VAPRI: Vallorii's Price of Risk model for infrastructure cost of equity

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VAPRI is an alternative to CAPM to estimate cost of equity for infrastructure. CAPM is "top-down" and relies on stock prices. VAPRI instead goes "bottom-up" with granular modelling of business risks. New academic research gives VAPRI a conceptual foundation for use by regulators, investors and utilities.

Based on **"A new approach to cost of equity for private infrastructure",** Lennart Baumgärtner, Jorge Cárdenas Prieto, Cameron Hepburn & Robert Ritz. EPRG Working Paper 2620 / Cambridge Working Papers in Economics 2671, August 2026.

EXECUTIVE SUMMARY

CAPM has been the workhorse model for cost of equity across regulated utilities but is reaching its limits. Implementing CAPM requires a stock price or a peer group of listed comparables for the asset in question. Yet many assets are not listed: only a third of UK regulated energy & water companies remain listed—even fewer are pure plays. The infrastructure context also clashes with CAPM's assumptions: project risks are often skewed downwards (not symmetric), infrastructure investors are often not widely diversified (don't hold "the market"), and political & regulatory risk cannot easily be hedged. Both regulators and investors increasingly recognize the need for a new approach.

In response to these challenges, Vallorii has built VAPRI—the Vallorii Price of Risk model. VAPRI builds the cost of equity bottom-up from probabilistic modelling of a project's cash flows. It prices total business risk from an investor perspective. Implementation does not require stock-market listing or a peer group. Government and regulatory risk-sharing mechanisms have become central to large infrastructure; unlike CAPM, VAPRI can estimate the implications of different support packages. The large nuclear project Sizewell C is a case in point: the Secretary of State rejected CAPM; the ensuing bid process revealed a cost of equity around 400 basis points above CAPM, even with government risk-sharing.

The VAPRI approach now has an academic foundation. A new working paper at Cambridge University, written by Vallorii co-authors, establishes when a total-risk model like VAPRI estimates cost of equity better than CAPM. It is horses for courses, and the conditions can be tested. Unlike CAPM, VAPRI can explain investor behaviour in Sizewell C.

1 Cost of equity matters in infrastructure

How to allocate capital to infrastructure is one of the defining questions in policy, regulation, and asset management in the next decade. Assets like electricity grids, water networks, airports, electricity generation and data centres will operate for decades to come, locking up capital for the long-term. Getting capital allocation in this sector right is an imperative to long-term growth and sustainability.

The cost of equity is a key determinant of capital allocation. Risky investments warrant a high cost of capital. Investors must decide how much return they require to compensate for the risk borne. Regulators determine the fair trade-off between higher bills and higher return.

UK utility regulators traditionally seek to answer this trade-off with the Capital Asset Pricing Model (CAPM). This practice traces back to a 1972 academic recommendation that US regulators use CAPM for the allowed WACC. Today, it is codified in most regulatory guidance.

This approach has been workable for decades but is increasingly at odds with reality. Firstly, bond markets and inflation expectations point towards a materially different macroeconomic environment with higher-for-longer interest rates and inflation. Secondly, many infrastructure assets have been run down and are no longer compliant with environmental regulation. Thirdly, there is a step-change in greenfield infrastructure investment; estimating cost of equity requires a model that works absent a stock price or obvious peer group.

The question therefore becomes: is CAPM really the best model at all times, for every asset and every investor? New research sheds light on when an alternative modelling approaches to cost of equity can do better than CAPM.

2 Where CAPM reaches its limits

Two problems arise in the application of CAPM to infrastructure assets, one practical and one conceptual.

The comparators are disappearing

Implementation of CAPM requires either that an infrastructure asset is listed on the stock market or that suitable listed comparators exist. But the comparator set has thinned since privatisation, as companies delisted into private ownership.

Of the fourteen regulated energy entities in Britain, two are listed, National Grid and SSE, and neither is a pure play. Three of the regulated water companies in England and Wales are directly listed. Overall, less than a third of UK regulated companies are listed. With poor comparators, a hurdle-rate estimate from CAPM is both noisy and biased.

Moreover, CAPM relies on sufficient historical data to estimate betas. If the future looks different from the past in infrastructure, this becomes an issue. That is especially true for sectors undergoing large operational changes, such as energy networks moving from a yield to a growth environment.

The theory sits uneasily

CAPM assumes risks are symmetric and prices only “systematic” risk that cannot be diversified. The reasoning is that a well-diversified investor should be indifferent to other risks—and should not need compensation.

Three features of infrastructure make these assumptions fragile. First, infrastructure returns are often skewed to the downside, such as through construction cost overruns. Second, infrastructure investors are far from fully diversified: direct investors often hold stakes in a handful of companies, and even large funds might not hold more than ten to twenty assets. Third, projects face political and regulatory uncertainty that cannot easily be hedged.

