Cambridge Judge Business School

EPRG Working Paper EPRG 2620

Cambridge Working Paper in Economics CWPE 2671

A New Approach to Cost of Equity for Private Infrastructure

C. Lennart Baumgärtner, Jorge Cárdenas Prieto, Cameron Hepburn and Robert A. Ritz

Energy Policy Research Group

UNIVERSITY OF CAMBRIDGE
Judge Business School

Abstract : What rate of return is needed to compensate investors in an infrastructure project? This question is central to the delivery of future investment into sectors like energy, water and transport. CAPM is often difficult to implement for unlisted green-field investments, and its assumptions sit uneasily with the infrastructure context. In this paper, we present a new simple model—the Infrastructure Risk Pricing Model (IRPM)—which better reflects real-world practice and also prices idiosyncratic risk. We show how IRPM can perform better than CAPM in estimating investor hurdle rates, especially for concentrated funds. To illustrate, we argue that IRPM rationalizes investor behaviour in Sizewell C, a recent large, government-backed UK nuclear energy project.

Keywords : Cost of equity, hurdle rate, infrastructure investment, idiosyncratic risk, regulation

JEL Classification : G11, G12, G31, H54, L94, Q48

Contact	Robert Ritz, rar36@cam.ac.uk
Publication	August 2026

A new approach to cost of equity for private infrastructure[*]

C. Lennart Baumgärtner[†] Jorge Cárdenas Prieto[‡]
Cameron Hepburn[§] Robert A. Ritz[¶]

This version: 21 August 2026

Abstract

What rate of return is needed to compensate investors in an infrastructure project? This question is central to the delivery of future investment into sectors like energy, water and transport. CAPM is often difficult to implement for unlisted greenfield investments, and its assumptions sit uneasily with the infrastructure context. In this paper, we present a new simple model—the Infrastructure Risk Pricing Model (IRPM)—which better reflects real-world practice and also prices idiosyncratic risk. We show how IRPM can perform better than CAPM in estimating investor hurdle rates, especially for concentrated funds. To illustrate, we argue that IRPM rationalizes investor behaviour in Sizewell C, a recent large, government-backed UK nuclear energy project.

JEL Classifications: G11, G12, G31, H54, L94, Q48

Keywords: Cost of equity, hurdle rate, infrastructure investment, idiosyncratic risk, regulation

---

[*]We thank Chris Bennett, Enrico Biffis, Tony Curzon Price, Gaia Guadagnini, Dieter Helm, Jay Hoon, Justin Knight, Ranjita Rajan and Alessia Testa for their help and advice. We also thank Amy Tang for excellent research assistance. All views expressed and any errors remain our own. This paper does not constitute financial advice.

[†]INET Oxford and Vallorii

[‡]Vallorii

[§]New College, Oxford University and Vallorii

[¶]Peterhouse and Energy Policy Research Group (EPRG), Cambridge University and Centre for Climate Finance & Investment (CCFI), Imperial Business School and Vallorii; corresponding author: `rar36@cam.ac.uk`

1 Introduction

Infrastructure investment is a defining challenge of the current age. It spans electricity grids, water reservoirs and pipelines, airports, renewable energy, data centres and so on. It often involves large, long-lived and largely irreversible projects. A central challenge facing investors and regulators alike is, what rate of return is sufficient to compensate investors for risks borne?

In this context, CAPM, the finance and regulatory practitioner's workhorse model, often reaches its limits. First, empirical implementation can be challenging. It requires either that the asset in question is itself listed on the stock market or that suitable listed comparators are available. The former is likely never the case for a greenfield project. The latter has become challenging in that many infrastructure assets today are owned by private equity and the remaining listed companies are rarely pure plays (especially in energy). With poor listed comparators, CAPM-based hurdle rates may be very noisy (or biased). Second, CAPM's theoretical assumptions sit uneasily against characteristics of infrastructure investment: project risks are often skewed to the downside (for example, in construction cost overruns, see Flyvbjerg et al. (2002) and Flyvbjerg (2009)), infrastructure funds are far from fully diversified, investment faces political and regulatory uncertainty that cannot easily be hedged, and so on.

This paper develops a simple model of hurdle rates for equity investors that is closer to real-world practice. Unlike under CAPM, investors are less than fully diversified so also care about idiosyncratic risk. We refer to the simple model as the Infrastructure Risk Pricing Model (IRPM); it prices total risk—a combination of overall capital market conditions and idiosyncratic risk. IRPM is similarly easy to implement empirically as CAPM but is also less reliant on stock-market data and the existence of comparable companies. This is advantageous again especially for greenfield infrastructure—but also increasingly for brownfield infrastructure companies that are no longer listed.

Our main contribution lies in comparing the relative performance of CAPM and IRPM. We consider a setting in which the true model of expected returns is derived by a standard portfolio problem (akin to a textbook like Cochrane (2005a)). This yields a general linear pricing equation which reflects how an asset's returns co-vary with the investor's portfolio. CAPM sits at one extreme where the investor fully diversifies by holding the market portfolio. IRPM lies at another extreme where the investor is undiversified and prices asset-level risk. We ask which simple model, as an approximation of the true model—as assumed to be given by general linear pricing—has the smaller (absolute) error in estimating the cost of equity.

We find that IRPM does better than CAPM under a range of circumstances. An investor who holds the market always prefers CAPM. An investor who holds a single asset always prefers IRPM. The interesting cases lie in between; both simple models are wrong but which is less so? In particular, we show that investors for whom the returns on the asset are relatively more strongly correlated with their portfolio than with the wider market will prefer to employ IRPM. The intuition is that idiosyncratic risk matters more for investors with such relatively concentrated portfolios—and so CAPM tends to underestimate their required returns. IRPM is skewed in the other direction by pricing idiosyncratic risk. Under a range of conditions, IRPM provides a better proxy of the true model than CAPM does—Proposition 1 and Figures 1-3 summarize.

Related literature. Our analysis speaks to several strands of the finance and regulation literature. First, a growing literature documents the risk–return characteristics of private assets. Cochrane (2005b) finds large, positive "alphas" alongside high idiosyncratic risk in venture capital. Particularly relevant is Brown et al. (2023), who study portfolio concentration in private equity—and find that more concentrated funds earn higher average returns with substantially more volatility. Industry evidence suggests that direct infrastructure investors often hold stakes in only a handful of companies and the portfolios of even the larger funds may contain not much more than 10-20 assets (see also Andonov et al. (2021)).[1] Such patterns of underdiversification, in the form of holding a concentrated set of assets, have been rationalised by information acquisition costs (Van Nieuwerburgh and Veldkamp, 2010). In our paper, IRPM captures this spirit: concentrated infrastructure investors also price idiosyncratic risk and thus have high (expected) returns, and often achieve a better hurdle estimate than by using CAPM.

Second, a puzzle in the corporate finance literature is that investors use discount rates that are well in excess of the cost of capital implied by CAPM (Gormsen and Huber (2025)). At least for infrastructure sectors, and possibly beyond, this paper suggests a potential explanation in terms of limited diversification and hurdle rates factoring in non-systematic risks. We would not be surprised if this behaviour also has relevance in the corporate sector beyond private infrastructure. Indeed, it is well-understood that idiosyncratic risk is an important driver of observed returns across the stock market (see, e.g., Campbell et al. (2001), Goyal and Santa-Clara (2003) and Fu (2009)). Our approach builds on classic work by Merton (1987) that establishes how non-market-risk factors drive expected returns due to incomplete diversification.[2]

Third, Wright et al. (2018) review the use of CAPM and related factor models in (UK) regulatory practice across energy, water, airports and other sectors; for a critique,

[1]More broadly across the investment universe, concentrated strategies—such as "industry bets" or "home bias"—can generate outperformance relative to diversified benchmarks (Kacperczyk et al. , 2005; Choi et al., 2017).

[2]Ewens et al. (2013) provide a deeper connection between these two strands of literature; in their model, investor returns depend on diversifiable risk as a result of seeking to address a principal-agent problem between investors and funds. So hurdle rates are high, and idiosyncratic risk is priced even with *diversified* investors.

see Helm (2009). This practice still largely follows the original recommendation of Myers (1972) to use CAPM to set the regulated WACC. It focuses mainly on *existing* whole-business utilities for which (comparable) stock prices are available to be able to inform allowed regulatory returns. In this paper, we instead focus primarily on *new* infrastructure assets that are often also private and unlisted. Fama and French (2004) review CAPM's features and shortcomings more generally.

