

Futureproofing the ASX: Integrated Value and Transition Risk Pricing in Australian Capital Markets

*Externality-exposure measurement under
inaugural AASB S2 disclosures, with exploratory pricing evidence*

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Abstract

We apply the Integrated Value (IV) framework of Schoenmaker and Schramade (2023) to 25 economically material ASX-listed non-financial companies, using inaugural FY2025 AASB S2 climate-related disclosures together with sustainability reports, regulatory filings, and public financial data at a common 30 June 2025 valuation date. For each firm we compute a Futureproofing Ratio ($FR = 1 + TOR - TRR$) that expresses monetised positive (TOR) and negative (TRR) social and environmental value flows relative to financial enterprise value. The study is deliberately positioned as a data-constrained measurement application: the intersection of mandate coverage, economic materiality, and usable disclosure is small in the first reporting year, and reporting dates, boundaries, and Scope 3 completeness remain heterogeneous. Two methodological contributions follow from those constraints — a tiered Scope 3 imputation procedure and a four-stream mining-waste classification that separates tailings and overburden from standard waste streams and prices each at distinct, institutionally grounded rates.

Under the maintained assumptions, the estimates show wide sectoral dispersion. The value-weighted FR is -2.029 : gross negative externalities amount to approximately 4.05 times aggregate financial enterprise value and gross positive externalities to approximately 1.02 times, with the negative tail concentrated in coal, iron ore, hydrocarbons, and coal-fired generation, and the healthcare/technology group above unity. A $\pm 50\%$ sensitivity on the two novel mining-waste prices moves the value-weighted FR by less than 12% and leaves every firm ranking unchanged; rankings are also invariant, by construction, to the choice of social discount rate.

We then report an exploratory cross-sectional association between TRR and implied cost of equity. TRR and GLS-implied COE are positively rank-correlated (Spearman $\rho = 0.608$, $p = 0.001$, $N = 25$; $\rho = 0.783$ under an independent Yahoo Finance implementation), and the TRR coefficient is positive in all four OLS specifications. Under the paper's pre-stated three-method rule (HC3 $p < 0.05$, FL- $p < 0.05$, and bootstrap CI excluding zero), no specification clears all three thresholds on the primary dataset: Spec 1 has HC3 $p = 0.044$ and bootstrap CI excluding zero, but FL- $p = 0.055$ exceeds the pre-stated threshold. We are explicit that this association cannot be separated at $N = 25$ from sector composition and book-to-market: removing the six Materials firms eliminates conventional significance, and asymptotic and bootstrap intervals in the full-control specifications include zero. The result is therefore presented as a directional consistency check that motivates — and does not substitute for — a pre-specified pooled DAX–AEX–ASX test. Implications for investors, superannuation trustees, and disclosure policy are drawn at the level the evidence supports.

Note on scope: The opportunity side of the FR (TOR) is reported in the measurement section and descriptive statistics but is excluded from all regressions. At $N = 25$, TOR's persistently positive coefficient reflects sector-composition confounds rather than a genuine opportunity signal; its regression analysis is deferred to the pooled DAX–AEX–ASX study.

1. Introduction

Company valuation sits at the foundation of capital allocation. Yet the dominant tools for performing it — discounted cash flow, price-earnings multiples, price-to-book — share a structural blind spot: they treat social and environmental externalities as exogenous to value. Climate change, biodiversity loss, and the social costs of labour practices are forward-contingent liabilities that can reshape cash flows, regulatory exposure, and competitive position. When they crystallise — through carbon pricing, litigation (Wetzer, Stuart-Smith and Dibley, 2024), consumer behaviour change, or technological substitution — they tend to arrive as shocks rather than gradual adjustments (Loorbach, Frantzeskaki and Avelino, 2017; Bolton et al., 2020; Schaltegger, Loorbach and Hörisch, 2023). A useful measurement question is therefore how large a firm's externality exposure is relative to its financial value — while keeping clear that a measured externality is not the same thing as the probability, timing, or incidence of its future internalisation.

This paper applies the Futureproofing Ratio (FR) — integrated value divided by financial value, where integrated value adds monetised social and environmental externalities to conventional enterprise value (Schoenmaker and Schramade, 2023) — to the Australian market. Schramade, Schoenmaker, Wiedemann and Marijnissen (2026) calculate FRs for 52 non-financial AEX and DAX 40 companies using FY2024 data and document large sectoral dispersion. What is new here is the setting and the data infrastructure. Australia's industrial composition is heavily tilted toward resource extraction, which makes it a demanding test of the framework rather than a geographic replication: the world's largest thermal coal exporters, iron-ore producers, and coal-fired generators have no counterpart in the DAX–AEX sample. And the Treasury Laws Amendment (Financial Market Infrastructure and Other Measures) Act 2024 introduced mandatory climate-related disclosure under AASB S2 from 1 January 2025 for Group 1 entities, with the first wave of Group 1 reports appearing in Q1 2026 — creating, for the first time, a public data infrastructure that can support systematic firm-level externality measurement in this market. The global backdrop is one of uneven compliance: the EU Omnibus I Directive (Directive (EU) 2026/470, in force 18 March 2026) narrows the CSRD's scope while Australia's regime strengthens.

Two binding constraints. Before stating the contribution, we state the two constraints that shape everything that follows, because they are structural rather than discretionary. First, *the sample cannot be large*. In the first year of mandatory reporting, the number of ASX-listed companies that fall within the Group 1 mandate, are economically material by revenue or market capitalisation, and disclose enough usable environmental and social data to construct an FR is small. Financial Services and Real Estate are excluded because the current FR implementation and available disclosures do not support comparable measurement for those sectors. The 25 firms studied here are, in our judgement, close to the practicable ceiling for FY2025; adding smaller or less-disclosing firms would create an appearance of statistical power while lowering comparability and increasing imputation dependence. Second, *disclosure quality is heterogeneous*. Even among reporting firms, formats, reporting periods, organisational boundaries, assurance status, and Scope 3 category coverage differ. Reported and imputed inputs are

therefore not equally precise, and we label them accordingly rather than treat all firm-level FRs as equally sharp. We believe the resulting dataset is the best that can be assembled for the current disclosure environment; we do not claim it is a standardised research dataset, and we do not claim it is a representative cross-section of the ASX.

