Evaluating Flexibility in Railroad Construction Projects

by

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Submitted to the Department of Civil and Environmental Engineering
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Abstract

This thesis aims to valuate flexibilities in a large-scale railroad construction project. In general, a railroad construction project involves a large amount of flexibilities due to its long construction period and conflicts among various participants. Therefore, railroad construction projects require investors to examine the feasibility of the project, taking into account managers' ability to make strategic decisions to deal with flexibilities during the construction. However, this important value is not considered in conventional valuation methods, such as Net Present Value (NPV) or Internal Rate of Return (IRR) analysis.

This study introduces methods to identify and valuate the flexibilities involved in a project. Decision Tree Analysis (DTA) and Real Option Analysis (ROA) are mainly discussed as primary methods to avoid pitfalls of the conventional valuation methods. DTA helps managers to make future decisions in an effective way by providing graphical diagrams of decision opportunities. ROA appraises the value of mitigating risks by allowing managers to defer investing decisions until a situation that affects a project's success seriously becomes obvious.

As a case study, the additional station construction projects in Incheon International Airport Railroad (IIAR) are analyzed to apply the methodologies to valuate the flexibilities. The case study shows that the use of DTA and ROA enables us to visualize the risks, and to quantify the value of flexibilities in the project.

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Finally, I would like to dedicate this thesis to my parents and my wife, Eunjoo, who have encouraged and supported me with love.

Choong-Ryun Oh

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Chapter 1 Introduction

1.1. Thesis Structure

In the first chapter, the structure and background of this thesis will be addressed. With the concept and development of Private Participation in Infrastructure, its applications to development projects in South Korea will be described. Thereafter, the motivation and the objective of this thesis will be introduced.

In Chapter 2, traditional methods to evaluate a development project will be discussed. Net Present Value and Internal Rate of Return will be reviewed as the two most commonly used tools when investors are making investment decisions. In addition, Payback Period and Benefit/Cost ratio will be briefly introduced as the other alternatives.

Chapter 3 will review several analysis tools that can help a decision maker who is under uncertainty of a development project. Based on the uncertain future cash flow of a project, the tools that can provide a practical basis of decision making, such as Sensitivity Analysis, Decision Tree Analysis, and Real Option Analysis, will be examined in terms of how these methodologies can be applied to the project management in a project.

In Chapter 4, we will analyze the Incheon International Airport Railroad (IIAR) project as a case study. The railroad project, which will connect Incheon Airport and Seoul, was initiated with private participation in 2001. After the construction started, however, the project company has been contemplating the construction of extra stations. The methodologies to analyze and measure the uncertainties and viabilities of the station construction projects will be examined.

In Chapter 5, a summary of this research will be provided with a few recommendations.

1.2. Overview of the Private Participation in Infrastructure

The concept of Private Participation in Infrastructure (PPI) has significantly developed throughout the world since the 1990s. The main objective of this concept is to allow private sectors to develop and operate public infrastructure projects. Traditionally, most infrastructures, such as railroad, highway, or power supplies, used to be delivered by the government; the government was responsible for design, construction, finance, operation, and maintenance of the project. However, the cost of constructing infrastructure has been steeply increased, and thus many of the governments could no longer afford to provide sufficient infrastructure services to boost their economies. Furthermore, the government's bureaucratic and inefficient management of infrastructure projects is not able to effectively respond to rapidly changing environments. Thus, the idea of Private Participation in Infrastructure was suggested both to overcome the insufficient budget of a government and to improve the efficiency and quality of infrastructure services.

In South Korea, the government launched this concept by enacting the "Promotion of Private Capital into Infrastructure Investment Act" and established the Private Participation in Infrastructure system in 1994. However, the initial system showed only limited success due to several reasons such as insufficient Government support, complicated implementation procedures, and lack of compliance with global standards. As a matter of fact, there were only five projects financed in the period from 1995 to 1998. To

make matters worse, the Asian financial crisis in 1997 seriously affected the economic and financial environment of Korea. Sponsors cancelled some planned projects and held off new investment, and financial investors did not want to invest in PPI projects due to uncertain economic prospects.

Eventually, the government decided to alter the PPI system and regulations in order to activate private investment and to meet global standards. "The Act on Private Participation in Infrastructure" was announced and became effective in 1998. As a result, a variety of support from government was added, and implementation procedures became simplified. After the successful reform of the PPI system along with the recovery from the financial crisis, PPI projects started to thrive and came to be perceived as one of the most attractive investment vehicles for institutional investors. While the ratio of private investment to total infrastructure investment remained 4.4% in 1998, it grew up to 10.4% in 2003[1].

The brief procedure of this system for an infrastructure project can be explained in this way. The private sectors invest in PPI projects through public bidding for solicited projects. As for the project, the competent authority, such as the Ministry of Construction and Transportation (MOCT) in the case of transportation infrastructure, undertakes the initial development of the project and appoints a concessionaire after evaluating the proposals submitted by private bidders according to the instruction for proposals. The designated concessionaire negotiates the terms of the concession agreement and the execution plan with the authority. The competent authority is responsible for the approval

[1] Leo S.H. Kim, Asia Pacific Report, "Turning Point", 2005

of the implementation plan, including the detailed design and the confirmation of project completion.

Financing Year	Project Name	Financing Amount
1995	Incheon Int'l Airport Highway	1,300 billion won
2000	Daegu-Busan Expressway	990 billion won
2002	Meiya Yulchon Power Plant	262 billion won
2003	Incheon North Seaport Phase 2-1	140 billion won
2004	Incheon Int'l Airport Railroad	3,310 billion won

Table 1-1 Major PPI Projects in South Korea[2]

The Korean PPI program has been generally successful from its establishment in 1994 until 2004. The number of projects has been steadily increasing, and the types of infrastructure have become more diverse, except the fact that most projects were focused on roads, tunnel, bridges and harbors. The sources of funding were limited to loans from banks and the range of participants was also restricted; sponsors were mostly construction companies. However, new types of financing sources such as bonds, ABS[3], off-shore loans and subordinated loans have been adopted, and insurance companies, pension funds, mutual funds, and several investment banks are now actively participating in equity and debt. According to the data from the Korea Development Bank, the total financing amount for 2004 is approximately 20 trillion won, which is equivalent to 19 billion USD. This is tremendous growth, considering that the total financing amount for the entire 1990s was

[2] Leo S.H. Kim, Asia Pacific Report, "Turning Point", 2005

[3] Asset-backed securities (ABS) are bonds that represent pools of loans of similar types, duration and interest rates.

only 1.7 trillion won. This increase is mainly because of the Incheon International Airport Railroad (IIAR) project, the biggest PPI project as well as the first railroad PPI project in Korea. Most of the financial institutions in the PPI market including banks, insurance companies, and pension funds have participated in this deal, which has a total size of 3.31 trillion won. The Incheon International Airport Railroad project will be discussed further as a case study in Chapter 4.

1.3. Motivation and Objectives

Traditionally, Net Present Value (NPV) and Internal Rate of Return (IRR) have been widely used for valuating the feasibility of development projects. The two methods that are based on Discounted Cash Flow (DCF) are generally accepted by investors as the most valuable methods for an investment analysis. However, in real-world situation with uncertainties, project managers and investors often feel these tools are insufficient for the analyses of their development projects. Although NPV and IRR with a hurdle rate are still standard methods for valuing income-generating development projects in the construction industry, the two assessment tools off and on fail to identify what investors can do to capitalize on future uncertain events. For instance, strategically important projects often fail internal financial tests. Analysts, in order to justify their gut feelings, tend to manipulate the evaluation process by raising cash flow forecasts to unlikely levels. Key managers make decisions distorted by their optimism and the degree of risk aversion. Everyone recognizes the limitations of the quantitative analysis and discount it heavily with one's own judgment. Consequently, the decision making process lacks credibility. In today's extremely turbulent

world, managers should recognize how risky the most valuable investment opportunities are, and how useful a flexible strategy can be. [4]

The objective of this thesis is to evaluate flexibilities in a large-scale infrastructure development projects. The flexibilities are critical for large-scale infrastructure projects with a relatively longer construction period. The first of the thesis reviews the methodologies to evaluate development projects and to deal with uncertainties involved. As conventional valuation methods, NPV, IRR, and a couple of other analysis tools will be discussed, and then Decision Tree Analysis and Real Options theory will be introduced as methods to identify and valuate the flexibilities involved in projects. The second half of the thesis is a case study of the "Incheon International Airport Railroad (IIAR)" project in South Korea. The IIAR project is to construct a railroad connecting the Incheon International Airport and Seoul. The construction project started in 2001, with 10 originally planned stations. However, petitions have been filed by three cities asserting 6 more stations to be built, and whether or not to build them has been issued between the cities and the project company. In the case study, the financial structure of the whole railroad project will be analyzed first. Thereafter, the application of Decision Tree and Real Options analysis will demonstrate the reason why flexibilities and options is critical for such a large-scale infrastructure projects with a high-level of uncertainties, and how to valuate options of constructing additional stations.

[4] Martha Amram&Nalin Kulatilaka, "Real Options: Managing Strategic Investment in an Uncertain World," Harvard Business School press, 1999

Chapter 2 Economic Evaluation Analysis in Projects

This chapter provides general methodologies to evaluate development projects in investment decisions. The investment decision of a project is concluded on the basis of the project's financial and economic feasibility. For private investors, including developers in construction projects, a principle for financial feasibility is the value that the project will create. Additionally, for public organizations, the criteria may expand to social and political benefits, which are difficult to be quantified in money.

When we evaluate the feasibility of a project, the comparison of costs and benefits of a project is essential. Thus, a financial feasibility study should be based on the costs and projected revenues in the project. As a traditional method, Discounted Cash Flow (DCF) analysis has been a fundamental principle in business decisions, where money is invested for future revenues. The principle of any DCF analysis is that expected revenues need to be discounted with an appropriate risk-adjusted discount rate. The two most popular methods that base on DCF analysis are Net Present Value (NPV) and Internal Rate of Return (IRR). These two methods will be discussed in detail in the next two sections. In addition, Benefit/Cost Ratio and Payback Period are used occasionally, depending on the nature of projects.

2.1. Net Present Value

Net Present Value is the Present Value (PV) of all costs and profits involved in a project. The principle of PV is that it enables you to calculate the value of any stream of

cash flows in terms of today's dollars. For PV calculation, the cash flows and the correct discount rate in a project should be determined. The discount rate means the rate of return given by equivalent investment alternatives. Theoretically, if there is an existing investment opportunity in the capital markets equivalent to the project, and if the rate of return of the existing investment is known, you can precisely calculate the PV, based on the cash flows that the project will generate. Finally, NPV for the project will be gained by subtracting the initial investment. Suppose that we have a stream of costs and revenues in the future and a certain source of borrowing or saving at the same rate. The Present Value is relative to a borrowing or saving rate, which indicates the opportunity cost, against which gains are measured. The value as of now or the Present Value for the project can be calculated as follows:

$$V_0 = \frac{E_0[CF_1]}{1+E_0[r]} + \frac{E_0[CF_2]}{(1+E_0[r])^2} + \cdots + \frac{E_0[CF_{T-1}]}{(1+E_0[r])^{T-1}} + \frac{E_0[CF_T]}{(1+E_0[r])^T}$$

Where:

CFt: Net cash flow generated by the property in period "t"

Vt: Property value at the end of period "t"

$E_0[r]$: Expected average multi-period return (per period) as of time "zero" (the present), also known as the opportunity cost of capital

T: The terminal period in the expected investment holding period, such that CFT would include the re-sale value of the property at that time (VT), in addition to normal operating cash flow

The general DCF valuation procedure will be:

1. Forecast the future cash flows generated by the project.
2. Ascertain the required total return or the Opportunity Cost of Capital (OCC), which reflects both the time value of money and risks involved in the project.
3. Discount the cash flows at the required rate of return or OCC.
4. Subtract the initial investment from the sum of the discounted cash flows and add the salvage value if the asset has cash value at the end of the project.

It is easy to valuate the project with NPV analysis only if we can obtain the precise projection of cash flows as well as the equal investment opportunity in the capital markets. In most real cases, however, a future stream of cash flows is uncertain, and finding an existing investment opportunity that has the same risk and return is impossible. Therefore, the NPV analysis critically depends on the two important assumptions: what the cash flows of the project will be and what the appropriate discount rate is. We will discuss how to deal with the uncertainty of the future cash flows in Chapter 3 in order to avoid the pitfalls of DCF analysis. As for the discount rate adjustment issue, we will discuss in the next two analyses: Weighted Average Cost of Capital (WACC) and Capital Asset Pricing Model (CAPM).

Weighted Average Cost of Capital (WACC): Assuming an appropriate Opportunity Cost of Capital (OCC) would be one of the most important but difficult work for the calculation of the NPV in a project. In the capital markets, some projects are not profitable enough for

investors. If your company is trying to decide whether to invest in five-year Treasury notes, you will have no problem finding the appropriate rate of return you are expecting. You may easily find the exact information on the rate in a newspaper everyday. However, the determination of a proper OCC of a development project is not as straightforward as that of Treasury notes. Suppose a developer is considering an investment to build a shopping mall in an area. Determining the proper discount rate for the NPV calculation becomes a lot harder than investing in Treasury notes, because investments that are equivalent to this project are scarce. As a result, finding the same rate of return that investors demand for this project will be extremely difficult.

Under the circumstances, we need to consider the capital structure of a firm and its impact on the cost of capital in order to assume the appropriate OCC in a project. The Weighted Average Cost of Capital (WACC) is a widely accepted method for this purpose by combining cost equity and cost of debt, where each of the two is weighted according to their share in total value of a firm. WACC for a firm is cost of equity (in %) plus cost of debt (in %), where each weighted by their share in total value of the firm:

$$V = E + D \quad \text{or} \quad 1 = E/V + D/V$$

Then

$$WACC = r_e\,(E/V) + r_d(D/V)(1\text{-}ta)$$

Where

WACC : Weighted Average Cost of Capital

r_e: current expected rate of return of equity

r_d: current rate of its borrowing

E/V: share of equity in total value of firm

D/V: share of debt in total value

ta: tax rate

Capital Asset Pricing Model (CAPM): Another commonly used method for determining the risk-adjusting discount rate is Capital Asset Pricing Model (CAPM). It describes the relationship between risk and expected return, and also serves as a model for the pricing of risky securities. CAPM helps obtain a more appropriate value of the discount rate by taking into account the project performer's idiosyncratic risk. In other words, it shows how we can value the individual risk premium in relation to its covariance to the market by using a simple linear formula. In CAPM, the expected return of a security or a portfolio equals rate of a risk-free security supplemented with a risk premium. If this expected return does not meet our required return, the investment should not be undertaken. The commonly used formula to describe the CAPM relationship is as follows:

$$R = R_f + \beta\,(K_m - R_f)$$

Where

R: expected return rate on a project
Rf: rate of a risk-free investment
K_m: expected return rate for the market portfolio
β: volatility of a project

It should be remembered that high-beta shares usually give the highest returns. Over a long period of time, however, high-beta shares would be the worst performers if the markets decline. While you might receive high returns from high beta shares, there is no guarantee that the CAPM return will be realized.

With the help of the two methods described above, WACC and CAMP, we can determine the discount rate for a certain project, based both on the capital structure of a firm and on the firm's evaluation in the security market. In this case, however, there is an assumption that the project's risk is the same as the firm's average risk. In fact, each project managed by the same company is different in its degree of risk, depending on the size and character of the project. Treating the firm's average risk as the project's risk by using the same "β" in the CAPM has possibilities to be misleading in an investment decision. Consequently, although the use of WACC and CAPM for NPV analysis will help us understand the risk related to its performer, and help adjust the discount rate based on the firm's performance, the two methodologies still have a limit in adjusting the discount rate; they disregards each project's nature.

2.2. Internal Rate of Return

The Internal Rate of Return (IRR) is another popular tool to valuate a project using the concept of DCF. The IRR is defined as the rate of return that makes the NPV of a project equal to zero. To find the IRR for an investment project lasting T years, we must solve for IRR in the following expression[5]:

$$NPV = C_0 + \frac{C_1}{1+IRR} + \frac{C_2}{(1+IRR)^2} + ... + \frac{C_T}{(1+IRR)^T} = 0$$

The IRR itself is not as useful as the NPV analysis since it does not provide any

[5] Brealey and Myers, "Principle of Corporate Finance", Irwin McGraw-Hill, 2001

information about the risk of the project. The IRR analysis only becomes useful when it is used in relation to the OCC or the required return of a project. Comparing the IRR with the required return is similar to the case of NPV analysis. That is to say, when the IRR is higher than the required return, the project would have a positive NPV. Following this method, the decision rule for the IRR analysis is[6]:

- Maximize the expected IRR across mutually exclusive projects.
- Never do a project with an expected IRR less than the required return.

Generally, the NPV analysis and the IRR analysis give the same results when prioritizing projects based on the financial feasibility. Nowadays, many companies use IRR as their primary measure for investment decisions, because IRR can be easily understood by non-financial managers. For example, you can say "Project G has a 33 percent return" when the IRR of the project G is 33%. They understand what this expression means intuitively. However, we have to keep in mind several disadvantages of the IRR analysis; 1) IRR does not assume the Opportunity Cost of Capital. As the OCC reflects the involved risk in a project, the IRR analysis misses one of the critical factors in an investment decision. 2) IRR only shows the rate of gain, not the size of gain. This may lead investors or managers to choose short-lived projects requiring relatively small initial investments, which may not help increase the value of the firm. 3) IRR analysis can be misleading when the cash flow stream changes its sign more than twice. In this case, two different IRR values will be shown and you cannot choose either of them.

[6] Geltner and Miller, "Commercial Real Estate Analysis and Investment", Princeton University Press, 2001

Although a number of adaptations of the IRR analysis have been devised to overcome the drawbacks, the simple solution of using both NPV analysis and IRR analysis has been accepted as the best way to analyze the feasibility of a project in an investment decision.

2.3. Other Evaluation Methods

In addition to the NPV and IRR analysis, there are a couple of other methods to evaluate the desirability of projects. Depending on the nature of projects, the two additional valuation methods, Payback Period and Benefit/Cost ratio, can take an important role as the right criteria for the investment decision.

Payback Period: The Payback Period method is one of the simplest ways of looking at a project. It shows you how long it will take before you recover the same amount of money that you will spend on the project. The length of time required to recover the cost of an investment is calculated as:

$$\textit{Payback Period} = \textit{Cost of Project} / \textit{Annual Cash Inflows}$$

When all other factors are identical, the better investment is the one with the shorter payback period. At the payback period method, projects with shorter payback periods rank higher than those with longer payback periods. That is to say, the projects with shorter paybacks are more liquid, and thus less risky. If you reimburse your

investment sooner, you can have more chance to reinvest the money elsewhere. Moreover, with a shorter payback period, there is less chance that some factors, which affect the project's profitability, such as market conditions, interest rates, and the economy will drastically change. Generally, a payback period of three years or less is preferred in real estate development projects[7].

However, there are a couple of drawbacks in the payback period method. First of all, it ignores any benefits that occur after the payback period. So, a project that returns $1 million after a six-year payback period is ranked lower than a project that returns zero after a five-year payback. In addition, probably the more serious drawback is the fact that a straight payback method ignores the time value of money. To avoid these problems, you should also consider the NPV and IRR method in an investment decision.

Benefit/Cost ratio: Benefit/Cost ratio is to identify the relationship between the costs and benefits of a proposed project. This ratio has been frequently employed for many forms of government projects, and recently its application is growing even in business investments. This ratio gives you ways to measure both quantitative and qualitative factors involved in a project. Many components of benefits and costs are intuitively obvious, but there are some factors that intuition fails to suggest methods of measurement. Therefore, some basic principles are needed as a guide. For instance, in order to evaluate the desirability of a project, all aspects of the project must be expressed in terms of a common unit. The most convenient common unit is money. This means that all benefits and costs of a project should be measured in terms of their equivalent money value. A project may provide

[7] Geltner and Miller, "Commercial Real Estate Analysis and Investment", Princeton University Press, 2001

benefits that cannot be directly expressed in terms of dollars. However, there is some amount of money that the recipients of the benefits would consider just as good as the project's benefits. So, we need to set a criterion to measure the benefits in terms of the money value. It is assumed that some esoteric benefits such as those from preserving open space or historic sites have a finite equivalent money value to the public.

The benefits and costs of a project have to be expressed not only in terms of equivalent money value but also in terms of dollars at a particular time. When the dollar value of benefits at some time in the future is multiplied by the discounted value of one dollar at that time in the future, the result is discounted present value of that benefit of the project. The same thing applies to costs. The same applies to costs. The net benefit of the projects is just the sum of the present value of the benefits less the present value of the costs[8]. Hence, the Benefit/Cost ratio of the project is the figure of the present value of the benefits divided by the present value of the costs.

[8] Thayer Watkins, "Introduction to Cost Benefit Analysis", San Jose State University, 2003

Chapter 3 Project Valuation under Uncertainty

We summarized fundamental economic valuation methods in Chapter 2. Except for Payback Period, Discounted Cash Flow (DCF) method is a basis for most valuation methods, including the NPV and IRR analysis. To make an investment decision based on the DCF analysis, we have to make two important assumptions, determining the discount rate and estimating a stream of uncertain cash flows. We examined the issue of the appropriate discount rate application in the last chapter. In brief, when the risk of a project increases, we increase the denominator, risk-adjusted discount rate, without changing the numerator, future cash flows. Thereby, cash flows in riskier projects are discounted more heavily. For instance, WACC and CAMP methods give us a tool to adjust the risk of a project according to the firm's overall performance. In this chapter, we will discuss the ambiguity of cash flows and how to deal with the uncertainties in a project.

3.1 Sensitivity Analysis

The Sensitivity Analysis enables us to foresee how the NPV will vary according to some critical parameters. This is a simple technique to assess the effects of adverse changes on a project. It involves changing the value of one or more selected variables and calculates the resulting changes in the NPV or IRR. In the sensitivity analysis, we do not have to estimate the beta (ß) for a project, which requires identifying another company in the same line of business as the project. Instead, we can concentrate on the fundamental variables affecting NPV. The extent of change in the selected variables to test can be derived from

post-evaluation and other studies of similar projects. Changes in variables can be assessed one at a time to identify the key variables. Possible combinations can also be assessed. The results of the sensitivity analysis could be summarized in a sensitivity indicator and in a switching value. As an example, Table 3-1 below shows the result of a sensitivity analysis in an irrigation rehabilitation project.

Item	Change (%)	NPV (Rs mn)	IRR (%)	Sensitivity Indicator	Switching Value (%)
Base Case		1,440	19.0		
Costs					
Investment Costs	+10.0	1,291	17.9	1.03	97
Fertilizer, economic price	+42.1	753	15.8	1.13	88
Benefits					
Rice economic price	-38.9	-1,427	1.7	5.12	-20

Table 3-1 Results of Sensitivity Analysis: Irrigation Rehabilitation Project[9]

In this analysis, the forecast price of rice and fertilizer are key variables, as the project will increase both the quantity of rice output and the quantity of fertilizer input. Suppose the forecast price of rice, which has declined over the last ten years, is predicted to follow the same pattern, and this is equivalent to a price 39 percent lower than that of the base case. The NPV changes to -1,427 from 1,440 of the base case. On a similar basis, if the fertilizer price is anticipated to be 42 percent higher than that of the base case, the NPV changes to 753 from 1,440. We can see that the change of rice price affects the project's

[9] Asian Development Bank, "Guidelines for the Economic Analysis of Projects", 1997

NPV more than the change of fertilizer price because the change is in proportion to each sensitivity indicator.

The sensitivity analysis is used to assess the effects of changes in project variables that are quantified. The results can be presented together with recommendations on what actions to take or which variables to monitor during implementation and operation period. However, many projects involve institutional and social risks that cannot be readily quantified. A statement of such risks and any mitigating actions should be included alongside the conclusions from the sensitivity analysis.