In this paper, we (mostly) give CAPM the benefit of the doubt by assuming that it is indeed implementable. As an example of applicability of IRPM, the new, to-be-built third runway at London Heathrow airport will require a regulatory framework—including a regulatory cost of capital. While some international airports are listed on their respective stock markets, due to differences in business models and ownership structure, none could be deemed a close comparator. So what to do? In this case, it may not be possible to run CAPM in a satisfactory manner, so an alternative model is needed. IRPM offers one such potential alternative.

The plan for the paper is as follows. Section 2 sets out the benchmark of general linear pricing for an investor's portfolio problem of utility maximization. Section 3 develops our benchmark comparison between CAPM and IRPM. Section 4 presents a case study of Sizewell C, a large new nuclear power generation plant in the UK, for which we argue IRPM is able to rationalize observed investor bids while CAPM is not. Section 5 concludes. In the Appendix, we briefly show how the key insights from the baseline model carry over to a richer setting with real options (Dixit and Pindyck (1994); McDonald (1998)).

2 Cost of equity under general linear pricing

Consider an investor evaluating an infrastructure asset i. The asset's return is a random variable with mean and variance defined as follows:

$$\mu_i \equiv E[r_i], \qquad \sigma_i^2 \equiv Var(r_i). \tag{1}$$

The hurdle rate h_i is the minimum expected return required for a positive investment decision. An investment proceeds if and only if $\mu_i \geq h_i$, so the mean project return exceeds the hurdle rate. For a marginal investment, we have that the hurdle rate $h_i = \mu_i$.

The investor is a price-taker who wishes to maximize expected utility in a portfolio problem. The investor allocates wealth between a riskless asset yielding a per-period return $\rho \geq 0$ and $N \geq 1$ risky assets. The portfolio IRR is given by:

$$r_p = \rho + \sum_{i=1}^{N} w_i(r_i - \rho), \tag{2}$$

where w_i is the portfolio weight on asset i. The mean and variance of portfolio returns are defined as:

$$\mu_p \equiv E[r_p], \qquad \sigma_p^2 \equiv Var(r_p). \tag{3}$$

We make two simplifying assumptions that are standard in financial economics (Markowitz (1952); Sharpe (1964); Cochrane (2005a)), including in derivations of CAPM:

Assumption 1. The investor utility function exhibits mean-variance preferences, with expected utility $U = \mu_p - \frac{\gamma}{2}\sigma_p^2$, where $\gamma > 0$ is the coefficient of absolute risk aversion.

Assumption 2. Portfolio weights satisfy $w_i \in (0, 1]$ for all i, so there are no short sales.

Define the portfolio correlation of asset i as $\theta_{ip} \equiv Corr(r_i, r_p) \in [-1, 1]$, to capture the comovement between the asset's return and the portfolio return.

Also define the price of risk in the portfolio as $\lambda_p \equiv (\mu_p - \rho)/\sigma_p > 0$, which is the return in excess of the risk-free rate normalized by the standard deviation. This corresponds to a Sharpe ratio, expressing risk-adjusted returns, a widely used metric across finance.

This leads to a first result on what we term "general linear pricing" of assets:

Lemma 1. (*General linear pricing*) For asset i with a portfolio weight $w_i > 0$, the investor hurdle rate satisfies:

$$h_i = \rho + \lambda_p \theta_{ip} \sigma_i.$$

Proof of Lemma 1. The investor maximises expected utility $U = E[r_p] - \frac{\gamma}{2}Var(r_p)$, by Assumption 1, over $\{w_i\}$ subject to $w_i \geq 0$ as per Assumption 2. The portfolio return $r_p = \rho + \sum_i w_i(r_i - \rho)$ from (2) yields the portfolio mean return and variance:

$$\mu_p \equiv E[r_p] = \rho + \sum_i w_i(\mu_i - \rho) \tag{4}$$

$$\sigma_p^2 \equiv Var(r_p) = \sum_i \sum_j w_i w_j \sigma_{ij}, \tag{5}$$

where $\sigma_{ij} = Cov(r_i, r_j)$ measures the covariance between the returns of two assets in the portfolio. The first-order condition for an interior solution in terms of asset allocation $(w_i > 0)$ is thus given by:

$$\mu_i - \rho - \gamma \sum_{j=1}^{N} w_j \sigma_{ij} = 0 \Longrightarrow \mu_i - \rho = \gamma Cov(r_i, r_p). \tag{6}$$

At the portfolio level (for which effectively $r_i = r_p$), it must therefore hold that $\mu_p - \rho = \gamma\sigma_p^2$. This implies that the coefficient of risk aversion, at the optimum, satisfies $\gamma = (\mu_p - \rho)/\sigma_p^2$.

We can therefore rewrite (6) as:

$$\mu_i - \rho = \frac{\mu_p - \rho}{\sigma_p} \cdot \frac{Cov(r_i, r_p)}{\sigma_p} = \lambda_p \cdot Corr(r_i, r_p) \cdot \sigma_i = \lambda_p \theta_{ip} \sigma_i, \tag{7}$$

which uses the definition of the portfolio correlation $\theta_{ip} \equiv Corr(r_i, r_p)$ and of the price of risk $\lambda_p = (\mu_p - \rho)/\sigma_p$. For a marginal investment, the hurdle rate $h_i = \mu_i$ thus establishing the result. ■

Under general linear pricing, the risk premium $\lambda_p \theta_{ip} \sigma_i$ in the hurdle rate compensates the infrastructure investor for the asset's contribution to her *portfolio* risk. This contribution is driven linearly by three elements. First, the price of risk λ_p which captures risk-adjusted returns across the portfolio; if investors face the same opportunity set, this becomes the market-wide price of risk. Second, the portfolio correlation θ_{ip} of the asset; those that comove with the overall portfolio have required returns above the risk-free rate. Third, the riskiness σ_i of the asset; all else equal, more volatile assets also need higher returns.

General linear pricing captures the basic intuitions of textbook asset pricing—see, e.g., Cochrane (2005a). It is a simplified version, in returns space, of fuller derivations of the portfolio problem that are stated based on consumption and derive the result in terms of a stochastic discount factor. For our purposes here, the simplified version is sufficiently flexible to nest well-known models such as CAPM as a special case. In what follows, we will take general linear pricing as the "true model" of asset returns—and ask how different simpler models like CAPM perform against it.

Simple model: CAPM. Our first special case is CAPM—which further assumes that the (marginal) investor holds the market portfolio. We write r_m for the market return with mean μ_m and variance σ_m^2, $\lambda_m = (\mu_m - \rho)/\sigma_m > 0$ for the market price of risk, and $\theta_{im} \equiv Corr(r_i, r_m) \in [-1, 1]$ for the correlation between the asset and the market.

So, in terms of general linear pricing, as the investor portfolio holds the market, we now have $\theta_{ip} = \theta_{im}$ for the asset-portfolio correlation and $\lambda_p = \lambda_m$. This yields:

Lemma 2. (*CAPM*) Under CAPM, for asset i with a portfolio weight $w_i > 0$, the investor hurdle rate satisfies:

$$h_i^C = \rho + \beta_i(\mu_m - \rho) \tag{8}$$

where $\beta_i \equiv \frac{Cov(r_i, r_m)}{\sigma_m^2} = \theta_{im}\frac{\sigma_i}{\sigma_m}$ is the standard CAPM beta and $(\mu_m - \rho) > 0$ is the equity risk premium.

Proof of Lemma 2. Under the CAPM assumptions, the investor holds the market so that $\theta_{ip} = \theta_{im}$ and $\lambda_p = \lambda_m$ and so the formula of Lemma 1 becomes

$$h_i - \rho = \lambda_p \theta_{ip} \sigma_i \Longrightarrow h_i^C - \rho = \lambda_m \theta_{im} \sigma_i = \frac{(\mu_m - \rho)}{\sigma_m} Corr(r_i, r_m)\sigma_i = \frac{Cov(r_i, r_m)}{\sigma_m^2}(\mu_m - \rho)$$

which yields the claim using the standard CAPM definition of $\beta_i \equiv \frac{Cov(r_i, r_m)}{\sigma_m^2}$. ■

It is perhaps easiest to think of CAPM as being the special case of general linear pricing where $\theta_{ip} = \beta_i \frac{\sigma_m}{\sigma_i} \equiv \theta_{im}$, from which we also conclude that $\text{sign}(\theta_{im}) = \text{sign}(\beta_i)$—it is the asset-market correlation that drives risk premia.

