Thesis title:  
Use of real options for valuation of R&D projects in the pharmaceutical industry

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Abstract

The main objective of this thesis is to explore the application of real options used for valuation of pharmaceutical R&D projects. Today, the use of real options in valuation of R&D projects is quite limited. Instead, most companies rely on the traditional present value approaches when valuing assets.

The thesis constructs a valuation model incorporating elements of present value approach, risk-adjusted present value approach and real option approach. The model consists of 4 steps.

The model is then tested on a R&D project, NN9526 conducted by Novo Nordisk.

The thesis finds that the practical application of applying real option analysis for valuation purposes in the pharmaceutical industry is somewhat limited due to the high complexity of the model. However, when applied under close scrutiny, the model does contributes to increased value of pharmaceutical R&D projects. However, the input parameters used in calculating the real options can easily be biased by the analyst conducting the valuation resulting in potential wrongly estimated valuation of the project being valued.
Introduction

The pharmaceutical industry generates tremendous revenues all over the world each year. Few products other than pharmaceuticals produce such high profits and concentrate more wealth, which makes the industry very attractive for all kinds of investors, private corporate and institutional. Over the past three decades more and more money has been injected into research and into early-stage development of new compounds. In fact, it is estimated that the pharmaceutical industry spends around USD 75 billion on research and development of new drugs on an annual basis. Despite the high R&D spend in the industry, only 1 out of 10,000 compounds will be brought to market and even if the compound turns out to be successful in a medical sense it may turn out to be a failure from a commercial perspective.¹

Part of the reason to the high failure-rate for pharmaceutical compounds lies in the complex approval process mixed with regulatory constraints, commercial pressures, reimbursement constraints and various local regulatory challenges.

Moreover, society demands a lot from the pharmaceutical companies. The medicines and medical devices must be innovative improvements based on state of the art scientific ideas, and the products must deliver better results with hardly any side effects.

All these factors contribute to a very inefficient market with few winners and many losers. Despite the hostile market conditions the number of players in the pharmaceutical industry is rising. After all, the business model seems quite simple: Invent a new medicine, prove that it works and has no side effects, get it on the market and it will generate billions in revenue.

This simple model hides the huge complexities of the research and development process.

Pharmaceutical companies are faced with an enormous pressure from various stakeholders who demand that the companies maximise the firm-value by selecting the projects with the highest revenue-potential. But how do the companies choose what projects to undertake?

When managers in general are presented with investment proposals, they will evaluate the cash flow forecasts by applying the traditional capital budgeting method of the net present value. If a project really has a negative NPV, the sooner you can identify it, the better, as this will save the company cost of conducting further research and development.

However, given the high complexity of the R&D process, applying the traditional capital budgeting method of the net present value in the pharmaceutical industry may not always be the best solution. Consequently, this thesis aims at investigating a different approach to R&D project valuation in the form of real option analysis.

¹ "Accelerating access in emerging markets, Pharma’s next big launch challenge,” McKinsey and Company
Problem definition
The traditional NPV methods are today the most widely used tool for investment decisions. There are several different NPV techniques, but overall the models are based on the same principle: Estimate future cash flows and discount rates to date with a relevant discount rate. The methods are simple and easy to communicate to management, but contain the overall disadvantage that the models are static, thus excluding managerial flexibility. The NPV methods use a constant discount rate, and thus assume a constant risk factor throughout the life of the asset. These limitations have meant that real options have become more valuable as a valuation tool in recent years, in which managerial flexibility can be modeled, thus providing a better starting point for assessing the profitability of an asset. I therefore want to explore how real options can in practice be used as a tool for valuation as well as what advantages and disadvantages real options have

Problem statement
*Can real options as a valuation tool contribute to increased value creation in the pharmaceutical industry? What are the challenges of using real options for valuation rather than the traditional NPV method?*

Structural framework
In order to answer the problem statement, the thesis is divided into a theoretical part and an empirical part. The structural framework of the thesis can be shown as the follows:

Theoretical part:
- Investigation of traditional valuation methods versus real option analysis
- What are the attributes that characterizes an ideal valuation model?
- What are advantages/disadvantages of applied these models in valuation?
- Construction of a real option model for valuation

Empirical part:
- The constructed valuation model from the theoretical part is applied on a pharmaceutical R&D project
- The project in valued on a step-by-step basis and
- As a rounding on the empirical part, real options for valuation purposes are assessed based on the attributes characterizing an ideal valuation model
Methodology

The first part of the thesis focuses on the most common valuation models used in modern decision making. Each model is assessed on simple pros and cons basis. Based on these findings, a valuation model using a mixture of the present value approach and real options is then constructed. The constructed model uses a total of 4 steps for project valuation.

Afterwards, an empirical part follows, where the constructed model from the theoretical framework will be applied on a R&D project for a case company. The empirical part will start by identifying the case-company. Then, the R&D pipeline for the case-company will be analyzed in order to find the most suitable R&D project for the valuation. Finally, the market of where to base the valuation of the R&D project is being identified.

Then the empirical part moves on to a valuation of the R&D project. The first step of the model starts with a thorough strategic analysis of the case-company in order to identify the future earnings prospects of the R&D project. The first step is concluded with a static PV valuation of the project. Step 2 is then being conducted, where a modified version of the present value approach will be applied.

Step 3 incorporates the managerial flexibility by identifying potential real options that the case-company has. Hereafter, the real option of the project is being valued by use of a binomial lattice. Finally, step 4 discounts the real option value back to today to derive at a final value of R&D project.

To integrate the theoretical and empirical part, a discussion of the practical application of real options for project valuation is made.

Assumptions and limitations

- The date of valuation is June 1st 2019
- The USD/DKK currency at 01-06-2019 of 6,51 DKK is applied throughout the thesis
- The valuation of the R&D project assumes that the product is only launched in America. Hence, only the American market is being considered
- as the analytical focus is on the practical application of real options, inflation will not be considered
Theory section
This section discusses the most commonly used valuation models for modern investment decision making.

Valuation models
The key to driving a modern successful business is to make sound business decisions that ensure that a company earns enough money on its investments. In order to do so, the company needs to measure the risk and return inherent in every decision choice it faces, and be able to convert the figures into measures of value creation.

In the past 50 years, corporations have undergone a significant change in how they make investment decisions. The increase in data availability and more sophisticated computational tools have contributed to a more complex valuation framework. Today, a wide portfolio of different valuation techniques exists. However, independent of what valuation technique is applied, four attributes can characterise an ideal valuation approach:

- Unbiased estimates
- Realistic assumptions
- User friendly
- Understandable output

The first two attributes regards the accuracy of the valuation technique, and can be referred to as value attributes, whereas the last two attributes are referred to as user attributes.

Before applying a certain technique on a project or company, one needs to keep focused on the reason for the valuation, as valuation of companies is carried out in large variety of contexts, such as, M&A’s, IPO’s, compensation, impairment tests etc.

Ideally, one will apply more than one valuation technique to value an asset to ensure an unbiased valuation in the sense that is does not contain any technical errors. Despite the number of different valuation techniques is quite large, the techniques can generally be classified into the following groups:

![Valuation approaches diagram](image)

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3 Own creation based on Plenborg & Petersen, 2009: “Financial statement analysis”p. 215
The following section contains an introduction of each of the four valuation approaches. However, as this thesis will be focusing entirely on the use of the present value techniques and real options, a significantly larger focus will be on those two valuation techniques.

**Liquidation approach**
The liquidation value is the value of a project if all assets are sold and all debt is settled. The liquidation approach values a project as if it were to go out of business immediately, and is therefore most suited for projects that find themselves at the end of the product lifetime or if the project has negative outlooks and poor returns.

Although the valuation is fairly simple to perform and easy to communicate to laymen, the calculated liquidation value of a project is not recommended to use on projects with attractive growth rates and positive investment returns.4

**Relative valuation (Multiples)**
Relative valuation is a fairly simple way of valuing a company or asset. A multiple valuation relies on the relative pricing of peers’ earnings, where a multiple is a ratio that is calculated by dividing the estimated value of an asset by a specific item on the financial statement or other financial measure. For instance, a commonly used multiple is EV/EBIT. If a company has an enterprise value of 140 and the expected EBIT is 10, the EV/EBIT multiple would be 14.

A valuation based on multiples assumes that the companies, which are compared, are truly comparable, and that the accounting numbers are based on the same accounting principles. Furthermore, the transitory items such as gains and losses from divestment of assets needs to be taken into consideration when using multiples for valuation purposes. This process can be somewhat time consuming.

Besides from assuming same accounting principles used across peer group, multiple valuation relies on a number of other restrictive assumptions. For instance, a valuation based on the EV/EBIT multiple requires an identical tax rate across the companies, which are compared. An assumption that is hardly realistic is cross-country multiples are applied.

**Net present value**
Today, the net present value approach is the single most widely used tool for valuations of investments made by corporations. The basic principle of the net present value approaches is to discount future cash flows with a discount rate that reflects the risk of the project. If the sum of all the discounted cash flows are greater than zero, the project is considered financially attractive.5

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5 Plenborg & Petersen, 2009: “Financial statement analysis”, 218
There are multiple present value techniques which are all theoretically equivalent as they are based on this same basic principle. However, the discounted cash flow model (DCF) is the most popular of the present value models, and will be the net present value model of choice throughout this thesis. The DCF model assumes that the value of an asset is determined by the present value of future cash flows. The DCF model can be specified as a two-stage model:

\[
Enterprise\ value = \sum_{t=1}^{n} \frac{FCFF_t}{(1 + WACC)^t} + \frac{FCFF_{n+1}}{(WACC - g)} * \frac{1}{(1 + WACC)^n}
\]

The enterprise value is the expected market value of the company’s invested capital (i.e. the market value of its operations). Enterprise value includes both the estimated market value of the equity and the estimated market value of net interest-bearing debt. If a firm or project is 100% equity financed, the enterprise value is equal to equity value.

FCF is the free cash flow to the firm and covers the cash an asset generates after cash outflows to support operations and maintain its capital assets. The FCFF is a measure of profitability and excludes non-cash expenses in the income statement but includes spending on equipment and assets as well as changes in working capital.

As the above example illustrates, if a project does not require any investments or foreign capital funding, the cash flow from operations will equal the free cash flow to equity holders. Note that the free cash flow from operations is calculated on the basis on NOPAT (EBIT after tax). This is to account for the tax shield that a company’s financing activities may provide.

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6 Plenborg & Petersen, 2009: “Financial statement analysis”,221
7 Plenborg & Petersen, 2009: “Financial statement analysis”,218
In order to estimate the FCFF of the company or asset, a sound understanding of the company’s business environment and competitive position is required. This is typically done through a strategic analysis of the company and by looking at historical financial data. In this way, the estimation of the future cash flows can be conducted on a well-founded basis.

The period in which the free cash flows are forecasted is referred to as forecasting period. The length of the forecast period varies between companies; where high-growth companies typically have a longer forecast horizon, mature companies will have a growth rate close of that of the economy, and will hence have a shorter forecast horizon. In practice, the forecast horizon is between 5-30 years.

The period after the forecasting period is referred to as terminal period. Usually, the terminal value accounts for 60-80% of the total value of the company so one needs to pay close attention to how the parameters used to calculate the terminal value are estimated.

The DCF model calculates the value of the terminal period as:

\[
\text{Enterprise value}_{\text{terminal}} = \frac{\text{FCF}_{n+1}}{(WACC - g)} \times \frac{1}{(1 + WACC)^n}
\]

Where,

\[
g = \text{the long - term stable growth rate (terminal period)}
\]

The basic assumption behind dividing the DCF model into a two-stage model consisting of a forecasting period and a terminal period, is that growth rate of a company will eventually approach the long-term growth rate of the economy in which the company operates. However, as hardly any company grows at a constant rate to infinity, the underlying assumption in the model is that the growth rate will fluctuate around a long-term mean. For valuation of projects with a pre-specified lifetime, a terminal value will typically not be needed, as all future cash flows can be projected in the forecasting period.²

Discount rate:
A company’s stakeholders are risk averse and want to be compensated for bearing the risk that the company accepts to achieve its objectives, like developing a new pharmaceutical product for instance. Consequently, the underlying risk of the project needs to be translated into a cost of capital measure.

As seen, the DCF model discounts the free cash flows with the weighted average cost of capital, WACC.

WACC is a weighted average of the required rate of return (cost of capital) for both sources of capital: debt and equity.

² Plenborg & Petersen, 2009: “Financial statement analysis”, 224
\[ WACC = \frac{NIBD}{(NIBD + E)} * r_d * (1 - t) + \frac{E}{(NIBD + E)} * r_e \]

Where

- \( NIBD = Value\ of\ net\ interest\ bearing\ debt \)
- \( E = Value\ of\ equity \)
- \( r_d = Required\ rate\ of\ return\ on\ NIBD \)
- \( r_e = Required\ rate\ of\ return\ on\ equity \)
- \( t = Corporate\ tax\ rate \)

Estimation of the company’s capital structure

Capital structure is how a company finances its overall operations by using different sources of funds and shows the proportion of debt and equity for the company. As most companies are privately held, they don’t disclose their capital structure. For an estimation of the capital structure, one could look at comparable listed companies, which would provide a reasonable estimate, assuming that the comparable companies are truly comparable.\(^9\)

Estimation of owner’s required rate of return:

For the estimation of the owner’s required rate of return, most financial textbooks suggest using the CAPM model. According to CAPM the investor’s required rate of return is defined as:

\[ r_e = r_f + \beta_e * (r_m - r_f) \]

Where

- \( r_e = Investor’s\ required\ rate\ of\ return \)
- \( r_f = Risk\ free\ interest\ rate \)
- \( \beta_e = Systematic\ risk\ on\ equity\ (levered\ beta) \)
- \( r_m = Return\ on\ market\ portfolio \)

Estimation of the risk-free interest rate

The risk-free rate expresses how much an investor can earn without incurring any risk. A zero-coupon government bond is generally used as a proxy for the risk-free rate assuming the government bond is risk-free.

To handle the issue of inflation, the government bond chosen as the risk-free rate should be denominated in the same currency as the cash flows. Hence, a Danish government bond would be chosen for a cash flow stream denominated in DKK.

**Estimation and interpretation of systematic risk, \( \beta_e \):**

The systematic risk, \( \beta_e \) expresses the systematic risk (i.e. market risk) of a company or asset. A \( \beta_e = 1 \) means that the asset has the exact same risk as the market portfolio, whereas \( \beta_e = 0 \) is a risk-free asset.

Usually, \( \beta_e \) is estimated from historical stock returns, where \( \beta_e \) measures the covariance between the company-specific returns and the returns of the market portfolio (i.e. the index in which the company stock is traded):

\[
\beta_{e,\text{company}} = \frac{\text{Cov}(r_{\text{company}}, r_{\text{market}})}{\text{variance}_{\text{market}}}
\]

However, the interval that is used between each observation can affect the value of \( \beta_e \) quite significantly. For instance, a \( \beta_e \) estimated from a company’s daily stock returns for the past 3 months may be way different if the time period is extended to a year. Also, a sound estimate of \( \beta_e \) requires a long time-series of historical observations, which may be problematic for only just recently listed companies. Moreover, for privately held companies, no information on stock returns exist, so the systematic risk will here have to be estimated by use of comparable companies.

**Estimation of market portfolio risk premium**

The market portfolio’s risk premium is defined as the difference between market returns and returns from a risk-free investment. Assuming that the market portfolio’s historical risk premium is a reasonable indicator for the future, the market portfolio risk premium is estimated from historical data.

**Estimation of the interest rate of NIBD**

The cost of debt is typically calculated on an after tax basis to account for the tax shield on interest (note). The cost of debt after tax is calculated as:

\[
r_d = (r_f - r_s) \times (1 - t)
\]

Where,

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\[ r_d = \text{required rate of return on NIBD} \]
\[ r_s = \text{Risk premium on debt (Credit spread)} \]
\[ t = \text{Corporate tax rate} \]

The risk premium on debt represents the compensation required by the company’s creditors on investments of a specific risk category compared to a risk-free investment. For an estimation of the company’s credit spread, it is recommended to look at the company’s credit rating.\(^{11}\)

The standard DCF model is by far the most used practice for evaluating and valuing projects and companies. However, one major disadvantage of the NPV valuation approaches is that the models are all static meaning that managerial flexibility is not accounted for in the models. The DCF model will discard projects that are considered unprofitable today but does not take into account that the project may be profitable at a later time. The NPV models discount the expected cash flows at a constant rate because risk is assumed to be unchanging during the lifetime of the asset being valued, which is obviously a restrictive assumption. The NPV approach does not take into consideration the decisions available to management such as the option to expand, wait or abandon a project but values the asset on a one-time stop/go basis.

Moreover, the DCF model does not distinguish between different types of risks, but assumes that all risk inherent in the cash flows are incorporated into the WACC. In the finance world however, risks are broadly classified as market risk and private risk.

- **Market risk**: Risks due to the volatility of future cash flows driven by market forces such as market demand, competition, currency fluctuations etc.

- **Private (technological) risk**: Risks related to the efficiency of the company in completing the project and well as the effectiveness of the technology related to the project

Not all cash flows in a project or company are subject to the same risk type and should hence not be discounted at the same rate. For instance, investment costs consisting of development costs and production phase capital costs (i.e. R&D expenses) in a project is not driven by market forces. Successful completion of the development phases is primarily driven by private risk (i.e. the company’s ability to carry out the project). Hence, the cash flows not driven by market risk should be discounted at a rate different from the cash flows driven by market risks.

