Time for a change? Cost of capital for future-proof infrastructure

Thematic Paper, March 2025

1. A pivotal moment of change in infrastructure investment

The coming years will be critical in determining how the world responds to societal challenges, including climate change, and infrastructure will play a critical role. Our estimates suggest capex needs of £169bn over the next five years to 2030 in key UK regulated infrastructure sectors: electricity transmission & distribution, water & wastewater, and rail: an increase of 63% over the previous five-year period (see Figure 1). In the eyes of both the general public and infrastructure players, it is deeply uncertain if, how and by when these investment volumes can actually be delivered. It will require a shift from the "harvest" regime that followed privatization of maximizing value from existing assets, often relying on debt financing, to a new "growth" regime of building new assets—and raising fresh equity.

Getting the cost of capital right will be critical to unlocking new investment. On one hand, setting the cost of capital too low risks investability—notably in a world where the UK competes internationally for mobile capital. On the other hand, setting it too high ultimately increases already-stretched consumer bills and risks affordability. The job of regulators will be to navigate this basic trade-off to find the "Goldilocks" point that minimizes the social cost of delivering investment. This trade-off also interfaces with how risks around project outturns are shared between consumers and investors—which is also a function of the regulatory regime underpinning the investment.

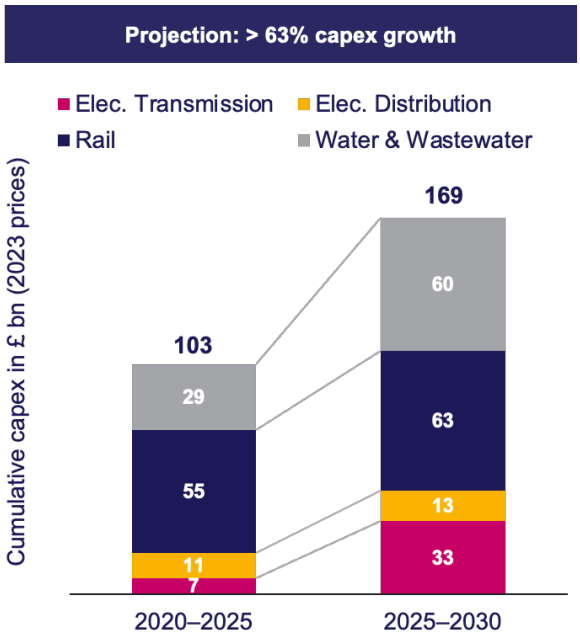

***Figure 1**: Over the next 5 years, capex requirements in key UK infrastructure sectors are projected to exceed £169 billion*[1]

Changes since 2020 in the macroeconomic and financial environment pose three new challenges to infrastructure investment. The first is the change in interest rates: both nominal and real rates in Europe and North America have left the "zero lower bound" environment of the 2000s and 2010s, with the UK (nominal) yield on 10-year gilts almost reaching 5% in January 2025. The second stems from stretched balance sheets: during the years of very low interest rates,

[1] Sources: Electricity Transmission: Ofgem: RFPRs & RIIO-T3 Business Plans; Electricity Distribution: Ofgem: RFPRs & DESNZ: Appendix I: Electricity Networks Modelling; Water: APRs & PR24 FD; Rail: Annual Reports (Network Rail & HS2 Ltd.) & NIC: 2nd National Infrastructure Assessment

infrastructure relied heavily on debt financing. Elevated gearing levels for many players, notably in the water sector, now means raising fresh equity is required to fund the additional capex. The third is a less optimistic wider macroeconomic and fiscal outlook.

Going forward, the question for the UK and other countries is whether current RAB-based regulation will be sufficient to deliver the step change in capital investment. If, as some stakeholders believe, the answer is "no"—or "perhaps"—then a rethink is needed. An incremental approach retains the basic structure—RAB-based regulation with use of the Capital Asset Pricing Model (CAPM) to estimate the cost of capital—but seeks improvements in implementation. A more radical approach shifts to a different model of the cost of capital that replaces CAPM.