For empirical implementation, CAPM requires three things. First, an estimate of the risk-free rate. Second, the analyst also needs an estimate of the equity risk premium $(\mu_m - \rho)$. While some empirical details remain contested, there is a large academic and practitioner literature on this including over 100 years of long-run stock market data for major markets like the US and UK. (See, e.g., Wright et al. (2018) for more discussion of empirical issues and the recent state of best practice in UK regulatory policy.)

Third, the analyst needs an estimate of beta. For listed assets with a good time-series of market data, this is a relatively straightforward undertaking. In regulatory practice for energy networks and the water sector, an important challenge is the decreased number of listed players. Over the years since privatization, many companies have moved into private-equity ownership so no longer have a stock price. This can make it challenging to find good comparables—even for brownfield companies. For greenfield assets, our focus in this paper and an increasing policy focus, the challenge is further compounded.

To illustrate: In energy alone, there are 14 regulated entities in Britain: three major electricity transmission companies, six regional electricity distribution companies, one gas transmission operator and four regional gas distribution companies. Of these, only two are listed on the stock market: National Grid and SSE. Moreover, neither is a pure play: the former's assets are split roughly equally between the UK and US regulated businesses and the latter is a diversified energy company with assets also in fossil and renewable power generation.[3] Similarly, of the 16 regulated water companies in England and Wales, only three are directly listed: Pennon, Severn Trent and United Utilities (which all control several regional water businesses). Overall, only around a third of British regulated companies are listed while the others are private.

Finally, by contrast, CAPM does not require an estimate of asset risk σ_i; its role is diversified away and therefore becomes irrelevant to the result. Insofar as a company's several business assets have similar CAPM betas (and similar capital structures), they will also have similar equity hurdle rates under CAPM.

Simple model: IRPM. Our second special case is what we term the Infrastructure Risk Pricing Model (IRPM). In this setup, the investor prices the total risk associated with an asset. This corresponds to the investor acting as if they hold an undiversified portfolio. As discussed in the introduction, we think that this captures how many infrastructure investors act in practice—especially with regard to large greenfield infrastructure projects.

IRPM is therefore directly nested within the general linear pricing approach, with the asset-portfolio correlation $\theta_{ip} \equiv Corr(r_i, r_p) = 1$ as the asset and the portfolio are interchangeable. (For a single-asset fund, r_p is an affine transformation of r_i.)

Lemma 3. (*IRPM*) Under the Infrastructure Price of Risk Model, for asset i with a

[3]Scottish Power is owned by Iberdrola which is listed on the Spanish stock market but is also a diversified energy company (roughly along the lines of SSE).

portfolio weight $w_i > 0$, the investor hurdle rate satisfies:

$$h_i^I = \rho + \lambda_p \sigma_i.$$

Proof of Lemma 3. Set an asset-portfolio correlation $\theta_{ip} = 1$ in Lemma 1. ■

For empirical implementation, IRPM goes down a different route to CAPM. First, the analyst needs an estimate of the asset's own risk, σ_i. This can be obtained in two main ways. One is from a simulation of its cash flows and risk factors, either via econometrics or machine learning. If the asset is listed, another is by estimating total risk (not only market risk) from stock returns. This makes IPRM more flexible than CAPM.

Second, the analyst also needs an estimate of the investor's portfolio price of risk, λ_p; this is a single number that does not vary from one asset to another (as long as these are not too large a fraction of the portfolio, as we assume here). In contrast to CAPM, empirical implementation of IRPM does *not* require establishing co-movements with the stock market, and therefore does not require the asset to be listed or suitable comparables to be found.

IRPM, in this setting, leads to a relatively high discount rate—due to pricing of idiosyncratic risk—but note that it does not lead to a *uniform* discount rate being used indiscriminately across all projects in capital budgeting: even if the market price of risk should be identical across projects, differences in idiosyncratic risk still warrant different hurdle rates. This is in the spirit of McDonald (1998): "Anecdotal evidence suggests that firms making capital budgeting decisions routinely do a number of things... hurdle rates are sometimes higher for projects with greater idiosyncratic risk" (page 1).

IRPM's setup therefore also speaks to discussions around technology maturity, perhaps especially around low-carbon energy. Less mature technologies are likely to have more volatile cash flows (higher σ_i) and so, all else equal, IRPM investors will require a higher expected return (and thus higher h_i^I). For example, a mature technology like solar PV will typically have a lower cost of equity capital than, say, a new generation of nuclear reactors.[4] (We revisit this point in the case study on nuclear energy in Section 4.)

3 Comparing models: CAPM versus Infrastructure Risk Pricing Model

Both CAPM and IRPM are polar special cases of the GLP: under CAPM, there is full investor diversification (so that θ_{ip} may be at its minimum) while under IRPM, there is

[4]In clean energy policy, this is often proxied by the "technology readiness level" (TRL) and (sometimes ad-hoc) adjustments to the cost of capital, see e.g. the Clean Energy Technology Guide and Cost of Capital Observatory of the International Energy Agency, available at: `https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide` and `https://www.iea.org/reports/cost-of-capital-observatory`

no diversification (so $\theta_{ip} = 1$). Which model does better?

In sum, the three hurdle rates under comparison are:

$$h_i^{GLP} = \rho + \lambda_p \theta_{ip} \sigma_i \qquad \text{(GLP "truth", } \lambda_p = (\mu_p - \rho)/\sigma_p), \tag{9}$$

$$h_i^{C} = \rho + \lambda_m \theta_{im} \sigma_i \qquad \text{(CAPM approximation, } \theta_{ip} = \theta_{im},\ \lambda_m = (\mu_m - \rho)/\sigma_m), \tag{10}$$

$$h_i^{I} = \rho + \lambda_p \sigma_i \qquad \text{(IRPM approximation, } \theta_{ip} = 1,\ \lambda_p = (\mu_p - \rho)/\sigma_p). \tag{11}$$

We define the two approximation errors, relative to GLP as the "true model", as

$$\varepsilon_i^C \equiv h_i^C - h_i^{GLP} = \sigma_i(\lambda_m \theta_{im} - \lambda_p \theta_{ip}), \tag{12}$$

$$\varepsilon_i^I \equiv h_i^I - h_i^{GLP} = \lambda_p \sigma_i (1 - \theta_{ip}) \geq 0, \tag{13}$$

so that the absolute errors are given by:

$$|\varepsilon_i^C| = \lambda_p \sigma_i \left| \frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip} \right| \qquad |\varepsilon_i^I| = \lambda_p \sigma_i (1 - \theta_{ip}). \tag{14}$$

IRPM is biased in terms of the cost of equity: it effectively assumes the worst-possible state of the world in terms of diversification, and therefore always overestimates the hurdle rate. By contrast, CAPM here is not obviously biased in either direction; depending on how well its assumptions hold, it could over- or underestimate the true hurdle rate. Relative to general linear pricing, there are two potential sources of error: first, a wedge between the correlations (θ_{im} vs θ_{ip}) and, second, a wedge between the price of risk (λ_m vs λ_p).

Our focus on absolute approximation errors is mostly for simplicity so as to obtain a clean linear comparison across models. We leave to future research the study of different loss functions and also consider the broader problem of choosing a welfare-maximizing (regulatory) model of cost of capital.

Our first result clarifies which simple model does better when:

Proposition 1. (*Preferred model for cost of equity*) The IRPM has a smaller absolute error than CAPM, $|\varepsilon_i^I| \leq |\varepsilon_i^C|$ if either of the two following conditions holds:
(a) The asset-portfolio correlation θ_{ip} is sufficiently high:

$$\theta_{ip} \geq \frac{1}{2}\left[1 + \frac{\lambda_m}{\lambda_p}\theta_{im}\right] \equiv \widehat{\theta}_{ip}$$

in which case CAPM underestimates the true hurdle rate h_i^{GLP}.
(b) The asset-market correlation θ_{im} is sufficiently high:

$$\theta_{im} \geq \frac{\lambda_p}{\lambda_m} \equiv \widehat{\theta}_{im},$$

in which case CAPM overestimates the true hurdle rate h_i^{GLP}.