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\(^{11}\) Plenborg & Petersen, 2009: “Financial statement analysis”, p.240
Risk-adjusted present value (rNPV)

$r$PV is an effective tool in valuation of projects that involve contingent decisions. $r$PV uses the DCF model as a base, but is more sophisticated and offers the most value when used on multistage projects such as a pharmaceutical development project. It differs from DCF in the sense that, to account for private risk inherent in the asset, is uses probabilities of outcomes rather than risk-adjusted discount factors. In short, the $r$PV approach modifies the standard NPV approach by adjusting (multiplying) each cash flow by the estimated probability that is occurs. Whereas the DCF model yields a NPV only considering market risk, the DTA model yields a risk-adjusted NPV ($rNPV$), where both types of risk are considered. This is particularly useful when dealing with risky cash flows such as cash flows generated from drug development projects.\(^{13}\)

*Example of a decision tree for a R&D pharmaceutical project:*

In the above example, the risk-adjusted NPV, rNPV, is calculated through the decision tree by multiplying the probabilities of success for each clinical phase with the NPV.

$$rNPV = 45\% \times 60\% \times 90\% \times 100DKK = 24,3DKK$$

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\(^{12}\) Own creation  
\(^{14}\) Own creation
Project cash flows represent both the benefits and the costs of the project. Overall, there are two types of cash flow streams generated from a project:

- Investment costs (Development phase)
- Net revenues in the production phase (Market phase)

The two cash flow streams are influenced by different factors and hence, have different risk profiles. A particular advantage of DTA is that the approach accounts for the private risks inherent in the development process of a project. Whereas the NPV in the above example is discounted back at WACC, the rNPV incorporates the private risk by multiplying the probabilities with the NPV. When using DTA, the cash flows would have to be discounted at the risk-free rate, because the contingent decisions inside the decision tree are related to cash flows driven by private risk. However, practitioners argue that a discount rate slightly higher than the risk-free rate is a better representative of the risks inside the tree for two main reasons:\(^{15}\):

- It is difficult to completely separate market risk from private risk
- The outcome probabilities do not truly account for all the risks

When constructing decision trees it is important that at each decision point the probabilities of all subsequent options add up to 100%. However, the probabilities used in DTA are usually not known with high degree of certainty. Critics of DTA claim that management can pick probabilities to skew to the decision in their favour, which poses a major pitfall for the model.

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<th><strong>Risk-adjusted present value</strong></th>
<th><strong>Pros</strong></th>
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<td><strong>Pros</strong></td>
<td><strong>Differentiates between private risk and market risk</strong>&lt;br&gt;<strong>User friendly and easy to compute</strong>&lt;br&gt;<strong>Structured way of evaluating different project paths</strong></td>
<td><strong>Subjective probabilities</strong>&lt;br&gt;<strong>Very generic – especially for early projects where future probabilities are difficult to estimate</strong>&lt;br&gt;<strong>Only accounts for a limited number of outcomes</strong></td>
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**Real option analysis (ROA)**

Despite the common use of the DTA valuation approach for R&D projects, a growing amount of literature suggests using the real option theory instead. Real options account for management flexibility and acknowledges that some decisions in a project’s lifetime can occur at a later stage.


\(^{16}\) Own creation
depending on market conditions, which may be fundamentally different from current market conditions. This delivers a significant value contribution when dealing with high uncertainties as the flexibility is used either to increase profit or to avoid losses.

In the DCF model the course of the project is predefined no matter how market conditions unfold, whereas in real option theory the development of the project is dependent on the changing market conditions.

Therefore, it is suggested that real option theory is more adequate than the net present value approach when it comes to financial evaluation of R&D projects. However, ROA is not a substitute for DCF as the model uses the DCF as a foundation for the option valuation.  

**Fundamental option terminology:**

A prerequisite for understanding the mechanics of real options is firstly to understand how financial option markets are organized, what terminology is used and so on. This section serves as the foundation for understanding the mechanics used later on in the thesis.

- **Call option:** The right, but not the obligation to buy an asset by a certain date for a certain price
- **Put option:** The right, but not the obligation to sell an asset by a certain date for a certain price
- **Expiration date:** The date specified in the option contract
- **Exercise price (X):** The price specified in the contract
- **Underlying asset (S):** Any asset on which the option contract is based on
- **Intrinsic value:** The maximum of zero and the value the option would have if it was exercised immediately
- **American option:** Options that can be exercised any time up to the expiration date
- **European option:** Options that can be exercised only on the expiration date

Options are referred to as *in the money, at the money,* or *out of the money.* A call option is in the money if \( S > X, \) at the money if \( S = X, \) and out of the money if \( S < X. \) A put option is in the money if \( S < X, \) at the money when \( S = X, \) and out of the money if \( S > X. \) The holder of the option will only choose to exercise the option when it is in or at the money (i.e. the owner of a call option will only benefit from the contract if he or she can buy the underlying asset at a lower price than the market price).

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The above diagram shows the different payoff profiles from different option positions. The payoff profiles and the value of the options depend on 5 variables:\(^{19}\):

1. **The value of the underlying asset,** \(S_0\): For financial options, the underlying asset typically has a form of a common stock or other traded security, whereas the underlying asset for a real option is a tangible asset like a project or product. If a call option is exercised at some time in the future, the payoff to the owner of the option will be the amount by which \(S\) exceeds \(K\). Hence, the value of a call option increases if the value of underlying asset increases. Put options behave the opposite way from call options; the value increases as the exercise price increases.

2. **The exercise price,** \(K\): For a call option, the exercise price is the money invested to buy the asset. For a put option, the exercise price is the money you get from selling the asset.

3. **The time to expiration,** \(T\): The value of the option increases as the time to expiration increases. This is because the longer the life of the option, the more exercise opportunities are open to the owner.

4. **The volatility of the underlying asset,** \(\sigma\): Put basically, the volatility of the option measures the uncertainty of the future price fluctuations of the risky asset. An increase in volatility means an increase in likelihood that the risky asset either performs very well or very poorly. The value of the option increases with the volatility of the underlying asset. This is because the owner of a call benefits from price increases but has limited downside risk in the event of a price decrease because the most the owner can lose is the price of the option. Similarly, the owner of a put benefits from price decreases, but has limited downside risk in the event of a price increase.

5. **The risk-free interest rate,** \(r_f\): The risk-free interest rate is most often determined by using the effective rate on a treasury bond that reflects the length of cash flows on the underlying asset. As interest rate increases, the required rate of return from investors tend to increase as well, and the present value of the future cash flows decreases. The combined impact of these two

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movements is an increase in the value of a call option and a decrease in the value of a put option.

Comparison of financial and real option

Options can be classified into two main categories: financial and real options, depending on whether the underlying asset is a financial or real asset. Financial assets are typically stocks and bonds that are traded in financial markets whereas real assets typically have form of a company division or a project. An important difference between financial and real options is that the owner of a financial option cannot affect the value of the underlying asset, whereas the owner of a real option (e.g. the company) is responsible for operating a real asset and thereby can affect the value. For most financial options, the agent that issues an option on a company stock has no influence over the actions of the company and no control over the company’s share price. The value of the underlying asset of real options however, is controlled by the management in the way that management can make decisions that may enhance the value of the underlying project and thereby enhances the value of the option.

Another difference is that the parameters for financial options are usually easier to estimate than for real options. The security price is often observable for a financial asset, and the variance of its rate of return can be easily estimated from historical data.

For real options however, the underlying asset is tangible in the form of a company division or project, which is usually not traded. Hence, in order to estimate the volatility parameter for a real option, a security that mirrors the performance of the underlying asset needs to be found. Therefore, when valuing a project by use of the real option approach, the best security to use as the underlying asset is the NPV of the project itself (that is, the value today of the project without flexibility). This is what literature refers to as the market asset disclaimer (MAD): that the present value of the project to be valued is the best unbiased estimate of the market value of the project if it was treated as a traded asset. The MAD assumption will be used later on in the thesis for estimating the volatility of the underlying asset.

As oppose to financial options, an exact financial value to a real options is difficult to estimate. The price of a financial call option represents the purchase an investor will have to make in order to have the option of buying a stock at a later date.

For a real option however, the value of the option is measured as the managerial flexibility the option offers. Broadly speaking, the value of a real option is the difference between the expected future outcomes of the underlying asset.

The value of a real option is here illustrated with an example:

A project with an initial investment of 100 is expected to generate future cash flows one year from now. Management estimates that the project will generate a cash flow of 170 in a best case scenario and 80 in a worst case. The two outcomes are equally likely to occur.

By use of the static NPV method, the project has a NPV of 9 today.

Management holds the option of deferring the decision to invest in the project by one year. Hence, the NPV of the project in the two scenarios are:

In the worst case scenario, management will not invest in the project but for the best case scenario, the project NPV is 21 and the management will invest. Thus, the value of the option of deferring the project is the difference between the static project NPV of 9 and the best case NPV of 21, \((21 - 9 = 12)\).

Whereas DCF accounts for the downside of the project by discounting the cash flows with a risk-adjusted rate, ROA calculates the value of the project for the upside potential by accounting for the managerial decisions that would be taken in order to limit the downside risk.

As the above example shows, the value of real option increases with the uncertainty of the future values of the underlying asset as the option value would be greater for a bigger spread in the future values of the underlying asset.

An important similarity between financial and real options is that they both consider the risk of the underlying asset to be exogenous – that is, that the issuer of the option has no control over the underlying asset. Using the terminology from the rPV section, this means that real options only takes market risk into account, but do not consider the private risk of the underlying asset. (However, there are some exceptions to this statement, as ROA can still be applied to options with multiple sources of uncertainty as explained later on).
Types of real options:

Just like financial options, a real option is the right, but not the obligation to take an action at an exercise price for a predetermined period of time. Real options are classified by the type of flexibility that they offer. For example, a company may have the option to defer, abandon or expand a project. The following summarizes the most frequently used real options:

Deferral option is embedded in many projects, where the company may choose to delay the start of the project at a later date. Its exercise price is the money invested in getting the project started. If the project can be deferred at any date, the option corresponds to an American call option. Vice versa, if the project can only be deferred at the end of the option life, it corresponds to a European option.

Abandonment option occurs in situations where a company can choose to close the project down at a fixed exercise price. Hence, an abandonment option corresponds to a put option.

Contract option is an call option where a company can choose to contract its operations in the near future though outsourcing and internal cost reduction.

Expand option is an call option where one has the right to expand a project through additional investments.

Extend option is the option a company has to extend its business areas into other markets for instance. The option to extend is an American call and the price paid by the company to enter a new market is the exercise price.

Switching option can be classified as portfolios of American call and put options, where the company is allowed to switch between to modes of operation at a fixed cost. For example, a company may exit an industry and then reenter at a later time.

Sources of risk

Whereas the uncertainty for the value of financial options is market driven, the sources of risk of real options are more complex.

The options explained above all falls under the category as simple options because their value only depends on one source of risk (market risk). Hence, when applying real option analysis to project valuation, it is important to consider the sources of risk. Options that are driven by multiple sources of risk is referred to as rainbow options. For instance, an option may be subjected to both private risk and market risk. If the controlling variables are independent of each other, one can choose to keep the sources of risk separate. If the variances are kept separate, you will have to solve the option problem through a rainbow option. The standard computational framework of solving real options with multiple uncorrelated uncertainties is complex. However, as will be shown later in the thesis, it is

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possible to solve options problem for options with different sources of risk by use of a combination of
decision tree analysis and real option analysis thereby decreasing complexity of the valuation model.

**Estimation of input parameters for real options**

Whereas the parameters are relatively easier to estimate for financial options, some of the parameters
need to be estimated differently for real options. The following explains how to estimate each
parameter needed to price a real option:

The value of the underlying asset, $S_0$: Cf. the MAD assumption explained in previous section, the best
best security to use as the underlying asset is the NPV of the asset itself

The exercise price, $K$: depending of the type of real option, the exercise price is the cost associated
with launching a new product, building of a new facility, launching a marketing campaign and so
forth. As oppose to financial options where exercise happens immediately, exercising a real option
may take years.

The time to expiration, $T$: is typically determined by managerial judgement. For example, if a
company plans to defer a product launch, the time to expiration of the option will have be based on
expectations of future market conditions such as competitive rivalry and expiration of patent.

The volatility of the underlying asset, $\sigma$ is the most difficult parameter to estimate for real options.
The literature suggests multiple ways of estimating volatility for a real asset depending on what
sources of volatility the asset is subjected to. For simple options as explained earlier, the different
sources of uncertainty can be combined into a single volatility estimate, which is known as the
consolidated approach. Here, the recommended method to estimate volatility is by use of Monte Carlo
simulation.

For a given project with a series of uncertain cash flows $F_t$, the present value in time $n$ of the project
is expressed as:

$$PV_n = MV_n + F_n = \sum_{t=n}^{T} F_t * e^{-r(t-n)}$$

Where,

$r = \text{continuously compounded discount rate}$

$MV_n = \text{value of cash flows after time } n$

---

The rate of return of the project can be expressed as:

\[ PV_n = MV_{n-1} * e^{k_n} \]

Where,

\[ k_n = \text{The continuously compounded rate of return of the project} \]

This expression can be rewritten as:

\[ k_n = \ln \left( \frac{PV_n}{MV_{n-1}} \right) \]

Hence, \( k_n \) is the rate of return on the project between time \( n-1 \) and time \( n \), and represents the volatility of the project. The relative returns of projected cash flows for each time interval are calculated, the natural logarithm for each return in then taken, and the standard deviation of the natural logarithms of the relative returns is finally calculated. Although this method is fairly simple, it’s major disadvantage is that when the cash flows are negative the returns will also be negative for which no natural logarithm exists. This may yield an imprecise volatility estimate. However, by use of Monte Carlo simulation, a probability distribution for \( k_n \) can be performed, which yields a more precise volatility estimate than if the volatility was only estimated once.

The probability distribution for \( k_n \) can be built by holding \( MV_{n-1} \) constant and thus only perform simulations for \( PV_n \).

The risk-free interest rate, \( r_f \) is typically estimated from a government bond, just like it is done in the DCF model. However, in real option theory, the risk-free rate is continuously compounded as oppose to discretely compounded in the DCF. The continuous rate is calculated from the discretely compounded rate as follows: 24

\[ r_f = \ln(1 + r_d) \]

Where,

\[ r_f = \text{continuously compounded rate} \]
\[ r_d = \text{discretely compounded rate} \]

Contingent parameters (leakage rate, \( \delta \)) Real options may generate cash payments, similar to a dividend on a common stock that decreases the overall asset value. This is known as leakage.

Unless an adjustment to the option valuation model is made for the leakage of the underlying asset, the option will not be correctly valued.

\[ \text{Plenborg & Petersen, 2009: “Financial statement analysis”p. 213} \]
Leakage of real options may arise if a company decides to defer a product launch. Hence, this can lead to potential losses in revenue for every year the launch is deferred because of a patent expiry or because of increasing future competition. This loss of revenue (leakage rate) is equal to dividends paid on financial assets.

Whereas the return on financial dividends are easy to estimate, the leakage rate on real assets is more complex as explained later on in the thesis. Therefore, most literature suggests to apply a constant rate of leakage as this significantly reduces the computational burden.

Real option models

Although there exist many models for option pricing, the two most commonly used methods are the Black-Scholes and binomial model. The following section focuses on the theoretical frameworks of the two models as well as their respective advantages and disadvantages.

Binomial model (risk-neutral probabilities):

A useful technique for option pricing is the construction of binomial trees, which is a lattice that represents different possible outcomes of the price of an asset over time. The binominal approach values the options under the assumption of risk-neutral valuation. In a risk-neutral valuation there is no possibilities of arbitrage. This means that in efficient markets, it is not possible to buy an asset at one price and simultaneously sell it at a higher price. The general idea under the risk-neutral valuation is to construct a riskless portfolio (i.e. hedge portfolio) consisting of a long position in the underlying asset (i.e. stock) and a short position in the option that is being priced. The portfolio is riskless because if the value of underlying asset goes down, so does the value of the option it is written on. But because the investor holds a short position in the option, the portfolio will yield the same value independent on the price movements of the underlying asset.

Consider below lattice, where $S_0$ is the current asset price, $f$ if the current option price, $S_0u$ is price of the asset if the price increases, $S_0d$ is price of the asset if the price decreases, $f_u$ is the option price is the asset price increases, and $f_d$ is the option price if the asset price decreases:

Because there are two securities, the stock and the stock option, and because only two possible outcomes exist, it is possible to make a riskless portfolio. The portfolio is riskless if the value of delta, $\Delta$ is chosen so that the value of the portfolio is the same if the stock price either goes up or down. $\Delta$ is therefore the value that makes the portfolio riskless.

Value of $\Delta$ can be calculated as

$$\Delta = \frac{f_u - f_d}{S_0 u - S_0 d}$$

Where,

$f_u =$ value of option is stock goes up
$f_d =$ value of option is stock goes down
$S_0 u =$ value of stock if price goes up
$S_0 d =$ value of stock if price goes down

By use of some algebra, the following equation for pricing options by the risk-neutral valuation approach can be obtained:

$$f = e^{-r\Delta T} [pf_u + (1 + p)f_d]$$

Where,

$u = e^{\sigma \sqrt{T}}$, the value of the underlying asset at time $T$ in case of an up movement
$d = \frac{1}{u}$, the value of the underlying asset at time $T$ in case of a down movement
$p = \frac{e^{rt-d}}{u-d}$ the probability of an up movement in the underlying asset at time $T$
$\sigma =$ volatility of the underlying asset
$r =$ risk free rate

The above formulas calculate the price of an option assuming that the underlying asset (stock) does not pay dividends.

Assuming that a stock is paying a continuous dividend yield at a rate of $q$, the stock price will thus provide a return of $r-q$. The probability for an up-movement in the stock is then expressed as:

$$p = \frac{e^{(r-q)T-d}}{u-d}$$

Where,

$q =$ return provided from the dividend

---

27 P assumes that no dividends from the underlying asset is paid out.
The dividend-paying option price in the binomial model can be applied directly on real options, where the return provided by from the dividend corresponds to the leakage rate of the underlying asset assuming a constant leakage rate.

Hence:

\[ \text{leakage rate, } \vartheta = \frac{e^{(r-q)T-d}}{u-d} \]

Where,

\[ q = \text{constant leakage rate of the underlying asset} \]

However, if the leakage rate varies throughout the life of the option, a separate value of \( p \) needs to be calculated at every single node in the lattice, where the leakage is changing.

