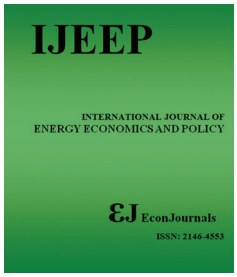

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Regionalized Discount Rate to Evaluate Renewable Energy Projects in Colombia

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ABSTRACT

In this paper we are interested in estimating the discount rate for electricity generation projects using renewable resources. More precisely we estimate the weighted average cost of capital (WACC). One of the most important feature of this research is that our WACC must be differentiated by regions, which is a challenging purpose taking into account that Colombia is a country with many regions that greatly differ among themselves. This goal requires estimating a risk parameter for each region, in this case for each state of the country, which would have the immediate effect of regionalizing the WACC for renewables non-conventional generation energy projects. it is worth noting that the emerging market bond index (EMBI+) is not a useful measurement of risk at regional level, so we have to look for a variables set in order to capture that risk. We propose to consider variables associated with corruption and violence levels in each state of the country in order to identify regional WACC.

Keywords: Electricity Generation, Renewable Energy Resources, Weighted Average Cost of Capital, Country and Regional Risk
JEL Classifications: C21, G11, G12, G18, Q33, Q42

1. INTRODUCTION

There are two ways of trading electricity in Colombia: a short-run market (daily-ahead or the spot market), and a long-term market of not standardized contracts (called forwards contracts). These contracts are bilateral agreements between agents, covering the risk induced by electricity price volatility in the trade pool. Over 80% of electricity in Colombia is traded using forwards instruments. Those markets are complemented by an ancillary services market (frequency secondary regulation) known as AGC services. In order to ensure the electricity demand is satisfied, even in extreme weather conditions, there exits an auction market that provides generators with the so called reliability charge. In addition, there is a market operator, XM company, which solves the ideal dispatch in the spot market (De Castro et al., 2014).

Despite the high potential and competitiveness of the Colombian electricity market, there is a lack of renewable electricity projects due to the absence of stimulus. In fact, more than 78% of the demand is supplied by large hydropower plants. As a consequence, Colombia has only one 19.5 MW wind power plant and two solar photovoltaic plants nowadays. Fortunately, the Colombian parliament recently passed a renewable energy Law (Law 1715 of 2014) that encourages the construction of new clean energy projects for the coming years (Castillo-Ramirez et al., 2017; Villada et al., 2017).

One common way to evaluate the feasibility of carrying out renewable energy projects is to calculate the Levelized Cost of Electricity (LCOE), which provides the unit costs of installing one megawatt or kilo-watt of power of any technology of generation along its lifetime. In other words, LCOE represents the kilowatt-hour (US$/kWh or US$/MWh) cost of building and operating a generating plant. So, LCOE can be split into the unit cost of capacity (c), the time-averaged operating fixed costs denoted by f and the time-averaged operating variable costs denoted by v, as represented by equation (1) (Reichelstein and Yorston, 2005):

$$LCOE = c + f + v \quad (1)$$

The unit cost of capacity can be calculated using equation (2):

$$c = \frac{I_0}{\sum_{j=1}^{n} \frac{E_j}{(1+r)^j}} \quad (2)$$

where I_0 is the initial investment; r is the discount rate; n is the expected life (in years); and E_j is the total of electricity generated in year j. As expressed in equation (2), evaluation of $LCOE$ of these projects requires determining the discount rate or minimum return demanded by the investors, with an important level of accuracy. A review of international published papers shows the weighted average cost of capital (WACC) as the most recommended method to calculate the discount rate r for evaluating electricity generation, transmission and distribution projects. Therefore r must be replaced by WACC in equation (2). Campisi et al. (2017) use the WACC in order to estimate the profitability to invest in light emitting diodes (LED) in the public light system of the Municipality of Rome, and Minh-Ha and Duy-Hoang (2017) apply the capital asset pricing model (CAPM) in order to identify the electricity retail price in Ho Chi Minh City. As might be expected, the CAPM model is the first step to estimate WACC for any investment project.