In practice, managers usually alter data and model co-efficiencies within a certain range (e.g., ±10%) based on their experience or guidelines. Another simple approach is to use the range from "optimistic" case to "pessimistic" case or taking "reasonable extreme" assumptions to compare outcomes. The underlying concept of this methodology is that more things can happen than they ordinarily happen, and we need to examine each possibility in dealing with uncertainty. This sensitive analysis helps managers identify the possible range of outcomes, consider the impacts, and make decisions on investment.[10]

3.2 Decision Tree Analysis (DTA)

Decision Tree Analysis (DTA) is one of the most important tools available that can assess flexibilities in a project. It was first advocated by J.Magee in 1964 and has remained an important tool for capital investment decisions. DTA is basically a tool that can depict strategic future pathways an investor can base on with a number of different future

[10] Yasuaki Moriyama, "Strategic Decision Analysis for Transportation Systems," MIT thesis, 2003

outcomes. It shows graphically a decision roadmap of an investor's strategic opportunities over time. DTA can be used when future outcomes are uncertain and investors have tools to react when new information is arrived in the future.[11]

Even though sensitivity analysis and Monte Carlo simulation provide managers with an understanding of the nature of a project like the possible range and distribution of outcomes, these methods do not consider the manager's ability to cope with unexpected events during the life of a project. If the condition around the project changes from initial assumptions, managers can deal with the situation in another way, such as by abandoning the project to minimize their loss or by expending it to increase its benefit. An investment decision is not simply an accept-or-reject decision that has to be decided at the beginning of the project. In reality, subsequent decisions are tied together during the entire period of a project. In this sense, Decision Tree Analysis can be an effective tool to analyze a project that involves sequential decisions.

Decision Tree Analysis incorporates the value of flexibilities by explicitly laying out the structure of a project in such a way that all uncertainties and the potential decisions to be made are represented in a tree from. A Decision Tree is composed of three basic nodes:

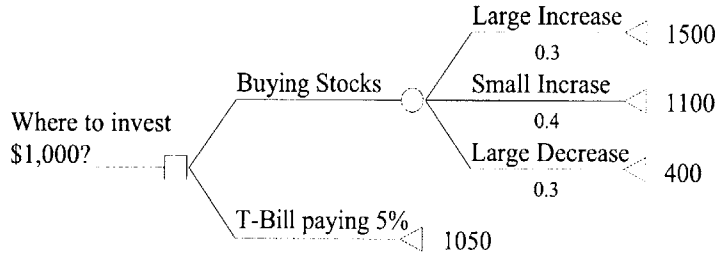
- Decision nodes (square), where possible decisions are contemplated and a decision made.
- Chance nodes (circle), where outcomes are determined by events or states of nature. Chances nodes have probability of each chance happening, and the sum of the

[11] Jihun Kang, "Valuing Flexibilities in Large Scale Real Estate Development Projects, MIT thesis, 2004

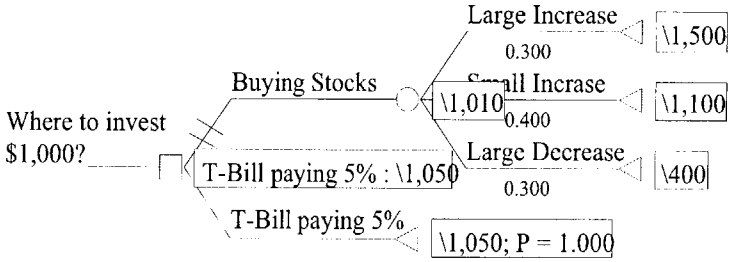
probabilities equals one.

- Terminal nodes (triangle), where a project is completed or abandoned. They are the end points of the decision tree branches and typically accompanied by terminal value of the path.

In most basic forms, a Decision Tree has series of decision nodes and chance nodes branching out to form a tree-shaped structure. By assigning probabilities in chance nodes and terminal payoffs at the terminal nodes of each branch, it is possible to value the project at each decision node.



Structuring of Decision Tree



Expected Value of Each Node

Figure 3-1 Example of Decision Tree Analysis in Investment Decision

The simple analysis in Figure 3-1 identifies T-Bill as a superior investment than buying stocks, based on the expected value calculation. This model is deterministic model in that it assumes all future probabilities of outcomes are already known. It is possible to estimate probabilities and payoffs based on past data, but it is not possible to know the real probabilities in most cases. The real world application of Decision Tree analysis would have much more complex forms and many variables. The major advantage of Decision Tree analysis is that it exposes all the uncertainties and accompanying flexibilities of a project wide open, which otherwise would have been treated as a "black box" that only gives a single value estimation[12].

3.3 Monte Carlo simulation

Monte Carlo simulation was named for Monte Carlo, Monaco, where the primary attractions are casinos containing games of chance. Games of chance, such as roulette wheels, dice, and slot machines, exhibit random behavior. In the similar way with the random behavior in games of chance, Monte Carlo simulation can simulate real life movements of underlying assets by randomly generating values for uncertain variables repeatedly. In this simulation, you define the possible values with a probability distribution for each uncertain variable. The type of distribution you select is based on the conditions surrounding that variable. Distribution types include:

[12] Jihun Kang, "Valuing Flexibilities in Large Scale Real Estate Development Projects, MIT thesis, 2004

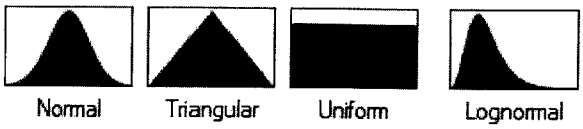


Figure 3-2 Distribution types for values[13]

During a simulation, random numbers are drawn from these pre-defined probabilities, and the results of the values are calculated. The example in Figure 3-4 shows the outcome of Monte Carlo simulation in bidding price evaluation from the Decision Tree model in Figure 3-3.

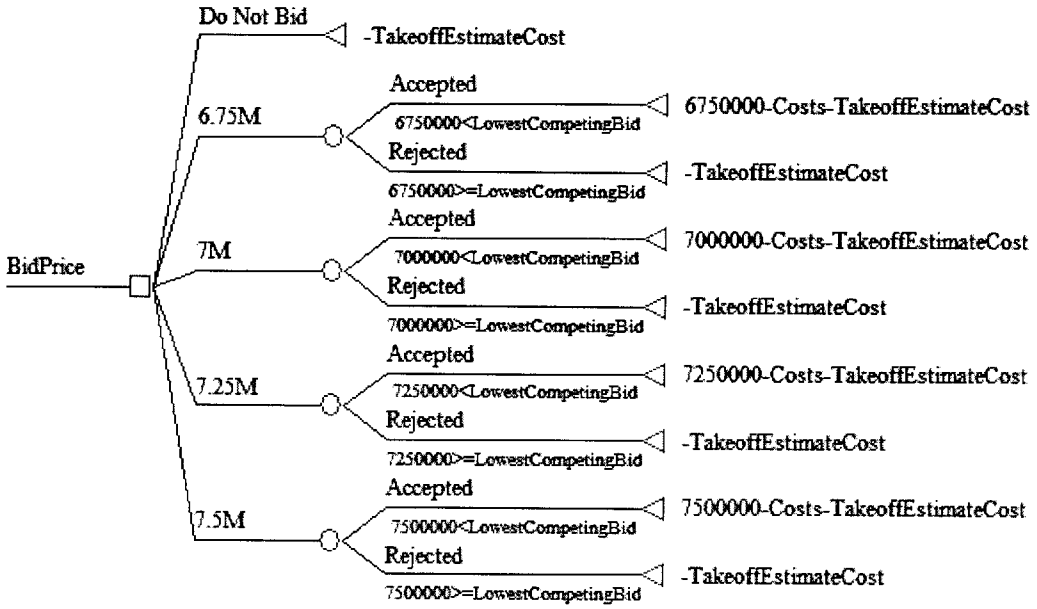


Figure 3-3 Example of Decision Tree Model for Bidding Price decision

[13] http://www.decisioneering.com/monte-carlo-simulation.html

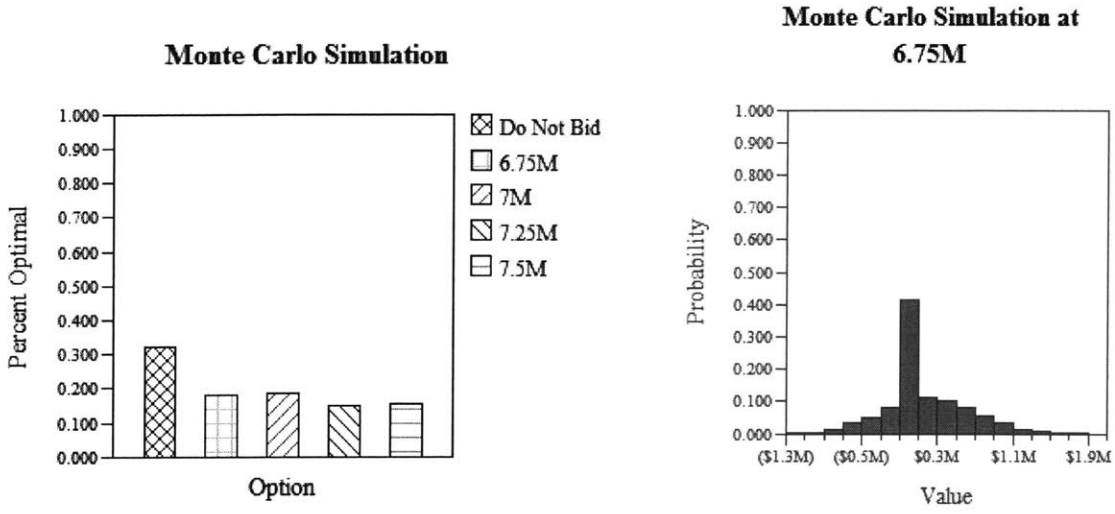


Figure 3-4 Examples of Monte Carlo simulation in Bidding Price decision

After finishing the model construction with Decision Tree, you should define the distribution type and range of the variable that is *LowestCompetingBid* in this case. Thereafter, running the simulation numerous enough times like 3000 trials will give us a better picture of the value of each choice.

The advantage of the Monte Carlo simulation is that it allows managers to acknowledge the uncertainty of their projects. The manager can gain a better understanding about how each variable's uncertainty affects their project feasibilities. However, this simulation has a couple of restrictions. First of all, it is difficult to construct an exact model for a complicated project with the interrelationship of each variable. In fact, a simulation model that tries to be completely realistic will be too complex to make. In addition, assuming the distribution type of each variable is often incorrect. Since the result depends on these assumptions, it is possible that the result will be biased.

3.4 Real Options Analysis (ROA)

While the traditional discounted cash flow analysis such as NPV or IRR is a great method to evaluate a project, it fails to consider any potential strategic options that may be associated with the quantifying any such options that may be apparent. If uncertainty is a major concern in a project, we may value the flexibilities as options to cope with unexpected events. For example, by investing in a particular project, a company may have the real options of expanding, downsizing, or abandoning other projects in the future. They are referred to as "real" because they usually pertain to tangible assets, such as capital equipment, rather than financial instruments. Taking into account real options can help to appraise the value of potential investments.

3.4.1 Types of Real Options

The following is list of three basic Real Options that is widely recognized and implemented.

Option to Delay a Project: Under traditional investment analysis, it is reasonable to accept or reject an investment proposal based on its net present value based on the expected cash flows and discount rates at the time of the analysis. However, such cash flows and discount rates change overtime, therefore a proposal that has a negative net present value today may have a positive net present value in the future. The option to delay a project represents the value gained by waiting to take advantage of any upside volatility in the net present value.

Option to Expend a Project: It is not unusual for firms to make "seed" investments into projects, which may even have negative net present values by themselves, but allow the possibility to enter other projects and markets in the future. In such cases, the firm is willing to pay a price for the possibility of expanding into these new markets. The option to expand a project represents the value gained by entering a project today that can offer the ability to participate in future projects with potential upside value.

Option to Abandon a Project: Not all projects or investments are successful and when the cash flows do not measure up to the original expectations, it is useful to value the option to abandon the project. The option to abandon a project represents the difference between the present value of continuing the project to the end of its useful life and the present liquidation value of the project.

As listed above, a majority of real world decisions in response to uncertainties can be modeled as a Real Options or combination of different types of Real Options. When applied to real world projects, even a simple project involves multiple options to choose from. Managers and investors often have to make strategic decisions during the project. To model this complex real world situation, it is essential to identify uncertainties that matter the most. If investors can effectively mitigate some risks, options valuation should focus on the risks that would affect the project outcome. Therefore, simplification without damaging integrity of analysis is one of the most important techniques for the Real Options Analysis.

3.4.2 Real Options Valuation

In a narrow sense, the real options approach is the extension of financial option theory to options on real assets. While financial options are detailed in the contract, real options embedded in strategic investments must be identified and specified. Moving from financial options to real options requires a way of thinking, one that brings the discipline of the financial markets to internal strategic investment decisions.

An option represents the right to buy (call) or sell (put) a specific quantity of an asset at a fixed price (exercise price) at a specific date in the future. This right is not an obligation, therefore the holder can choose not to exercise the purchase or sale and allow the option to expire. A call option gives the holder the right to buy an asset at a specified exercise price at any time before the specified expiry date. At the expiry date, if the asset value is less than the exercise price, the asset is not purchased and the option expires worthless. On the other hand, if the asset value exceeds the exercise price, the asset is purchased at the exercise price and difference represents the gross profit on the investment.

The net profit is the difference between the gross profit and the price paid for the call. The options to delay or expand a project are both variations of call options. For an instance, we can take advantage of the analogy with financial American call option on a stock that pays a continuously compound dividend yield. The main practical advantage of this analogy with financial option is the simplicity to treat complex problem of investment under uncertainty. The analogy between financial and real options is particularly interesting when performing sensibility analysis. The following table 3-2 presents the American call analogy between financial option and real option, for a general project.

FINANCIAL OPTION	REAL OPTION (F)
Stock or Other Financial Asset	Producing Project (V)
Exercise Price of the Option	Investment Cost for the Project (D)
Stock Dividend Yield	Cash Flows as Proportion of V (δ)
Risk-Free Interest Rate	Risk-Free Interest Rate (r)
Stock Volatility	Project Value Volatility (or proxy) (σ)
Time to Expiration of the Option	Time to Expiration (T)

Table 3-2 Comparison between American Call Option and Real Option

A put option gives the holder the right to sell an asset at a specified exercise price at any time before the specified expiry date. At the expiry date, if the asset value is greater than the exercise price, the asset is not sold and the option expires worthless. In contrast, if the asset value is less than the exercise price, the asset is sold at exercise price and the difference represents the gross profit on the option. The net profit is the difference between the gross profit and the price paid for the put. The option to abandon a project is a variation of a put option.

Black-Scholes Model: The calculation of option value (call or put price) can be accomplished in the model by employing modified versions of the Black-Scholes model. [14]

[14] Black-Scholes Formula:

$$C_0 = S_0 \cdot N(d_1) - X \cdot e^{-rT} \cdot N(d2)$$

$$d_1 = [ln(S_0/X) + (r + \sigma^2/2)T] / (\sigma \cdot T^{1/2})$$

$$d_2 = d_1 - (\sigma \cdot T^{1/2})$$

where

C_0: current option value

S_0: current stock price

N(d): probability that will be less than "d" in a normal distribution

In broad terms the model employs the use of a replicating portfolio consisting of the underlying asset and risk-free rate to determine the options value. Determinants of option value are the inputs required for such a model. The following table 3-3 summarizes the key inputs required for the modified Black-Scholes models and their effect on the option values.

Input	Effect of Increase in Input on values for:	
	Call (Delay, Expand)	Put (Abandon)
Current Value of Underlying Asset	Increase	Decrease
Variance in value of the underlying asset	Increase	Increase
Dividends or cash flows from the asset	Decrease	Increase
Exercise Price of the option	Decrease	Increase
Time to Expiration of the option	Decrease	Increase
Risk free interest rate	Increase	Decrease

Table 3-3 Relationship between Key Input and option value changes

It should be noticed that this model is essentially designed to value options on financially traded assets where inputs are readily available from market data sources. When applying such models to real options, some alternative adjustments and assumptions can be made in order to assist application. The following underlying assumptions of the Black-Scholes model illustrate this:

X: exercise price
e: base of the natural log (=2.71828)
r: risk-free interest rate
T: time to maturity of the option in years
In: natural log function
σ: standard deviation of annualized continuously compounded rate of return on the stock

- The value of the asset is continuous (i.e. no price jumps). While this is reasonable to expect for traded assets, non-traded assets often change value erratically. For many real options this will underestimate the value.
- The variance is known and constant. When applied to long-term real options, the assumption that the price variance is known and does not change over the lifetime of the option is unreasonable.
- Exercise is instantaneous. In many real option scenarios, exercising may take up to several years. In this case, the life of the option should be reduced to accommodate the time required to exercise.

Binomial Tree Model: Another important method of valuing Real Options is the Binomial Tree Model. This method is a popular due to its conceptual clarity and ease of use. It is flexible enough to be modified based on different structures and intuitive enough to be used by average practitioners. It graphically shows how future uncertainties unfold, and it is similar to Decision Tree in a way it incorporates flexibilities of future decisions. The example in the following Figure 3-5 is valued as an American Call option with three years of maturity.

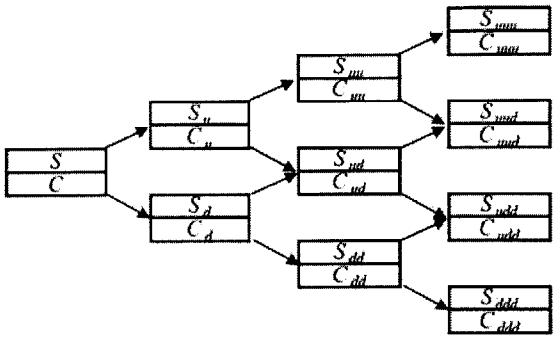


Figure 3-5 Binomial Tree with Asset Pricing (S) and Call Option Payoffs (C)

The Binomial Tree assumes many periods in exercising an option. This model varies the value of underlying assets based on the volatility in a given period, and rolls back the values from the expiration. For each period, the value of immediate payoff and holding of the option, and decides whether the owner should exercise the option. Thus, this model determines the optimal strategy of exercising options, and the value of options at the time of investment by summing up the values throughout the whole period. Value of holding the call option for the next period is:

$$C_h = [p \cdot C_u + (1-p) \cdot C_d]/(1+r)$$

where

p: risk-neutral probability

C_u: value of option at end if up

C_d: value of option at end if down

The concept of the risk neutral probability and no-arbitrage explicitly play crucial role in this approach. Based on this concept, we can replicate the payoffs of an option as if we bought an asset by borrowing a risk-fee loan.

Assuming the asset share is X, and loan share is Y, the replicated payoffs are:

$$X \cdot Su + Y \cdot S(1+r) = Cu$$

$$X \cdot Sd + Y \cdot S(1+r) = Cd$$

where

u: parameter to determine the S at end if up ($e \cdot \exp(\sigma\sqrt{\Delta t})$)

d: parameter to determine the S at end if down ($e \cdot \exp(-\sigma\sqrt{\Delta t})$)

r: risk-free interest rate

When we solve the equation, the option price (=value of the portfolio) is:

$$C_h = [(1+r-d)C_u+(u-(1+r)/C_d)(1+r)/(u-d)$$

We can rewrite the above formula by using a factor "q"

$$C_h = [q \cdot C_u+(1-q)/C_d]/(1+r)$$

$$q = (1+r-d)/(u-d)$$

This process leads us to adjust the investment situation as if we could calculate the expected value of options with binomial probabilities q and (1-q), which are risk-neutral probabilities. Finally, the value of options is the maximum of their immediate exercise, holding for another period, or zero:

$$C = max\{S-X, [q \cdot C_u+(1-q)/C_d]/(1+r), 0\}$$

where

S: value of asset

X: exercise price

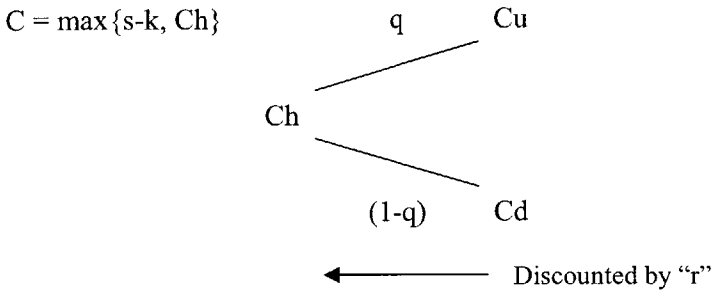


Figure 3-6 Expected Values of Options in Binomial Tree

To summarize, the current valuation and decision-making tools, including NPV and IRR analysis, do not work for the new business realities, such as strategic investments with lots of uncertainty and huge capital requirements; projects that must adapt to evolving conditions; complex asset structures through partnerships, licenses, and joint ventures; and the relentless pressure from the financial markets for value-creating strategy.[15] In this uncertain and risky investment environment, the real options approach can be substantially beneficial to managers because it helps them with the opportunities they have to plan and manage strategic investments. Real option is an important way of thinking about valuation and strategic decision making, and the power of this approach is starting to change the economic equations of many industries.

[15] Martha Amram&Nalin Kulatilaka, "Real Options: Managing Strategic Investment in an Uncertain World," Harvard Business School press, 1999

Chapter 4 Case Study – Incheon International Railroad Project

4.1 Project Overview and Background

The Incheon International Airport Railroad (IIAR) Project was initiated in April 2001 for the purpose of transporting airline passengers from Seoul to Incheon International Airport at a maximum speed of 120 km/h. Along the total distance of 61 km on the railroad, ten stations are to be constructed: Seoul, Gongduk, Hongik, Susaek, Gimpo Airport, Gyulhyun, Gyungseo, Supporting City, New Airport #1, and New Airport #2 stations. This project consists of two phases, and 1st phase construction has commenced with the aim of starting its service by March 2007 from Gimpo Airport to Incheon Airport (40.7 km).

This railroad project is part of Incheon International Airport, which sits at the center of Northeast Asia's transportation network comprising 51 cities - with populations exceeding 1 million - situated within a 3.5-hour flight radius. Since the airport opened in 2001, it has grown to be the second-largest airport in the world and is capable of handling 170,000 flights and 27 million passengers each year. Once the four-phase expansion is complete in 2020, the airport will be able to accommodate 530,000 flights, 100 million passengers, and 7 million metric tons of cargo per year. In addition to the airport passengers, several Custom Free Zones and large-scale tourist resorts are being developed around the airport near Seoul. However, 8-lane Incheon International Airport Highway is the only way to connect the airport to the mainland at the moment. Considering the rapidly growing numbers of airline passengers and future transport demand on the outskirts of the airport, the completion of this railroad project in a timely manner is critical to the success

of the whole Incheon International Airport Project.

