Saïd Business School
Research Papers

March 2017

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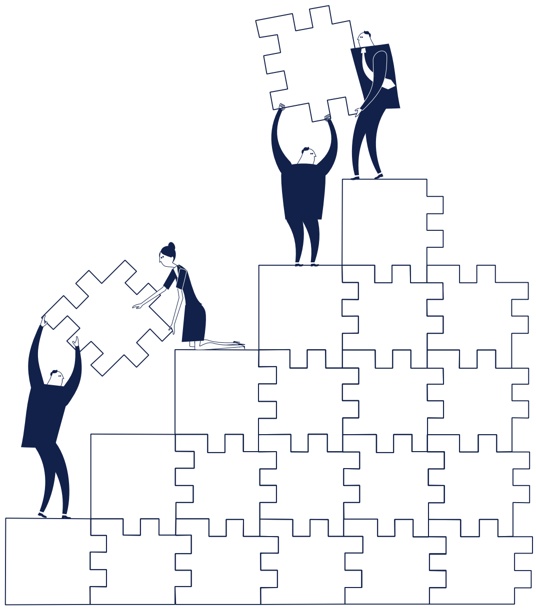

Saïd Business School RP 2017-06

How investment opportunities impact optimal capital structure[1]

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March 3, 2017

[1] We are grateful for helpful comments from Alex Guembel, Howard Jones, Oren Sussman ,Udara Peiris and Ji Yan. However all remaining errors are our own.
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Abstract

This article addresses the question of how competition for investments among firms in a certain industry impacts their capital structure. We develop a new modelling framework, which simulates financial variables of a set of firms in a given sector. We use it to analyse how firms are competing for new investments. The leverage of the firm impacts its flexibility to react upon investment opportunities, and we show how it can be optimised to maximise the firm's growth. As an illustration, we then apply the model on a set of European airlines and global pharmaceutical companies. The novelty that this paper introduces is the explicit modelling of the interaction among several companies. Invariably, the literature on optimal capital structure focuses on a single company optimising its capital structure in a world where the actions of its competitors are exogenous. Corporate Finance theory states that the optimisation of investment opportunities is one of three drivers of optimal leverage (together with reduction of the distress costs or tax expenditures). Our results suggest that the optimal capital structure should incorporate the competitive position of the firm as well as the availability of investment opportunities. Our framework allows corporate decision makers (CEOs and CFOs) to incorporate these aspects in their decision making.

Our main conclusion is that the leverage of the company impacts its ability to capture investment opportunities in a world where such opportunities are scarce. Companies with very low or very high leverage have reduced flexibility to invest, due to a high hurdle rate. Reducing the volatility of cash flows via hedging generally improves the ability to invest. The ability to invest in random growth opportunities is particularly important in mature industries, where investment opportunities are limited. Finally, if more flexible companies exploit investment opportunities this reduces the investment options for their less flexible competitors.

Keywords: Modigliani-Miller, corporate investment policy, capital structure, WACC, hurdle rate, financial flexibility, Monte Carlo simulation, optimal leverage

JEL Codes: *G31, G32*

1. Introduction

The topic of optimal capital structure[6] has been well-studied since 1958, when the original Modigliani-Miller theorem[7] appeared. Since then, many articles have tried to answer the question of how companies choose their target leverage from both theoretical and empirical perspectives.

A significant proportion of research on capital structure[8] focuses on the “Trade-off Theory” whereby a company decides on its leverage so that the financial benefits of holding debt due to the tax shield compensate the costs of financial distress and bankruptcy.

In order to be realistic and take into account the whole economic cycle, Trade-off models have to observe the firm over multiple time periods, which normally require Monte Carlo simulations[9]. Two such models were described in the Journal of Applied Corporate Finance by Opler, Saron and Titman[10] (1997) and Heine and Harbus[11] (2002). (from here on referred to as “Opler et al.” and “Heine and Harbus”)

Other sources[12], take a more pragmatic approach and also consider non-financial aspects such as target credit rating and the related value of financial flexibility. In our experience, from discussions with some of the largest European public companies, non-financial aspects are paramount in the minds of CFOs and Treasurers. For example, the Treasurer of one of the largest consumer good companies expressed the following view to one of the authors: “*We believe that a leading company in our sector should have a lower leverage than our competitors in order to be able to benefit from and drive consolidation in our sector*”. In practice, how should the company take into account the nature of its sector (e.g.: growth, fragmentation, cyclicality, etc.) and its own competitive position in determining its optimal leverage?

The main goal of the present article is to answer this last question in a systematic way. We model explicitly the financial flexibility resulting from lower credit risk and leverage. How

[6] For a good recent overview of literature in this field, see H. Kent Baker and Gerald S. Martin, Editors, Capital Structure and Corporate Financing Decisions (Hoboken, NJ: John Wiley & Sons, 2011).
[7] Franco Modigliani and Merton H. Miller, “The Cost of Capital, Corporation Finance and the Theory of Investment”, The American Economic Review, Vol. 48, No.3, (1958), pp.261-297.
[8] Other alternative theories, i.e. Pecking Order, Signalling and Market Timing models are all described in Baker and Martin (2011).
[9] Unless assumptions are made on the functional form of debt payments, in which case elegant closed form solutions can be derived. See, for example, Hayne E. Leyland and Klaus Bjerre Toft, “Optimal Capital Structure, Endogenous Bankruptcy, and the Term Structure of Credit Spreads”, The Journal of Finance, Vol. LI, No.3, (1996), pp.987-1012.
[10] Tim C. Opler, Michael Saron and Sheridan Titman, “Designing Capital Structure to Create Shareholder Value”, Journal of Applied Corporate Finance, Vol. 10, No.1, (1997), pp.21-32.
[11] Roger Heine and Fredric Harbus, “Toward a More Complete Model of Optimal Capital Structure”, Journal of Applied Corporate Finance, Vol.15.No.1,(2002),pp.31-45.
[12] For example Anil Shivdasani and Marc Zenner, “How To Choose a Capital Structure: Navigating the Debt-Equity Decision”, Journal of Applied Corporate Finance, Vol.17, No.1, (2005), pp.26-35.

exactly do we define this flexibility and how do we model it? By flexibility[13], we mean the ability of the firm to react to unexpected external growth opportunities. Taking an example from the airline industry, let us imagine that a new type of aircraft engine is invented, which consumes 50% less fuel than existing engines. However, the new engines are more costly to produce, adding an extra 25% to the initial cost of the plane. Moreover, the process is so new and complicated that the manufacturers can only produce 100 new efficient planes every year. If an airline decides to invest in the new engines it will initially incur higher costs, however over time it will be able to offer cheaper tickets and therefore capture a higher market share. More importantly, since the manufacturing capacity is limited, the first airline to order the new efficient planes will take away a certain amount of potential growth opportunities from its competitors. Similar situations are common across many industries and are characterised by two features. First, the unexpected or unpredictable nature of the investment, which the company has to finance at the outset, but which is expected to result in a higher return over time. Second, the approximately zero-sum nature of the growth opportunities in a mature industry: total revenues are constant or are growing slowly[14], so that those companies that are able to capture the new opportunities early reduce the potential growth alternatives for their competitors. The way we address this flexibility is to simulate the decision processes in parallel for a finite number of companies, which are calibrated to the real firms in a given sector.

We start by defining precisely the objectives of this study. Details of our model are described in Section 3. Section 4 shows the results of the model for the European airlines and global pharmaceutical companies and Section 5 the broader implications for financial policy. All technical details are in the Appendices.

2. Objectives of this study

It has been understood for a long time[15] that the behaviour of sector peers impacts any given corporation’s financial policy. In other words, financial directors and other decision makers often consider the behaviour of their competitors before establishing target leverage, target rating or risk management strategy. However, these decisions are by no means identical across the sector.

As an example, let us consider the net leverage (net Debt/Enterprise Value) and credit rating in two different sectors: global pharmaceutical companies and European airlines[16] in Table 1 and Table 2.

[13] This topic has been studied in several articles. See e.g. DeAngelo, H., L. DeAngelo, 2007, Capital Structure, Payout Policy, and Financial Flexibility, Marshall School of Business Working Paper No. FBE 02-06. Available at SSRN: http://ssrn.com/abstract=916093.

[14] See e.g. Quirry, P., Y.Le Fur, A.Salvi, M. Dallochio and P. Vernimmen, 2014, “Corporate Finance: Theory and Practice”, Fourth Edition, John Wiley & Sons, 2014.

[15] See e.g. Mark .T. Leary and Michael. R. Roberts (2014), “Do peer firms affect corporate financial policy?”, Journal of Finance, vol.69, pages 139 to 177.

[16] Source of the data is Bloomberg as of 15 August 2016.

Company	Net debt/EV[17]	S&P rating	Moody's rating
Pfizer	7%	AA	A1
Johnson & Johnson	-6%	AAA	Aaa
GlaxoSmithKline	12%	A+	A2
Merck & Co.	8%	AA	A1
AstraZeneca	9%	A-	A3
Bristol-Myers Squibb	-2%	A+	A2
Novartis	7%	AA-	Aa3
Roche	6%	AA	A1
Sanofi	6%	AA	A1
Bayer	19%	A-	A3
average	***7%***	***AA-***	***A1***
St.dev	***7%***	***1.9 notches***	***1.7 notches***

Table 1 - Global pharmaceutical companies

Company	Net debt/EV	S&P rating	Moody's rating
Air France-KLM	72%		
Lufthansa	40%	BBB-	Ba1
IAG	22%		
Ryanair	-2%	BBB+	
EasyJet	-8%		
Turk Hava Yollari	64%	BB-	Ba2
Air Berlin	92%		
SAS	15%	B	B2
Finnair	-109%		
Aer Lingus[18]	-26%		
average	***16%***	***BB+***	***Ba2***
St.dev	***58%***	***3.1 notches***	***2.1 notches***

Table 2 - European airlines

We have chosen three parameters to compare credit risk: Net leverage, S&P and Moody's rating. Considering these particular measures, we would like to illustrate the two points we make. First, we notice that the average rating in the airline sector is 7 notches lower than in the pharmaceutical sector. Secondly, there is a considerable discrepancy of ratings within the sectors. The first fact may be explained by the different nature of the pharmaceutical vs. airline industries, whereas the second one is of more interest to us. What does make Johnson & Johnson to decide on an extremely conservative financial policy with AAA/Aaa rating, while Bayer, ostensibly in the same sector, is 6 notches lower at A-/A3? There are two answers to this. On the one hand similarities between companies depend on the exact definition of the sector. For example, Johnson & Johnson produces different products from Bayer, so the two companies are not directly comparable. However, on the other hand, the decision on the capital structure, leverage and rating is a consequence of a large number of

[17] Enterprise Value (EV) = Net Debt + Market Capitalisation.
[18] Aer Lingus was acquired by IAG in September 2015. Here we are showing the 2014 data.

factors, some of which the firm does not control. Besides these answers, is there a more systematic way to decide on an optimal capital structure? What does exactly impact the capital structure choices of the firm, how does the interaction with its peers affect those choices, and what impact does the choice have on the evolution of key financial variables, such as the firm's market share, profit margin, etc.? Our objective is to set out a model that can answer these questions.

3. The model

We develop a model which describes the interaction among firms in a given industrial sector and in particular their competition for new investments. In the next section, we show the results of our model for the European airline and global pharmaceutical industries. Our first objective is to produce a realistic view of various industrial sectors and we evaluate the model based on its ability to predict future development of various financial variables such as market share of individual companies over time. However, the main focus of the model is to quantify the impact of leverage on company's ability to capture investment opportunities. Of course, a compromise has to be made between the model complexity and its ability to describe the actual dynamic in an industry.

In a similar way to Opler et al. and Heine and Harbus we use a Monte Carlo simulation of financial variables over a multi-year period. In addition, we simulate the joint time evolution of a number of firms. Then, the model is calibrated to the initial state of the firms in the past (in our example at year end of 2009), and consequently, we use it to simulate future development of key financial variables: Revenue, Capital, profit, Net debt etc. annually from 2009 to 2015. In this section, we outline the main idea of the model. For more details of the model procedure, see the Appendices.

3.1. Financial variables

Key financial variables[19] modelled for each firm over time are:

- Income and cash flow statements:
    - Revenue
    - Net Operating Profit After Tax (NOPAT)
    - Operating margin
    - Free Cash Flows to the Firm (FCFF)
- Balance sheet:
    - Invested capital
    - Cash
    - Net debt

[19] We find that this set is sufficiently large to allow for the description of companies in the airline and pharmaceutical sectors while being sufficiently small to keep model outputs intuitive and computationally tractable.

Unlike Heine and Harbus, we do not model an explicit set of market variables: currencies and interest rates. All of our financial variables are in the reporting currency of the company and their volatility is based on historical distribution, as described in the Appendices.

Similarly to Heine and Harbus, we assume that all investments are funded by either the existing cash, free cash flows generated by the business or new debt, but not by equity issuance[20].

We introduce two key modelling novelties. First, we simulate several firms at the same time. For example, in the European airlines, we simulate 10 publicly listed airlines from Table 2 over a period of 6 years, from 2009 to 2015.

Second, in order to take into account the value of flexibility resulting from a conservative financial structure, we model explicitly the competition between companies for investment opportunities. We assume that in a mature industry, investment opportunities are scarce and the competition among firms is akin to a zero-sum game, i.e. since the market size is at best slowly growing, one company's investment will reduce growth opportunities for its competitors. At every point during the cycle, companies are randomly offered investment opportunities, whose size, expected return and return volatility have been calibrated to the past. Furthermore, we assume that the companies decide on whether to take the opportunity depending on whether it will increase the expected Economic Profit (EP) created:

$$EP = Capital * (ROIC - WACC) \qquad (1)$$

Here, ROIC is Return On Invested Capital and WACC is the Weighted Average Cost of Capital. In a world with taxes and non-zero costs of distress, companies with different leverage will have different WACC, which determines the hurdle rate on new investments, as shown in the equation above. Therefore the leverage of the firms affects the ability of the firm to invest profitably.