Any action taken by the regulator, government announcements, regional acts-laws for environmental protection, and/or actions of external agents (armed illegal groups, state and/or private corruption) will obviously impact the discount rate. Therefore, it is important to consider those impacts both in terms of choosing appropriate comparators for assessing the parameters of the WACC and for setting its overall level that is appropriate for the industry (that is, attractive for investors) and sufficient for regulators.

Computing the WACC requires assessment of the firm's equity and debt available to finance the project, the estimation of systematic risk, known as beta and denoted by β, and identification of the country risk. Nevertheless, power plants with different technologies require evaluating the environmental and weather conditions for each region; in addition to evaluating the risk derived from particular conditions of corruption and violence. Consequently, a unified WACC for the country would not be appropriate as discount rate. For this reason, this paper proposes a method to calculate a regionalized WACC in Colombia (one for each state of the country) in order to have a more accurate evaluation of the upcoming renewable energy projects.

2. THE DISCOUNT RATE

2.1. Overview

In finance, discount rate is the rate used to calculate the present value of future cash flows or the minimum company's return on investment for project funding. For this reason, the concept is very important to evaluate businesses or acquisitions. As explained in the introduction, it is recommended to use WACC as discount rate for generation, transmission and distribution projects; additionally, the cost of equity can be calculated using the CAPM. This approach will base the estimate of the discount rate on a measure for the opportunity cost of funds. Therefore, the main parameters in the calculation will be estimated from financial market data and from information on electricity companies with similar characteristics to those established in Colombia (Frontier, 2005).

For the case of two sources of financing, the WACC can be calculated after taxes using equations (3) and (4):

$$WACC = \frac{D}{D+E} r_d (1-T) + \frac{D}{D+E} r_e \quad (3)$$

$$r_e = r_f + \beta (r_m - r_f) + r_c \quad (4)$$

where D is the value of debt; E is the value of equity; r_d is the cost of debt; r_e is the cost of equity; r_f is the risk free rate; r_m is the market return; the difference $r_m - r_f$ is the market risk premium; r_c is the country risk; and finally, β is the systematic risk.

2.2. Discount Rate for Renewable Energies in Colombia

Given the expectation of new renewable energy projects for the next years in Colombia, it is necessary to determine their appropriate discount rate according to the risk conditions of the new technologies. For that reason, the discount rate using after-tax WACC is calculated in this section.

The cost of debt is estimated using the information of long-term preferential loans for the productive sector, published by the Central Bank of Colombia. The average value for the last 12 months is 8.05%. The risk free rate is calculated using the average value of the 10-year, 20-year, and 30-year U.S. Treasury Bonds. The market risk premium is estimated with the arithmetic mean of annual data based on the returns of Standard and Poor's Index 500 (SP500) (Damoradan, 2017).

Systematic risk (beta-β) is calculated with the renewable energies subsector of the companies included in the electric service industry (SIC4911) of the United States. Finally, using equations (3) and (4) with an average debt proportion of 40% for the Colombian utilities and a tax rate of 34%, after-tax WACC for renewable energy companies in Colombia is 8.08%.

3. REGIONALIZED DISCOUNT RATE

3.1. Theoretical Literature

Value of WACC above was calculated for specific conditions; that is why some authors disagree when keeping this discount rate with a constant value for a long period of time, because of the increasing volatility of the financial markets. Then it is very important to select the appropriate discount rate and take into account the impact of inflation or uncertainty in future costs; otherwise the method can give rise to misleading results (Mauleon, 2019).

In a research project developed by the Secretariat of Energy of Colombia (Ministerio de Minas y Energía), a regionalized LCOE was calculated for each renewable energy technology, using the discount rate calculated in Section 2.2. One of the final recommendations was to develop a regionalized WACC in order to have a more precise LCOE in each country region.

Academic evidence shows that country risk must be included in the CAPM calculation as discussed by Damodaran (2017). This author published a regularly updated database of country risk premiums for most countries in the world relative to the United States market (Damodaran, 2011). A problem arises when trying to determine differential risks between regions of the same country.

A possible alternative is to calculate the discount rate which takes into account government concerns about the entire society and its awareness about the environment, sustainability and safety, among others. This rate is lower than the financial discount rate because the social discount rate describes situations in which markets work perfectly and it is considered appropriate that market criteria govern all decision-making, while the former takes into account markets imperfections that characterize private investments (Garcia-Gusano et al., 2016).