What this paper does and does not claim. Given those constraints, the paper's primary contribution is a transparent, parameter-explicit measurement of externality exposure for a set of economically material Australian firms, and a documented account of how such measurement can be conducted from inaugural, heterogeneous disclosures. Its secondary contribution is exploratory: an association between negative externality exposure (TRR) and implied cost of equity that is directionally consistent with H_1 but that cannot be identified as a *ceteris-paribus* premium at $N = 25$. The paper does *not* claim that FR measures a market-implied liability, that TRR causes a higher cost of equity, that the 25 firms represent the ASX, or that FR is superior to ESG ratings. Where a stronger test exists — the pooled DAX–AEX–ASX design, a Safeguard-Mechanism event study, or an incremental-information test against ESG scores — we say so and defer it to Section 6.4.

Contributions. Within those limits we make three contributions. The first is empirical: to our knowledge, and subject to a comprehensive literature search in the journal version, this is the first application of the FR framework to the ASX using inaugural mandatory AASB S2 data, in a market whose externality intensity is an order of magnitude beyond the European sample. The second is methodological: a tiered Scope 3 imputation procedure and a four-stream mining-waste classification that separates tailings and mineral-rock overburden from standard waste streams and prices each via distinct, institutionally grounded rates, replacing a uniform coal-ash proxy that overstated overburden costs. The third is diagnostic: a fully disclosed exploratory pricing exercise — Spearman association, four OLS specifications with three inference methods, leave-one-sector-out and single-firm exclusions, Frisch–Waugh orthogonalisation, and an independent re-implementation — that documents exactly where the $N = 25$ cross-section is and is not informative, and thereby specifies what the pooled study must resolve.

2. Literature Review

2.1 Valuation Ratios and Their Limitations

Both discounted cash flow and relative-multiple methods assume that all value-relevant information is captured in financial line items. Social and environmental externalities represent a category the balance sheet does not see. Zingales (2015) offers a structural explanation: Friedman's (1970) division of labour relies on governments being able to regulate externalities efficiently — a condition that does not hold reliably (Hart and Zingales, 2017). The result is systematic underpricing of social and environmental risk.

2.2 The Integrated Value Framework

The Integrated Value (IV) framework of Schoenmaker and Schramade (2023) expands valuation to include monetised social and environmental effects. Shadow prices follow remediation-cost frameworks (True Price, 2025); the social discount rate is set at 2.2%, following Schoenmaker and Schramade (2019). (Pástor, Stambaugh and Taylor (2024) use a rate of 2.0%; we follow the Schoenmaker–Schramade (2019) calibration throughout.) Kurznack, Schoenmaker and Schramade (2021) develop a long-term value creation model that grounds the IV framework analytically; Schramade, Schoenmaker, Wiedemann and Marijnissen (2026) applied this framework to 52 non-financial companies from the AEX and DAX 40 (FY2024), reporting a value-weighted average FR of 0.20 and a carbon burden approximately equal to 160% of sample market capitalisation. Their Monte Carlo simulation across 1,000 joint-parameter draws confirms that company rankings are stable across parameter variations (Spearman ρ = 0.958–0.997 with the baseline).

2.3 Transition Risk and Externality-Exposure Pricing

A growing literature documents the pricing of environmental externality exposure. Bolton and Kacperczyk (2023) find a significant carbon premium globally. Pástor, Stambaugh and Taylor (2024) estimate the carbon burden equals approximately 131% of US corporate equity and is priced in the cost of capital. Krueger, Sautner and Starks (2020) document institutional investor concerns about climate financial risk. Sautner, van Lent, Vilkov and Zhang (2023) construct firm-level climate change exposure measures. Benlemlih, Ge and Zhao (2021) show the market reacts positively to sustainability news from undervalued firms with high information asymmetry. Our TRR is conceptually adjacent to carbon burden but broader: it captures all negative social and environmental externalities, not only greenhouse gas emissions. We distinguish externality exposure (a measurable physical-and-economic stock) from transition risk proper (the probability, timing, and magnitude of future internalisation through policy, litigation, or market dynamics), and our hypothesis is about the former.

2.4 The FR in the Monetised-Impact Literature

The FR belongs to a literature that monetises social and environmental impacts rather than scoring them. Rouen and Serafeim (2021) and Freiberg, Park, Serafeim and Zochowski (2020) construct impact-weighted accounts (IWA): firm-level environmental and social impacts translated into financial quantities using shadow prices. Two results are directly relevant. First, monetised environmental impact correlates little with commercial ESG ratings, establishing the information gap between money-based and opinion-based measures. Second, firms with worse monetised environmental impact carry lower market valuations in materials, mining, power, chemicals, and conglomerates (Freiberg et al., 2020) — a cross-sectional pattern structurally equivalent to H_1 : a lower valuation with unchanged fundamentals implies a higher implied cost of equity. The FR shares the IWA logic — physical quantities $\times$ shadow prices, with all inputs visible and replaceable at the parameter level — and extends it in two directions: impacts are expressed relative to financial enterprise value (a ratio, not an income-statement flow), and positive and negative externalities are combined in a single metric.

Pástor, Stambaugh and Taylor (2024) provide the closest pricing analogue: a carbon burden — capitalised carbon harm per unit of market value — estimated to equal 131% of US corporate equity, with $\lambda \approx 1.0\%$ – 2.7% priced in the cost of capital. Our TRR extends the carbon burden logic to all negative environmental and social externalities; our λ estimates and their comparison to the Pástor et al. benchmark are discussed in Section 5.2. On the ESG rating question: our TRR and the Sustainalytics ESG Risk Rating are substantially correlated in this sample (Spearman $\rho = 0.738$, $N = 25$, $p < 0.001$; Sun, 15 August 2026). Whether the FR's architectural transparency translates into incremental predictive power for cost of equity or returns is the H_2 question deferred to the pooled study; the current paper makes no claim of comparative superiority.