For the sake of simplicity, we empirically derive the WACC as a function of leverage[21].

3.2. WACC

We derive the formula relating WACC to net leverage by fitting the cost of equity and debt separately to 1800 rated[22] non-financial corporations from the S&P Global index, from 2000 to 2009. In Figure 1, we are showing the best-fit of WACC as a function of leverage. Red dots correspond to average WACC for European airlines over this period. Ideally, we would like to compute the fit only considering European airlines in the sample, but lack of data in

[20] In Appendix A, we are showing to what extent this is accurate among the companies in our data sample.
[21] WACC and Cost of debt do not depend only on leverage but on sector, year, etc. Limitations of this approximation and ways of improving it are discussed in Appendix C.
[22] We exclude non-rated companies in order to eliminate the 'non-rated' premium, normally observed in their credit spreads.

the high leverage section of the graph forces us to extrapolate the WACC using the complete set of companies.

For our data set, the leverage at the minimum WACC is near 73%.

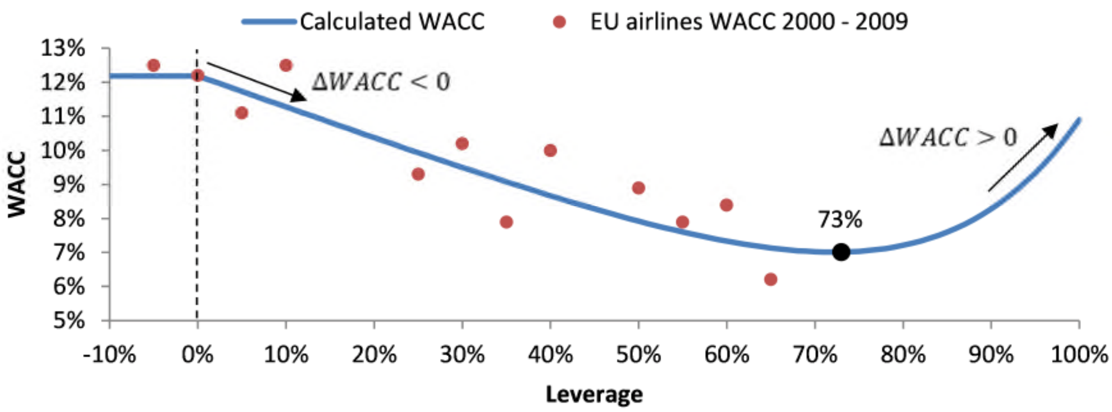


Figure 1 - WACC as a function of leverage (Net Debt/Enterprise Value)

The firm invests as long as the expected ROIC net of WACC on the marginal investment is higher than the change in WACC applied to the whole invested capital of the firm[23]. This condition[24] can approximately be written as:

$$\text{Expected return} > \Delta\text{WACC} + \text{Cost of new capital} \qquad (2)$$

The shape of the WACC curve determines the hurdle rate, as shown in Figure 1, where we denote by ΔWACC the change in the cost of the existing capital due to new investment.

We see that for the companies with low positive leverage on the left side of the graph, $\Delta\text{WACC} < 0$. This means that the hurdle rate on new investments is lower than the cost of new capital, which helps low-leveraged companies to capture more investments. Moreover, companies that are to the right of the minimum have $\Delta\text{WACC} > 0$, which means that the hurdle rate on new investments is higher than the Cost of the new capital, thereby reducing the possibility of investments for highly leveraged companies.

The conclusion is that, *ceteris paribus*, companies with a lower leverage will be able to accept more growth opportunities than their competitors and will grow at a higher rate.

3.3. Investment opportunities

Interaction between companies is modelled through random investment opportunities offered to companies in the sector. Each investment opportunity is specified by two parameters: average investment size as a proportion of total capital (g) and expected investment return (y).

[23] See Léautier, Thomas-Olivier, 2007, Corporate Risk Management for Value Creation (London: Risk Books).
[24] For details see Appendix A.

In Figure 2 and Figure 3, we show these parameters, estimated from historical data from 2000 to 2015 for our sample of 1,800 global companies, with sectors according to Bloomberg Industrial Classification. We highlight the airline and pharmaceutical sectors with darker colours.

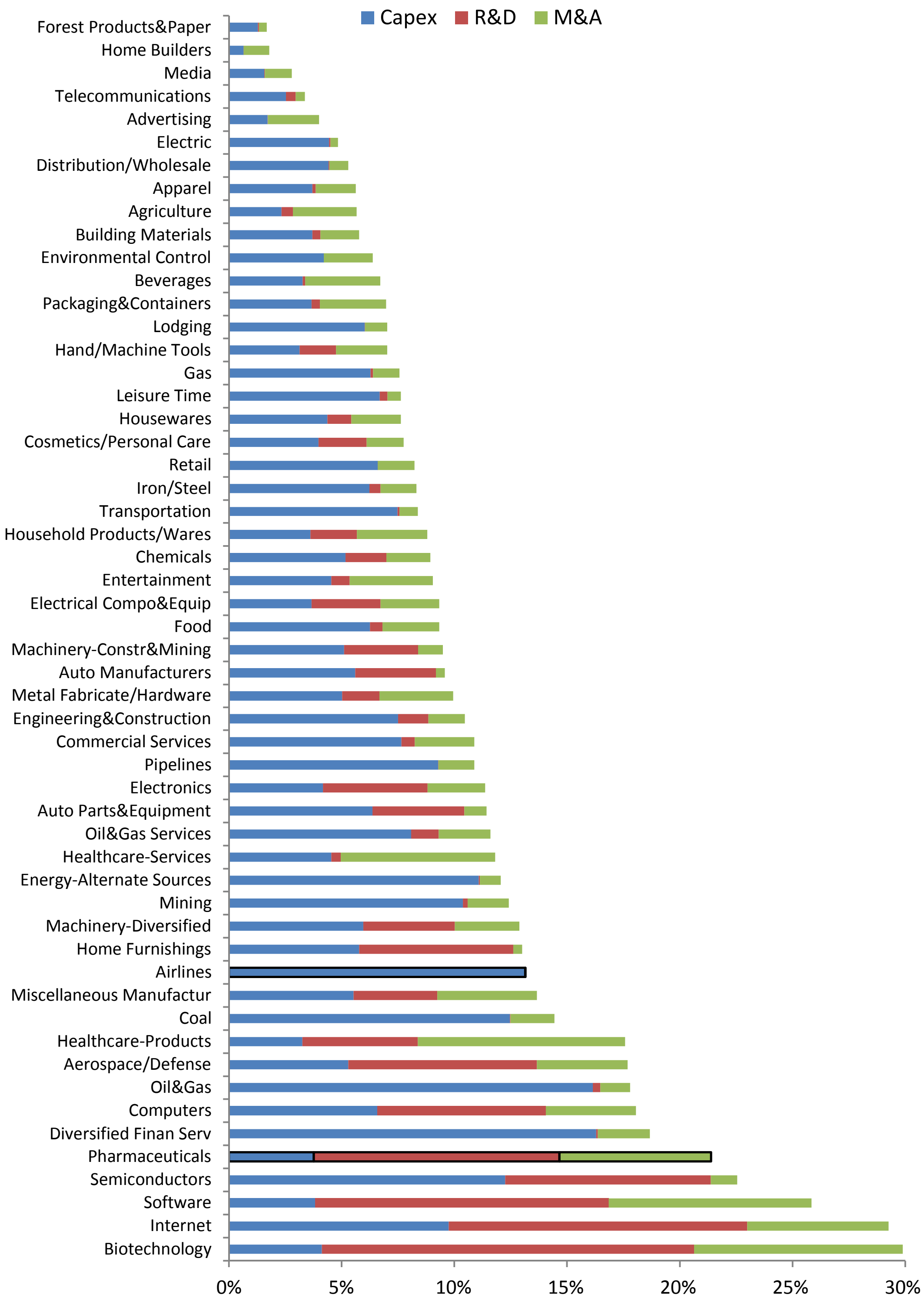


Figure 2 – Investment size as a proportion of total capital

In Figure 2, we are roughly estimating the parameter g, from historical data on Capital Expenditure (Capex)[25], Research & Development (R&D) and Mergers & Acquisitions (M&A). For airlines it is 13%, with most of it coming from Capex. The estimation of these parameters is subject to certain assumptions and should be modified on a sector by sector basis. For example, certain sectors, such as retail, restaurants, apparel, airlines and shipping rely on leases (not included in Capex) to fund a significant part of investments. In the case of airlines, we include this adjustment explicitly. In other sectors, there are additional investments, for instance marketing costs, costs of hiring new staff etc. which are not included in Capex or R&D. It is easier for companies to estimate the figures internally based on the expected or historical total investment size rather than for an outside investor relying purely on public financial statements.

The estimation of expected investment return is even more difficult for an external analyst since there is no proxy for it in financial reports. We use the "Miller-Modigliani formula"[26] to estimate it, assuming that the company earns the projected ROIC for 10 years. Results of the formula are in Figure 3 and for airlines the expected investment return is 13.7%.

[25] We exclude from Capex the maintenance Capex, which we proxy by the depreciation expense.
[26] See Appendix A.

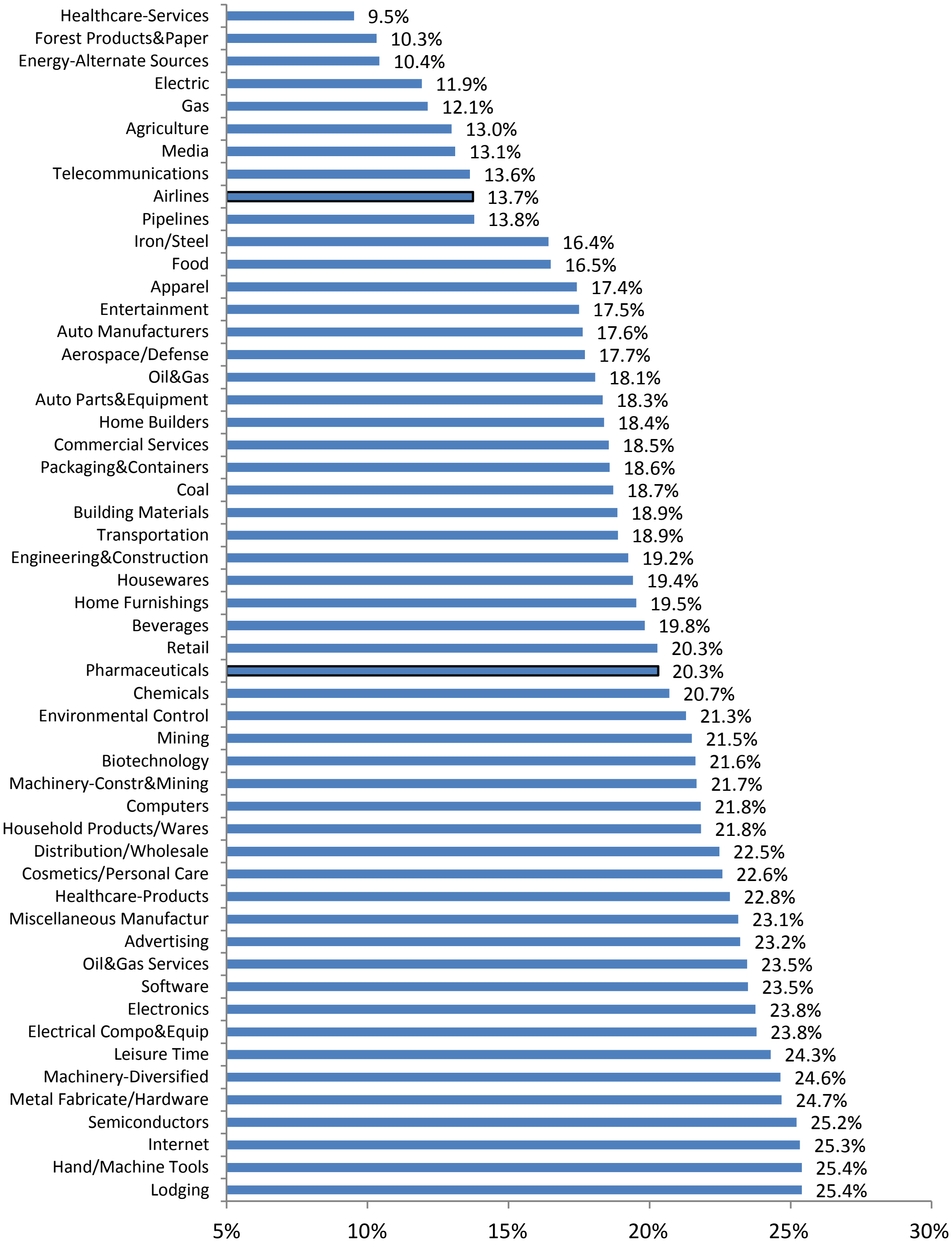


Figure 3 – Average investment return vs. sector

In each period, various investment opportunities are presented to the companies in the sector[27]. The first opportunity is presented to a randomly chosen company which decides

[27] The investment decision process presented here is obviously a huge oversimplification, where each company makes only one large investment decision per year. In real life, each company faces many investment

whether to invest. If it invests, another opportunity of lower risk and reward is presented to another randomly chosen company, until all opportunities are exhausted. No company has more than one investment per period but some companies may not have any investment opportunities at all. Size of investment, g, varies so that riskier and higher returning investments have less capital invested. The average investment return offered is equal to the average of the sector as calibrated to market data and the maximum return matches the historical distribution.

