LUT School of Business and Management

A210A0350 Real Options and Managerial Decision Making

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ROV Valuation

Project: Expansion of Intel

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1. INTRODUCTION

This report presents Intel's project to expand its production and evaluate it by using Real option valuation method called Fuzzy pay-off. Intel has two different options to conduct the investment. The challenge is to identify the best option by using a fuzzy payoff method, as the potential outcomes of both options are uncertain and depend on various factors.

1.1 Intel

Intel is a semiconductor chip maker founded in 1968 and is currently one of the largest semiconductor companies Their product portfolio is wide, and their chips are used in various devices. Intel differs significantly from many other semiconductor companies by manufacturing its own chips and not just assembling them. In 2022 Intel's net revenue was 63 billion dollars. (Intel 2023a)

1.2 Expansion of production capacity

The increasing use of chips in various products and covid-19 have caused a shortage of microchips. Most of the factories are in Asia which has complicated the supplies when supply chains are cut off. Due to the shock, Intel has seen a possibility to expand its production and has published many investments in U.S. and Europe. (Stankiewicz K. 2022)

As a motivation for our project, we are using the announcement of Intel to invest 20 billion dollars in two factories in 2021 in Arizona (Intel 2021). To minimize risk there should be considered other options as well which also helps conduct an evaluation and comparison of the investment. Taking these points into account we can put together two possible options. In option 1 Intel constructs two factories in one phase in Arizona and in option 2 we are considering Intel constructing two factories in two phases one factory at a time.

2. METHODOLOGY

2.1 Fuzzy pay-off

In contract to financial options which are contracts with a fixed maturity and precisely contracted conditions and the underlying asset is typically a security trading in liquid markets, where risk-type uncertainty is present, real options are most often non-contracted managerial possibilities to take action with regards to physical investments residing in illiquid markets, where even structural uncertainty can be present (Stoklasa, Luukka, Collan, 2020). Therefore, pricing models intended for financial options are not necessarily the best possible method of evaluation. Fuzzy payoff method of real options valuation is based on analysis done on fuzzy sets of data which allow the analysis to consider gradation of belonging which can be more subtle than in traditional binary sets which indicate either full belonging or non-belonging (Collan, Fullér, Mezei, 2009). In general, these sets when they are about fundamentally uncertain future can be constructed based on managerial estimation, opinions of professionals or using another similar process of estimation. Fuzzy sets allow us to better consider uncertainties present during the lifetime of the real option.

In this case net present values of three possible scenarios for the real option in question are calculated using the traditional method discounting future net cashflows into present moment using the risk-free interest rate as a discount rate. Having three sets representing three distinct scenarios allows us to consider possible variation in fundamental variables which ultimately determine the value of the investment opportunity and of the option based on it. These scenarios represent the maximum, minimum and the “best guess”-scenarios based on these three scenarios we can then calculate the payoff distribution which forms our fuzzy NPV, like said above this can be interpreted as expressing NPV’s degree of belonging to various scenarios between the maximum and minimum scenario. The final NPV of the investment project can be viewed as strategic NPV as it includes the “option premium” derived from managerial flexibility in addition to the static NPV of the investment (Trigeorgis, 1996).

2.2 Construction phase

The construction period and cost of the semiconductor factory have been obtained from various sources, including Intel's official website and other published articles. The construction process for one factory typically takes around three years, during which time the company is not generating revenue from the facility. The cost of constructing a factory is estimated to be around 10 billion dollars. (Intel 2023c). It is assumed that the development of the factory will not incur any additional costs related to patent and licensing, given that Intel already operates 15 factories across 10 locations worldwide (Intel 2023d).

2.3 Discount rates

To make optimal decisions and evaluate the options, the present value of the project can be calculated using discount rates. The present value of investment cost can be calculated using the current risk-free rate of return, which is the minimum return an investor expects for any investment. Typically, the interest rate for US Treasury bills is used as the risk-free rate for US-based investors (Hayes 2022).

To calculate the present value of operating cash flow, we can use a discount rate that reflects the market risk. The Capital Asset Pricing Model (CAPM) can be used to determine the cost of capital, which shows the relationship between the required return on investment and risk. (Kenton 2022)

By using CAPM, we can calculate the cost of capital using the following formula:

$$ER_i = R_f + \beta_i * (ER_M - R_f) \qquad (1)$$

Where:

ER_i = *expected return of investment*

R_f = *risk-free rate*

B_i = *beta of the investment*

ER_m = *market return*

As of March 2023, the US Treasury yield rate is 3.97% (Ycharts 2023). Intel's current beta is 0.78 (Yahoo Finance 2023b). It measures how risky the investment is compared to the market. The value is less than 1, which suggests that the investment is not riskier than the market. The current expected market return of the Nasdaq composite index is 10.24. Taking these into account Intel's discount rate for operational cash flow can be expressed as equation below.

$$ER_i = 3.912\% + 0.78 * (10.24\% - 3.912\%) = 8.84\% \qquad (2)$$

2.4 Operating costs and cash flows

To calculate the operating cash flow, we subtract the average operating expenses from the average revenue and then divide the result by 15, which represents the total number of factories. This gives us the operating cash flow for one factory, as the historical revenue data represents the total revenue from all 15 factories.

