Global Heterogeneity in Financing Cost for Renewable Energy Projects

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Agenda

- 1 Introduction
- 2 Methodology
- 3 Results 1: Estimation methods
- 4 Results 2: Empirical evidence
- 5 Conclusion

For renewables, cost of capital a key driver of levelized cost



Note: Assumes 5% cost of debt, 10% cost of equity, European fuel costs. Fossil fuel based is the average of hard coal, natural gas and diesel. Based on Schmidt, T.S. (2014). Low-carbon investment risks and de-risking. *Nat. Clim. Chang.* 4, 237–239; Steffen, B., 2018. The importance of project finance for renewable energy projects. *Energy Economics* 69, 280–294.

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Meta-analysis taking stock of estimation methods and results

- Many wind & solar PV plants are project-financed, so WACC is project-specific
- Hence, technology choices are highly sensitive to WACC (or discount rates)
- Great differences in private cost of capital are empirically observed
- Issue: Suitable data on WACC cost is hardly available for researchers
- Recently, research emerged estimating WACC but great variety of measures and methodologies, consistent picture of state of the knowledge is missing

Here, systematic meta-analysis, answering two questions:

- 1. Which methods are appropriate for estimating cost of capital for RE projects?
- 2. What is the <u>state of the empirical knowledge?</u>

Characteristics of WACC for renewable energy

Measures of cost of capital

Vanilla WACC

 $WACC_{vanilla} = \delta C_d + (1 - \delta)C_e$

After-tax WACC

$$WACC_{after-tax} = \delta (1 - \tau) C_d + (1 - \delta)C_e$$

Expected heterogeneity

Between countries



Between technologies



Over time



Pre-tax WACC

$$WACC_{pre-tax} = \delta C_d + (1-\delta) \frac{1}{(1-\tau)} C_e$$

Sources: Schmidt, T.S. (2014). Low-carbon investment risks and de-risking. Nat. Clim. Chang. 4, 237–239; Ondraczek, J., Komendantova, N., Patt, A., 2015. WACC the dog: The effect of financing costs on the levelized cost of solar PV power. Renew. Energy 75, 888–898; Egli, F., Steffen, B., Schmidt, T.S., 2018. A dynamic analysis of financing conditions for renewable energy technologies. Nat. Energy 3, 1084–1092.

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Reproducible protocol resulting in 19 peer-reviewed articles

Preliminary

Column	No	Reference	Technologies	Countries	Years	Estimated cost of capital component		mponents	Estimation method	
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Note: CoD = cost of debt, CoE = cost of equity, DS = debt share, WACC = weighted average cost of capital

Methods for WACC estimation follow 4 distinct approaches



WACC_{after-tax}

Overview estimates of the WACC for solar PV projects

Preliminary



Solar PV



Abbreviations:

AE United Arab Emirates, BR Brazil, BE Belgium, CL Chile, CN China, DE Germany, GR Greece, GT Guatemala, IN India, MX Mexico, MY Malaysia, PE Peru, JO Jordan, SA Saudi Arabia, SV El Salvador, TH Thailand, ZA South Africa

Note: Only countries with at least 50 MW installed capacity end of 2017 are shown.

Overview estimates of the WACC for onshore wind projects

Preliminary



Onshore wind

Elicitation of project finance data
Egli et al 2018
Lorenzoni/Bano 2009
Shrimali et al 2013
Survey of expert estimates
Angelopoulos et al 2016
Angelopoulos et al 2017
Wood/Ross 2012

Analysis of financial market data

Estache/Steichen 2015
Partridge 2018
Werner/Scholtens 2016

Abbreviations:

AT Austria, BG Bulgaria, BR Brazil, BE Belgium, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, HR Croatia, IE Ireland, IN India, IT Italy, LT Lithuania, NL Netherlands, PL Poland, PT Portugal, RO Romania, SE Sweden, US United States

Note: Only countries with at least 50 MW installed capacity end of 2017 are shown.

Overview estimates of the WACC for <u>offshore</u> wind projects

Offshore wind

Preliminary



WACC_{after-tax}



Patterns over time corrected for general interest rate changes

Preliminary



Average WACC for 2017 interest rate levels

Preliminary



^aUnweighted average of values from OECD/non-OECD countries for which data is available (cf. Table 2)

Conclusion

WACC estimates for solar PV and wind in 46 countries available

Large heterogeneity emphasizes necessity to use different WACC assumptions in different contexts

Future research could improve accuracy of estimates, by including all refinements proposed in literature, and by combining different methods

Empirical scope should address new countries (e.g. France, Italy, United States), and also well-studied ones to further assess precision of methods

For policymakers, country differences suggests considering to explicitly address financing costs as part of a renewable energy policy mix

Thank you for your attention!



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Working paper:

Steffen, B., 2019. Estimating the Cost of Capital for Renewable Energy Projects, SSRN . https://doi.org/10.2139/ssrn.3373905

See also:

Egli, F., Steffen, B., Schmidt, T.S., 2018. A dynamic analysis of financing conditions for renewable energy technologies. Nature Energy 3, 1084–1092. <u>https://www.nature.com/articles/s41560-018-0277-y</u>

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