RESULTS

The simulations were run for 1, 2 and 3 companies. This allows us to examine several effects at the same time. First, we may see what happens in comparison to a monopoly situation, when a competitor enters the market. Second, the model shows how the oligopoly market changes as the number of firms increases. This means that competition increases and the marginal impact of firms on each other decreases. We simulated 15 years for each number of firms. This is repeated 100 times and the averages per year are examined.

The disadvantage of Monte Carlo simulation is that it only gives us an average picture of how things work. However, it is often precisely the specific case that the analyst is looking for. This paper presents simulations of two such special cases. The first case involves a macroeconomic boom followed by a downturn. In the second, the opposite is the case: first firms experience a recession and then the economy recovers.

Results of the Monte Carlo simulation

First, let's look at the cash flows generated by the companies in each market. Figure 1. shows the average cash flows (more precisely FCFEs) realised by firms. A general truth about oligopolies is that the Nash equilibrium condition is not Pareto efficient. This can be seen in the figure as the total amount of cash flows decrease with the number of firms. In the figure, the case with 1 firm can be compared to the other two in the sense that this is what would have happened in an oligopoly market if firms had cartelised. In this case, the whole market behaves as a monopoly and is optimized to maximize the joint profit. The 3-firm case towards the end of the period shows a contrary result, that higher profits are obtained by competing than by colluding. This can be explained by the bias due to bankrupt firms. By the end of the simulations, only markets with good states of the world have not gone bankrupt. We will see that as the number of firms increases, firms go bankrupt earlier, so in a 3-firm market there are fewer simulations taken into the mean at the end of the timeline.

Figure 1.: The sum of FCFEs generated in each market
Source: own calculation and editing

Now let's have a look at the main variables of interest, namely the debt-to-asset ratio and the probability of default. This is shown in Figure 2. The figure shows several effects. On the one hand, the average year of bankruptcy is much lower in a market with 3 firms (dashed line). By "increasing" the market (e.g., increasing A_0), the difference could be reduced, but the main point is that *the probability of bankruptcy increases with the number of firms in the market*. On the other hand, what can also be seen is that this is not clearly related to the capital structure.

As summarised earlier, in choosing the capital structure, the firm decides on the trade-off between the costs of financial distress and the tax savings provided by the tax shield. The extent to which these are chosen depends on the production. On the tax shield side, it is relatively straightforward: higher production will certainly require more investment, which will certainly lead to more borrowing and more interest, which will increase the tax shield. On the bankruptcy risk side, the situation is more interesting. The impact of higher production on cash flow depends on the "location on the demand function" of that production. We have seen that the more firms are present in the market, the further away is one firm from the optimal operation (the Nash equilibrium is not Pareto efficient). In other words, in an oligopoly market, higher leverage implies much higher risk, since firms already produce above the optimal level of production without leverage. In sum, the production and leverage decision is closely related and, for example, at a lower level of production, more credit is "allowed" if the resulting cash flow shortfall is compensated by the marginal tax shield effect.

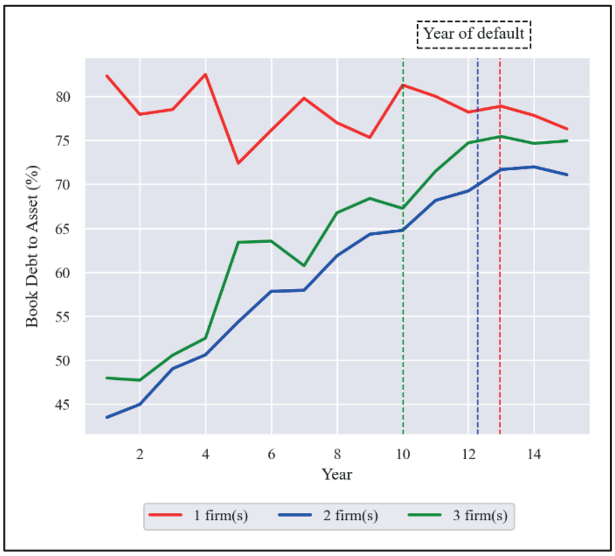

Figure 2.: Indebtness and probability of default
Source: own calculation and editing

The specific value of the optimal leverage is, of course, dependent on the parameters, but there are two observations to be made about the leverage ratios. First, it is of great importance whether there is a competitor in the market. The monopoly is able to produce at the Pareto-optimal level and can therefore adjust the higher leverage ratio accordingly. In an oligopoly market, however, firms "drive each other" into higher production, with lower cash flows, at which high leverage would result in too much risk. Interestingly, however, once it is a given that there is no optimal production (in the case of oligopolies), we see a different behaviour. For 3 firms we see higher leverage than for 2 firms. Here the other side of the theory comes into play. Higher production (with given leverage) increases the tax shield effect. In oligopoly competition, firms have an incentive to produce more, because if they do not produce more, the others do. This implies higher investment, in which the higher the share of credit, the greater the tax shield effect. Sub-optimal output reduces cash flow (FCFF), so the tax shield becomes more important in relative terms. This implies higher leverage and a higher risk of bankruptcy.

