

# The Optimal Machine Life in Tesla

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## ABSTRACT

Tesla is an American electric car and energy company that makes and sells electric cars, solar panels, and energy storage equipment. We analyze how can Tesla buy and sell the machines in the most profitable way. Based on photovoltaic (PV) and net present value (NPV) rules, the infinite time optimal machine life model is established to analyze the investment projects of Tesla. Next, we calculate the optimal machine life effectively by using HJB equation. The PV and NPV rules and HJB equation are introduced in Related theoretical concepts included definitions, formulas, and applicable situations. We get the conclusion that the theoretical optimal machine exists which is using one machine only a year. But that is subject to market demand and supply. If we take all the factors into account, the calculation becomes complicated. So we just use the ideal case, and explain the meaning of optimal machine life for the company and related calculations in it.

**Keywords:** component; the optimal machine life; NPV; Hamilton-Jacobi-Bellman equation; Cash inflow

## 1. INTRODUCTION

Project evaluation is put forward from two aspects of positive and negative opinions. For policymakers, choosing projects and the implementation plan provides various warning. It enables them to be in a relatively advantageous position to make correct and appropriate decisions in a practical and realistic manner. In this article, we try to utilize NPV method to evaluate the project investment.

NPV method is an important criterion for project evaluation. The discount method of cash flow is to restore the expected cash flow of the enterprise to the present value in a specific period in the future. NPV method not only has the basic advantages of DCF method, but also can be further used to evaluate the investment value of a project team or even a company (as a combination of multiple projects) in the foreseeable future, namely: the sum of NPV of the cash flows of each project. Therefore, compared with other DCF methods (such as IRR method), NPV method is more consistent with the goal of maximizing enterprise value when making capital budgeting and investment decisions.

We consider Tesla as an empirical study to present the project evaluation when it invests different machines. Tesla is a large company in the US which produces cars. The company puts a lot of money in the technology which can produce car components. So, the judgement about how to manage the money on those machines has become a big problem.

There are many literatures to research the investment valuation. Zizlavsky and Ondrej [1] dedicated to the issue of innovative performance measurement. It focuses on techniques that can be employed for evaluation of single innovation project. The framework is based on detailed literature review and net present value (NPV) approach analysis. Mays [2] proposed A new method for calculating the net present value and internal rate of return on an investment is provided. Here, the new method takes into account discounts that affect the net cash flow over the period of the investment. These discounts may be static or vary depending on the circumstances warranting their inclusion. Decisions in capital investment will have major impact on the future well-being of the firm. Normally NPV and IRR measurements to evaluate projects often results in the same findings. However, there are a number of projects for which using IRR is not as effective as using NPV to discount cash flows. This study objective is to

analyze conflicting areas between NPV and IRR [3]. The dispute between the limitations of NPV and IRR application is solved, and the two are connected with the equation [4]. Huang [5] shown that the model of NPV system can forecast under certain and even uncertain economic conditions. Feinstein et al., [6] pointed out that NPV has limitations in the changing market. Besides, a method to deal with NPV in the case of uncertain cash flow is proposed [7]. The choice rule between NPV and IRR is put forward, and some cases are discussed [8]. On the basis of advanced mathematics, the solvable problem of HJB equation is discussed [9-11].

In this paper, we analyze the data of the Tesla's Stock market. Then, to calculate the values, we use the Present Value Rule as the general solution. In addition, we build a mathematic model based on Hamilton-Jacobi-Bellman equation. In this way, we can express the cases into general equation when the time and circles are limited or unlimited. Next, the assumptions about the real situations will be used to test the methods and at last, we will give the conclusion [3].

The whole paper is divided into 6 parts. In the section 1, we discuss the data about the trend of Tesla's stock. In section 2, some methods to approach the conclusion are listed. In section 3, we put calculations for different situations based on the formula in section 2. In section 4, we discuss the limitations and advantages of our methods. In section 5 we will give a conclusion about what we have done and examined so far. In the last section, section 6, there are some references listed.

**2. DATA**

Tesla, an American electric car and energy company, makes and sells electric cars, solar panels, and energy storage equipment. Headquartered in Palo Alto, founded on July 1, 2003 by Martin Eberhard and Mark Tappenin, the founders named the company "Tesla Motors" in honor of physicist Nikola Tesla. Elon Musk joined the company in 2004 and led Round A financing. Tesla's chief executive, Elon Musk, said the company strives to provide every ordinary consumer with pure electric vehicles within its spending power range, and that Tesla's vision is to "accelerate the global transition to sustainable energy." In 2020, Tesla will achieve a total revenue of US \$31.54 billion, an increase of US \$6.96 billion over the previous year. The net income of common shareholders was \$721 million, an increase of \$1.58 billion over the previous year (figure 1).