Route	Incheon Airport - Gimpo Airport - Seoul
Project Scale	Total 61.5 km, 10 Railroad Stops
Maximum Speed	120 km/h
1st Phase	Incheon Airport - Gimpo Airport (6 stops) Distance: 40.7 km Construction Period: Apr 2001 - Mar 2007 (72 months)
2nd Phase	Gimpo Airport - Seoul (4 stops) Distance: 20.3 km Construction Period: Jan 2004 - Dec 2009 (72 months)
Project Company	Incheon International Airport Railroad Company (IIARC)
Delivery Method	Build - Operate - Transfer
Project Cost	3.95 trillion won (4.35 billion USD)
Project Period	Total 104 months
Concession Period	30 years from 2010
Financing Plan	Government Support: 0.85 trillion won (0.77 billion USD) Debt: 2.51 trillion won (2.28 billion USD) Equity: 1.15 trillion won (1.04 billion USD)

Table 4-1 IIAR Project Outline

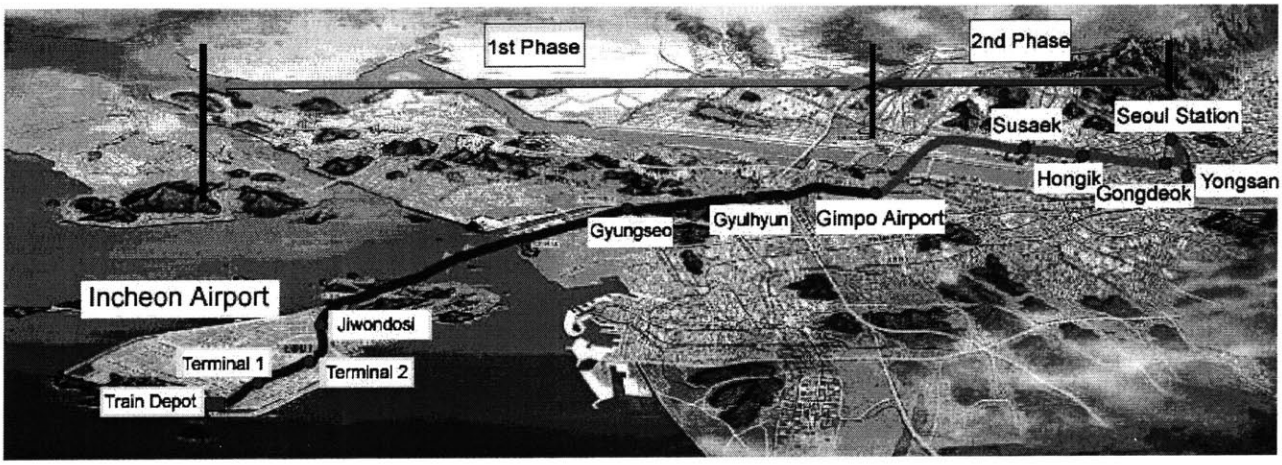


Figure 4-1 IIAR Project Location

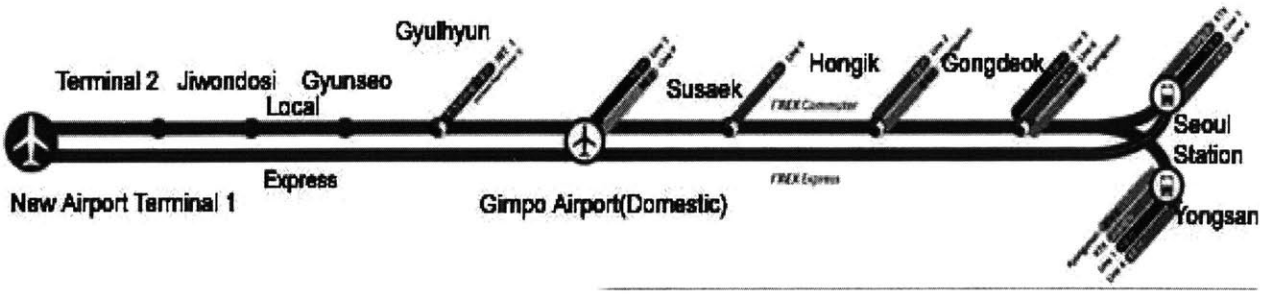


Figure 4-2 Originally Planned Stations

4.1.1 Project Schedule

Date	Schedule
1994. 04	Approved as Private Financing (PF) by the Korean Government
1998. 12	Preferred negotiating applicants designated
2001. 03. 23	Incheon International Airport Railroad Company formally established
2001. 03. 31	1st phase execution plan approved
2001. 04. 30	1st phase civil construction work commenced
2002. 11. 30	Submission of execution plan for 2nd phase
2003. 12. 31	2nd phase execution plan approved
2004. 01	2nd phase construction work commenced
2004. 10. 27	Project Finance contract awarded
2007. 01	Completion of construction for 1st phase
2007. 03	Beginning of operation for 1st phase
2009	Completion of construction and beginning of operation for 2nd phase
2039	End of concessionaire period

Table 4-2 IIAR Project Timeline

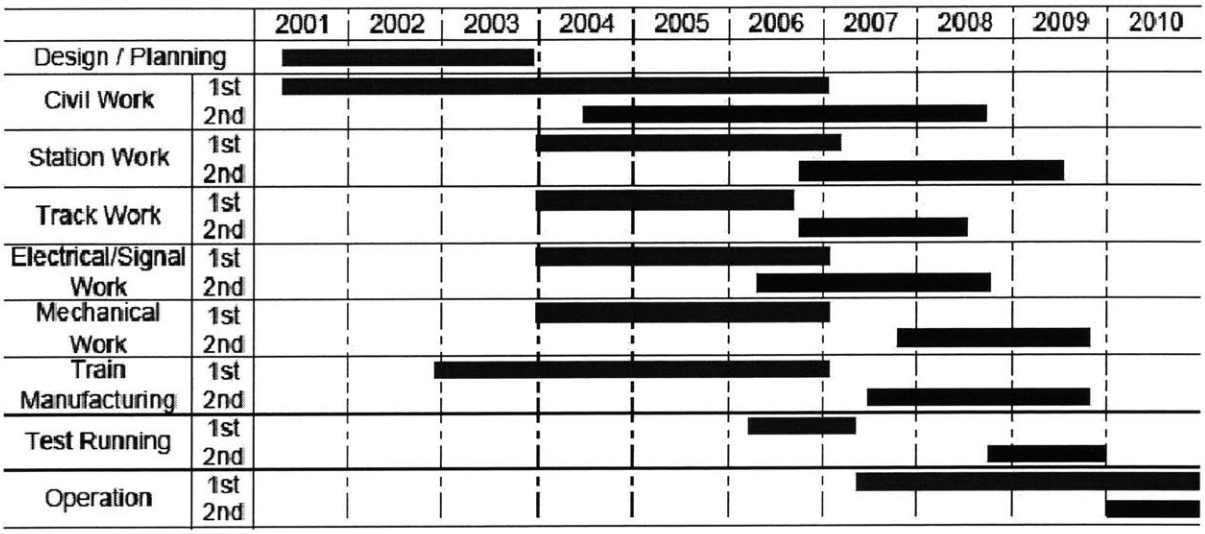


Figure 4-3 IIAR Project Schedule

4.1.2 Project Structure

This project has employed the Fast-track method, in which the design and construction periods are overlapped and proceed at the same time. Since the opening of Incheon Airport in 2001, the demand on the railroad connecting the airport and downtown Seoul has been enormous. Given the urgent need for opening the service and the huge size of the project, the keys to the success of the construction project are how to manage the complex process of the development and how effectively the diverse participants will cooperate with each other.

Under the guidance of the Ministry of Construction and Transportation (MOCT), Incheon International Railroad Company (IIARC) is in charge of constructing and operating the railroad for 30 years. For the project management, IIARC has a contract with a consortium composed of 4 companies including KOPEC. In addition, it has hired Bechtel

International Inc. as a foreign project manager to provide advanced technology and know-how. For the construction and design inspection, a consortium was established led by Yooshin Corporation Inc.

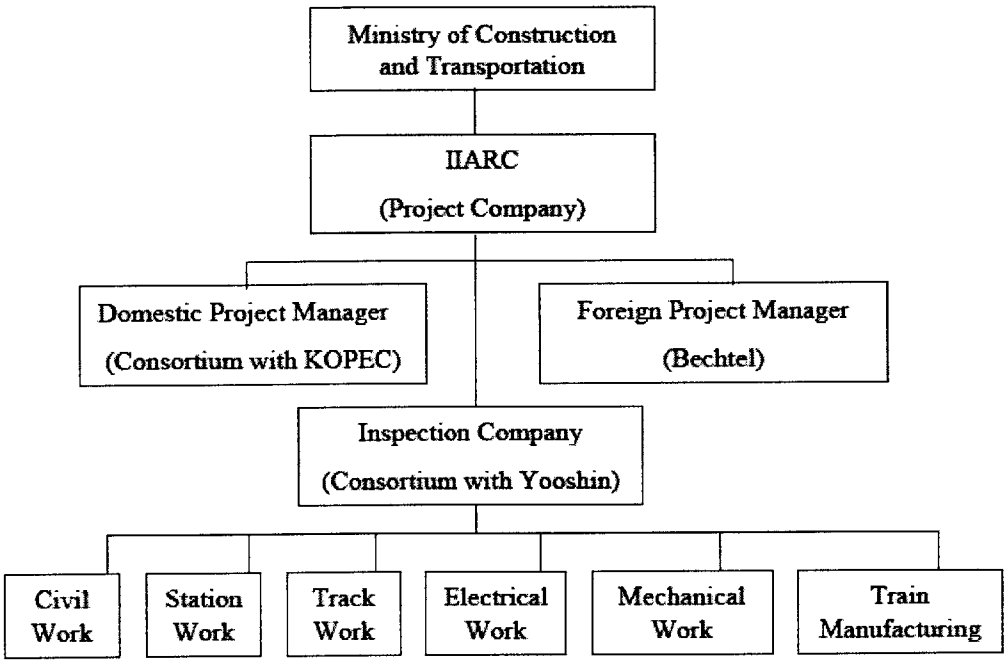


Figure 4-4 IIAR Project Contract Structure

4.2 Financing Structure Analysis

The project company, IIARC, is in charge of construction and management of the Incheon International Airport Railroad (IIAR) project for the next 30 years, after which it will be handed over to the government. IIARC is a private consortium composed of 10 major construction or engineering companies and the Ministry of Construction and

Transportation (MOCT). These sponsor companies are shareholders who own stock in IIARC and are responsible for 26% of the total cost of the project.

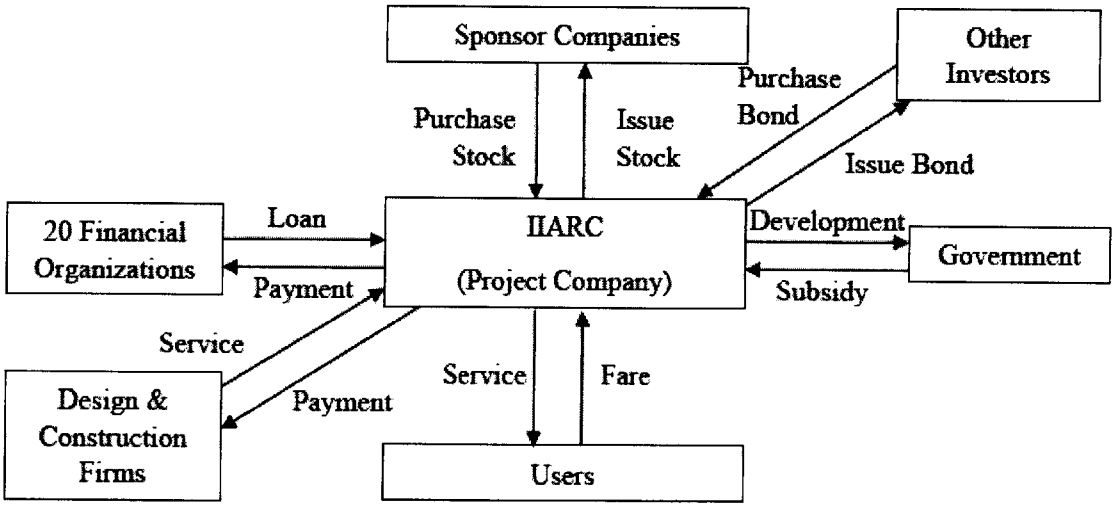


Figure 4-5 IIAR Project Financing Structure

In addition to equity from the sponsor companies, the 20 financial organizations will pool 2.31 trillion won into a syndicate loan, and Korean Development Bank, one of the institutions, will extend an additional 200 billion won in "stand-by facility" in case the project runs over budget. The Korean government supports the rest of the total project capital, 769 million USD, as a form of subsidy. This financial assistance from the government is a pure support to enhance the traffic condition and to foster developing the areas along the railway. The subsidy will be offered on condition that IIARC will complete and operate the project for 30 years and give it back to the government. The amount of subsidy accounts for 18.8% of the total capital.

4.2.1 Capital Structure

The capital of the project will be raised by 25.5% equity from the sponsor companies for initial construction, 55.7% debt from the syndicated loan, and 18.8% from the government subsidy. The 4.5-trillion won will be the largest single Project Finance in Korea's history. The scale of this PF is uncommon anywhere in the world. The previous largest PF in South Korea was worth 1.3 trillion won for the construction of the expressway connecting Seoul and Incheon International Airport.

	Execution Plan (Dec 2003)		Finalized Plan (Oct 2004)		
Unit	Billion Won	Million USD	Billion Won	Million USD	Proportion
Government Subsidy	846	769	846	769	18.8%
Equity	931	846	1,151	1,046	25.5%
Debt	2,172	1,975	2,510	2,282	55.7%
Total	3,949	3,590	4,507	4,097	100.0%

Table 4-3 IIAR Capital Structure

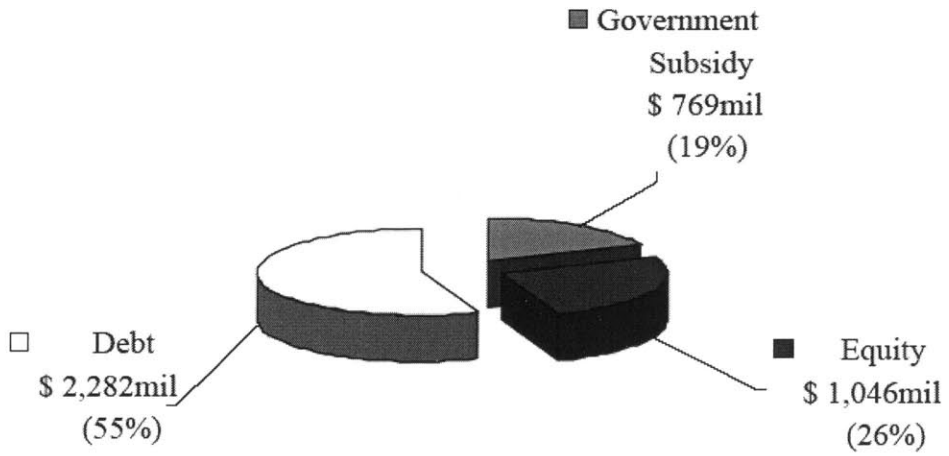


Figure 4-6 IIAR Project Capital Structure

4.2.2 Equity Investment from Sponsor Companies

"The equity investment in project financing represents the risk capital" [1]. Project financiers typically require equity investments from 20 to 40 percent of total financing. In this project, the equity from sponsor companies accounts for 26% of total capital, and this equity becomes the primary motivation for lenders to advance additional senior forms of capital to the project, considering the sponsors' equity as a commitment to the project.

The project sponsor generally consists of one or more corporations that have special interests in the development of the project. Typically, project sponsors are involved in either the construction or the management of a project. In the IIAR project, most sponsor companies are major Korean construction companies with healthy financial status and substantial experience in various civil construction projects. Among the sponsor companies, Kumgang Chemical (KCC) is a major supplier of construction materials and Sampyo KRT is a supplier of facilities and operating devices for railroads. Chungsuck Engineering is the firm in charge of design for the project. MOCT through its Korean Railroad Company is in charge of about 10% of the equity of the project. The investment represents the government's close relationship with the project company and the public character of this project.

In June of 2002, the project company, IIARC, was given a turnkey contract of as much as 1,251 billion won. The amount of each contract of individual companies is proportional to the amount of its equity investment. Hyundai Construction has the largest ownership, 27.0%, which is valued at 311 billion won, followed by Daerim Construction

[1] Nevitt, Peter K., "Project Financing", Euromoney Books, 2000

and POSCO, which have ownership of 18.9% and 11.9%, respectively. The investment proportions of the project are illustrated in Table 4-4.

Investment of Sponsor Companies (2004. 10)

Company	Ratio	Billion Won	Million USD
Hyundai Construction	27.0%	311	283
Daerim Construction	18.9%	218	198
POSCO	11.9%	137	125
Dongbu Construction	10.8%	124	113
MOCT	9.9%	114	104
Kumgang Chemical	7.6%	87	80
Samhwan Construction	5.4%	62	57
Sambu Construction	5.0%	58	52
Hyundai Insurance	1.3%	15	14
Chungsuck Engineering	1.2%	14	13
Sampyo KRT	1.0%	12	10
Total	100.0%	1,151	1,046

Contracts of Sponsor Companies (2002. 06)

Company	Ratio	Billion Won	Million USD
Construction Contracts			
Hyundai Construction	31.8%	704	640
Daerim Construction	19.7%	435	396
POSCO	14.5%	320	291
Dongbu Construction	12.1%	268	244
Kumgang Construction	8.6%	191	173
Samhwan Construction	6.1%	134	122
Sambu Construction	5.6%	124	113
Korea Development	1.6%	34	31
Subtotal	100.0%	2,210	2,009
Design Contracts			
Chungsuck Engineering	-	41	37
Total Turnkey Contracts		2,251	2,047

Table 4-4 Sponsor Companies' Investment and Contract Amount

As shown in Figure 4-7 below, the investment ratio of each company was primarily determined by the size and commitment of the participating construction companies. Hyundai Construction, POSCO, Daerim Construction, and Dongbu Construction each have more than 10% of ownership, and they are four of the largest firms in terms of revenue and assets.

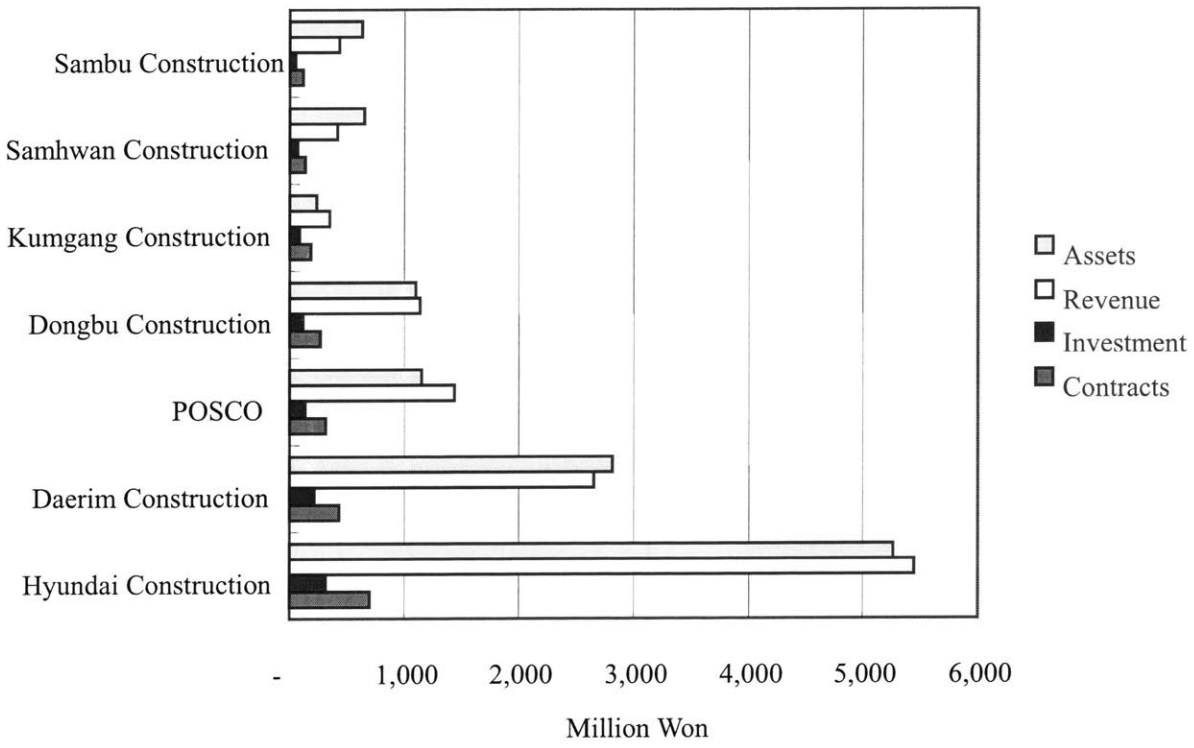


Figure 4-7 Comparison between the Size and Investment Ratio of Sponsor Companies

A balance sheet and income statement of the main sponsor companies is provided in Table 4-5.

Balance Sheet

Companies		2004/06			2003/12			2002/12		
		Assets	Liabilities	Equities	Assets	Liabilities	Equities	Assets	Liabilities	Equities
Hyundai Construction	Billion Won	4,583	3,843	740	4,750	4,011	738	5,266	4,668	599
	Million USD	4,166	3,493	673	4,318	3,647	671	4,788	4,243	544
Daerim Construction	Billion Won	3,278	1,535	1,742	3,048	1,403	1,645	2,811	1,312	1,498
	Million USD	2,980	1,396	1,584	2,771	1,275	1,496	2,555	1,193	1,362
POSCO	Billion Won	1,782	994	788	1,343	621	722	1,155	461	694
	Million USD	1,620	904	716	1,221	565	656	1,050	419	631
Dongbu Construction	Billion Won	1,292	866	426	1,142	709	433	1,098	714	384
	Million USD	1,174	787	387	1,038	644	393	998	649	349
Kumgang Construction	Billion Won	313	174	140	272	137	135	238	127	111
	Million USD	285	158	127	247	125	122	216	116	101
Samhwan Construction	Billion Won	680	295	385	657	275	382	661	299	362
	Million USD	618	268	350	597	250	347	601	272	329
Sambu Construction	Billion Won	722	452	269	642	381	260	637	386	251
	Million USD	656	411	245	583	347	237	579	351	229

Income Statement

Companies		2004/06			2003/12			2002/12		
		Revenue	Operating Income	Net Income	Revenue	Operating Income	Net Income	Revenue	Operating Income	Net Income
Hyundai Construction	Billion Won	2,392	153	69	5,152	307	79	5,443	195	27
	Million USD	2,174	139	63	4,684	279	71	4,949	178	25
Daerim Construction	Billion Won	1,933	140	276	3,329	232	312	2,652	128	191
	Million USD	1,757	127	250	3,026	211	284	2,411	117	174
POSCO	Billion Won	N/A	N/A	N/A	1,643	112	78	1,488	78	61
	Million USD	N/A	N/A	N/A	1,493	102	71	1,353	70	56
Dongbu Construction	Billion Won	548	22	35	1,025	67	70	1,136	86	74
	Million USD	498	20	32	932	61	64	1,033	79	67
Kumgang Construction	Billion Won	238	20	19	447	36	37	354	31	32
	Million USD	216	18	18	407	33	33	322	28	30
Samhwan Construction	Billion Won	242	15	17	436	17	21	414	29	19
	Million USD	220	13	16	396	15	19	376	26	18
Sambu Construction	Billion Won	263	13	17	492	28	12	434	18	5
	Million USD	239	12	15	447	25	11	395	16	5

Table 4-5 Sponsor Companies' Financial Status

The type of equity investment of each sponsor company is classified as "available-for-sale" securities and "non-marketable" securities.[2] Investments not classified as either held-to-maturity[3] or trading securities[4] are classified as available-for-sale securities. Non-marketable securities are recorded at the fair values derived from the discounted cash flows with an interest rate that approximates the market interest rate. In contrast, marketable securities are valued at the quoted market prices as of the period end. For instance, Hyundai Construction, which has 27% of ownership in IIARC had invested about 100 billion won through the purchase of IIARC's securities by 2003. POSCO invested around 45 billion Won till 2003.