Proof of Proposition 1. Since $\lambda_p \sigma_i > 0$, the inequality $|\varepsilon_i^I| \leq |\varepsilon_i^C|$ is equivalent to

$$1 - \theta_{ip} \leq \left| \frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip} \right|. \tag{15}$$

There are two cases. First, for (a), suppose that $\theta_{ip} \geq \frac{\lambda_m}{\lambda_p} \theta_{im}$ so CAPM underestimates the true hurdle rate h_i^{GLP}. As $\theta_{ip} \in [-1, 1]$, this implies that $\frac{\lambda_m}{\lambda_p} \theta_{im} \leq 1$. Then $|\frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip}| = \theta_{ip} - \frac{\lambda_m}{\lambda_p} \theta_{im}$, and so the condition becomes

$$1 - \theta_{ip} \leq \theta_{ip} - \frac{\lambda_m}{\lambda_p} \theta_{im} \Longleftrightarrow 1 + \frac{\lambda_m}{\lambda_p} \theta_{im} \leq 2\theta_{ip} \Longleftrightarrow \theta_{ip} \geq \frac{1}{2} \left[1 + \frac{\lambda_m}{\lambda_p} \theta_{im} \right] \equiv \widehat{\theta}_{ip}, \tag{16}$$

where $\widehat{\theta}_{ip} < 1$, in which case IRPM does better than CAPM. Second, for (b), suppose instead that $\theta_{ip} \leq \frac{\lambda_m}{\lambda_p} \theta_{im}$ so CAPM now also overestimates the true hurdle rate h_i^{GLP}. Then $|\frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip}| = \frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip}$, and so the condition becomes

$$1 - \theta_{ip} \leq \frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip} \Longleftrightarrow \frac{\lambda_m}{\lambda_p} \theta_{im} \geq 1. \tag{17}$$

There are again two sub-cases. First, if $\lambda_m < \lambda_p$, then the condition cannot be met since also $\theta_{im} \in [-1, 1]$, and so CAPM always does better than IRPM. Second, if instead $\lambda_m \geq \lambda_p$, then the condition is met if $\theta_{im} \geq \frac{\lambda_p}{\lambda_m} \equiv \widehat{\theta}_{im}$, where $\widehat{\theta}_{im} < 1$, and so IRPM does better. Combining the two cases yields the result as claimed. ■

To understand the result, suppose initially that the price of risk is comparable for the investor portfolio and the overall market, with $\lambda_p \simeq \lambda_m$. For example, an infrastructure fund may have a similar overall risk-adjusted return profile to that of the stock market.

The relevant case is then (a), so CAPM underestimates the true hurdle rate, and the condition boils down to $\theta_{ip} \geq \frac{1}{2} [1 + \theta_{im}] \equiv \widehat{\theta}_{ip}$. CAPM is preferred when $\theta_{ip} < \widehat{\theta}_{ip}$, the two models tie when $\theta_{ip} = \widehat{\theta}_{ip}$, and IRPM is preferred when $\theta_{ip} > \widehat{\theta}_{ip}$. The threshold $\widehat{\theta}_{ip}$ is the midpoint between the CAPM loading of θ_{im} and the IRPM loading of 1. Under the condition of (a), $\theta_{ip} > \widehat{\theta}_{ip}$, IRPM's overestimate of the true hurdle rate does better than CAPM's underestimate.

For other parameter values, where $\lambda_p \neq \lambda_m$, the condition of (a) in favour of IRPM is more easily met where $\lambda_p > \lambda_m$. Then CAPM, in effect, more strongly underestimates the investor's risk-return profile—which skews things further in favour of IRPM.

Consider now case (b) of Proposition 1. Here, both IRPM and CAPM overestimate the true hurdle rate. The condition $\theta_{im} \geq \widehat{\theta}_{im}$ pins down when IRPM's overestimate is less bad than CAPM's. A necessary (sub-)condition for it to hold is that $\lambda_m \geq \lambda_p$. The reasoning is now the opposite to (a): this here exacerbates CAPM's overestimate, and thus helps IRPM.

Perhaps surprising is that the model comparison of Proposition 1 does not depend on the extent of asset risk σ_i. This asset risk is, in effect, a common scale factor across general linear pricing, CAPM and IRPM; while it shifts *absolute* performance, it does not affect *relative* performance across the three models. The latter is pinned down solely by the two correlations underlying Proposition 1.

It is also worth highlighting that the condition of Proposition 1 may play out differently for different investors. This can arise because they hold substantially different portfolios under IRPM, and so view the same asset in a different way. The condition may, of course, also play out differently for different assets. It is horses for courses: CAPM may be the right model for one, and IRPM for another.

In practice, most correlations are non-negative, so we typically have $\theta_{ip}, \theta_{im} \geq 0$. Moreover, a new infrastructure asset is likely in practice to be more correlated with an existing infrastructure portfolio than with the wider stock market (e.g., because of sectoral overlap or similar macroeconomic exposure), so we typically also have $\theta_{ip} \geq \theta_{im}$. Taken together, the most relevant domain from an empirical perspective is therefore where $0 \leq \theta_{im} \leq \theta_{ip} \leq 1$.

We thus now illustrate Proposition 1 with three visuals for different values of λ_p, λ_m for a correlation range $(\theta_{ip}, \theta_{im}) \in [0, 1]^2$:

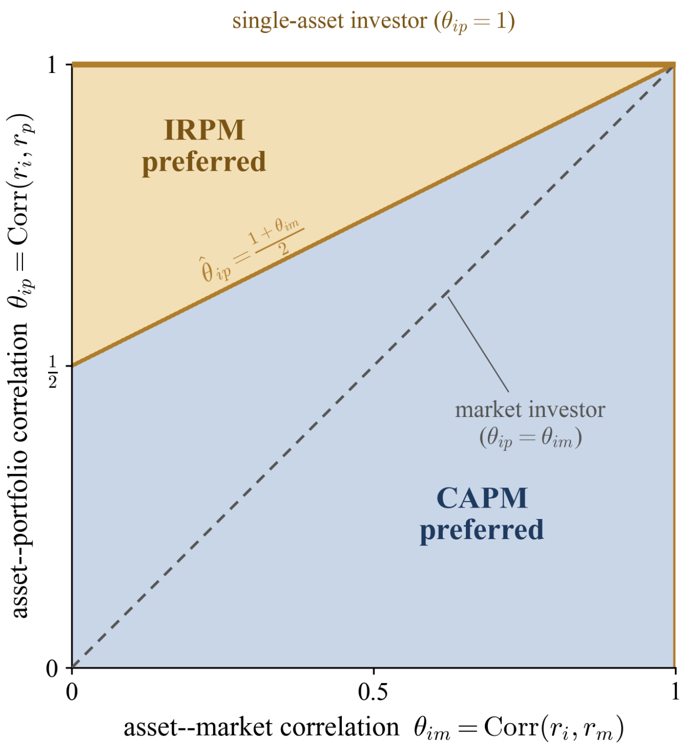

Figure 1. Comparing cost of equity models: IRPM vs CAPM where $\lambda_p = \lambda_m$

Figure 1 sets $\lambda_p = \lambda_m$ under which only the condition of Proposition 1(a) has bite. CAPM is preferred towards the south-east; IRPM is preferred towards the north-west.

An undiversified, single-asset investor who holds only asset i has $\theta_{ip} = Corr(r_i, r_p) = 1$, irrespective of the value of θ_{im} from CAPM so always prefers to use IRPM. A fully-diversified market investor has $\theta_{ip} = \theta_{im} = Corr(r_i, r_m)$ so always prefers CAPM. Figure 1 shows the generalization to intermediate cases. For the parameter range $0 \leq \theta_{im} \leq \theta_{ip} \leq 1$, CAPM and IRPM are each preferred in exactly half of the space.