Additionally, Intel has projected an increase in operating expenses of 25-27% and a growth in revenue of 10-12% per year by 2025 - 2026. (Intel 2023b) This information is used to estimate the annual revenue and operating expenses during the production phase of the project.

Table 1 Revenue and Operating Expense in millions of USD (Macrotrend 2023)

Income Statement	Total Revenue	Operating Expense
2022	63054.00	60720.00
2021	79024.00	59568.00
2020	77867.00	54189.00
2019	71965.00	49930.00
2018	70848.00	47532.00
2017	62761.00	44711.00

2.5 Scenarios

To determine the distribution of NPV, we have considered three distinct scenarios: best case, base case, and worst case. These scenarios aim to capture the uncertainty inherent in the project, specifically with regards to market demand and the economic situation, including changes in revenue and operating expenses. According to intel, the operating expense is expected to rise by 25-27% by 2026. However, after the year 2026 operating expenses are projected to increase by 2% annually based on historical data. In the Best-case scenario, a revenue growth rate of 12% per year is considered to reflect robust market demand and favorable economic conditions, with operational expenses set at 25% above the average operating expense. Conversely, the Worst-case scenario assumes a modest 2% annual revenue growth rate and operating expenses

set at 27% above the average operating expense. The Base case scenario assumes an 8% annual revenue growth rate and operational expenses set at 26% above the average operating expense. Additionally, operating expenses are projected to increase by 2% annually based on historical data.

3. EVALUATION OF THE OPTIONS

3.1 NPV Evaluation

Table 2 shows the values used to evaluate different options. For a semiconductor factory with a construction period of 3 years, the cost of construction is 10 billion. Option 1 has a total construction cost of 20 billion, while Option 2 i.e., building two factories in two phases would cost 21.22 billion. The higher cost of the phased approach is due to the time value of money, as 10 billion today is worth more than 10 billion in 3 years. Construction time and costs remain constant for both options across all scenarios, which are determined by market demand and economic conditions. To simulate these scenarios, growth rates for revenue and operating expenses are used, with projections based on Intel's official data and calibrated for each factory. While operating expenses are expected to increase by 2% annually for both options, different rates of revenue growth and expense increases above the average are used to model each scenario.

Table 2 Values for evaluation

	Option 1	Option 2
Construction time 1st phase Construction time 2nd phase Construction cost 1st phase Construction cost 2nd phase	6 years 20 billion	3 years 3 years 10 billion 11.22 billion
Expected revenue 2023: Best Scenario Base Scenario Worst Scenario	4728 million per factory 12 % year on year increase 8 % year on year increase 2% year on year increase	4728 million per factory 12 % year on year increase 8 % year on year increase 2% year on year increase
Average Operating Expense: Best Scenario	3519 million per factory 25% above average (2026)	3519 million per factory 25% above average (2026)

Base Scenario Worst Scenario Annual increase in operating Expense	26% above average (2026) 27% above average (2026) 2% annual increase	26% above average (2026) 27% above average (2026) 2% annual increase
Risk free rate Discounting rate for Operational Cashflow	3.91 % 8.84 %	3.91 % 8.84 %

Figures 1 and 2 present graphical representations of the NPV development in Option 1 and Option 2. Across all scenarios, Option 1 consistently exhibits higher NPV than Option 2 in the best and base case scenario, though the difference between the negative NPVs of the two options is small. Therefore, Option 1 is the preferred choice. In Option 2, the project's NPV is positive in years 8 and 10 for the best and base scenarios, respectively. However, because one of the factories ceases production after year 18 of the project, the NPV begins to decline from year 18 onward. Similarly, in Option 1, the NPV is positive from year 9 and 11 for the best and base scenarios, respectively. However, both options produce negative NPVs in the worst-case scenario. Therefore, the additional investment of 1.22 billion for Option 2 is not a wise decision.