2. Is the current approach to the cost of capital fit for purpose?

CAPM forms the bedrock of UK regulatory policy to set allowed returns for a regulated business. Historical stock market data yields an estimate of the "beta" of a company's equity which reflects its riskiness relative to the overall stock market. Together with the risk-free interest rate and the expected equity market premium (market return in excess of the risk-free rate), CAPM yields an estimate of return on equity—which, in a competitive market equilibrium, also equals its cost of equity. Together with the cost of debt, this translates into the allowed return on a company's regulated asset base (RAB) over the regulatory cycle. These allowed returns from the RAB, in turn, make up a large share of infrastructure revenue—around one third in the UK energy and water sectors, for instance—and are thus also a key driver of infrastructure valuation.

CAPM is based on a set of well-known assumptions drawn from mid-20th century neoclassical economics. [2] Investors like returns but dislike risk—and stock market risk-returns are assumed to be symmetric without any "fat tails" (that deviate from a normal statistical distribution). Investors can access a representative global market portfolio that spans all countries and sectors and are able to borrow and lend at the risk-free rate. Given this, investors are rational optimizers who hold well-diversified portfolios. As a result, higher returns are warranted only for bearing systematic risk from exposure to the stock market that cannot be (freely) diversified away in the way that idiosyncratic, project-specific risk can. On one hand, much has been written about how restrictive these assumptions are. On the other hand, they give CAPM the great advantage of being straightforward to implement—even if the dearth of publicly listed infrastructure companies to use as a peer group for return estimation is increasingly proving a challenge for unlisted regulated infrastructure (owned by private equity or mutually-owned).

A further set of assumptions takes CAPM into UK regulatory practice. There are three main components to this. First, regulatory practice estimates a single weighted average cost of capital (WACC) for a regulated business, rather than deriving more granular project-specific WACCs. Second, a regulated company's beta is

[2] See William Sharpe (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance*

typically treated as constant with respect to time over the regulatory cycle. Third, regulation relies on the concept of a notional (that is, hypothetical sector-representative) gearing level that also does not change over the regulatory cycle (even if the regulated companies may alter their actual capital structure). These three components yield a single WACC for a company's activities over the regulated period; risks judged by CAPM to be project-specific are not compensated (of course, regulatory practice involves many more detailed points of implementation, but these are not the focus of this paper).

While past returns to some infrastructure investors have been high, the outlook to 2030 and beyond is now much more uncertain. Infrastructure as an asset class has been driven by the promise of good (inflation-proof) and stable (bond-like) returns. Indeed, evidence from the US suggests that regulated energy infrastructure has over the last two decades made returns well in excess of its regulated returns.[3] A key reason was that the steady decline in interest rates only sluggishly fed through in form of lower regulated returns, thus leading to "excess" returns. The future may not be like the past, given the shifts in the macroeconomic and financial environment combined with a stronger public stance against underinvestment in physical assets. There is also a risk that regulation—which was arguably too generous in the past, at least in some instances—gets tightened for the wrong reasons and at precisely the wrong moment.

Our informal survey in January 2025 of a group of 23 senior leaders across UK utilities (see Figure 2), regulators and investors suggested broad agreement around two

