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Using DNPV for valuing investments in the energy sector: A solar project case study

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ABSTRACT

In this paper, a practical application of a valuation method that decouples the time value of money from the risk associated with the project is used to value an investment on a solar project. The proposed method is termed decoupled net present value (DNPV). A simple investment renewable energy project is presented using both the traditional NPV techniques and the proposed DNPV. The proposed methodology provides a consistent valuation method free from the problems typically associated with the application of traditional NPV and, more importantly, it allows a seamless integration of project risk assessment performed by technical experts and risk management implemented by business executives into the financial evaluation of the project.

1. Introduction

Although a boom in innovative techniques for risk quantification and management has been taking place in the financial industry over the last three decades, nonfinancial institutions have been slow in adopting these modern tools [1]. Different from investing in liquid financial securities where managers are mostly concerned with market forces and financial risk, infrastructure investments are more illiquid, can take several years to develop and additional time to show a profit. As a result, infrastructure investment requires a thorough understanding of the different aspects of the investment such that a proper assessment and quantification of the risks can be made. In addition, because most managers (business executives) only have a limited amount of financial resources, they need to evaluate competing investment alternatives to decide which investment opportunity is the most attractive one. In order to make a sound investment decision, these evaluations need to consider the many different risks surrounding each project under consideration.

The standard tool to value and compare investment propositions is the Net Present Value (NPV) method. However, as discussed in Ref. [4]; the use of a single discount rate to account for the riskiness of the project as it is done in the NPV method is fraught with a number of drawbacks that can lead to over (or under) invest when the opposite would have been more appropriate. The classical NPV method is a top-down approach that resulted from the process of acquiring capital in the form of debt and equity and mandating that all investments must earn its weighted average cost of capital (WACC). If the project is deemed to have a risk profile different from the firms overall risk, business executives heuristically adjust the company's WACC to account for the project perceived risk and, more often than not, inflated discount rates are adopted [3]. In essence, the discount rate in the classical NPV is more concerned with the source of funding than the project itself (i.e., it is exogenous to the project representing the demand of equity investors and debt holders) and adjustments of the discount rate to account for idiosyncratic risk is a feeble attempt to correlate the discount rate to the overall risk of the project. Although more sophisticated probability-based approaches such as real options, decision analysis, or a combination of the two have been proposed as a tool for valuation of risky projects and strategy [2], the use of such methods has been deemed difficult to apply and, more importantly, the results difficult to explain to decision makers [6].

To complement the NPV method, a new valuation methodology termed decoupled NPV (DNPV) has been recently proposed. Contrary to NPV, DNPV is a bottom-up approach that first identifies the project risks, uses probabilistic analysis and modern financial techniques (e.g., option pricing) to price these risks as a cost to the project, and then integrates these synthetic costs to the project valuation (i.e., it is endogenous to the project). Hence, DNPV can be

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Table 1
Free cash flow analysis.

Financial model (all figures in € unless otherwise indicated)					
Unlevered Proforma	Year				
Revenues	**1**	**2**	**...**	**19**	**20**
1) Installed capacity (inc. degradation) (kwp)	3970	3954	...	3694	3679
2) Average radiation (P_{50}) (Kwh/Kwp)	1164	1164	...	1164	1164
3) Average feed-in Tariff (€/Kwh)	0.43	0.44	...	0.68	0.69
Total revenues:	**2,003,847**	**2,045,727**	**...**	**2,907,784**	**2,968,557**
4) Maintenance	125,054	128,180	...	195,041	199,917
5) Administration costs	72,000	73,800	...	112,295	115,103
6) Inverter replacement	14,292	14,649	...	22,290	22,848
7) Land lease (prepaid)	–	–	...	–	–
8) Insurance	14,292	14,649	...	22,290	22,848
9) Local tax	40,111	41,114	...	62,560	64,124
EBITDA	**1,738,098**	**1,773,335**	...	**2,493,307**	**2,543,718**
10) Corporate tax	272,339	286,311	...	586,719	608,882
Free cash flow (FCF)	**1,465,759**	**1,487,024**	...	**1,906,588**	**1,934,836**

used to measure the risk performance of the project whereas NPV (using WACC unadjusted for risk) can be used as a measure of the financial performance of the project and both measures should be calculated when evaluating capital allocations or infrastructure projects. In the DNPV methodology, an investor is viewed as an insurance provider who gets compensated for all risks that have not been diversified away (i.e., risks owned by the investor) and the value of each of these risks are represented by synthetic insurance premiums estimated using either risk-neutral probability for market (public) risks and actual probabilities for non-market (private) risks. The use of neutral and actual probabilities along with decision tree analysis for valuation of risky projects was first introduced to analyze oil and gas investment projects [9,10]. The procedure, termed the Integrated Approach, consists of developing a decision tree that maps the possible future outcomes and assigns probabilities to each of the branches of the tree. Despite the soundness of the approach, the implementation of the integrated approach is not straight forward and, more importantly, the results are often difficult to convey to decision makers.