Description	Percentage of ownership	Won (millions) Cost	Fair value	Unrealized loss	Book value
Investment assets:					
Hyundai Merchant Marine Co., Ltd.	8.69%	₩ 89,541	88,720	(821)	88,720
Chohung Bank Co., Ltd.	0.38%	27,173	10,151	(17,022)	10,151
Other Marketable equity securities		506	74	(423)	74
Hyundai Asan Co., Ltd. (*2)	19.84%	89,274	21,441	(415)	35,290
Korea Housing Guarantee Co., Ltd.	0.55%	67,765	6,771	-	6,771
CheonAn-Nonsan Highway Co., Ltd.	12.50%	56,250	46,680	-	56,250
Hyundai Financial Service Co., Ltd.	9.29%	9,888	9,826	-	9,888
Kyungin Canal Co., Ltd. (*3)	51.76%	34,870	31,372	-	34,870
Incheon International Airport Railroad (*3)	27.00%	102,114	99,278	-	102,114
Pusan New Harbor Co., Ltd.	9.28%	27,587	24,673	-	27,587
Seoul Highway Co., Ltd.	8.00%	26,184	23,519	-	26,184
Korea Construction Financial Corporation	1.85%	50,603	64,278	-	50,603
Other (*1)		41,823	34,279	-	31,970
		₩ 623,578	461,062	(18,681)	480,472

Table 4-6 Available-for-sale securities of Hyundai Construction as of Dec 2003

Of the total equity investment of 1,151 billion won from sponsor companies, the

[2] Based on Statement of Korea Accounting Standards[SKAS] No.8, "Investments in Securities"
[3] Investments in debt securities that the company has the positive intent and ability to hold to maturity.
[4] Securities that are bought and held principally for the purpose of selling them in the near future.

rest of equity investment will be raised by way of issuing bonds and loans, which will amount to 210 billion won and 170 billion won respectively.

4.2.3 Debt Financing

A group of 20 financial organizations, including the Korea Development Bank, Shinhan Bank, Woori Bank, National Pension Corporation, National Agricultural Co-Fed, Samsung Life Insurance, and Korea Life Insurance decided to finance up to 1,700 billion won for this project in October of 2004. Among those organizations, KDB will contribute the largest amount of 500 billion won, followed by the National Pension Fund's 250 billion won and National Agricultural Cooperative Federation, known as Nonghyup, fronting 230 billion won. Shinhan Bank will provide 210 billion won and Woori Bank 200 billion won, while insurers and smaller banks based outside of Seoul will make up the remainder. The first fund-raising is planned to occur in April of 2005.

Of the total 2,510-billion-won debt, the remainder, 800 billion won, will be raised by selling Social Overhead Capital (SOC) bond. In order to attract private investment on infrastructure projects, the Korean Government is encouraging companies to issue SOC bonds by promising to cut 15% of income tax on the interest earnings.

Long-term Debt		1,710
Syndicated Loan		
Korea Development Bank	500	
National Pension Co.	250	
National Agricultural Co-Fed	230	
Shinhan Bank	210	
Woori Bank	200	
Other 15 Banks	320	
Total Loan	1,710	
SOC Bond		800
Total Debt		2,510

(unit: billion won)

Table 4-7 Sources of Debt

The repayment period of debt is 16 years of which the first 5 years is an unredeemed period. For the next 5 years after the unredeemed period, 40% will be repaid and the rest 60% will be repaid during for the next 6 years.

Total debt amount	1,710 billion won
Borrowing period	16 years (including 5 unredeemed years)
Repayment method	Principle: 40% in first 5 years, 60% in next 6 years
Interest rate	IRR of commercial bond with 3 years of maturity + Spread (2%)
Syndicated Banks	Korean Development Band and other 19 Banks

Table 4-8 General Outline of Debt Financing

4.2.4 Government Support

Of the 4,507 billion won of total project capital, 18.8% of 846 billion won comes from a government subsidy. This government subsidy does not need to be paid back in the future if IIARC transfers the railroad to the government at the end of 30 years of the operation period. It is generally considered to be the central government's investment in order to enhance the infrastructure condition, which connects Incheon international airport and Seoul. The Korean government has selected and financially supported large-scale infrastructure projects through these government subsidies, which are determined by the following formula in Figure 4-8. The subsidies are offered as soon as the sponsor companies complete the fund-raising of their own capital.

$$\sum_{i=0}^{n} \frac{CCi}{(1+r)^i} = \sum_{i=0}^{N} \frac{(ORi - OCi)}{(1+r)^i} + \sum_{i=0}^{N} \frac{ANRi}{(1+r)^i} + \sum_{i=0}^{n} \frac{Si}{(1+r)^i}$$

n:	The number of years from the Month when the Effective Date occurs to the Month when the Construction Period ends.
N:	The number of years from the Month when the Effective Date occurs to the Month in which the Operation Period ends.
CCi:	For any year, i, annual cost injected for the completion of Railroad
ORi:	For any year, i, the annual Fare Revenue
OCi:	For any year, i, the annual sum of operation cost
Si:	For any year, i, the annual Capital Subsidy payment
ANRi:	For any year, i, annual net profit from advertising and convenience store business
r :	The real financial internal rate of return for the Project

Figure 4-8 Formula for determining the amount of the Government Subsidy

The objective of the subsidy is to motivate private parties to undertake a project finance transaction by securing substantial return on the project as well as to provide affordable fares to passengers.

In addition to the subsidy, the Korean government supports this project by way of revenue guarantee, tax exemption, and a buyout option. The government guarantees 90% of the prospective revenue. If the revenue turns out to be lower than 90% of anticipated revenue, the government will subsidize the amount of deficit. On the contrary, if the revenue is over 110% of the anticipated revenue, the project company will reimburse the amount over 110%. In addition to the revenue guarantee, IIARC is exempt from the property tax for this infrastructure during the operation, and the Korean government can execute the buyout option on this project in case the project company goes bankrupt.

4.2.5 Projected Cash Flow

The total anticipated project cost is 3,949 billion won, including contingency and interests. Of the total costs, the construction cost is 2,413 billion won, which accounts for about 60%. The construction companies that are also major sponsor companies of IIARC have most of the construction contracts in proportion to their ownership in IIARC, the project company.

Project Costs	Inspection & Design	57
	Construction	2,413
	Overhead	372
	Facilities	233
	Others	62
	Sub Total	3,137
Reserve/ Interests	Reserve	431
	Interests	381
Total Costs		3,949

(unit: billion won)

Table 4-9 Total Cost Breakdown as of 2002

According to the feasibility study[5] regarding adding extra stations to the IIAR project, the Net Present Value of the railroad project without additional stations is 2,043 billion won when the discount rate is 7.1%, and Internal Rate of Return (IRR) is 12.24%. The anticipated project cash flow is shown in Table 4-10.

[5] Seoul National University Engineering Research Center and Chungsuk Engineering, "Feasibility Study about the Additional Stations Construction Project for Incheon International Airport Railroad", 2004

Table 4-10 Anticipated Project Cash Flows

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Projet Cost	29,122	170,639	254,013	455,288	718,641	669,717	448,779	308,087	100,803	-	-	-	-
Operating Cost	-	-	-	-	-	-	54,835	62,529	72,519	100,758	100,906	131,476	116,006
Total Costs	29,122	170,639	254,013	455,288	718,641	669,717	503,614	370,616	173,322	100,758	100,906	131,476	116,006
Revenue from Local train	-	-	-	-	-	-	104,828	148,486	164,109	403,756	418,189	433,263	449,132
Revenue from Express train	-	-	-	-	-	-	11,510	17,017	19,576	39,282	41,325	43,475	45,738
Total Revenue	-	-	-	-	-	-	116,338	165,504	183,685	443,038	459,514	476,738	494,870
Cash Flow	(29,122)	(170,639)	(254,013)	(455,288)	(718,641)	(669,717)	(387,276)	(205,112)	10,363	342,280	358,608	345,262	378,864
DCF @ 7% as of 2002	(31,161)	(170,639)	(237,395)	(397,666)	(586,625)	(510,924)	(276,122)	(136,675)	6,454	199,210	195,059	175,514	179,996

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Projet Cost	-	-	-	-	-	-	-	-	-	-	-	-	-
Operating Cost	115,243	112,214	98,173	131,048	103,743	105,338	146,163	100,033	161,057	99,021	99,272	130,229	105,978
Total Costs	115,243	112,214	98,173	131,048	103,743	105,338	146,163	100,033	161,057	99,021	99,272	130,229	105,978
Revenue from Local train	465,852	599,086	624,174	650,763	678,924	708,772	758,958	758,958	758,958	758,958	758,958	758,958	758,958
Revenue from Express train	48,127	53,997	57,646	61,543	65,707	70,164	76,797	76,797	76,797	76,797	76,797	76,797	76,797
Total Revenue	513,979	653,083	681,820	712,306	744,631	778,936	835,755	835,755	835,755	835,755	835,755	835,755	835,755
Cash Flow	398,736	540,869	583,647	581,258	640,888	673,598	689,592	735,722	674,698	736,734	736,483	705,526	729,777
DCF @ 7% as of 2002	177,044	224,441	226,348	210,674	217,091	213,244	204,025	203,433	174,355	177,931	166,234	148,829	143,873

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Projet Cost	-	-	-	-	-	-	-	-	-	-	-	-	-
Operating Cost	164,223	99,783	135,568	205,035	128,491	177,109	139,544	147,071	166,645	109,600	190,757	101,239	96,308
Total Costs	164,223	99,783	135,568	205,035	128,491	177,109	139,544	147,071	166,645	109,600	190,757	101,239	96,308
Revenue from Local train	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958	758,958
Revenue from Express train	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797	76,797
Total Revenue	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755	835,755
Cash Flow	671,532	735,972	700,187	630,720	707,264	658,646	696,211	688,684	669,110	726,155	644,998	734,516	739,447
DCF @ 7% as of 2002	123,729	126,731	112,681	94,862	99,415	86,524	85,476	79,020	71,752	72,775	60,412	64,296	60,493

NPV : 2,034,715

IRR : 12.24%

(Unit: billion won)

4.3 Additional Station Construction Projects

4.3.1 Demand for Additional Stations

Since the opening of Incheon International Airport in 2001, it has been growing as a hub airport in northeast Asia as well as an international gate to and from other countries. In addition to the airport itself, several large-scale development projects near the airport have been initiated to be completed within the next several years. As the highway from the airport to Seoul is the only way to access the mainland at the moment, Incheon International Airport Railroad (IIAR) and the 2nd Airport Bridge[6] construction project started a few years ago. The railroad will be superior to the highway not only in terms of economics and safety but also connectivity. It will connect to the existing National Railroad, Seoul's subway, the extended Seoul-belt railroad, and the High Speed Railroad. Under the 1st phase execution plan contracted between IIARC and the government, the railroad route, the amount of fare, and the station locations were determined.

In addition to the 10 originally planned stations, there have been petitions asking for the construction of 6 additional stations from Incheon, Goyang, and Seoul city. If the petitions are accepted, extra stations may both increase the accessibility of nearby residents and raise the passenger numbers. In contrast, this additional station construction has possibilities to decrease the total passenger number by reducing the average speed and total travel time.

[6] The 2nd Airport Bridge that will connect Songdo and the Incheon airport is planned to be completed by 2008.

In June of 2002 after the meeting among the participants involved in the project, the government decided to perform a thorough feasibility study in order to analyze the effect of extra stations development. According to the research, new extra station projects will be able to commence if each of the station additions is assessed to be financially feasible. When the construction of an additional station is decided upon, the railroad construction cost for each station within the total construction costs is agreed to be financed 50% from each city budget and 50% from the project company. As for the station construction itself, the government is asking the cities to finance all the costs involved. The history of additional stations construction requests from the cities and MOCT's replies is shown in Table 4-11 below.

Youngjong and Yongyoo Station	
2000. 7.	Incheon city asked MOCT[7] to add Youngjong and Yongyoo station to the IIAR project.
2000.12.	MOCT replied that the 2 station could be built only if Incheon city pays for the station construction costs.
2001. 7.	MOCT suggested that it would discuss the project when the details of development plans in the two areas are established.
2002. 1.	MOCT and Incheon City agreed to initiate the feasibility study regarding the construction of two extra stations in order to decide whether or not the construction would commence.
2002. 8.	The feasibility study was completed. Of the two, only Yongyoo station was concluded to be financially viable provided that it would open in around 2014, when the development plans would be successfully completed.
Chungla Station	
2000. 7.	The research on the land use of Gimpo, a reclaimed area including Chungla, was completed.

[7] Ministry of Construction and Transportation

2002. 6.	MOCT and Incheon City agreed to accept the additional station construction plan.
2002. 7.	The existing rail path was redesigned to obtain the land for Chungla station.

Magok Station

2001. 8.	Seoul city requested MOCT to add Magok station where the 9th line of subway connects.
2002. 3.	MOCT and Seoul city agreed to redesign the railway path to accommodate the future station.
2002. 5.	Seoul city requested to MOCT that the necessary civil work for the construction of the future station be started at the beginning of the railroad project.

Goyang Station

1996. 9.	Goyang city requested MOCT to add Goyang station in the IIAR project.
1997. 1.	MOCT replied that the station installation was technically impossible because the station was planned to be underground.
1999. 10	MOCT agreed to positively consider the additional station project on condition that the station would be above ground.
2001. 7.	Goyang city requested MOCT to add Goyang station again.
2002. 4.	MOCT replied that it would adjust the railway design to make the construction of future station possible

Sangam Station

2001.11.	Seoul city requested MOCT to add Sangam station or change the location of Susaek[8] station.
2002. 3.	MOCT replied that Susaek station could not be moved.
2002. 5.	Seoul city requested MOCT to adjust the railway design to build the station in the future.

Table 4-11 Timeline of Additional Station Construction Discussions

[8] Susaek station that connects to the Seoul city subway will be about 1 mile away from Sangam station if both are constructed.

4.3.2 Development Plans near Additional Stations

(1) Yongyoo Station area

According to the "Incheon International Airport Railroad Project Finance Research (1998)," the first phase execution plan, which was accepted in 2001, considered only the development plans at Yongyoo and Wangsan beach as the basis for the traffic forecast in the IIAR project. However, a couple of years later, Incheon city expanded the whole development plan near Yongyoo station by planning to develop resorts at Yongyoo and Moowy. Following this expanded plan, Incheon city requested an additional station be constructed at the center of the development areas. Details of the plans are illustrated in Table 4-12 below.

Resort	Park	Main Facilities
Allis Land (1.10 million SF, By 2007)	Magicpia	Casinos, Hotels, Condos, Convention centers
	Hanagae Valley	Golf course, Club house, Retail shops
	Angel town	Hotels, Condos, Department stores, Family park
Marine World (0.15 million SF, By 2012)	Mud park	Mud park, University, Sports complex, Residence
	Asian Showcase	Theme park, Condos, Restaurants, Sports complex
	Marine park	Theme park, Exhibition, Restaurants, Retail shops
Dragon City (1.41 million SF, By 2012)	Wangsan Village	Condos, Hotels, Retail shops
	Ulwang park	Hotels, Observatory, Restaurants
	Yongyoo plaza	Hotels, Shopping center

Table 4-12 Development plans for Yongyoo and Moowy resort

(2) Youngjong Station Area

Youngjong area was designated as one of the Incheon Free Trade Districts; it will play a main role of supporting Incheon Airport's increasing future traffic. This area is expected to draw airline logistics centers and also to be developed as resorts. The additional station will be located at the center of the Youngjong area. The entire development plan in this area can be separated into two phase. The fundamental facilities are expected to be finished by 2011 in the first phase, as illustrated in Table 4-13. In addition, by 2020, when Incheon Airport's expansion plan will be completed, the number of residents in this area is anticipated to be as much as 12 million with the second phase of development.

District	Development Concept	Area (million SF)	Main Facilities
Airport Support	New airport city, Tax free area, International business	605	Airport support, Logistics support, Hotels, Business support
Youngjong	Logistics support, High tech industry	167	Logistics center, High tech industry offices, residence
Resort	Tourist area, Leisure	76	Leisure and sports facilities, Hotels
Park	-	644	Park, Green area

Table 4-13 Development Plans in the first phase near Youngjong Station

(3) Chungla Station Area

The area between Gimpo and Chungla was reclaimed from the sea in the late 1980s, and it has remained undeveloped since the reclamation was completed. However, in 2002, after the first phase of the execution plan for the IIAR project was accepted, this area was

designated as the Incheon International Finance District. The district will be developed as a multi-functional city including residences, commercial districts, theme parks, and agricultural research centers by 2009, with the anticipated population of 89,000. It aims to be a business center for northeast Asia with the geographical advantage of Incheon Airport. In addition to this large-scale development plan, the Environmental Research Complex has been being built near this area since 1992. The first phase of the Complex will be finished by 2006, and the second phase of the construction plan will be created according to the area's future transportation conditions and economy.

(4) Magok Station Area

In the "Urban Development Plan for Seoul in 2020," the Magok area was selected to be one of the five strategically chosen areas for development in Seoul. This area has been relatively underdeveloped compared to other areas within Seoul. However, the Seoul 9th line subway station in Magok is now under construction to be completed by 2007. Taking advantage of the completion of the subway station and the geographically advantageous location between Incheon and Seoul in this area, the city is trying to foster the development of this area by building new facilities such as a high-tech research and development center or a convention center.

However, there are not specified plans including the start and finish date of the development yet. The future development in Magok area may depend upon the city's commitment and economic condition in the next decade. In fact, the additional station construction project in Magok area is not supposed to be financially viable at this point. For one reason, the opening of the Magok subway station in 2007 is not expected to

substantially increase the number of airport train passengers in this area, because Gimpo station, which connects the subway line and the airport railroad, will be just several miles away from the Magok subway station. The 9th line subway passengers do not have to transfer to the airport railroad in Magok station. The viability of the additional station project will be more dependent on the success of the whole development plan within Magok area. Therefore, the feasibility study mentioned before did not consider the possibility of this uncertain development plans as the basis for the passenger forecast in the airport railroad project.

(5) Goyang Station Area

Goyang city is planning to change the use of the land near the railroad station into residential districts from green areas by 2011. In addition to the changed land use, Media Valley and Techno Park development plans were recently suggested. However, the detailed schedule and development plans are still not established; therefore the success of the development plans is not very promising. As in the Magok station case, the financial viability of the additional station project in Goyang area will more depend on the city's future commitment and its economic condition. Similar to the Magok station, the feasibility study did not consider this development plans for the passenger forecast.

(6) Sangam DMC Station Area

Sangam Digital Media City (DMC) consists of the Research District, the High-tech Business District, and the International Business District. The development of this area started in 1998, and most of the constructions is scheduled to be completed by 2014. The

population in this area is expected to exceed 100,000 by 2009, and most of the apartment construction projects will be completed by 2006. In addition to the large-scale residential developments, a state-of-the-art stadium for the 2002 World Cup and several large-scale environmental parks were built several years ago, and these attract a lot of tourists annually. At the moment, a large number of commercial offices and research centers related to digital media are being built to be completed by 2012.

The success of the development plans in the Sangam area is clearly promising, and a lot of constructions have already been completed, which is not true of the Magok and Goyang areas. However, Susaek station, an originally planned airport railroad station, will be constructed just about a mile away from the additional station, DMC station, which was urgently requested by Seoul city. Susaek station will be located on the border of the DMC main district, and the airport railroad will be connected to the Seoul 6th line subway and the National Railroad in this station. However, Seoul city wants to have an additional station at the center of the DMC main district for convenience, and to entice private investment into the commercial district. On the contrary, from the perspective of the project company, whether or not the additional station project will make the whole railroad project financially more feasible is still uncertain at the moment. The viability of the additional station project will be clear only when the total development plans are completed.

4.4 Strategic Decision Analysis in Additional Station Projects

The petitions demanding additional stations from Incheon, Goyang, and Seoul city were filed in 2003, about two years after the railroad construction started. Those cities

argued that recently established development plans near additional stations would generate enough traffic volume to make the whole project profitable. However, each of the additional stations will have a different completion date and a different degree of riskiness, depending on the phase of the railroad project.

The first three additional stations - Yongyoo, Youngjong, and Chungla - in the first phase, from year of 2001 to 2007, will be located between Incheon airport and Gimpo airport. The areas between two airports are still underdeveloped, but large-scale development plans were initiated a few years ago by the Korean government with its firm support and commitment. Half a dozen new business centers and residence areas are going to be built between the two airports in expectation of the increasing traffic capacity of Incheon International Airport in the next decade. In fact, most of the development plans in the first phase has been already undertaken with a detailed schedule; furthermore the complete project has been mostly guaranteed by the Korean government.

On the contrary, the other three additional stations, – Magok, Goyang, and DMC – which belong to the second phase, from year of 2004 to 2009, are within or adjacent to Seoul city, where many office buildings and residences already have been built. The development plans that will determine the need for these three additional stations have been driven by each city in order to foster the development of areas near the airport railway. Although the completion dates of the development plans are set to be around 2020, and the success of each development plan depends mostly on the future economic status and each city's commitment to the development. Therefore, we need to base the strategic decision and the evaluation of the additional station construction projects on each project's certainty and riskiness.

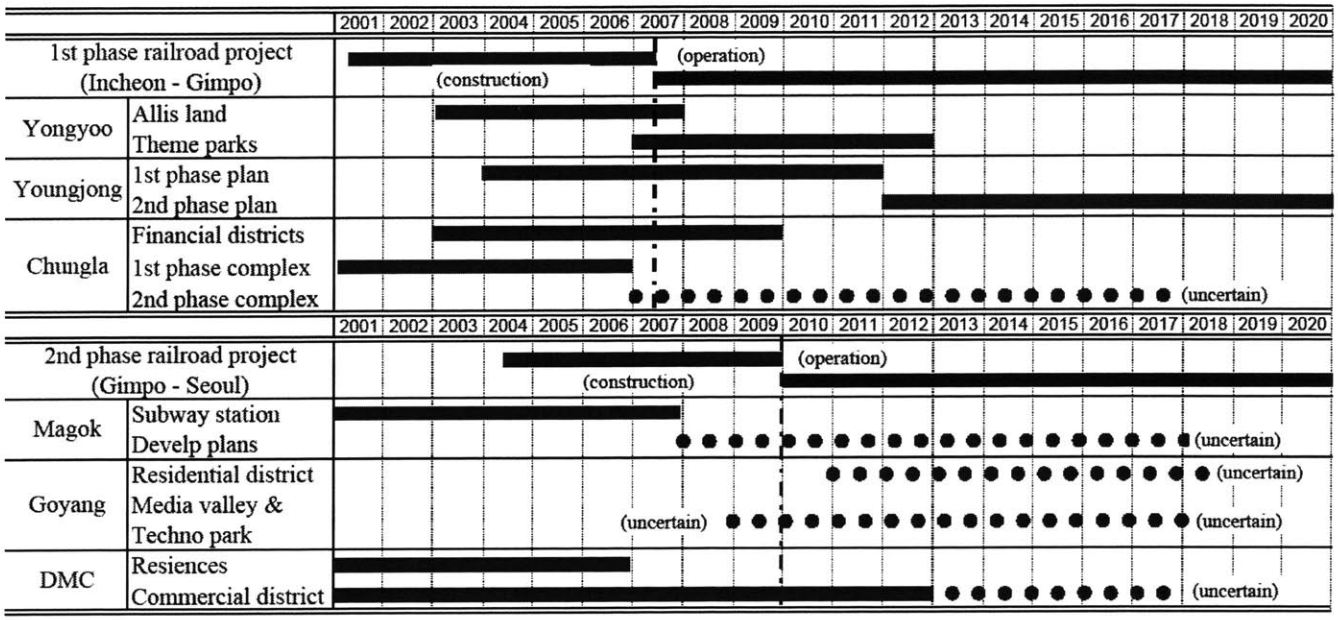


Figure 4-9 Schedule Comparison between the railroad project and development plans related to the additional station construction projects

4.4.1 Possible Options

At the request from the three cities, the government decided to perform a feasibility study on the construction projects for extra stations. The study[9] was carried out by Seoul National University Engineering Research Center in April of 2004. It reassessed the anticipated passenger number and the whole railroad project's profitability through the investigation of the recently proposed development plans near the extra stations and of the

[9] Seoul National University Engineering Research Center and Chungsuk Engineering, "Feasibility Study about the Additional Stations Construction Project for Incheon International Airport Railroad", 2004

influence on the number of prospective passengers. The study also securitized the railway route, the location of each extra station, the technical difficulties, the cost of each station construction, the forecasted passenger changes, and the operation profit in each case. As a conclusion, it suggested only the two most profitable stations, Yongyoo and Chungla, to be additionally built. However, after further discussion on this issue, Incheon city and Ministry of Construction and Transportation (MOCT) agreed to construct all three additional stations for the first phase, on the condition that Incheon city is responsible for 50% of total development cost of each station. Still, the construction of the other 3 extra stations in the second phase is under discussion among Goyang, Seoul city and MOCT.