Governments and regulators appear to be increasingly aware of CAPM's shortcomings. Sizewell C, a new nuclear energy project, is a case in point. In the 2025 equity raise process, CAPM was rejected by Secretary of State despite regulatory guidance. Instead, equity investors were asked to bid a cost of equity for the construction phase. The process produced a cost of equity of 10.8% (in real terms), compared to Ofgem's CAPM-based 5.70% cost of equity for regulated electricity networks. Getting to 10.8% through CAPM would need an equity "beta" of almost two, which observed data on infrastructure assets does not support.

In short, CAPM reaches its limits in today's infrastructure environment. What other approach can governments, regulators, and investors deploy?

3 VAPRI: pricing total risk, from the bottom-up

Vallorii's Price of Risk model (VAPRI) addresses this gap. It estimates the cost of equity bottom-up, from stochastic modelling of an assets projected cash flows. Three features distinguish it from CAPM.

First, VAPRI prices the asset's total risk, including the component CAPM excludes as idiosyncratic. In words:

hurdle rate = risk-free rate + (**investor's price of risk** × **project's total risk**)

The price of risk describes the risk-adjusted return they earn across their portfolio holdings, also referred to as Sharpe Ratio. The project's total risk is the variance of its returns. For example, newly built asset with contracted revenues has very cash flows with low variance. A risky nuclear project, in contrast, has high return variance. Total risk is affected by any government support or regulatory concessions.

Second, VAPRI does not depend on a stock market listing or on the existence of an appropriate peer group. Total risk is estimated from the asset's cash flows and its sensitivities, using econometrics or machine learning on the underlying risk factors. Where the asset is listed, total risk can also be estimates from historical stock returns, making the approach more flexible than CAPM.

Third, it is closer to what infrastructure investors actually do. A fund with a sector or country mandate is undiversified by design. These 'industry bets' are what drive outperformance. The corporate finance literature has long recorded that firms use discount rates in excess of what CAPM implies and set higher hurdle rates for projects with greater idiosyncratic risk. VAPRI captures that behaviour rather than treating it as an error.

Neither VAPRI nor CAPM are perfect, so the question becomes which model is preferred in practice?

4 The approach: two simple models within a general one

Rather than treating VAPRI and CAPM as two distinct models, both can be viewed as special cases of a more general asset pricing model. However, the general model can be difficult to implement in practice. Comparing both CAPM and VAPRI to the generalisation allows us to pick a model best suited for the data available

Step one: derive the general model that contains both. From a standard portfolio optimisation problem, with mean-variance preferences and no short sales, the true hurdle rate for any investor is:

hurdle rate = risk-free rate + (**price of risk** × **correlation between asset and portfolio** × **project's total risk**)

This general model is more complex than both VAPRI and CAPM since it accounts for the degree of diversification an investor has with the asset.

Both CAPM and VAPRI fall out of this general model. CAPM assumes the investor portfolio is equal to the entire equity market. VAPRI assumes a single-asset investor portfolio that does not hold any additional assets.

Step two: treat CAPM as a special case, not a benchmark. CAPM is what the general model collapses to for a fully diversified investor who holds the market portfolio.

Step three: build VAPRI as another special case. At the other extreme sits an investor holding a single asset, for whom the asset and the portfolio are the same thing. For her, the price of risk applies to total risk, and this is reflected in the cost of equity.

5 Horses for courses

There are two conditions that define whether VAPRI or CAPM is the preferred model for an investor.

The first condition is the correlation of the asset return with the existing investor portfolio. With high correlation, VAPRI is preferred. These are the specialised funds with limited ability to diversify. With low correlation, CAPM is the better model choice. This holds for funds that can diversify widely.

The second condition is the correlation of the asset return with that of the wider equity market. If an asset is closely correlated with the market, there is little difference between VAPRI and CAPM, so CAPM is the preferred model since it captures the diversification value of an asset, even if there is little diversification.