The main assumptions behind risk-neutral valuation are that investors are risk-neutral and that expected return on any asset is the risk-free rate. Hence, all cash flows are discounted with the risk-free rate. A fundamental difference between NPV approach and ROA approach is that the risk of an asset is adjusted for in the discount rate in the NPV approach whereas the risk in ROA is adjusted for in the cash flows.

Risk-neutral valuation is an important aspect of option pricing even though it can seem as an unrealistic assumption that risk does not exist. However, when options are priced in terms of the price of the underlying asset, risk preferences among investors are irrelevant as the formulas related to option pricing are unchanged by any risk preferences by investors.

The binominal tree can be extended to include multiple time periods, as it is obviously a simplification to assume that asset price movements during the life of the option only consist of two steps. The basic methodology of the risk-neutral approach is the same no matter how many time steps is included: make risk-adjusted cash flows throughout the lattice with risk-neutral probabilities and discount them back at the risk-free rate.

In the lattice above, the S-nodes represent the future prices of the underlying asset. For instance, node \( S_0 u^2 \) represents the value of the underlying asset if the price goes up for both time periods. The above
lattice is recombining meaning that the branches come back to the same point. The option values \( f \) in each node are calculated using backward induction. For instance, the value of node \( f_{uu} \) is calculated as \( \text{Max} [S_0u^2 - X; 0] \) and represents the value of the option at the time of expiry. The values at the endnotes of a lattice will never be negative because in the event that the option is out of the money, the investor will simply choose not to exercise, which corresponds to an option value of zero.

The option values in period 1 (\( T_1 \)) are equal to the end-of-period pay-outs multiplied by their risk-neutral probabilities and then discounted at the risk-free rate. This can be calculated by use of the equation:

\[
f = e^{-r \Delta T} [pf_{uu} + (1 - p)f_{ud}]
\]

Hence, \( f_u = e^{-r \Delta T} [pf_{uu} + (1 - p)f_{ud}] \) and so forth.

The binomial lattice has the same shape as a decision tree but should not be mistaken for DTA. Whereas the DTA only accounts for a very limited number of outcomes, ROA accounts for a wide range of possible outcomes.\(^{28}\)

An important restriction of the binomial lattice approach is that it only applies for options with one aggregated source of uncertainty, which does not always apply to real world scenarios. In some events, the option value may be subject to several uncorrelated uncertainties. In this case, a quadrinomial lattice approach can be used, which will not be discussed in this thesis.

### Real options: Binomial model

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| - Offers transparency by showing project values under different circumstances  
- Can price both American and European options  
- Incorporates managerial flexibility | - Accounts only for market risk  
- Complex theoretical framework  
- Relies on heavility on hypothesis and requires much data |

**Black & Scholes model (B&S) (closed form)**

The B&S model is a so-called closed form model meaning that the option price can be derived from simply plotting the variables into a formula.\(^{30}\) The B&S model is specifically designed to value European options (i.e. the option can only be exercised as the expiration date), which obviously makes the model irrelevant for most real options, as most real options typically can be exercised any time up to expiration date.

In short, the B&S model for pricing a call option can be expressed as:

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\(^{28}\) Copeland. T, & Antikarov, V. (2005) "Real options – a practitioner’s guide". 78

\(^{29}\) Own creation

\(^{30}\) Papadesu C. et. Al, 2006: “Project valuation using real options – A practitioner’s guide” p. 43
\[ c = S_0 N(d_1) - X e^{-rT} N(d_2) \]

Where,

\[ d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left( r + \frac{\sigma^2}{2}\right) T}{\sigma \sqrt{T}} \]

\[ d_2 = -\sigma \sqrt{T} \]

The mathematical framework behind the formulas is highly complex and is beyond the scope of this thesis.

Although the B&S model is easy to use and yields a precise price estimate, it is based on a set of strict assumptions that makes the model difficult to apply for real option analysis.

<table>
<thead>
<tr>
<th>Real options: B&amp;S model</th>
<th>Pros</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy to use and implement</td>
</tr>
<tr>
<td></td>
<td>Can calculate option price by use of single formula (No lattice needed)</td>
</tr>
<tr>
<td>Cons (not exhaustive)</td>
<td>Difficult to explain the intuition behind the model</td>
</tr>
<tr>
<td></td>
<td>Assumes no dividends (negative cash flows) on the underlying asset</td>
</tr>
<tr>
<td></td>
<td>Does not consider taxes</td>
</tr>
<tr>
<td></td>
<td>Does not work for American options</td>
</tr>
</tbody>
</table>

A standardized model for project valuation

In the empirical section of the thesis, a valuation of a clinical drug development project will be conducted. The management responsible for the project needs to make contingent decisions depending on the unfolding market conditions. In other words, they need to have some managerial flexibility to change the course of the project.

In addition, such a project is subject to both market risk in the form of exogenous factors affecting revenue and private risk in the form of the company’s ability to carry out the clinical phases efficiently. As these risk types are assumed to be uncorrelated, none of the real option models discussed in this thesis will be applicable. Hence, before valuing the project, I need to construct a valuation model that incorporates the following requirements:

- Easy to use and implement
- Accounts for both types of risk
- Incorporates managerial flexibility

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31 Own creation

32 Uncorrelated uncertainties can be solved with a quadrinomial lattice approach, which is highly complex and time consuming and therefore not discussed in this thesis
In order to forecast the revenue potential of the project, a strategic analysis is conducted. Based on these findings, the free cash flows from the project are estimated and the present value of the project is estimated using DCF. As the future cash inflows primarily will be subjected to market risks, WACC is chosen as the discount factor, yielding a total PV for the project. Afterwards, to account for private risk in the model, I apply risk-adjusted DCF approach where the projected cash flows are multiplied with the estimated probabilities of success in each clinical phase yielding a $r_{PV}$ value.

Finally, the managerial flexibility is incorporated into the model by construction of a binomial lattice. The starting point of the lattice will be the $r_{NPV}$ value derived from the risk-adjusted DCF approach. The lattice is analysed and the possible managerial decisions are identified and the corresponding option is valued yielding a risk-adjusted real option value, $r_{ROV}$. The $r_{ROV}$ is then discounted back at a rate slightly higher than the risk-free rate to account for the fact that cash flows in the development phase are primarily subjected to private risk. The model can be visualized as follows:

<table>
<thead>
<tr>
<th>Step 1: Static valuation of project, PV</th>
<th>Step 2: Adjust PV for private risk, $r_{PV}$</th>
<th>Step 3: Incorporate managerial flexibility</th>
<th>Step 4: Calculate $r_{NPV}$ of real option value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>Collect probabilities for each potential outcome of the project</td>
<td>Construct a binomial lattice showing all possible project outcomes</td>
<td>Discount ROV back to today using a risk-free rate slightly higher than the risk-free rate</td>
</tr>
<tr>
<td>Comments</td>
<td>Estimate PV of the project leaving development costs out of the picture.</td>
<td>Estimate the present value of the project leaving development costs out of the picture.</td>
<td>Estimate a discount rate slightly higher than the risk-free rate to discount cash flows in the development phase</td>
</tr>
<tr>
<td>Output</td>
<td>Obtain a static PV of the project based on a set of fixed input variables</td>
<td>Obtain $r_{PV}$ of the project based on the estimated probabilities of success for the different outcomes</td>
<td>Obtain a risk-adjusted real option value, $r_{ROV}$, of the project</td>
</tr>
</tbody>
</table>

The model is inspired by a four-step solution process for solving real option problems originally developed by Tom Copeland and Vladimir Antikorov (see appendix 2). The model will be referred to as modified T&V model for future references.

However, the modified T&V model differs from the original model as it allows the user to solve real option problems for scenarios where there are multiple uncorrelated sources of uncertainty without having to apply a complex model framework to combine the uncertainties (like a quadrinomial lattice). Instead, the model accounts for private uncertainty by use of the $r_{NPV}$ approach and accounts for market uncertainty by use of a binomial lattice.

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Own creation based on Copeland, T., & Antikarov, V. (2005) "Real options – a practitioner’s guide"
**Subset on theoretical part:**

The valuation models discussed in this thesis revealed the complexity in asset valuation. Whereas the DCF model is by far the most widely used model in modern valuations of investments, the fact that the valuation is based on a set of fixed input variables that is assumed to be unchanging throughout the lifetime of the asset, poses a major disadvantage to the model. In addition, the DCF model does not account for different cash flows being subjected to different kinds of risks, but assumes that all risk inherent in the cash flows are incorporated into the WACC. Whereas the risk-adjusted PV approach accounts for the private risk inherent in the cash flows by multiplying each cash flow by the estimated probability that it occurs, the rPV approach is also based on a set of fixed input variables throughout the asset lifetime, and thereby not incorporating managerial flexibility in the investment decision.

The real option approach accounts for the managerial flexibility by considering different future outcomes of the asset value but fails to account for the private risks inherent in the cash flows. Based on these findings, I have constructed a valuation model inspired by a model developed by Tom Copeland and Vladimir Antikorov\(^3^4\) referred to as modified T&V model. In short, the model applies the DCF approach to account for the market-driven risks of the cash flows, and accounts for the private risk in the cash flows by applying the rPV approach. Finally, the model incorporates the managerial flexibility in the decision making by constructing a binomial lattice that enables management to make contingent decisions based on a range of future outcomes.

I now move on to the empirical part of the thesis, where the valuation model will be used to value a development project in a pharmaceutical company. The empirical part therefore serves as a way of assessing the theoretical framework of the model in a real-life context.

**Empirical section**

This section aims at integrating the theoretical framework of real options into a practical context.

**The pharmaceutical industry:**

The section aims at uncovering the complexity and dynamics of the pharmaceutical industry, which will enable us to determine an appropriate level of strategic analysis when valuing a development project later on in the thesis. As explained in the introduction of this thesis, the pharmaceutical industry generates tremendous revenues all over the world each year. However, over the past two decades the pharmaceutical industry a productivity crisis. One of the reasons for that lies in poor portfolio management among executives in the companies. Choosing which drug candidates to progress through the R&D pipeline

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is crucial to the continuous survival of a pharmaceutical company. Many of today’s industry leaders have way over 100 projects in phase 2 and phase 3. Given the rising rate of failure for clinical trials in the industry, it is safe to say that all 100 projects will not make it to the market. Hence, the majority of the projects will fail and will represent a sunk cost for the companies within the next few years. Despite the hostile market conditions the number of players in the pharmaceutical industry is rising. All these factors contribute to a very inefficient market with few winners and many losers. Due to the highly dynamic pharmaceutical industry and its complex products, it is necessary to conduct a thorough strategic analysis dealing with the uncertainties on the market.

Choice of Novo Nordisk as case company

As seen in the previous section, the pharmaceutical industry in the United States represents a highly complex market with few winners and many losers. Moreover, the market is characterized as being increasingly more competitive, which shows in the declining growth rates in the industry over the past two decades. Therefore, pharmaceutical companies need to be innovative and explore new business opportunities if they want to attain market share in America. This is particularly true for the Danish company Novo Nordisk, as the company generates around half of its global sales in the United States. Novo Nordisk is currently ranked as number 14 of the world’s top biopharmaceutical players with annual global sales of over 100 mDKK.\(^{35}\) From looking at earlier versions of the list of the top biopharmaceutical players, the companies represented in the top 50 of global sales leaders have remained somewhat stable over time, but their relative positioning within the list continues to shift. This reflects the importance of new product launches and innovative campaigns to build a sales advantage against the high levels of competition on the pharmaceutical market.

The strategic areas of Novo Nordisk is diabetes care, haemophilia, growth disorders and obesity, with diabetes care being the largest business area by far with a share of growth of over 80%.\(^{36}\) Despite the highly competitive insulin market, Novo Nordisk has successfully managed to grow its market share in the United States by increasing healthcare provider’s awareness of the product portfolio. However, as competition intensifies, incentives to undertake new unexplored R&D activities increases, and Novo Nordisk needs to rethink its business and have a greater focus on innovation than ever before. To meet these challenges, Novo Nordisk has been researching in a new protein, called Glucagen-like peptide (GLP-1), which has proved very effective in treatment of type 2 diabetes. Today, Novo Nordisk is the market leader in the GLP-1 segment for treatment of type 2 diabetes. Novo Nordisk has continued to study the GLP-1 molecule, which has led to the creation of semaglutide. Semaglutide has proven to be very effective for obesity, which has led Novo Nordisk to expand into the obesity area with semaglutide. The key to future success for Novo Nordisk lies in

\(^{35}\) Seekingalpha.com

\(^{36}\) Novo Nordisk annual report 2018 p. 12
bringing new innovative products to new markets, so a successful launch of semaglutide in treatment of obesity is crucial for the company.

**Choice of development product to be valued:**
The previous section highlighted the importance for Novo Nordisk in exploring new market opportunities through continued research in order for the company to maintain its position as one of the leading pharmaceutical companies in the world.

Novo Nordisk has multiple development projects in its obesity pipeline.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Description</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Filed</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN9536</td>
<td>A long-acting GLP-1 analogue intended as a once-weekly treatment for obesity</td>
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<tr>
<td>NN9838</td>
<td>A novel amylin analogue intended as a once-weekly treatment for obesity</td>
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<tr>
<td>NN9499</td>
<td>A modified and protected FGF21 analogue intended for the treatment for obesity</td>
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<tr>
<td>NN9030</td>
<td>A novel glucagon which, in combination with liraglutide, is intended for the treatment of obesity</td>
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</tr>
<tr>
<td>NN9277</td>
<td>A novel glucagon and GLP-1 co-agonist intended for the treatment of obesity</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NN9747</td>
<td>An appetite-regulating hormone which, in combination with semaglutide, is intended for treatment of obesity</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NN9423</td>
<td>A tri-agonist of human GLP-1 and glucagon receptors intended for the treatment of obesity</td>
<td></td>
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</tbody>
</table>

Novo Nordisk’s diverse obesity pipeline indicates that the company has a strong strategic focus on entering the obesity market. The success of this pipeline is essential for both the company and its investors, as this is what is going to generate the future cash flows.

From looking at the pipeline for obesity trials and from the analysis of the challenges Novo Nordisk is facing in the future, the obesity pipeline seems to be a reasonable area to base this analysis on. If one or more of the obesity trials has a negative financial impact on Novo Nordisk, the sooner the company can identify it, the better, as this will save the company cost of conducting further research and development. Also, given the fierce competition of the pharmaceutical markets, the money saved from abandoning unfeasible R&D projects and placing it into profitable areas is crucial for the company’s aspiration of leading in all disease areas in which it operates.

Moreover, obesity is a disease with a high global prevalence, which is expected to grow in the foreseeable future. Adults with a body mass index (BMI) equal or greater than 25 are defined by the World Health Organisation (WHO) as being overweight, and adults with a BMI equal to or greater

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37 Novo Nordisk annual report 2018 p. 12
than 30 are classified as having obesity. In 2016, it was estimated that 13% of the world’s adult population (at the age of 20 or more) had obesity and the rates are expected to increase further (note: WHO).\textsuperscript{38} The high global prevalence poses severe implications for the global population’s health and economic development, as people suffering from obesity are more exposed to a series of other medical conditions. In fact, obesity has been linked to no less than 236 different diseases, including cardiovascular disease, high blood pressure, elevated blood lipids, type 2 diabetes and some types of cancer.

Despite the size and significance of the disease, there are very few anti-obesity pharmaceuticals available on the markets, leading to a huge unmet need in treatment options of obesity.

In 2015, Novo Nordisk launched its first obesity product under the brand name Saxenda. The product has obtained broad commercial access on key markets and is now launched in 41 countries. It contains the active ingredient liraglutide, which Novo Nordisk has patented. However, the patent expires in 2023 (note: only in America).

This means that if Novo Nordisk wants to continue to benefit from this unmet need in obesity treatment options, it will have to introduce new obesity pharmaceuticals. If Novo Nordisk is able to successfully do so, it will have a substantial effect on the Company’s earnings prospects.

Based on Novo Nordisk’s obesity pipeline and the analysis of the challenges in the pharmaceutical industry, the phase 2 project NN9536 is chosen to be the product for valuation; a project investigating the effect of injectable semaglutide on obesity treatment. Moreover, the choice of NN9536 is also justified by the fact that the future cash flow estimates for the product will be more precise on later-stage development trials, as information and estimates become more accurate the longer the product is in the development phase. Hence, if one of the phase 1 trials was chosen for the valuation, it would be virtually impossible to conduct a sound estimate of the sales prospects of the product, as the available product information at this point in time is very limited.

**Choice of market to enter:**

Novo Nordisk currently has marketed products in 170 countries. The markets are divided into 6 regions, where region US represents around half of Novo Nordisk’s global sales and is thus the largest market for the company. The other 5 regions are Europe, AAMEO (Africa, Asia, Middle East & Oceania), Japan & Korea, China and Latin America. The latter region is referred to as “International Operations”.

\textsuperscript{38} WHO.com
Though Novo Nordisk’s global presence can be divided into 6 overall regions, each region represents multiple heterogeneous markets. For instance, the region of International Operations consists of 110 countries allocated on 4 continents and is thus the far most diverse region in terms of geography, culture and legislation. Many countries in this region, such as China, India, Brazil, Argentina and Mexico, can be classified as pharmerging markets. Pharmerging markets often have complex and difficult approval processes, and it usually takes much longer time in order for the companies to get approval to start selling on the market. According to IMS, the average regulatory approval process is 4-6 years in China as oppose to only 16-22 months in the U.S.  
Thus, the high heterogeneity across Novo Nordisk’s markets means that a valuation of a development project, launched across all markets, would become too unmanageable and inaccurate, and the number of parameters that would have to be estimated would be in the thousands. Therefore, the thesis will be focusing on the single biggest region of Novo Nordisk, the United States, which accounts for more than half of Novo Nordisk’s global sales, and where Novo Nordisk historically has chosen to launch new products before moving into other regions. (note)

Contributing to the U.S. as the market of choice for this thesis, is the fact that the United States is the largest pharmaceutical market globally. Since 2001, sales in the American pharma market has grown at an average compound annual growth rate (CAGR) of 6.6%, and the CAGR is expected to remain positive for the next two decades at least, which means growth opportunities for the pharmaceutical companies.
Consequently, this attracts many players to the market making the American pharma industry a highly competitive environment with the biggest company measured by market share is Pfizer with a share of 8.5% of the market.