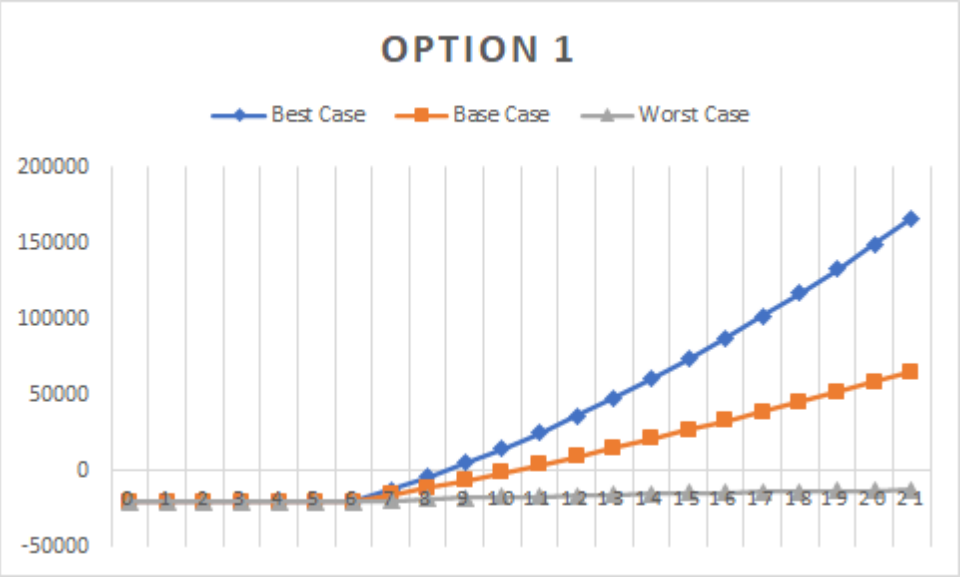

Figure 1 Graphical Evaluation Option 1

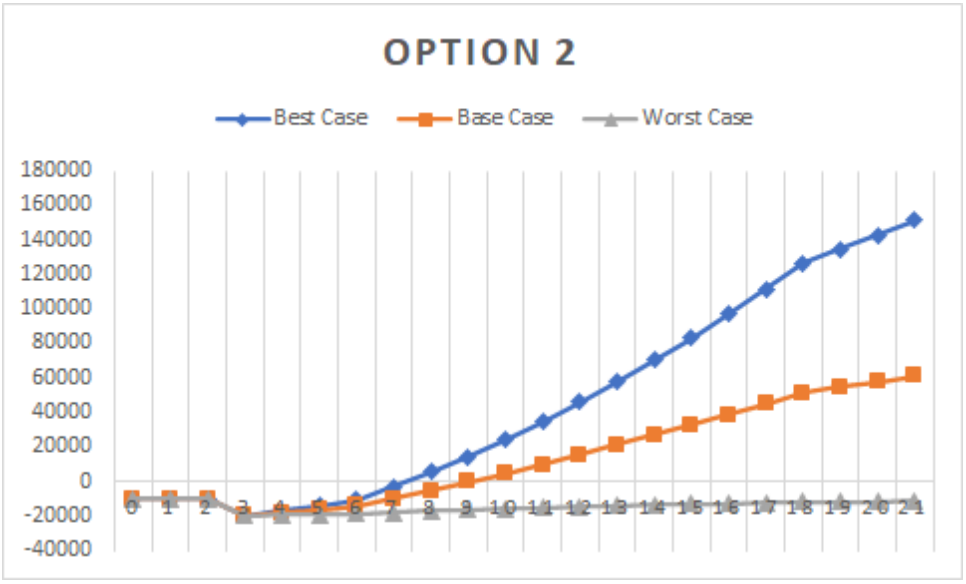

Figure 2 Graphical Evaluation Option 2

Figure 3 provides a graphical comparison of the NPVs of Option 1 and Option 2 across three scenarios: Best, Base, and Worst case. In the Best-case scenario, Option 1 demonstrates a higher NPV compared to Option 2. However, in the Base and Worst-case scenarios, the NPV differences between the two options are small. Specifically, Option 1 yields a slightly higher NPV in the Base-case scenario. Notably, Option 2 exhibits a higher negative NPV than Option 1, indicating that Option 1 is riskier than Option 2 in the Worst-case scenario.

