Real Options Analysis for Urban Renewable Energy Projects

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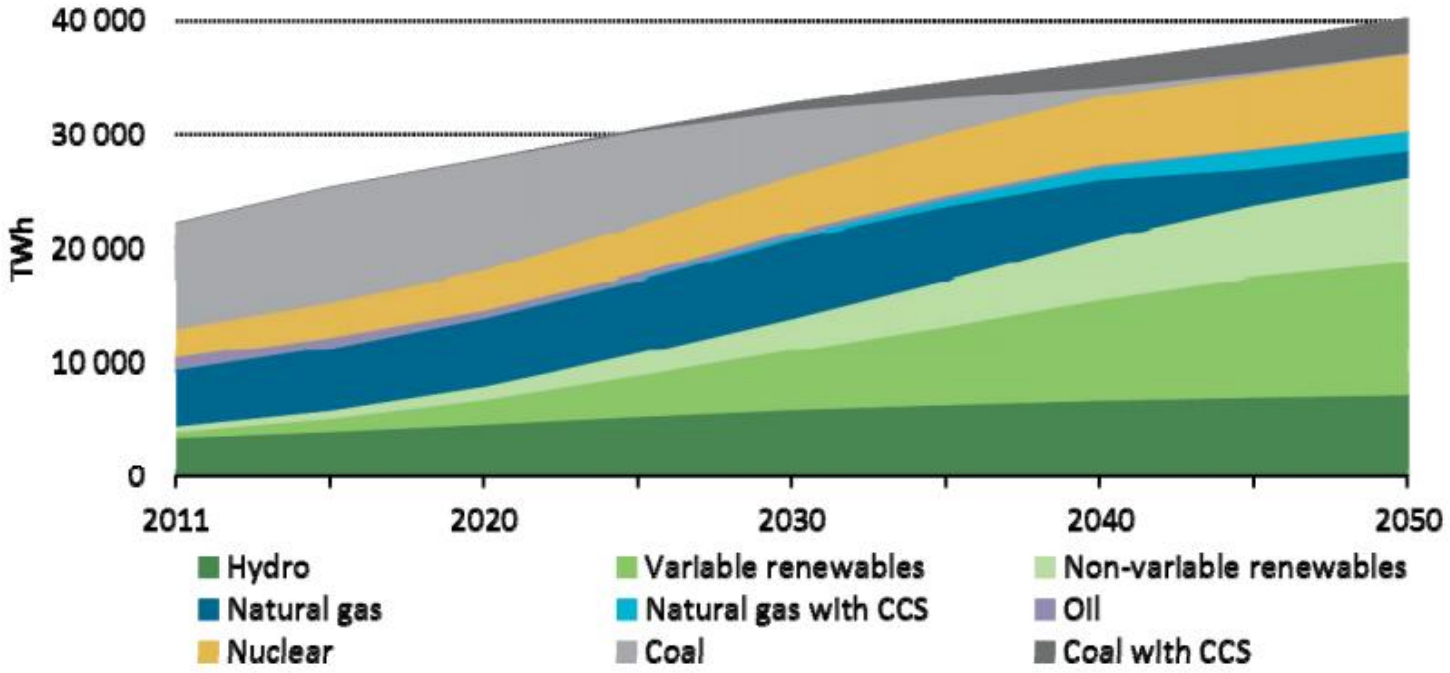
The World Needs a "Clean Trillion"



- Generation today:
  - Fossil fuels: 68%
  - Renewables: 20%
- Generation 2DS 2050:
  - Renewables: 65%
  - Fossil fuels: 20%

International Energy Agency

The World Needs a "Clean Trillion"

- RE needs $1 trillion more per year over the next 36 years.
- In 2013, RE investment in Europe alone was down 41%
- Less than 1% of institutional investor assets are allocated to infrastructure projects
- Only ~0.1% of institutional investment is allocated to clean energy infrastructure (CERES)

Urban Renewable Energy

Why is RE investment lagging?

- Projects are perceived as too risky:
  - Policy Risk
  - Long life cycles
  - Novel technology
  - Budget constraints
  - Affected by greater energy price uncertainty
    - An increase of 1% in energy price reduces investment by 1.9% (Ratti, Seol, & Yoon, 2011).