39 Novo Nordisk annual report 2018, p. 19
40 Launch Excellence IV: a new launch environment, IMS white paper p. 16
41 Market research report p. 19
Despite Pfizer as the overall market leader in the U.S., Novo Nordisk holds the role as market leader within diabetes care with a market share of 40%. Thus, being a well-established player on the American market, Novo Nordisk can benefit from this when launching a new product.

Another factor that makes the U.S. an ideal market to choose for a valuation of a new obesity product is the fact that the country has the highest obesity rate within the OECD grouping of large trading countries and the rates have been steadily increasing since the 1970s. An estimated 106.8 million Americans are today living with obesity and only around 2.8 million of them are using antiobesity drugs, which highlights the huge unmet need for obesity pharmaceutical in the United States. The American obesity market is expected to increase in value from 544 mUSD in 2016 to 1.2 bUSD in 2026 at an CAGR of 8%. Growth will primarily be driven by increase in use of branded pharmaceuticals to treat obesity, as well as the rising prevalence of the disease.

**Use of the modified T&V model for valuing NN9536**

The following section aims at applying the modified T&V model to value the development project, NN9536.

**Step 1: Static valuation (PV) of the project**

The aim of this section is to calculate a static PV of the project that will serve as a foundation for the remainder of the valuation.

**Strategic analysis**

Now that we have defined the development project to be valued and the optimal market to launch the product, we move on to a strategic analysis of the American obesity market and the competitive position of Novo Nordisk in the U.S. The overall analysis of the pharmaceutical industry uncovered to dynamics of the market as well as the complexity and high costs of developing a new pharmaceutical drug. Since Novo Nordisk operates in a complex business environment, it makes little sense to rely purely on historical information when forecasting the future NN9536’s future earnings potential. Therefore, we start by identifying the macro factors that could influence NN9536’s cash flow potential and risk. In order to do so, we apply the PEST model indicating the impact of Political, Economic, Social and Technical factors. Afterwards, a financial statement analysis of Novo Nordisk and peers is conducted in order to to use the historical levels and trends in key financial drivers as a foundation when developing projections of NN9536’s future earnings capacity.

**Pest analysis**

Political, Economic, Social and Technical factors influencing Novo Nordisk

Political/legal
Overall legislation and regulation: The legislation on medical products is highly regulated by the US Food and Drug Administration (FDA) who is responsible for protecting and promoting public health through the control and supervision of all pharmaceutical drugs in the United States. FDA imposes a number of complex regulations on companies that promote and advertise pharmaceuticals. The pharmaceutical process for drug development can be broken down into 5 different phases. An understanding of each phase is crucial later on when valuing a development project. In the following, each section is briefly introduced.42

Discovery and decision to develop as a drug
The process starts with the discovery of a potential new drug. However, the decision to move a newly discovered compound from research to preclinical development is made by the pharmaceutical company which will consider many issues, including the degree of difficulty in manufacturing the product, the likelihood of obtaining regulatory approval and the potential for its successful marketing. If the company decides to go on with the newly discovered compound, the company must put together a project plan for how the clinical trials will be conducted. The clinical trials must be very well designed and carried out with a goal of providing a statistically sound demonstration of safety and effectiveness for the proposed use.43

Also, moving from research to project status requires the establishment of protection of the intellectual property through patent filing. Moreover, patient-related issues such as whether the patients must be treated at home or in a physician’s office, and whether the condition is life-threatening must be addressed.

Moreover, the regulatory requirements to the safety of testing the compound on humans are very strict. Preclinical animal safety studies are conducted well in advance of human testing in order to prove that it is reasonably safe to conduct the proposed clinical trials.

When the compound has been sufficiently tested in animals to “anticipate its potential significant toxicities in humans (...),” the company will file an investigational new drug application (IND) with local authorities, who will then decide whether it is safe to move on to human testing in clinical trials. The preclinical costs are highly variable depending on the disease area and size of the company. The average preclinical costs for big pharmaceutical companies ranges between 8-19 mUSD. The probability for a newly discovered compound to make it to a clinical phase 1 trial is estimated to be around 65%. This is referred to as “success rate”.

Phase 1 clinical trials

42 Launch Excellence IV: a new launch environment, IMS white
43 Krueger, B. (2008)”Fundamentals in Life Sciences”. P. 35
Phase 1 trials establish whether the drug has any negative effects on the patients, for how long the patients are affected by drug (i.e. how quickly the drug enters and leaves the body) and what effects the drug has on the target cells. Usually the number of patients enrolled in a phase 1 trial ranges between 20-100 subjects. The patients may have the condition for which the drug may be used, or the patient may simply act as healthy control subjects. The success rates of phase 1 trials are very dependent on the disease group.44

The duration of an average phase 1 trial is 10-12 months. Given the relatively short length and small population size of phase 1 trials, the trials are the least costly of the clinical trials to conduct. The costs for an average phase 1 trial based on 100 patients excluding drug supply and non-clinical costs amounts to 2 million $. If all costs are included, the average cost is 4-5 million $. Since most of Novo Nordisk’s pharmaceuticals fall under the category of metabolic diseases, I will solely be focusing on the success rates for this disease group. For metabolic diseases, the average success rate is 47.8%.

**Phase 2 clinical trials**

When a project is ready to proceed to phase 2, the information about the compound is still very limited. The main purpose of phase 2 trials is to test whether the experimental drug has beneficial activity and safety in patients for whom the drug is intended. The length of phase 2 trials may vary from a couple of months to up to 2 years depending on the compound to be tested. Similarly, number of patients enrolled in a phase 2 trial may vary from only a couple of patients to several hundreds. However, the population enrolled in the trial should be large enough for the company to prove statistical significant efficacy of the compound. The costs for an average phase 2 trial based on 300 patients are 7-8 m$, and including all non-clinical costs the total cost is 10-11 m$ while the duration ranges between 24-28 months. The success rate is estimated to be 52% for a phase 2 trial to make it into phase 3.

**Phase 3 clinical trials**

If the phase 2 trials has shown promised results and the company decides to move on with the development project, they will initiate a phase 3 trial, which is a more extensive, randomized, well-controlled, double-blinded evaluation of the long-term safety and effectiveness in a larger number of patients. The length of phase 3 trials are generally longer than the previously conducted trials, which makes it possible to discover any less frequent and later side effects of the compound. Once again, the overall purpose of phase 3 trials is to provide sound evidence of efficacy and safety of the compound. Phase 3 trials have the highest success rates of approval with more than 80% of the completed trials

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getting approved. Average clinical costs range from 10-50 m$ and 30-60 m$ including non-clinical costs with average duration of 28-32 months. The success rate is estimated to be 78.9%.\textsuperscript{45}

**Approval**

When all clinical trials have been conducted and the data has been analyzed, the company collects all relevant information about the new drug, including animal testing, the manufacturing procedure, and the results of all clinical trials. This information goes into a document called New Drug Application (NDA). The NDA is then sent to regional drug authorities (i.e. FDA for United States), who review the validity of the trial conclusions. The review of the NDA can take anywhere from a few months to seven years, depending on the complexity of the program and whether the NDA has to be resubmitted after an initial review and rejection. The duration process typically takes between 16-20 months to complete and cost around 3 mUSD (note: in the US). The success rate of approval is not surprisingly the highest of all the clinical phases with 92.8% off all post-phase 3 trials being approved.

**Phase 4 clinical trials**

Phase 4 of a clinical trial is also known as post-approval research. Phase 4 trials involve the safety surveillance and ongoing technical support of a drug after it has received regulatory permission to be marketed. The trial is typically designed to detect any rare long-term adverse effects over a much larger patient population than was possible during the phase 1-3 trials. The pharmaceutical companies may decide to conduct a phase 4 trial for competitive reasons. For instance, the company may wish to find a new market for the drug or the drug may not have been tested for interactions with other drugs. An unsuccessful phase 4 trial can result in the product being restricted to certain uses or it may show that competitive products are more efficient. On the other hand, a successful phase 4 trial can turn out to be highly profitable for the company as the results from the trial can allow the company to add further therapeutic claims to the product leading to an increase in sales. The minimum duration mandatory for a phase 4 trial is 24 months.

The below chart summarizes the activities taken place in each phase of the clinical development process:

Cost, duration and success rates of clinical trials

The costs for the clinical trials encompass all necessary expenses to conduct the trials, including project management, drug supplies, toxicology, investigator fees and study design. The costs included below are average estimates, and vary according to the different disease groups, as certain studies are more complex than others. Same goes for the drug development duration and success rates, as these variables are dependent on the disease group. Nevertheless, the costs and duration intervals included in below table are good approximations to be used for the purpose of the valuation.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Avg. costs (mUSD)</th>
<th>Avg. duration (months)</th>
<th>Avg. no. of enrolled patients</th>
<th>Success rate (metabolic diseases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-clinical</td>
<td>8-11</td>
<td>30-42</td>
<td>-</td>
<td>65.0%</td>
</tr>
<tr>
<td>Phase 1</td>
<td>4-5</td>
<td>18-22</td>
<td>20-100</td>
<td>47.8%</td>
</tr>
<tr>
<td>Phase 2</td>
<td>10-11</td>
<td>24-28</td>
<td>100-300</td>
<td>52.0%</td>
</tr>
<tr>
<td>Phase 3</td>
<td>30-60</td>
<td>28-32</td>
<td>500-20,000</td>
<td>78.9%</td>
</tr>
<tr>
<td>Approval</td>
<td>3</td>
<td>16-20</td>
<td>-</td>
<td>92.8%</td>
</tr>
<tr>
<td>Phase 4</td>
<td>10-70</td>
<td>24-48</td>
<td>&gt;10,000</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Tax rates:** As a general rule, Novo Nordisk subsidiaries pay corporate tax in the countries in which they operate and business activity generates profits. Novo Nordisk has a balanced tax risk profile and does not engage in any tax avoidance activities.\textsuperscript{48}

The US tax reform of 2017 reduced the U.S. federal corporate income tax rate from 35% to 21%, which has contributed to a lower tax expense for Novo Nordisk. The lower tax also means that the U.S. is seen as a more lucrative market to enter for other companies. Further, the U.S. R&D tax credit has been introduced in the U.S. as a financial incentive for companies engaging in R&D activities to maintain those activities on U.S. soil. The R&D tax credit permits all R&D related activities to be deducted on the company’s tax bill.

**General perception of obesity:** In the recent years, there has been a shortage of novel therapies as pharmaceutical companies are facing challenges in achieving regulatory approval from the FDA. This is particularly profound among anti-obesity drugs, where the perception of obesity as a lifestyle

\textsuperscript{46} Own creation
\textsuperscript{47} Krueger, B. (2008) "Fundamentals in Life Sciences". P. 56
\textsuperscript{48} Novo Nordisk annual report 2018, p. 89
disease that is not suited for therapeutic intervention has hampered market growth and will continue to do so in the coming years (note). Despite the growing obesity population in the United States, many American institutes are researching and developing non-medical strategies to prevent and address obesity. The federal government spends billions of dollars each year on nutrition assistance programs for low-income Americans and children. For instance, 35 states have made investments to increase healthy food access in underserved communities and in 2017 new rules were implemented that strengthened school wellness policies to ensure healthier food marketing in schools across the country.49

The perception of obesity as a lifestyle disease that does not require medical treatment also shines through in a report published by Stateofobesity.org, which argues that the most efficient way of fighting the increasing obesity rates is to provide the American population with healthier food. In addition, fiscal policies to promote better nutrition have been initiated. An example hereof is the Healthier Food Financing initiative, which helps establishment of new grocery stores in communities that lack access to affordable, healthy food. Providing people with financial incentives to make healthier food choices has proved effective in the United States, where a sugar-sweetened beverage tax of 1 cent per ounce were implemented in Berkely, California in 2015. 4 month after the tax implementation, sales of sugar-sweetened beverages had declined by 21%. There are also surgical approaches to treat severe obesity that are becoming increasingly accepted in the United States such as a gastric bypass operation

*Healthcare coverage and programs:* The estimated annual healthcare cost of obesity-related diseases in 190 billion USD which corresponds to 21% of the total annual medical spending in the United States. Today, only a small fraction of the total American obesity population is receiving medical treatment for the condition. One of the primary concerns from the American key opinion leaders (KOLs) is the lack of reimbursement for the often costly obesity drugs which continues to prohibit patient access.

"The problem is that reimbursement is a decision by the society on what is considered a disease. Obesity is not considered a disease, like diabetes or cardiovascular disease. The perception of the treatment of obesity (...) is not considered a priority, but rather a luxury, when patients can always go on a diet." (note)

However, an uptick in the drug treatment rate is expected in the coming years due to higher awareness of obesity as a disease with life-threatening implications that require medical attention. This uptick is likely to lead to substantial market growth.

Moreover, FDA has recommended that all public – and private health plans should cover the full range of obesity-prevention, treatment and management services.

49 “Accelerating access in emerging markets, Pharma’s next big launch challenge,” McKinsey and Company
Despite the recognition from FDA of obesity as an actual disease and its enourmous cost to the American health care system, coverage of and reimbursement for drugs to treat the condition to both public – and private payers are lacking. However, third-party reimbursement, (i.e. an insurance company covers the cost for the patient) for anti-obesity drugs appears to be evolving.

**US rebates:** There is an increasing political pressure on the American healthcare system to lower costs including the cost of prescription medication. Several US states have proposed laws relating to price controls of prescription medication. Examples hereof is the state of California which in 2017 signed a law that requires pharmaceutical companies to notify the state 60 days prior to price increases of medicines. Across all medicines in 2017, rebates and discounts consumed 64% of gross sales meaning that for every dollar in sales, Novo Nordisk paid 64 cents in rebates and discounts leaving the company with 36 cents to pay for all expenses including R&D, manufacturing, sales and marketing.

**Patents:** The global (and hence American) standard for patent rights are 20 years from the date of application. Patent applications are generally filed during the discovery research phase of the drug discovery process. Hence, the date of the patent application is generally years prior to the actual launch of the product. To make up for the time invested in the clinical trials and FDA approval process, pharmaceutical companies hold the right to file for a patent extension on a pharmaceutical drug after successful FDA approval. However, a patent may not be extended for more than 14 years beyond FDA approval.\(^5^0\)

**Economic:**
The economic development level is a critical variable for determining future cash flow potentials. Fluctuations in USD/DKK exchange rate have a direct effect on Novo Nordisk’s future earnings potential, since around half of Novo Nordisk global sales are generated in the United States. Consequently, the company’s foreign exchange risk is most significant in USD.

Novo Nordisk cash flows from sales are negatively impacted if the American dollar depreciates against the DKK. Through hedging strategies (typically of 12 months) Novo Nordisk mitigates the exposure to foreign exchange risk, but given the size of US value market share of Novo Nordisk, fluctuations in USD/DKK exchange rate are one of the company’s most significant financial risks. The future expectations to USD are that it will increase primarily due to the increase in the American interest rate. Also, since the inauguration of President Donald Trump, the US employment rate has been historically high, which has further contributed to a strengthened American currency.\(^5^1\)

Consequently, the outlook of a strong American currency contributes to higher earnings potential for Novo Nordisk. However, the prospect requires that the growth in the American economy continues, which depends on several macro factors – a significant factor being the American unemployment rate.

\(^{50}\) Eli Lilly annual report 2018 p. 37
\(^{51}\) https://www.berlingske.dk/emne/dollarkursen
Even though the unemployment rate is at its lowest in nearly 50 years, projections show a slight increase over the next couple of years. In view of the fact that obesity is being perceived as a non-lifethreatening disease, this could potentially affect Novo Nordisk’s future earnings prospects on obesity drugs, as unemployed people would turn to other and cheaper treatment options such as regular exercise instead of buying pharmaceuticals.

However, the unemployment rate is only projected to increase with 2-3 percentagepoints over the next decade, making this factor a negible risk to Novo Nordisk’s earnings potential.

**Sociocultural factors**

It is crucial for Novo Nordisk to understand the sociocultural dynamics on the American market to obtain a successful product launch.

It is estimated that 32,7% of American adults at the age of 20 or more are obese, which corresponds to 106,8 million people today. The United States has the highest obesity rate within the OECD grouping of large trading countries and the rates have been steadingly increasing since the 1970s.\(^\text{52}\)

There are many varying estimates of the future obesity rates in the United States. For instance, The OECD found that 75% of the the American population will likely to be overweight or obese by 2020.

A study based on a nonlinear regression model was conducted in 2009-2010, and used data from 1990-2008 to forecast obesity levels up until 2030. It finds that by 2030, 33% of the American population will be obese. Another study projected an obesity rate of 50% by 2030 ceretis paribus.

By looking at the historical obestiy rates in the United States, there is a clear increasing trend. From an adult obesity rate of 19,4% in 1997 to 31,3% in 2017, which corresponds to an annual growth rate of 2,4%. However, the annual growth rate in adult obesity has been decreasing in the same period – from an increase of 6,2% in 1997-1998 to an increase on 0,7% in 2016-2017.

One of the contributing factors of the increase in adult obeisty rates is that the prevalence of obesity in children are also increasing. For children and teenagers aged 2-19 years, the prevalence of obesity was 18.5 % in 2017, which corresponds to 13.7 million people. As more than 80% of obese children will become obese adults, this trend will continue to add the high rates of adult obeisty. The annual American population has been increasing with an annual rate of 0,7% and is expected to linear increase at this pace for the next 2 decades (note). The growing American population and the increasing obesity rates are both factors that contribute to an expected market growth and hence, a business opportunity for Novo Nordisk.

