A study on the risk management of the CASA-1000 project

Daisuke Sasaki¹ and Mikiyasu Nakayama¹
¹Graduate School of Frontier Sciences, The University of Tokyo, Japan

Abstract:

This study aimed at conducting both qualitative and quantitative analyses of the Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000) to obtain risk management information. Consequently, real options were introduced in the form of risk hedges, and we attempted to estimate the hedge cost. Through qualitative analysis we identified the geopolitical risks. We also see that a certain degree of demand risk exists. Therefore, when evaluating project feasibility, it would be better to consider the hedge cost of these risks. Through quantitative analysis, when weighted average cost of capital is ≤10.0% and volatility is below a certain value, a hedge risk based on real options and the introduction of private funds may be possible. Thus, from a risk management viewpoint, it could be suggested that introducing private funds is possible in certain situations.

KEYWORDS electricity trading; CASA-1000; risk management; discounted cash flow; real options analysis

INTRODUCTION

Electricity trading is widely performed all over the world. In particular, due to the recent growing demand for renewable energy, surplus electricity trading derived from renewable energy sources, such as hydropower, is remarkable. The development of mechanisms (e.g., feed-in tariffs) provides business opportunities for further electricity trading. Under such circumstances, electricity trading projects that take advantage of high-voltage direct current technology, which is effective for long-distance transmission, are currently being planned. In Japan, the Asia Super Grid Initiative has been proposed (Japan Renewable Energy Foundation, 2014); indeed, these projects are worth considering from security and electricity supply diversification viewpoints. However, while there are business opportunities for electricity trading, there are many risks in these projects. In other words, international infrastructure projects carry several risks, so it is necessary to appropriately manage such risks. Some examples of the risks involved include political, demand, funding, and interest rate risks. From the viewpoint of performing the project smoothly, firms commonly take proper hedges. In addition, in handling the uncertainty associated with continuing projects, applying real options theory is currently being discussed. Real options theory applies finance theory to real assets or projects and is an attempt to quantify the option value of real assets or projects and trade similar to financial options. In electricity trading, from a risk management viewpoint, the movement to explore the applicability of real options theory is going to become more active.

In this study, the Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000) is analyzed. In 2006, Tajikistan, Kyrgyzstan, Afghanistan, and Pakistan agreed to cross-border electricity trading between Central Asia and South Asia, supplied by hydropower sources in Central Asia. The CASA-1000 project was launched with the support of international financial institutions with a focus on the World Bank (SNC-Lavalin, 2011). As shown in Figure 1 (Nakayama et al., 2015), in this project, 1,200 km of transmission cable line was laid with a plan to trade the surplus electricity of 1,300 MW in the summer season from Tajikistan and, in future, from Kyrgyzstan to Pakistan via Afghanistan. Thanks to the realization of this project, the international community expects to eliminate power shortages in Afghanistan and Pakistan, provide economic development through foreign currency revenue, and contribute to Afghanistan’s reconstruction and social stability. For more information on CASA-1000, refer to the Supplement.

Figure 1. Planned electricity trade in Central Asia as the CASA-1000 project. Arrows indicate the planned path of electricity trade

PREVIOUS RESEARCH

The Asian Development Bank (ADB) analyzed risk management in the power sector using qualitative data (ADB, 2013).
RISK MANAGEMENT OF CASA-1000 PROJECT

2009). Irwin (2007) performed an analysis of government guarantees used to manage risk in infrastructure projects funded by the private sector. In these studies, they first identify and classify risks qualitatively by observation; thus, we adopt a similar approach.

As a recent example of applying real options in the power sector, we can refer to Pringles et al. (2015), Abadie (2015), Kucsera and Rammerstorfer (2014), and Boomsma et al. (2012). Moreover, Martinez-Cesena et al. (2013) conducted a real option application review in the power sector since 2000 and found many examples. However, there are very few studies applying real options to risk management in the power sector.