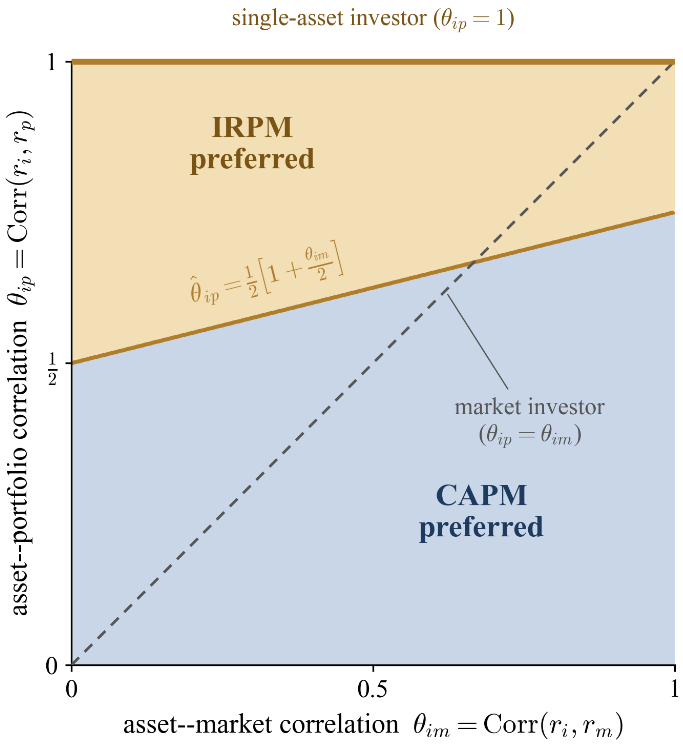

Figure 2. Comparing cost of equity models: IRPM vs CAPM where $\lambda_p = 2\lambda_m$

Figure 2 presents a variation where now $\lambda_p = 2\lambda_m$, so the fund's price of risk is twice that of the market. As in Figure 1, only Proposition 1(a) is relevant. The basic shape of the space is the same but IRPM now does relatively better than CAPM. Given that $\lambda_m < \lambda_p$, CAPM now underestimates the investor's risk-return profile—which diminishes some of its prior advantage. For the parameter range $0 \leq \theta_{im} \leq \theta_{ip} \leq 1$, IRPM is now preferred in two thirds of the space.

This case is perhaps especially interesting in that infrastructure funds frequently claim to achieve higher risk-adjusted returns than the wider market. For example, KKR (2026) notes that, over the period 2005 to 2024, both listed infrastructure and private infrastructure have Sharpe ratios above those of global equities—suggesting that $\lambda_p > \lambda_m$. Private infrastructure, in particular, has a Sharpe ratio $\lambda_p \simeq 1.0$ while the wider market has $\lambda_m \simeq 0.5$—so indeed $\lambda_p \simeq 2\lambda_m$. While acknowledging the complexities of measuring performance especially of unlisted assets, this suggests that IRPM is directionally likely to be relevant particularly in the case of highly-performing infrastructure funds.

Figure 3 instead sets $\lambda_p = \frac{1}{2}\lambda_m$. This makes both Propositions 1(a) and 1(b) relevant. For the former, the parameter region now favours CAPM—for the opposite reason to that underlying the previous Figure 2: CAPM overestimates the investor's risk-return profile. For the latter, the condition of Proposition 1(b) is now met whenever $\theta_{im} \geq \frac{1}{2} \equiv \widehat{\theta}_{im}$. In this region, CAPM's overestimate is sufficiently pronounced to always exceed that of IRPM. In terms of the visual, this means a compressed triangle towards the north-west and new rectangle towards the east. IRPM is again preferred in exactly half of the parameter range $0 \leq \theta_{im} \leq \theta_{ip} \leq 1$.

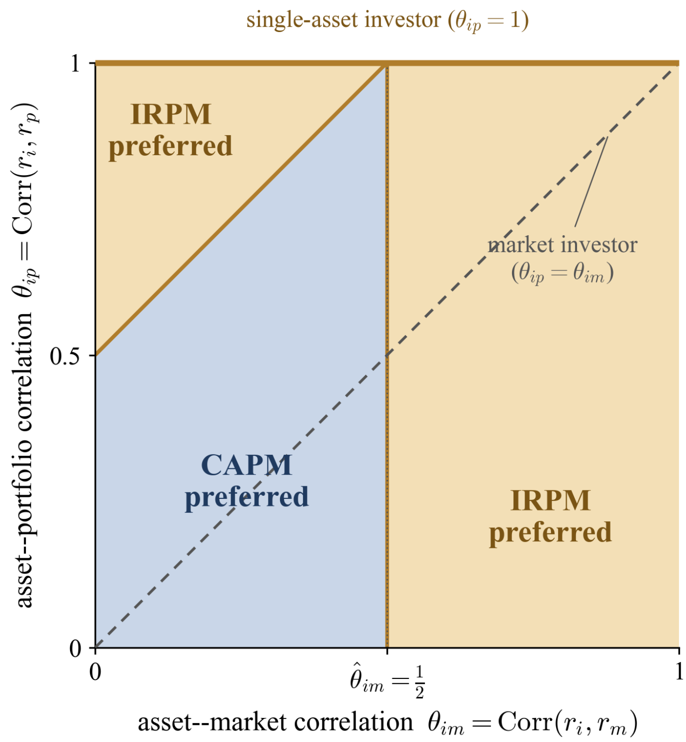

Figure 3. Comparing cost of equity models: IRPM vs CAPM where $\lambda_p = \frac{1}{2}\lambda_m$.

Numerical illustration. To illustrate, consider an infrastructure fund that holds an equal-weight portfolio of n assets with common pairwise correlation $\kappa \in [\frac{-1}{(n-1)}, 1]$ and common standard deviation σ. The asset-portfolio correlation for asset i is then given by:

$$\theta_{ip}(n, \kappa) = \sqrt{\frac{1 + (n-1)\kappa}{n}}. \tag{18}$$

For a single-asset fund, with $n = 1$, the correlation is always $\theta_{ip} = 1$. For a large-numbers fund, as $n \to \infty$, the correlation converges to $\theta_{ip} \to \sqrt{\kappa} \in [0, 1]$. Note that this correlation could still be close to 1, despite the many assets held.

Our question is, when will this fund prefer to use CAPM or IRPM? Consider a numerical example. Suppose that the equity risk premium is $(\mu_m - \rho) = 5\%$ and that the market volatility satisfies $\sigma_m = 15\%$, so that the market price of risk under CAPM is $\lambda_m = \frac{1}{3}$. These numbers are illustrative but roughly correspond to financial practice in the US and UK (see, e.g., Dimson et al., 2002). (All numbers are on an annual basis.)

An analyst is able to run CAPM on asset i—either because it is listed or because suitable listed comparators can be found—and obtains an estimate $\beta_i = 0.50$ on the equity. Suppose further that the underlying volatility of asset i is $\sigma_i = 20\%$.

What does the condition of Proposition 1 tell us? There are two steps:

The first step is about the *asset*—how does it move with the market? We compute the implied correlation within CAPM as $\theta_{im} \equiv Corr(r_i, r_m) = \beta_i \frac{\sigma_m}{\sigma_i} = 0.50 \times \frac{15\%}{20\%} = 0.375$, so the asset has positive but muted co-movement with the market, as might be expected from infrastructure.

The second step is about the *investor*—how does the asset move with the investor's portfolio? To simplify, suppose that $\lambda_p = \lambda_m$ so the fund carries a similar risk-return profile to the market. Then, by Proposition 1(a), for $\theta_{ip} = Corr(r_i, r_p) \geq \widehat{\theta}_{ip} \equiv \frac{1+\theta_{im}}{2} \simeq 0.688$, the preferred model is IRPM. In such cases, the overestimate of IRPM is smaller than the underestimate of CAPM.

When is this condition met for the investor? Suppose that the average correlation is $\kappa = \frac{1}{3}$. As a function of the portfolio size, we here therefore have $\theta_{ip}(n) = \sqrt{\frac{1+\frac{1}{3}(n-1)}{n}}$. Hence a single-asset portfolio $\theta_{ip}(1) = 1$ always prefers IRPM as expected. It is easy to check that the same conclusion applies when $n \in \{2, 3, 4\}$. Furthermore $\theta_{ip}(5) = \sqrt{\frac{7}{15}} \simeq 0.683$ so the two simple models are almost equally-good—but the investor now fractionally prefers CAPM. For $n \geq 6$, the investor prefers CAPM.