There are substantial variations in obesity rates by education and income level. In 2016, 35,5% of adults with less than a high school education had obesity compared to 22,2 % of college graduates – a difference of more than 50 %. Consequently, this trend also shows in the income level, where income

\(^{52}\) From visions to decision - Pharma 2020 by PwC
groups below the federal poverty line (FPL) and those at 100-199% above the FDL have higher obesity rates than those with incomes of 400% or more above the FDL. This low healthcare expenditure in the American middle – and low-income segments represents a constrain to future market growth.

**Technological**

A crucial aspect in the pharmaceutical industry is the persistent focus on innovation and development of new medicines.

Today, Novo Nordisk has more focus on innovation than ever before and because of increasing R&D expenditures a bigger focus will likely come on optimising the way research trials are conducted in order to minimise costs. Also contributing to the increased focus on innovation is the fact that some patents on high-earning pharmaceuticals will expire in the coming years, which encourages the industry to adopt new models of innovation in order to retain marketshare. For instance, many of the big pharma companies are looking towards M&As and in-licensing activities to make up for the loss of revenues that will occur when patents expire on key products.53

The innovative focus in the pharmaceutical industry also shows in the level of R&D investments. In the United States, R&D investments have grown consistenly over the past 15 years and made up 27.3% of the total pharmaceutical manufacturing costs in the United States in 2014. Novo Nordisk has contributed to this development by investing in a large production facility in Clayton, U.S., which was expanded with a new plant in 2015 for a cost of 2 billion USD. The new plant will produce active pharmaceutical ingredient. It is the first facility outside of Denmark where Novo Nordisk produces pharmaceutical products. The plant is expected to be operational in 2020.

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53 From visions to decision - Pharma 2020 by PwC
Porter’s 5 forces: Industry factors influencing Novo Nordisk’s cash flow potential and risk:

In previous section, the most significant macro factors in the United States were identified. We now move on to analysing the competitive landscape of the American pharma market.

The attractiveness of an industry is ultimately a result of the possibility of earning acceptable returns. It is generally accepted that the more competition in an industry the smaller chances of obtaining abnormal returns. In order to understand the competition in the pharmaceutical industry, we apply Porter’s five forces approach in the following. The five forces analysis serves to cover the different forces affecting the competition on the pharmaceutical market in the United States and the possibility for Novo Nordisk to earn acceptable returns.

Threat of entrants:
This section aims at covering how the threat of new players affects the pharmaceutical industry. New entrants generally affects returns negatively as they bring in new capacity and desire to gain market share.

As the analysis of the pharmaceutical R&D process revealed, the pharmaceutical industry is subject to strict requirements imposed by FDA and the government. Moreover, if a company wishes to undertake the entire R&D function by itself, from early discovery to FDA approval, it requires a large amount of capital, as the cost of developing a single drug amounts to over USD 1.5 billion compared to USD 138 million in 1975. (see section x.x). Hence, the strict legislation and the capital requirements both act as barriers of entry.

For smaller pharmaceutical companies, with a limited product portfolio, it can be difficult to leverage a limited salesforce and gain sufficient market penetration. A limited portfolio also means that success of the company is more reliant on one or two drugs. Moreover, companies that have had previous success with FDA approval are also perceived as more attractive investment candidates than smaller or newer companies with historical limited FDA success. This acts as a barrier of entry for small and new pharmaceutical companies that wishes to raise capital in order to penetrate the American market. Even though new pharmaceutical companies continue to enter the market, these companies pose no serious threat to Novo Nordisk. In fact, many new and smaller pharmaceutical companies apply a strategy to sell out their invention or patent as soon as it is through the initial development phase, leaving the pharmaceutical market to be dominated by the big players.

Supplier’s bargaining power:
Novo Nordisk suppliers can be categorized into three main groups: suppliers of raw materials, suppliers of manufacturing technology and suppliers of packaging material. Novo Nordisk has very strict requirements to all of it’s supplier’s and continuously conducts supplier audits so assess compliance levels with the company’s standard for suppliers. Even though Novo Nordisk is using highly specialized suppliers with high intellectual capital for production of its pharmaceuticals, the
suppliers have limited bargaining power. This is because most of the raw materials used for production of Novo Nordisk’s pharmaceuticals are commodity products in the chemical industry, which therefore is available through multiple different sources. As for the bargaining power of the suppliers of packaging material and manufacturing equipment, a large number of suppliers exists and are thus able to provide these to Novo Nordisk in the desired quantities. Moreover, Novo Nordisk uses its own manufacturing plants in the United States to produce pharmaceuticals, making the company independent of other firms on this matter. This also means that the switching costs in the pharmaceutical industry generally is low making the overall bargaining power of Novo Nordisk’s suppliers low.  

**Buyer’s bargaining power:**
If buyers posses a high bargaining power it typically limits the potential returns in the industry. The global (and hence American) standard for patent rights are 20 years from the date of application, which theoretically allows the pharmaceutical companies to dictate the prices within this time period. However, large customers such as pharmacies and hospitals possesses higher bargaining power than the end-users (i.e. patients) because they are the ones to decide what product to prescribe. In recent years, wholesalers, pharmacy benefit managers and other supply chain stakeholders have been clustering into fewer, larger entities, which has led to an enhancement of their purchasing strength and importance. 

In the past decades however, the increased accessibility to information via internet, television, social media, and other digital information sources has made the American people significant stakeholders of pharmaceutical companies. Back in the days, sales representatives were the sole source of information on new pharmaceutical products for both doctors and patients, but today patients play a much bigger role in determining how they are treated, as information on alternative pharmaceutical products is easily accessible. This active movement away from traditional information sources has meant a decrease in decision power among prescribers and sales representatives of pharmaceutical companies in determining what products the patients will use. This means that patients play a bigger role today in determining how they a treated, making the patients significant stakeholders of pharmaceutical companies.

Moreover, with patients being able to choose among different pharmaceutical products, many patients will most likely turn to the product that seems most comfortable to use. This further stresses the need for Novo Nordisk to bring new innovative products to new markets in order retain growth rates.

54 Novo Nordisk annual report 2018 p. 34
55 Launch Excellence IV: a new launch environment, IMS white pater p. 16
56 “Accelarting access in emerging markets, Pharma’s next big launch challenge,” McKinsey and Company
Threat of substitutes

As earlier mentioned, the standard for patent rights are 20 years from the date of application. Once a drug loses its patent, generic drug manufacturers start selling generic versions at substantially lower prices. However, given the increasing obesity rates in the United States, more companies turn towards development of anti-obesity drugs, which poses a threat to Novo Nordisk. Moreover, as patients gain more decision power in terms of choosing what product to buy, as shown in the previous section, the threat of substituting products increases.\textsuperscript{57}

One of the biggest competitive challenges the company faces is from generic pharmaceuticals. In the U.S., the regulatory approval process for pharmaceuticals exempts generic manufacturers from the costly and time-consuming clinical trials to demonstrate the safety and efficacy of the drug. This means that generic manufacturers can rely on the safety and efficacy of the innovator product and can price their generic products at a much lower price, because they do not have invest in any research and development before launching the product. Consequently, when a patent on a branded pharmaceutical expires, it quickly faces intense price competition from generic forms of the product. Moreover, many public and private payers typically encourage the use of generics as alternative to brand-name drugs in their healthcare programs.

\textbf{Competition rivalry}

Competition in the pharmaceutical industry in the U.S. is intense and is characterized by costly and extensive research efforts and rapid technological progress. In recent years, the market has become even more competitive, both within branded pharmaceuticals as well as the generic product segment. Consequently, the pharma companies are becoming more active in R&D and production of drugs in the segments with the highest earnings potential. However, despite the large market opportunity for anti-obesity agents, there are relatively few competitive products in late stage clinical development (note: Orexigon annual report p. 14).

Novo Nordisk biggest competitors on the total American pharmaceutical market and their respective market shares are listed below:

<table>
<thead>
<tr>
<th>Company</th>
<th>Pfizer Inc.</th>
<th>Merck &amp; Co.</th>
<th>Eli Lilly</th>
<th>Sanofi</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. market share %</td>
<td>8.5 %</td>
<td>6.1 %</td>
<td>4.7 %</td>
<td>4.1 %</td>
</tr>
</tbody>
</table>

\textsuperscript{57} From visions to decision - Pharma 2020 by PwC p. 34
\textsuperscript{58} Market research report p. 301
**Pzifer Inc.**
With a market share of 8.5% of the American pharmaceutical market, Pzifer is the biggest player in the U.S. Pzifer manufacturers and sells pharmaceuticals for a wide range of therapy areas such as immunology and cardiology. The company faces industry-specific challenges such as patent expiry, price pressure from government regulations and private payers, who are continuing to seek increasing discounts on pharmaceuticals by means of leveraging their purchasing power or implementing price controls. In recent years, the company has invested massively in new manufacturing plants in the U.S. to meet the future manufacturing capabilities. Pzifer currently has over 100 development project in its pipeline – however, no obesity projects are currently running.59

**Merck & Co.**
The U.S. based company Merck & Co. is with a U.S. market share of 6.1% the second largest player on the market. The company’s operational segment includes medicine for diabetes, oncology as well as a various vaccine products. In 2015, the company entered into collaboration with NGM Biopharmaceuticals to develop and market novel medicines on new therapeutic areas. The collaboration has led to a preclinical project investigating a treatment for obesity. As the project is currently in the preclinical phase, there is huge uncertainty as to whether the company wishes to further invest in it. However, the fact that a big pharma company like Merck & Co.is beginning to research into treatment options for obesity stresses the fact that the obesity market will become highly competitive in the foreseeable future.

**Eli lilly and Company**
Eli Lilly and Company is one of the overall biggest competitors to Novo Nordisk, and is also the big competitor on the American pharma market. With a total market share of 4.7% of the American pharma market, Eli lilly is the fifth biggest pharmaceutical company in the U.S. and have strong relationships with the American healthcare providers and insurers. The company has diabetes as a key area of business and some of the company’s blockbusters drugs no longer have patent protection, which is likely to lead to rapidly and severe decline in revenue. Hence, Eli Lilly is currently investing heavily in research and development of other disease areas such as oncology and neuroscience as innovation is a critical factor to the company’s long-term competitiveness. As for Eli Lilly’s presence on the anti-obesity market, the company has currently no marketed drugs nor any obesity drugs in its pipeline.

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59 Pzifer annual report 2018 p. 19-67
Sanofi

Sanofi’s primary therapeutic areas include diabetes, multiple sclerosis and cardiovascular diseases. It is one of Novo Nordisk key competitors on the insulin market and currently has a market share of 4.1% on the overall U.S. pharmaceutical market. Similar to the other analysed companies, Sanofi is investing heavily in R&D activities in order to meet the future competitive landscape by introducing innovative product on new therapeutic areas. However, neither the company’s R&D pipeline nor its marketed products consist of any obesity products.60

Benchmark analysis of Novo Nordisk’s peer group

The four main competitors described above share the same risk factors as well as general characteristics as Novo Nordisk. They all belong to the group of “Big Pharma” companies with annual revenues way above 100 billion $. Hence, in the following section, the companies are referred to as the peer group to Novo Nordisk.

To be able to further assessing Novo Nordisk’s competitive strength relative to its peers, a benchmark analysis is conducted.

<table>
<thead>
<tr>
<th>Activity/company</th>
<th>Eli Lilly</th>
<th>Pfizer</th>
<th>Merck &amp; Co.</th>
<th>Sanofi</th>
<th>Novo Nordisk</th>
<th>Peer Group average</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>COGS/Revenue</td>
<td>26.1%</td>
<td>20.9%</td>
<td>35.5%</td>
<td>32.4%</td>
<td>15.7%</td>
<td>28.7%</td>
<td>13.1%</td>
</tr>
<tr>
<td>Marketing, selling &amp; admin. / Revenue</td>
<td>30.7%</td>
<td>28.4%</td>
<td>25.7%</td>
<td>27.8%</td>
<td>25.9%</td>
<td>28.2%</td>
<td>2.3%</td>
</tr>
<tr>
<td>R&amp;D/Revenue</td>
<td>23.8%</td>
<td>16.2%</td>
<td>21.8%</td>
<td>15.5%</td>
<td>13.4%</td>
<td>19.3%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Inventory / revenue</td>
<td>16.8%</td>
<td>13.6%</td>
<td>13.9%</td>
<td>20.2%</td>
<td>13.2%</td>
<td>16.2%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Accounts receivable / revenue</td>
<td>18.9%</td>
<td>16.0%</td>
<td>16.7%</td>
<td>21.4%</td>
<td>17.1%</td>
<td>18.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Other receivables / revenue</td>
<td>3.3%</td>
<td>5.2%</td>
<td>11.3%</td>
<td>6.5%</td>
<td>4.2%</td>
<td>6.6%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Deferred tax liabilities / revenue</td>
<td>1.4%</td>
<td>1.2%</td>
<td>3.8%</td>
<td>8.5%</td>
<td>0.2%</td>
<td>3.7%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Accounts payable / revenue</td>
<td>6.1%</td>
<td>8.0%</td>
<td>7.1%</td>
<td>12.6%</td>
<td>5.3%</td>
<td>8.5%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Other operating liabilities / revenue</td>
<td>11.4%</td>
<td>20.6%</td>
<td>26.0%</td>
<td>27.0%</td>
<td>12.5%</td>
<td>21.2%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Net working capital/revenue</td>
<td>20.1%</td>
<td>4.9%</td>
<td>5.2%</td>
<td>0.0%</td>
<td>16.6%</td>
<td>7.5%</td>
<td>9.0%</td>
</tr>
</tbody>
</table>

60 Sanofi annual report 2018 p. 345
61 Own creation based on peer group annual reports 2014-2018

48
The above figures give insight into how efficient Novo Nordisk is managing its primary activities relative to its peers. It reveals that Novo Nordisk on all operating activities is more cost efficient than its peer group average, and thus appear to have a significant competitive advantage. The analysis also reveals that marketing, selling and administration is the most important function to monitor in the valuation as the costs make up the majority of the operating expenses. The fact that Novo Nordisk’s R&D expenses make up a smaller fraction of the revenue relative to its peer group confirms that the big pharma companies are significantly investing in R&D to prepare for the future competitive landscape. This confirms the conclusion from Porter’s five forces that the future in the pharmaceutical market lies in the companies’ ability to develop and market new innovative products.

Existing obesity drugs in the U.S. and their companies
The previous section analysed Novo Nordisk’s competitive position relative to its peer group. The analysis also revealed that Novo Nordisk is the only one from the “Big pharma” companies that has entered the market for obesity pharmaceuticals in the U.S. though Novo Nordisk’s primary competitors are researching heavily into other therapeutic areas. However, there are currently other pharmaceuticals for treatment of obesity on the American market released by companies much smaller than Novo Nordisk. These companies were not included in the peer group for the value chain analysis as their size, risk profile and general characteristics are much different from Novo Nordisk. Thus, they cannot be regarded as comparable companies. However, an analysis of the companies and their obesity products is necessary in order to obtain a thorough understanding of the competitive landscape on the obesity market but is it also vital in terms of being able to conduct a sound revenue estimate of NN9536 which will be needed when valuing the product.

In the following section, each of the 4 biggest FDA approved branded pharmaceuticals for obesity treatment is introduced.

Saxenda by Novo Nordisk
In 2015, Novo Nordisk launched the obesity product under the brand name Saxenda, which was Novo Nordisk’s first entry into the market for anti-obesity treatment. The product has obtained broad commercial access in America and is the most widely used pharmaceutical for treatment of obesity. The product is now launched in 41 countries. It contains the active pharmaceutical ingredient (API) liraglutide, which Novo Nordisk has patented. The patent expires in 2023 in America.

In the United States, Saxenda accounted for 52% of the total value of anti-obesity medications in 2017, which corresponds to 4% of the total volume market share.62

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62 Novo Nordisk annual report 2018 p. 35
As seen from the above chart, the sales of Saxenda are expected to peak in 2022 – one year before patent expiration.

The recommended dosage for Saxenda is 3mg daily of the active pharmaceutical ingredient (API), liraglutide. Saxenda is a subcutaneous solution meaning that the patient has to inject the solution into the abdomen, thigh or upper arm. (note: drugs.com). The price of Saxenda on the American market is 1.311 USD for a pack containing 90 mg of the API, which lasts for 30 days assuming that the patient is following the recommended dosage schedule.

**QSYMIA by Vivus Inc.**

Vivus is an American company with annual revenues at around 400 mDKK. The company is developing therapies to address obesity among other diseases and launched the product Qsymia in 2012 in the United States – an orally taken capsule intended for treatment of obesity. The recommended dosage of Qsymia is a tablet once daily. The products come in a pack containing 30 tablets at the price of 197 USD.

The patent on the active ingredient in the product expires in 2020 in the United States. Currently, Qsymia is approved for sale in the U.S. The company expects the sales of Qsymia to hit a significant decrease upon patent expiration in 2020.64

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63 Own creation based on market research report p. 7-19
64 Market research report p. 45
BELVIQ by Eisai Co., Ltd.
Belviq is an anti-obesity drug launched in the U.S. in 2013 by the global pharmaceutical company, Eisai. The product comes as a tablet and should be taken orally twice daily. It comes in a pack containing 60 tablets at the price of 321 USD.\(^{65}\)

CONTRAVE by Takeda
Orexigen therapeutics (Orexigen) is a company focused entirely on the treatment of obesity. The company has only one marketed product in the United States, which sells under the brand name Contrave and was commercially launched in the U.S. in 2014 and the company holds a patent for the use of Contrave for the treatment of obesity, which expires in 2024.\(^{66}\) Contrave comes in a tablet form and should be taken twice daily. It comes in a pack of 70 tablets at the price of 257 USD.