3. Theoretical Framework

3.1 Integrated Value and the Futureproofing Ratio

Following Schoenmaker and Schramade (2023), the IV identity is:

$$IV_i = FV_i + SV_i + EV_i \quad (1)$$

For impact j at firm i , the annual value flow is:

$$VF_{i,j} = Q_{i,j} \times SP_j \times AF_{i,j} \quad (2)$$

where Q is the quantity of impact, SP the shadow price, and AF the attribution factor. Annual value flows are discounted at the social rate r_s :

$$SV_i + EV_i = \sum_j VF_{i,j} / r_s \quad (3)$$

where $r_s = 2.2\%$, following Schoenmaker and Schramade (2019). The FR decomposes as:

Equation (3) is the maintained modelling assumption throughout this paper: annual externality flows are held constant at their FY2025 levels in perpetuity — emissions intensity unchanged, no reserve depletion, no asset retirement, no policy-driven curtailment. For going-concern service, healthcare, and technology firms this is a reasonable perpetual-franchise approximation. For extractive and energy firms — where the most extreme FR values arise — it implies coal production, iron-ore extraction, and gas combustion continuing at current scale indefinitely. This assumption is transparent and useful as a stress-test benchmark rather than a projection. Table 3 Panel A reports headline FR estimates under this maintained assumption alongside two falling-path alternatives.

$$TOR_i = (SV_i^+ + EV_i^+) / FV_i \quad (4)$$

$$TRR_i = |SV_i^- + EV_i^-| / FV_i \quad (5)$$

$$FR_i = 1 + TOR_i - TRR_i = IV_i / FV_i \quad (6)$$

TOR captures positive externalities that function as embedded call options, paying off when internalisation shocks arrive. TRR captures negative externalities that function as

embedded short positions — exposures that would crystallise if policy, litigation, or market shifts force recognition. Two interpretive points follow. First, $FR < 1$ means that, under the framework's maintained shadow prices and discount rate, positive externalities do not offset negative ones relative to financial enterprise value; $FR < 0$ means integrated value is itself negative. Neither is a solvency threshold, a forecast of realised loss, or an estimate of the fraction of externalities that will be internalised: FR is a transparent stress-test measure conditional on stated parameters (Caldecott et al., 2021, on the asset-level logic). Second, because r_s enters equation (3) as a uniform scalar, the rank ordering of firms by TOR, by TRR, and by FR — and the sign of $(FR - 1)$ — is invariant to the choice of social discount rate; r_s changes magnitudes, not orderings. The same holds for any uniform proportional rescaling of all shadow prices. Ranking robustness to *non-uniform* changes (for example, the carbon price alone) is an empirical question addressed in Sections 4.4 and 6.4.

3.2 Theoretical Channel, Estimand, and the λ Specification

Channel selection. Three mechanisms predict a positive relationship between negative externality exposure and cost of equity, all yielding the same predicted sign but differing in mechanism, magnifying factor, and policy implication. The first — and the one we build on — is an internalisation risk premium: investors holding high-TRR firms bear the risk that negative externalities will be internalised through future carbon pricing, environmental regulation, or climate litigation. Because this risk is correlated with economy-wide policy shifts rather than being purely idiosyncratic, it cannot be fully diversified away, and rational investors demand a premium proportional to the firm's externality exposure. Bolton and Kacperczyk (2023) confirm this channel for carbon-transition risk in a large global sample; our TRR extends the logic from carbon alone to all negative environmental and social externalities subject to potential internalisation. The second mechanism works through investor preferences: if a sufficient mass of investors tilts toward low-externality assets, prices of high-TRR stocks decline and expected returns rise as a taste premium rather than a risk premium (Pástor, Stambaugh and Taylor, 2021). The third involves information and undervaluation: mandatory disclosure of negative externalities can reprice assets with high information asymmetry, raising the cost of equity for overvalued high-externality firms (Benlemlih, Ge and Zhao, 2021). All three are consistent with H_1 ; a 25-firm cross-section cannot separate them. We develop H_1 on the internalisation risk channel and defer channel identification to the pooled sample.

H_1 : $\partial COE / \partial TRR > 0$ — firms with higher negative externality exposure relative to financial enterprise value face higher implied cost of equity. (7)

Estimand. TRR measures a firm's current negative externality exposure, conditional on the framework's shadow prices, attribution factors, and capitalisation assumption. Transition risk additionally depends on the expected probability, timing, and financial pass-through of future internalisation. A high TRR can coexist with low near-term financial risk if market participants expect little internalisation; a lower TRR can coexist with high transition risk if a business model faces rapid displacement. H_1 therefore tests externality-exposure pricing — a necessary but not sufficient condition for transition-risk

pricing in the fuller sense — and we use the term "externality exposure" consistently throughout. A positive coefficient at $N = 25$ is directionally consistent with H_1 ; it does not identify a causal premium.

The λ specification. Following Pástor, Stambaugh and Taylor (2024), we re-express the pricing equation with an economically interpretable slope coefficient. TRR is a stock measure — annual negative externalities capitalised at the social discount rate r_s . Dividing by implied equity duration D_i (Dechow, Sloan and Soliman, 2004) converts TRR into an annual externality burden per unit of market value:

$$COE_i = \beta_0 + \lambda \times (TRR_i / D_i) + \gamma'X_i + \varepsilon_i \quad (9')$$

where λ measures the fraction of annual harm per unit of market value that investors require as additional return: $\lambda = 0$ means externality exposure is unpriced; $\lambda = 1$ means investors demand one dollar of return for every dollar of annual harm per unit of market value. Pástor, Stambaugh and Taylor (2024) estimate λ in the range 1.0%–2.7% for US carbon burden. Because TRR uses the social rate $r_s = 2.2\%$ while investors' own required returns average well above that, our λ estimates and theirs are approximate comparisons; Section 5.2 reports the firm-COE-capitalisation diagnostic that addresses this directly. When a market-wide average duration $\bar{D}$ is used, equation (9') is a scalar rescaling of the original equation (9) and the regression fit is unchanged: $\hat{\lambda} = \beta_1 \times \bar{D}$. Table 5 reports $\hat{\lambda}$ for each specification alongside β_1 .

H_2 : $\text{Adj } R^2(\text{TOR, TRR}) > \text{Adj } R^2(\text{ESG score})$ — deferred pending aligned ESG data for the pooled study. Preliminary motivation: Spearman $\rho(\text{TRR, Sustainalytics ESG Risk Rating}) = 0.738$ ($p < 0.001$, $N = 25$); Spearman $\rho(\text{COE, Sustainalytics}) = 0.543$ ($p = 0.005$). The high TRR–ESG correlation indicates substantial overlap; the lower COE–ESG correlation relative to COE–TRR (0.783) is suggestive but is not a test of H_2 .
(8)

3.3 The FR as a Framework for Externality Measurement

The FR pursues the analytical objectives of ESG measurement while addressing its main weakness at the aggregation layer: inputs are physical quantities and shadow prices, analytical compatibility with DCF mechanics is maintained, and normative choices are visible and contestable at the parameter level rather than embedded in a rating architecture. The four-stream mining-waste reclassification in Section 4.4 exemplifies this property: by separating tailings from overburden and applying a regulatory rehabilitation rate for mineral rock rather than a coal-ash proxy, the key measurement choice becomes explicit and available for contestation by anyone who believes the WA MRF Class 1 rate is an inappropriate societal-cost proxy.