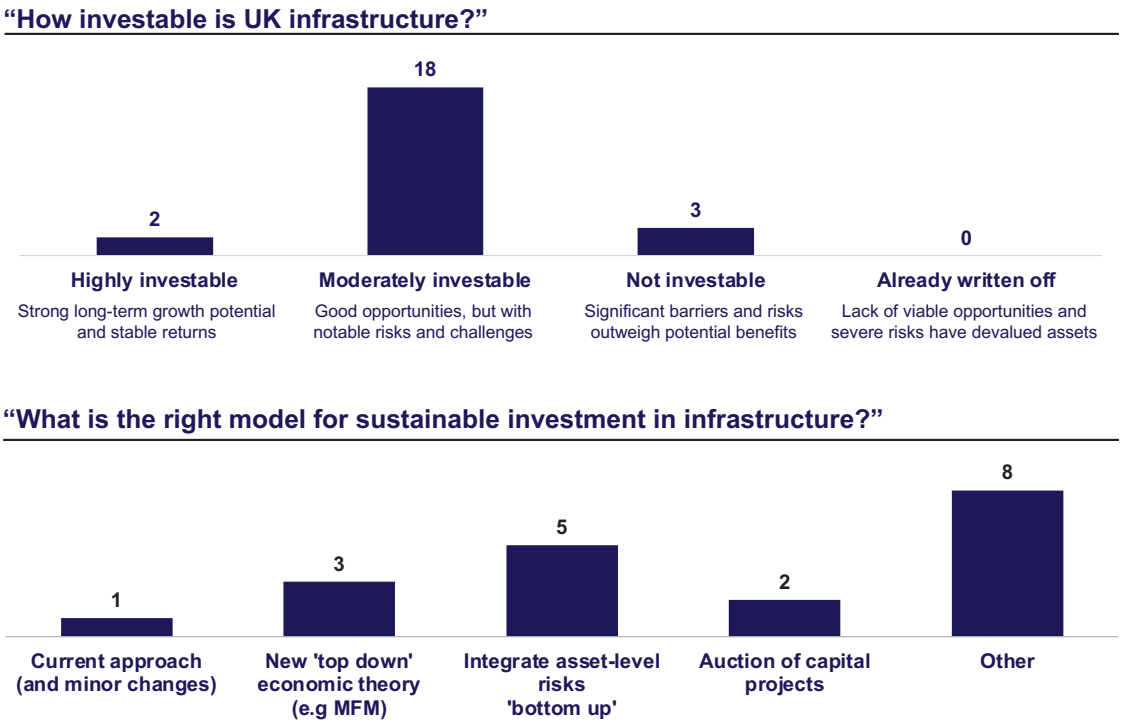

***Figure 2**: An informal survey of 25 senior UK infrastructure leaders reveals a mixed picture on investability and little clarity on alternative regulatory approaches*

See Rode, David, C. & Paul S. Fischbeck (2019). Regulated equity returns: A puzzle. *Energy Policy* and David Havyatt, David & David Johnstone (2024). Estimating the cost of equity for performance-based regulation: Important consequences from finance theory. *The Electricity Journal*

themes. One is that a majority thought that UK infrastructure is "moderately investable", albeit with significant differences across sectors—itself a potential critique of the "one size fits all" use of CAPM. Another is no consensus on what exactly the required changes to deliver on higher capex needs actually are—including if these need to be incremental or more radical. Strikingly, however, only one person in the group thought that the current approach based on CAPM is the right one. This suggests a need for (re-)testing the underlying premises of the regulatory practice from first principles.

3. A balanced framework to assess cost-of-capital analytics

Assessing the benefits and drawbacks of the status quo in regulatory practice on the cost of capital requires a balanced framework to evaluate the CAPM-based modelling approach—as well as potential alternatives. Such an assessment framework needs a set of criteria that reflects what the modelling is meant to deliver. An important observation is that the infrastructure sits within the wider context of what government policy is seeking to achieve; estimation of cost of capital here is not *solely* a question of financial asset pricing; it sits within the wider context, remit and objectives of regulation.

Important work in the mid-late 2010s by the UK Regulators Network [4] established two criteria to assess cost-of-capital analytics, namely that a modelling approach is:

- **"Empirically implementable"** in that the required data are easily accessible to regulators and other interested stakeholders;
- **"Empirically defensible"** in that the empirical results it delivers are robust, for example, in that estimates of "beta" are stable over time.

These two criteria together pointed to the use of a "plain vanilla" CAPM approach to the cost of capital, not least given the existing experience in its practical application.