A higher pairwise correlation κ skews things towards IRPM. For example, if instead $\kappa = \frac{1}{2}$, then $\theta_{ip}(n) \geq \theta_{ip}(n)|_{n\to\infty} = \sqrt{\frac{1}{2}} \simeq 0.707 \geq \widehat{\theta}_{ip}$, so here the investor *always* prefers IRPM over CAPM, for any $n \in [1, \infty)$.

Strictly speaking, in our setting, the informational requirement of general linear pricing is no greater than that of Proposition 1. The comparison underlying Proposition 1(a) between CAPM and IRPM requires information on $(\theta_{ip}, \theta_{im})$. Implementation of the hurdle rate under IRPM, as per Lemma 3, requires information on $(\rho, \lambda_p, \sigma_i)$. Taken together, this informational requirement is sufficient to implement general linear pricing as per Lemma 1—which requires $(\rho, \lambda_p, \theta_{ip}, \sigma_i)$. The looser idea underlying our approach, which we comment on further below, is that the analyst has a preference for using a simple model. Indeed, IRPM's own informational requirement is, of course, lower precisely because θ_{ip} is not needed (as $\theta_{ip} = 1$ is assumed).

A final perspective on these results is in terms of model combination. A linear combination of CAPM, with weighting α_i, and IRPM can perfectly replicate general linear pricing, with the optimal CAPM-weight α_i^* given by

$$\theta_{ip} = \alpha_i \theta_{im} + (1 - \alpha_i) \Longrightarrow \alpha_i^* = \frac{1 - \theta_{ip}}{1 - \theta_{im}}.$$

In situations where CAPM is accurate, $\theta_{im} = \theta_{ip}$ and so $\alpha_i^* = 1$. In other situations, with $\theta_{im} < \theta_{ip}$, the optimal weight on IRPM is positive, with $\alpha_i^* < 1$.

4 Case study: Financing new nuclear power

We now illustrate the case for an infrastructure-led cost of capital approach with a case study: the new Sizewell C nuclear power generation project in the UK. We argue that CAPM fails to explain the outcome on observed cost of capital and the UK government's approach to finding project investors, while a model along the lines of IRPM is able to rationalize investor behaviour.

The investment context. Large new nuclear power generation assets fit well the criteria set out in the introduction: they are large, irreversible, illiquid, long-lived investments that typically also come with concentrated set of potential owners. Nuclear involves government: either directly as a corporate owner-operator (as in France and South Korea) or indirectly as the underwriter of a regulatory framework and its risk sharing with the private sector (as in the UK). Nuclear generation projects face a wide array of risks, ranging from planning and environmental risks to construction cost uncertainty to operational risks and exposure to interest rates, supply chain costs and power prices. In some countries, new nuclear generation is also seen to be crucial to climate-policy targets—given its scale and near-zero emissions.[5]

The UK government has faced the challenge of attracting equity investors into Sizewell C, a new 3.2 GW (gigawatt) nuclear power station in the south-east of England expected to require investment on the order of US$ 50 billion. The government's approach consisted of four main components: (1) a joint venture corporate structure that combines public and private ownership, (2) a government equity stake combined with government underwriting of debt, (3) a new version of the Regulated Asset Base (RAB) framework for nuclear, and (4) a government support package to mitigate investor risk. (For further institutional background, see National Audit Office (2026).)

Sizewell C will operate through a version of the established RAB framework. The model spreads the consumer-funded recovery of its capital cost over a 60-year lifetime. Under the RAB model, an allowed return based on a WACC applied to the capital base governs revenue during the construction phase of the project (see Newbery et al. (2019)). These revenues are recouped via the bills of electricity consumers. The RAB framework makes Sizewell C similar to regulated electricity and gas network utilities in the UK—but unlike electricity generation assets using natural gas or renewable energy that operate without a RAB.

To help attract private investors, the UK government further provided a support package designed to cover specific high impact, low probability risks, that private investors would not be able or willing to finance themselves—at least not without large risk premia (see DESNZ (2025), page 5). In particular, the government support package bounded the extent of losses that would be borne by investors in the event of construction cost overruns.

[5]See Davis (2012) for a useful perspective on the economics of nuclear power.

This design choice was based, in part, on the earlier success of attracting low-cost private sector investment into Thames Tideway Tunnel—a new sewerage tunnel for London—that had pioneered such a hybrid, partially de-risked RAB model. Prospective bidders for the Sizewell C project included utilities like EDF, with a long history in nuclear, as well as infrastructure investors like Brookfield and pension funds like USS.[6]

The cost of equity question. So how should the allowed cost of equity for Sizewell C investors be determined? The government trade-off is classic: all else equal, a lower cost of equity increases value-for-money from a social viewpoint while a higher cost of equity increases project investability from a private viewpoint. The government's problem boils down to trying to minimize the cost of equity subject to the project remaining "investable".

From an ex ante perspective, the Sizewell C project characteristics and investor context sit uneasily with the use of CAPM that is the UK norm to determine the cost of capital for regulated infrastructure. Sizewell C is a first-of-a-kind nuclear project under a new type of RAB regulatory framework, with a very long construction period and a single-asset structure. This creates two sets of problems for CAPM. The first is conceptual: the project characteristics do not align well with the economic assumptions underpinning CAPM, not least on investor diversification and the government support package. The second is empirical: running CAPM requires an equity beta estimated from "comparables" but for Sizewell C it was not clear what suitable listed equities there would be.

These challenges were recognized by the UK Secretary of State in the equity raise process. CAPM, given its track record in regulation, was considered—as "Option 1" following UK regulatory guidance (UKRN, 2023)—but rejected. Instead, "equity investors participating... would be asked to bid a fixed (real) cost of equity" for the construction phase (see DESNZ (2024), §4.10). This followed similar uses of bid-based cost of equity for the Thames Tideway Tunnel by the water regulator (Ofwat) and for offshore electricity transmission connections by the energy regulator (Ofgem). A key advantage of this approach was thought to be its simplicity relative to other options and the ability to reveal information and leverage competition in capital markets.

Explaining the outcome. The Sizewell C competitive bid process produced a cost of equity of 10.8%, in real terms, excluding inflation. Together with a government-specified cost of debt of 4.5% and gearing level of 65%, this implied a real WACC of 6.7% (pre-tax) which will yield a revenue stream based on the project's RAB. The winning bidders included investors La Caisse (with a 20% project stake) and Amber Infrastructure (with 7.6%) as well as utilities EDF (with 12.5%) and Centrica (with 15%), investing alongside the UK government. The project reached Final Investment Decision on 22 July 2025. One of the winning bidders, Centrica, disclosed a £1.3 billion funding commitment with a

[6]See *Financial Times* (2025), Ministers prepare to reduce UK stake in Sizewell C nuclear project, 21 July 2025. `https://www.ft.com/content/4ae7842c-df91-41c3-a7a0-5b626f6cb6d9`

modelled project IRR (nominal, post-tax) above 12%.[7] In the end, the government took a 44.9% equity stake, through DESNZ.

This investor cost of equity is not easy to reconcile with CAPM. To illustrate, the latest regulatory cost of equity set by Ofgem for electricity transmission networks has a real cost of equity of 5.70% (see Ofgem (2025)). This is not much more than half of the bid-revealed number for Sizewell. Ofgem's regulatory policy is derived using CAPM following established UKRN regulatory guidance. Underlying it is a CAPM equity beta of 0.74. Arriving at a cost of equity of 10.8% would instead require an equity beta of almost 2. This high market-sensitivity, in turn, is difficult to generate from observed data for infrastructure assets. Taken together, this suggests that investors were pricing risk premia not captured by CAPM.[8]

IRPM can help rationalize the cost of equity revealed by the Sizewell C competitive bid process. The fact that it is difficult to reconcile observed investor behaviour with CAPM suggests, through the lens of this paper, that the conditions against it of Proposition 1 may have been met. An immediate advantage of IRPM, unlike CAPM, is that empirical implementation does not hinge on the availability of stock market data (so as to estimate market covariances). Instead, the cost of equity calculation, and hence the bidding strategy, focuses on the investor price of risk (λ_p) and on project risk (σ_i).