As in the case of the integrated approach, DNPV allows for risk integration but in a simple and easy-to-communicate manner. Furthermore, similar to the integrated approach, DNPV is a tool that can be used to align risk management, financial objectives, operational alternatives and strategic options. Thus, the five-step Integrated Risk Return Management (IRRM) program for corporate risk management proposed by Ref. [3] can be adapted as described below to evaluate infrastructure projects using the proposed DNPV methodology. Accordingly, the five-step process in an infrastructure project evaluation are: (i) Step 1: Project risk identification and understanding; (ii) Step 2: Risk ownership selection; (iii) Step 3: Identification of acceptable amount of risk; (iv) Step 4: Selection of risk mitigation mechanisms; and (v) Step 5: Risk monitoring and management.

To show the capabilities of the proposed DNPV method along with the IRRM concept, a simple solar renewable project is presented in this paper. The project consists of solar panels installed in France generating approximately 4.6 GWh per year since 2012. To incentivize the development of renewable energy projects, the French government offered a significant premium for energy from renewable sources. At this particular facility, a purchase power agreement (PPA) that guarantees the solar plant owner a tariff of €0.43/kWh for a period of 20 years was signed. After this period, the price will revert back to the price of non-renewable energy (i.e., €0.06/kWh in 2012 prices).

2. NPV analysis

After financing, developing, and initially operating the power plant, the project developer was interested in selling the facility to interested buyers. The projected revenues and expected costs base are presented in Table 1 and are labeled from 1 through 10. Prices were adjusted assuming a 2.5% annual inflation whereas the installed capacity degraded at about 0.4% per year. Using this information, the earnings before interest, taxes, depreciation and amortization (EBITDA) were calculated. The free cash flow (FCF) for years 1 through 20 is presented in Table 1. Using the FCF information along with a discount rate of 10%, the present value of the future revenues was estimated to be €13.7 million. The discount rate was selected based on rates used for similar solar projects in France. A similar project in Germany would typically require a lower discount rate (i.e., 8%); thus, apparently, the market imposes an additional 2% premium to account for country risk. In such a case, the present value of the project future revenues would be worth €16 million. Hence, if the transacted price for the project is

Table 2
Hazard identification analysis.

Source	Parameter	Potential risk	Risk management
Revenue	Installed Capacity	Less capacity than advertised	Minimal risk mitigated by obtaining an expert report supported by professional liability insurance.
	Radiation[a]	Lower than expected performance on any given year	Moderate risk (to be assumed by the buyer).
	Feed in tariff[a,b]	Unilateral change in PPA that results in a net tariff reduction	Significant risk as it can reduce permanently future revenues. Risk can be either assumed by buyer or shared with seller.
Operating costs	Maintenance[a]	Company breaks contract and an alternative needs to be found	Moderate risk (to be assumed by buyer).
	Administration costs[a]	Fixed price contract broken and new contract/management needs to be put in place	Minimal risk (to be assumed by buyer) as cost estimated appears to be above market prices.
	Inverter replacement[a]	More inverters going wrong in any given year	Negligible risk (to be assumed by buyer) compared to other risks in this project.
	Land lease[a]	Lease increase	Negligible risk as a 20-year lease is already prepaid.
	Insurance	Insurance does not pay its commitments	Negligible risk mitigated by obtaining insurance from AAA insurance providers.
	Local sales tax[a b]	Increase in tax rates that could affect profit	This risk can be addressed under the feed in Tariff risk.
Additional costs	Financial Costs	Changes in interest rates	Negligible risk. Fixed rate loans are structured.
	Corporate tax[a b]	Increase in corporate tax rates	This risk can be addressed under the feed in Tariff risk.

[a] Risk to be partially or completely borne by investor.
[b] Reducing feed in tariffs, increasing local taxes or corporate taxes have the similar effect (i.e., reduce FCF) and they are all government decisions, therefore only one will be evaluated.