The below table sums up the main properties for each of the above mentioned pharmaceutical drugs for treatment of obesity. As the table shows, Saxenda is the only injectable treatment option on the market with a sales price significantly above the other products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Company</th>
<th>Form</th>
<th>Year of U.S. launch</th>
<th>Patent expiration</th>
<th>Daily dose</th>
<th>Unit price (USD)</th>
<th>Units per product</th>
<th>Cost per product (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belviq</td>
<td>Eisai</td>
<td>Tablet</td>
<td>2013</td>
<td>2023</td>
<td>2</td>
<td>5.35</td>
<td>60</td>
<td>321</td>
</tr>
<tr>
<td>Qsymia</td>
<td>Vvus</td>
<td>Tablet</td>
<td>2012</td>
<td>2020</td>
<td>1</td>
<td>6.55</td>
<td>30</td>
<td>197</td>
</tr>
<tr>
<td>Contrave</td>
<td>Orexigen</td>
<td>Tablet</td>
<td>2014</td>
<td>2024</td>
<td>2</td>
<td>3.67</td>
<td>70</td>
<td>257</td>
</tr>
<tr>
<td>Saxenda</td>
<td>Novo Nordisk</td>
<td>Subcutaneous (mg)</td>
<td>2015</td>
<td>2023</td>
<td>3</td>
<td>14.57</td>
<td>90 (mg)</td>
<td>1,311</td>
</tr>
</tbody>
</table>

Despite other pharmaceutical alternatives, which are all oral solutions at lower prices, and thus intuitively more comfortable treatment options, Novo Nordisk has managed to become the market leader on the American obesity market with Saxenda. Part of the reason for this can be found in the high degree of efficacy in the API liraglutide that has made liraglutide the number one choice among healthcare providers. However, the primary reason for Novo Nordisk’s rapid overtake of the American obesity market, is that the company has managed to use its name as a well-established pharmaceutical company with high-quality products to gain marketshare in this new therapy area.

\(^{65}\) market research report p. 43
\(^{66}\) Market research report p. 33
\(^{67}\) Own creation
The chart above illustrates just how fast Novo Nordisk has become the market leader on the U.S. obesity market. Today, Saxenda accounts for 55% of the total market value of the U.S. obesity market while the other obesity drugs seem to have hit a plateau in market share.

Now that we have better understanding of Novo Nordisk competitive position, its key strategic priorities and the growth and margin potential of the industry, we now move on to forecasting the future cash flows for NN9536.

**Estimation of future cash flows of NN9536**

In the previous section, Novo Nordisk’s key strategic priorities were identified. Moreover, the analysis provided insights about the future growth and margin potential for the company. Based on these findings, an estimation of the future cash flows of NN9536 can be conducted. In order to do so, a forecasting template that reflects the underlying economics of Novo Nordisk and that ensures articulation of the pro forma statement, needs to be designed. Moreover, the product cycle (i.e. forecasting period) of the product needs to be defined.

**Choice of forecasting period**

Table xx in the strategic analysis including the average duration estimates of the clinical phases will be used as referene in the valuation.

As stated in the strategic analysis, the American standard for patent rights are 20 years from the date of application meaning that the launch of the product is usually years after the patent application. Also, NN9536 is currently in phase 2 meaning that the project has already pasted the preclinical phase and phase 1. It is expected that NN9536 will proceed to phase 3 a year from now and hereafter the
project will enter the FDA approval process. According to table xx in the strategic analysis, the average duration time for phase 3 is 2.5 years and 1 year for approval, meaning that the project is expected to reach the market in 2024.

Due to the fierce competition from generics that occurs after patent expiry, it is expected that NN9536 will be taken off the market within 6 years after patent expiry. This gives us a total forecasting period of 19.5 years.

Design of the forecasting template

For the design of the forecasting template, a sales-driven approach is chosen where the different accounting items such as operating expenses are driven by the expected level of activity (i.e. revenue). The forecasting template distinguishes between strategic value drivers and financial value drivers. A strategic value driver is defined as strategic or operational initiative that can be undertaken by the company with the purpose of improving value. In this case, the strategic value driver of Novo Nordisk is the development a new pharmaceutical for obesity and to further dominate the market for obesity in the U.S.

A financial value driver is a financial ratio number that mirrors the company’s underlying performance, such as growth rates, margins or investment ratios. When choosing the design of financial the value drivers is it important to choose the appropriate level of aggregation in the template. For instance, if the purpose of the analysis is short-term forecasting, a more refined approach would be chosen with many different financial value drivers.

In this thesis however, the purpose of the analysis is to forecast the entire cash flow potential of the NN9536. Thus, we choose a fairly aggregated value driver setup with fewer financial value drivers than what would have been the case if we only were to forecast one year ahead. This is primarily due to the fact that information tends to become less accurate the further in advance forecasts are made.

The financial drivers included in the following forecasting template are:

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69 Own creation
70 Plenborg & Petersen, 2009: “Financial statement analysis”, p. 128
Estimation of future sales of NN9536

For the estimation of future sales of NN9536, we first estimate the peak sales of the product, defined as the maximum sales the drug will reach in its lifecycle. The earlier stage a development project is in, the less we know about the product’s future sales potential and efficacy and the more challenging it is to estimate the peak sales of the product. Once the project advantages, more information about the details of the drug is available such as its safety and efficacy, dosing schedule and price, which calls for a more detailed estimation of future sales. In this case, the project in scope for valuation is the development project NN9536, currently in phase 2. Hence, we do not have any information about NN9536’s dosing schedule or safety and efficacy. In order to estimate a peak sales for NN9536 that is as precise and justifiable as possible, a top-down approach is therefore chosen. The total value of the U.S. obesity market is defined and then the future market share of NN9536 is estimated.

Total value of U.S. obesity market

As stated in the strategic analysis, the value of American obesity market is expected to increase from 3.8 bDKK in 2016 to 7.6 bDKK in 2026 corresponding to an CAGR of 8%. Growth will primarily be driven by increase in use of branded pharmaceuticals to treat obesity, as well as the rising prevalence of the disease.72

Currently, Novo Nordisk accounts for 55% of the total value of the U.S. obesity market being the only pig pharma company to have launched an FDA approved treatment solution for obesity, Saxenda. The U.S. peak sales for Saxenda is expected to be 4.483 mDKK in 2022, which by the time will correspond to 80% of the total obesity market value. Where Saxenda is a once-daily injectable treatment solution, NN9536 will be a once-weekly treatment, which obviously is more comfortable for the patients. Due to the superior convenience of NN9536 relative to Saxenda, I do expect NN9536 to capture a significant value market share.

However, as the strategic analysis stated, the pharmaceutical industry is facing intense competition and many of the big pharma companies are researching intensly for launching products in new therapy areas to fight the inevitable threat of generic pharmaceuticals. Therefore, I do not expect

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71 Own creation
72 Market research report p. 23
NN9536 to obtain a value share of the U.S. market at the size of Saxenda’s. Based on Novo Nordisk’s strong competitive position in the U.S. and the fierce competitive outlook of the obesity market, I expect NN9536 to capture a value market share of 20% at the time of its peak sales, corresponding to a peak sales of 2.215 mDKK.

The peak sales corresponds to the sales once NN9536 reaches its maximum market share. It is unrealistic to assume the peaksales will happen in the first year after product launch. Therefore, an uptake curve is used for modelling of the sales for the entire product lifecycle, which describes how fast the product reaches its full market share.

Using the expected uptake curve of Saxenda as reference, I expect NN9536 to reach its full market share (i.e. peak sales) 7 years after market launch in 2031. Due to the convenience of NN9536, the uptake is expected to be rather fast with a sharp decline after patent expiry.

### Cost of goods sold

Cost of goods sold refers to the direct cost attributable to the production of the goods sold for NN9536. The costs include the cost of the materials used in production along with the direct labour costs. It excludes indirect costs such as distribution costs and sales force costs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Novo Nordisk</th>
<th>Peer group average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>15.4%</td>
<td>29.19%</td>
</tr>
<tr>
<td>2015</td>
<td>15.0%</td>
<td>28.67%</td>
</tr>
<tr>
<td>2016</td>
<td>15.37%</td>
<td>29.28%</td>
</tr>
<tr>
<td>2017</td>
<td>15.75%</td>
<td>28.35%</td>
</tr>
<tr>
<td>2018</td>
<td>15.75%</td>
<td>28.07%</td>
</tr>
</tbody>
</table>

Novo Nordisk’s cost of goods sold has remained relatively stable over the past 5 year of around 16% of the net revenue - significantly lower than peer group.
As stated in the Porter’s five forces analysis, the bargaining power of Novo Nordisk’s suppliers are low due to the fact that the materials being bought is available from a large number of different suppliers. Moreover, being one of the leading pharmaceutical companies in the world further brings down the bargaining power of the suppliers.

In addition to that, Novo Nordisk have had an increasing focus of streamlining its production facilities, among other things by investing in a large state-of-the-art production facility in the U.S.

It is expected that Novo Nordisk will be able to take advantage of its competitive advantage while NN9536 is on the market by optimizing its supplier agreements and by further streamlining production, which will lead to a marginal decrease in COGS relative to revenue.

Therefore, this financial value driver is set to start out at the level of its historical average and then decrease by 1 percentage point every fifth year over the lifetime of NN9536.

[Graph showing the cost of goods sold of NN9536]

**Marketing, selling & administration**

Administration has historically made up a small fraction of Novo Nordisk’s revenue and in accordance with the aggregated design of the forecasting template, I have chosen to integrate the administration expenses with marketing and selling costs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Novo Nordisk</th>
<th>Peer group average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>26.16%</td>
<td>29.18%</td>
</tr>
<tr>
<td>2015</td>
<td>26.23%</td>
<td>29.20%</td>
</tr>
<tr>
<td>2016</td>
<td>25.39%</td>
<td>28.01%</td>
</tr>
<tr>
<td>2017</td>
<td>25.37%</td>
<td>27.80%</td>
</tr>
<tr>
<td>2018</td>
<td>26.29%</td>
<td>26.61%</td>
</tr>
<tr>
<td>Average</td>
<td>25.89%</td>
<td>28.16%</td>
</tr>
</tbody>
</table>

Novo Nordisk’s spending on marketing, selling and administration as a percentage of revenue has historically been slightly lower than peer group average. One explanation to this could be that the

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74 Own creation
company has been able to take advantage of its strong business relationship with its core marketing channels such as pharmaceutical sales representatives and wholesalers, which has led to reduced spending on these activities. However, in the first year after market launch, Novo Nordisk is expected to significantly increase its expenditures on promotional activities of NN9536 to ensure a fast uptake in sales. Hence, marketing, selling and administration is expected to be 270% of revenue in the first 1 years primarily driven by increased marketing expenses. This corresponds to a market launch cost of 600 mDKK.

The distribution costs for NN9536 is expected to be fairly stable throughout the forecasting period. This is primarily due to the fact that Novo Nordisk plans on producing NN9536 in the U.S., which thereby stabilises the distribution costs as the products can be distributed freely without any customs fee or risks of any major logistitical delays.

1 year after product launch, the marketing, selling and administration costs is expected to stabilise around its historical average of 25 %, which primarily is made up by distribution costs.

![Marketing, selling & admin. of NN9536](image)

**Launch cost of 600 mDKK in case of launch**

**R&D expenses**

While the other forecasting accounting items all have been driven by expected level of revenue, the R&D expenses for NN9536 is only expected in the development phase of the project – i.e. before any revenue is generated.

The project is currently in phase 2, and has thus already incurred cost to pass through the previous clinical phases. These costs will be treated as sunk costs in the valuation and will thus be ignored. Hence, the only costs including for the valuation in the remaining costs of the phase 2 trial (expected to be finalised in 1 year), the costs for the entire phase 3 trial and the cost for submitting regulatory approval.

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75 Own creation
As table xx in the strategic analysis was used as reference in determining the duration of the clinical trials for the forecasting period, the table will also be used as reference in determining the costs for the clinical trials. The costs are divided into clinical and non-clinical costs, where non-clinical includes costs related to project management, investigator fees etc. The clinical costs includes costs for drug supply primarily. As I do not expect any significant investments related to the clinical trials, the costs are distributed evenly throughout the duration of each clinical phase.

![R&D expenses for NN9536 (mDKK)](image)

**Tax rate**

As stated in the strategic analysis, the US tax reform of 2017 reduced the U.S. federal corporate income tax rate from 35% to 21%. Novo Nordisk’s historical average effective tax rate (that is, income taxes as a percentage of profit before income taxes) has been relatively stable around 21%.

<table>
<thead>
<tr>
<th>Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novo Nordisk</td>
<td>22.30%</td>
<td>19.00%</td>
<td>20.70%</td>
<td>21.70%</td>
<td>18.90%</td>
<td>20.68%</td>
</tr>
</tbody>
</table>

For the valuation of NN9536, the company’s average historical tax rate of 21% will be used for the entire forecasting period. (Note see plenborg s. 265 nederst for effective tax)

Moreover, the taxable income in the development phase of the project will be treated as a deferred tax asset so that Novo Nordisk is entitled to use the loss in that period in order to lower its taxable income once NN9536 starts generating profits.

**Net working capital**

Working capital is defined as current assets less current liabilities and measures the liquid assets Novo Nordisk has available for its business.

<table>
<thead>
<tr>
<th>Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novo Nordisk</td>
<td>16.16%</td>
<td>15.55%</td>
<td>15.01%</td>
<td>16.13%</td>
<td>19.90%</td>
<td>16.55%</td>
</tr>
<tr>
<td>Peer group average</td>
<td>7.45%</td>
<td>7.19%</td>
<td>7.44%</td>
<td>8.53%</td>
<td>7.11%</td>
<td>7.54%</td>
</tr>
</tbody>
</table>
As above table reveals, Novo Nordisk has been able to fully cover its short-term liabilities, which shows in a historical NWC average of around 17%.

Working capital usually increases with growth as higher sales are associated with higher accounts receivable and inventories. However, as sales decline after patent expiry, a corresponding decline in accounts receivable and inventories are expected, resulting in a decrease in working capital. As a result, this value driver is expected to be slightly above its historical average during the first years after product launch where the sales uptake is high, but will stabilise around 17% after peak sales has been reached in 2031. After patent expiry in 2033, NWC will approach its peer-group average of around 8% due to lower sales and competition from generics.

![Net working capital of NN9536](image)

**Depreciation & Net financial expenses**

The development of NN9536 is completely equity financed and the project does not require any investments in non-current assets. As stated in the strategic analysis, Novo Nordisk has invested in a large production facility in the US which will house the production of the API for NN9536. However, the plant will also be used for production and manufacturing of other Novo Nordisk pharmaceuticals, so the investment cost for the plant is expected to be depreciated on a consolidated level.

As for the net financial expenses, there will be none, since no foreign capital is raised for the project.

**Estimating discount rate**

As the DCF method will be used for the valuation of NN9536 without flexibility, I apply WACC as the discount rate

\[
WACC = \frac{NIBD}{(NIBD + E)} \times \tau_d \times (1 - t) + \frac{E}{(NIBD + E)} \times \tau_e
\]

---

76 Own creation
However, as the project is 100% equity financed there is no creditors to compensate for the risk they bear by investing in the project. Hence, the D/E ratio is 0 % meaning that WACC equals the owner’s required rate of return, $r_e$.

For estimation of $r_e$, I apply CAPM, expressed as $r_e = r_f + \beta_e \times (r_m - r_f)$ cf. section x.x

For the risk-free rate, I choose a Danish government bond with a maturity of 10 years since the cash flows generated from NN9536 are denominated in DKK. The current rate of a 10-year Danish government bond is -0.08%.\(^77\) The interpretation of this is that an investor is better off by keeping his money in his wallet than having to pay interest on a risk-free investment. The practical implication of discounting cash flows with a negative rate is that the present value of the cash flow will be higher than the future value of the cash flow, which implies that the investors are willing to pay for an investment in the asset. As this scenario does not comply with the context of NN9536, I choose a risk-free rate based on historical monthly returns of a 10-year Danish government bond for the past 5 years, which is 0.58%.

For the beta-value, I use the OMX C25 index as the market portfolio and calculate the $\beta_e$ of Novo Nordisk to 1.38. However, given the practical implications of calculating $\beta_e$ using historical observations as explained earlier, I compare my beta-value to the value calculated from various financial institutes and take an average of these values. Hence, I arrive at $\beta_e = 1.41$.

The market portfolio risk premium is estimated from empirical studies and is set to 5.30%.

<table>
<thead>
<tr>
<th>Owner’s required rate of return</th>
<th>Beta value for Novo Nordisk</th>
<th>Annual rate - 10 year Danish bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-free rate</td>
<td>0.58%</td>
<td>Own calculation (1Y daily) 1.38</td>
</tr>
<tr>
<td>$r_f$</td>
<td>1.41</td>
<td>Reuters.com May-2019 0.08%</td>
</tr>
<tr>
<td>Market risk premium ($r_m - r_f$)</td>
<td>5.30%</td>
<td>CNBC.com May-2017 0.40%</td>
</tr>
<tr>
<td>D/E ratio</td>
<td>0.00%</td>
<td>FT.com May-2016 0.71%</td>
</tr>
<tr>
<td>$r_e$</td>
<td>8.05%</td>
<td>Yahoo Finance (3Y monthly) 1.44</td>
</tr>
<tr>
<td>WACC</td>
<td>8.05%</td>
<td>Avg beta 1.41 avg. Risk-free rate 0.58%</td>
</tr>
</tbody>
</table>

**Calculation of DCF value of NN9536**

Now that all necessary parameters have been estimated, the present value of the future cash flows generated from sales of NN9536 in the US can be estimated.