According to the recent research about the projected passenger numbers and the profitability changes in case of adding each station, only Chungla station was assessed to be profitable following the NPV analysis. The research assumed the construction of each station would be completed before its operation taking into account all the fixed costs and operating costs as well as the future revenues caused by the passenger numbers change. As illustrated in Table 4-14 below, however, the year showing a significant increase of the passenger number would be at least several years after the beginning of the railroad's operation in most cases. One of the main reasons why Chungla station project is the most profitable would be the fact that the developments near the station are expected to be over earlier than the other five stations[10]. This infers that deferring the completion of each station by the time when the traffic volume reaches to a substantial degree will be able to make the whole railroad project's profitability much better. In other words, most of the

[10] The Incheon International Finance District will be finished by 2009 and the Environmental Research Complex by 2006.

additional station construction projects, which are originally anticipated to lower their NPVs, may make the overall project's profitability even better by postponing each station's completion date until when development plans near these stations will be finished.

Passenger number changes caused by adding each station

	Yongyoo	Youngjong	Chungla	Magok	Goyang	DMC
2007 1st phase starting operation	-	218	910	-	-	-
2009	1,199	316	929	-	-	-
2010 2nd phase starting operation	1,409	262	54,164	210	67	1,629
2015	2,144	2,860	76,019	255	77	3,289
2020	2,800	5,870	110,525	285	91	4,586
	0.26%	*0.54%*	*10.18%*	*0.03%*	*0.01%*	*0.42%*

unit: passenger number/day

Profitability changes caused by adding each station

	Base Case	Yongyoo	Youngjong	Chungla	Magok	Goyang	DMC
NPV(bill won)	**1,962,039**	1,924,152	1,932,978	2,200,402	1,862,051	1,913,854	1,873,318
IRR(%)	**12.20**	12.09	12.10	12.60	11.89	12.05	11.91

Table 4-14 Changes Caused by Adding Each Additional Station[11]

Suppose only Youngjong station is being discussed whether or not to be constructed. As a decision maker in the railroad project, you may have three choices at the moment. You may 1) start to build the station from now on 2) deny the petition of adding the station 3) build only civil works at the location to enable the construction of the future station.

[11] The research was performed on condition that each station's addition does not interfere with another station's addition.

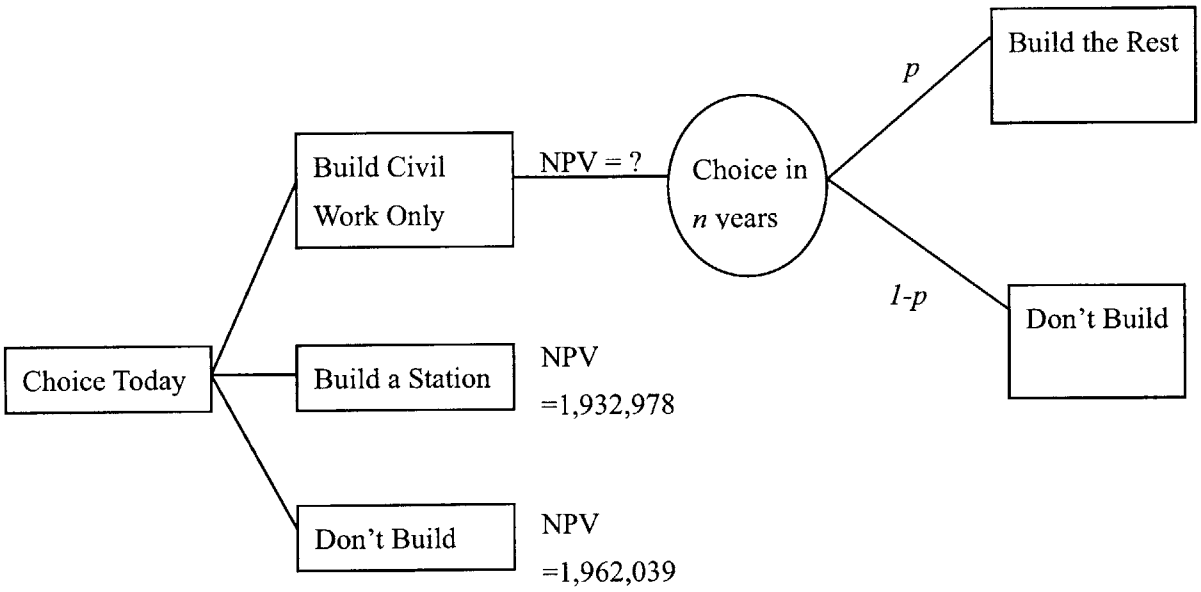


Figure 4-10 Decision Tree of the Yongyoo Station Addition Project

If you decide to build the station from now on in 2005 with two years of construction period, the station will be completely constructed and start its operation in 2007, when the 1st phase of railroad will start its service. As a result, however, the NPV of total project may decrease to 1,932,978 billion won from 1,962,039 billion won compared to the base case. The railroad company will not accept the proposal unless Incheon city makes up for the loss in some ways, such as by paying the construction fee for the station. For the second choice, you may abandon the additional station construction projects due to its financially negative effect on the whole railroad project. In this case, the NPV is the same as the one of the original plan.

Last but not least, you may choose an alternative way of completing a minimum portion of civil work[12], about 1.7 billion won, which enables the future station construction in the future, when the development projects adjacent to the station will be completed. This

[12] This will be discussed further in the next Chapter 4.3.2.

option enables you to wait until when the development projects will be almost finished and the traffic demand looks more promising. If the substantial increase of the traffic demand is expected in 2012 and also two years' construction period is required, you will be able to wait until 2010 to start the station construction in order to maximize the profitability of the railroad project. Otherwise, in the case of the worst-case scenario that the development plans fail or just decrease seriously for some reason, you will also have an option to abandon the station construction project, and then sell the land. To sum up, by deciding to invest the minimum amount of money for making the future construction of the station possible, you can get an "Option to defer" and "Option to abandon" at the same time.

To valuate this option of investing the minimum amount of money, which makes future station construction possible, the seeding cost will be calculated based on the existing feasibility study; furthermore the application of Decision Tree Analysis and Real Option Analysis will be discussed in the next several chapters.

4.4.2 Seeding Cost for Future Station Construction

The total cost for additional stations construction includes the pre-design cost, the design cost, the construction cost, the inspection cost, the land price, and the operation cost[13]. The detailed cost breakdown is listed Table 4-15 below. Generally, the construction cost takes most of the total costs followed by the operation cost.

Of the decomposed costs, we can assume that the seeding cost enabling the

[13] Operating cost of each station was calculated by discounting future cash flow of each operating cost as of December 2003.

construction of the future station includes the pre-design cost, the design cost, the civil part of the construction cost, and the land price. Once those works are competed, the other works such as architectural, mechanical, electrical, signal, inspection, and operation works can be performed without damaging the railroad train operations and with no significant financial risks in the future.

Additional Station Construction Project Cost Breakdown

		Yongyoo	Youngjong	Chungla	Magok	Goyang	DMC
Pre-design cost		4	8	42	11	9	11
Design cost		337	661	923	2,749	856	2,417
Construction cost	Civil work	1,344	2,618	9,652	57,123	7,805	51,640
	Others	6,934	13,530	13,530	17,870	13,530	14,218
Inspection cost		119	225	318	987	293	871
Land purchase price		-	600	1,763	2,162	104	6,161
Operating cost		8,676	8,676	17,352	8,676	8,676	8,676
Total		**17,414**	**26,318**	**43,580**	**89,578**	**31,273**	**83,994**

Minimun Costs to Enable Future Stations Construction

	Yongyoo	Youngjong	Chungla	Magok	Goyang	DMC
Pre-design cost	4	8	42	11	9	11
Design cost	337	661	923	2,749	856	2,417
Construction cost(Civil Work)	1,344	2,618	9,652	57,123	7,805	51,640
Land purchase price	-	600	1,763	2,162	104	6,161
Total	**1,685**	**3,887**	**12,380**	**62,045**	**8,774**	**60,229**

Table 4-15 Cost Breakdown of The Additional Stations Construction Project

As shown in Table 4-15, each additional station's the seeding cost lies between 10% and 30% of the total cost except for Magok station and DMC station. Magok station is planned to connect to Seoul 9th subway underground, so the civil construction work demands much more subterranean works than those of other stations. The cost for civil construction work for Magok station accounts for as much as 75% of the total cost. Similar to the Magok station, the DMC station should also be built underground, because the area

for the station will be located at the center of large-scale business office districts. The civil work for DMC station takes up to 75% of the total station construction cost as well[14]. In Figure 4-11, the comparisons between the seeding cost and the total cost of each station construction are illustrated.

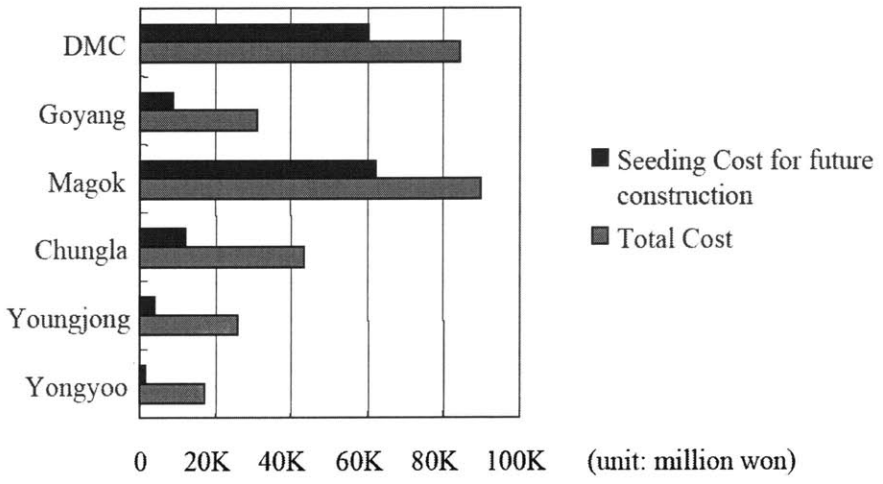


Figure 4-11 Comparison between Seeding Costs and Total Costs

4.4.4 Application of Decision Tree Analysis

As a method for comparing each option's value in the additional station projects, Decision Tree Analysis (DTA) would be one of the most useful tools especially for the first

[14] The cost breakdown in the research assumed that the station construction takes place at once. Therefore, the actual seeding costs for Magok and DMC station may a bit less than the sum of each cost listed, because the pre-performed subterranean works for both stations can be reduced in case the least scope of works are invested for the future construction.

three extra stations –Yongyoo, Youngjong, and Chungla - in the first phase. If the development plans near the stations are so completely designed with the exact completion dates that we can firmly expect the success of the plans, the use of DTA to compare each possible option would be appropriate. In the previous example of Youngjong station construction, we can think of four different scenarios: Do not build, Build-it-now, Build civil works only and defer it by 2012, and Build civil works only and delay it by 2015. Based on the feasibility study's revenue change projection, we can calculate each case's IRR as illustrated Figure 4-12.

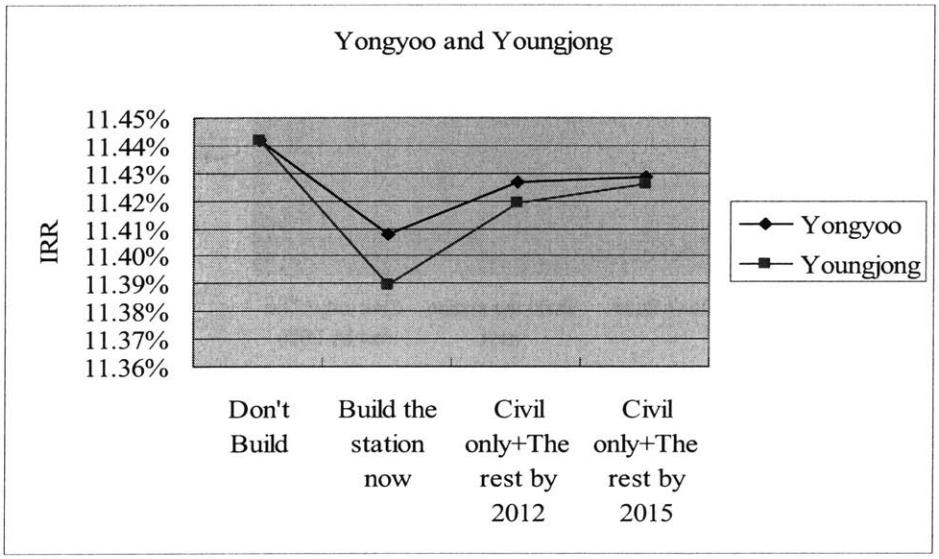


Figure 4-12 IRR Changes of the Railroad Project in Each Scenario

As development plans near the Yongyoo station are planned to be completed by around 2012, the number of passengers is expected to grow significantly from the year of 2012. Therefore, if we defer the completion either until 2012 or 2015, the profitability of the railroad project would be better than that of constructing the entire station at the moment. However, any scenarios cannot get more profitable than the base case, the case of

not building the station. In the same manner, the 1st phase of development plans near Youngjong station is planned to be finished by 2011, and the profitability changes of Youngjong station project shows the similar pattern to Yongyoo station. However, in the case of Chungla station, the 1st phase of the complex plans that will be finished by 2006 is expected to generate enough traffic in 2007 to make the total railroad project's profitability better than the base case. Thus, building the station at the moment would be the best choice among the three cases.[15]

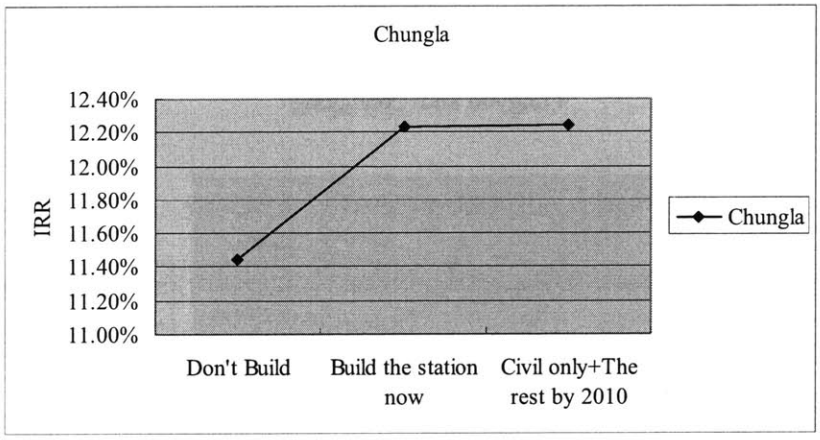


Figure 4-13 IRR Changes of Chungla Station

Although we can make several scenarios and calculate IRRs to compare each case's value based on the projected cash flows, we still cannot consider the flexibilities in the projects. In fact, the cash flows in the feasibility study involve a great deal of volatilities that are hard to be considered as a fixed stream of costs and revenues. The use of DTA addresses the flexibility issues to a certain degree. Going back to the Yongyoo station project, we can compare the previous four scenarios using the DTA method. Instead of

[15] The postponing scenario was set to 2010 in Chungla station because the financial district is planned to be completed by 2009.

depending on the fixed stream of cash flows[16], we can separate the optimistic and pessimistic cases with different probabilities according to the volatilities.

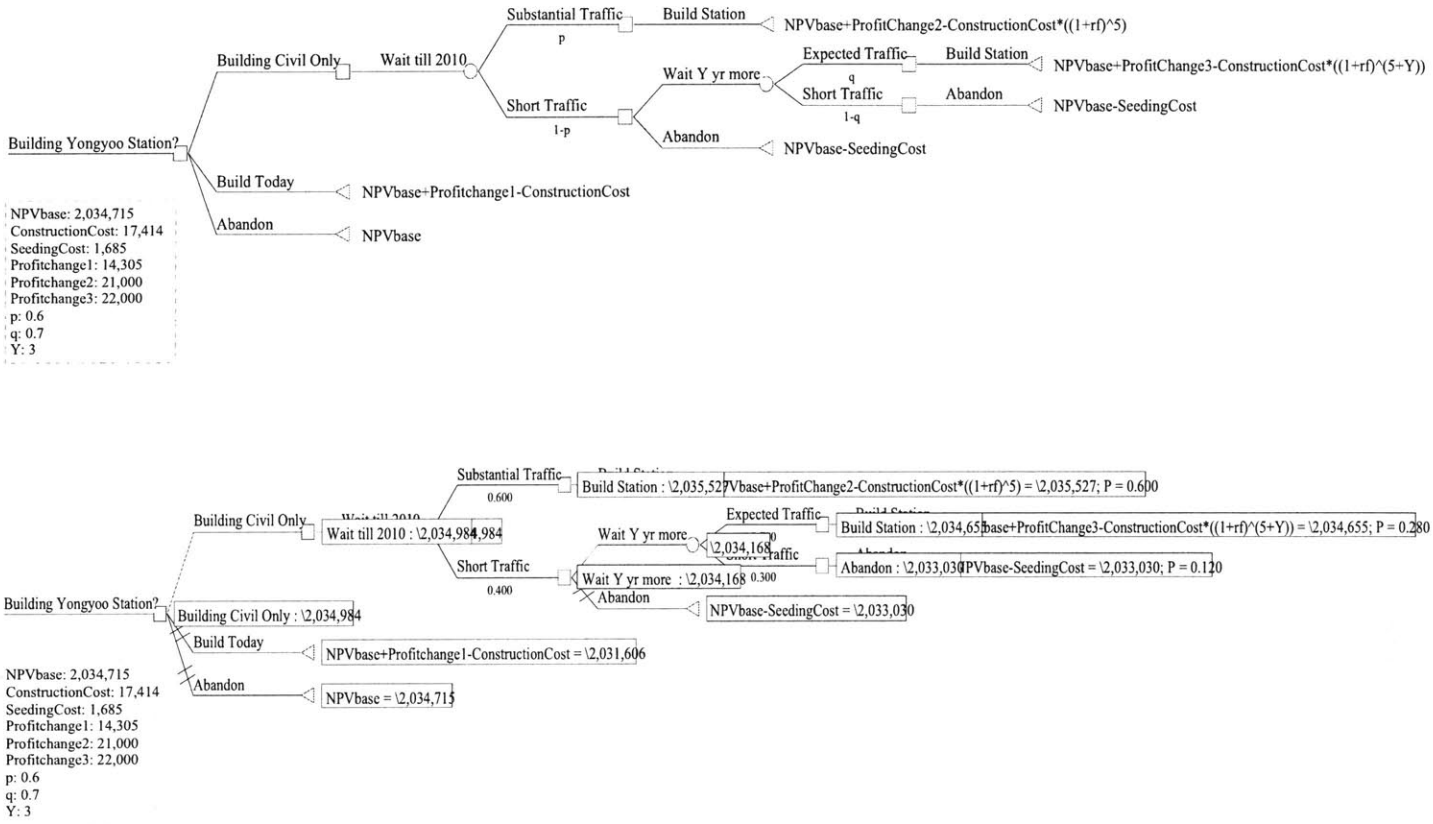


Figure 4-14 Decision Tree Analysis for Yongyoo Station Project

As a simplified version of DTA method in Figure 4-14, we can compare each scenario with its payoff and select the most rewarding choice. As a base setting, the present value of profit change in case of building the station by 2012 was assumed 21,000 million won for optimistic case with 60% of its probability, and that of building it by 2015 was assumed 22,000 with 70% of the next probability. Based on these assumptions, the resulting value of doing only civil works to make the future station construction possible is

[16] See the appendix A for cash flows of Yongyoo station project.

2,034,984 million, and this is a bit higher than those of the other cases, building-it-now or abandoning the project. This result is critically dependent upon the profit change in case of delaying the rest works until by 2012. Therefore, by the sensitivity analysis using the decision tree structure, we need to find the range of the profit change that can make this delaying option more viable than the abandoning or the building-it-now option.

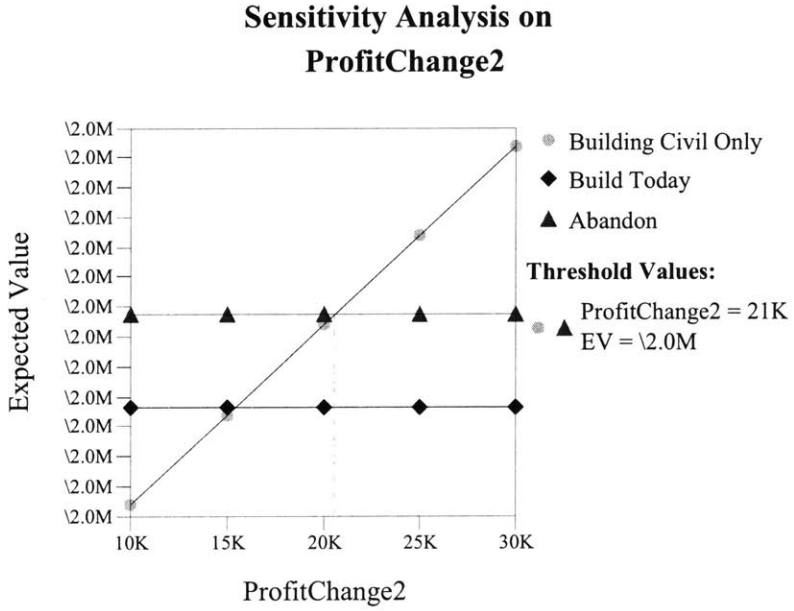


Figure 4-15 One Way Sensitivity Analysis for the Yongyoo Station Project

Figure 4-15 shows that the present value of the profit change for delaying the construction by 2012 should be more than about 20,500 million won for this option of defer ring to be the best choice among the three. At least, it should be more than 15,000 million won to be more viable than the option of building-it-now if the station really needs to be constructed. The second critical valuables in this analysis would be the probability (p), assumed 60%, of achieving substantial traffic in 2012. Both the range of the probability and

the present value of the profit change are illustrated in Figure 4-14. We can see the present value of profit change is much more sensitive when the difference of profit changes in 2012 and in 2015 is not so huge.