3.4. Outputs

There are many potential outputs of our simulation. For the European airlines we show the following ones: market share[28] and investments exploited.

4. Results for the European airline sector

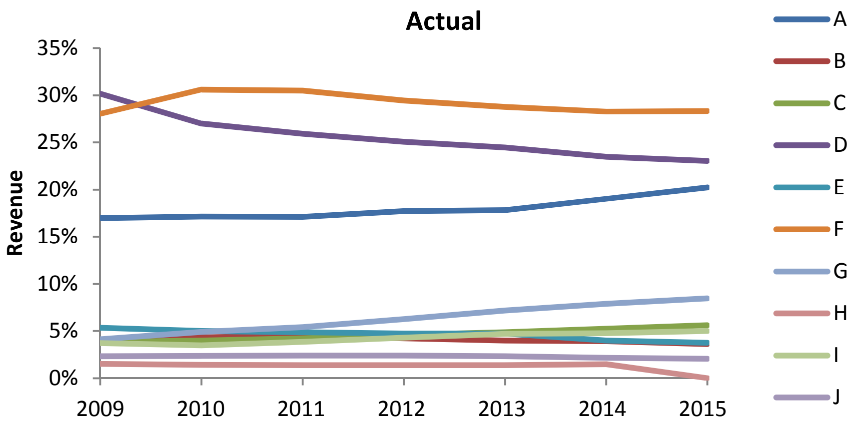
In this section, we are showing the results from the model for the European airline sector, consisting of 10 publicly listed airlines in Table 2, which in 2015 together accounted for approximately 59% of the total market by revenue[29]. The airlines are labelled A to J in order to protect their confidentiality.

In Figure 4 we show the evolution of the market share of individual airlines from 2009 to 2015, based on the calibration to historical data from 2006 to 2009.

opportunities per year. The analysis can be refined by breaking the investment into a series of investments of a realistic size. We checked that doubling the number of investments but halving their size does not impact the results.

[28] Market share is defined so that the 10 modelled airlines always add up to 100%.

[29] Source: IATA. The rest is split between Middle Eastern airlines: Etihad, Emirates and Qatar Airways, together with a group of smaller European airlines. Since these companies are not publicly listed (and many of them have government support), it is impossible to model them due to scarcity and incomparability of financial information.



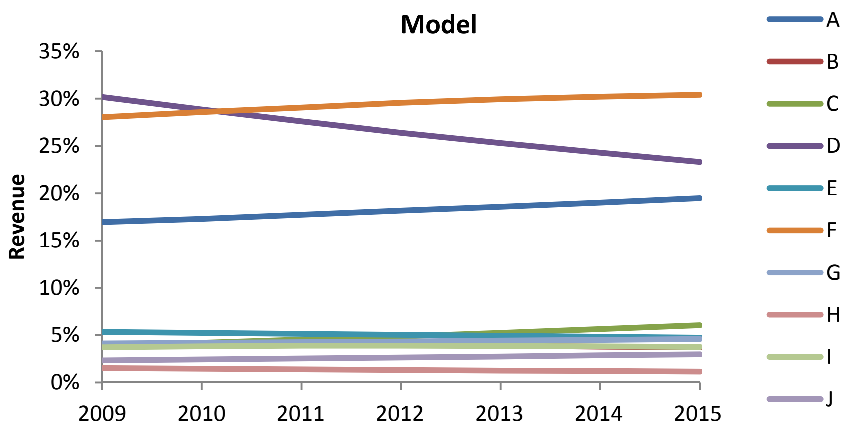


Figure 4 - Market Share - Actual vs. Model

Airline revenue market share 2015	A	B	C	D	E	F	G	H	I	J
actual	20%	4%	6%	23%	4%	28%	8%	1%	5%	2%
modelled	19%	4%	6%	23%	5%	30%	5%	1%	4%	3%

Table 3 - Market Share - Actual vs. Model

The upper schedule in Figure 4 shows the actual historical revenues as reported by the companies. Companies are split into two subgroups. The smaller 7 airlines have around 5% or less market share each, while the three biggest ones, A, D and F have between 15% and 30% of the market. The bottom schedule shows the model results. As we can see in Table 3, our model predicts the development of market share over time correctly with the largest discrepancy for G, where the model predicts a constant market share of 5% whereas in reality, G's market share increased to 8% during this period.

Even though in the case of European airlines, the model predicts the market share relatively well, we do not suggest that the model can be used to predict future financial results. Indeed, we showed the market share to illustrate the advantages and limitations of our model. However, we now focus on our main objective, which is to quantify the impact of leverage on a company's ability to exploit investment opportunities.

How do we evaluate the captured investments opportunities? As we have explained previously, companies are randomly offered investment opportunities. In Figure 5, we are showing the proportion of investments captured for different airlines over the 6 year period 2009 - 2015 as a function of leverage. Each coloured point in the graph corresponds to one airline. We see that the highest leveraged airlines, B and D capture less than 100% of investment opportunities offered to them. They are 'economically constrained[30]' due to a higher investment hurdle.

In Figure 1, companies which are far to the left of the optimal leverage of 73% are underleveraged and it is easier for them to invest as long as condition (2) is satisfied. These companies are on the central part of the dashed line in Figure 5 (i.e. A, C, E, F, G and J).

Since the WACC curve in Figure 1 is increasing as the leverage decreases below 73%, the more the company is underleveraged, the higher its hurdle rate on new investments. This constrains airlines I and H. In other words, potential investments are reduced not only for excessive leverage, beyond 73% but also for leverage which is too low, both due to the high WACC.

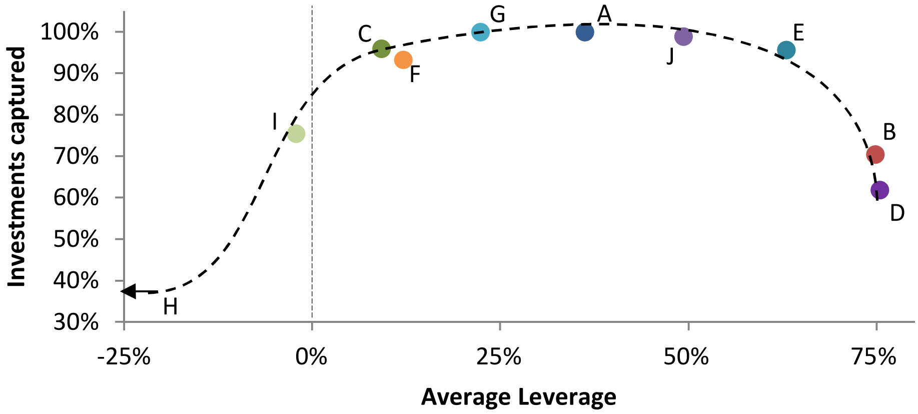


Figure 5 – Average investments captured vs Average leverage (2009 – 2015) – European airlines

This framework can be useful in estimating the level of under-investment due to high hurdle rates, which has attracted a lot of attention lately. The confidence of many companies has been badly shaken during the financial crisis of 2008-9, and as a result they are much more prudent in their financial policies. As an example, in Figure 6 we show how the investments captured would decrease if in 2009 companies used the higher WACC from 2009 (see Figure 20), instead of the average WACC through the cycle from 2000 to 2009. By 'Economic hurdle rates' we mean using the average WACC from 2000 to 2009 as in the previous figure, while 'Risk-averse hurdle rates' means using the 2009 WACC for the hurdle rates. We can

[30] See Léautier (2007), cited earlier.

see that the investment opportunities captured drop significantly for all but the least leveraged firms.

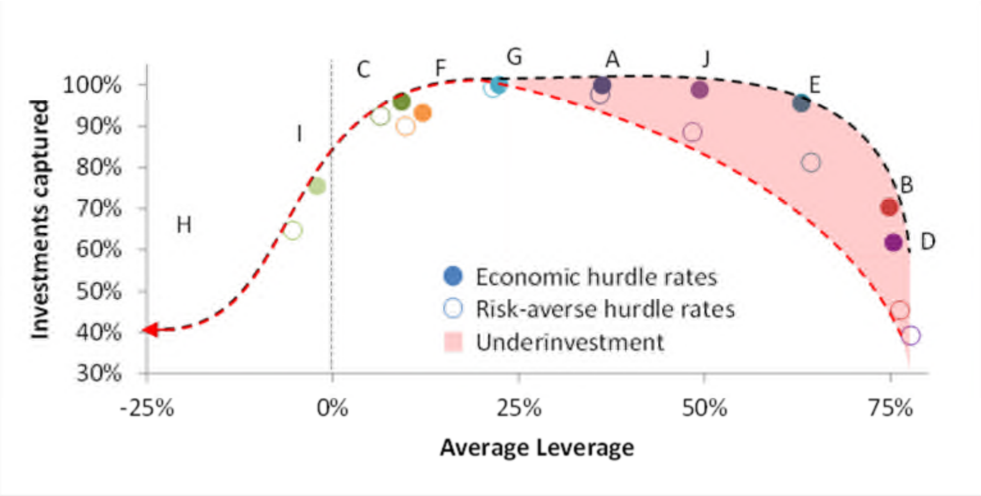


Figure 6 – Underinvestment when not using through-cycle WACC

The fact that a through-cycle approach can help companies refine their hurdle rate has been made by Marc Zenner, Evan Junek and Ram Chivukula[31]. From now on, we assume that the companies act in this way and in 2009 determine their hurdle rates based on the average WACC from 2000 to 2009.

Figure 7 shows the average return of the investments accepted by each company. We can see that the reason why companies that are under- or over- leveraged invest less is that they are forced to accept only the most profitable investment opportunities and forego the less profitable ones. The other companies are able to accept the most profitable investments as well as the less profitable ones, which allows them to grow faster.

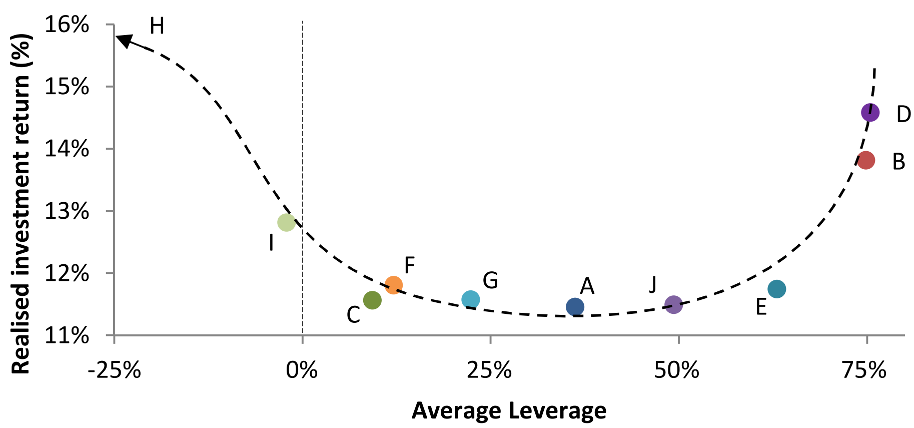


Figure 7 - Average investment return vs Average leverage (2009 – 2015) – European airlines

[31] “Bridging the Gap between Interest Rates and Investments”, Journal of Applied Corporate Finance, Vol. 26, No.4, (2014), pp.75 – 80.

The fact that there is an optimal level of WACC is not novel, and is a well-known feature of the trade-off model once the tax shield and cost of distress are included. Our contribution is that we add other elements to the WACC optimization that describe the nature of the industry and competition for investments. This allows us to observe that in the airline sector there is a fairly wide range below the optimal WACC, which allows capturing most investments.

4.1. Impact of hedging

In Figure 8 and Table 4, we show the impact of hedging on captured investment opportunities. In order to highlight the effect, we first increase the volatility of returns on existing capital in the sector from historically observed 7% to 21%. Then, we define the impact of hedging as reducing the volatility of returns from 21% to zero (obviously not a realistic assumption).

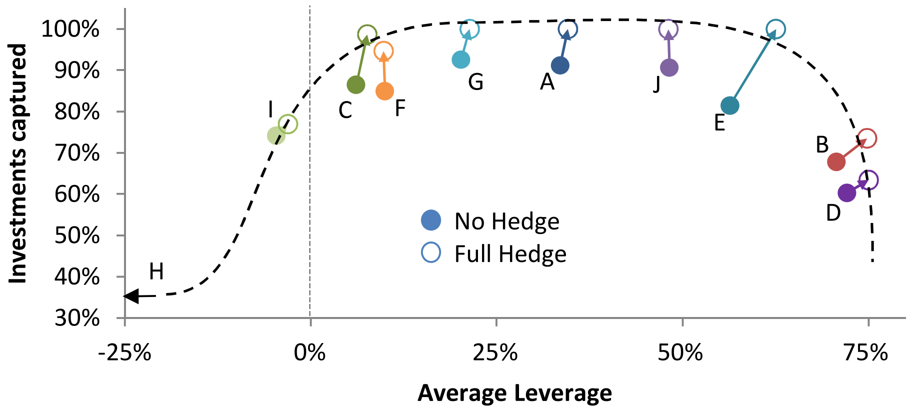


Figure 8 – Impact of hedging (volatility = 21%)

	A	B	C	D	E	F	G	H	I	J
Leverage No Hedge	34%	71%	6%	72%	56%	10%	20%	-157%	-5%	48%
Leverage Full Hedge	35%	75%	8%	75%	63%	10%	21%	-306%	-3%	48%
Investments captured No Hedge	91%	68%	86%	60%	81%	85%	93%	42%	74%	91%
Investments captured Full Hedge	100%	74%	99%	63%	100%	95%	100%	42%	77%	100%

Table 4 – Impact of hedging (volatility = 21%)

We can immediately see that the impact of hedging in this hypothetical world would be, in all cases but one, to increase the investment opportunities captured. This is hardly surprising, since hedging helps to ensure sufficient investment capital. If we were to use the real data for the European airlines, with volatility of returns on existing capital equal to 7%, the impact of hedging on captured investment opportunities would be much smaller. Therefore, there must be alternative reasons for hedging (e.g. reduction of taxes or expected costs of financial distress)

4.2. Case of no interaction

Let us for a moment consider a hypothetical economy with no interactions, in which any company accepting an investment opportunity does not impact the potential opportunities for the other companies.