- But what about traditional project valuation? Does it hinder RE projects?

Project Valuation

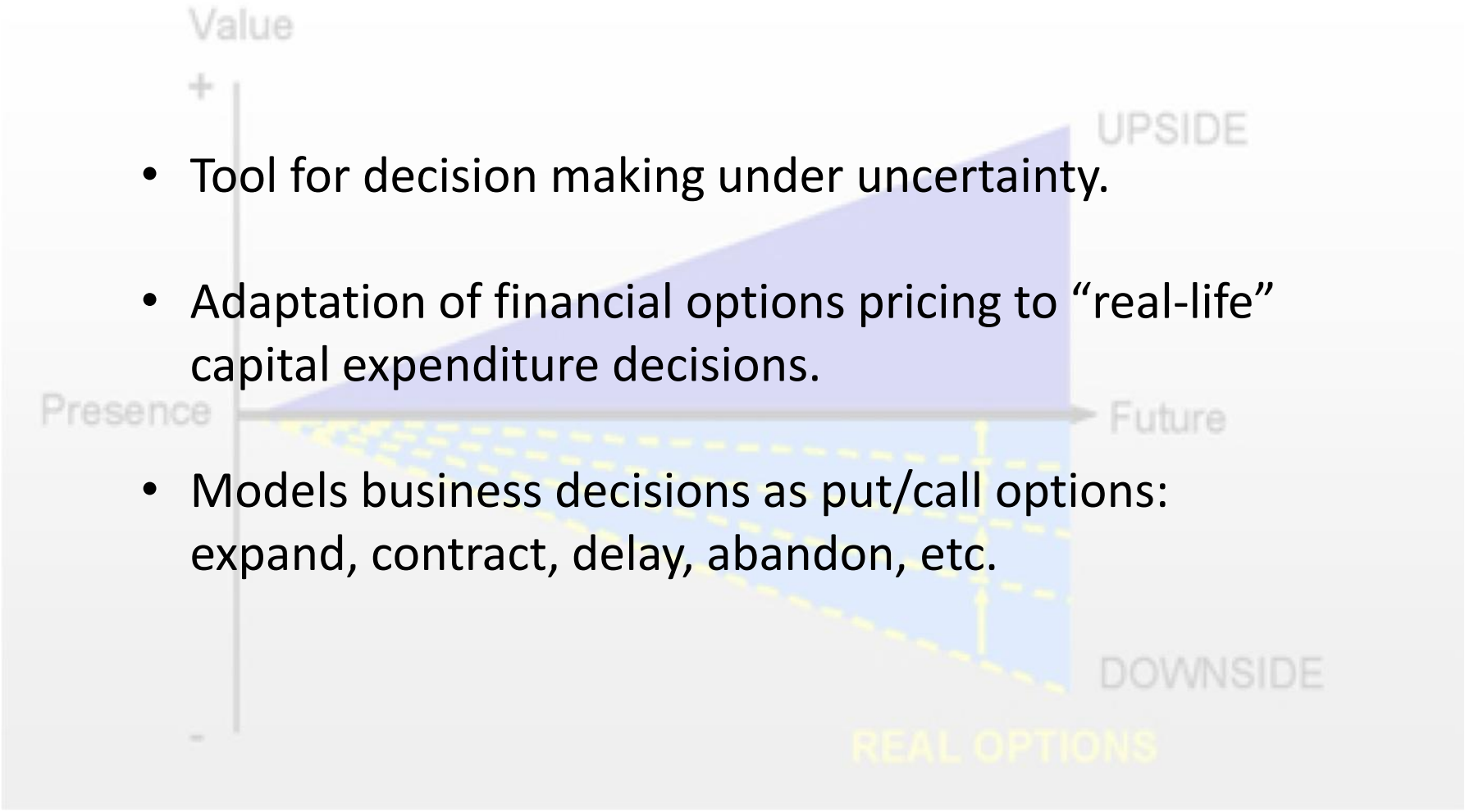
- NPV “systematically undervalues every project” due to the fact that “it fails to capture the value of flexibility” (Copeland & Antikarov 2003)

- **Real Options Analysis (ROA)** provides a framework for making strategic investments under uncertainty for projects with flexibility.