13€ million, in France would represent a NPV of €0.7 million for a project in France whereas in Germany would represent a NPV of €3 million. The actual price paid for a project depends upon the buyer's interest on acquiring the project (e.g., a utility needs to increase its portfolio of renewable energy may pay a premium for the project) as well as the seller's interest on divesting the project (e.g., a project developer that needs to raise funds to meet its financial obligations may be willing to sell the project at a discount).

3. DNPV analysis

3.1. Introduction

Different from a typical NPV valuation where a discount rate is assumed to account for the uncertainty associated with the estimated FCF, the proposed DNVP method requires the identification of potential risks that could affect the project's FCF, thus forcing investors to think about the potential project risk and evaluate the appropriate risk mitigation strategies. For instance, the Revenue (R) line is composed of three factors:

$$R = Q \times P_{50} \times U$$

where Q is the installed capacity (kWp), P_{50} is the average radiation (kWh/kWp), and U is the unit price per kwh/kWp. Lower FCF in any given year could be the result of a reduction of any of the three factors listed above. Similarly, the FCF could be negatively affected if higher than expected costs are attained at any given year.

In line with the proposed IRRM concept, a hazard identification analysis (Step 1) for each of the factors items identified in Table 1 is first performed. For this particular project, analysis indicates that the estimated FCF is affected by eleven factors (numbered from 1 through 11). Each of these factors along with the potential risks that could negatively affect the FCF are described in Table 2. The following phase (Step 2) is to decide which of these risks will be eliminated/transferred and which risks will be owned. Knowledge of the risks owned by investors is essential to understand if the expected cash flows from the potential business venture fairly compensate them for the assumed risks. It is not uncommon to see firms/investors owning risks that they either had not considered (therefore not compensated for such risks) or for which they were not well prepared.

Each of the quantities listed in Table 1 has a risk associated with the assigned expected value and there is a risk that the actual values could be lower than the assigned ones, thus resulting in a lower FCF. A description of the sources of uncertainty and the manner how these risks are mitigated is presented in detail in Table 2.

This is the most important feature of the proposed DNPV methodology, it forces project managers/decision makers to identify the risks associated with the project, take the appropriate steps to manage the identified risks, and retain those that are considered the appropriate ones to own. Based on this evaluation and for discussion purposes, three items are selected to illustrate the sources of uncertainty that are to be borne by the investor: amount of radiation, the feed in tariff, and maintenance cost. In what follows, the quantification of the price of risk for each of these risks is discussed.

3.2. Radiation risk

Solar radiation can vary from year to year and this variation can affect revenues in a given year. Solar data has been fitted to a normal distribution and it is typically described by two parameters: the average radiation (P_{50}) and the ratio P_{50}/P_{90} where P_{50} and P_{90} indicate that the solar radiation will exceed the specified value (i.e., P_{50} and P_{90}) 50% and 90% of the time, respectively. For this example the ratio $P_{50}/P_{90} = 1.07$ (thus $P_{90} = 1088$ kWh/kWp). With these two values, the standard deviation (σ) can be calculated as follows.

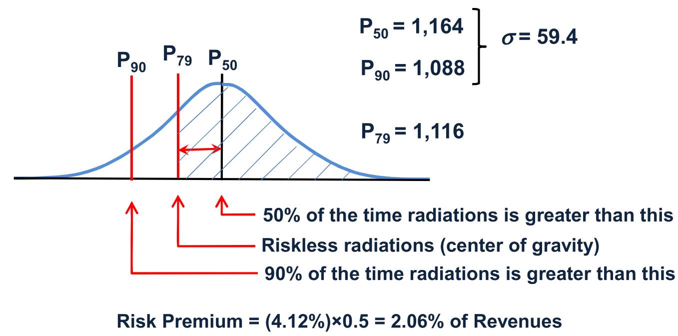

Fig. 1. Solar radiation variation.

$$N\left(\frac{P_{90} - P_{50}}{\sigma}\right) = 0.1$$

where $N(\bullet)$ is the standard cumulative normal distribution operator and $N^{-1}(0.1) = -1.28$. It follows that $\sigma = 59.4$ and the coefficient of variation for the solar radiation ($c_v = \sigma/P_{50}$) is 5.1%. Because revenues in Table 1 are estimated using an average radiation (i.e., P_{50}), anything below this amount is considered a “loss”. Consistent with the DNPV methodology described by Refs. [4]; the expected value of the loss is represented by the center of gravity of the area to the left of P_{50} (see Fig. 1). The center of gravity is located at approximately $x = -0.79$ which equivalent to P_{79} (i.e., 79% of the data is greater than this value which corresponds to the hatched area in Fig. 1) or $N^{-1}(0.21) = -0.80$. This value can be used to estimate P_{79} (i.e., the riskless radiation) as follows:

$$\left(\frac{P_{79} - P_{50}}{59.4}\right) = N^{-1}\left(0.21\right) = -0.80$$

From above, P_{79} is equal to 1116 kWh/kWp. Hence, the synthetic insurance premium (assuming risk neutrality[1]) can be calculated as the difference between the expected radiation value (P_{50}) and the expected loss (P_{79}). The normalized insurance premium is:

$$\left(\frac{1164 - 1116}{1164}\right) \times \Pr\left[\text{Radiation} < P_{50}\right] = 4.12\% \times 0.5 = 2.06\%$$

Thus, the annual price of risk that covers lower revenues than expected due to less radiation than expected is approximately 2% of the expected annual revenues. The cost of risk for each year is summarized in Table 3.

3.3. Feed-in-tariff

The feed-in-tariff (FiT) scheme is a key renewable energy sources (RES) support mechanism as this scheme provides support for RES such as wind, solar, hydro, biomass and geothermal sources which otherwise would not be able to compete with less expensive (and less environmentally friendly) forms of energy generation. The

[1] Synthetic insurance premiums for conditions other than risk neutrality is explained in detail by [5].

Table 3
Cost of risk.

Financial model (all figures in € unless otherwise indicated)					
Cost of risk	Year				
	1	**2**	**...**	**19**	**20**
2) Average radiation (P_{50}) (Kwh/Kwp)	41,245	42,107	...	59,851	61,102
3) Average feed-in Tariff (€/Kwh)	1,022,521	1,013,075	...	229,823	120,603
4) Maintenance	6253	6409	...	9752	9996
Total Cost of Risk	1,070,019	1,061,592	...	299,426	191,701
Decoupled Free Cash Flow (DFCF)	**395,433**	**425,117**	**...**	**1,606,682**	**1,742,643**

system is financed through public contribution to the electricity service which is an amount added to the electricity bill of each electricity consumer, a mechanism which provides security for investors by guaranteeing revenues with a long-term perspective to production capacity for renewable energy. For this solar RES project, the FiT negotiated by the developer was 0.43€ (partially adjusted for inflation) which is in the high range of other similar RES projects that range from 0.12€ to 0.46€. However, when an economic crisis extends in time, and local governments battle to find sources of additional revenues or reduction of expenses, potential buyers of the solar power plant may perceive a significant political risk that could result in a reduction of the FiT or increases in taxes that could affect future project revenues. This significant potential risk is estimated at 12% likelihood of such a reduction could take place during the 20 year period and that, in such event, the equivalent FiT would then be left at 0.28€ which is equivalent to the recent average FiT for similar solar projects in France. The 12% likelihood was selected assuming that the political risk above described equates to the risk of defaulting on a bond from a municipal entity. According to Moody's, the historical default rate on a municipal bond with investment grade of BB is 11.89%. Also, there is a small chance that the city could reject the contract all together and pay retail prices for the energy generated from the solar project. The probability of this event is equated to the probability of defaulting on their loans which is 1.5% as reported by the publicly traded credit default swaps at the time of this evaluation. This risk profile is represented in Fig. 2.

The potential political risk can be modeled as a Poison process (i.e., negative jump) that can result in a permanent condition as once the FiT is reduced or eliminated, it will never be increased (or reinstated) back up again, thus affecting future potential revenues from the time the event takes place onward. The methodology to estimate the cost of risk for this particular risk is described in detail by [5]. As described, the intertemporal relationship of the cost of risk in a given year is captured by considering the remaining revenues from that year on discounted at a rate equal to $r_f + \Theta$ where r_f is the risk free interest rate and Θ is the permanent shutdown risk factor.[2] Assuming risk neutrality, the risk factor can be estimated as the expected revenue loss. It follows from the tree in Fig. 2 that the expected cost of risk each period is equal to 0.024€ which is about 5.54% (0.024/0.43) of the expected revenues. Hence, $\Theta = 5.54\%$ can be used to estimate the cost of risk for each period. It follows that as time goes by, future remaining revenues reduces; hence, the risk associated to a tariff reduction also decreases. The estimated cost of risk for this case is summarized in Table 3.

[2] Although the proof included in Appendix A of [5] assumes constant revenues throughout the period analyzed, it can be shown that the same result is obtained assuming variable revenues.