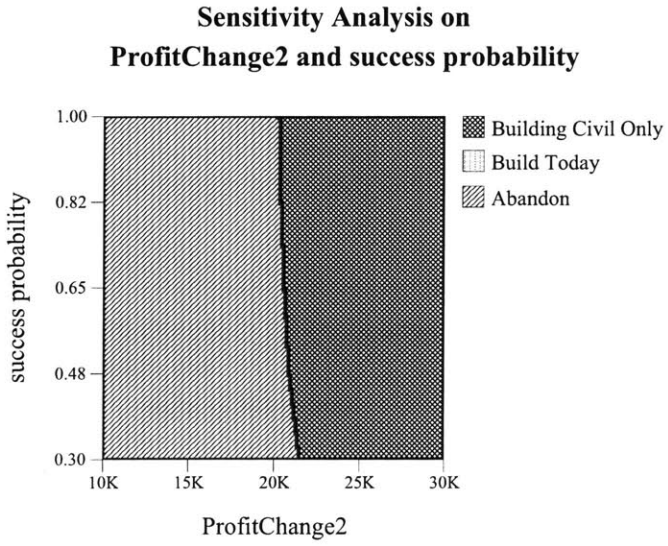
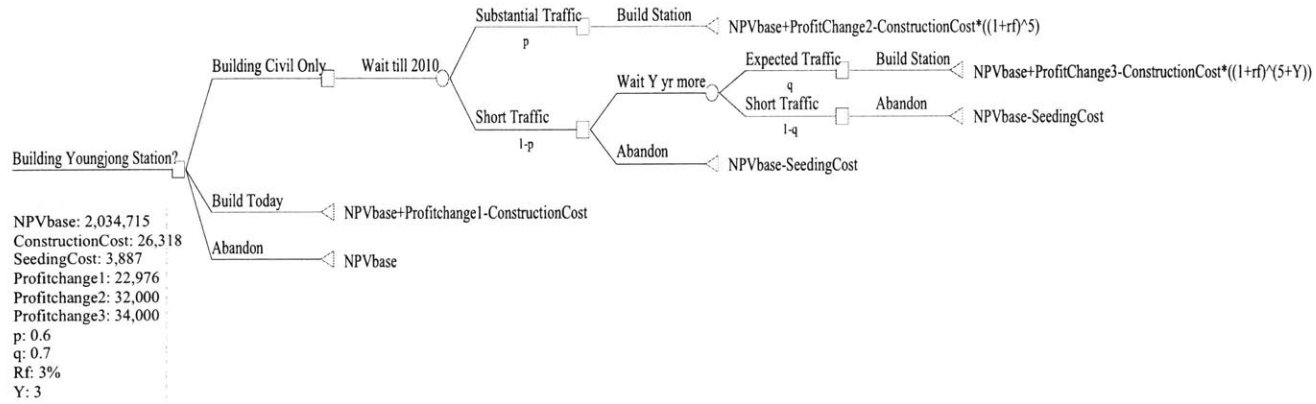
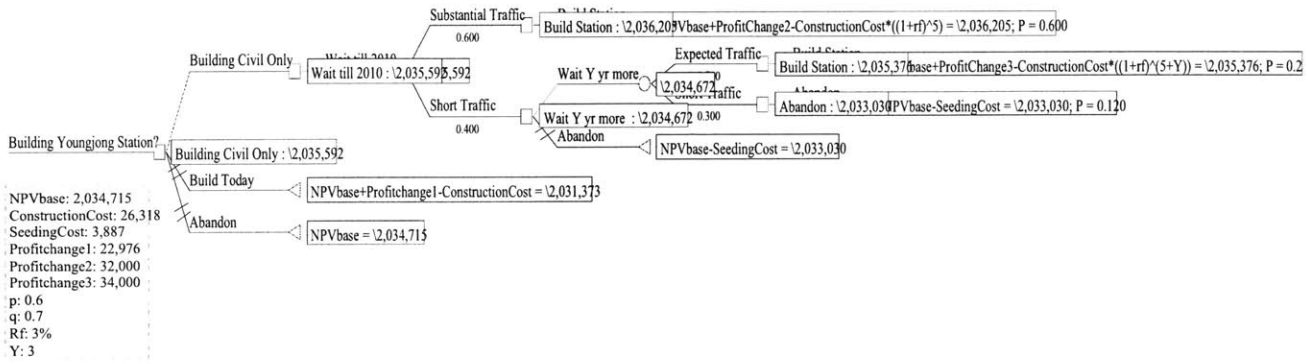


Figure 4-16 Two Way Sensitivity Analysis for the Yongyoo Station Project

Each of the decision tree structure with its resulting value and its one way sensitivity analysis for Youngjong and Chungla station project is shown in the next figures.





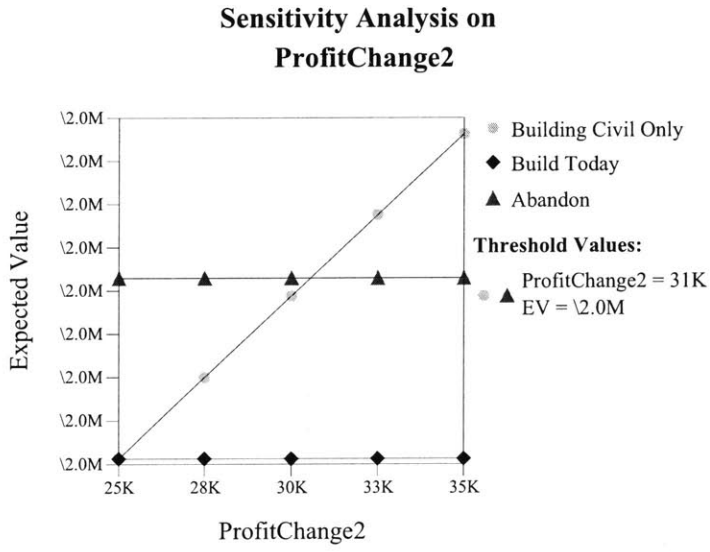
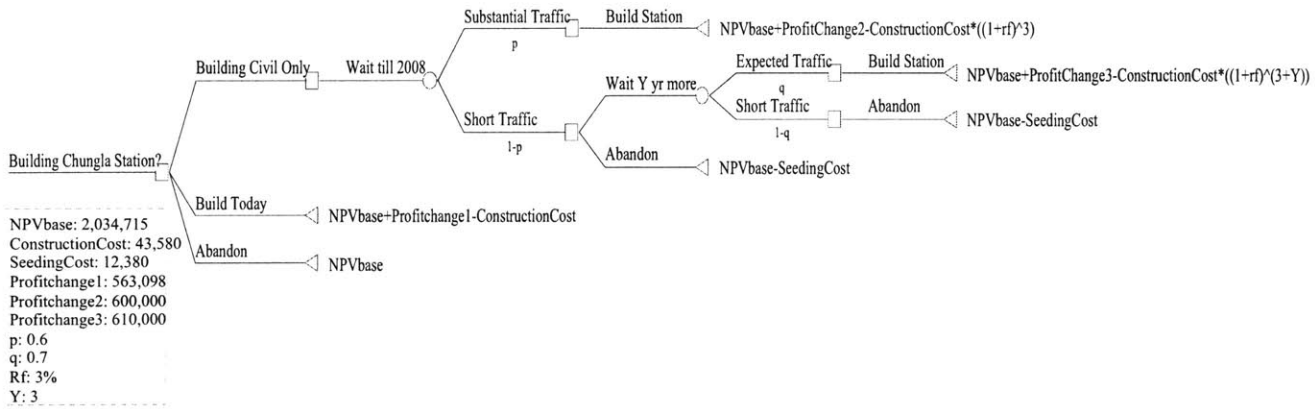
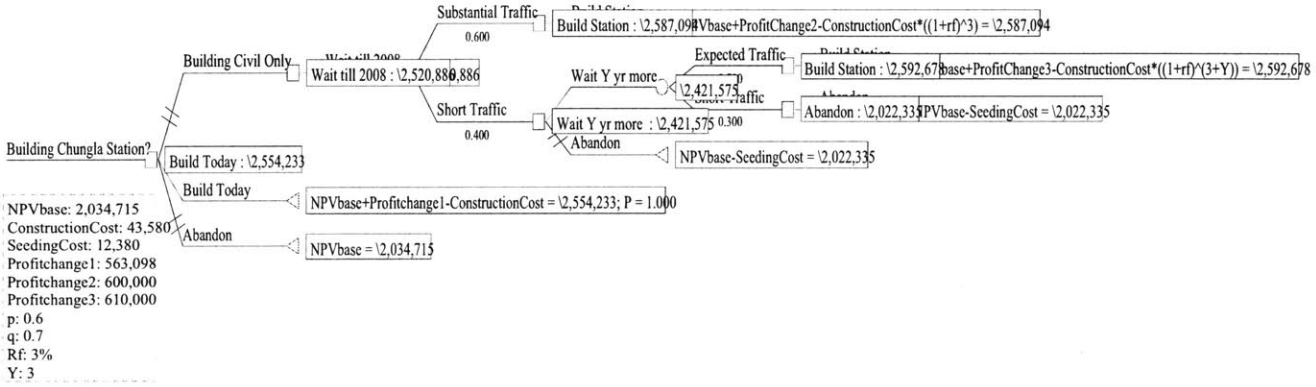


Figure 4-17 DTA and Sensitivity Analysis for the Youngjong Station Project





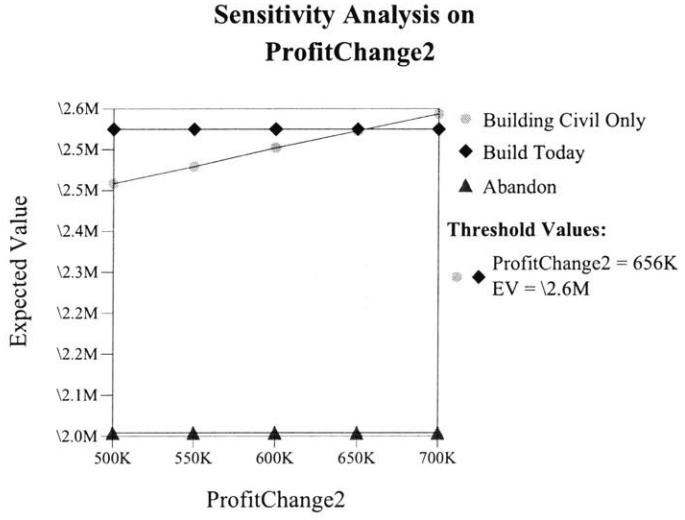


Figure 4-18 DTA and Sensitivity Analysis for the Chungla Station Project

Similar to IRR changes in the four different scenarios, the Chungla station project shows that the option of build-it-now is more feasible than that of abandoning and delaying by 2010, unless the profit change of the delay option exceeds 655,000 million won, which seems too optimistic compared to 558,199 million won from the cash flows forecast.

The Decision Tree Analysis in this section provides a suitable framework that helps project managers to layout the risks involved, and to prepare themselves for future uncertainties by further analyses like a sensitivity analysis. However, DTA also shows some shortcomings. For any given future events, there would be a number of alternative actions managers could choose as well as countless variables that influence the project's outcome. Therefore, to make DTA useful, it is important to identify critical variables and conditions for success. Another problem in DTA is that it eventually involves some degree of subjective judgment on input variables. This shows its complete dependence on the initial cash flow projection. If the initial DCF valuation is poorly done, the outcome of DTA would not be reliable.

In addition to those shortcomings, DTA shows important limitations to value the flexibilities involved in a project. Although it helps identify the future strategic decision choices with a clear view of future cash flows and risks in a project, it is difficult to use this as a valuation tool due to the subjective assumptions required in the analysis process in most cases. It would be more useful as a strategic tool for future decisions than a precise valuation tool.

4.4.4 Application of Real Option Analysis

Compared to the Decision Tree Analysis, the Real Option Analysis puts us in a better position to evaluate flexibilities in the project. The Real Option is particularly useful compared to other methods since it clearly identifies what drives values in projects with a flexible design. While valuing irreversible investment opportunities under uncertainty based on NPV analysis does not take account of managerial options, the Real Option approach can help recognize the value of managerial abilities and prevent mistakes. As we discussed in the last chapter, the Real Option Analysis is an effective tool to make better strategic decisions for projects like the additional station construction projects.

In the previous research about the profitability of building Yongyoo, Youngjong, and Chungla station, we found that postponing the station construction by investing the minimum money helps improve the whole railroad project's profitability, compared to starting the station construction from now on. However, based on the projected cash flows, this choice still is not as viable as just abandoning the project. At this moment, we need to think about the volatility of the steam of cash flows in a project. Although using the cash flows as it is would be the best or only way to calculate the present value of abandoning option or that of build-it-now, this is not the case for the valuating the option of deferring the station construction. When depending on the fixed cash flows, the managerial abilities to deal with future uncertainties cannot be reflected to valuate this deferring option. However, once the civil work in a station construction is done, managers can make a decision whether or when build the rest parts of a station according to the future traffic demand in each period time in the future. While we could only design a very simplified

structure to compare several choices using DTA method in the previous section, the Real Option Analysis enables us to valuate the flexibility involved in the additional station projects.

The first step to do ROA is to recognize options in the project. As we already discussed, the option of deferring the rest of station construction gives managers options to start the construction or wait at each period of time, until it expires in 2039 by giving the railroad facilities to the government. Among the three stations, Yongyoo, Youngjong, and Chungla, we will discuss only Yongyoo and Youngjong stations. For the Chungla station project, the option of build-it-now is far more profitable than giving up the project. Therefore, we do not have to consider the option of deferring the construction in order to figure out whether the additional station construction project is viable.

Now, we should determine the parameters that determine the price of the options. There are five parameters we need to get in the projects;

Stock Price (S): this means an asset value of the project. In the additional station construction projects, the increase of the present value of the whole railroad project caused by building a new station becomes the asset value.

Exercise Price (K): this is the value of executing the option of completing the station. In our projects, the construction cost except for the civil works equals the exercise price. As the construction price was calculated as of 2002, it needs to be reversely discounted by risk-free-rate when years pass.

Uncertainties (σ): the changed numbers of passengers who use the related station affect the volatility of the underlying asset in these projects. Therefore, based on the fact that the increase of traffic depends on the level of residential and commercial development near the

station, we would use the volatilities of Korean housing market and commercial asset market. The Hosing and Commerce Bank of Korea has complied a housing sales price index since 1986, and it is considered the most reliable data available for the Korean real estate market. Based on this index, the annual return volatility of the hosing market from 1986 to 2004 is 17.8%.[17] For commercial markets, we could depend on broker's research reports. According to the data from the brokerage firm BHP Korea, the annual return volatility shows 7.9% from 1993 to 2003. Considering that the ratio of present values of the residential and the office components are roughly 60% and 40% respectively, we can assume the total volatility as 13.8% by using these weights. However, given these indexes are based on existing assets price, the project level volatility should be higher than the index level. Moreover, the properties in the entirely undeveloped areas are likely to be more volatile than existing assets. Thus, we will assume the development projects near the additional stations are 50% more volatile than the existing asset market. So, the volatility (σ) in the projects is assumed to be 20.7%, slightly higher than the range in the US market.

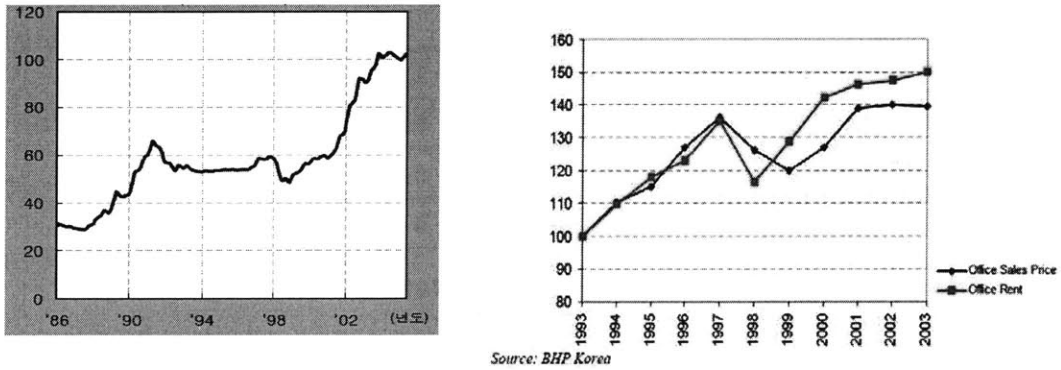


Figure 4-19 Volatilities of Housing Markets (left) and Office Markets (right) in Seoul

Risk-fee Rate (Rf): the interest of Korean Government 5 year T-Bill rate could be

[17] http://est.kbstar.com/quics?page=A005332

considered as a risk-free rate in the project. The average rate of 5 year T-Bill from 2003 to 2005 is 4.5%[18].

Time Interval: In these projects, 1 year of time interval is assumed, which enables managers can make investment decisions every year based on the level of developments near the station until the end of concessionaire in 2039.

Based on the assumptions about the parameters above and each station project's cash flows analysis in appendix A, we can get the figures for the inputs to valuate the options involved in the projects in Table 4-16.

		Yongyoo	Youngjong
Asset Value	V	3,673	22,020
Strike Price	K	15,271	21,778
Seeding Cost	-	1,636	3,887
Risk-free Rate	Rf	4.5%	4.5%
Volatility(year)	σ	24.8%	24.8%
Time Interval(year)	Δt	1	1
			(unit: mil. won)
Up Factor	u	1.282	1.282
Down Factor	d	0.780	0.780
Up Prob.	p	0.528	0.528
Down Prob.	1-p	0.472	0.472

Table 4-16 Parameters for ROA in the Station Construction Projects

With these parameters, we can build a binomial model to price options to build the station sometime in the future. Table 4-17 shows the binomial model for option pricing in the Yongyoo station project. The asset value changes according to the up or down factors in

[18] http://ecos.bok.or.kr/

each period. The strike price, the construction cost for completing the station, increases with risk-free rate of 4.5%. The exercise value is the payoff from operating the new station, which is the asset value subtracted from the strike price. The holding value is the expected value of the project in the next period.[19] Finally, the option value becomes the higher figure between the holding price and the exercise value subtracted from the seeding cost.

Year	*2002*	*2003*
Period	*0*	*1*
Asset Value	13,673	16,818
Strike Price	15,271	15,958
Exercise Value	(1,598)	859
Holding Value	2,090	3,233
Option Value	2,090	3,233
Exercise?	Hold	Hold
		(unit: mil. won)
Asset Value		11,116
Strike Price		15,958
Exercise Value		(4,842)
Holding Value		1,175
Option Value		1,175
Exercise?		Hold

Table 4-17 Binomial Model for Yongyoo Station Project (Period 0-1)

In each period of time, managers can start construction to complete the station and get the exercise value, the payoff from the project whenever they believe the traffic demand is sufficient in each period. Otherwise, they can wait another year to see the change of traffic demand. In other words, managers have options to invest in the next period and

[19] "Certainty Equivalent Valuation" form of the DCF valuation model is used to calculate the holding value: $C_0 = \frac{CEQ_0[C_1]}{1+r_f} = \frac{E_0[C_1] - (C_{up} - C_{down})\left(\frac{E[r_V] - r_f}{V_{up}\% - V_{down}\%}\right)}{1+r_f}$

compare the values of exercising and holding to make an investment decision. Option values will be determined by this decision. In case of investing, the option value equals to the exercise value subtracted from the seeding cost that is the initially invested money for civil works. On the other hand when wait another year, the option prices equal to holding values. We can calculate the option value by expanding the same process to the final periods where the holding value comes to zero due to the expiration.[20]

The resulting values of the Real Options in the Yongyoo and Youngjong station project are shown in Table 4-18, compared with the NPV of each project. The values of the Yongyoo and Youngjong station projects increase by 4,692 and 6,355 respectively from their negative NPV values. This means that managers can invest the station construction projects to make the whole railroad project more profitable, only if they utilize options to delay the completion date by investing the minimum money that enables the future construction. Otherwise, if they start building the stations from now on, the additional projects would end up damaging the profitability of the entire railroad project.

	Net Present Value	Real Option Value
Yongyoo	(2,602)	2,090
Youngjong	(2,575)	3,780

(unit: mil. won)

Table 4-18 Comparison between Net Present Value and Real Option Value

Finally, we need to do a sensitivity analysis with volatilities, the most critical parameter assumed without reliable data, to observe a range of potential values. Table 4-19 shows the result of the sensitivity analysis in relation to volatility of underlying assets. It

[20] Please see the appendix B for the binomial model of each station construction project.

shows that there is less option value when the volatility level becomes below 10%, and the volatility of above 10% is needed to undertake the projects.

	Yongyoo	Youngjong
5%	0	1
10%	261	667
20%	1,953	3,564
30%	3,825	6,534

(unit: mil. won)

Table 4-19 Sensitivity Analysis with Different Volatilities of Underlying Assets

Chapter 5 Conclusion

In this thesis, we brought up the issue of flexibility that is critical to capital investments in railroad projects. The characteristics of railroad projects require investors to scrutinize the feasibility of the project, taking into account managers' ability to optimizing their performance overtime. However, due to the absence of intuitive analytical method of valuing flexibilities, investors just ignores this important value or more often depend on their intuition for the critical investment decisions in development projects. Here in the thesis, two tools to valuate a project with managers' strategic decisions were introduced; Decision Tree Analysis (DTA) and Real Option Analysis (ROA), both of which can address the issue of valuing flexibilities in development projects.

The case study of the Incheon International Airport Railroad Project (IIARC) reveals that maximizing the value of flexibility is a key to success in its additional station construction projects. It proves that DTA and ROA provide effective methodologies for investors to valuate development projects with a strategic approach to assess flexibilities. While the traditional DCF valuation would easily underestimate long-term and large-scale railroad projects, ROA allows us to assess the additional value of mitigating risks by the flexibility of deferring the station construction until the next period when the traffic demand gets better. In addition, DTA provides strategic decision opportunities graphically overtime and, help managers make future decisions until more concrete information arrives. Based on the research in the thesis, the following procedure for valuing a large-scale and long-term railroad project is recommended.

1. Perform economic valuation analyses thoroughly, incorporating the expected future cash flows and the involved risks. A rigorous DCF valuation analysis, such as NPV and IRR analysis, is significant because it is also used as a basis for later analyses.

2. Research market data such as volatility of underlying asset returns in order to quantify risks. When reliable data is unavailable, a best subjective judgment should be made.

3. Determine the possible options in the project with the identified risks. It is critical to know which options are more influential and select them, since real world projects would involve numerous options.

4. Identify strategic opportunities overtime with Decision Tree Analysis. The graphically shown decision trees help investors understand the different kind of flexibilities and compare consequences. Results from the valuation analysis can be used as base settings for DTA.

5. Perform Real Option Analysis to valuate the project's flexibility. While DTA can consider relatively few dynamic decision choices, ROA helps make decisions at discrete time periods with almost infinite number of opportunities. The binomial tree approach is recommended as the most intuitive options valuation model.

6. Do a sensitivity analysis to understand the relationship between input variables and the outcomes. The single value estimate from the proposed model is not reliable to make critical decisions. This analysis enables managers to find vital variables and options and to mitigate risks in the future.

Through this valuation procedure, we can evaluate a project, which involves long

development period and uncertainties, with an analytical perspective of flexibility. As we discussed in the case study, identifying and utilizing important flexibilities as a form of options can maximize the value of a project. As the ROA on additional station projects proves, many development projects, which are classified to be financially unviable with traditional valuation methods, often turn out to be profitable by analyzing flexibilities involved in those projects. This approach is critically effective when uncertainty is a major concern, and future decisions of managers can significantly affect the profitability of the project.