While these two assessment criteria remain relevant, they also reflect the relatively narrow remit under which they were produced. At the time of the mid-late 2010s, climate change, wider consumer and societal challenges, and the case for system change did not feature in regulatory objectives. These developments, in turn, are the basis underlying the need for higher capital expenditure in critical infrastructure sectors. The set of model selection criteria therefore needs to be augmented to be reflective of where the journey is going.

A more balanced set of criteria adds three considerations to these criteria:

- **capture the "realities of the regulatory framework"**, including representing how regulation shape risks and returns and mandates on net zero and social objectives;
- **capture the "realities of capital markets"**, including investor perceptions of risk factors, the question of "optimal" gearing, and institutional characteristics such as limited diversification of investors;
- **be "theoretically defensible"**, by representing economic and financial

[4] UK Regulators Network (2018). Estimating the cost of capital for implementation of price controls by UK regulators. Technical report by Stephen Wright, Phil Burns, Robin Mason and Derry Pickford

mechanisms with plausible causal interpretations

Figure 3 proposes a structure that combines these three criteria with those of UKRN. The structure refines "defensible" to span both theory and empirics, and adds two criteria around being "representative".

replicate regulatory approaches to the cost of capital.

CAPM meets some of this richer set of assessment criteria but does less well against others. It is empirically implementable—even if struggling with the dearth of publicly listed UK infrastructure—and empirically defensible in certain

Criterion		Description	Most important to?
1 IMPLEMENTABLE	Empirically implementable	• Readily usable by stakeholders and based on widely available data	Investors, regulators, utilities
2 REPRESENTATIVE	(A) Realities of regulatory framework	• Represents how regulation shapes returns and risks, with mandates on net zero and social objectives	Regulators, utilities, society
	(B) Realities of capital markets	• Captures investor concerns such as political risk and institutional factors such as limited diversification	Investors, utilities
3 DEFENSIBLE	(A) Theoretically defensible	• Represents economic and financial mechanisms that have plausible causal interpretations	Regulators, society
	(B) Empirically defensible	• Can be implemented with limited user discretion and yields results that are sufficiently robust and stable	Investors, utilities, regulators

Figure 3: *A balanced set of assessment criteria can be used to evaluate different approaches to modelling the cost of capital for infrastructure*

Different criteria will be of central importance to different infrastructure stakeholders. Regulators will certainly care about both empirical implementability and defensibility—and should also value theoretical defensibility as a way of avoiding arbitrariness of the model results. Utilities are naturally concerned about the realities of the regulatory framework as they see it and about the realities of capital markets—not least in the new world of a growth regime with a step change in funding requirements. Investors will also care about empirical implementability and their ability to

economic regimes based on UKRN's earlier analysis; it is also theoretically defensible in that it is rooted in traditional economic theory, albeit this theory having evolved since CAPM's inception in the 1960s. Less clear is how well it captures the realities of the regulatory framework, not least because regulation can play no role under CAPM's assumption that markets are efficient—there is nothing to regulate from the outset. Also less clear is how it captures realities of capital markets, in which infrastructure investors pay attention to a wide array of risk factors including climate, geopolitical, and cyber risk that are hidden away under CAPM.

4. Alternative modelling approaches from finance and machine learning

Game-changing advances in data science and financial economics have opened the door for new modelling approaches to the cost of capital. Today we have access to big and granular data on economic, financial and social metrics that simply did not exist even 5 or 10 years ago; new large-scale data and computational modelling tools such as LLMs (large language models), AI and machine learning have become mainstream. CAPM, by contrast, has not fundamentally changed since the 1960s. Indeed, the frontier of the finance literature and investment practice abandoned CAPM long ago, not least by honing in on the many "anomalies" that it produces in its inability to explain observed asset returns.[5]