**Figure.1** Monthly chart of Tesla's stock price for 2020.

In 2020, Tesla's operating profit margin was 6.3%, an increase of 6.6% over the previous year. By the end of 2020, Tesla had \$19.38 billion in cash and cash equivalents, an increase of \$13.12 billion over the end of 2019. Cash flow from operating activities will be \$5.94 billion in 2020, compared with \$2.41 billion in 2019, and capital expenditure will be \$3.16 billion in 2020, compared with \$1.33 billion in 2019. On the automotive side, Tesla produced 509737 vehicles and delivered 499647. At present, Tesla focuses on increasing automobile production and capacity, developing and upgrading battery technology, improving the cost performance of automobiles, expanding the global production network, and launching the next generation of automobiles. During this year, the stock price of Tesla rose from 430.26 dollars per share at the beginning to 705.67 dollars per share. The highest price appeared on August 28, 2020, and the stock price reached 2318.49 dollars per share. The lowest price appeared on September 8, 2020, and the stock price reached 329.88 dollars. During the year, Tesla's stock price experienced huge fluctuations, but on the whole, Tesla's stock price still rose by 68.09 percent in 2020.

**3. PREPARE RELATED THEORETICAL CONCEPT**

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

**3.1. Present Value**

In general, suppose that you will receive a cash flow of C t dollars at the end of year t. The

present value of this future payment is

$$\frac{C_t}{(1+r)^t} \tag{1}$$

You sometimes see this present value formula written differently. Instead of dividing the future payment by, you can equally well multiply the payment. The expression is called the discount factor. It measures the present value of one dollar received in year t.

Suppose that you wish to value a stream of cash flows extending over a number of years.

Our rule for adding present values tells us that the total present value is:

$$PV = \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \dots + \frac{C_T}{(1+r)^T} \tag{2}$$

This is called the discounted cash flow (or DCF) formula. A shorthand way to write it is

$$PV = \sum_{t=1}^T \frac{C_t}{(1+r)^t} \tag{3}$$

To find the net present value (NPV) we add the (usually negative) initial cash flow:

### 3.2. Hamilton-Jacobi-Bellman equation

Since this equation is too complicated and can be solved only in a few special cases, only the simple form simplified by mathematical induction is used, and this will be shown in part.

We built a mathematic model to solve the optimal machine life problem. Assume that we can hold the machine for t [0, T]. Discretize T into N pieces so that=k [0, N]

**Table 1.** Notation Table

Notation	Meaning
<i>p</i>	Purchase price
<i>c</i>	Cash inflow each year
<i>f(k)</i>	Maintenance cost of each $\delta$
<i>g(k)</i>	Salvage value of each $\delta$
<i>r</i>	Discount rate

Based on the finished time of projects, we consider two situations, unlimited time and limited time, respectively.

(1) unlimited time

NPV of each program (hold the machine to)

$$\sum_{i=1}^k \frac{c-f(i)}{(1+r)^i} + \frac{g(k)}{(1+r)^k} - p = a \tag{4}$$

we can use Least common multiple (LCM) of 1~N.

We assume that each circle we is LCM

So NPV of each program in a circle is

$$\sum_{b=1}^{LCM} \frac{\sum_{i=1}^k \frac{c-f(i)}{(1+r)^i} + \frac{g(k)}{(1+r)^k} - p}{(1+r)^{bk}} = m_k \tag{5}$$

### 3.3. Limited time

If we have to make the optimal choice in time  $T' = \delta n$   
 $n=k' (LCM)+s$

So we are going to make the best choice in s, but it's hard to calculate out the best choice because there will be many portfolio, and we can simplify HJB equation like this.

assume that there is an optimal strategy

the cash flow for each period is and the maintenance cost is

We get

$$V \geq \frac{C_1 - M_1 + V}{1+r} \tag{6}$$

And we get

$$V \geq \sum_{i=1}^{T-1} \frac{C_i - M_i}{(1+r)^i} + \frac{V}{(1+r)^T} \tag{7}$$

And we can calculate out the optimal one

## 4. EMPIRICAL STUDY

When considering how to approach the most profit for Tesla, the machine life is an very important point. Assume that each machine in Tesla costs 300\$. Each year, extra money will be spent on maintenance and the salvage value is decreasing by years which is shown in the Table 1, and the discount rate is always 10%.

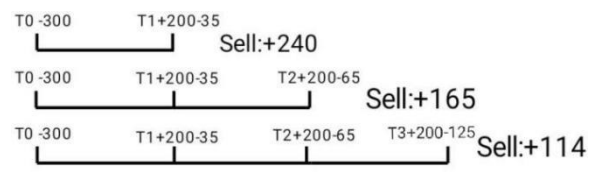
**Table 2.** Maintenance costs and salvage value

	T1	T2	T3
Maintenance costs	35	65	125
Salvage value	240	165	114

In this assumption, the NPV rules should be used to calculate the profits at the end of each year.

According to the formula (1)

In the first situation, Tesla will only buy one machine. The line graph will be shown below as figure 2.