Appendix A: Cash Flows of Additional Station Construction Projects

Yongyoo: Build Now (Unit: million won)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seeding Cost			1,685															
Exercising Cost			15,729															
Total Costs		-	17,414	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Revenue		-	-	-	-	-	-	155	213	1,031	1,077	1,126	1,177	1,230	1,620	1,708	1,801	1,900
Cash Flow	0	0	(17,414)	0	0	0	0	155	213	1,031	1,077	1,126	1,177	1,230	1,620	1,708	1,801	1,900
DCF @ 7% as of 2002	0	0	(16,275)	0	0	0	0	103	132	600	586	572	559	546	672	662	653	644
NPV@2002	**(2,602)**																	
IRR :	**6.00%**																	

Youngjong: Build Now

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seeding Cost			3,887															
Exercising Cost			22,431															
Total Costs	-	-	26,318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Revenue	-	-	-	-	-	-	121	131	135	192	347	508	678	857	2,161	2,535	2,932	3,352
Cash Flow	0	0	(26,318)	0	0	0	121	131	135	192	347	508	678	857	2,161	2,535	2,932	3,352
DCF @ 7% as of 2002	0	0	(24,596)	0	0	0	86	88	84	112	189	258	322	381	897	983	1,063	1,136
NPV(2002) :	**(2,575)**																	
IRR :	**6.44%**																	

Chungla: Build Now

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seeding Cost			12,380															
Exercising Cost			31,200															
Total Costs	-	-	43,580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Revenue							503	6,393	8,572	39,643	41,039	42,498	44,035	45,654	57,440	63,305	69,527	76,125
Cash Flow	0	0	(43,580)	0	0	0	503	6,393	8,572	39,643	41,039	42,498	44,035	45,654	57,440	63,305	69,527	76,125
DCF @ 7% as of 2002	0	0	(40,729)	0	0	0	359	4,260	5,338	23,073	22,322	21,604	20,921	20,271	23,836	24,551	25,200	25,786
NPV(2002) :	**520,787**																	
IRR :	**28.56%**																	

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,005	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179
2,005	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179	2,179
635	645	602	563	526	492	460	430	401	375	351	328	306	286	268	250	234	218	204	191	178

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3,799	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538
3,799	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538	4,538
1,203	1,343	1,255	1,173	1,096	1,024	957	895	836	781	730	683	638	596	557	521	487	455	425	397	371

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83,126	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723
83,126	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723	94,723
26,316	28,025	26,192	24,478	22,877	21,380	19,981	18,674	17,453	16,311	15,244	14,247	13,315	12,443	11,629	10,869	10,158	9,493	8,872	8,292	7,749

Appendix B: Binomial Trees for Additional Station Construction Projects

Yongyoo

Asset Value @ 2002	V	13,673	u(up factor)	1.230
Strike Price @ 2002	K	15,271	d(down factor)	0.813
Seeding Cost @ 2002		1,636	p(up prob.)	0.556
Risk-free Rate	Rf	4.5%	1-p(down prob.)	0.444
Volatility(year)	σ	20.7%		
Time Interval(year)	Δt	1		

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Period	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
Asset Value	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187
Strike Price	15,271	15,958	16,676	17,427	18,211	19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
Exercise Value	(1,598)	859	4,009	8,016	13,083	19,460	27,456	37,450	49,907	65,401	84,641	108,493	138,029	174,564	219,717	275,480	344,302	429,198	533,876	662,897	821,871	1,017,700
Holding Value	2,090	3,233	4,981	7,646	11,694	17,234	24,643	34,349	46,453	61,514	80,219	103,415	132,143	167,685	211,615	265,875	332,848	415,471	517,352	642,932	797,675	988,299
Option Value	2,090	3,233	4,981	7,646	11,694	17,824	25,820	35,813	48,270	63,765	83,004	106,857	136,393	172,928	218,081	273,843	342,666	427,562	532,240	661,261	820,235	1,016,064
Exercise?	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
		11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141
		15,958	16,676	17,427	18,211	19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
		(4,842)	(3,003)	(609)	2,474	6,412	11,407	17,709	25,626	35,537	47,908	63,313	82,458	106,213	135,646	172,074	217,114	272,760	341,460	426,228	530,773	659,654
		1,175	1,837	2,858	4,427	6,830	10,496	15,818	22,916	32,437	44,455	59,425	78,037	101,135	129,760	165,194	209,013	263,155	330,006	412,501	514,248	639,689
		1,175	1,837	2,858	4,427	6,830	10,496	16,073	23,990	33,901	46,272	61,677	80,822	104,576	134,010	170,437	215,478	271,124	339,824	424,592	529,137	658,018
		Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
			9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472
			16,676	17,427	18,211	19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
			(7,638)	(6,310)	(4,538)	(2,213)	798	4,661	9,577	15,797	23,628	33,449	45,726	61,032	80,075	103,722	133,043	169,354	214,272	269,790	338,356	422,985
			643	1,017	1,600	2,506	3,906	6,058	9,352	14,373	21,199	30,348	42,272	57,145	75,653	98,644	127,157	162,474	206,171	260,185	326,903	409,257
			643	1,017	1,600	2,506	3,906	6,058	9,352	14,373	21,992	31,812	44,089	59,396	78,439	102,086	131,407	167,718	212,636	268,154	336,720	421,349
			Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
				7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033
				17,427	18,211	19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
				(10,079)	(9,173)	(7,914)	(6,214)	(3,964)	(1,032)	2,748	7,578	13,708	21,445	31,168	43,342	58,542	77,472	101,003	130,201	166,384	211,169	266,547
				340	545	870	1,381	2,181	3,424	5,348	8,313	12,860	19,403	28,146	39,889	54,654	73,051	95,924	124,315	159,504	203,067	256,942
				340	545	870	1,381	2,181	3,424	5,348	8,313	12,860	19,809	29,532	41,706	56,906	75,836	99,366	128,565	164,748	209,533	264,910
				Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
					5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627
					18,211	19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
					(12,237)	(11,682)	(10,849)	(9,665)	(8,044)	(5,877)	(3,030)	660	5,396	11,428	19,062	28,678	40,740	55,822	74,630	98,033	127,098	163,141
					172	281	456	734	1,177	1,875	2,969	4,673	7,311	11,372	17,586	25,992	37,286	51,935	70,209	92,954	121,212	156,261
					172	281	456	734	1,177	1,875	2,969	4,673	7,311	11,372	17,586	27,041	39,104	54,186	72,994	96,396	125,462	161,505
					Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer
						4,857	5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276
						19,030	19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
						(14,173)	(13,913)	(13,434)	(12,679)	(11,578)	(10,047)	(7,965)	(5,213)	(1,621)	3,013	8,937	16,460	25,958	37,898	52,852	71,527	94,789
						83	138	228	374	610	988	1,592	2,547	4,050	6,398	10,044	15,673	23,712	34,479	48,965	67,105	89,711
						83	138	228	374	610	988	1,592	2,547	4,050	6,398	10,044	15,673	24,322	36,262	51,216	69,890	93,153
						Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer
							3,949	4,857	5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096
							19,887	20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
							(15,938)	(15,925)	(15,743)	(15,346)	(14,678)	(13,666)	(12,225)	(10,246)	(7,596)	(4,111)	410	6,218	13,617	22,988	34,794	49,609
							37	64	107	180	299	495	813	1,327	2,149	3,456	5,516	8,737	13,733	21,422	31,772	45,721
							37	64	107	180	299	495	813	1,327	2,149	3,456	5,516	8,737	13,733	21,422	33,158	47,973
							Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer
								3,210	3,949	4,857	5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491	47,343	58,231
								20,782	21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
								(17,571)	(17,768)	(17,837)	(17,741)	(17,435)	(16,860)	(15,947)	(14,608)	(12,736)	(10,198)	(6,831)	(2,432)	3,248	10,514	19,745
								16	27	47	81	137	232	391	653	1,082	1,779	2,904	4,702	7,550	12,023	18,993
								16	27	47	81	137	232	391	653	1,082	1,779	2,904	4,702	7,550	12,023	18,993
								Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
									2,610	3,210	3,949	4,857	5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443	31,294	38,491
									21,717	22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
									(19,107)	(19,484)	(19,767)	(19,926)	(19,924)	(19,715)	(19,243)	(18,437)	(17,211)	(15,456)	(13,040)	(9,801)	(5,535)	4
									6	11	19	33	58	100	173	297	506	855	1,431	2,377	3,913	6,381
									6	11	19	33	58	100	173	297	506	855	1,431	2,377	3,913	6,381
									Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
										2,122	2,610	3,210	3,949	4,857	5,974	7,348	9,038	11,116	13,673	16,818	20,685	25,443
										22,694	23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
										(20,572)	(21,105)	(21,572)	(21,949)	(22,200)	(22,307)	(22,206)	(21,846)	(21,157)	(20,053)	(18,426)	(16,144)	(13,044)
										2	4	7	12	22	39	70	123	215	375	648	1,110	1,885
										2	4	7	12	22	39	70	123	215	375	648	1,110	1,885
										Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
											1,725	2,122	2,610	3,210	3,949	4,857	5,974	7,348	9,038	11,116	13,673	16,818
											23,715	24,783	25,898	27,063	28,281	29,554	30,884	32,273	33,726	35,243	36,829	38,487
											(21,990)	(22,660)	(23,288)	(23,853)	(24,332)	(24,697)	(24,910)	(24,925)	(24,688)	(24,127)	(23,156)	(21,669)
											1	1	2	4	7	13	24	45	81	146	261	463
											1	1	2	4	7	13	24	45	81	146	261	463
											Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold

2024	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*	*2038*	*2039*
22	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*
1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076	4,498,140	5,532,633	6,805,041	8,370,080	10,295,052	12,662,732	15,574,938	19,156,899	23,562,649	28,981,644
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
1,258,872	1,555,831	1,921,419	2,371,436	2,925,314	3,606,957	4,445,765	5,477,901	6,747,846	8,310,312	10,232,593	12,597,464	15,506,732	19,085,624	23,488,167	28,903,810
1,223,070	1,512,154	1,868,057	2,306,162	2,845,389	3,509,011	4,325,653	5,330,525	6,566,937	8,088,157	9,959,706	12,262,177	15,094,696	18,579,187	22,865,618	0
1,257,236	1,554,194	1,919,783	2,369,799	2,923,678	3,605,321	4,444,129	5,476,265	6,746,210	8,308,676	10,230,957	12,595,827	15,505,096	19,083,988	23,486,530	28,902,173
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076	4,498,140	5,532,633	6,805,041	8,370,080	10,295,052	12,662,732	15,574,938	19,156,899
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
818,482	1,014,158	1,255,171	1,551,963	1,917,377	2,367,212	2,920,900	3,602,345	4,440,945	5,472,864	6,742,583	8,304,812	10,226,846	12,591,457	15,500,455	19,079,065
794,286	984,757	1,219,369	1,508,286	1,864,016	2,301,939	2,840,975	3,504,398	4,320,833	5,325,488	6,561,673	8,082,656	9,953,959	12,256,171	15,088,419	0
816,846	1,012,522	1,253,535	1,550,327	1,915,741	2,365,576	2,919,264	3,600,708	4,439,309	5,471,228	6,740,946	8,303,175	10,225,210	12,589,821	15,498,819	19,077,429
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
567,602	698,141	858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076	4,498,140	5,532,633	6,805,041	8,370,080	10,295,052	12,662,732
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
527,384	656,112	814,781	1,010,291	1,251,130	1,547,739	1,912,963	2,362,600	2,916,081	3,597,308	4,435,682	5,467,364	6,736,835	8,298,805	10,220,569	12,584,898
510,859	636,147	790,585	980,890	1,215,327	1,504,063	1,859,602	2,297,326	2,836,156	3,499,362	4,315,569	5,319,988	6,555,925	8,076,650	9,947,682	0
525,747	654,476	813,145	1,008,654	1,249,493	1,546,103	1,911,327	2,360,964	2,914,444	3,595,672	4,434,045	5,465,728	6,735,199	8,297,169	10,218,933	12,583,262
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
375,186	461,472	567,602	698,141	858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076	4,498,140	5,532,633	6,805,041	8,370,080
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
334,967	419,443	523,682	652,245	810,739	1,006,067	1,246,716	1,543,127	1,908,144	2,357,563	2,910,817	3,591,808	4,429,934	5,461,358	6,730,558	8,292,246
323,514	405,716	507,158	632,280	786,543	976,666	1,210,913	1,499,451	1,854,782	2,292,290	2,830,892	3,493,861	4,309,822	5,313,982	6,549,649	0
333,331	417,807	522,046	650,608	809,103	1,004,431	1,245,080	1,541,491	1,906,507	2,355,927	2,909,181	3,590,172	4,428,298	5,459,721	6,728,922	8,290,610
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076	4,498,140	5,532,633
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
207,780	263,005	331,266	415,576	519,641	648,021	806,326	1,001,455	1,241,896	1,538,090	1,902,880	2,352,063	2,905,070	3,585,801	4,423,657	5,454,798
199,678	253,400	319,812	401,848	503,116	628,056	782,129	972,054	1,206,093	1,494,414	1,849,519	2,286,790	2,825,145	3,487,855	4,303,545	0
206,143	261,369	329,630	413,939	518,005	646,385	804,689	999,819	1,240,260	1,536,454	1,901,244	2,350,427	2,903,433	3,584,165	4,422,021	5,453,162
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332	2,973,275	3,657,076
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
123,709	159,599	204,079	259,137	327,224	411,352	515,227	643,409	801,506	996,418	1,236,633	1,532,590	1,897,133	2,346,057	2,898,793	3,579,242
117,823	152,719	195,977	249,533	315,771	397,624	498,702	623,444	777,309	967,017	1,200,830	1,488,914	1,843,771	2,280,783	2,818,868	0
122,072	157,963	202,442	257,501	325,588	409,716	513,591	641,773	799,870	994,782	1,234,997	1,530,954	1,895,496	2,344,420	2,897,157	3,577,606
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187	1,299,091	1,597,859	1,965,338	2,417,332
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
68,137	91,248	120,007	155,731	200,037	254,914	322,811	406,740	510,407	638,372	796,242	990,918	1,230,885	1,526,584	1,890,856	2,339,498
63,716	86,169	114,121	148,852	191,935	245,309	311,357	393,012	493,883	618,407	772,046	961,517	1,195,082	1,482,907	1,837,495	0
66,501	89,611	118,371	154,095	198,401	253,278	321,174	405,104	508,771	636,736	794,606	989,282	1,229,249	1,524,948	1,889,220	2,337,861
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187	1,299,091	1,597,859
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
31,405	46,067	64,436	87,380	115,966	151,508	195,623	250,301	317,991	401,703	505,144	632,872	790,495	984,912	1,224,608	1,520,025
28,881	42,180	60,015	82,302	110,080	144,628	187,522	240,697	306,537	387,976	488,619	612,907	766,298	955,510	1,188,806	0
29,769	44,431	62,800	85,744	114,330	149,872	193,987	248,665	316,355	400,067	503,508	631,236	788,859	983,275	1,222,972	1,518,389
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141	858,701	1,056,187
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
7,125	16,203	27,704	42,200	60,395	83,156	111,552	146,896	190,803	245,265	312,728	396,203	499,396	626,865	784,218	978,352
10,304	16,473	25,945	38,704	55,973	78,078	105,666	140,016	182,702	235,660	301,274	382,475	482,872	606,901	760,022	0
10,304	16,473	26,068	40,563	58,758	81,520	109,916	145,259	189,167	243,629	311,091	394,567	497,760	625,229	782,582	976,716
Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472	567,602	698,141
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
(8,925)	(3,537)	3,424	12,335	23,662	37,976	55,981	78,544	106,732	141,859	185,540	239,765	306,980	390,197	493,120	620,306
3,170	5,279	8,698	14,173	22,830	35,021	51,560	73,466	100,846	134,979	177,438	230,160	295,526	376,469	476,595	0
3,170	5,279	8,698	14,173	22,830	36,340	54,345	76,908	105,096	140,223	183,904	238,128	305,344	388,560	491,483	618,670
Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
20,685	25,443	31,294	38,491	47,343	58,231	71,623	88,096	108,356	133,276	163,927	201,627	247,998	305,033	375,186	461,472
40,218	42,028	43,920	45,896	47,961	50,120	52,375	54,732	57,195	59,769	62,458	65,269	68,206	71,275	74,482	77,834
(19,533)	(16,586)	(12,626)	(7,405)	(618)	8,112	19,248	33,364	51,161	73,507	101,469	136,359	179,792	233,758	300,703	383,638
815	1,421	2,456	4,199	7,097	11,849	19,525	31,120	46,892	68,429	95,583	129,479	171,691	224,153	289,250	0
815	1,421	2,456	4,199	7,097	11,849	19,525	31,727	49,525	71,871	99,833	134,722	178,156	232,122	299,067	382,001
Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer

Younglong

Asset Value @ 2002	V	22,020	u(up factor)	1.230
Strike Price @ 2002	K	21,778	d(down factor)	0.813
Seeding Cost @ 2002		3,887	p(up prob.)	0.556
Risk-free Rate	Rf	4.5%	1-p(down prob.)	0.444
Volatility(year)	σ	20.7%		
Time Interval(year)	Δt	1		

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Period	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
Asset Value	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997
Strike Price	21,778	22,758	23,782	24,852	25,970	27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
Exercise Value	243	4,327	9,532	16,123	24,429	34,851	47,886	64,145	84,380	109,515	140,688	179,300	227,073	286,128	359,072	449,113	560,197	697,179	866,032	1,074,101	1,330,423	1,646,112
Holding Value	3,780	5,807	8,885	13,538	20,506	29,772	42,158	57,955	77,621	102,057	132,370	169,924	216,397	273,851	344,827	432,447	540,553	673,873	838,222	1,040,750	1,290,257	1,597,564
Option Value	3,780	5,807	8,885	13,538	20,542	30,964	44,000	60,259	80,494	105,628	136,802	175,413	223,187	282,242	355,185	445,226	556,310	693,293	862,146	1,070,215	1,326,536	1,642,225
Exercise?	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
		17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361
		22,758	23,782	24,852	25,970	27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
		(4,855)	(1,761)	2,233	7,344	13,836	22,039	32,354	45,276	61,418	81,530	106,537	137,576	176,048	223,675	282,577	355,360	445,234	556,144	692,944	861,606	1,069,476
		2,163	3,359	5,194	7,995	12,256	18,714	27,639	39,548	55,227	74,771	99,078	129,258	166,672	212,998	270,299	341,115	428,568	536,500	669,638	833,796	1,036,125
		2,163	3,359	5,194	7,995	12,256	18,714	28,467	41,390	57,532	77,644	102,650	133,689	172,161	219,788	278,690	351,474	441,348	552,257	689,057	857,720	1,065,589
		Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
			14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204
			23,782	24,852	25,970	27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
			(9,226)	(6,949)	(3,950)	(54)	4,954	11,339	19,429	29,626	42,426	58,440	78,418	103,284	134,177	172,496	219,963	278,698	351,307	440,999	551,718	688,319
			1,203	1,891	2,958	4,602	7,127	10,983	16,850	25,449	36,906	52,249	71,659	95,826	125,859	163,120	209,286	266,421	337,062	424,333	532,074	665,013
			1,203	1,891	2,958	4,602	7,127	10,983	16,850	25,740	38,540	54,553	74,531	99,398	130,291	168,609	216,077	274,812	347,421	437,112	547,831	684,432
			Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
				11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259
				24,852	25,970	27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
				(13,018)	(11,415)	(9,236)	(6,348)	(2,552)	2,344	8,612	16,579	26,648	39,314	55,188	75,019	99,733	130,466	168,617	215,910	274,463	346,881	436,374
				648	1,033	1,637	2,580	4,046	6,309	9,787	15,102	23,188	34,223	48,997	68,260	92,274	122,147	159,242	205,233	262,186	332,636	419,708
				648	1,033	1,637	2,580	4,046	6,309	9,787	15,102	23,188	35,428	51,301	71,133	95,846	126,579	164,731	212,024	270,576	342,995	432,487
				Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
					9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722
					25,970	27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
					(16,349)	(15,305)	(13,805)	(11,734)	(8,950)	(5,279)	(506)	5,633	13,467	23,396	35,915	51,636	71,308	95,854	126,413	164,382	211,484	269,837
					335	542	874	1,399	2,226	3,521	5,537	8,658	13,460	20,815	31,412	45,562	64,548	88,396	118,094	155,006	200,807	257,560
					335	542	874	1,399	2,226	3,521	5,537	8,658	13,460	20,815	32,029	47,749	67,421	91,968	122,526	160,496	207,598	265,951
					Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
						7,822	9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642
						27,139	28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
						(19,317)	(18,739)	(17,802)	(16,414)	(14,461)	(11,800)	(8,257)	(3,619)	2,381	10,068	19,844	32,204	47,757	67,255	91,619	121,987	159,757
						165	272	446	726	1,176	1,892	3,024	4,802	7,574	11,866	18,469	28,557	42,187	60,495	84,160	113,668	150,381
						165	272	446	726	1,176	1,892	3,024	4,802	7,574	11,866	18,469	28,557	43,871	63,368	87,732	118,100	155,870
						Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer
							6,360	7,822	9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879
							28,360	29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
							(22,001)	(21,814)	(21,349)	(20,530)	(19,264)	(17,439)	(14,912)	(11,510)	(7,017)	(1,171)	6,357	15,966	28,151	43,522	62,829	86,994
							76	129	215	358	591	970	1,581	2,560	4,113	6,562	10,394	16,348	25,536	38,589	56,069	79,535
							76	129	215	358	591	970	1,581	2,560	4,113	6,562	10,394	16,348	25,536	39,636	58,942	83,107
							Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer
								5,171	6,360	7,822	9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990	76,247	93,782
								29,636	30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
								(24,466)	(24,610)	(24,541)	(24,199)	(23,508)	(22,377)	(20,691)	(18,311)	(15,061)	(10,739)	(5,049)	2,304	11,730	23,725	38,897
								33	57	97	165	279	468	780	1,291	2,120	3,455	5,585	8,952	14,228	22,416	34,967
								33	57	97	165	279	468	780	1,291	2,120	3,455	5,585	8,952	14,228	22,416	35,010
								Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer
									4,204	5,171	6,360	7,822	9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975	50,399	61,990
									30,970	32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
									(26,766)	(27,193)	(27,460)	(27,520)	(27,311)	(26,760)	(25,775)	(24,243)	(22,022)	(18,940)	(14,782)	(9,284)	(2,122)	7,105
									13	23	40	70	121	209	357	607	1,024	1,712	2,839	4,668	7,606	12,280
									13	23	40	70	121	209	357	607	1,024	1,712	2,839	4,668	7,606	12,280
									Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
										3,418	4,204	5,171	6,360	7,822	9,621	11,834	14,556	17,903	22,020	27,085	33,314	40,975
										32,364	33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
										(28,946)	(29,616)	(30,171)	(30,573)	(30,772)	(30,710)	(30,312)	(29,487)	(28,121)	(26,075)	(23,175)	(19,208)	(13,910)
										5	8	15	27	48	85	149	260	452	778	1,330	2,253	3,781
										5	8	15	27	48	85	149	260	452	778	1,330	2,253	3,781
										Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
											2,779	3,418	4,204	5,171	6,360	7,822	9,621	11,834	14,556	17,903	22,020	27,085
											33,820	35,342	36,932	38,594	40,331	42,146	44,043	46,024	48,096	50,260	52,522	54,885
											(31,041)	(31,934)	(32,729)	(33,424)	(33,971)	(34,324)	(34,421)	(34,190)	(33,540)	(32,357)	(30,501)	(27,800)
											1	3	5	9	16	30	55	99	178	316	560	982
											1	3	5	9	16	30	55	99	178	316	560	982
											Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
22	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*
,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750	7,244,289	8,910,349	10,959,572	13,480,081	16,580,262	20,393,430	25,083,560	30,852,338	37,947,832	46,675,166
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
,034,841	2,513,429	3,102,560	3,827,680	4,720,087	5,818,276	7,169,599	8,832,297	10,878,008	13,394,846	16,491,192	20,300,352	24,986,293	30,750,694	37,841,614	46,564,168
,975,983	2,441,890	3,015,424	3,721,360	4,590,169	5,659,335	6,974,960	8,593,749	10,585,454	13,035,865	16,050,507	19,759,173	24,321,508	29,933,875	36,837,798	0
,030,955	2,509,542	3,098,674	3,823,794	4,716,200	5,814,389	7,165,712	8,828,410	10,874,121	13,390,959	16,487,305	20,296,465	24,982,407	30,746,807	37,837,728	46,560,282
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750	7,244,289	8,910,349	10,959,572	13,480,081	16,580,262	20,393,430	25,083,560	30,852,338
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
,325,589	1,641,061	2,029,563	2,507,913	3,096,796	3,821,657	4,713,793	5,811,699	7,162,725	8,825,114	10,870,502	13,387,002	16,482,995	20,291,786	24,977,342	30,741,340
,285,423	1,592,513	1,970,705	2,436,374	3,009,660	3,715,336	4,583,875	5,652,758	6,968,086	8,586,567	10,577,948	13,028,022	16,042,311	19,750,608	24,312,557	0
,321,703	1,637,175	2,025,677	2,504,027	3,092,910	3,817,771	4,709,906	5,807,812	7,158,839	8,821,227	10,866,615	13,383,116	16,479,108	20,287,900	24,973,456	30,737,453
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750	7,244,289	8,910,349	10,959,572	13,480,081	16,580,262	20,393,430
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
856,773	1,064,425	1,320,311	1,635,546	2,023,800	2,501,890	3,090,502	3,815,080	4,706,919	5,804,516	7,155,219	8,817,270	10,862,305	13,378,437	16,474,044	20,282,432
828,962	1,031,074	1,280,145	1,586,997	1,964,942	2,430,351	3,003,366	3,708,759	4,577,002	5,645,575	6,960,580	8,578,723	10,569,751	13,019,456	16,033,360	0
852,886	1,060,539	1,316,425	1,631,659	2,019,913	2,498,003	3,086,616	3,811,193	4,703,033	5,800,629	7,151,333	8,813,384	10,858,418	13,374,550	16,470,157	20,278,546
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
604,239	743,204	914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750	7,244,289	8,910,349	10,959,572	13,480,081
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
546,885	683,268	851,495	1,058,910	1,314,547	1,629,522	2,017,505	2,495,313	3,083,629	3,807,897	4,699,413	5,796,672	7,147,023	8,808,705	10,853,354	13,369,083
527,241	659,962	823,684	1,025,558	1,274,381	1,580,974	1,958,647	2,423,774	2,996,492	3,701,576	4,569,496	5,637,731	6,952,383	8,570,157	10,560,800	0
542,998	679,382	847,608	1,055,023	1,310,661	1,625,636	2,013,619	2,491,426	3,079,742	3,804,011	4,695,527	5,792,786	7,143,136	8,804,818	10,849,467	13,365,196
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750	7,244,289	8,910,349
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
342,048	431,323	541,607	677,752	845,731	1,052,886	1,308,253	1,622,945	2,010,632	2,488,130	3,076,123	3,800,053	4,691,217	5,788,107	7,138,072	8,799,351
327,803	414,657	521,963	654,447	817,920	1,019,535	1,268,087	1,574,397	1,951,774	2,416,591	2,988,986	3,693,733	4,561,299	5,629,166	6,943,432	0
338,162	427,436	537,720	673,866	841,844	1,049,000	1,304,367	1,619,058	2,006,745	2,484,243	3,072,236	3,796,167	4,687,330	5,784,220	7,134,185	8,795,464
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132	4,788,484	5,889,750
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
206,651	264,787	336,770	425,807	535,843	671,729	839,437	1,046,309	1,301,380	1,615,762	2,003,126	2,480,286	3,067,926	3,791,488	4,682,266	5,778,753
195,974	252,510	322,525	409,141	516,199	648,423	811,626	1,012,958	1,261,214	1,567,214	1,944,268	2,408,747	2,980,790	3,685,167	4,552,348	0
202,764	260,900	332,884	421,921	531,956	667,843	835,550	1,042,422	1,297,493	1,611,876	1,999,239	2,476,400	3,064,040	3,787,601	4,678,379	5,774,866
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365	3,165,193	3,893,132
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
117,153	154,706	201,373	259,271	331,006	419,784	529,549	665,152	832,563	1,039,126	1,293,874	1,607,918	1,994,929	2,471,721	3,058,975	3,782,134
108,835	145,330	190,696	246,994	316,761	403,118	509,905	641,846	804,753	1,005,775	1,253,708	1,559,370	1,936,071	2,400,182	2,971,839	0
113,267	150,820	197,486	255,385	327,120	415,898	525,662	661,265	828,677	1,035,240	1,289,987	1,604,032	1,991,043	2,467,834	3,055,089	3,778,248
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997	2,092,196	2,573,365
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
57,995	81,943	111,875	149,191	195,609	253,248	324,712	413,207	522,675	657,969	825,057	1,031,282	1,285,677	1,599,353	1,985,978	2,462,367
51,800	74,484	103,557	139,815	184,932	240,971	310,467	396,541	503,031	634,663	797,247	997,931	1,245,511	1,550,805	1,927,120	0
54,109	78,056	107,989	145,304	191,723	249,361	320,826	409,320	518,789	654,083	821,171	1,027,396	1,281,791	1,595,466	1,982,092	2,458,480
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361	1,382,944	1,700,997
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
18,892	33,846	52,717	76,427	106,111	143,167	189,315	246,671	317,839	406,024	515,169	650,125	816,861	1,022,717	1,276,726	1,589,999
19,641	31,115	47,238	68,969	97,793	133,791	178,638	234,393	303,593	389,358	495,526	626,819	789,050	989,366	1,236,560	0
19,641	31,115	48,831	72,541	102,225	139,281	185,428	242,784	313,952	402,137	511,283	646,239	812,974	1,018,830	1,272,840	1,586,113
Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204	914,128	1,124,361
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
(6,956)	2,054	13,614	28,331	46,953	70,404	99,817	136,590	182,441	239,488	310,333	398,180	506,972	641,560	807,910	1,013,363
6,284	10,337	16,821	27,069	42,491	63,303	91,499	127,214	171,765	227,211	296,087	381,514	487,329	618,254	780,099	0
6,284	10,337	16,821	27,069	43,067	66,518	95,931	132,703	178,555	235,601	306,446	394,294	503,086	637,673	804,023	1,009,477
Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
33,314	40,975	50,399	61,990	76,247	93,782	115,350	141,879	174,508	214,642	264,006	324,722	399,403	491,259	604,239	743,204
57,355	59,936	62,633	65,451	68,397	71,475	74,691	78,052	81,564	85,235	89,070	93,078	97,267	101,644	106,218	110,998
(24,041)	(18,960)	(12,234)	(3,461)	7,850	22,307	40,659	63,827	92,944	129,407	174,936	231,644	302,136	389,615	498,021	632,206
1,708	2,941	5,012	8,448	14,069	23,129	37,505	57,453	84,626	120,031	164,259	219,367	287,891	372,949	478,378	0
1,708	2,941	5,012	8,448	14,069	23,129	37,505	59,940	89,057	125,521	171,049	227,758	298,249	385,728	494,135	628,320
Hold	Hold	Hold	Hold	Hold	Hold	Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer

Chungla

Asset Value @ 2002	V	736,033	u(up factor)	1.230
Strike Price @ 2002	K	30,291	d(down factor)	0.813
Seeding Cost @ 2002		12,380	p(up prob.)	0.556
Risk-free Rate	Rf	4.5%	1-p(down prob.)	0.444
Volatility(year)	σ	20.7%		
Time Interval(year)	Δt	1		

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Asset Value	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734
Strike Price	30,291	31,654	33,079	34,567	36,123	37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
Exercise Value	705,742	873,654	1,080,434	1,335,034	1,648,462	2,034,262	2,509,089	3,093,432	3,812,493	4,697,268	5,785,884	7,125,237	8,773,010	10,800,150	13,293,925	16,361,670	20,135,411	24,777,533	30,487,771	37,511,797	46,151,782	56,779,393
Holding Value	674,497	837,947	1,039,241	1,287,091	1,592,219	1,967,808	2,430,076	2,998,973	3,699,034	4,560,440	5,620,312	6,924,312	8,528,600	10,502,255	12,930,244	15,917,074	19,591,289	24,110,998	29,670,670	36,509,501	44,921,700	55,269,139
Option Value	693,362	861,273	1,068,054	1,322,654	1,636,082	2,021,882	2,496,709	3,081,052	3,800,113	4,684,887	5,773,503	7,112,857	8,760,629	10,787,770	13,281,544	16,349,290	20,123,030	24,765,152	30,475,391	37,499,417	46,139,401	56,767,013
Exercise?	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
		598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705
		31,654	33,079	34,567	36,123	37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
		566,755	702,954	870,741	1,077,390	1,331,853	1,645,138	2,030,788	2,505,459	3,089,639	3,808,529	4,693,125	5,781,555	7,120,713	8,768,282	10,795,210	13,288,762	16,356,276	20,129,773	24,771,642	30,481,615	37,505,364
		539,137	671,709	835,034	1,036,197	1,283,910	1,588,895	1,964,334	2,426,446	2,995,179	3,695,070	4,556,297	5,615,984	6,919,788	8,523,872	10,497,315	12,923,081	15,911,679	19,585,052	24,105,107	29,664,513	36,503,068
		554,375	690,574	858,360	1,065,010	1,319,472	1,632,758	2,018,408	2,493,079	3,077,359	3,796,148	4,680,745	5,769,174	7,108,333	8,755,902	10,782,830	13,276,382	16,343,895	20,117,393	24,759,261	30,469,235	37,492,983
		Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
			486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550
			33,079	34,567	36,123	37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
			453,440	563,842	699,910	867,560	1,074,066	1,328,379	1,641,508	2,026,995	2,501,495	3,085,496	3,804,200	4,688,601	5,776,827	7,115,773	8,763,120	10,789,815	13,283,125	16,350,384	20,123,617	24,765,208
			428,771	536,224	668,665	831,853	1,032,872	1,280,437	1,585,264	1,960,541	2,422,482	2,991,037	3,690,741	4,551,773	5,611,256	6,914,848	8,518,710	10,491,920	12,919,444	15,905,788	19,579,496	24,098,673
			441,060	551,462	687,530	855,179	1,061,685	1,315,999	1,629,128	2,014,614	2,489,115	3,073,116	3,791,819	4,676,221	5,764,447	7,103,393	8,750,739	10,777,435	13,270,744	16,338,004	20,111,237	24,752,828
			Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
				395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292
				34,567	36,123	37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
				360,982	450,396	560,661	696,586	864,086	1,070,436	1,324,585	1,637,544	2,022,852	2,497,166	3,080,973	3,799,472	4,683,661	5,771,665	7,110,378	8,757,482	10,783,924	13,276,968	16,343,951
				338,710	425,727	533,043	665,341	828,380	1,029,242	1,276,643	1,581,300	1,956,398	2,418,153	2,986,513	3,686,013	4,546,833	5,606,094	6,909,453	8,513,073	10,486,029	12,913,288	15,899,355
				348,602	438,016	548,281	684,206	851,705	1,058,055	1,312,205	1,625,164	2,010,472	2,484,786	3,068,592	3,787,092	4,671,281	5,759,285	7,097,998	8,745,102	10,771,544	13,264,588	16,331,571
				Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
					321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832
					36,123	37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
					285,467	357,801	447,072	557,187	692,956	860,292	1,066,471	1,320,443	1,633,215	2,018,328	2,492,438	3,076,033	3,794,310	4,678,267	5,766,028	7,104,487	8,751,326	10,777,491
					265,144	335,529	422,403	529,569	661,711	824,586	1,025,278	1,272,501	1,576,971	1,951,874	2,413,426	2,981,573	3,680,851	4,541,439	5,600,456	6,903,562	8,506,916	10,479,596
					273,086	345,421	434,691	544,807	680,576	847,912	1,054,091	1,308,063	1,620,835	2,005,948	2,480,058	3,063,652	3,781,930	4,665,886	5,753,647	7,092,107	8,738,946	10,765,110
					Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
						261,459	321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395
						37,748	39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
						223,710	282,142	354,327	443,442	553,394	688,992	856,150	1,062,142	1,315,919	1,628,488	2,013,388	2,487,276	3,070,638	3,788,673	4,672,375	5,759,871	7,098,054
						204,972	261,820	332,055	418,772	525,776	657,747	820,444	1,020,949	1,267,977	1,572,244	1,946,934	2,408,263	2,976,178	3,675,214	4,535,548	5,594,300	6,897,129
						211,330	269,762	341,947	431,061	541,014	676,612	843,769	1,049,762	1,303,539	1,616,107	2,001,008	2,474,896	3,058,258	3,776,292	4,659,995	5,747,491	7,085,674
						Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
							212,571	261,459	321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283
							39,447	41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
							173,124	220,236	278,512	350,534	439,477	549,251	684,663	851,626	1,057,415	1,310,979	1,623,325	2,007,993	2,481,639	3,064,747	3,782,516	4,665,942
							155,675	201,499	258,190	328,262	414,808	521,633	653,418	815,920	1,016,222	1,263,037	1,567,082	1,941,539	2,402,626	2,970,287	3,669,057	4,529,114
							160,744	207,856	266,132	338,153	427,097	536,871	672,283	839,246	1,045,035	1,298,599	1,610,945	1,995,613	2,469,258	3,052,366	3,770,136	4,653,562
							Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
								172,824	212,571	261,459	321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655
								41,222	43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
								131,602	169,494	216,443	274,548	346,391	435,148	544,728	679,935	846,686	1,052,253	1,305,584	1,617,688	2,002,102	2,475,482	3,058,313
								115,200	152,044	197,705	254,226	324,119	410,479	517,110	648,690	810,980	1,011,059	1,257,642	1,561,444	1,935,648	2,396,470	2,963,854
								119,222	157,113	204,063	262,168	334,011	422,768	532,347	667,555	834,305	1,039,872	1,293,204	1,605,307	1,989,722	2,463,102	3,045,933
								Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
									140,510	172,824	212,571	261,459	321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601	1,684,585	2,072,010
									43,077	45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
									97,432	127,809	165,530	212,300	270,219	341,867	430,421	539,787	674,773	841,391	1,046,615	1,299,693	1,611,531	1,995,669
									81,882	111,407	148,080	193,563	249,897	319,596	405,252	512,169	643,528	805,585	1,005,422	1,251,751	1,555,288	1,929,215
									85,052	115,428	153,149	199,920	257,839	329,487	418,041	527,407	662,393	828,911	1,034,235	1,287,313	1,599,151	1,983,289
									Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
										114,237	140,510	172,824	212,571	261,459	321,589	395,549	486,519	598,410	736,033	905,308	1,113,513	1,369,601
										45,016	47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
										69,221	93,468	123,666	161,201	207,777	265,492	336,927	425,259	534,393	669,136	835,400	1,040,459	1,293,260
										55,034	77,918	107,264	143,751	189,039	245,169	314,656	400,590	506,775	637,891	799,694	999,266	1,245,318
										56,841	81,088	111,286	148,820	195,396	253,111	324,547	412,878	522,012	656,755	823,020	1,028,079	1,280,880
										Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
											92,877	114,237	140,510	172,824	212,571	261,459	321,589	395,549	486,519	598,410	736,033	905,308
											47,041	49,158	51,370	53,682	56,098	58,622	61,260	64,017	66,898	69,908	73,054	76,341
											45,836	65,079	89,139	119,142	156,473	202,836	260,329	331,533	419,621	528,502	662,979	828,967
											34,829	51,468	73,589	102,740	139,024	184,099	240,007	309,261	394,952	500,884	631,734	793,260
											34,829	52,699	76,759	106,762	144,093	190,456	247,949	319,152	407,241	516,121	650,599	816,586
											Hold	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612	242,140,008	297,827,949	366,323,135	450,571,009	554,194,412	681,649,373	838,416,732	1,031,237,825	1,268,404,375	1,560,115,058
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
69,851,776	85,931,212	105,709,300	130,036,694	159,959,685	196,765,196	242,036,118	297,719,384	366,209,685	450,452,454	554,070,521	681,519,907	838,281,440	1,031,096,445	1,268,256,633	1,559,960,668
67,996,915	83,652,490	102,909,237	126,595,390	155,729,667	191,565,072	235,642,783	289,858,418	356,543,560	438,566,015	539,453,135	663,543,504	816,173,505	1,003,906,798	1,234,816,571	0
69,839,395	85,918,832	105,696,920	130,024,314	159,947,305	196,752,816	242,023,738	297,707,003	366,197,305	450,440,073	554,058,141	681,507,527	838,269,060	1,031,084,065	1,268,244,253	1,559,948,287
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612	242,140,008	297,827,949	366,323,135	450,571,009	554,194,412	681,649,373	838,416,732	1,031,237,825
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
46,145,059	56,772,368	69,844,434	85,923,540	105,701,283	130,028,316	159,950,931	196,756,047	242,026,558	297,709,393	366,199,245	450,441,544	554,059,120	681,507,993	838,268,990	1,031,083,434
44,914,977	55,262,114	67,989,573	83,644,818	102,901,220	126,587,012	155,720,912	191,555,924	235,633,222	289,848,427	356,533,120	438,555,104	539,441,734	663,531,590	816,161,055	0
46,132,679	56,759,987	69,832,054	85,911,160	105,688,903	130,015,936	159,938,550	196,743,667	242,014,178	297,697,013	366,186,864	450,429,163	554,046,740	681,495,613	838,256,610	1,031,071,054
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612	242,140,008	297,827,949	366,323,135	450,571,009	554,194,412	681,649,373
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
30,474,892	37,498,338	46,137,717	56,764,696	69,836,417	85,915,163	105,692,528	130,019,167	159,941,370	196,746,057	242,016,118	297,698,483	366,187,844	450,429,630	554,046,670	681,494,983
29,657,791	36,496,043	44,907,636	55,254,442	67,981,556	83,636,441	102,892,465	126,577,863	155,711,352	191,545,933	235,622,782	289,837,517	356,521,719	438,543,190	539,429,283	0
30,462,512	37,485,958	46,125,337	56,752,315	69,824,037	85,902,782	105,680,148	130,006,787	159,928,990	196,733,676	242,003,737	297,686,103	366,175,463	450,417,249	554,034,289	681,482,602
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612	242,140,008	297,827,949	366,323,135	450,571,009
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
20,116,894	24,758,183	30,467,551	37,490,666	46,129,700	56,756,318	69,827,662	85,906,014	105,682,968	130,009,177	159,930,930	196,735,147	242,004,717	297,686,569	366,175,393	450,416,619
19,572,773	24,091,648	29,650,449	36,488,371	44,899,619	55,246,064	67,972,801	83,627,292	102,882,904	126,567,873	155,700,911	191,535,023	235,611,381	289,825,603	356,509,268	0
20,104,514	24,745,803	30,455,170	37,478,286	46,117,320	56,743,938	69,815,282	85,893,633	105,670,587	129,996,796	159,918,549	196,722,766	241,992,336	297,674,189	366,163,013	450,404,239
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612	242,140,008	297,827,949
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
13,270,246	16,336,926	20,109,553	24,750,511	30,459,534	37,482,289	46,120,946	56,747,169	69,818,102	85,896,023	105,672,527	129,998,266	159,919,529	196,723,232	241,992,266	297,673,558
12,906,565	15,892,329	19,565,432	24,083,976	29,642,432	36,479,993	44,890,864	55,236,915	67,963,241	83,617,301	102,872,464	126,556,963	155,689,510	191,523,109	235,598,931	0
13,257,865	16,324,546	20,097,172	24,738,131	30,447,153	37,469,908	46,108,565	56,734,789	69,805,722	85,883,643	105,660,147	129,985,886	159,907,148	196,710,852	241,979,886	297,661,178
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732	160,054,820	196,864,612
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
8,744,603	10,770,465	13,262,904	16,329,254	20,101,536	24,742,133	30,450,779	37,473,140	46,111,385	56,737,179	69,807,662	85,885,113	105,661,126	129,986,352	159,907,078	196,710,222
8,500,194	10,472,570	12,899,223	15,884,658	19,557,414	24,075,599	29,633,677	36,470,844	44,881,304	55,226,925	67,952,801	83,606,391	102,861,063	126,545,049	155,677,060	0
8,732,223	10,758,085	13,250,524	16,316,874	20,089,155	24,729,753	30,438,399	37,460,760	46,099,005	56,724,798	69,795,281	85,872,733	105,648,746	129,973,972	159,894,698	196,697,842
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579	105,796,418	130,127,732
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
5,753,148	7,091,029	8,737,262	10,762,794	13,254,887	16,320,876	20,092,781	24,732,985	30,441,218	37,463,149	46,100,945	56,726,268	69,796,261	85,873,199	105,648,676	129,973,342
5,587,577	6,890,104	8,492,852	10,464,899	12,891,206	15,876,280	19,548,660	24,066,450	29,624,117	36,460,853	44,870,863	55,216,014	67,941,400	83,594,477	102,848,613	0
5,740,768	7,078,648	8,724,882	10,750,413	13,242,507	16,308,496	20,080,401	24,720,604	30,428,838	37,450,769	46,088,565	56,713,888	69,783,880	85,860,819	105,636,296	129,960,962
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734	69,931,552	86,014,579
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
3,775,793	4,658,917	5,745,807	7,083,357	8,729,245	10,754,416	13,246,132	16,311,727	20,083,220	24,722,994	30,430,778	37,452,239	46,089,544	56,714,354	69,783,810	85,860,188
3,662,335	4,522,089	5,580,236	6,882,432	8,484,835	10,456,521	12,882,451	15,867,131	19,539,099	24,056,459	29,613,677	36,449,943	44,859,462	55,204,100	67,928,949	0
3,763,413	4,646,537	5,733,427	7,070,977	8,716,864	10,742,035	13,233,752	16,299,347	20,070,840	24,710,614	30,418,398	37,439,859	46,077,164	56,701,974	69,771,430	85,847,808
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705	46,224,836	56,855,734
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
2,468,760	3,051,288	3,768,452	4,651,245	5,737,790	7,074,979	8,720,490	10,745,267	13,236,572	16,301,737	20,072,780	24,712,084	30,419,377	37,440,325	46,077,094	56,701,344
2,389,747	2,956,829	3,654,993	4,514,417	5,572,219	6,874,054	8,476,080	10,447,372	12,872,891	15,857,140	19,528,659	24,045,549	29,602,276	36,438,029	44,847,012	0
2,456,379	3,038,908	3,756,072	4,638,865	5,725,410	7,062,599	8,708,110	10,732,887	13,224,192	16,289,356	20,060,400	24,699,704	30,406,997	37,427,945	46,064,713	56,688,964
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550	30,554,669	37,581,705
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
1,604,809	1,988,644	2,461,418	3,043,616	3,760,435	4,642,867	5,729,035	7,065,830	8,710,929	10,735,276	13,226,132	16,290,827	20,061,379	24,700,170	30,406,927	37,427,315
1,548,565	1,922,190	2,382,405	2,949,157	3,646,976	4,506,039	5,563,464	6,864,905	8,466,520	10,437,381	12,862,451	15,846,230	19,517,258	24,033,635	29,589,825	0
1,592,428	1,976,263	2,449,038	3,031,236	3,748,055	4,630,487	5,716,655	7,053,450	8,698,549	10,722,896	13,213,751	16,278,446	20,048,999	24,687,789	30,394,547	37,414,934
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer
1,113,513	1,369,601	1,684,585	2,072,010	2,548,536	3,134,655	3,855,570	4,742,283	5,832,925	7,174,395	8,824,380	10,853,832	13,350,022	16,420,292	20,196,671	24,841,550
79,777	83,367	87,118	91,038	95,135	99,416	103,890	108,565	113,450	118,556	123,891	129,466	135,292	141,380	147,742	154,390
1,033,736	1,286,235	1,597,467	1,980,972	2,453,401	3,035,239	3,751,680	4,633,718	5,719,475	7,055,840	8,700,489	10,724,366	13,214,731	16,278,913	20,048,929	24,687,159
992,543	1,238,292	1,541,224	1,914,518	2,374,388	2,940,779	3,638,221	4,496,891	5,553,903	6,854,915	8,456,080	10,426,471	12,851,050	15,834,316	19,504,808	0
1,021,356	1,273,854	1,585,087	1,968,592	2,441,021	3,022,858	3,739,300	4,621,338	5,707,094	7,043,459	8,688,109	10,711,986	13,202,350	16,266,532	20,036,549	24,674,779
Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer	Exer

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