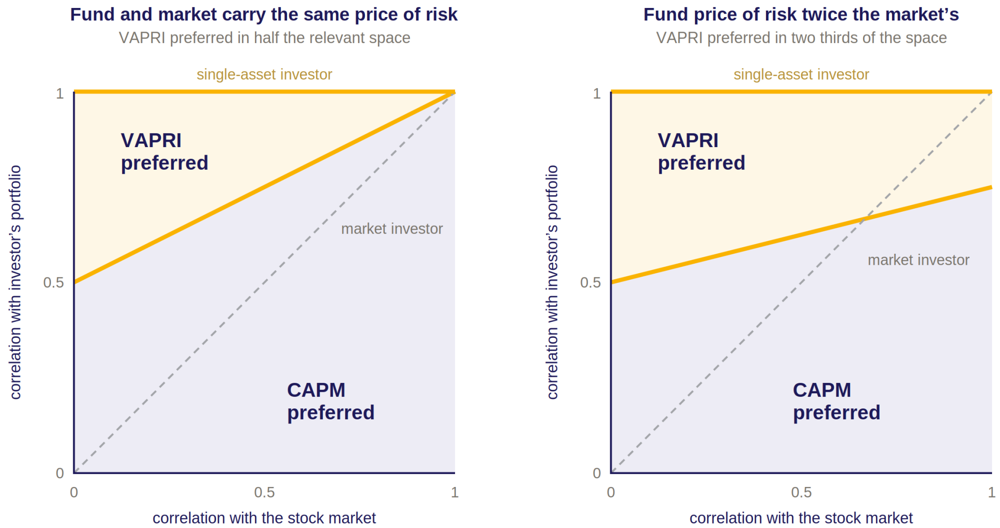

Figure 1. Which model is preferred, and for whom. The gold threshold line separates the region where VAPRI has the smaller error from the region where CAPM does. The dashed diagonal is the fully diversified market investor, who always prefers CAPM; the top edge is the single-asset investor, who always prefers VAPRI. The empirically relevant region is above the diagonal, because a new infrastructure asset is usually more correlated with an existing infrastructure portfolio than with the wider stock market. Redrawn from Figures 1 and 2 of the working paper.

The geometry of both conditions is shown in Figure 1. The left panel shows a situation where the market and an infrastructure fund carry the same price of risk: their Sharpe ratios are identical.

The most relevant part of the space is where correlations are positive but the asset is more strongly correlated with the investor's portfolio than with the wider market. This space is to the north-west of the 45 degree line.

VAPRI is then preferred across exactly half the relevant space. As expected, this corresponds to a relatively concentrated investor. The fully-diversified market investor always prefers CAPM.

Instead, in the right panel, where the fund's price of risk is twice the market's, VAPRI is preferred across two thirds of the relevant space. This case corresponds to recent investor estimates: by some estimates, over 2005 to 2024, private infrastructure has run a Sharpe ratio of around 1.0 against roughly 0.5 for global equities. Measuring unlisted performance is difficult but this directionally favours VAPRI for better-performing funds.

The conditions can be calibrated. For an asset with an equity beta of 0.50 and 20% volatility, in a market with a 5% equity risk premium and 15% volatility, the implied asset-market correlation is 0.375 and the threshold correlation with the investor portfolio is 0.688. These can be tested against an actual investor portfolio.

Applied to Sizewell C, the reconciliation is straightforward. With a real risk-free rate of 2.5% and a portfolio price of risk of one third, the observed 10.8% corresponds to project risk of 24.9%, which sits between the two highlighted cells in Figure 2. This is not implausible, given that nuclear projects worldwide have a mean cost escalation of 117%. Losing bidders must have held a higher price of risk or a higher estimate of project risk. This reflects a “nuclear-specific risk premium”.

	PROJECT TOTAL RISK				
Portfolio price of risk	10%	15%	20%	30%	40%
1/6	4.17%	5.00%	5.83%	7.50%	9.17%
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%

Figure 2. Applying VAPRI to Sizewell C. Cost of equity implied by a total-risk model at a real risk-free rate of 2.5%. The bid-revealed 10.8% falls between the two outlined cells, at a portfolio price of risk of one third and project risk of 24.9%.

6 What follows for investors, utilities and regulators

Implications

The choice of cost-of-equity model should be made deliberately for the case at hand. For a listed whole-business utility, with a credible peer group and diversified holders, CAPM can be a good choice. For greenfield infrastructure investments with no or limited listed comparators, held by a small set of concentrated investors, a total-risk approach performs better. The paper gives regulators, utilities and investors guidance on the conditions under which different models are likely to provide better estimates in each case. The answer will vary by project and by investor.

Implementation

Putting a total-risk model like VAPRI to work requires estimating the project's total risk, either from stock prices where they exist or, for greenfield, from bottom-up stochastic modelling of cash flows. VAPRI decomposes total risk into individual risk factors, such as construction and operational risk, macroeconomic and geopolitical exposure, and financing risk. Each risk factor is calibrated bottom-up using traditional and AI-enabled data. Correlations between risk factors are also modelled. The output is a distribution, not a single number.

Government and regulatory risk-sharing mechanisms have become central to large infrastructure; unlike CAPM, VAPRI can estimate the cost-of-equity implications of different support packages. This requires running VAPRI several times for different de-risking packages, obtaining the resulting cost of equity estimates, and using decompositions to understand what is driving any differences.

This paper does not constitute financial advice. It is part of a series of Vallorii thematic papers that sets out new ideas on infrastructure regulation, cost of capital, valuation and asset allocation. For constructive feedback, and without necessarily implicating them in the paper's viewpoint, the author is grateful to a number of regulators, investors and utility leaders.