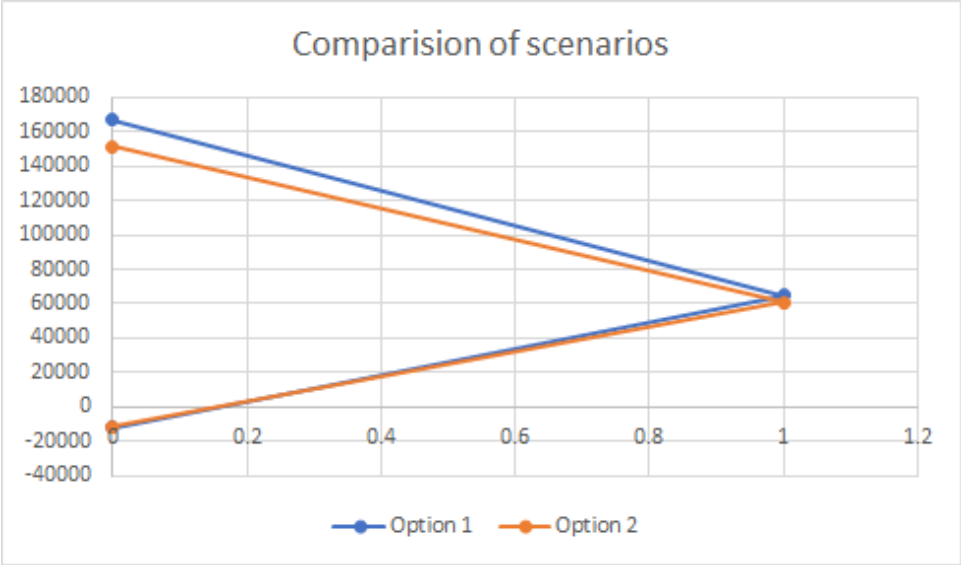

Figure 3 Graphical comparison of Options

3.2 ROV Evaluation

Table 3 depicts the NPV of option 1 and option 2 in three different scenarios. Furthermore, the table illustrates the calculation of alpha, beta and a which is necessary for the calculation of pay-off distribution. Figure 4 shows the payoff distribution when the fuzzy NPV distribution is partially above zero, so that zero is between the worst possible NPV and the best possible NPV which illustrates the situation in this project. The ROV in this situation can be calculated by using the equation below.

$$ROV = -a^3/(6\alpha^2) + a^2/2\alpha + a/2 + \beta/6$$

Table 3 ROV Calculation

NPV (Million Dollar)	Build in one phase	Build in two phases
Best-Case Scenario	166865.853	151434.5639
Base-Case Scenario	64996.346	60968.02988
Worst-Case Scenario	-12305.718	-11478.70
ROV: Fuzzy Numbers		
α	77302.06	72446.73
a	64996.34	60968.02
β	101869.50	90466.53

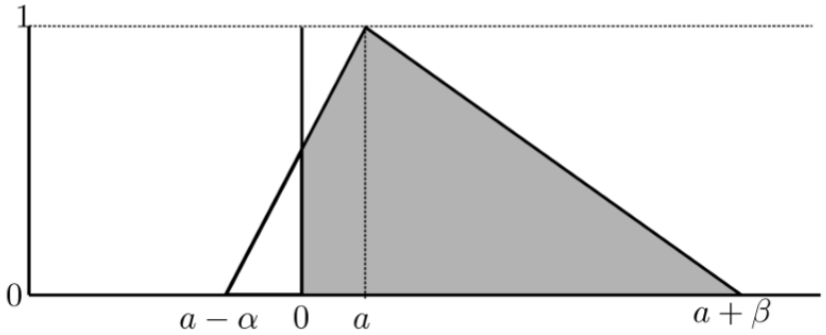

Figure 4 Pay-off Distribution

ROV (Option 1: Build in one phase) = 69142.89 million USD

ROV (Option 2: Build in two phase) = 64019.35 million USD

Upon comparing the ROV of Option 1 and Option 2, it is evident that the ROV of Option 1 is higher, indicating that Option 1 is more profitable than Option 2. Although Option 2 is less risky than Option 1, the substantially higher NPV in the Best and Base case scenarios strongly suggests that Option 1 is the more favorable choice.

4. CONCLUSIONS

After analyzing the NPV and ROV calculations, it can be concluded that Option 1 is more profitable than Option 2, as it has a higher NPV and ROV in both the best and base case scenarios. However, in the worst-case scenario, both options result in losses.

Although Option 2 has a higher NPV than Option 1 in worst case scenario, indicating that it may be less risky, it is important to consider other factors such as the beta value of Intel. Intel's beta value suggests that the investment is less risky than the market. Therefore, Option 1 is the more suitable choice for the project, as it is more profitable and still carries an acceptable level of risk.

In summary, while Option 2 may appear less risky on paper due to its higher NPV, the beta value of Intel should be considered when making the final decision. Ultimately, Option 1 provides the best balance between profitability and risk.

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