Transparency does not make the choices objectively correct; it makes them inspectable and replaceable, which in the current Australian disclosure environment is the property that matters most.

4. Data and Methodology

4.1 Sample Construction, Valuation Date, and Data Audit

Sample construction. The sample comprises 25 ASX-listed companies across five non-financial sectors (Table 1). Firms were selected on three criteria applied jointly: (i) economic materiality by market capitalisation and revenue; (ii) integrated-value materiality — the presence of externality flows large enough for the FR to be economically informative; and (iii) feasibility of constructing the full input set from inaugural FY2025 AASB S2 climate-related disclosures together with sustainability reports, regulatory filings, and public financial data, using imputation only where Section 4.4 permits it. Financial Services and Real Estate are excluded because the present FR implementation and available disclosures do not support comparable measurement for those sectors. The sample is therefore purposive, not random, and is not intended to represent the ASX. As stated in Section 1, we regard 25 as close to the practicable ceiling for FY2025 in our judgment; the journal version will document this with a formal universe flow table (S&P/ASX 200 → non-financial → mandate scope → usable disclosure → final sample). Throughout, FV denotes enterprise value (market capitalisation plus net debt) at 30 June 2025 in Australian dollars; we do not use “market capitalisation” as a synonym for FV.

Table 1: Sample composition by sector

Sector	Companies
Materials (6)	BHP, Rio Tinto, Fortescue, South32, Whitehaven Coal, Mineral Resources
Healthcare & Technology (6)	CSL, ResMed, Pro Medicus, Cochlear, Xero, WiseTech Global
Consumer Staples & Services (4)	Wesfarmers, Woolworths, Coles, Seek
Industrials & Infrastructure (4)	Brambles, Transurban, James Hardie Industries, Qantas Airways
Energy & Utilities (5)	Woodside Energy, Santos, Origin Energy, AGL Energy, APA Energy

Valuation date and timing design. All enterprise-value inputs are measured as of 30 June 2025. The first Group 1 AASB S2 reports appeared in Q1 2026, after the valuation date. The exercise is therefore an *ex post** FY2025 measurement anchored to a common financial valuation date*: it uses reported FY2025 physical quantities to compute what the framework’s externality position was during the fiscal year that market prices at 30 June 2025 were valuing. It is not a claim that investors possessed the reported dataset in June 2025, and mandatory disclosure functions in this paper as a measurement-data source, not as an information event (the return comparison in Section 5.3 is labelled accordingly). For Rio Tinto, FV is the full dual-listed (plc+Ltd) combined enterprise value of AUD 188.1 billion, derived from: (a) net debt of USD 14,597 million (Rio Tinto H1 2025 interim results); (b) RIO.AX closing price A\$107.13;

(c) combined shares 1,625.2 million; (d) AUD/USD 0.65. Equity betas are estimated from 60 monthly returns to June 2025 against the S&P/ASX 200; two betas have very low explanatory power (AGL Energy $R^2 = 0.01$; Whitehaven Coal $R^2 = 0.03$) and are disclosed as imprecise. The risk-free rate is 4.208% (RBA F2.1, June 2025).

Pre-finalisation data audit. An audit of the regression input layer identified and corrected two errors. First, ResMed's ASX-listed securities are CHES Depositary Interests trading at a 10:1 ratio to the primary shares; the prior input file mixed a per-CDI price with full-share book value and share count, corrupting ResMed's market capitalisation (A\$5.8bn $\rightarrow$ corrected A\$57.6bn), book-to-market (1.365 $\rightarrow$ 0.137), and GLS implied COE (12.61% $\rightarrow$ 8.58%, recomputed on a consistent per-CDI basis with the estimation procedure unchanged). Second, Rio Tinto's size control inherited a corrupted market-capitalisation field flagged for exclusion in the source workbook; it is recomputed from the confirmed combined DLC figures (A\$102.16 $\times$ 1,625.5m shares = A\$166.1bn, consistent with the FV of A\$188.1bn above). Both corrections are documented line-by-line in the Data Reconciliation sheet of the replication workbook. We disclose them because a result built on hand-collected inputs should carry its correction history with it; the pattern also raises the bar for the replication package that will accompany the journal version.

4.2 Environmental and Social Value Data and Disclosure Quality

Environmental value data are drawn from inaugural FY2025 AASB S2 climate-related disclosures together with sustainability reports, regulatory filings, and public financial data. The carbon shadow price is True Price 2025 (EUR 312/tCO₂e, approximately A\$558), consistent with Schramade, Schoenmaker, Wiedemann and Marijnissen (2026); the social discount rate r_s is 2.2%; FX rates follow ECB 30 June 2025 references (EUR/AUD 1.790; USD/AUD 1.530; NZD/AUD 0.930). These are maintained modelling assumptions, visible to the reader and replaceable in alternative scenarios; they are not estimates of the carbon price expected by the market.

Data provenance note. AASB S2 is a climate-related disclosure standard; social value flows, mining waste, and other non-climate inputs in this paper are drawn from the broader FY2025 sustainability reporting suite: annual reports, sustainability reports, mine plans, environmental regulatory filings, and third-party data, with imputation where direct data are unavailable (Tiers 2–4, Section 4.4). Inaugural AASB S2 climate-related disclosures are an important advance, but they do not yet constitute a standardised research dataset. KPMG Australia (2026) documents readiness issues across Group 1 reporters including heterogeneous Scope 3 treatment and boundary definitions. Formats, reporting periods, organisational and operational boundaries, assurance status, and Scope 3 category coverage differ across issuers. We therefore distinguish reported from imputed values by tier (Section 4.4), maintain a per-item source and confidence log for hand-collected inputs, and caution that firm differences in FR may reflect genuine differences in externality exposure, differences in reporting coverage, or both. Firm-level FRs should be read together with their data tier and, where available, their sensitivity range; they should not be used to rank firms with false precision.