The model in special cases

First let's analyse what happens in a growing economy, i.e. when the parameter A is going up in the trinomial tree (then it is going down). Figure 3. presents the realised cash flows in such conditions. We can see similar patterns as in the Monte Carlo simulations. The level of cash flows is highly dependent on the level of price function. This example illustrates what happened during the Monte Carlo simulation and why the oligopoly markets defaulted earlier.

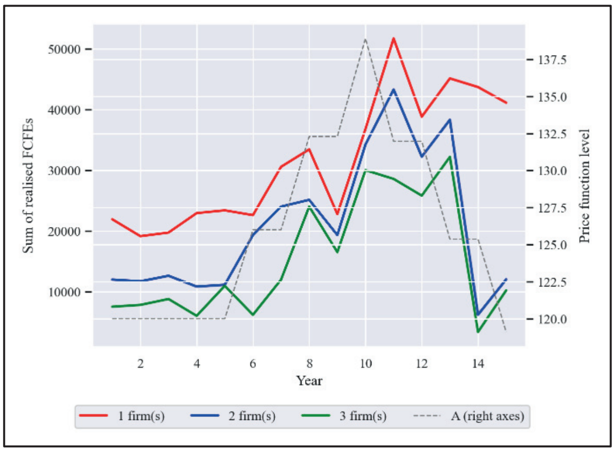

Figure 3.: The realised FCFEs in the up-and-down market
Source: own calculation and editing

Looking at debt-to-asset ratios in Figure 4., we can observe an interesting feature of the model. Similar to what we saw in the Monte Carlo simulation, we observe higher indebtedness in the 3-company market than in the 2-company market, for the same reasons. However, this simulation also shows why it is not worth comparing a monopoly and an oligopoly market or trying to model them in the same way. The monopoly market was able to operate with very high credit ratios from the outset, with a low risk of bankruptcy. As soon as demand rose above a certain level, the monopoly started to reduce its indebtedness. It can do this quickly because of the short machine life and loan maturity, which is why we see such a rapid decline. A kind of *shift of strategy* has occurred here. With higher demand, the firms chose to produce at a higher level. With such higher production, the company is now investing with a lower credit ratio, because the risk of bankruptcy has increased significantly. The monopoly firm could have continued with its previous strategy, but in the expected present value this operation with higher production and investment was already higher with the high level of demand that had developed.

Oligopoly companies have experienced the same market conditions, except that they cannot shape the market to their own taste and they have to take competitors into account. With higher demand, they also increase their production. But why do not they reduce their credit ratios, as the monopoly did? Let us examine the question from the point of view of what the purpose of the reduction might be: to reduce the risk of bankruptcy. In other words, in their case, more intensive financing from equity would not have sufficiently reduced the probability of default vis-à-vis the other side of the trade-off, the tax shield. A higher-than-optimal non-Pareto-efficient production implies higher investment, which could potentially generate larger tax savings with high leverage. What happened in their case was that they did not want to finance the high investment with less debt, as this would have reduced the tax shield too much compared to the relatively small reduction in the risk of bankruptcy. It is important to stress that this is only one example, under other parameters and other realisations this might not have happened. The lesson of the example is that it exists, i.e. that such a situation can occur at all. This highlights the importance of market structure when examining different financial indicators.

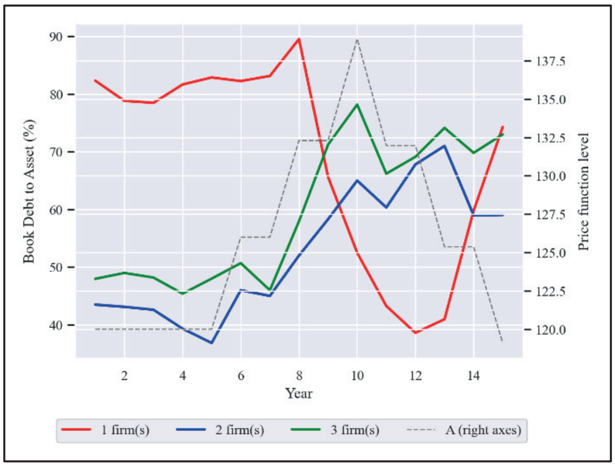

Figure 4.: Debt-to-asset ratios in the up-and-down market
Source: own calculation and editing

Finally, let's look at the case when the economy if first in a downturn, then it recovers. Figure 5. shows the debt-to-asset ratios in such conditions. In this scenario the 3-company market goes bankrupt, it can no longer withstand such a large fall in demand.