In Figure 9 and Table 5, we are comparing the impact of no interactions on the market share change from 2009 to 2015 (positive numbers correspond to an increase in the market share and negative numbers to a reduction in the market share).

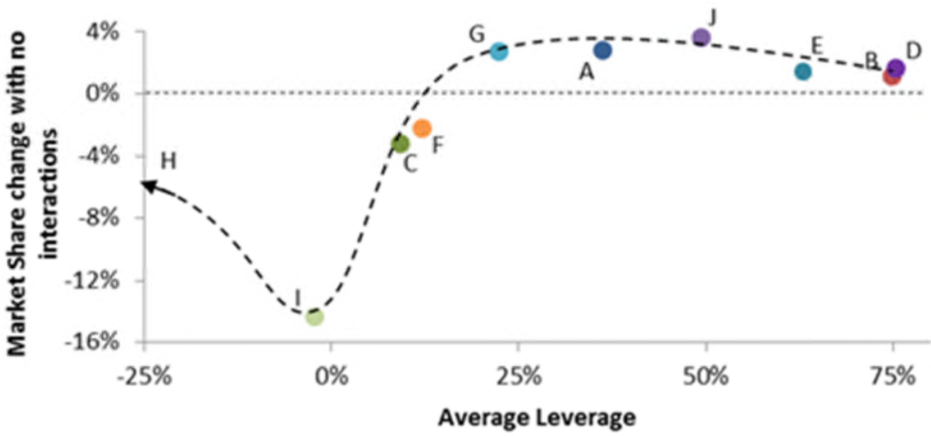


Figure 9 – Impact of no interactions

	A	B	C	D	E	F	G	H	I	J
Leverage	36%	75%	9%	75%	63%	12%	22%	-249%	-2%	49%
Market share growth 2009 - 2015	15%	-9%	57%	-23%	-11%	8%	12%	-24%	1%	28%
Market share growth 2009 - 2015 no interactions	18%	-8%	54%	-21%	-10%	6%	14%	-25%	-14%	32%
Market share change no interactions	3%	1%	-3%	2%	1%	-2%	3%	-1%	-14%	4%

Table 5 – Impact of no interactions

We see that the less leveraged airlines F, C, I and H in a hypothetical world with no interactions lose their market share. In contrast, the more leveraged companies gain the market share. In this scenario, the companies are no longer competing for the same opportunities, a process that penalises those companies with the lower flexibility.

We do not believe that the no-interaction case is realistic in a mature industry like airlines, but this could be the case in a rapidly growing industry with a high number of growth opportunities, e.g., internet companies during the dot-com bubble in the late nineties.

As our last result for airlines, in Figure 10 we show the total amount invested as a percentage of capital in the period 2009 – 2015 according to our model and we compare it with the actual observed growth of the market share in the same period as shown previously in Figure 4. Naturally, the two parameters are positively correlated. Of course, besides the amount invested there are other company-specific parameters such as EBITDA margin, which also impact the market share growth. That is why the correlation is not perfect.

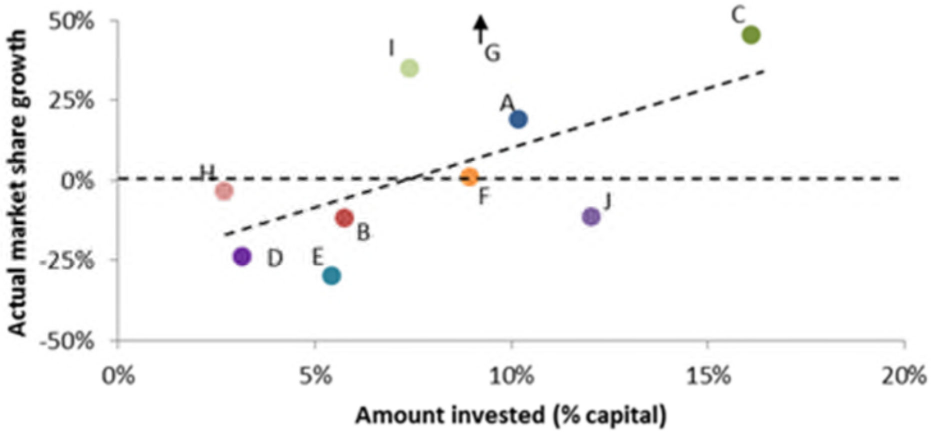


Figure 10- Amount invested vs. Actual market share growth

4.3. Normal model

In the Appendices we derive the simple formula which allows determining the investments captured for a simplified one-time static model with no interactions and assuming that the Book value of equity is equal to Market capitalisation.

In Figure 11 we compare the results of the Normal model and the model with interactions for the airline sector from 2010 to 2015. The inputs in the model are the expected investment return and volatility of those returns. These parameters refer to the promised investment returns and can be roughly estimated from the history of realised investment returns. In Figure 11 we assumed the values of 13.7% and 6.5% respectively[32].

[32] Volatility of promised investment return of 6.5% has been approximated by one half of the volatility of the historically realised investment return, which is 1.9%, while the expected promised return at 13.7% is equal to the historically realised average investment return.

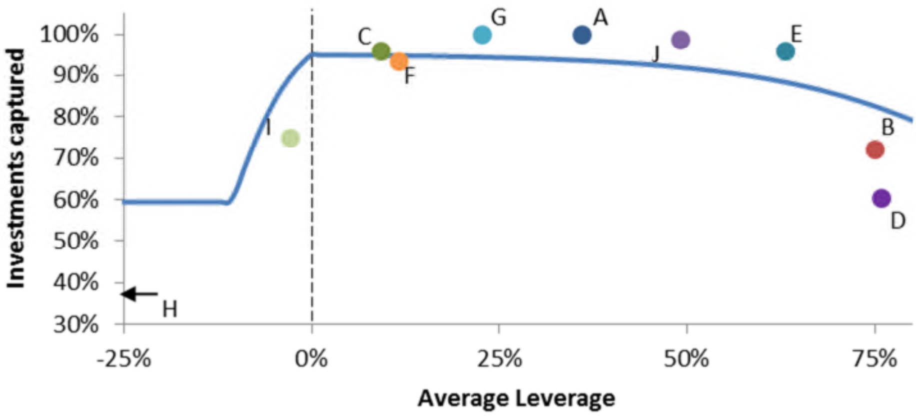


Figure 11 – Normal model vs. model with interactions

We can see that with chosen parameters the Normal model is approximating the results of the model with interactions fairly well. The interactions impact mostly those companies with negative leverage or whose leverage is very high.

4.4. Results for the global pharmaceutical sector

In Figure 12 we show the results for the global pharmaceutical sector from Table 1.

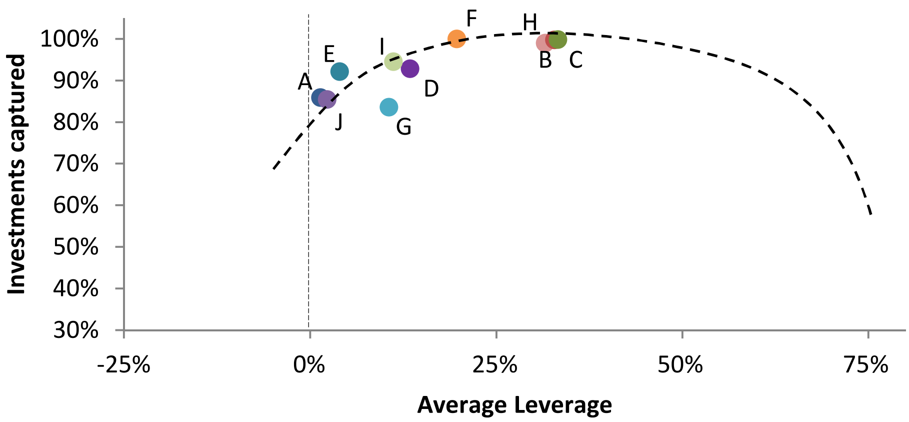


Figure 12 - Average investments captured vs Average leverage (2009 – 2015) – global pharmaceuticals

The comparison of results of the two sectors in Figure 5 and Figure 12, suggests a similar pattern with respect to lower investments captured for companies with lower leverage. However, as mentioned before, there are no highly leveraged companies among the largest pharmaceutical companies. In addition, as shown in Figure 3, the average investment return at 20.3% is higher than for airlines, so on average global pharmaceutical companies capture a higher proportion of potential investments than European airlines.

5. Implications for financial policy

Moving away from the airline and pharmaceutical industries, let us consider a broader question. What is the optimal leverage of the company that allows it to grow by capturing the largest proportion of profitable investment opportunities? A company has to overcome three types of constraints in order to grow:

1. **Economic constraints** – company has a high hurdle rate (due either to high WACC or being to the right of the minimal WACC) and it has to reject a large number of investment opportunities which are below the hurdle rate
2. **Financial constraints** – company is highly leveraged so its cost of debt is high and availability of new debt is low, reducing the possibility to finance large new investments by debt
3. **Opportunity constraints** – industry has a low expected return on investments (for instance, sectors on the top of Figure 3)

The first two constraints are specific to the company, but the third one is specific to the sector. We assume that the company has no way of influencing sector-wide characteristics. Economic constraints apply to organic growth opportunities of any size and to acquisitions. Financial constraints apply only to large growth opportunities (including acquisitions), which the company cannot finance from existing cash flows. If the company wants to maximise growth its capital structure should take into account these constraints and adapt to them. In Figure 13 we illustrate how economic and financial constraints can be represented on the graphs of WACC vs. leverage and Cost of Debt vs. leverage.

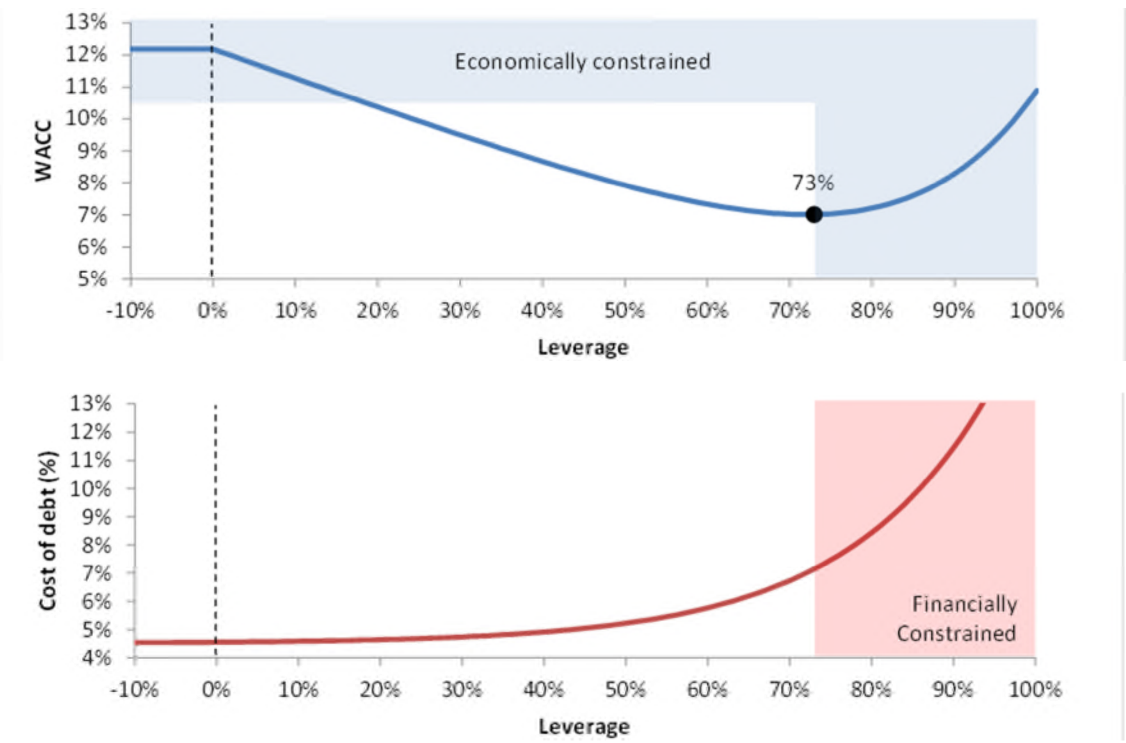


Figure 13 - Economic vs. Financial constraints

The exact location of where the blue area begins (i.e., minimum WACC or leverage above which the company is economically constrained) depends on the sector and the expected returns available. Similarly, the position of the red area (i.e., minimum cost of debt above which the company is financially constrained) depends on many parameters, including investor appetite, which changes over time.

Finally, let us now consider how industrial sector impacts the choice between economic and financial constraints and, therefore, the optimal leverage of the company. If the industry as a whole presents few large investment opportunities, companies are not expected to invest much and the value of financial flexibility decreases. Consequently, the company should minimise its hurdle rate and target the bottom of the WACC curve in Figure 13. If the industry offers high expected investment returns or it is rapidly consolidating, financial flexibility is paramount for the company's growth. Hence, the company should minimise its leverage and target the left side of Figure 13. In certain cases, the company should aim for an intermediate financial strategy between these two extremes or even go for a riskier, higher leverage strategy in the case of limited investment opportunities.