One family of alternatives takes a top-down perspective using richer "factor" models. These modelling approaches add additional return drivers and betas beyond the overall stock market return and the single-market beta of CAPM. On the macro side, these factors include systematic risks like GDP and inflation, credit spreads, the yield curve in the bond market, and some commodity price fluctuations.[6] This extends to emerging risk factors such as geopolitical, regulatory and trade risk. The point is that these risk factors are just as systematic as overall stock market risk and investors cannot (fully) diversify them away. On the micro side, factors include company-specific characteristics ranging from price-to-book ratios, company size to stock price momentum. [7] A burgeoning finance literature has found many other relevant factors—which can be tailored to infrastructure investment. It is by now well-established that these additional factors significantly improve the explanatory power in terms of observed asset returns. This also manifests itself by way of global inflows of $800bn in AuM (assets under management) into factor-ETFs (Exchange Traded Funds) since 2010. [8] This, in turn, shows that investors are already willing to commit significant capital to factor-based asset returns.

A promise of top-down approaches is greater congruence with the set of assessment criteria; a challenge is around the choice of which factors to employ. On one hand, a wider range of factors affords greater model flexibility and an enhanced ability to replicate the realities of capital markets and regulatory practice than what is possible under CAPM. On the other hand, unlike with CAPM, the choice of risk factors requires serious analysis—which factors matter may vary by company, by sector, and by country. Moreover, their relevance may evolve over time: for example, as an asset-pricing anomaly becomes recognized in the investment community, the factor's explanatory power can fade. The challenge for regulatory practice is to develop a framework on risk factors that aligns with the assessment criteria on cost-of-capital modelling. It is also worth highlighting that

[5] See John Cochrane (2011). Presidential address: Discount rates. *Journal of Finance*; Theis Ingerslev Jensen, Bryan Kelly and Lasse Heje Pedersen (2023). Is there a replication crisis in finance? *Journal of Finance*

[6] See Stephen Ross (1976). The arbitrage theory of capital asset pricing. *Journal of Economic Theory* and Nai-Fu Chen, Richard Roll & Stephen Ross (1986). Economic forces and the stock market. *Journal of Business*

[7] See Eugene Fama and Kenneth French (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*; Eugene Fama and Kenneth French (2015). A five-factor asset pricing model. *Journal of Financial Economics*; Eugene Fama and Kenneth French (2018). Choosing factors. *Journal of Financial Economics*

[8] Source: Blackrock via https://www.ft.com/content/e0f98278-432e-4ece-b170-2c40e40d2835

the addition of risk factors does not necessarily imply that a higher cost of equity than what would be estimated under CAPM; the idea is to obtain a more precise estimate of required returns rather than a higher (or lower) number.

A second approach flips the perspective to a bottom-up model. It aims to reconstruct the fundamental economic drivers of cash flows—often down to the project or asset level—and aggregate them back up into a cost-of-capital estimate. This is where big/granular data and AI allow much richer analysis of construction, operational and other risk factors than has been possible in the past. It is now possible to assess these metrics at the project- and asset-level, for example, by leveraging satellite data and other real-time data streams. While some bottom-up modelling has been deployed in regulatory practice around cost-benefit analysis, it has yet to be established in the context of the cost of capital. This level of granularity also makes it possible to depart from the assumptions currently used to take CAPM into regulatory practice—notably a single company-wide WACC that remains fixed over time. Neither assumption is necessary; data science makes possible spatially and temporally granular estimates of the cost of capital. The challenge for regulatory practice is how to integrate such disaggregated analytics into a transparent framework, especially if different parts of a regulated business exhibit distinct risk profiles.

Top-down factor modelling and bottom-up analytics are not the only routes for determining allowed returns. One possibility is an auction-based approach, whereby infrastructure projects—or at portions of them—are competitively tendered so that capital providers effectively "bid" their required returns. This can, under the right conditions, reveal market-clearing prices for risk and incentivize cost discipline. It may be that no single "silver bullet" model emerges as the right answer to all questions at all times. Instead, the future might lie in a combination of approaches that is better suited to deal with the uncertainties around the cost of capital. One advantage in this respect is that other approaches—bottom-up and top-down—come with valuable experience and precedent from financial economics.