4.3 Cost of Equity Estimation, Econometric Specification, and Inference Protocol

The primary test of H_1 is the OLS regression:

$$COE_i = \beta_0 + \beta_1 TRR_i + \gamma X_i + \varepsilon_i \quad (9)$$

where X includes market beta, $\ln(\text{market capitalisation})$, book-to-market, and leverage. The primary COE estimate uses Gebhardt, Lee and Swaminathan (2001) (GLS), implemented with a 12-period horizon in which forecast ROE fades linearly from the FY2 level to the sector-median forecast ROE, with a terminal perpetuity; PEG (Easton, 2004), Ohlson–Juettner-Nauroth (2005), and the average of available estimates are reported in Table 4. Consensus inputs (EPS FY1/FY2, DPS FY1, book value per share) were hand-collected from public sources with a per-item source and confidence log.

Note: A Hou, van Dijk and Zhang (2012) COE estimate — replacing analyst forecasts with a cross-sectional earnings prediction model, which eliminates the sector-fade artefact identified by Easton and Monahan (2005) in the GLS fade-to-sector-median procedure — is being implemented and will be added as a primary robustness column in the journal version. The composite ICC (GLS, PEG, OJ average) in Table 4 serves as the interim robustness comparison.

Implied COE as an exploratory outcome. Implied cost of equity is model- and forecast-input dependent, and in a small heterogeneous cross-section that dependence matters. Two properties of Table 4 require disclosure rather than footnoting. First, six primary GLS estimates (Pro Medicus, APA, WiseTech, Cochlear, Xero, Wesfarmers) sit below the 4.208% risk-free rate. Estimates below the risk-free rate are arithmetically possible in a residual-income model — they arise when a high current multiple is reconciled with an ROE path that fades toward the sector median — and their PEG and OJ counterparts are also low for the same firms, but they should be read as model outputs for high-multiple growth firms rather than as economically literal required returns. All six are below-median-TRR firms; the rank-order association in Section 5.2 is invariant to any monotone transformation of COE and is therefore unaffected by their level, whereas the OLS coefficients are not. We do not exclude them, because exclusion after inspection would be post-hoc; a formal below-risk-free diagnostic and separate GLS/PEG/OJ/composite regressions are queued for the journal version. Note: Transurban (GLS 4.07%) and Origin Energy (GLS 4.06%) are also marginally below the risk-free rate of 4.208%, within 15 basis points; the six firms named above are materially below it and are the primary disclosure concern. Second, an independent implementation by a co-author, using Yahoo Finance consensus inputs and a separately written pipeline, produces firm-level COE estimates that differ from the primary implementation by 1.9 percentage points on average, with the largest single discrepancy for ResMed (8.58% primary vs. 3.35% independent, attributable to CDI-basis differences in the EPS/BVPS inputs used by each source). The differential reflects forecast-source dispersion rather than TRR: Yahoo Finance consensus forecasts generate larger COE spreads across the cross-section, particularly for energy and utility firms (AGL: 9.16% vs. 4.70%; STO: 10.48% vs. 6.36%; WDS: 12.25% vs. 8.05%). We

treat the two implementations as a robustness pair, report both, and will adopt a single frozen, dated forecast-input file for the pooled journal analysis.

Inference protocol. With $N = 25$ and four to five regressors, effective degrees of freedom are 19–20 and no inference method manufactures more. We report three methods and state in advance how disagreement between them is read. (i) HC3 heteroskedasticity-robust standard errors with asymptotic p-values. (ii) Monte-Carlo permutation p-values: 100,000 label reshuffles with seed 42, computed by re-estimating the specification on each reshuffled sample and locating the observed HC3 t-statistic on TRR in the resulting null distribution. The reshuffled vector is the **outcome** (COE): for each permutation, the COE vector is randomly reordered across firms while the covariate matrix (TRR, beta, size, B/M, leverage) is held fixed; the HC3 t-statistic for TRR is recomputed on the permuted outcome; and the two-sided proportion of permuted $|t| \geq |t_{\text{observed}}|$ is the Monte-Carlo p-value (using absolute values, making this effectively a two-sided test). This tests the sharp null of no association between TRR and COE, but because controls are held fixed (not re-fitted), it is an *unconditional* permutation test of the marginal outcome distribution rather than a strict test of the conditional coefficient β_1 . To address the reviewer critique that outcome-label permutation in the presence of covariates does not test the conditional slope, we add a **Freedman–Lane (FL) conditional permutation test** (Freedman and Lane, 1983): (a) regress COE on the nuisance controls only (reduced model without TRR); (b) obtain residuals $\hat{e}$; (c) randomly permute $\hat{e}$ to obtain $\hat{e}^*$, *reconstruct the permuted outcome as* $COE^* = \hat{y}_{\text{reduced}} + \hat{e}^*$; (d) *re-fit the full model on* COE^* and compute the HC3 t-statistic for TRR. This procedure preserves the joint distribution of the controls and tests whether TRR adds explanatory power for residuals that are already purged of control effects. Both procedures use 100,000 draws, seed 42. (iii) Bootstrap 95% confidence intervals from 10,000 pairwise resamples, seed 42. Our **reading rule**, adopted in this paper: a specification is described as “supported by all three methods” only when $HC3\ p < 0.05$, $FL\text{-}p < 0.05$, *and* the bootstrap CI excludes zero; otherwise we report the disagreement explicitly. On the corrected dataset, Spec 2 residuals are consistent with normality (Shapiro–Wilk $W = 0.971$, $p = 0.677$); Cook’s distance flags AGL Energy, APA Energy, and Qantas ($D > 4/N$), and the exclusion battery in Table 7 addresses each flagged structure. TRR is winsorised at the 5th–95th percentile in the regressions; all variance inflation factors are below 2.2.

TOR is not interpreted in the regressions. In earlier drafts TOR was included alongside TRR in every specification. Its coefficient carries a persistently positive sign inconsistent with the framework’s opportunity interpretation. We attribute this to a sector-composition confound at $N = 25$ — the firms with the largest positive social value flows are the same resource-sector firms with the highest TRR, so TOR proxies for gross extractive scale rather than the opportunity channel. We report this fact rather than suppress it, and we draw the corollary explicitly: the same argument that prevents interpreting TOR also limits a clean conditional interpretation of TRR in this sample. Following that logic, TOR is removed from the regression tables in this version and its regression analysis is deferred to the pooled DAX–AEX–ASX study where sector fixed effects become feasible; the TOR-inclusive tables from the earlier draft are retained in the online appendix so that readers can see the coefficient rather than take our word for

it. TOR is unchanged in the descriptive statistics and throughout the framework and measurement sections; it is a necessary component of the FR decomposition.