We hasten to add that there may be internal reasons why the company decides otherwise; for example: rating considerations, dividend policies, etc.

5.1. Case study: optimal leverage in the food and beverage sector

The company under consideration is one of the leaders in the global food and beverage sector that has a low leverage and a good credit rating. The first part of the project consisted in identifying an appropriate peer group and populating the data base of financial variables for the period 2000 – 2015. We then ran the simulation based on the expected investment size as a proportion of total capital and expected investment return, which (see Figure 2 and Figure 3) for the food sector are around 9.3% and 16.5% respectively and for the beverage sector 6.7% and 19.8% respectively. The investment size figures were adjusted by additional investment opportunities estimated by the firm. On the one hand, the sector is dominated by very large global companies so that there are no sufficiently large acquisition opportunities. During the past, the company has expanded successfully to emerging markets by adjusting its product offering to the tastes of local consumers. In summary, the company has profitable investment opportunities, which it needs to finance. However, on the other hand, the company's existing business is cash generating and predictable. Running the model on the company and its peers allowed us to determine the optimal leverage. Our results show that it was higher than the one company expected. In conclusion, the company should issue extra debt and increase its dividends or stock buybacks.

6. Conclusion

We have presented a framework which companies should use to determine optimal leverage while taking into account the nature of their industry, competition for random growth opportunities and the strategic flexibility to accept them. Model details are available in the Appendices. The practical implementation of the model requires some assumptions on future growth opportunities, which the company can determine either from the historical data or from its own forecasts.

Appendix A: Model flow

In this section, we describe the main steps in our model for European airlines:

1. We run 1,000 Monte Carlo simulations of key financial variables for 10 airlines in Table 2
2. Each firm is modelled over 6 consecutive years, from 2009 to 2015. Key financial variables modelled for each firm are:
   - Income and cash flow statements: Revenue, NOPAT, Operating margin, FCFF
   - Balance sheet: Invested capital, Surplus cash, Net debt
   - Financial ratios: Return on Invested Capital (ROIC), net leverage (Net Debt/Enterprise Value)
3. The returns of the firm depend on two sets of parameters: return on existing capital, x and return on new investments, y
4. Return on existing capital, x is a Normal random variable, with average and volatility calibrated to the historical values for the period 2000 - 2009. For example, for the European airlines average x = 9.5% and volatility of x = 7.0%
5. Return on new investments, y is a Normal random variable, which is computed from the Miller-Modigliani formula[33]:

   $$EV = \frac{NOPAT}{WACC} + g \cdot capital \cdot N \frac{y - WACC}{WACC(1 - WACC)}$$

   Here g is investment as a proportion of capital and N number of years during which the company is earning the projected return y. We are assuming that N = 10[34]. For example, for European airlines average y = 13.7% and volatility of realised investment returns y = 16.5%

6. At every time step, a company is randomly chosen among all the companies in the sector and it is offered an 'investment opportunity', which is described by two stochastic parameters, g and y. g is the size of the investment compared to the Invested Capital and is calibrated historically, proxied by the historical ratio of Capex, R&D and M&A expenditures to Capital. This is adjusted by the leases. y is the expected return on the investment, as described in point 5. The company decides to accept the investment opportunity if it increases the expected economic profit created: EP = Capital * (ROIC – WACC). It can be shown[35] that this is equivalent to:

   Invested capital * Expected Return >
   Total capital * Change in WACC + Invested capital * WACC
7. If the company decides not to pursue the investment, we offer the same opportunity to another company. Once the investment is accepted or no company accepts it, another

[33] See Merton Miller and Franco Modigliani, "Dividend Policy, Growth, and the Valuation of Shares", Journal of Business, (September 1961), pp.411-433.
[34] For details see Appendix D
[35] See Léautier, Thomas-Olivier, 2007, Corporate Risk Management for Value Creation (London: Risk Books).

investment, with a lower return y and risk vol(y) is offered to another company at random, until the total opportunities are exhausted. No company can invest in more than one opportunity per period, but companies can have zero opportunities. See Figure 14 for the graph of returns and risks offered in the European airline sector[36]. In this graph, the blue columns show the ‘promised investment returns. We require that, the lowest promised return is equal to the minimum WACC (otherwise the company would not consider the investment opportunity). The realised y can be different from the expected return, but the company does not know the realised y until after it has decided whether to accept the opportunity. Black error bars show the 1 standard deviation of the distribution of realised investment opportunities, if a given investment is accepted. In Figure 15 we show the comparison between the realised investment returns from 2000 - 2015 and simulated investment returns from 2010 – 2015. Here we replace individual points with the average for every return bucket of size 5%.

8. When a company decides to invest, the amount committed depends on the expected return and risk. Since higher returns also carry higher risks, the amount that a company invests as a proportion of total capital drops proportionally to the investment volatility vol(y). For example, investment 1 is riskier than investment 2 since it has higher expected returns. Therefore the amount invested in 1 is lower than investment 2 by the same ratio. This is done for each investment, until we obtain a profile guaranteeing that the average matches the amount calculated from the market data for each individual company. As an example, we show in Figure 16 the investments size as a proportion of capital for company A.

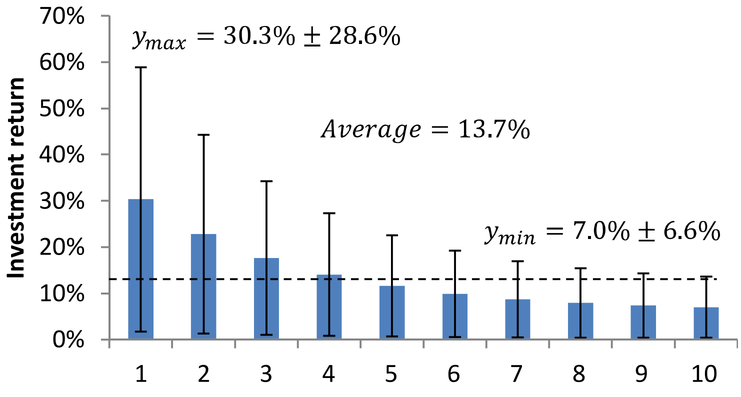


Figure 14 – Return of investments offered to European airlines

[36] Max return of 27.6% has been chosen so that the historical probability of investment returns greater than it is 10% = 1 over number of airlines. Min return is the lowest WACC in Figure 1.

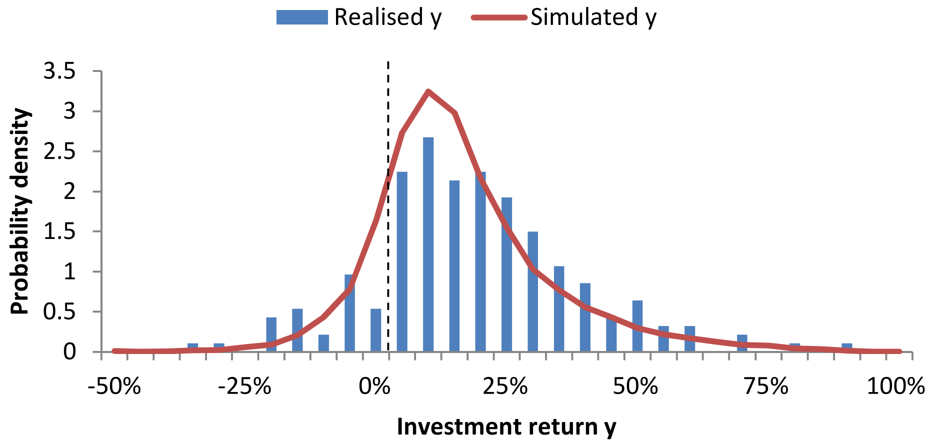


Figure 15 – Realised investment returns (2000 – 2015) vs. simulated investment returns (2010 – 2015) for global airlines

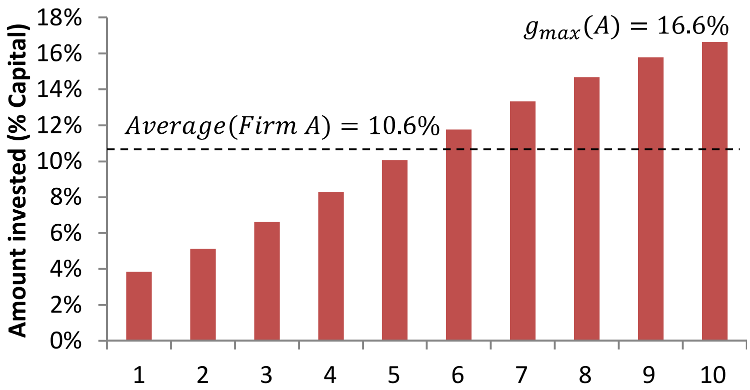


Figure 16 – Investment size as percentage of capital for each investment offered for airline A

9. WACC in point 6 is computed based on net leverage. We model the market capitalization as a constant multiple of the book value of equity. This seems like a strong assumption, but it only impacts the WACC, which we observe to be a smooth and slowly changing function of its arguments for a broad range of leverage. The WACC and cost of debt as functions of leverage have been fitted to the historical data of 1,800 companies, as shown in Appendix C.
10. Capital in the next time period is modelled by increasing the previous capital by the returns from previous and current investments[37]. To this we add the amount of the new investment, if the company accepts it. This is assumed to be funded by debt. We can introduce the equity raising in the model, but as the Table 6 and Figure 17 show, the amount of equity issuances are much lower than the amount of new debt financing

[37] We assume that the maintenance capex is exactly offsetting the Depreciation & Amortization and that the change in the working capital is low, but these assumptions can be relaxed.

which justifies our approximation that large companies finance investments primarily by issuing debt

Total issuances (USD bn)	S&P Global Index, rated non-financial companies
Equity	3,000 (9%)
Debt	32,300 (91%)

Table 6 - Equity vs. Debt issuance years 2000 – 2015

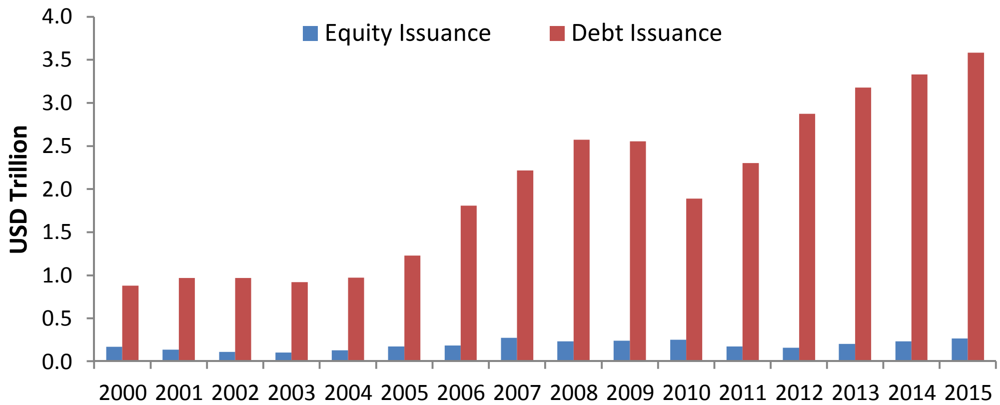


Figure 17 - Equity vs. Debt issuance, S&P Global rated, non-financial companies

11. Payments to stakeholders are accounted for in the model as interest cost and dividend repayments. Interest cost is modelled as a function of net leverage according to the calibration procedure in Appendix C. We do not explicitly model the repayment of the existing total debt (i.e. maturing debt is assumed to be refinanced whenever possible), but any amount of excess cash at the end of the period is used to reduce the net debt. In some cases, the dividend could be negligible. For instance in the European airline sector we do not take the dividends into account (but we do for global pharmaceutical companies) since they are very low for all the companies we analyse except Lufthansa. In other sectors, dividends can be modelled as a constant or increasing Dividend Payout Ratio (calibrated from historical analysis) which multiplies the NOPAT, depending on which behaviour better fits the observed dividend policy of the firms.

Appendix B: Airlines

We have selected 10 largest European airlines, based on the following criteria:

- 6 years of financial data from 2009 – 2015
- Revenues have to be at least 3% of the total sector
- Geographical focus on Europe

This gives us the ten airlines chosen in Table 2.

Appendix C: Fitting WACC and Cost of debt to leverage

We derive the formula relating WACC to net leverage by fitting the cost of equity and debt separately to a sample of rated non-financial corporates from the S&P Global index, from 2000 to 2015. We exclude the non-rated companies in order to avoid the contagion of their credit spread by a "non-rated premium". The resulting sample comprises more than 1,800 companies from many different sectors. The resulting WACC is shown in Figure 1 and has a minimum at 73% net leverage.

The WACC is computed using the "indirect method":

$$WACC = \frac{debt}{debt + equity}(1 - tax)C_{debt} + \frac{equity}{debt + equity}C_{equity}$$

In addition, we impose that WACC for negative leverage is equal to the unlevered value.[38] We assume the tax rate to be constant over time but different for each company, equal to its average tax rate from 2006 to 2009.

To evaluate the cost of debt, we use the 5 year CDS[39] for the companies and fit it to leverage with an exponential formula, as shown in Figure 18:

$$Credit\ Spread = CS_0 + b_0 * \exp(b_1 * lev_i)$$

Here we replace individual points with the average for every leverage bucket of size 5%. The fit has an R^2 = 99% and the parameters are $b_0 = 4.11$, $b_1 = 5.75$, $CS_0 = 82.23$.