Real option mechanisms are classified into three patterns: the differential equation, the tree (lattice) model, and simulation. This study uses the differential equation technique (Black-Scholes equation, Black and Scholes, 1973).

OBJECTIVES

This study aimed at conducting both qualitative and quantitative analyses of the CASA-1000 project to obtain project knowledge from a risk management viewpoint. Consequently, real options were introduced in the form of risk hedges, and we attempted to estimate the hedge cost. If the initial project value is greater than the hedge cost, then theoretically risk hedge will be applicable. According to the World Bank (2014), the introduction of private funds in the project is not plausible; however, if they secure an appropriate profit level and risk hedge, the introduction of private funds is not necessarily impossible. Thus, from a risk management viewpoint, we examine the possibility of introducing private funds.

METHOD

Qualitative analysis

In addition to a literature survey, the authors conducted interviews with relevant experts, both in the national governments of the two basin countries and in international aid organizations (e.g., the Asian Development Bank, the World Bank, and the Japan International Cooperation Agency) with the understanding that the Chatham House Rule applied. The names of the informants remain confidential. Media sources were also used to understand the positions of the governments as well as the expert opinions in these nations.

Quantitative analysis

Figure 2 shows an overall illustration of the quantitative analysis. In this paper, based on World Bank (2014), we first performed the analysis using the traditional project evaluation using the discounted cash flow (DCF) method. In this method, the net present value (NPV) is given by Equation (1) to assess the project feasibility in a manner that sees whether NPV is greater than zero, where \((FCF)_t, r, \) and \(I\) are free cash flows at time \(t\), the weighted average cost of capital (WACC), and the amount of the initial capital expenditure, respectively.

\[
NPV = \sum_t (FCF)_t \exp^{-r} - I
\]

That is, if NPV is positive, it is determined that the project is feasible. In addition, WACC varies depending on each business entity. Therefore, even in the same project, WACC for business entities that require fund resources is larger than that for business entities with funding resources; thus, their NPVs are expected to be smaller. In this study, we conducted a sensitivity analysis in accordance with the risk-adjusted discount rate, and based on the results, discuss the possibility of introducing private capital.

Following analysis by the DCF method, we introduce real options theory. Myers (1977) first proposed the concept of real options theory, and Dixit and Pindyck (1994) organized the theory. In short, real options are concepts that apply finance theory to real assets or projects and are attempts to quantify the option value of real assets or projects and trade similar to financial options. Incidentally, Copeland and Antikarov (2003) advocated the assumption that the present value of the cash flows of the project without flexibility is the best unbiased estimate of the market value of the project were it a traded asset. This assumption is called the marketed asset disclaimer; similarly, we make that assumption in this study.

As shown in Table I, there are various option types, such as put and call options. A call option is the right to purchase assets at a previously determined price (exercise price). In the case of real options for projects, if a rise in the future capital investment is expected, then by holding the call option, the investor will be freed from the risk of price increases. Conversely, the put option is the right to sell assets at a previously determined price (exercise price). Therefore, if there is a possibility that the project value will fall in future, a put option is a risk hedge. There is also a difference between European and American option mechanisms. In the European case, options can only be exercised at maturity; in the American market, options can be exercised at any time until maturity. Therefore, the value of American options are higher than European options because there is value in the ability to exercise before maturity in the American case.

In this study, we take real options as a form of risk hedge. That is, we consider “withdrawal options” (put options), which means the right to transfer the project at the previously determined price (exercise price) when inherent business risks emerge. By carrying this option, the business entity is released from the risks associated with fluctuations.
Qualitative analysis

The World Bank, which finances the CASA-1000 project, assumes that the magnitude of the risks associated with the project is significantly higher than for national-level projects given that this large infrastructure development project involves four countries, comprising one fragile state (Afghanistan) and two states (Kyrgyzstan and Tajikistan) with limited experience in developing large infrastructure under commercially sustainable frameworks (World Bank, 2014).