\(^77\) Statistikbanken.dk
### Market launch

<table>
<thead>
<tr>
<th>Income statement, NOK536</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>221.5</td>
<td>501.1</td>
<td>913.5</td>
<td>1378.7</td>
<td>1682.6</td>
<td>1975.7</td>
<td>2647.6</td>
</tr>
<tr>
<td>COGS</td>
<td>34.7</td>
<td>87.9</td>
<td>143.1</td>
<td>215.9</td>
<td>285.1</td>
<td>298.7</td>
<td>390.2</td>
</tr>
<tr>
<td>Brutto result</td>
<td>186.9</td>
<td>413.2</td>
<td>766.4</td>
<td>1162.8</td>
<td>1397.5</td>
<td>1676.9</td>
<td>2257.4</td>
</tr>
<tr>
<td>Sales &amp; admin expenses</td>
<td>66.5</td>
<td>168.3</td>
<td>236.5</td>
<td>356.9</td>
<td>438.2</td>
<td>511.5</td>
<td>536.1</td>
</tr>
<tr>
<td>R&amp;D expenses, Clinical</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>R&amp;D expenses, non-clinical</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>EBITDA</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>EBIT</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Interest</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>PBT</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Income before tax</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Tax</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Net earnings</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
</tbody>
</table>

#### Deferred tax asset

-229.6  -185.6  -53.4  115.8

#### Net working capital

48.5  123.4  210.1  330.9  408.3  454.4  471.0

#### Determining FCF:

<table>
<thead>
<tr>
<th>Year</th>
<th>01-01-2024</th>
<th>01-01-2025</th>
<th>01-01-2026</th>
<th>01-01-2027</th>
<th>01-01-2028</th>
<th>01-01-2029</th>
<th>01-01-2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBIT</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Tax on EBIT</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>NOPAT</td>
<td>120.4</td>
<td>304.9</td>
<td>529.0</td>
<td>809.0</td>
<td>984.4</td>
<td>1174.6</td>
<td>1217.3</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Changes in net working capital</td>
<td>49.5</td>
<td>40.7</td>
<td>120.8</td>
<td>20.4</td>
<td>41.8</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td>Cash flow from Operations</td>
<td>165.9</td>
<td>361.8</td>
<td>620.6</td>
<td>809.0</td>
<td>857.0</td>
<td>975.1</td>
<td>976.2</td>
</tr>
<tr>
<td>Inv. non-current assets</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Free cash flow to the firm</td>
<td>165.9</td>
<td>361.8</td>
<td>620.6</td>
<td>809.0</td>
<td>857.0</td>
<td>975.1</td>
<td>976.2</td>
</tr>
<tr>
<td>Net financial expenses after tax</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Changes NBD</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Free cash flow to equity holders</td>
<td>165.9</td>
<td>361.8</td>
<td>620.6</td>
<td>809.0</td>
<td>857.0</td>
<td>975.1</td>
<td>976.2</td>
</tr>
</tbody>
</table>

#### Days between cash flows

0.0  3.8  7.1  10.6  14.1  18.7  21.9

#### T-value

0.0  0.0  0.0  0.0  0.0  0.0  0.0

#### Discount factor

1.0  0.93  0.86  0.79  0.73  0.68  0.63

#### PV

165.9  353.3  512.0  629.5  626.0  602.4  614.4

---

**Continued**
Hence, the present value for NN9536 at year 2024 is 5,821.4 mDKK without considering the R&D expenses, the launch of cost, the private risk of the cash flows and the managerial flexibility.

**Step 2: Adjust Present value of NN9536 for private risk, \( rPV \)**

The foundation of the valuation has now been conducted in the form of an estimated PV of NN9536 of 5,821.4 mDKK by the time of market launch in 2024.

I now move on to account for the private risk inherent in the development of the product.

In the theoretical section, the average success rates for metabolic diseases was introduced. These success rates serve as a foundation for adjusting the cash flows for private risk. However, given that NN9536 is currently in clinical phase 2 and is expected to enter phase 3 a year from now, I will apply a slightly higher success rate for phase 2 completion than the rate introduced in strategic analysis.

The decision tree for Novo Nordisk can be visualized as follows:

The accumulated probability for the project entering the market is now multiplied with the future cashflows:

Hence, the risk-adjusted present value (\( rPV \)) of NN9536 on 01-01-2024 is 2,557.5 mDKK while not considering the development costs.

**Step 3: Incorporate managerial flexibility into the project:**

Having adjusted the static PV of NN9536 for the private risk inherent in the development phase, I now incorporate managerial flexibility into the project.

---

74 Own creation
75 Own creation
This risk-adjusted estimate derived in previous section is based on a set of fixed input parameters that are assumed to be fixed throughout the entire project lifetime. As discussed in the theory section, this poses a challenge for the management responsible for the project as the project needs to be valued today on stop/go basis. Therefore, real option analysis can be applied to identify the options available for management to change to course of the project during its lifetime.

**Identification of real options for NN9536**

NN9536 is expected to be launched in the US in 2024. Cf. section xx, Novo Nordisk already has an obesity pharmaceutical on the US market under the brand name Saxenda. Saxenda is expected to reach its peak sales in 2022 – two years prior to expected market launch of NN9536. However, at the time of the peak sales of Saxenda, Novo Nordisk is expected to hold 80% of the total value of the US obesity market. It is likely, that launching a new product into the market will cannibalize some of the revenue generated from Saxenda. Hence, Novo Nordisk may choose to defer the launch of NN9536 to benefit longer from the high revenues of Saxenda – a real option to defer. Assuming that Novo Nordisk can choose to launch the project anytime within a given time range, the real option to defer the project corresponds to an American call option.

**Choosing the real option model**

Since I am to value a real option corresponding to an American call, I choose the binomial model to analyze the option as the B&S model is only applicable for European options (i.e. exercise happens at expiration date)

**Estimation of input parameters**

In order to calculate to value of the option to defer the launch of NN9536 in the US, the option input parameters need to be estimated:

**The value of the underlying asset, \( S_0 \)**

Cf. the MAD assumption, the value of the underlying asset of Novo Nordisk’s deferral option is the PV of the project itself. i.e. \( S_0 = 2.557,5 \text{ DK} \)

**The exercise price, \( K \):**

As explained earlier, when projecting the marketing, selling & administration expenses, the expected launch cost of the first year of product launch is 600 mDKK. Hence, if Novo Nordisk decides to exercise the option of launching NN9536, the exercise price, \( K = 600 \text{ mDKK} \). The option and exercise price can be shown graphically as follows:
The time to expiration, $T$:
The patent for the API in NN9536 expires in 2033 and a substantial decrease in revenue is expected hereafter due to fierce competition from generic manufacturers. The competition is expected to intensify, which eventually will lead to NN9536 being taken off the American market in 2039. This means that the option of deferring the product launch is limited to only a few years because of fierce market conditions. I assume that Novo Nordisk can wait a maximum of 5 years with launching the product before the project turns unprofitable, which yields $T = 5$. I assume that Novo Nordisk can exercise the option of launching NN9536 twice a year - Hence, $\Delta T = 0.5$.

The volatility of the underlying asset, $\sigma$:
As NN9536 is currently in phase 2 of the development phase it is subject to private risk as the risk of completion of the project is related to the efficiency of Novo Nordisk in completing the project and well as the effectiveness of the technology related to the project. Since the private risk of the project was accounted for in step 2, the real option analysis will only be accounting for the market risk of the project.
The PV of NN9536 in influenced by multiple input parameters (i.e. financial value drivers), which each represent a source of uncertainty to the asset value. Since all financial value drivers are market driven, I choose to combine the risk of the financial value drivers into one aggregated volatility estimate. In order to determine which ones to include in the Monte Carlo simulation, I perform a sensivity analysis to explore the key financial value drivers that have to most significant impact on the project value. The base-case values in the below table are the likely values of the variables that was used previously to budget to future cashflows of the project.
The sensitivity analysis reveals that the project value is relatively insensitive to changes in networking capital and CAGR of US obesity market share. Hence, I choose to exclude these value drivers in the simulation of the volatility factor while including all others.

I now estimate the volatility factor by use of Monte Carlo simulation. I apply the Logarithmic cash flow returns method explained previously where the natural logarithm of the relative returns of each time period is estimated.

\[ k_n = \ln \left( \frac{PV_n}{MV_{n-1}} \right) \]

\( MV_{n-1} \) will represent the base case PV of NN9536 derived previously (i.e. 2557,5 mDKK) and I will simulate \( PV_n \). A probability distribution for each financial value driver is defined and a random value from within its probability distribution is computed. This process is repeated 10,000 times. Hence, thousands of iterations are computed for \( PV_n \) yielding a probability distribution for natural logarithm of the relative returns. The standard deviation for this distribution will represent the volatility factor for NN9536.
A disadvantage of the natural logarithm returns methods is that no value exists for negative returns. However, by applying Monte Carlo simulation and computing thousand of iterations, the probability distribution of the In returns are a good representative for asset volatility.

**Defining probability distribution for financial value drivers**

As the cost for NN9536 can be significantly affected by uncertainty. The uncertainty implies that the cost or any other parameter will vary over some range of values. This range of possible values can be thought as a random variable over this range.

To show the probability of a particular parameter will be realized within a specific range of values, probability distribution is applied.

Before the simulation can be run, each financial value driver needs to be assigned a probability distribution with each average value and standard deviation. As no historical data exists on NN9536 and no financial security mirrors its performance, I apply the base case values used in the DCF valuation as the average values. I will focus on the following probability distributions for the simulation:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Description</th>
<th>Underlying conditions</th>
</tr>
</thead>
</table>
| Normal       | Used to describe many natural phenomena such as inflation | - Some value of the unknown variable is the most likely (the mean of the distribution)  
- The unknown variable is just as likely to be above the mean as under the mean  
- The unknown variable is more likely to be close to the variable than far away |
| Triangular   | Used when the minimum, maximum, and most likely value is known with high certainty | - The minimum value is fixed  
- The maximum value is fixed  
- The most likely values is between the minimum and maximum. (hence the triangular shape) |
| Discrete uniform | Discrete probability distribution. Outcome of rolling a dice is discretely uniformly distributed | - Minimum value is fixed  
- Maximum value is fixed  
- All integer values between minimum and maximum are equally likely to occur |
| Lognormal    | Used where values are positively skewed and where prices cannot become negative. | - The unknown variable can increase without bound but cannot decrease below zero  
- The distribution is positively skewed  
- The natural logarithm of the unknown variable yields a normal curve |

I choose a triangular probability distribution for the following value drivers:

- Market share of NN9536 at the time of peak sales
- COGS
- Marketing, selling & admin.
- Corporate tax rate
- WACC

---

82 Own creation based on CrystalBall software application
As the most likely value of these variables have been based on thorough strategic analysis, their likely values are known with relatively high certainty. However, I choose min/max values of \(-/+/15\%\) of base values from the DCF valuation.

For the probability distribution of the sales uptake curve of NN9536, I choose a discrete uniform distribution. This is justified by the fact that the project’s sensitivity to sales uptake is high and that there is great uncertainty as to when peak sales will be reached. I have assumed three plausible scenarios for sales uptake – each uptake curve assumes that peak sales can be maintained for 2 years after peak sales has been reached. (See graph)

For the fast uptake curve, peak sales will happen in 2027 and for the slow uptake curve, peak sales will happen in 2032. Hence, a total range of 6 years where peak sales can occur. Therefore, I choose a discrete uniform probability distribution for this input variable with a minimum value of 3 and a maximum of 8.

Now that each financial value driver has been assigned a probability distribution, I apply the software application CrystalBall to simulate a value of \(PV_n\) while holding \(MV_{n-1}\) constant:

Using formular \(k_n = \ln \left( \frac{PV_n}{MV_{n-1}} \right)\) derived previously, I now conduct 10,000 iterations of the natural logarithm of the relative return in CrystalBall and get the following probability distribution:

---

83 Own creation
$k_n = \ln\left(\frac{PV_n}{MV_{n-1}}\right)$ follows a lognormal probability distribution and has a standard deviation of 24.829% Hence, I will apply this estimate for the volatility factor for NN9536.

**The riskfree rate, $r_f$:**
Similar to the DCF model, I will apply Danish government bond with a maturity of 10 years as the risk-free rate. Whereas the rate was discretely compounded in the DCF model, the binomial model uses continuously compounded discount rates.

$r_f = \ln(1 + 0.58\%) = 0.578\%$

**Leakage rate, $\delta$:**
If Novo Nordisk decides to exercise the option of deferring the launch of NN9536, the leakage rate is presumably high due to fierce competition of generic manufacturers after patent expiry. An adjustment to the option valuation model is therefore made for the leakage rate as the option would otherwise be incorrectly priced. To keep matters simple, I apply a constant annual leakage rate of 20% implying that Novo Nordisk will experience a 20% loss of revenue for every year the project is deferred. The rate is justified by the fact that all uptake curves for sale of NN9536 considered in this thesis show a drastic decline in sales after patent expiry.
Calulation of option parameters

The previous section defined the following input parameters for the valuation of the deferral option of NN9536:

- \( S_0 = 2557.5 \text{ mDKK} \)
- \( X = 600 \text{ mDKK} \)
- \( T = 5 \text{ years} \)
- \( \Delta T = 0.5 \text{ years} \)
- \( \sigma = 24.829\% \)
- \( r_f = 0.578\% \)
- \( \delta = 20\% \)

Based on these input parameters, I now calculate to option parameters by use of the risk-neutral approach discussed previously to be able to construct the binomial lattice:

- \( u = e^{0.24829\times\sqrt{0.5}} = 1.192 \)
- \( d = \frac{1}{0.192} = 0.839 \)
- \( p = e^{\left(0.00578-0.2\right)\times0.839-0.839} = 0.194 \)

The parameters \( u \) and \( d \) are multiplied by the asset value in \( S_{n-1} \) and for each time period until expiration of the option in year 2029.

The parameter \( p \) is the risk-neutral probability of an up-movement in the asset value and is used to calculate the option values in each if the intermediate nodes.

Construction of binomial lattice

Based on these parameters, a construction of a binomial lattice can be made. The lattice represents the different possible outcomes of NN9536 and the corresponding option values over the course of the five year period. The life of the option is divided into 10 time steps. In each of the time steps, there is a binomial asset price movement. The lattice is recombining meaning that the branches come back to the same point. The notations at each node represents the path of the underlying asset from its starting point in year 2024. Hence, if the asset has an up-movement for three periods followed by two down-movements, the notation for this node will be \( S_0 u^2 d^2 \).

The terminal nodes in H2-2029 \( (S_0 u^{10} - S_0 d^{10}) \) are calculated as \( \text{Max}(S_t - X, 0) \).

\( S_0 u^{2} - S_0 d^{10} \) is the spread of the uncertainty cone, where each of the end nodes represent the extreme values of the project in the sense that these values are the least likely to occur.

The option values, \( f_n \) at each note (white cells) is calculated using backward induction. The option values in period H1 in 2029 are equal to the end-of-period payouts multiplied by their risk-neutral
probabilities and then discounted at the risk-free rate. This can be calculated by use of the equation

\[ f = e^{-r \Delta T} [pf_u + (1 - p)f_d] \]

Hence, \( f_{u^2d^2} = e^{-0.00578 \times 0.5} [0.194 \times 7.033 + (1 - 0.194) \times 5.162] = 5.554 \) and so forth.

## Terminal nodes (2029H2):

At each of the terminal values, the management of Novo Nordisk has the option to either exercise the option of launching NN9536 at a cost of 600 mDKK or letting the option expire and abandoning the project.

A notable feature of the binomial lattice is that at terminal node \( S_0u^5d^5 \) the value of NN9536 is 5.2821 mDKK, which is exactly the same value as in \( S_0 \). Hence, the middle node of the terminal period corresponds to the DCF value of the project where it is assumed that market conditions are

---

85 Own creation
unchanged. This implies that at zero volatility, the binomial lattice will become a straight horizontal line where all asset values are based on the static DCF calculation. But as the volatility of the underlying asset increases, the spread of the uncertainty cone gets bigger, and so does the option values.

At the upper-most terminal node, \( S_0u^{10} \), the value of NN9536 is 14.801 mDKK. If the management of Novo Nordisk exercises the option and spends 600 mDKK of the product launch, the corresponding option value is \( \text{Max}(14.801 - 600; 0) = 14.201 \). Given that the overall objective of Novo Nordisk (and any other rational investor) is to maximize the return of the investment, Novo Nordisk would choose to exercise the option and launch the product.

At node \( S_0d^{10} \), the value of NN9536 has decreased to 442 mDKK. Given the exercise price of 600 mDKK, Novo Nordisk will choose not to exercise and thus not launching NN9536 on the US market.

At first glance, the values at both ends of the terminal period seem extreme given the fact that the life of the option is only 5 years. However, the extreme values are justified by the fact that these scenarios are the least likely to occur.

**Intermediate nodes (2025H1 – 2029H1):**

At \( S_0d^9 \), the value of the project is 527 mDKK. If the management decides to exercise the option at this node, the expected project value is \((527 - 600) = -73 \text{ mDKK}\). Therefore, management will choose not to exercise the option but let it remain open, because the project value of doing so is greater than to exercise. The corresponding option value at node \( S_0d^9 \) is calculated as follows:

\[
f_0d^9 = e^{-0.00578 \times 0.5} \times [0.194 \times 28 + (1 - 0.194) \times 0] = 5
\]

Hence, accounting for the probability of an up-movement in the next period, Novo Nordisk will decide to defer to product launch instead of abandoning the project completely.

Node \( S_0d^9 \) is interesting, because it is the only node in the lattice, where the management can benefit from deferring the project, and thus, benefit from applying real option analysis to the project. In all other nodes, the asset value of exercising is far greater than keeping the option open. This proves that real option analysis offers the most value for the company when the PV of the asset is close to zero.

For projects with high PV’s, ROA does not provide much value in investment decisions, as the additional value of managerial flexibility makes a little difference in deciding whether to proceed with the project. If the NPV is extremely high, the management will most likely invest in the project regardless of the managerial flexibility. On the contrary, in projects with extremely low NPV’s, no amount of flexibility can rescue the project, so real option analysis in these cases are of little use.

**Start node:**

Moving backwards through the lattice, I arrive at the starting point, \( S_0 \). The asset value at this node represents the risk-adjusted present value (rPV) of NN9536 in year 2024 and the corresponding
option represents the risk-adjusted real option value (rROV) of deferring the project. Hence, if NN9536 is launched as soon as the development phase in completed, the rPV in 2024 is \((2557 - 600) = 1957.5\) mDKK. The rPV of the project if Novo Nordisk decides to defer is 376 mDKK. Since \((2557 - 600) > 376\), Novo Nordisk will choose to launch the project right after FDA approval expecting a total rPV of NN9536 of 1957.5 mDKK in the year 2024. In other words, as the static rPV of the project is already positive without considering the managerial flexibility, the real option element does not affect the decision to launch the project right after FDA approval.