5. A call to action for regulators, government, and investors

Regulated infrastructure stands at a crossroads with an unprecedented investment challenge driven by net zero commitments, rising interest rates, the need to replace or upgrade aging assets, and consumer affordability pressures. At the heart of meeting this challenge lies the cost of capital. Near-term choices made by governments and regulators will be crucial in determining what investments are made into the 2030s.

Current regulatory practice effectively adopts a "corner solution", with a single CAPM market risk factor from CAPM and a single WACC, supplemented by "cross-checks" of different model specifications. Is this still the optimal approach? Data science and financial economics have made great strides over the last decade, thereby expanding the "solution space" that regulation can draw upon. Any new approach needs to be able to demonstrate tangible advantages over the status quo.

In our interviews with senior infrastructure leaders spanning regulators, government and investors, three high-level perspectives emerged:

1. **"CAPM Revamp":** Proponents of this view still see CAPM as a robust foundation for cost-of-capital estimation but seek refinements and greater rigor—for example, improved peer group selection, estimates that reflect actual company gearing rather than notional gearing, and using a long-term equity risk premium (ERP) in addition to the Total Market Return to reflect shifts in risk-free rates. The next steps in this view are to identify best practices from across different sector regulators and different jurisdictions, and to figure out how much adaptability remains within the current paradigm

2. **"CAPM+ Evolution":** Others suggest that CAPM remains a useful starting point but in some instances needs to be augmented by factor modelling in form of company-level and/or systematic/macroeconomic variables. This perspective acknowledges that systematic risk for infrastructure can be multidimensional, especially during periods of rapid capacity expansion and macroeconomic volatility. The next steps in this view are to build on the current modelling foundations to obtain a richer set of risk factors that more accurately describes forward-looking required returns, aligned with the balanced assessment criteria;

3. **"Bottom-up Pivot":** A more radical camp argues that CAPM-type approaches are simply ill-suited to capturing the highly granular—and potentially correlated—risks faced by modern infrastructure businesses. They point to AI-driven, asset-level analytics, that can precisely distinguish risk premia for different project types, technology deployments, or geographical regions. The next steps in this view are a proof of concept of the bottom-up approach to the cost of capital that leverages advances in data science and whose results can be compared and contrasted with those of CAPM.

No matter where one sits on this spectrum, it seems inevitable that regulatory practice will be tested over the upcoming review cycles. Electricity transmission sees Ofgem's RIIO-T3 by 2026; electricity distribution sees RIIO-ED3 by 2027; Gas transmission and distribution see RIIO-3 by 2026; telecoms will see Ofcom's Telecom Access Review by 2026; the rail sector will have CP8 by 2029, and water will have Ofwat's PR29 in 2029. Each represents a potential window of opportunity for incremental or more radical reforms. While it is unlikely that any regulator can—or should—pursue an overnight revolution, finding a "zero constraints" long-term vision can help clarify the direction of travel and thereby also guide near-term changes.

One concrete interim solution is to move towards using several modelling approaches in parallel. In so doing, regulators, investors, and consumer groups can gain deeper insight into how different modelling assumptions affect allowed returns—and, ultimately, which approach best delivers the balance of affordability, attractiveness to capital, and societal objectives. Over time, experience from a "multi-model" approach can inform convergence to a new and better model or combination of models that proves itself most robust.

This is the first paper in a series of Vallorii thematic papers that sets out new ideas on infrastructure regulation, cost of capital, valuation and asset allocation. The authors are Robert Ritz, Lennart Baumgärtner, Jorge Cardenas and Sandy Arbuthnott. Thanks for help to Dieter Helm, Cameron Hepburn, Ranjita Rajan, Henry Tian, Cassandra Etter and Cassian Burger. For constructive feedback, and without necessarily implicating them in the paper's viewpoint, the authors are grateful to a number of regulators, investors and utility leaders.