The geopolitical risks of the CASA-1000 project are closely related to the future large hydropower projects planned in Central Asia, such as the Rogun dam project in the Vakhsh river basin of Tajikistan. Rogun dam, with 3.6 GW of generation capacity, is supposed to (a) solve Tajikistan’s deficit of electricity and (b) let Tajikistan export electricity to Afghanistan and Pakistan. Nonetheless, it has been a major geopolitical issue between Tajikistan and Uzbekistan, which strongly opposes the plan.

The Rogun dam has been highly politicized because Tajik President Emomali Rakhmon has staked his legacy on the Rogun dam (Trilling, 2014). He once agitated for support to build the Rogun dam, saying “Rogun is not only a source of light but a national honor and dignity” (Demytrie, 2010). Conversely, Uzbek President Islam Karimov called the Rogun dam a “stupid project” (Rickleton, 2014). It is assumed that Uzbekistan does not want to see a change in the political power balance with Tajikistan in the event Tajikistan completes the Rogun dam. Moreover, Uzbekistan fears that the Rogun dam will change the runoff pattern of the Amu Darya river with more discharge in winter, which will result in a water shortage for irrigation in summer (Jalilov, 2010). Such a strong distrust on the part of Uzbekistan seems to stem from past conflicts with Kyrgyzstan over the use of water in the Syr Darya river basin. Kyrgyzstan ignored its commitments and excessively released water in winter from its reservoirs, which resulted in enormous flooding and damage to Uzbekistan (Azam and Makhmjejanov, 2010). If Uzbekistan’s strong distrust of Tajikistan persists, then it may endanger the Rogun dam construction. Uzbekistan once disrupted rail transport from Uzbekistan to Tajikistan (Radio Free Europe, 2010) and may employ the same maneuver to prevent equipment and materials from being transported to Tajikistan.

Yet another risk is a possible decrease in power demand by Pakistan. For example, China offered to export 3.2 GW of electricity to Pakistan (Pakistan Observer, 2013). This offer was made by Chinese officials in October 2013 during talks with the Punjab Chief Minister who then visited China to discuss cooperation between the two nations, particularly in the energy sector. These two countries are strengthening economic relations, as illustrated by the planned construction of the China Pakistan Economic Corridor, which is to be built between Gwadar in Pakistan and Kashgar in China (Shah and Page, 2015). Further electricity export from China to Pakistan may lead to Pakistan losing interest in the CASA-1000 project.

Quantitative analysis

The analysis of empirical data using the DCF method is as follows. The projection of cash flows shown in Table II was based on that of the World Bank (2014). Note that we changed WACC from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted). First, NPV was USD 1,302 million. This is much bigger than capital expenditure (USD 1,035 million); thus, we can see a sufficient profitability. In addition, a sensitivity analysis on WACC is presented in Table III and Figure 3. In this study, WACC was changed from 2.0% to 30.0% in 2.0% increments. Consequently, NPV became negative when WACC was changed from 2.1% to 10.0% to verify the feasibility of private funds (unless otherwise noted).
We therefore introduce real options as a form of risk hedge and attempt to estimate the hedge cost. In other words, if the initial project value is greater than the hedge cost, then the risk hedge by real options can be theoretically possible; the possibility of private funds is suggested also from a risk management viewpoint.

First, we set the volatility as 20.0% and change WACC from 2.0% to 20.0% in increments of 2.0% and calculate NPV, option value, and the difference. The pre-requisites of the simulation parameters are shown in Table IV. The calculation results are shown in Table V and Figure 4. For example, if WACC is 2.0% (almost the same as World Bank), NPV is USD 4,002 million and option value is USD 501 million or a difference of USD 3,501 million. Even when they pay the price to buy the withdrawal option, there is still recognized project feasibility. Conversely, if WACC is 20.0%, NPV is USD 220 million and option value is USD 1,300 million or a difference of USD –1,080 million. That is, when paying the premium by purchasing an option, the project value becomes negative. The difference changes from positive to negative when WACC changes from 10.0% to 12.0%. Therefore, if WACC is ≥12.0% because the option value exceeds NPV, then it is not possible to perform a risk hedge based on real options.