**Figure 2.** Line graph of different projects

If Tesla only buys the machine for one year, it will get an NPV of:

$$P = -300 + \frac{200 - 35}{1 + 10\%} + \frac{240}{1 + 10\%} = 68.18$$

If Tesla wants to keep the machine for 2 years, then it will get a net profit of:

$$P = -300 + \frac{200 - 35}{1 + 10\%} + \frac{200 - 65}{(1 + 10\%)^2} + \frac{165}{(1 + 10\%)^2} = 97.93$$

If Tesla prefer to use the machine for the whole 3 years, then Tesla will finally get:

$$P = -300 + \frac{200 - 35}{1 + 10\%} + \frac{200 - 65}{(1 + 10\%)^2} + \frac{200 - 125}{(1 + 10\%)^3} + \frac{114}{(1 + 10\%)^3} = 103.56$$

When comparing the results, it is clear that  $T3 > T2 > T1$ . So the result is that if Tesla only prefers to buy one machine, it would better use the machine for 3 years.

In the second situation, Tesla will buy 2 machines and consider about the optimal machine life. According to the result in the first situation, the second machine should be used for 3 years to approach the maximum profit. Then, we only need to decide whether to use the first machine for 2 years or 3 years.

If Tesla wants to use the first machine for 3 years, the calculation will be:

$$P = 103.56 - \frac{300}{(1 + 10\%)^3} + \frac{200 - 35}{(1 + 10\%)^4} + \frac{200 - 65}{(1 + 10\%)^5} + \frac{200 - 125}{(1 + 10\%)^6} + \frac{114}{(1 + 10\%)^7} = 181.38$$

If Tesla uses the first machine only for 2 years, then the equation will be changed to:

$$P = 97.93 + \frac{(-300)}{(1 + 10\%)^2} + \frac{200 - 35}{(1 + 10\%)^3} + \frac{200 - 65}{(1 + 10\%)^4} + \frac{200 - 125}{(1 + 10\%)^5} + \frac{114}{(1 + 10\%)^6} = 183.52$$

As  $183.52 > 181.38$ , We can see that if Tesla uses the first machine for 2 years, it will get the highest profit.

For the last situation, Tesla can buy unlimited machines. In this situation, it means that Tesla can repeat buying and selling machines in one year for many times. If Tesla wants to keep the machine for 2 years, then Tesla will gain:

$$P = -300 + \frac{200 - 35}{1 + 10\%} + \frac{240}{1 + 10\%} - \frac{300}{1 + 10\%} + \frac{200 - 35}{(1 + 10\%)^2} + \frac{240}{(1 + 10\%)^2} = 130.16$$

According to the data get in the first situation,  $130.16 > 97.93$ . So Tesla will gain more if it repeats the one-year life circle. As  $130.16 > 103.56$ , So the one-year life circle will be the most efficient. In this way, the net present value can be figured out. As the  $t$  approaches to the infinity, the Present value formula will change into:

$$PV = \frac{CF}{r} \tag{8}$$

So if Tesla only has one machine in one year, the highest NPV that Tesla can get will be equal to:

$$NPV = \frac{-300 + 200 - 35 + 240}{10\%} = 1050$$

## 5. DISCUSSION

Advantages of NPV method include that considering the time value of money; The net cash flow of the whole process is considered. Investment risk is taken into account consideration.

The disadvantages of the net present value method is that it is difficult to measure the net cash flow and determine the discount rate; Can not reflect the actual income level of the investment project, depends on the expectation of future cash flow; It is difficult to determine the advantages and disadvantages of mutually exclusive projects only by using net present value method when the investment amount of mutually exclusive projects is different or the benefit period is different.

## 6. CONCLUSION

The investment evaluation is crucial to company's decision-making. Based on the PV and NPV rule, we first build up the model of optimal machine life in unlimited time to analyze the Tesla's investment project. Then, with the help of HJB equation, we can calculate out the optimal machine life in a more efficient way.

Based on the results, we found that in first condition (one machine for investment) Tesla should use the machine for three years if Tesla does not want to buy machines anymore in the future after the evaluation by the NPV rules. Then, if Tesla wants to get one more machine (investment for two machine), then they should only use the first machine for 2 years to get the highest profit. This may because that the shortage of the  $t$  makes the discount rate for the next machine smaller. Also, the first machine can remain a higher salvage value, so this is more efficient. But if Tesla ignores the market demand and supply, it can buy machines without limitations and Tesla can use each machine only for one year to get the highest profit. While in reality, the market of the machine is unpredictable, meaning that the salvage value and costs are always changing. If the costs increase quickly or the salvage value decrease dramatically, it will be better to wait for some time for the equilibrium in the market. In this situation, the one-year machine life will be inefficient.

This article has some limitations. Firstly, the traditional NPV method is a static investment strategy, which believes that the future cash flow of the project is fixed and is the most likely cash flow to occur. Failure to consider the project construction and operation of the

uncertainty of the strain capacity. Secondly, the traditional NPV method assumes that the investment project is completely reversible, and there is no cost to abandon the investment project. But starting a new project often involves a large amount of sunk costs that are difficult to recover in full when you abandon the project. In the future, we will study how to better eliminate the uncertainty to increase the accuracy of NPV calculation of optimal machine life

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