We present three points to show how IRPM can help reconcile investor behaviour on cost of equity. First, working backwards, assuming a (real) risk-free rate of $\rho = 2.5\%$, the revealed cost of equity of 10.8% would be justified by a market price of risk at the portfolio level $\lambda_p = (\mu_p - \rho)/\sigma_p = (7.5\% - 2.5\%)/15\% = \frac{1}{3}$ (Dimson et al., 2002; Wright et al., 2018) together with project risk of $\sigma_i = 24.9\%$. This is a "brute force" rationalization of the observed data to show that IRPM can explain it while CAPM does not.

Second, these figures are broadly in line with historical stock market data and estimates of project risk on other large infrastructure projects in the construction phase. As of January 2026, the Damodaran database at NYU Stern gives an annual equity volatility of 14.96% for US utilities and 18.95% for European utilities; these are plausible (weak) lower bounds on the project risk of Sizewell C. For many other US sectors, equity volatility exceeds 30% or even 50%.[9] Much of the early-stage Sizewell C project risk stems from the possibility of construction cost overruns. From the investor perspective, these are partly—but not fully—mitigated by the government support package. Estimates find that cost overruns in large infrastructure projects are common, large and uncertain (Flyvbjerg et

[7] See Centrica (2025), Centrica acquires a 15% equity stake in Sizewell C, 22 July 2025. https://www.centrica.com/media/tfnbsmm5/centrica-2025-sizewell-c-rns-announcement-final-220725.pdf

[8] An alternative explanation would be that the bidding process was not competitive. However, the outcome in terms of interest and number of potential and actual bidders suggests that the process was workably competitive.

[9] This is the standard deviation in monthly stock prices, estimated using 5 years of data, with the number being annualized. Source: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/data.html.

al., 2002; Flyvbjerg, 2009). Almost all nuclear power projects around the world have overshot cost forecasts, with a mean cost escalation of 117.3% (Sovacool, 2014).

Third, it is clear that, even in the absence of detailed projected cash flow information for Sizewell C being available in the public domain, IRPM has the potential to explain the observed outcome for different estimates of project risk. Table 1 shows the implied cost of equity for a range of different value for the portfolio price of risk (Sharpe ratio) and project risk. The observed cost of equity of 10.8% can easily be rationalized for different parameter values. Moreover, IRPM can explain investor behaviour of *losing* bidders in the Sizewell C sales process; these must have had a *higher* estimate of the required return for the project, driven either by a higher price of risk in their existing portfolio or by a higher estimated project riskiness. In short, this is a "nuclear-specific premium."

		Project risk σ_i				
		10%	15%	20%	30%	40%
Portfolio	1/6	4.17%	5.00%	5.83%	7.50%	9.17%
price of risk λ_p	1/3	5.83%	7.50%	9.17%	12.50%	15.83%
	1/2	7.50%	10.00%	12.50%	17.50%	22.50%
	2/3	9.17%	12.50%	15.83%	22.50%	29.17%
	1	12.50%	17.50%	22.50%	32.50%	42.50%

Table 1. Illustrative cost of equity for Sizewell C nuclear energy project using IRPM
Notes: Calculations are based on Lemma 3 and assume a (real) risk-free interest rate $\rho = 2.5\%$

5 Conclusion

This paper has presented a novel comparison between two simple models of cost of equity: CAPM, the workhorse model of systematic risk, and another simple model, the Infrastructure Risk Pricing Model (IRPM) which instead also prices idiosyncratic risk and is closer to what practitioners actually do. The main insight is that, while both models are wrong (because of their simplicity), IRPM does better than CAPM for investors with relatively concentrated portfolios—like an infrastructure fund with a focused investment mandate. This result is derived in the context of a "plain vanilla" portfolio problem with mean-variance preferences.

There are numerous avenues for future research. One is to consider risk measures that go beyond mean-variance utility. This might include other measures used in practice such as value-at-risk (VaR) or asymmetries and ranges in hurdle rates used by investors.

Another concerns implementation of a model like IRPM. One advantage is that it can be implemented empirically based on project cash flows (and their riskiness) rather than requiring stock market returns. This might be done by way of using machine learning on a stochastic analysis of cash flows and their key sensitivities. Similar to the literature on factor investing, much more data on risk factors has become available over the last decade. IRPM might thus serve as a benchmark for infrastructure investors and regulators alike.

A final related topic is the importance of real options ((Dixit and Pindyck, 1994; McDonald, 1998)) for infrastructure projects, driven by uncertainty, irreversibility and the value of learning. The standard CAPM approach does not take this into account. In the Appendix, we show that the main insight from Proposition 1 is preserved when general linear pricing is augmented with a real options overlay. Once again, under a sizable set of conditions, CAPM does better than IRPM at estimating the investor cost of equity.

Appendix: Cost of equity with real options

In this appendix, we generalize the baseline model from the main text to incorporate an option value of delaying an irreversible investment. This captures a consideration around investment timing that is often important in practice, especially for greenfield infrastructure.

We show that the basic insights on cost of equity from the baseline model—and Proposition 1—are preserved with real options; in particular, CAPM and IRPM are the preferred model under different circumstances. To do so, we employ a reduced-form version that follows (Dixit and Pindyck, 1994; McDonald, 1998).

As is well-established in the literature, the presence of a real option adds an option premium to the hurdle rate. The value of this real option tends to be higher with greater project risk; the option to wait and learn more information is then more valuable. Recall from Lemma 1 that the hurdle rate under general linear pricing satisfies $h_i = \rho + \lambda_p \theta_{ip} \sigma_i$. Following McDonald (1998), we write a reduced-form hurdle rate function

$$f(h_i) = h_i \frac{\phi(h_i)}{[\phi(h_i) - 1]} > h_i \tag{19}$$

where $h_i > 0$, $\phi(h_i) > 1$ captures the option value, and we assume $f'(h_i) > 0$. The wedge $f(h_i) - h_i > 0$ thus captures the option premium. It can be further specified by imposing parametric/statistical assumptions on the value function of asset i (such as a geometric Brownian motion; see Dixit and Pindyck (1994)). For our purposes here, the reduced-form version is sufficient.

Including the option premium, the three hurdle rates under comparison become:

$$h_i^{GLP,opt} = f(h_i^{GLP}) = f(\rho + \lambda_p \theta_{ip} \sigma_i) \qquad \text{(GLP “truth”)}, \tag{20}$$
$$h_i^{C,opt} = f(h_i^{C}) = f(\rho + \lambda_m \theta_{im} \sigma_i) \qquad \text{(CAPM approximation)}, \tag{21}$$
$$h_i^{I,opt} = f(h_i^{I}) = f(\rho + \lambda_p \sigma_i) \qquad \text{(IRPM approximation)}. \tag{22}$$

We define the two approximation errors as before:

$$\varepsilon_i^C \equiv h_i^{C,opt} - h_i^{GLP,opt} = f(\rho + \lambda_m \theta_{im} \sigma_i) - f(\rho + \lambda_p \theta_{ip} \sigma_i), \tag{23}$$
$$\varepsilon_i^I \equiv h_i^{I,opt} - h_i^{GLP,opt} = f(\rho + \lambda_p \sigma_i) - f(\rho + \lambda_p \theta_{ip} \sigma_i). \tag{24}$$

Given the presence of option values, the errors no longer reduce to a linear comparison as for Proposition 1. Assuming differentiability, we expand $f(.)$ around h_i^{GLP} in a Taylor series. Define the first-order base deviations:

$$\Delta^C \equiv h_i^C - h_i^{GLP} = \lambda_p \sigma_i \left(\frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip} \right) \text{ and } \Delta^I \equiv h_i^I - h_i^{GLP} = \lambda_p \sigma_i (1 - \theta_{ip}) \geq 0. \tag{25}$$

Expanding to a second order Taylor approximation gives:

$$\varepsilon_i^C \approx f'(h_i^{GLP})\Delta^C + \tfrac{1}{2} f''(h_i^{GLP})(\Delta^C)^2, \tag{26}$$

$$\varepsilon_i^I \approx f'(h_i^{GLP})\Delta^I + \tfrac{1}{2} f''(h_i^{GLP})(\Delta^I)^2. \tag{27}$$

We thus obtain a benchmark result:

Proposition 2. (*Preferred model with option value*) (i) To first order in Δ^C and Δ^I, the result of Proposition 1 on when IRPM has a smaller absolute error than CAPM, $\left|\varepsilon_i^I\right| \leq \left|\varepsilon_i^C\right|$, is preserved.