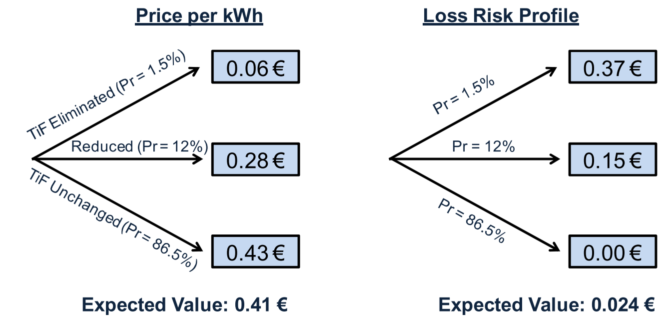

Fig. 2. Tariff risk profile.

3.4. Maintenance cost

Maintenance cost was another item that was identified that may pose a moderate risk to the project. As described in Table 2, the main risk was that the contract with an existing company is broken and a new (more expensive) maintenance contract is obtained. The risk can be modeled as a binomial risk and does only affect the annual expenses. Fig. 3 represents this risk. As shown in this figure, the potential price increase was estimated to be 25% (obtained from the difference of the chosen provider and the average of the unsuccessful service providers) whereas the likelihood of this event taking place was estimated to be 20% (equivalent to the default rate of maintenance service providers (i.e., average credit rating in the sector)). As shown in this figure, the cost of risk was estimated to be approximately 5% of the cost of maintenance. The cost associated to each of these items is summarized in Table 3. Different from a political risk, this risk can be considered independent and identically distributed.

3.5. Summary

A summary of each of the risks evaluated above are presented in Table 3. As shown in this table, the biggest risk is posed by the uncertainty in future FiT. Because this risk is intertemporally correlated (i.e., if a reduction happens in year 5, the remaining years will be equally affected), its effect is magnified. In any given year, this correlation is captured by adding the future potential revenues that could be lost when computing the cost of risk.

Using the yield of a 20-yr maturity German bond as the risk free rate for the euro, the risk-free discount rate was estimated to be 2.79% at the time the estimates were made. Discounting the Decoupled Free Cash Flows (DFCF) using this rate, the estimated value of the project was calculated to be 12.8€ million. Hence, paying 13€ million for the project would result in a negative DNPV of −0.2€ million. From Table 3, it is clear that the main source of

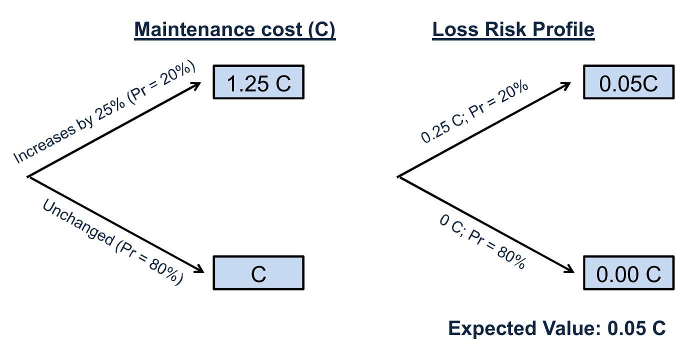

Fig. 3. Maintenance cost risk profile.

risk is due to the fact that the PPA could be unilaterally changed (i.e., increase taxes and/or reduced tariffs) thus resulting in reduced profits. After the risks have been identified and the synthetic insurance premiums calculated, an assessment of the type and amount of risk that matches the buyer's risk appetite should be performed (Step 3) and an evaluation of feasible mechanisms that could be used to mitigate the identified risks (Step 4). For instance, buyer and interested seller could agree to equally share the political risk (i.e., reduction in Fit) therefore the cost of risk to the buyer would be reduced by 50%. The contract terms would need to clearly specify the triggering mechanism to minimize potential disputes in case the guarantee needs to be enforced. The seller's credit risk could be backed by an insurance provider and the associated cost included in the project cash flows. Alternatively, the buyer could identify a partner to share the risk. For projects in emerging economies, actual insurance products to protect investors against this type of risk can be obtained from the Multilateral Investment Guarantee Agency (MIGA), a subsidiary of the World Bank. In such a case, depending on the cost, the investor may purchase a policy to protect a fraction of the revenues and assume the remaining risk.