[38] See Vernimmen "Corporate Finance" (2005), pp 452.
[39] Where no CDS is available, we use the CDS implied from equity via the Bloomberg function DRSK.

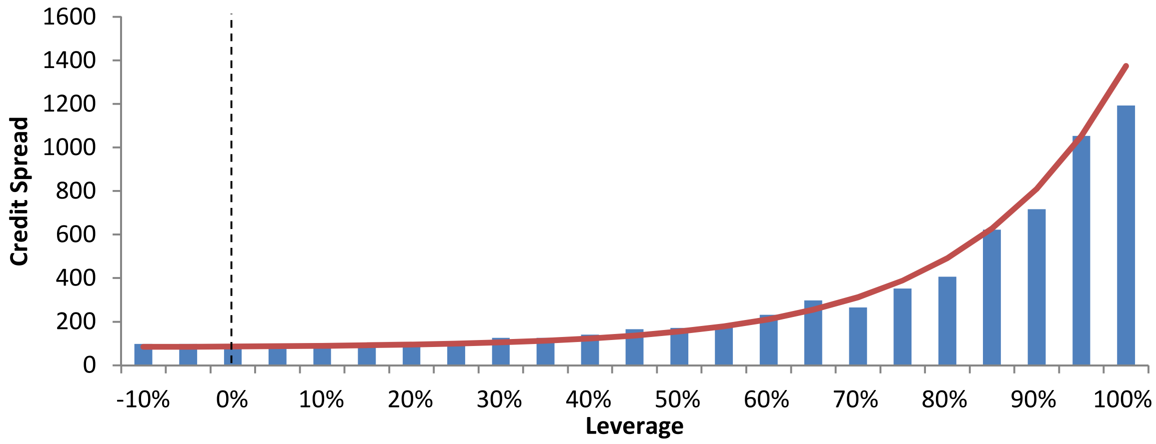


Figure 18 - Credit Spread vs. Net Leverage (2000 - 2009)

To evaluate the cost of equity, we obtain a formula for β as a function of leverage. We first compute the β as

$$\beta = \frac{Cov(r_i, r_M)}{Var(r_M)}$$

for each individual company in each year, using local indices as the reference for the market return r_M. We use one year weekly returns for the calculation. We then fit β to leverage with an exponential formula, as shown in Figure 19:

$$\beta = 1 + a_0 * \exp(a_1 * lev_i)$$

Here we replace individual points with the average for every leverage bucket of size 5%. The fit has an R^2 = 78% and the parameters are $a_0 = 0.001$, $a_1 = 6.46$.

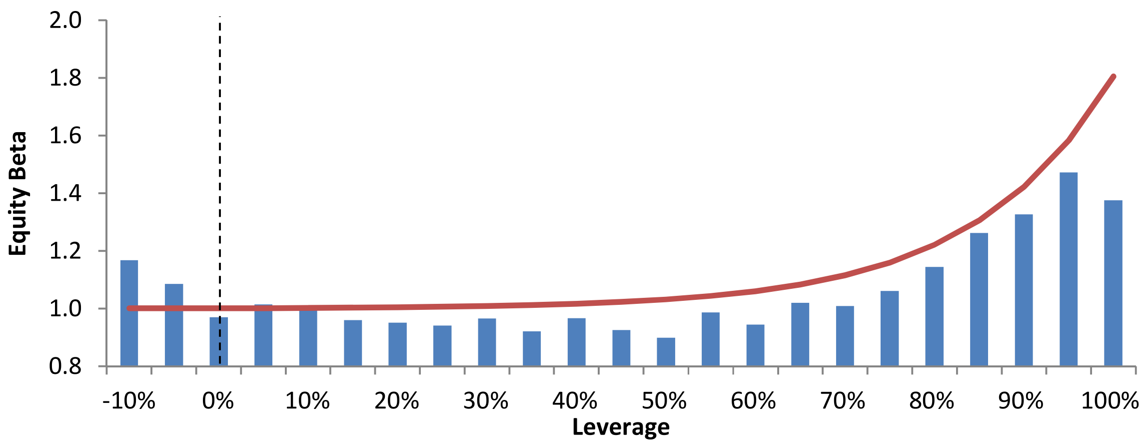


Figure 19 - Equity Beta vs. Net Leverage (2000 - 2009)

The Credit Spread and β are then used to compute the cost of debt and equity via:

$$C_{debt} = r_f + Credit\ Spread$$
$$C_{equity} = r_f + \beta * (r_M - r_f)$$

We take for the risk free rate r_f the US 10 yr government bond (2000-2015 average = 3.7% and estimate the market return r_M = 10.0% using the discounted dividend model on the sample of companies considered.

The WACC shown in Figure 1 aggregates all industrial sectors over the years 2000 – 2009. If we were to look at any individual year, the graph would change.

We analyse the stability of the fit over time by calculating the WACC in 3 different years: before the financial crisis in 2007, during the crisis in 2009 and with the most recent data in 2015. The results are shown in Figure 20. We can see that in periods of high volatility such as in 2009, all the curves for the WACC components are steeper and the resulting WACC is higher. In relatively less risky periods such as 2007, the WACC is less steep up to the point that the minimum WACC is shifted to high leverage ratios. The 2015 period is in between 2009 and 2007. As previously mentioned, the WACC curve we use in the calculation is calculated averaging the results from 2000 to 2009, therefore capturing various market conditions. This is because if the simulation was run in 2010, we could not predict the riskiness of the subsequent years.

Similarly, different sectors have different costs of debt, Betas, costs of equity and therefore WACC. Our analysis can be refined by looking at the subset of the data, but in doing this, we run into the problem that for many sectors there are not sufficient data points to extract a sufficiently reliable WACC curve. This is why our analysis is based on a single WACC curve depicted in Figure 1.

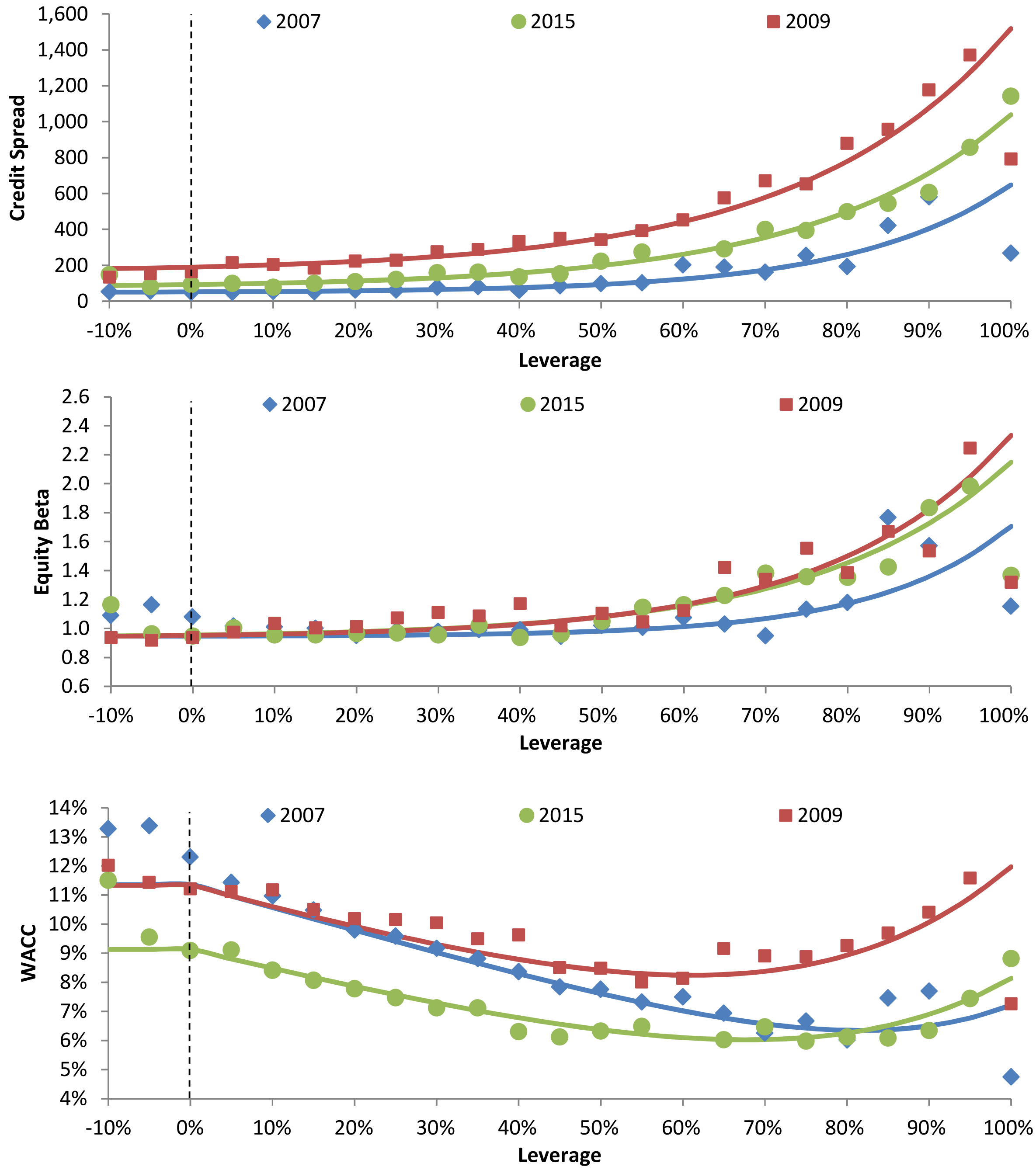


Figure 20 – Stability of the WACC and its components over time

Appendix D: Details of the model

D.1. Initial Invested Capital

Invested Capital for company i at time t is calculated from historical reported values and is defined as:

$$C_i(t) = Book\ Equity + Net\ Debt = E_i(t) + \mathrm{D}_i(t)$$

For example, if company A has book equity of EUR 800 m, gross debt of EUR 300 m and cash of EUR 100 m as of FY 2009, the initial invested capital $C_A(0)$= EUR 1,000 m.

D.2. NOPAT

Net Operating Profit After Tax (Tax rate = T_c) for company i at time t is equal to:

$$\boldsymbol{NOPAT_i(t) = EBIT_i(t) * (1 - T_c) = C_i(t) * ROIC_i(t)}$$

$$= C_i(0) * x_i(t) + \sum_{\tau=0}^{t} C_i(\tau) * g_i(\tau) * y_i(\tau)$$

Where the Return On Invested Capital for the period, $ROIC_i(t)$ is comprised of the return on existing capital $x(t)$ (normally distributed random number with average x_{mean} and standard deviation x_{vol} calibrated from historical values), the portion of capital invested at previous periods $g(\tau)$, and the return from the investment from those periods $y(\tau)$ (also random, with mean y_{mean} and standard deviation y_{vol}). This allows the model to keep memory of past investments. For example, for period 1, if a company i invested in period 0 and also 1, the $NOPAT_i$ would be

$$NOPAT_i(1) = \underbrace{C_i(0) * x_i(1)}_{Return\ of\ original\ capital} + \underbrace{C_i(0) * \big(g_i(0) * y_i(0)\big)}_{Return\ from\ past\ investment} + \underbrace{C_i(1) * \big(g_i(1) * y_i(1)\big)}_{Return\ of\ new\ investment}$$

If it did not invest in period 1, it will still get the return from period 0

$$NOPAT_i(1) = \underbrace{C_i(0) * x_i(1)}_{Return\ of\ original\ capital} + \underbrace{C_i(0) * \big(g_i(0) * y_i(0)\big)}_{Return\ from\ past\ investment}$$

This allows firms to benefit from investments for all subsequent periods.

For example, let’s say that company A has a return on capital in place $x_A(0)$ = 10% and in the first year it invests amount g = 5% of its capital with a return of $y_A(0)$ = 20%. The NOPAT at the end of the first year would be:

$$NOPAT_A(0) = \underbrace{1{,}000 * 10\%}_{Return\ of\ original\ capital} + \underbrace{1{,}000 * (5\% * 20\%)}_{Return\ from\ new\ investment} = 100 + 10 = 110$$

If in the second year company A invests again, this time obtaining a lower investment return of 12% and still investing g = 5% of the new capital EUR 1,050 m, the NOPAT at the end of year 2 would be

$$NOPAT_A(1) = \underbrace{1{,}000 * 10\%}_{Return\ of\ original\ capital} + \underbrace{1{,}000 * (5\% * 20\%)}_{Return\ from\ past\ investment} + \underbrace{(1{,}000 + 50) * (5\% * 12\%)}_{Return\ of\ new\ investment} = 110 + 6.3 = 116.3$$

D.3. Interaction between companies

When a firm grows, it does so by acquiring a portion of the revenues from the companies that had a lower potential growth. This is because total sector revenues are a realistic representation of overall market size. Potential Revenues will be calculated from

$$\boldsymbol{Potential\ Revenues_i(t+1) = \frac{C_i(t) * \left(1 + g_i(t)\right)}{Capital\ Intensity_i} = \frac{C_i(t+1)}{Capital\ Intensity_i}} \qquad (\mathbf{3})$$

We will assume that Capital Intensity (Capital divided by Revenues) has a constant value for each company, equal to the value at the start of the simulation for that company. For example, if the simulation starts in 2009, it is equal to the 2009 value for each of the successive years until 2015.

Let's assume company A has capital intensity = 50% in 2009. At the end of year 1, it has capital equal to EUR 1,000 m and invested g = 5%. Therefore

$$Potential\ Revenues_A(1) = \frac{1{,}000 * (1 + 5\%)}{50\%} = 2{,}100$$

This is the amount that the company would have obtained if there were no competition in the market.