We see that, initially, when the demand has fallen less, the monopoly keeps its debt-to-asset ratio at the same level, while the duopoly starts to increase it. Eventually, both markets start to invest with less debt. In the duopoly (and of course in the 3-company market) we can see the effect of *limited liability*. As explained in the theoretical summary, in bankruptcy firms become more aggressive. In the present model, this is reflected in the fact that below-threshold realisations are "ignored" and the firm optimises for the event of survival. By increasing the debt ratio, the threshold level can be increased, i.e. the firm is left with the higher realisation scenarios for which it optimises. It has to be discounted with the probability of survival, but by "filtering out" the bad cases, the expected present value of cash flows will be higher even after the correction. The threshold level is also influenced by the choice of production, but their hands are tied because of competition.

SUMMARY

The paper presents a *dynamic and stochastic simulation model* that combines standard elements of neoclassical economics and corporate finance. On the corporate finance side, firms need to invest in order to produce, for which they need to determine the capital structure. Furthermore, the concept of profit maximisation used in microeconomics is clarified and the market value added (*MVA*) used in the valuation of the firm becomes the value to be optimised for the firm. On the neoclassical economics side, a demand function is introduced in the model through which firms interact directly with each

other in the market. From a game-theoretic point of view, a Nash equilibrium will emerge in the market. In this equilibrium situation, firms make a decision such that no actor would want to deviate from its decision in a situation where the other actors are making a decision.
The model reflects the theoretical results at the level that as the number of firms increases, the realised cash flow decreases. Even within the present framework, we recover the general truth that the Nash equilibrium is not Pareto efficient. We found that *as the number of firms increases, the risk of bankruptcy increases*.

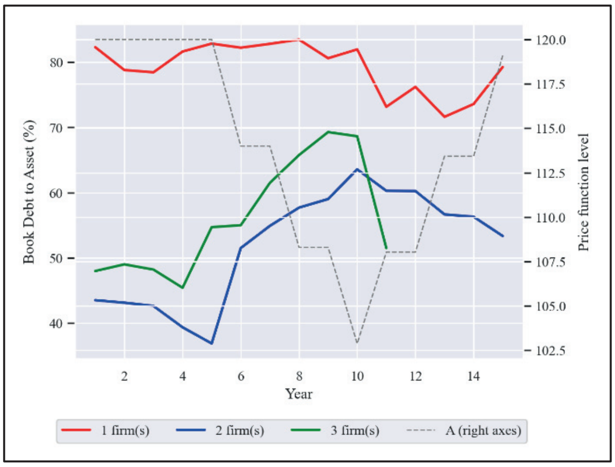

Figure 5.: Debt-to-asset ratios in the down-and-up market
Source: own calculation and editing

In several situations, we find evidence that the presence of a competitor fundamentally changes the operation: monopoly firms are more leveraged and can more easily switch investment-financing strategies. The reason is that in an oligopoly, competition "ties firms' hands" and they have to produce at a higher level anyway. If they do not produce, the competitor will and will gain a bigger market share. As a consequence, they are also given a sub-optimal level of cash flow. This implies a higher risk of bankruptcy, so in general *the oligopoly firm will be less leveraged than the monopoly*.
As the number of companies grows, the market moves further and further away from Pareto efficiency. As a consequence of the resulting lower cash flow, *relatively more importance will be attached to the profits from the capital structure*, the tax shield. Thus, if there is a competitor in the market, i.e. we are not talking about a monopoly, as the number of firms increases, firms will operate with an increasing debt-to-asset ratio in order to take maximum advantage of this effect. This of course increases their risk of bankruptcy, which brings us back to our first point.
The results obtained by our simulation cannot be considered as a general truth, other parameters might lead to different results. Rather, the point of the analysis is that such situations can occur, thus demonstrating the importance of taking market structure into account in various financial analyses and modelling exercises.

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APPENDIX

The Python code used for the simulation: https://github.com/babotanmark/oligopoly-capital_structure

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