Objectives

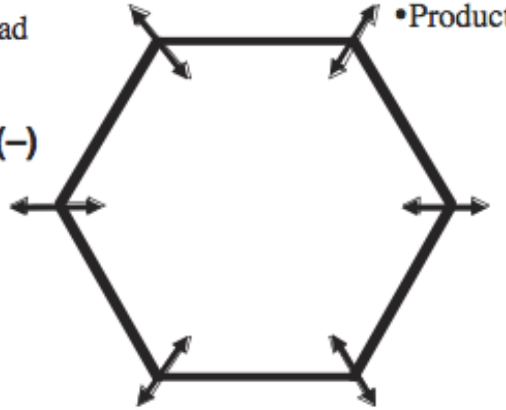
- To see if ROA helps to increase the value of the project/make it more attractive to potential investors.
- To see if fuzzy ROA models give reasonable and robust valuations despite “fuzziness”.
- To compare results of the FROA against classical options pricing models in order to see if they are consistent.
- To see if the use of fuzzy numbers allows us to easily capture uncertainties in the project.

Real Options Analysis (ROA)



- Tool for decision making under uncertainty.
- Adaptation of financial options pricing to “real-life” capital expenditure decisions.
- Models business decisions as put/call options: expand, contract, delay, abandon, etc.

Real Options Analysis (ROA)



Time to maturity (+)
- Maintain protective barriers
- Communicate implementetion possibilities
- Maintain technological lead

Cash flow volatility (+)
- Develop opportunitiess to expand to corresponding products' markets
- Product innovations
- Product combinations

Expected value of fixed costs (–)
- Implement production scalability benefits
- Utilise learning benefits

Current value of expected cash flows (+)
- Develop marketing strategies
- Develop subcontractor relations

Riskless returns (+)
- Monitor changes in interest rates

Value lost during the option (–)
- Create business barriers for competitors
- Manage key resources

The impact of 6 factors on the real option values. The (+/−) shows an increase or a decrease of the ROV.

Black-Scholes

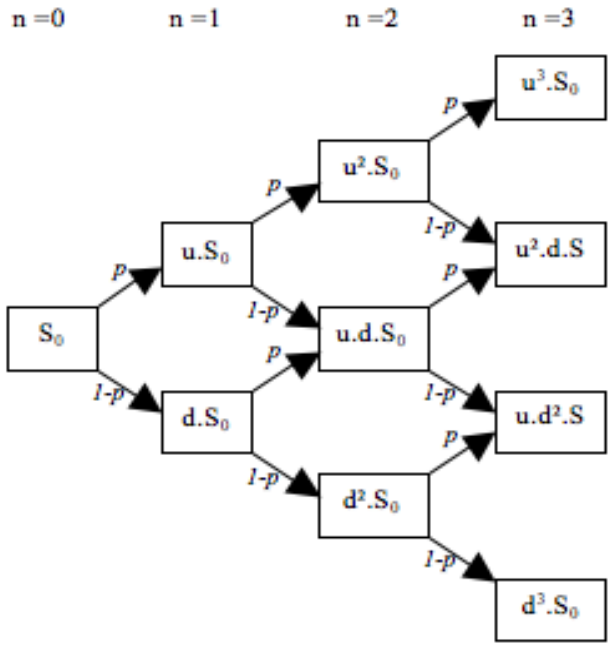
- Inputs are: asset price (S_0), or the PV of the project cashflows; strike price (X), or the salvage value of the solar arrays; volatility of the cashflows, and risk-free interest rate (r).