A geopolitical context of the situation was shown by ACM (2016) when calculating the regional risk in Bonaire, a country in the Caribbean Netherlands. Although Bonaire is not classed as a sovereign country, it nevertheless is classed as a special municipality with a separate currency from the Netherlands and poses some uncertainties for investors because of upcoming events such as the referendum to change the status from special municipality to an independent country. The proposed solution was to estimate Bonaire's regional risk premium by taking the average across three countries with geopolitical and historical similarities such as Aruba, Curacao, and Saint Maarten.

CAPM methodology considers the country risk measured by the Emerging Markets Bond Index (EMBI+), but it does not take into account specific risks for regions inside the country. There are local political, violence and demographic factors that can affect investment decision, then, it is important to calculate their effects on the discount rate. Using comparable countries as in ACM (2016) is not applicable to Colombia because it is not possible to obtain specific regional risk from databases. For that reason, this paper proposes a methodology to calculate regional discount rates using indicators of transparency (level of corruption) and violence in each region of the country.

3.2. Regional Risk and Violence and Corruption Data in Colombia

A method for measuring regional risk to be taken into account in the discount rate is proposed in this section. It involves particular conditions in remote regions such as corruption, violence, forced displacement and combats between the army and irregular groups. Quantitative data of these unwanted factors constitute valuable information for potential investors.

The Human Rights Observatory of the Vice-Presidency of the Colombian Republic contains comparative data for each state for the following violence variables: (1) Homicides; (2) Massacres; (3) Displaced people; (4) Kidnappings; and (5) Combats. Complementarily, the Center for Analysis of Conflicts (CERAC for its Spanish initials) has developed a very complete database for the analysis and register of conflict actions related to violent episodes in each region of the country. This database constitutes valuable and detailed historical information of the above variables. CERAC (2018) shows the description of this dataset.

The institution Transparency for Colombia (2018), which is a chapter of Transparency International, identifies institutional conditions and practices that favor transparency or increase corruption risk in public entities. In its latest report it uses three factors to measure corruption risks in states and municipalities. These are visibility, institutional, and control factors. Each one has its own indicators and associated weights with the results shown in Restrepo et al. (2006).

4. METHODOLOGY AND RESULTS

We define the violence risk index as the overall effect of the violence related variables, and can be calculated using equation (5):

$$\Delta_j^1 = \delta_j \eta_j \quad j = 1,\ldots,M \tag{5}$$

where η_j is the proportion of population in region j calculated by equation (6), and δ_j represents the result of the product of the violence events, which is calculated using equation (7):

$$\eta_j = \frac{N_j}{N} \quad \text{with} \quad \sum_{j=1}^{M} \eta_j = 1 \tag{6}$$

$$\delta_j = \frac{\neq Co_j}{Tc} + \frac{\neq K_j}{TK} + \frac{\neq D_j}{TD} + \frac{\neq H_{oj}}{TH} \qquad j = 1,\ldots,M \tag{7}$$

where N_j is the population in region j, $\neq Co_j$ is the number of combats, $\neq K_j$ is the number of kidnappings, $\neq D_j$ is the number of displacements, and $\neq Ho_j$ is the number of homicides. The denominators are respectively the total amount of combats, kidnappings, displacements, and homicides.

In addition, we define the corruption risk index Δ_j^2 as the product of the risk indexes γ_i reported by CERAC (2018) and the proportion of population in each region, η_j, as shown in equation (8):

$$\Delta_j^2 = \frac{\gamma_j}{100}\eta_j \quad j = 1,\ldots,M \tag{8}$$

It must be noted that the constructed indexes for each region induce $M\times1$ vectors as shown in equation (9):

$$\Delta^1 = \left(\Delta_1^1, \Delta_2^1, \ldots, \Delta_M^1\right) \text{ and } \Delta^2 = \left(\Delta_1^2, \Delta_2^2, \ldots, \Delta_M^2\right) \tag{9}$$