Proof of Proposition 2. To first order in Δ^C and Δ^I, the condition $|\varepsilon_i^I| \leq |\varepsilon_i^C|$ is equivalent to

$$\left| f'(h_i^{GLP})\Delta^I \right| \leq \left| f'(h_i^{GLP})\Delta^C \right|. \tag{28}$$

By assumption, the hurdle rate function is increasing, with $f'(.) > 0$. Hence the condition boils down to $\left|\Delta^I\right| \leq \left|\Delta^C\right|$ which, noting that $\lambda_p \sigma_i > 0$, also writes as:

$$|1 - \theta_{ip}| \leq \left| \frac{\lambda_m}{\lambda_p} \theta_{im} - \theta_{ip} \right|, \tag{29}$$

given that $\theta_{ip} \leq 1$. This is exactly the same condition as analyzed in Proposition 1, so its result applies here too. ■

Proposition 2 demonstrates that, at least in an important special case, the results of the main text apply identically to a situation with real options. We therefore think that the main point of the paper—that IRPM does better than CAPM—applies considerably more broadly.

Of course, Proposition 2 makes use of a convenient linearazation so as to preserve the exact model structure. A second-order result would generally shift around the precise condition under which IRPM is preferred over CAPM, depending on the concavity or convexity of the hurdle rate function $f(.)$. By continuity, it is clear that IRPM will still be preferred for a significant part of the parameter space (akin to Figures 1-3).

References

Andonov, A., Kraussl, R., and Rauh, J. (2021). Institutional investors and infrastructure investing. *Review of Financial Studies*, 34(8), 3880–3934. https://doi.org/10.1093/rfs/hhab048

Brown, G., Fei, C., and Robinson, D. (2023). Portfolio management in private equity. *NBER Working Paper* 31664. https://www.nber.org/papers/w31664

Campbell, J., Lettau, M., Malkiel, B., and Xu, Y. (2001). Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk. *Journal of Finance*, 56(1), 1–43. https://doi.org/10.1111/0022-1082.00318

Choi, N., Fedenia, M., Skiba, H. and Sokolyk, T. (2017). Portfolio concentration and performance of institutional investors worldwide. *Journal of Financial Economics*, 123, 189–208. https://doi.org/10.1016/j.jfineco.2016.09.007

Cochrane, J. (2005a). *Asset Pricing*. Princeton University Press, revised edition. https://press.princeton.edu/books/hardcover/9780691121376/asset-pricing

Cochrane, J. (2005b). The risk and return of venture capital. *Journal of Financial Economics*, 75(1), 3–52. https://doi.org/10.1016/j.jfineco.2004.03.006

Davis, L.W. (2012). Prospects for Nuclear Power. *Journal of Economic Perspectives*, 26(1), 46–92. https://doi.org/10.1257/jep.26.1.49

Department for Energy Security & Net Zero (2024). Consultation on the methodology to determine the Initial Weighted Average Cost of Capital in the proposed Economic Licence for SZC. 20 March 2024 https://assets.publishing.service.gov.uk/media/660407ff91a320001182b072/IWACC_CDA_LRT_HRT_Consultation_Letter_Redacted_FINAL.pdf

Department for Energy Security & Net Zero (2025). Sizewell C (SZC) Final Investment Decision Value for Money (VfM) assessment. July 2025. https://assets.publishing.service.gov.uk/media/687f951dfdc190fb6b84689d/szc-fid-vfm-assessment.pdf

Dimson, E., Marsh, P., and Staunton, M. (2002). *Triumph of the Optimists: 101 Years of Global Investment Returns*. Princeton University Press. https://doi.org/10.1515/9781400829477

Dixit, A. and Pindyck, R. (1994). *Investment Under Uncertainty*. Princeton University Press. https://doi.org/10.1515/9781400830176

Ewens, M., Jones, C.M. and Rhodes-Kropf, M. (2013). The Price of Diversifiable Risk in Venture Capital and Private Equity. *Review of Financial Studies*, 26(8), 1854–1889. https://doi.org/10.1257/0895330042162430

Fama, E. and French, K. (2004). The Capital Asset Pricing Model: Theory and evidence. *Journal of Economic Perspectives*, 18(3), 25–46. https://doi.org/10.1257/0895330042162430

Flyvbjerg, B., Holm, M., and Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American Planning Association*, 68(3), 279–295. https://doi.org/10.1080/01944360208976273

Flyvbjerg, B. (2009). Survival of the unfittest: Why the worst infrastructure gets built—and what we can do about it. *Oxford Review of Economic Policy*, 25(3), 344–367. https://doi.org/10.1093/oxrep/grp024

Fu, F. (2009). Idiosyncratic risk and the cross-section of expected stock returns. *Journal of Financial Economics*, 91(1), 24–37. https://doi.org/10.1016/j.jfineco.2008.02.003

Goyal, A. and Santa-Clara, P. (2003). Idiosyncratic risk matters! *Journal of Finance*, 58(3), 975–1007. https://doi.org/10.1111/1540-6261.00555

Gormsen, N. J. and Huber, K. (2025). Corporate discount rates. *American Economic Review*, 115(6), 2001–2049. https://doi.org/10.1257/aer.20231246

Helm, D. (2009). Infrastructure investment, the cost of capital, and regulation: An assessment. *Oxford Review of Economic Policy*, 25(3), 307–326. https://doi.org/10.1093/oxrep/grp027

Kacperczyk, M., Sialm, C. and Zheng, L. (2005). On the industry concentration of actively managed equity mutual funds. *Journal of Finance*, 60, 1983–2011.

KKR (2026). Investing through volatility and a rapidly evolving world. Investment Insights, May 2026. https://www.kkr.com/insights/private-infrastructure-2026

Markowitz, H. (1952). Portfolio selection. *Journal of Finance*, 7(1), 77–91. https://doi.org/10.1111/j.1540-6261.1952.tb01525.x

McDonald, R. (1998). Real options and rules of thumb in capital budgeting. In Brennan, M.J. and Trigeorgis, L. (Eds.), *Project Flexibility, Agency, and Competition*, 13–33. Oxford University Press. https://www.kellogg.northwestern.edu/faculty/mcdonald/htm/realopt.pdf

Merton, R.C. (1987). A simple model of capital market equilibrium with incomplete information. *Journal of Finance* 42(3), 483–510. https://doi.org/10.1111/j.1540-6261.1987.tb04565.x

Myers, S.C. (1972). The application of finance theory to public utility rate cases. *Bell Journal of Economics* 3(1), 58–97. https://doi.org/10.2307/3003071

National Audit Office (2026). Sizewell C–Department for Energy Security & Net Zero and Sizewell C Ltd. Session 2026-27, 20 May 2026, HC 33 https://www.nao.org.uk/reports/sizewell-c/

Newbery, D., Pollitt, M., Reiner, D. and Taylor, S. (2019). Financing low-carbon generation in the UK: The hybrid RAB model. EPRG Working Paper 1926, July 2019. https://www.jbs.cam.ac.uk/wp-content/uploads/2023/12/eprg-wp1926.pdf

Ofgem (2025). RIIO-3 Financial Determinations - Finance Annex. 4 December 2025. https://www.ofgem.gov.uk/sites/default/files/2025-12/RIIO-3-Final-Determinations-Finance-Annex.pdf

Sharpe, W. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance*, 19(3), 425–442. https://doi.org/10.1111/j.1540-6261.1964.tb02865.x

Sovacool, B.S. (2014). Construction Cost Overruns and Electricity Infrastructure: An Unavoidable Risk? *The Electricity Journal*, 27(4), 112–120. http://dx.doi.org/10.1016/j.tej.2014.03.015

UK Regulators Network. (2023). *UKRN Cost of Capital Study*. UKRN. https://ukrn.org.uk/publications/cost-of-capital-annual-report/

Van Nieuwerburgh, S. and Veldkamp, L. (2010). Information Acquisition and Under-Diversification *Review of Economic Studies*, 77, 779–805. https://doi.org/10.1111/j.1467-937X.2009.00583.x

Wright, S., Mason, R., and Miles, D. (2018). *A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the U.K.* Report for Ofgem, Ofwat, and CAA. https://www.ukrn.org.uk/publications/