**Step 4: Calculation of rNPV of real option value**

In order to calculate the rNPV of NN9536 today (01-06-2019), the development costs are now considered.

The annual development costs are multiplied with the accumulated success rates yielding a row of risk-adjusted cash flows. As discussed earlier, investment costs in the development phase of NN9536 are independent of market forces and is thus primarily subjected to private risk. Therefore I apply a different discount rate than the WACC used to discount the future cash inflows of the project.

Theoretically, I would apply the risk-free rate of a government bond, but due to the fact that it is difficult to completely separate market risk from private risk and that the success rate may not truly account for all the risks, I apply a discount rate slightly higher than the risk-free rate. The discretely compounded risk-free rate applied in the DCF valuation of NN9536 was 0.58% derived from the historical monthly returns of a 10-year Danish government bond for the past 5 years.

Accounting for the above mentioned reasons to apply a discount rate marginal higher than the risk-free rate, I apply a rate of 1% to discount the cash flows of NN9536 related to private risk. (discretely compounded)

To calculate a total rNPV of NN9536, the rPV of NN9536 of 1.957.5 mDKK in year 01-01-2024 is discounted back to today (01-06-2019) using the rate of 1% as well, as there is no market-driven uncertainty to this value in the period 01-01-2024 – 01-06-2019. The calculations are summarized in below table:
Therefore, as the real option analysis revealed that the optimal launch date of the project was immediately after FDA approval, the expected rNPV of NN9536 on 01-06-2019 is 1.275,1 mDKK.

The effect of leakage rate on real option value of NN9536

In previous section, it was decided to launch NN9536 immediately after FDA approval, as the binomial lattice revealed a small option value of deferring the launch. This decision was based on an assumed annual leakage rate of 20% for every year the launch was deferred due to significant loss of market share (i.e. revenue) after patent expiry in 2033.

Below graph depicts the effect of leakage rate the option value for NN9536 and reveals, not surprisingly, that the option value decreases as the leakage rate increases.

---

86 Own creation
87 Own creation
As explained in the strategic analysis, pharmaceutical companies hold the right to file for a patent extension in the US on a pharmaceutical drug after successful FDA approval and the patent can be extended for up 14 years after FDA approval. Assuming that Novo Nordisk can extend the patent for the full 14 years after FDA approval in 2024, meaning that the patent for NN9536 expires in 2038 instead of 2033, I expect no leakage rate for the project. Ceteris paribus, I now calculate the real option value of the project with zero annual leakage rate.

**Real option value of NN9536 with zero annual leakage rate due to filing of patent extension:**

<table>
<thead>
<tr>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>H2</td>
<td>H1</td>
<td>H2</td>
<td>H1</td>
<td>H2</td>
<td>H1</td>
</tr>
</tbody>
</table>

The calculations of the asset values in each node of the lattice are exactly the same as in the first binomial lattice.

In the absence of leakage rate, the risk-neutral probability for an up-movement in the project value has increased from 19.4% to 46.4%.
As the lattice reveals, all asset values of NN9536 are unaffected by the decrease in leakage rate. However, the corresponding options representing the value of deferring the project, have increased. The logic behind the increase in quite intuitive: if there is no revenue loss (leakage rate) of deferring the project launch, Novo Nordisk might as well decide not to exercise the option and let it remain open and assess how the market conditions unfold.

Working backwards through the lattice from the terminal nodes, the lattice ends at node $S_0$, which represents the rPV of NN9536 if launched right after FDA approval. The corresponding option value represents the rROV of deferring the launch at a later date.

If the management decides to conduct the market launch at $S_0$, the rPV of the project is $2,557 - 600 = 1,957 \text{ mDKK}$. If, on the other hand, management decides to defer the product launch, the expected rROV of the project is $1,975 \text{ mDKK}$.

Given the overall objective of Novo Nordisk to maximize the return of the project, the management will decide not to exercise the option at $S_0$. Hence the value of deferring the project at $S_0$ represents the overall rPV of the project.

To calculate the total rNPV of the project with zero leakage rate, I apply the exact same method as before: multiplying the annual development costs with the accumulated success rates and discounting them back at rate slightly higher than the risk-free rate. The rROV in 2024 is also discounted back to today with this rate, as there is no market-driven uncertainty to this value in the period 01-01-2024 – 01-06-2019:

<table>
<thead>
<tr>
<th>Year</th>
<th>01-06-2019</th>
<th>01-06-2020</th>
<th>01-01-2021</th>
<th>01-01-2022</th>
<th>01-01-2023</th>
<th>Market launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free cash flows related to private risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INN expenses</td>
<td>-139.5</td>
<td>-366.2</td>
<td>-366.2</td>
<td>244.1</td>
<td>97.7</td>
<td></td>
</tr>
<tr>
<td>Clinical success rates</td>
<td>60%</td>
<td>79%</td>
<td>100%</td>
<td>70%</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>Accumulated success rates</td>
<td>60%</td>
<td>47%</td>
<td>47%</td>
<td>47%</td>
<td>44%</td>
<td></td>
</tr>
<tr>
<td>Days between cash flows</td>
<td>-</td>
<td>356</td>
<td>580</td>
<td>945</td>
<td>1,310</td>
<td></td>
</tr>
<tr>
<td>T-value</td>
<td>-</td>
<td>1.06</td>
<td>2.71</td>
<td>2.59</td>
<td>3.09</td>
<td></td>
</tr>
<tr>
<td>Discount factor</td>
<td>1.00</td>
<td>0.95</td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>rPV of cash flows related to private risk</td>
<td>-139.5</td>
<td>-362.8</td>
<td>-356.4</td>
<td>237.9</td>
<td>94.2</td>
<td></td>
</tr>
<tr>
<td>Risk-adjusted PV of R&amp;D (rPV)</td>
<td>-83.7</td>
<td>-171.6</td>
<td>-168.7</td>
<td>-112.6</td>
<td>-41.4</td>
<td></td>
</tr>
<tr>
<td>rNPV (01-06-2019) NN9536</td>
<td>1.899,7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rNPV (01-06-2019) total R&amp;D expenses</td>
<td>578,1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rNPV (01-06-2019) NN9536, mDKK</td>
<td>1.291,6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If management decided to launch NN9536 right after FDA approval, the total static rNPV was 1,275,1 mDKK. If they instead leave the option open and exercise at a later date, the total rNPV is 1,291,6 mDKK.
The difference between these two values represents the value of the managerial flexibility in the option to defer. Hence:

\[
\text{Value of managerial flexibility} = 1.291.6 - 1.275.1 = 16.4 \text{ mDKK}
\]

This means that the managerial flexibility of the deferral option of NN9536 is worth 16.5 mDKK for Novo Nordisk under the assumption of no annual leakage rate of the project.

**Subset on empirical part**

In the empirical part of the thesis, the modified T&V model was used to value the phase 2 development project, NN9536 in the US. The project, carried out by Novo Nordisk, is investigating the effect of injectable semaglutide on obesity treatment.

Applying the modified T&V model to the valuation on this project was justified by the fact that the project faces private risk as well as market risk. Moreover, given fierce competition from generic manufacturers and challenges with patent expirations, there is great uncertainty related to the future cash flows of NN9536.

The first step of the valuation process revealed a static present value (PV) of 5.821.4 mDKK without considering the cost of development.

Step 2 of the modified T&V model accounted for the private risk inherent in the project, as the project is currently in phase 2. Therefore the future cash flows were multiplied with the success rates for each of the clinical phases, and yielded a risk-adjusted present value, \( r\text{PV} \) of 2.557.5 mDKK.

In step 3, I incorporated managerial flexibility into the valuation model, and identified an option of deferring the launch of the project with a maximum of 5 years, corresponding to an American call option with \( T=5 \). Due to the patent expiry, I applied a constant annual leakage rate of 20%. The binomial lattice revealed a risk-adjusted real option value, \( r\text{ROV} \) of 1957.5 mDKK, which was similar to the \( r\text{PV} \). Therefore, it was decided to immediately launch the project on the US market after FDA approval.

In step 4, I took development costs into account, and calculated the \( r\text{NPV} \) to 1.275.1 mDKK on 01-06-2019, which thus represented the final value of the project.

To explore the effect of leakage rate on the real option value of NN9536, I recalculated the binomial lattice, where leakage rate was set to 0. This was justified by the fact that Novo Nordisk holds the right to file for a patent extension for up to 14 years after FDA approval, which, theoretically, should yield a leakage rate of 0 if the patent extension is granted.

The lattice revealed a \( r\text{ROV} \) value higher than the \( r\text{PV} \) in year 2024, which implied that Novo Nordisk should rather let the option remain open than exercising immediately.
Discounting the rROV back to 01-06-2019 revealed a total rNPV of 1.291,6 mDKK as oppose to a rNPV of 1.275,6 if the project was launched immediately after launch, yielding a value of the managerial flexibility of 16,4 mDKK.

\[ Value \ of \ managerial \ flexibility = 1.291,6 - 1.275,1 = 16,4 \, mDKK \]

**Discussion of real option application in a real-world context**

In the theoretical part of the thesis, four attributes that can characterize an ideal valuation approach was introduced. The four attributes were:

- Unbiased estimates
- Realistic assumptions
- User friendly
- Understandable output

To assess the practical applicability of using real options as a valuation model, I hold up my results from the empirical part of the thesis against these the four attributes.

**Unbiased estimates:**
Real option uses the DCF model as a foundation for the analysis. In the case of NN9536, the cash flow potential of the project was estimated through a thorough analysis of the competitive position of Novo Nordisk as well as the company’s financial strengths relative to its peers. Therefore, one could argue that the foundation of a real option valuation approach is based on unbiased estimates from the DCF. However, the estimation of the input parameters used in the real option calculations was based on many managerial estimates that could affect the value of the option. For instance, it is difficult to base the number of time steps used in the binomial lattice on a well-founded basis. Also, the volatility factor was estimated through Monte Carlo simulation, where each variable was assigned a probability distribution as well as max/min values. In practice, a variable such as revenue growth or market share will typically not be following an exact probability distribution, which potentially could lead to management intentionally picks probability distribution to bias the volatility factor in their favor. The same argument applies to the estimation of leakage rates, where the analysis showed that a change in leakage rate can have a significant impact on the investment decision.

**Realistic assumptions**
Whereas the inputs to financial options are based historical data of the underlying financial security, some of the parameters for real options are estimated differently. For instance, the security to use as
the value of the underlying asset for real options, is the PV of the asset itself cf. the MAD assumption. Given that the asset is 100% correlated with itself, it could be argued that the MAD assumption for real option analysis is a realistic assumption.

In the case of NN9536, the real option value was priced with a binomial lattice under the assumptions of risk-neutral valuation where investors are assumed to be risk-neutral and where the expected return on any asset is the risk-free rate. Although this assumption is convenient it violates the attribute of realism, as investors do not have identical risk-profiles.

The exercise price for the deferral option of NN9536 was assumed to be 600 mDKK corresponding to the total launch costs of the project. The binomial lattice assumed that the option could be exercised any time throughout the lattice, and did not consider that launching of the project may take years, which obviously violates the assumption of realism.

User friendly

Although the mathematical framework behind real option pricing is highly complex, the binomial lattice offers transparency by showing project values under different circumstances. Once the input parameters are identified, the lattice is relatively easy to compute and can be done in a standard software program like Microsoft Excel. Thus, the output of the binomial model is fairly user friendly. However, the estimation of the input parameters used in the binomial model is somewhat more complex. For instance, the computation of the volatility estimate for NN9536 was estimated in the software program CrystalBall and is time-consuming to conduct. For less experienced users of Monte Carlo simulation, is it easy to get lost in all the probability distributions and iterations of cash flows.

In addition, the modified T&V model used to value NN9536 in this thesis is a step-by-step model, which, at first glance, should be fairly easy to follow. However, given the complex calculations inside the model with use of different discount rates and risk-adjusted present values etc., the model requires a sound financial understanding.

Understandable output:

As oppose to financial options, where the price of the option is a simple purchase made by an investor, the value of real options are more diffuse as it represents the managerial flexibility the option offers. In the case of NN9536 (assuming to leakage rate), the value of the managerial flexibility offered by the deferral option was calculated to 16,4 mDKK, which was the difference between the static rNPV and the rROV. This value may be difficult to communicate to management as it does not have an exact financial value to it. To assess whether the output of real option valuation is understandable, requires knowledge of the users of the tool. For experienced Excel users with an academic background in finance, the output of the models will probably be fairly easy to interpret and understand, whereas for laymen, the output might seem useless.
Conclusion

The theoretical part of the thesis revealed the complexity in asset valuation. The findings from the theoretical section revealed that the fact that the DCF model is based on a set of fixed input variables that is assumed to be unchanging throughout the lifetime of the asset, poses a major disadvantage to the model. Also, the model does not account for different types of cash flow risks (i.e. private and market risk), which limits the use of the model for R&D projects in the pharmaceutical industry, since the cash outflows in the development phase are subject to private risk.

The real option approach accounts for the managerial flexibility by considering different future outcomes of the asset value but fails to account for the private risks inherent in the cash flows. Based on these findings, a construction of a valuation model inspired by a model developed by Tom Copeland and Vladimir Antikorov referred to as modified T&V model, was made. This model applies the DCF approach to account for the market-driven risks of the cash flows, and accounts for the private risk in the cash flows by applying the rPV approach. Finally, the model incorporates the managerial flexibility in the decision making by constructing a binomial lattice that enables management to make contingent decisions based on a range of future outcomes.

In the empirical part, the model was being tested on a R&D project carried out by Novo Nordisk under the name NN9536. The results from applying the model on this project was that the model create additional value to the project by incorporating managerial flexibility. However, the input parameters used for valuing the real option of the project are somewhat subjective. At first, it was assumed that the leakage rate of the project was 20% annually, which resulting in a decision to launch the project right after FDA approval. Afterwards, the leakage rate was set to zero, resulting in a decision to not launching the project immediately after FDA but to wait and assess how the market conditions unfold. The value of the managerial flexibility was calculated to 16,4 mDKK.

Finally, a discussion of the practical applicability of using real options as a valuation model based on the four attributes that characterizes an ideal valuation model.

It was concluded that real option valuation fails to meet the attributes of being based on realistic assumption and unbiased estimates. Moreover, the user friendliness of the models are somewhat limited and requires a thorough financial understanding.

*Can real options as a valuation tool contribute to increased value creation in the pharmaceutical industry? What are the challenges of using real options for valuation rather than the traditional NPV method?*

The answer to the overall problem statement of this thesis is that real options are able to contribute to increased value creating in the pharmaceutical industry if however, the input parameters for the real option are carefully analyzed and estimated before a valuation is conducted.
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## Appendix 1: input parameters for Monte Carlo simulation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Triangular Distribution</th>
<th>Discrete Uniform Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Worst</strong></td>
<td>15%</td>
<td>3</td>
</tr>
<tr>
<td>Likely</td>
<td>Market share of peak sales</td>
<td>20%</td>
</tr>
<tr>
<td>Best</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td><strong>Discrete uniform distribution</strong></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Likely</td>
<td>Year of peak sales</td>
<td>7</td>
</tr>
<tr>
<td>Slow</td>
<td>8</td>
<td>8</td>
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</tbody>
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### Continuous data

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>COGS</strong></td>
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</tr>
<tr>
<td>Likely</td>
<td>15%</td>
</tr>
<tr>
<td>Best</td>
<td>15%</td>
</tr>
<tr>
<td><strong>M.S &amp; A</strong></td>
<td>25,50%</td>
</tr>
<tr>
<td>Likely</td>
<td>20,00%</td>
</tr>
<tr>
<td>Best</td>
<td>25,50%</td>
</tr>
<tr>
<td><strong>Corporate tax rate</strong></td>
<td>-15%</td>
</tr>
<tr>
<td>Likely</td>
<td>18%</td>
</tr>
<tr>
<td>Best</td>
<td>18%</td>
</tr>
<tr>
<td><strong>WACC</strong></td>
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</tr>
<tr>
<td>Likely</td>
<td>9.0%</td>
</tr>
<tr>
<td>Best</td>
<td>6.8%</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Triangle Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year of peak sales</strong></td>
<td>7</td>
</tr>
<tr>
<td>Slow</td>
<td>8</td>
</tr>
<tr>
<td><strong>Corporate tax rate</strong></td>
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</tr>
<tr>
<td>Best</td>
<td>15%</td>
</tr>
<tr>
<td><strong>WACC</strong></td>
<td>9.0%</td>
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<tr>
<td>Best</td>
<td>6.8%</td>
</tr>
</tbody>
</table>

### 17% input parameters for Monte Carlo simulation

<table>
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<th>Parameter</th>
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<tbody>
<tr>
<td><strong>COGS</strong></td>
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</tr>
<tr>
<td>Best</td>
<td>25.50%</td>
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<td><strong>Corporate tax rate</strong></td>
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<td>Best</td>
<td>0%</td>
</tr>
<tr>
<td><strong>WACC</strong></td>
<td>6.8%</td>
</tr>
<tr>
<td>Best</td>
<td>6.8%</td>
</tr>
</tbody>
</table>
The software application automatically highlights the cells in green after a probability distribution has been assigned to it. Note that no probability distribution is assigned to the tax rate until year 2027. This is because I have applied the effective tax rate to calculate corporate tax, and since the R&D expenses yields a tax asset, no taxes are paid on the project income until after 2027.
## Appendix 2: Four-step model for valuing real options by Copeland, T, & Antikarov

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model the uncertainty using event trees</td>
<td>Compute base case present value without flexibility</td>
<td>Identify and incorporate managerial flexibilities creating a decision tree</td>
<td>Calculate real option value</td>
</tr>
</tbody>
</table>

### Objectives
- Identify major uncertainties in each stage
- Understand how those uncertainties affect the PV

### Output
- Detailed event tree capturing the possible values of the major uncertainties
- Project's PV without flexibility
- A detailed decision tree combining possible events and management responses
- ROA of the project and optimal contingent plan for the available real options