Then, the risk in region j is calculated as the weighted sum of the specific risks in each region using equation (10):

$$\Delta_j = \rho_1 \Delta_j^1 + \rho_2 \Delta_j^2 \qquad j = 1,\ldots,M \tag{10}$$

where $0 \le \rho_i \le 1 \quad i = 1,2$

A careful analysis of the existing correlation between Δ^1 and Δ^2 and the economic activity (measured by the Gross Domestic

Table 1: Regional risk and WACC

Colombia states	Δ_j * 100	$WACC_j$ (%)
Amazonas	0.0157	8.088
Antioquia	2.0333	9.298
Arauca	0.0820	8.127
Atlántico	0.8328	8.578
Bolívar	0.6219	8.451
Boyacá	0.4703	8.360
Caldas	0.3692	8.300
Caquetá	0.1396	8.162
Casanare	0.0964	8.136
Cauca	0.4020	8.319
Cesar	0.2300	8.216
Chocó	0.1086	8.143
Córdoba	0.5210	8.391
Cundinamarca	0.8953	8.615
Guainía	0.0100	8.084
Guaviare	0.0192	8.090
Huila	0.3340	8.277
La Guajira	0.2167	8.209
Magdalena	0.3873	8.310
Meta	0.2768	8.240
Nariño	0.5832	8.432
Norte de Santander	0.4658	8.359
Putumayo	0.0776	8.125
Quindío	0.1989	8.197
Risaralda	0.3347	8.279
San Andrés y Prov.	0.0230	8.091
Santander	0.7794	8.547
Sucre	0.2483	8.225
Tolima	0.4467	8.343
Valle del Cauca	1.4792	8.971
Vaupés	0.0095	8.084
Vichada	0.0161	8.088

Source: Own calculations based on equation (10). WACC is after tax

Product per capita of the regions and denoted by g_j) is proposed for an automatic rule of choice for weights ρ_i. Then, estimated ρ_i corresponds to the coefficient of determination (or R^2) of a regression from the regional gross domestic product (GDP) per capita on Δ_j^1 and Δ_j^2 separately. More precisely, we estimate the conditional mean of the following regression models:

$$g_j = c_1 + \Delta_j^1 \beta_1 + \varepsilon_{1j} \qquad j = 1,\ldots,M \tag{11}$$

$$g_j = c_2 + \Delta_j^2 \beta_2 + \varepsilon_{2j} \qquad j = 1,\ldots,M \tag{12}$$

Under assumption of the classical linear regression model, estimators of β_1 and β_2 are obtained by performing ordinary least squared. Those indexes are highly correlated with the economic performance of the regions because corruption and violence are,as a matter of fact, the main factors affecting regional GDP.

The use of the proposed methodology applying equation (10) to all the M (=32) states in Colombia allowed calculating the regional risk for each state of Colombia. Values were consistent with their condition of security and corruption. The lowest value was obtained for the state of Vaupes with Δ_j of 0.0095% and the highest value for the state of Valle del Cauca with Δ_j of 1.4792%. This specific risk is added to the value calculated for the cost of equity in equation (4), more precisely r_c have to be replaced by Δ_j index computed in equation (10), which produces both regionalized cost of equity and the weighted average cost of capital denoted by $WACC_j$ (%). Consolidated results for WACC in each state are shown in Table 1, where unwanted effects (higher values for WACC) are observed in regions with high levels of corruption and violence.

5. CONCLUSIONS

Technical and scientific literature suggests WACC and CAPM as the most recommended methods to determine, respectively, the discount rate and the cost of equity for regulated markets such as electricity.

A unified WACC for renewable energies in Colombia is not adequate due to the particular conditions of each region. Therefore, regionalized values of WACC are necessary because of the great potential of renewable resources distributed throughout the country which, supplemented by the incentives granted by law, will bring new projects in all regions of the country.

The regional risk calculated with the proposed methodology provides results consistent with the violence and corruption conditions in each state of the country. Values from almost zero to over 1% were found, reflecting each particular condition. Therefore, investors would demand higher returns in riskier states.

WACC calculated for each region in Colombia can be a helpful decision to evaluate new renewable energy projects in riskier states affected by violence and corruption.

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