Addressing the price-deflation problem. A structural feature of equation (9) requires disclosure and correction in the journal version. The share price P_i appears on the left-hand side (COE_i is derived from price; lower P_i implies higher COE), the right-hand side ($TRR_i = \text{harm}/(r_s FV_i)$ where FV_i contains $P_i \times \text{shares}$, so lower P_i raises TRR), and in the book-to-market control ($B/M_i = \text{book}/P_i$, also rising as P_i falls). A 20% decline in P_i with unchanged emissions, forecasts, and book value therefore simultaneously raises COE, TRR, and B/M — mechanically generating the pattern H_1 predicts, with no change in actual externality exposure. Pearson (1897) and Kronmal (1993) establish the statistical problem; Barth and Kallapur (1996) develop the accounting-research application; Pástor, Stambaugh and Taylor (2024) address it by deflating harm by book assets rather than market value and excluding price-based controls. This is also visible in our own data: Spearman $\rho(\text{TRR}, B/M) = 0.723$ (Table A1, winsorised TRR) — exactly as the price-deflation equation predicts. The journal version will adopt equation (9'') as primary: $COE_i = \beta_0 + \beta_1 \times (\text{harm}_i / \text{BookAssets}_i) + \gamma'X^{**}_i + \varepsilon_i$, where $\text{harm}_i = \text{TRR}_i \times r_s \times FV_i$ recovers the annual flow and X^{**} excludes book-to-market. Table 5A (see below) presents this specification.

⚠ NOTE FOR JOURNAL VERSION: Table 5A to follow: re-run OLS with $\text{harm}_i / \text{BookAssets}_i$ replacing TRR. Compute: $\text{harm}_i = \text{TRR}_i \times 0.022 \times FV_i$; $\text{BookAssets}_i = (B/M)_i \times \text{MktCap}_i + \text{NetDebt}_i$. Run Specs 1B–3B with same HC3/FL/bootstrap protocol. Estimated effort: 1–2 hours.

Independent verification. The full regression battery was independently re-implemented by a co-author using the Yahoo-Finance-based COE described above. Results differ by implementation. Under the Yahoo Finance implementation, all four specifications produce positive TRR coefficients that are significant under outcome-label permutation (Sun, 13 August 2026). Under the primary MH GLS implementation, all four specifications produce positive TRR coefficients but no specification clears all three thresholds of the reading rule (Section 4.3): Freedman–Lane p-values range from 0.045 to 0.149, and bootstrap CIs include zero for Specs 2–4. The leave-one-sector-out, exclusion, and Frisch–Waugh directional patterns agree across both implementations. The independent implementation yields Spearman $\rho(\text{TRR}, \text{COE}) = 0.783$ ($p < 0.001$) against 0.608 in the primary implementation; the difference reflects the larger COE dispersion in the alternate forecast source, not a difference in TRR, showing that the rank-order association is retained under a second forecast-input source.

4.4 Scope 3 Imputation and Mining Waste Treatment

Tier 1. Reported AASB S2 Scope 3 figures used directly.

Tier 2 — Activity-based. For Woodside, Santos (oil/gas), and Whitehaven Coal, downstream Scope 3 is estimated from physical sales volumes multiplied by NGAF 2025 combustion factors. Whitehaven: 26.5 Mt equity coal sales $\times$ 2.436 tCO₂/t bituminous = 64.6 Mt CO₂ base, scaled to 67.9 Mt (central) via peer-derived multiplier of 1.051 (P25–P75 range: 67.3–72.0 Mt).

Tier 3 — Intensity-based. Mineral Resources (MIN), CSL, Pro Medicus, and ResMed use sector-average intensity benchmarks. Materials benchmark peer-median: 5,675 tCO₂/AUD M (BHP, Fortescue, Rio Tinto, South32; corrects a prior FX double-conversion error that understated the benchmark by ×1.53, raising MIN imputed Scope 3 from 16.4 to 25.4 Mt, +55%). Healthcare benchmark peer-median: 28.5 tCO₂/AUD M (Cochlear, WiseTech Global, Xero).

Benchmark data dependency. The Materials intensity benchmark used to impute Mineral Resources is derived from BHP, Fortescue, Rio Tinto, and South32 — all of which appear in the sample. This is not endogeneity in the classical sense (TRR is a regressor, not the outcome), but it creates shared measurement dependence: systematic Scope 3 reporting error in the benchmark firms would cascade into the imputed observation. We therefore treat the MIN estimate as a sensitivity-sensitive measurement result rather than an independent validation point. Across lower/central/upper Scope 3 assumptions, MIN's TRR ranges from approximately 10.1 to 16.4 (central: 13.2); in every scenario MIN remains among the highest-TRR firms and its rank is unchanged. Leave-one-peer-out benchmarks are queued for the journal version.

Tier 4 — Third-party cross-check. All imputed estimates are cross-checked against MSCI ESG, S&P Trucost, and CDP; where divergence exceeds 50%, we investigate and adopt the more conservative figure.

Mining waste reclassification. Prior versions applied a uniform coal-ash shadow price (€18/t) to all extractive waste. The corrected methodology separates mining waste into four streams: (i) non-mining hazardous waste and (ii) non-mining non-hazardous waste, both at standard shadow prices; (iii) tailings, priced via a bottom-ash proxy (96% managed / 4% recycled); and (iv) mineral rock (overburden/waste rock), converted from tonnes to hectares via bulk density and 20-metre dump height and priced at the WA Mining Rehabilitation Fund Class 1 rate of A\$50,000/ha. The WA MRF rate is a regulatory rehabilitation liability, not a full societal remediation cost; we use it as a conservative, operationally grounded lower bound and state explicitly that it does not settle the normative question of the appropriate social cost of overburden. If full societal costs were applied, TRR for the major miners would be higher. The reclassification materially reduces the per-tonne cost of overburden while introducing an institutionally grounded rate for large-volume low-hazard rock, and substantially changes the FRs of BHP, Rio Tinto, Fortescue, South32, and Whitehaven Coal relative to prior versions. Its sensitivity is quantified in Section 6.4.

5. Empirical Results

5.1 Cross-Sectoral FR Dispersion

Table 2 reports the FR estimates by company and sector at the 30 June 2025 valuation date, from the authoritative ASX_MasterFile_WM_0811 data layer.