$$V = S_0\, N(d_1) - X\, e^{-rT}\, N(d_2)$$

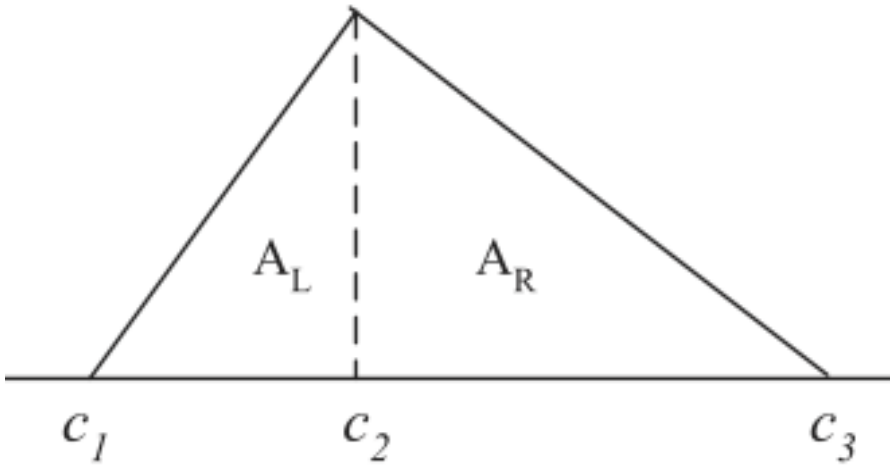
- The Fuzzy BS model uses fuzzy trapezoidal numbers for S_0 and X the spread of which is determined by a "fuzzy parameter" *(Collan, M., Carlsson, C. & Majlender, P., 2003; Collan, M., Fullér, R. & Mezei, J., 2009; 2012)*

Binomial Tree

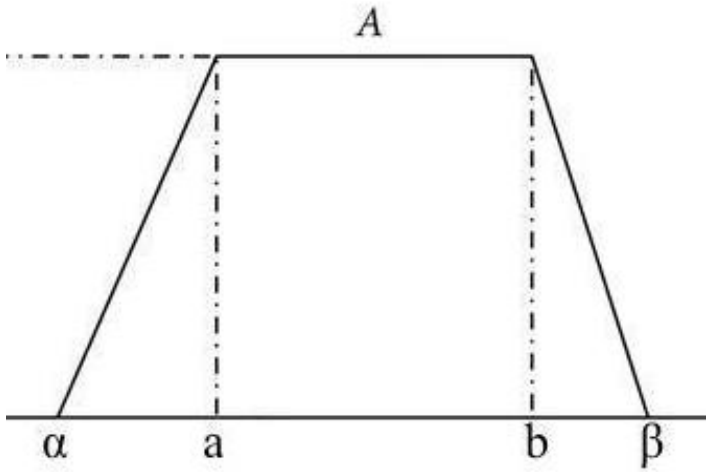
- Cox-Ross-Rubinstein binomial tree options pricing model uses binomial lattices to price options that are non-analytic; takes the same inputs as BS.
- The Ho & Liao Fuzzy CRR model uses fuzzy triangular numbers for the volatility, the spread of which is determined by a "fuzzy parameter"
- *(Liao & Ho 2010; Ho & Liao, 2011)*