After fixing WACC at 10.0%, we change volatility from 10.0% to 100.0% in increments of 10.0% and calculate NPV, option value, and the difference. The calculation results are shown in Table VI and Figure 5. For example, if the volatility is 10.0% and option value is USD 862 million, then NPV

![Figure 3](image-url)

Figure 3. Sensitivity analysis where the horizontal axis corresponds to the weighted average cost of capital (WACC) (%) and the vertical axis corresponds to the net present value (NPV) (USD million)
is USD 1,302 million or a difference of USD 441 million. Even when they pay the price to buy the withdrawal option, there is still recognized project feasibility. Conversely, if the volatility is 100.0%, option value is USD 1,962 million and the difference is USD –660 million. In other words, if they pay the price to buy the option, the project value becomes negative. The difference changes from positive to negative when the volatility changes from 40.0% to 50.0%. Therefore, if volatility is ≥50.0% because the option value exceeds NPV, then it is not possible to perform a risk hedge based on real options.

We summarize the results in a matrix format shown in Table VII. According to this, if WACC is 2.0%, even if the volatility is any value from 10.0% to 100.0%, the difference obtained by subtracting the option value from NPV is positive, and the risk hedge based on real options is possible. Conversely, if WACC is ≥12.0%, even if the volatility is any value from 10.0% to 100.0%, the difference is negative, and the risk hedge based on real options cannot be performed. Similarly, if volatility is 10.0% and WACC is ≤10.0%, the difference obtained by subtracting the option value from NPV is positive, and risk hedge based on real options is possible. Conversely, if the volatility is 100.0%, then the difference obtained by subtracting the business withdrawal option value from NPV is negative (unless WACC is ≤6.0%), and it is impossible to perform a risk hedge based on real options.

Given the above discussion, when WACC is ≤10.0% and volatility is below a certain value according to WACC (Table VII), they can possibly hedge risk based on real options and by introducing private funds.

**SUMMARY**

To evaluate the CASA-1000 project from a risk management perspective, this study analyzed qualitative and quanti-

---

**Table IV. Simulation parameters**

<table>
<thead>
<tr>
<th>Risk Free Rate (%)</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity (years)</td>
<td>10</td>
</tr>
<tr>
<td>Exercise Price (USD million)</td>
<td>Discounted Free Cash Flow at maturity</td>
</tr>
</tbody>
</table>

**Table V. Real options analysis when WACC changes**

<table>
<thead>
<tr>
<th>WACC (%)</th>
<th>NPV (USD million)</th>
<th>Option Value (USD million)</th>
<th>Difference (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>4,002</td>
<td>501</td>
<td>3,501</td>
</tr>
<tr>
<td>4.0</td>
<td>3,020</td>
<td>624</td>
<td>2,397</td>
</tr>
<tr>
<td>6.0</td>
<td>2,285</td>
<td>746</td>
<td>1,539</td>
</tr>
<tr>
<td>8.0</td>
<td>1,728</td>
<td>865</td>
<td>864</td>
</tr>
<tr>
<td>10.0</td>
<td>1,302</td>
<td>974</td>
<td>328</td>
</tr>
<tr>
<td>12.0</td>
<td>973</td>
<td>1,071</td>
<td>–98</td>
</tr>
<tr>
<td>14.0</td>
<td>715</td>
<td>1,152</td>
<td>–437</td>
</tr>
<tr>
<td>16.0</td>
<td>512</td>
<td>1,218</td>
<td>–706</td>
</tr>
<tr>
<td>18.0</td>
<td>350</td>
<td>1,267</td>
<td>–917</td>
</tr>
<tr>
<td>20.0</td>
<td>220</td>
<td>1,300</td>
<td>–1,080</td>
</tr>
</tbody>
</table>