Table 2: FR estimates by company and sector (valuation date 30 June 2025)

Company	Sector	FV (A\$bn)	TOR	TRR	FR
Cochlear	H&T	19.7	0.983	0.068	1.915
ResMed	H&T	58.6	0.936	0.116	1.820
CSL	H&T	130.3	0.507	0.165	1.342
Xero	H&T	27.6	0.299	0.018	1.281
Pro Medicus	H&T	29.8	0.253	0.004	1.249
WiseTech Global	H&T	36.2	0.151	0.014	1.137
Coles	Cons. St.	29.2	3.254	2.302	1.953
Woolworths	Cons. St.	54.0	2.981	2.164	1.817
Seek	Cons. St.	9.5	0.278	0.026	1.251
Wesfarmers	Cons. St.	98.8	1.012	1.010	1.002
Brambles	Ind. & Inf.	36.0	0.471	0.068	1.403
James Hardie	Ind. & Inf.	17.4	0.961	0.621	1.340
Transurban	Ind. & Inf.	62.7	0.121	0.111	1.010
Qantas Airways	Ind. & Inf.	20.9	1.439	11.762	-9.323
APA Energy	En. & Util.	23.9	0.444	1.690	-0.245
Santos	En. & Util.	33.8	0.565	3.783	-2.218
Woodside	En. & Util.	57.2	0.609	5.299	-3.690
Origin Energy	En. & Util.	23.2	0.282	12.070	-10.787
AGL Energy	En. & Util.	9.4	0.707	20.159	-18.452
BHP	Materials	206.3	1.387	5.210	-2.824
Rio Tinto ‡	Materials	188.1	1.050	6.671	-4.621
South32	Materials	15.6	1.255	10.512	-8.258
Mineral Res.	Materials	9.5	0.579	13.234	-11.654
Fortescue	Materials	48.7	1.695	15.324	-12.628
Whitehaven Coal	Materials	5.1	2.453	34.187	-30.734

Notes: $FR = 1 + TOR - TRR = IV / FV$. FV = enterprise value at 30 June 2025 (A\$bn).
‡ Rio Tinto: corrected combined DLC (plc+Ltd) EV AUD 188.1bn from H1 2025 interim results. Within each sector, firms ordered by FR descending. Value-weighted averages: TOR = 1.017, TRR = 4.046, FR = -2.029. Equally-weighted averages: TOR = 0.987, TRR = 5.864, FR = -3.877. Median FR $\approx$ 1.002 (Wesfarmers); 13 of 25 firms have FR > 1.0. The WA MRF Class 1 rate (A\$50,000/ha for mineral rock) is a regulatory rehabilitation lower bound, not a full societal remediation cost. Source: ASX_MasterFile_WM_0811 (Marijnissen, 11 August 2026); Santos stock price corrected to A\$7.66 and Xero to NZD 179.80 per Marijnissen flag and He confirmation, 11 August 2026.

Aggregate FR decomposition. A common misreading of $FR = -2.029$ is that the externality burden equals roughly twice the financial enterprise value. The correct decomposition is: (1) gross positive externality value ($TOR \times FV$) = $1.017 \times$ aggregate FV; (2) gross negative externality burden ($TRR \times FV$) = $4.046 \times$ aggregate FV; (3) net externality position = $(TOR - TRR) \times FV = -3.029 \times$ aggregate FV; (4) integrated value = $FR \times FV = -2.029 \times$ aggregate FV. The gross negative burden of approximately $4.05 \times$ FV is a model-based social-and-environmental burden expressed at shadow prices and in perpetuity; it is not an unrecognised financial liability. Whether and how much of it converts into a corporate cash-flow claim depends on policy, market structure, contractual pass-through, technology, location, timing, and stakeholder response — the gap between social valuation and financial internalisation that future pricing research must address.

Sector pattern and the “typical” firm. The value-weighted average is driven by a concentrated negative tail. All six Materials firms sit below $FR = 0$; Energy & Utilities contains several markedly negative observations; Industrials & Infrastructure is mixed, with Qantas a negative outlier; Consumer Staples & Services is mostly above unity; and all six Healthcare & Technology firms are above unity (1.137 – 1.915). The median FR is approximately 1.002 (Wesfarmers) and 13 of 25 firms have $FR > 1.0$. The weighted aggregate and the typical firm therefore tell different stories: the negative value-weighted average reflects the concentration of externality burden in a small number of large-footprint resource and energy companies, not a sample-wide condition. BHP’s move from $+1.25$ (V8.2.5) to -2.82 reflects the four-stream waste reclassification applying the WA MRF rate to mineral rock; AGL Energy’s FR of -18.45 (previously $+0.61$) reflects Scope 1 and 2 coal-fired generation emissions that, at A\$558/tonne, generate a perpetuity carbon flow substantially exceeding AGL’s A\$9.4 billion enterprise value.

Reading the extreme ratios. The most extreme values require careful interpretation. AGL’s FR of -18.45 and Whitehaven Coal’s -30.73 do not predict a loss of that size and do not state that such amounts are recognised or recognisable liabilities. They express the scale of a perpetual, shadow-priced flow relative to a small current enterprise value: for AGL, a carbon flow that if internalised at the maintained shadow price would be roughly 17.5 times its A\$9.4 billion enterprise value; for Whitehaven, an externality burden — driven primarily by Scope 3 downstream combustion — of roughly 30 times its A\$5.1 billion enterprise value. These are stress-test magnitudes under stated assumptions. They are useful for locating which assumptions and which flow types drive a firm’s result; they are not investable price targets, and the framework does not supply the internalisation probability, schedule, or fraction that would be needed to convert them into a financial claim.

Size–TRR relationship. On the corrected dataset, the correlation between $\ln(\text{market capitalisation})$ and TRR is -0.498 (Pearson, $p = 0.011$): larger-by-market-value firms are on average lower-TRR firms, because lighter-footprint consumer, healthcare, and technology companies include many of the largest by market value. This runs opposite to patterns documented at firm level in European and US samples, where larger firms by book assets tend to carry larger absolute externality burdens (Freiberg, Park, Serafeim and Zochowski, 2020; Pástor, Stambaugh and Taylor, 2024), and it matters

for the regressions: in this sample the size control does not mechanically absorb the TRR effect. Using book assets instead, the correlation reverses strongly positive ($r \approx +0.87$): the largest by capital stock are the highest-TRR firms. We use $\ln(\text{market capitalisation})$ as the primary size control and report the assets-based orthogonalisation as a robustness disclosure.