Fuzziness



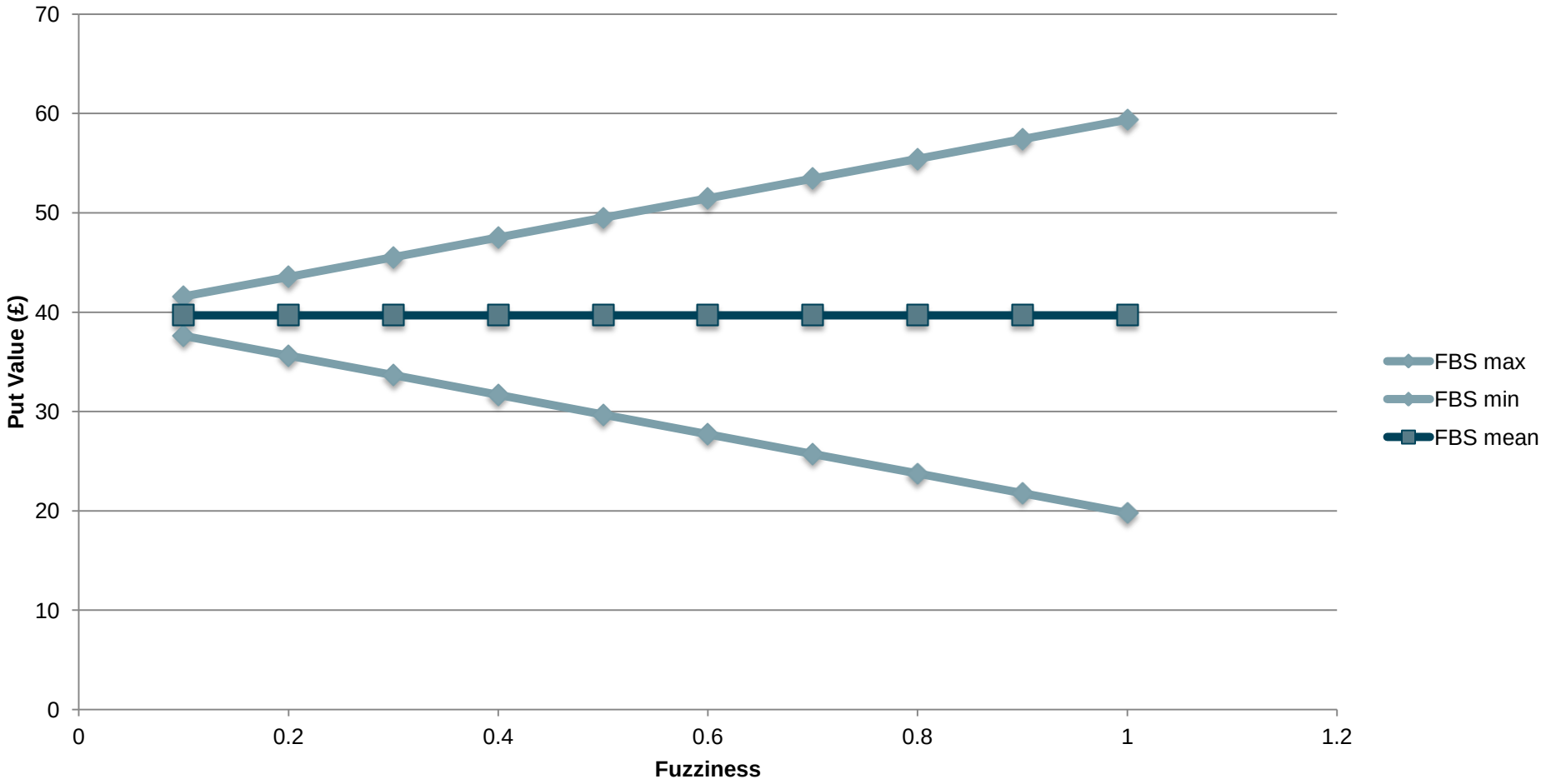
Triangle Fuzzy Number



Trapezoidal Fuzzy Number

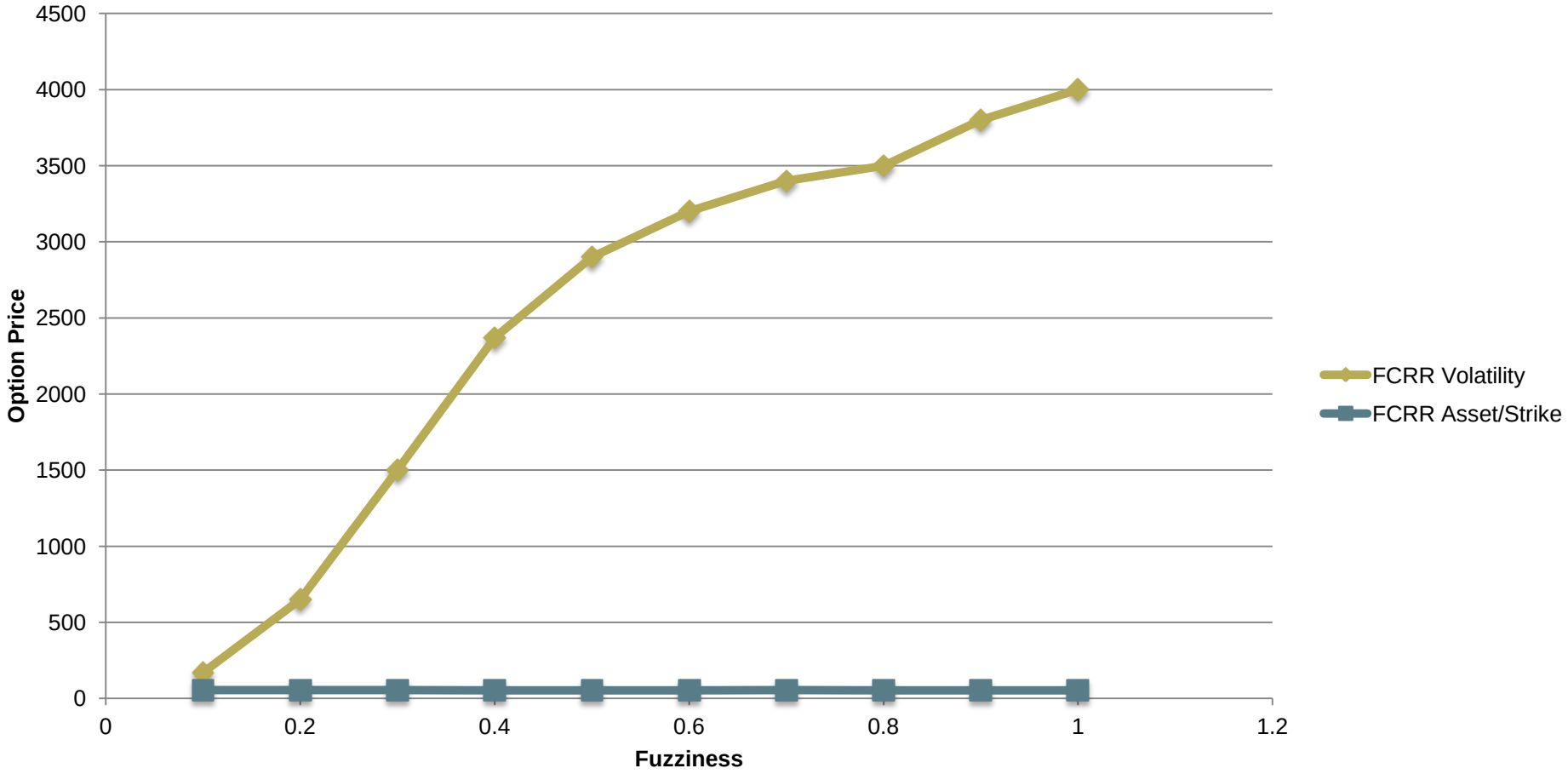
Uncertainties in the cashflows, etc. for a project can be accounted for by using a "fuzziness parameter", which determines the width of the fuzzy number.

What does the fuzzy parameter do?



The fuzzy parameter adjusts the spread of the fuzzy inputs/outputs.

Adjustment to the Ho & Liao FCRR Model



A robust FRO model gives stable option prices despite increasing fuzziness

Repowering London: Brixton Solar

Repowering London: Brixton Solar

Project	Size	Investment
Brixton 1	37 kW	£75,000
Brixton 2	45 kW	£61,500
Brixton 3	52.5 kW	£67,000

Revenues: 20 year Feed in Tariff (FIT) contracts for each project ~14p/kWh

The projects were modelled in two ways:

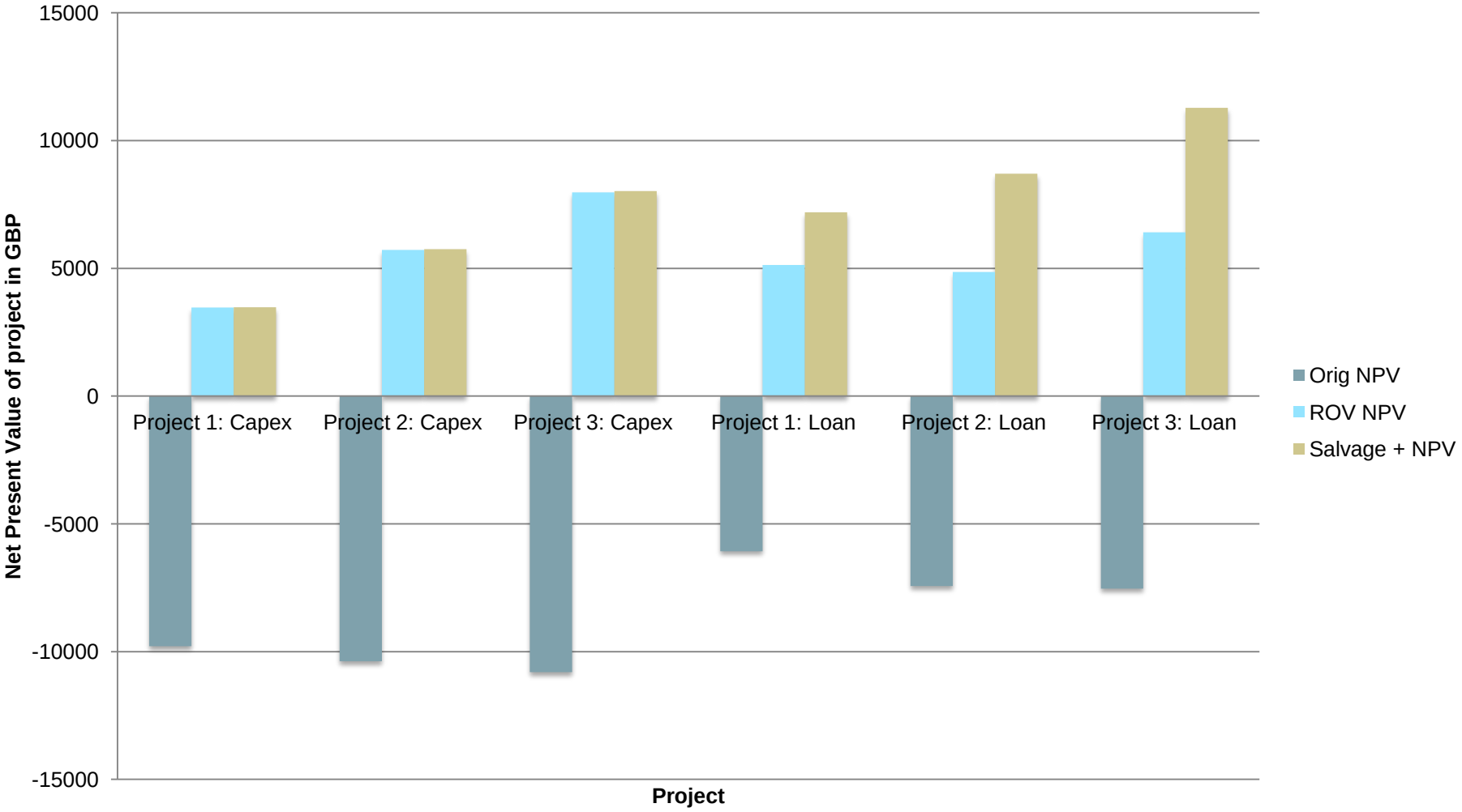
- Capex, up front capital investment
- 20 year 5% interest loan with £10k down payment

Brixton Salvage Put Options Values

TYPE	BS	FBS	ECRR	EFCRR	Error
Capex 1	6.93	6.96	5.46	5.45	0.134
Capex 2	34.10	34.14	28.40	29.02	0.097
Capex 3	47.17	47.32	44.75	44.83	0.031
Loan 1	2087.93	2089.30	2032.82	2033.50	0.015
Loan 2	3859.54	3862.70	3820.67	3821.30	0.006
Loan 3	4885.09	4888.40	4855.61	4855.00	0.004

With 5% fuzziness, average of 1000 runs for each model.

Real Options increased the project value



Summary of Findings

- ROV increased the potential project value, but is not always appropriate to every project.
- ROV can give deeper insight into investment prospects.
- Fuzzy ROV allows for flexibility of inputs, but must be robust to increasing fuzziness.
- Ultimately, FROV does not capture the types of uncertainty that hinder investment in RE projects.

Thank You!

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