We then have to correct the value of potential revenues to take into account the competition within the sector, which will limit the actual amount obtained during the period. We do so by imposing that the sum of revenues over all the companies in a given period and for a certain simulation path must be equal to a given predefined value. This value is computed by increasing the total revenue of all the companies at the beginning of the simulation at the constant historical growth rate. We then calculate Actual Revenues for company i as:

$$Actual\ Revenues_i(t+1) = Potential\ Revenues_i(t+1) * \frac{Actual\ Sector\ Revenues\ (t+1)}{\sum_{j=1}^{n} Potential\ Revenues_j(t+1)}$$

For example, let us assume that the market is only comprised of two companies, A and B. Company B has the same capital intensity = 50% and initial invested capital = EUR 1,000 m as A, but has managed to invest more due to the lower leverage, obtaining g = 20%. In this case we have:

$$Potential\ Revenues_B(1) = \frac{1{,}000 * (1 + 20\%)}{50\%} = 2{,}400$$

The total potential revenues for the sector are therefore

$$\sum_{j=1}^{2} Potential\ Revenues_j(1) = 2{,}100 + 2{,}400 = 4{,}500$$

From historical data, we calculate for example that in FY 2009 the total revenues in this two company sector were EUR 4,000 m (2,000 for company A and 2,000 for company B) and the historical growth rate from 2006 to 2009 was 4% per year. Therefore in the first year of the simulation we expect the actual sector revenues to be

$$Actual\ Sector\ Revenues\ (1) = 4{,}000 * (1 + 4\%) = 4{,}160$$

This is higher than the sum of potential revenues of the two companies of 4,500 and we have to adjust the actual revenues they can obtain:

$$Actual\ Revenues_A(1) = 2{,}100 * \frac{4{,}160}{4{,}500} = 1{,}940$$
$$Actual\ Revenues_B(1) = 2{,}400 * \frac{4{,}160}{4{,}500} = 2{,}220$$

Therefore, Company A revenues were expected to grow by EUR 100 m, and instead shrink by EUR 60 m because of market competition. Similarly, Company B revenues grow by just EUR 220 m instead of EUR 500 m. The market share of company A is reduced from 50% to 47%, because company B gained 3% market share by investing more than company A.

Note that this kind of adjustment is justified in mature markets, which can be assumed to grow at a historical rate, with no space for further growth. In rapidly growing markets, the assumption would not be valid, since the companies cannot 'crowd each other'.

We can now modify the NOPAT (modified or actual NOPAT is symbolised with a _ sign) to reflect this actual revenue. Note that we do not modify the capital in the same way, since the capital invested by a company in the past should be independent on its peers. However, the NOPAT obtained from the invested capital, instead, is influenced by the competition:

$$\overline{NOPAT_i}(t+1) = Actual\ Revenues_i(t+1) * Operating\ Margin_i(t+1)$$

To calculate the Operating margin, we use the relationship:

$$Operating\ Margin_i(t+1) = ROIC_i(t+1) * Capital\ Intensity_i$$

Therefore the actual NOPAT becomes:

$$\overline{NOPAT_i}(t+1) = Actual\ Revenues_i(t+1) * ROIC_i(t+1) * Capital\ Intensity_i$$

Since $NOPAT_i(t+1) = C_i(t+1) * ROIC_i(t+1)$,

$$\overline{NOPAT}_i(t+1) = Actual\ Revenues_i(t+1) * \frac{NOPAT_i(t+1)}{C_i(t+1)} * Capital\ Intensity_i$$

Using (3) we obtain:

$$\overline{NOPAT}_i(t+1) = \frac{Actual\ Revenues_i(t+1)}{Potential\ Revenues_i(t+1)} * NOPAT_i(t+1)$$

and since we imposed that $C_i(t)$ does not change, the renormalisation corresponds to changing the ROIC for the period.

The reason we do not use operating margin from the market in place of capital intensity is that the former is much more volatile than the latter, and it should be related to ROIC.

For example, Company A had a NOPAT of EUR 110 m (see previous section), real revenues of EUR 1,940 m and potential revenues of EUR 2,100 m. The actual NOPAT obtained is therefore reduced to:

$$\overline{NOPAT}_A(1) = \frac{1{,}940}{2{,}100} * 110 = 102$$

Therefore, the competition in a mature market has reduced the NOPAT for company A by EUR 8 m. Obviously, the impact of competition depends on the capital, capital intensity and investment size g for different companies. As we will see, the consequences of underinvesting in earlier years impact future years through a progressively higher leverage leading to reduced investments and thus to a progressively reduced market share.

D.4. FCFF

Free Cash Flows to the Firm (FCFF) for company i are defined by:

$$FCFF_i(t) = \overline{NOPAT}_i(t) + D\&A_i(t) - \Delta WC_i(t) - capex_i(t)$$

Where:

$$capex_i(t) = maintenance\ capex_i(t) + C_i(t) * g_i(t),$$

Here we make two approximations:

$$D\&A_i(t) - maintenance\ capex_i(t) \simeq 0,$$
$$\Delta WC_i(t) \simeq 0$$

In practice we noticed that in the airline and pharmaceutical sectors, these approximations work well, but it is easy to remove them in a general case.

Hence we have:

$$FCFF_i(t) = \overline{NOPAT}_i(t) - C_i(t) * g_i(t)$$

The free cash flow generated is available for paying shareholders and debt holders.
For Company A, following the examples in previous sections, we have

$$FCFF_A(1) = 102 - 1{,}000 * 5\% = 52$$

D.5. Surplus Cash

The cash generated is used to fund the payout to investors incurred during the period:

a) Pay interest on debt

We calculate interest assuming the interest paid is the cost of total debt

$$Interest\ Expense_i(t) = (\mathrm{D}_i(t) + \mathrm{Cash_i}(t)) * C_{debt}(lev_i) * (1 - T_c)$$

Here $D_i(t)$ is net debt of the company, T_c is the tax rate and $C_{debt}(lev_i)$ is the cost of debt, as a function of leverage, which is explained later.

For Company A, assuming $C_{debt}(lev_i) = 2\%$ and $T_c = 30\%$ this equals to:

$$Interest\ Expense_A(1) = 300 * 2\% * (1 - 30\%) = 4.2$$

b) Cash from financing activities / debt repayment

We add back the new debt issuance since it corresponds to a cash injection. We assume that the capital expenditure is financed through new debt issuance:

$$Cash\ from\ debt\ issuance = C_i(t) * g_i(t)$$

Here Capex = $C_i(t) * g_i(t)$

In principle, the company could raise less debt if it uses the cash reserves instead, but the impact on net debt will be the same.

c) Pay dividend

We include the payment of dividend as a constant Dividend Payout Ratio α_i:

$$\begin{aligned} &Dividend\ Paid_i(t) = \\ &\quad = (FCFF_i(t) - Interest\ Expense_i(t) + Cash\ from\ debt\ issuance_i(t)) \\ &\quad * \alpha_i \end{aligned}$$

For the simulation, we calculate α_i from the median historical dividend payout ratio for each company from 2006 to 2009.

In some cases, the dividend could be negligible. For the airlines, we do not take the dividends into account since they are very low for all the companies we analyse except one, so for airlines, $\alpha_i = 0$

The remainder is surplus cash:

$$
\begin{aligned}
&\Delta Cash_i(t) = \\
&= FCFF_i(t) - Interest\ Expense_i(t) - \ Dividend\ Paid_i(t) \\
&\qquad\qquad + Cash\ from\ debt\ issuance_i(t) \\
&= \overline{NOPAT}_i(t) - C_i(t) * g_i(t) - Interest\ Expense_i(t) - Dividend\ Paid_i(t) + C_i(t) \\
&\qquad\qquad * g_i(t) \\
&= \overline{NOPAT}_i(t) - Interest\ Expense_i(t) - Dividend\ Paid_i(t)
\end{aligned}
$$

We assume that all surplus cash generated goes in retained earnings:

$$\Delta Cash_i(t) = \Delta Retained\ Earnings_i(t)$$

For example, for Company A we obtain:

$$\Delta Cash_i(t) = \Delta Retained\ Earnings_i(t) = 102 - 4 - 0 = 98$$

D.6. Invested Capital evolution, retained earnings, surplus cash

Having calculated the surplus cash, we can now use it to compute the capital at next iteration. Since we assume that the investment is founded by debt, the increase in net debt is equal to the capex minus the increase in cash:

$$\boldsymbol{\Delta D_i(t) = C_i(t) * g_i(t) - \Delta Cash_i(t)} \qquad (\mathbf{4})$$

The cash also represents retained earnings on the balance sheet which increase book equity at next period, therefore we have:

$$\mathrm{E_i(t+1) = E_i(t)} + \Delta Cash_i(t),$$

Using (4):

$$\mathrm{D_i(t+1) = D_i(t) + \Delta D}_i(t) = \mathrm{D}_i(t) + C_i(t) * g_i(t) - \Delta Cash_i(t),$$

$$
\begin{aligned}
\mathrm{C_i(t+1)} &= \mathrm{E_i(t+1)} + \mathrm{D}_i(t+1) \\
&= C_i(t) + \Delta Cash_i(t) + C_i(t) * g_i(t) - \ \Delta Cash_i(t) \\
&= C_i(t) * \left(1 + g_i(t)\right)
\end{aligned}
$$

Recovering the result from Leautier[40].
For Company A we have therefore

$$
\begin{aligned}
&\mathrm{E_A}(1) = 800 + 98 = 898, \\
&\mathrm{D_A}(1) = 200 + 50 - 98 = 152, \\
&\mathrm{C_A}(1) = 898 + 152 = 1{,}050
\end{aligned}
$$

[40] Leautier, (2007), cited earlier, pp 194.

D.7. Investment opportunity

At each period, N investment opportunities are presented to the companies in the sector. The first opportunity is presented to a company at random and it decides whether to invest or not. If it invests, another opportunity with lower risk and return is presented to another company at random, until the total opportunities are exhausted. If it does not invest, the same opportunity is offered to another company at random. No company can have more than one opportunity per path per period (but can have 0).

The expected return of the investment, y_{mean} is different for each investment according to a simple exponential formula:

$$\mathbf{y_{mean}} = \mathbf{a} * \mathbf{e}^{-\mathbf{b}*\mathbf{n}} + \mathbf{c} \quad (\mathbf{5})$$

Where n is the investment number (for example, first, second, third investment offered etc.) and the parameters a, b and c are calibrated to the implied distribution of returns obtained historically for the sector. Details can be found in the calibration section. For the airline sector, we obtained a = 21.5%, b = 36.2%, c = 6.2%.

Choice of parameters is such that the average of all N investments y_{mean} is equal to the average investment return for the sector, and the maximum $\bar{y}_{max}$ is such that in the distribution of implied sector returns[41] there is $1/N$ probability that returns are above that value. For example, if there are $N = 10$ investments, we choose $\bar{y}_{max}$ so that the probability according to the normal distribution that the historical implied returns are above $\bar{y}_{max}$ is $1/N = 10\%$. In addition, the minimum $\bar{y}_{min}$ is chosen to be equal to the minimum WACC, since in our model there would be no reason to invest if the expected return is below the minimum WACC and such investment would in that case never be chosen. For the airline sector the average return is 13.7% and the standard deviation is 16.5%, and the maximum return of the investments offered is 30.3%[42].

As we decrease the expected investment return y_{mean} we also reduce its volatility y_{vol} by the same proportion, so that different investments have the same risk / return ratio. We also increase the proportion of capital invested in the opportunity g by the same ratio, to ensure that riskier and higher returning investments have less capital invested in them.

Example: In Figure 12, first investment has y_{mean} = $\bar{y}_{max}$ = 27.6%. Second investment is reduced according to the formula (5) so that $\bar{y}$ = 21.1%, etc. For the first investment, y_{vol}= 24.1% and the second one is reduced proportionately to 21.1%/27.6% * 24.1% = 18.4%. Size of the first investment is g = 4.1% and the second investment is increased proportionately to 27.6%/21.1% * 4.1% = 5.4%.

The companies deem an opportunity profitable, and they invest in it, if it increases the expected economic profit created[43]

[41] We assume that the investment returns have a normal distribution with the same average and standard deviation as the actual historical distribution of implied returns. See details in the calibration section.
[42] N(30.3%) = 90% = 1 – 1/10, where N – cumulative normal distribution with mean 13.7% and standard deviation 16.5%.
[43] Leautier (2007), cited earlier, pp 197

$$E[\Delta EP_i] = E[EP_i(investment)] - E[EP_i(no\ investment)] \geq 0$$

Where

$$E[EP_i(investment)] = C_i(t) * \left[ROIC_i(t) + g_i(t) * y_{mean} - WACC_i\left(lev_i(g_i(t)\right) * \left(1 + g_i(t)\right)\right]$$

$$E[EP_i(no\ investment)] = C_i(t) * \left[ROIC_i(t) - WACC_i\left(lev_i(g = 0)\right)\right]$$

Therefore we have:

$$E[\Delta EP_i] = C_i(t) * \left[g_i(t) * y_{mean} - WACC_i\left(lev_i(g_i(t)\right) * \left(1 + g_i(t)\right) + WACC_i\left(lev_i(g = 0)\right)\right] \geq 0$$

This can be simplified to

$$\underbrace{\mathbf{g_i(t) * y_{mean}}}_{\textbf{Expected return}} \geq \underbrace{\mathbf{WACC_i\left(lev_i(g_i(t)\right) - WACC_i\left(lev_i(g = 0)\right)}}_{\textbf{Change in cost on the existing capital}} + \underbrace{\mathbf{g_i(t) * WACC_i\left(lev_i(g_i(t)\right)}}_{\textbf{Cost of the new capital}} \quad (\mathbf{6})$$

Hence, the expected investment return must be superior to the expected increase in the cost of existing capital plus the cost of new capital.