**Table VI. Real options analysis when volatility changes**

<table>
<thead>
<tr>
<th>Volatility (%)</th>
<th>NPV (USD million)</th>
<th>Option Value (USD million)</th>
<th>Difference (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>1,302</td>
<td>862</td>
<td>441</td>
</tr>
<tr>
<td>20.0</td>
<td>1,302</td>
<td>974</td>
<td>328</td>
</tr>
<tr>
<td>30.0</td>
<td>1,302</td>
<td>1,132</td>
<td>170</td>
</tr>
<tr>
<td>40.0</td>
<td>1,302</td>
<td>1,295</td>
<td>7</td>
</tr>
<tr>
<td>50.0</td>
<td>1,302</td>
<td>1,449</td>
<td>–147</td>
</tr>
<tr>
<td>60.0</td>
<td>1,302</td>
<td>1,588</td>
<td>–285</td>
</tr>
<tr>
<td>70.0</td>
<td>1,302</td>
<td>1,708</td>
<td>–406</td>
</tr>
<tr>
<td>80.0</td>
<td>1,302</td>
<td>1,811</td>
<td>–508</td>
</tr>
<tr>
<td>90.0</td>
<td>1,302</td>
<td>1,895</td>
<td>–593</td>
</tr>
<tr>
<td>100.0</td>
<td>1,302</td>
<td>1,962</td>
<td>–660</td>
</tr>
</tbody>
</table>

---

**Figure 4. Real options analysis where the horizontal axis corresponds to WACC (%) and the vertical axis corresponds to NPV, option value, and the difference (USD million)**
tative data. Through the qualitative analysis, we identified large geopolitical risks. We see also that a certain degree of demand risk exists. Therefore, when evaluating the project’s feasibility, it would be better to consider hedge cost for these risks. Through the quantitative analysis using the DCF method, the CASA-1000 project is feasible even if WACC is relatively large, i.e., even if introducing money that requires a high return rate. However, given the project risks described above, we consider whether it is possible to hedge risks based on real options. Consequently, when a stricter condition is satisfied, i.e., when WACC is ≤10.0% and volatility is below a certain value according to WACC, they can hedge risk based on real options, and introducing private funds may be possible. Figure 6 provides a brief summary of the aforementioned conclusion. Thus, from a risk management viewpoint, it could be suggested that introducing private funds is possible under certain situations.

The future challenges of this study with respect to real options are three-fold. First, the option transaction method is not yet examined. In this study, by calculating the option value, we estimate the hedge costs; however, these cannot actually carry the risk hedge if the options are traded. In the financial world, options are traded in the market; however, for projects such as CASA-1000, it would be difficult to envisage trading options in the market. In that case, by some

---95---
negotiated transactions (contracts), it is conceivable to achieve option transactions. For example, the guarantee mechanisms the World Bank provides, such as partial risk guarantees and partial credit guarantees, may also become a choice.

Second, the stochastic processes used here require further elaboration. In this study, for simplicity, the present value of the cash flow (NPV) is assumed to follow GBM. However, we need to adopt more complex stochastic processes in future.

The third challenge is the issue of geopolitical risks. Political risk is the risk that the project profitability deteriorates due to the impact of political issues, such as policy changes of other countries. Modeling this type of risk is difficult and it is not easy to factor it into the simulation; however, because it is a major risk in the CASA-1000 project, it will be necessary to consider effective handling techniques in the future.

This study identifies the risks of the CASA-1000 project more clearly and suggests new risk hedge possibilities based on real options and introducing private funds. In future, we hope that a more practical discussion proceeds.

ACKNOWLEDGMENTS

This study was supported by KAKENHI (25570003 and 15H02864), “the 21st century culture Academic Foundation academic incentives (2013 fiscal year),” “University of Tokyo Graduate School of Frontier Sciences, University fusion research promotion expenses (2013 fiscal year),” and the Ministry of Economy, Trade and Industry’s Oil-Producing Countries Advanced Personnel Training Support Project subsidy (2013, 2014, and 2015).

SUPPLEMENT

Table SI. The summary of the CASA-1000 Project Appraisal Document (PAD) data of the World Bank

REFERENCES