Hence, for the case of 50% risk sharing with the seller, the risk factor would become $\Theta = 2.77\%$ and the estimated present value of the project DFCF would be 17.5€ million which would result in a DNPV of 4.5€ million (assuming a 13.0€ million purchase price still holds). Furthermore, a similar project with identical cash flows where the political risk is perceived to be negligible (e.g., a project in Germany), this risk factor would be nearly nil (i.e., $\Theta = 0$) and the calculated present value of the project DFCF would be 24.0€ million which would result in a DNPV of 11.0€ million.

Fig. 4 shows a plot of DNPV vs. NPV for the different cases analyzed. As shown in Fig. 4, the variation in the risk profile of the acquisition (i.e., 50% risk sharing) does not translate into a change of the NPV valuation only in a change in DNPV. The diagonal line in Fig. 4 represents the line where the financial performance is in line with the risk profile of the project. As shown in this figure, for a purchase price of 13€ million, the project has a positive NPV in France as well as in Germany. However, the project in France without risk sharing has a slightly negative DNPV (−0.2€ million) whereas the one in Germany is positive (11€ million). For this particular example, since a project in Germany would have a DNPV >> NPV, in a competitive bidding process, an interested buyer of a solar project could bid a purchase price higher than the one obtained from a standard NPV analysis. Finally, once the project is acquired, the investor can implement the operational and managerial systems to monitor and minimize the identified risks that are owned (Step 5).

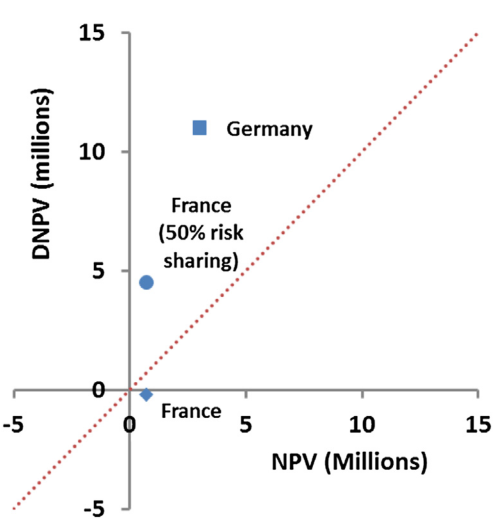

Fig. 4. Risk vs. financial metric.

The simplicity of DNPV along with its ability to integrate valuation with risk mitigation strategies and present the results in a format familiar to decision makers (i.e., annual cash flow analysis) using standard Excel spreadsheets are among the most important features of the proposed procedure. As this example shows, DNPV allows buyers/sellers to consistently analyze different risk profiles, how these risks affect the value of the project, how the project financial performance (NPV) and risk performance (DNPV) compare, and how different risk sharing mechanisms could be structured (which can then be included in the contract documents) to facilitate the transaction. The application of DNPV can be further enhanced with the application of Stochastic Information Packets (SIPs) which can used to represent the loss distribution for each of the identified risks. SIPs are standardized pre-processed Monte Carlo simulation of a given sample size that can be easily implemented in typical Excel spreadsheets[3] [7] and [8]. Once the potential loses are represented by SIPs, these loses can be easily added and the synthetic insurance premium of the sum calculated.

4. Closing

An application example to value an investment in a renewable energy project using a consistent valuation method termed DNPV along with the risk ownership and IRRM concepts have been presented. The risk and time value of money are decoupled allowing for a consistent pricing of risk. The concept of synthetic insurance is introduced within the realm of project valuation to price the risk associated with obtaining lower revenues or higher costs than originally expected and these synthetic insurance products are treated as “real” costs to the project which are then subtracted from the expected cash flows to create a “riskless” free cash flows. Because the risks associated with the project are accounted for by these synthetic insurance products, the riskless cash flows can be discounted using a risk-free rate. By relating risk to its original source (i.e., the cash flows), institutional information, market data and experts experience can then be used in a consistent and unbiased manner to value investment opportunities.

The proposed procedure is simple, intuitive and, more importantly, solves the conundrum associated with the selection of the proper “hurdle” rate to value an investment as the discount rate is given by, independent of the investors risk preference, the risk-free rate of return. The cost of risk of the asset and the expenditures were estimated separately using actual data (e.g., radiation for this particular application) and/or comparable risk data (e.g., bond default rates). For some industries, the proposed DNPV method will allow business executives to mine available data using business analytic techniques to develop risk profiles of the revenues/expenditures to estimate the synthetic insurance premiums, thus improving their valuation results. As demonstrated in this example, DNPV allows decision makers to evaluate alternative risk sharing mechanisms that can then be embedded in contract documents, thus facilitating the transaction.

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