For example, let us assume Company C and Company D have a leverage of 80% and 30% respectively. An opportunity of $\bar{y} = 7.0\%$ expected return is offered to Company C and the management decides they would invest in it a proportion $g_C(0) = 17\%$ of capital if the investment is profitable, and fund it by debt issuance. Let us assume that the leverage would consequently increase by 5% to 85%, leading to an increase in WACC from 7.2% to 7.6%.

Equation (6) yields:

$$\underbrace{17.0\% * 7.0\%}_{Expected\ return} \geq \underbrace{7.6\% - 7.2\%}_{Change\ in\ cost\ on\ the\ existing\ capital} + \underbrace{17.0\% * 7.6\%}_{Cost\ of\ the\ new\ capital} \Rightarrow$$

$1.2\% \geq 0.4\% + 1.3\%$, which is false, so the company does not invest.

Since the leverage of Company C is above the optimal leverage of 73%, increasing leverage increases the WACC, thus the investment return required has to compensate for both the cost of new capital and the increased cost of outstanding capital. Since this is not the case, Company C does not invest in the opportunity since it would reduce the economic profit, thus the company value. Therefore, the same opportunity is offered to Company D, which has a leverage of 30%. Let us assume that the amount Company D chooses to invest in the opportunity is still $g_D(0) = 17\%$ for simplicity and that the leverage would consequently increase by 5% to 35%, leading this time to a decrease in WACC from 9.5% to 9.1%.

Equation (6) now yields:

$$\underbrace{17.0\% * 7.0\%}_{Expected\ return} \geq \underbrace{9.1\% - 9.5\%}_{Change\ in\ cost\ on\ the\ existing\ capital} + \underbrace{17.0\% * 9.1\%}_{Cost\ of\ the\ new\ capital} \Rightarrow$$

$1.2\% \geq -0.4\% + 1.5\%$, which is true, so the company invests.

Since leverage of the Company D is below the optimal WACC, despite the fact that the final cost of capital of 9.1% would be above the expected investment return of 7.0%, they would still invest in the opportunity since the increase in leverage would also reduce the cost of all outstanding capital by 0.4%.

D.8. Deriving the WACC from net debt and estimate market capitalisation

The leverage is calculated from net debt and market capitalisation. To calculate the market capitalisation, we keep the ratio γ between market capitalisation and book equity constant to the historical value at the start of the simulation, for example FY 2009:

$$\gamma_i = \frac{Market\ Capitalisation_i(t)}{E_i(t)} = \frac{Market\ Capitalisation_i(2009)}{E_i(2009)}$$

If the company does not invest, hence $g_i(t) = 0$, the leverage is calculated as:

$$\mathrm{lev_i}(\mathrm{g} = 0) = \frac{\mathrm{D_i}(t)}{D_i(t) + Market\ Capitalisation_i(t)} = \frac{\mathrm{D_i}(t)}{D_i(t) + E_i(t) * \gamma_i}$$

If the company invests, it will fund the investment through debt issuance. Since the invested amount is $C_i(t) * g_i(t)$, the debt is going to rise by that value. Therefore, the leverage after the investment will increase:

$$\mathrm{lev_i}\big(\mathrm{g_i(t)}\big) = \frac{\mathrm{D_i}(t) + C_i(t) * g_i(t)}{\mathrm{D_i}(t) + C_i(t) * g_i(t) + E_i(t) * \gamma_i}$$

This is used for the calculation of WACC using the formula (see Figure 1):

$$\begin{cases} WACC_i(\mathrm{lev_i}) = (1 - \mathrm{lev_i}) * C_{equity}(\mathrm{lev_i}) + \mathrm{lev_i} * C_{debt}(\mathrm{lev_i}) * (1 - T_c) & if \quad \mathrm{lev_i} > 0 \\ WACC_i(\mathrm{lev_i}) = C_{equity}(\mathrm{lev_i} = 0) & if \quad \mathrm{lev_i} \leq 0 \end{cases}$$

Where T_c is the tax rate, C_{equity} is the cost of equity and C_{debt} is the cost of debt. The variation of C_{equity} and C_{debt} with leverage has been derived by fit to market data, as described in the Appendix C.

For example, let's take Company A that has initial book equity of EUR 800 m, gross debt of EUR 300 m and cash of EUR 100 m, thus the net debt equals EUR 200 m. If we assume that the Market Capitalisation at FY 2009 is EUR 1,800m, we obtain:

$$\gamma_A = \frac{1{,}800}{800} = 2.25$$

And the leverage is:

$$\mathrm{lev_A}(\mathrm{g}=0)=\frac{200}{200+1{,}800}=10.0\%$$

Consider an investment opportunity offered to Company A which requires it to invest an additional g = 5% portion of capital. If the opportunity is taken, the leverage would grow to

$$\mathrm{lev_A}\big(\mathrm{g_A}(0)\big)=\frac{200+1{,}000*5\%}{200+1{,}000*5\%+1{,}800}=13.5\%$$

This new leverage will be used in the WACC formula to evaluate the overall cost of capital achieved if the opportunity is taken, that will determine if the company will invest in it or not using the methodology described in the previous paragraph.

Appendix E: Model inputs calibration

E.1. Return on existing capital: x

The parameter $x_i(t)$ for company i represents the return of the capital already employed by the company at the time the simulation starts.

For each company, we calculate x_{mean} from the median of the yearly historical ROIC from the years 2000 to 2009. For companies without previous history, we use the average of the peers as proxy to calculate the statistics. The yearly sector average is also used to obtain the expected volatility of returns x_{vol} from its standard deviation.

E.2. Capital intensity

Capital intensity is taken from historical data in 2009. Capital intensity is calculated as:

$$Capital\ Intensity=\frac{book\ equity+net\ debt}{Revenues}$$

We assume that this is constant throughout the simulation.

E.3. Calibration of g and Invested Capital

To calculate g, which is defined as the proportion of capital that is invested yearly by a given company, we first proxy the invested capital as

$$Invested\ Capital_i(t)=[Capex_i(t)+R\&D\ expense_i(t)+M\&A\ expense_i(t)]*$$
$$*\,(1-\%\ of\ Depreciation\ expense_{sector})$$

As we mentioned earlier, we subtract the depreciation expense since we assume that it is equal to maintenance capex, and we are only interested in new investments. The percentage of depreciation expense is calculated on a sector basis and is kept constant over time and on each company in a given sector.

After we have obtained the Invested Capital, we calculate g as

$$g_i(t) = \frac{Invested\ Capital_i(t)}{C_i(t-1)}$$

We divide by the capital from the previous year since the capital for this year already contains the newly invested capital.

For the simulation input parameters, g is calibrated using the average of the historical results from the previous 5 years. For example, if 2009 is chosen, we use historical data from 2005 to 2009. For companies without previous history, we use the average of the peers as proxy to calculate the statistics.

For the calculation of y described below, g is calculated over the companies within the S&P global index for each individual sector, from 2000 to 2015.

E.4. Return on new investments: y

We calculate the y(t) value implied by the current enterprise value of the company, similarly as we did for x. This is the expected return of the new investments this year, net of the return from the existing investments x(t). We assume that the Enterprise value can be calculated via the Miller-Modigliani formula[44]:

$$\begin{aligned} Enterprise\ Value(t) \\ = \underbrace{\frac{NOPAT(t)}{WACC(t)}}_{Value\ of\ assets\ in\ place} \\ + \underbrace{K(t) * NOPAT(t) * N * \frac{y(t) - WACC(t)}{WACC(t) * [1 + WACC(t)]}}_{Value\ of\ growth} \end{aligned}$$

Where

$$K(t) * NOPAT(t) = Invested\ Capital\ (t) = g_i(t) * C_i(t)$$

N = Expected number of years that the company will continue to benefit from the investment.

We can invert this formula to obtain y(t), yielding

[44] See Merton Miller and Franco Modigliani, "Dividend Policy, Growth, and the Valuation of Shares", Journal of Business, (September 1961), pp.411-433. Also Copeland et al., "Valuation", pp 154 and Copeland et al., "Financial Theory and Corporate Policy", pp 505-506

$$y(t) = \left[Enterprise\ Value(t) - \frac{NOPAT(t)}{WACC(t)} \right] * \frac{WACC(t) * [1 + WACC(t)]}{Invested\ Capital\ (t) * N} + WACC(t)$$

We make the simplifying assumption that N = 10 years[45]. We use the formula to compute the yearly implied investment return y(t) for each company in each year from 2000 to 2015[46]. The average y for all companies is 18.7%, while the average for the airlines is 13.7%, with a standard deviation of 16.5%. For Pharmaceutical companies we instead obtain an average of 20.3% with a standard deviation of 12.4%.

E.5. Calibration of tax rate

The tax rate for each company is calculated as the average effective tax rate between the years 2000 to 2009.

E.6. Derivation of Analytical investment probability for one firm

We want to have an analytical derivation of the investment probability given the leverage for a firm, in absence of interactions.

We start from the investment formula (6), which we reproduce dropping the t dependence below for ease of reading:

$$\underbrace{\mathbf{g_i * y_{mean}}}_{\textbf{Expected return}} \geq \underbrace{\mathbf{WACC_i(lev_i(g_i) - WACC_i\big(lev_i(g=0)\big)}}_{\textbf{Change in cost on the existing capital}} + \underbrace{\mathbf{g_i * WACC_i(lev_i(g_i)}}_{\textbf{Cost of the new capital}}$$

We know from the WACC calibration that the function $\mathrm{WACC_i}\big(\mathrm{lev_i}(\mathrm{g_i}(t)\big)$ has an explicit formulation:

$$\begin{cases} WACC_i(\mathrm{lev_i}) = (1 - \mathrm{lev_i}) * C_{equity}(\mathrm{lev_i}) + \mathrm{lev_i} * C_{debt}(\mathrm{lev_i}) * (1 - T_c) & if \quad \mathrm{lev_i} > 0 \\ WACC_i(\mathrm{lev_i}) = C_{equity}(\mathrm{lev_i} = 0) & if \quad \mathrm{lev_i} \leq 0 \end{cases}$$

And for the leverage:

$$\mathrm{lev_i}(\mathrm{g_i}) = \frac{\mathrm{D_i} + \mathrm{C_i} * \mathrm{g_i}}{\mathrm{D_i} + \mathrm{C_i} * \mathrm{g_i} + \mathrm{E_i} * \gamma_\mathrm{i}} \quad and\ thus \quad \mathrm{lev_i}(0) = \frac{\mathrm{D_i}}{\mathrm{D_i} + \mathrm{E_i} * \gamma_\mathrm{i}}$$

Without loss of generality, we make the simplifying assumption $\gamma_\mathrm{i} = 1$ so that the leverage becomes

$$\mathrm{lev_i}(0) = \frac{\mathrm{D_i}}{\mathrm{D_i} + E_i} = \frac{\mathrm{D_i}}{\mathrm{C_i}} \quad and \quad \mathrm{lev_i}(\mathrm{g_i}) = \frac{\mathrm{D_i} + \mathrm{C_i} * \mathrm{g_i}}{\mathrm{C_i} * (1 + \mathrm{g_i})} = \frac{\mathrm{lev_i}(0) + g_i}{1 + g_i}$$

We can then re-arrange equation (6) to get the formula for the minimum return required for the investment to be accepted

---

[45] This is close to the average from 2000 to 2015 for all the sectors of the asset replacement period defined as fixed assets + intangible assets divided by depreciation and amortisation.

[46] We exclude extreme implied values of more than 50% and less than -50%, which are unrealistic, and instances when the invested capital as a percentage of capital is below 5%.

$$y_{accepted}(\mathrm{lev_i}(0), \mathrm{g_i}) \geq \frac{\mathrm{WACC_i}(\mathrm{lev_i}(\mathrm{g_i}) - \mathrm{WACC_i}\big(\mathrm{lev_i}(\mathrm{g}=0)\big)}{g_i} + \mathrm{WACC_i}(\mathrm{lev_i}(\mathrm{g_i})$$

This is an explicit function of both the initial leverage $\mathrm{lev_i}(0)$ and the amount invested $\mathrm{g_i}$. Given a leverage $\mathrm{lev_i}(0)$ and an amount invested $\mathrm{g_i}$, we can then calculate $\mathrm{y}_{accepted}$, the minimum investment return that could be accepted by the company.

We can infer the distribution of returns of the possible investments offered to the company from the distribution of realised returns for the sector that we can observe in the market. For example, for the Airlines sector this distribution has average 13.7% and standard deviation 16.5%. Out of those investments, only the ones with returns above the minimum WACC of 7.0% could be offered to the management. The average return should match the one observed in the market, equal to 13.7%.

We can approximate such distribution with a normal distribution with average of $\mu_{possible} = 13.7\%$ and standard deviation of $\sigma_{possible} = 8.3\% = \frac{16.5\%}{2}$.
Therefore the probability $\mathrm{p_{accepted}}$ of accepting an investment with return $\mathrm{y}_{accepted}$ is equal to the probability that the distribution of $\mathrm{y}_{possible}$ is above that level. This can be easily calculated as

$$\mathrm{p_{accepted}}(\mathrm{lev_i}(0), \mathrm{g_i}) = 1 - \mathrm{N}\big[y_{accepted}(\mathrm{lev_i}(0), \mathrm{g_i}), \mu_{possible}, \sigma_{possible}\big]$$

This is an explicit formula that links the probability of accepting an investment with the present leverage of the company $\mathrm{lev_i}(0)$ and the amount is willing to invest $\mathrm{g_i}$.