Table 3: Emissions-assumption sensitivity and cross-market comparison

Panel A: Emissions path sensitivity — ASX 25	Value-weighted FR	Gross harm / FV
Held at FY2025 levels forever (perpetuity — all results in this paper)	−2.03	4.05×
All harms fall 2% per year indefinitely (multiplier 23.8 yrs = $1/0.042$)	−0.59	2.1×
Linear decline to zero by 2050, Paris-aligned (multiplier ~10.0 yrs)	+0.33	0.9×
Notes: Scaling factors: row 2 = $23.8/45.5 = 0.523\times$; row 3 = $10.0/45.5 = 0.220\times$. VW FR row 2: $1+(1.017-4.046)\times 0.523=-0.59$. Row 3: $1+(1.017-4.046)\times 0.220=+0.33$. Rankings unchanged across all assumptions. Source: Bams (2026, Vlerick); independently verified by present authors.		
Panel B: Cross-market comparison (indicative)		
Metric	ASX 25 (this paper, Jun 2025)	DAX-AEX 52 (Schramade et al., 2026)
Value-weighted FR	−2.029	+0.20
Gross negative externality / FV	4.05× (TRR component)	~1.6× (carbon burden) †
Firms with FR > 1.0	52% (13 of 25)	Not separately reported
Principal negative-FR driver	Coal, iron ore, coal-fired power	Dispersed materials/energy

† DAX-AEX carbon burden $\approx 160\%$ of market cap reported in Schramade et al. (2026); full TRR decomposition not separately published. Not directly comparable to ASX TRR (which covers all environmental and social externalities). Comparison indicative only; valuation-date differences will be addressed in the planned pooled analysis.

Cross-market context, not a head-to-head test. The gap between the ASX value-weighted FR of −2.029 and the DAX–AEX reference of +0.20 is large and economically intuitive given the ASX sample’s concentration in coal, iron ore, hydrocarbons, and coal-

fired generation, whereas the DAX–AEX drag is dispersed across a services- and manufacturing-weighted index. We retain the comparison as context for why the Australian application is informative — it is a genuinely different externality environment, not a geographic replication — but we do not treat it as a formal cross-market result: the DAX–AEX comparator reports a carbon burden rather than a fully aligned all-externality TRR, and valuation dates and coverage differ. Alignment of definitions and dates is a task for the pooled analysis.

5.2 Externality-Exposure Pricing: Exploratory Evidence and Its Limits

Table 4 reports implied cost of equity estimates on the corrected dataset. ResMed’s GLS estimate is recomputed on the consistent per-CDI basis (8.58%; the 12.61% reported in prior versions reflected the input-basis error documented in Section 4.1). Readers should note that since AASB S2 disclosures appeared in Q1 2026 after the 30 June 2025 valuation date, the cross-sectional exercise does not establish that investors priced the measured TRR at the valuation date. The exercise is more precisely described as a cross-sectional association between a subsequently measured physical footprint (TRR) and contemporaneous implied COE — a necessary, but not sufficient, condition for a causal externality-exposure pricing claim, and subject to the confounds identified below.

Table 4: Implied cost of equity by firm (per cent)

Ticker	Company	Sector	GLS %	PEG %	OJ %	ICC avg
BHP	BHP	Mat.	10.45	n/a	n/a	10.45
RIO	Rio Tinto ‡	Mat.	10.77	6.60	10.24	9.21
FMG	Fortescue	Mat.	11.11	n/a	n/a	11.11
S32	South32 †	Mat.	14.85	17.52	21.32	17.89
WHC	Whitehaven †	Mat.	14.87	6.74	9.98	10.53
MIN	Mineral Res.	Mat.	18.22	18.71	18.52	18.48
CSL	CSL	H&T	6.65	5.96	7.45	6.69
RMD	ResMed §	H&T	8.58	7.05	8.20	7.94
PME	Pro Medicus	H&T	1.41	3.65	5.06	3.37
COH	Cochlear	H&T	2.67	5.47	7.30	5.15
XRO	Xero	H&T	3.25	4.82	6.00	4.69
WTC	WiseTech	H&T	2.53	4.27	5.59	4.13
WES	Wesfarmers	CSS	3.92	4.35	6.70	4.99
WOW	Woolworths	CSS	5.45	6.94	9.53	7.31
COL	Coles	CSS	5.29	5.80	8.75	6.61
SEK	Seek	CSS	8.42	6.45	8.51	7.79
BXB	Brambles	I&I	6.72	9.69	12.11	9.51
TCL	Transurban	I&I	4.07	6.55	11.03	7.22

Ticker	Company	Sector	GLS %	PEG %	OJ %	ICC avg
JHX	James Hardie	I&I	10.11	10.08	11.03	10.41
QAN	Qantas	I&I	17.56	10.12	12.39	13.36
WDS	Woodside	E&U	8.05	n/a	n/a	8.05
STO	Santos	E&U	6.36	6.26	9.43	7.35
ORG	Origin	E&U	4.06	5.27	9.48	6.27
AGL	AGL Energy	E&U	4.70	3.21	7.47	5.13
APA	APA Energy †	E&U	1.69	3.24	10.27	5.07

Notes: GLS = Gebhardt-Lee-Swaminathan (2001); PEG = Easton (2004); OJ = Ohlson–Juettner-Nauroth (2005). RF = 4.208% (RBA F2.1, June 2025). † Fallback consensus inputs; IBES/LSEG June-2025-vintage confirmation pending. ‡ Combined DLC basis. § ResMed recomputed on consistent per-CDI basis; ICC average updated accordingly. Corrected dataset. Six GLS estimates (PME, APA, WTC, COH, XRO, WES) fall below the risk-free rate (4.208%); all are below-median-TRR firms and are retained (not excluded post-hoc); see Section 4.3.

What N = 25 can and cannot establish. Three structural features of the sample bound what multivariate OLS can establish, and we state them before the results so that the tables are read against them. First, TRR is heavily concentrated in Materials and Energy: the six Materials firms are the highest-TRR observations, and removing them raises the permutation p-value to 0.114 and collapses R^2 to 0.094 (Table 6). At N = 25 the TRR coefficient cannot be cleanly separated from sector membership. Second, Spearman ρ (B/M, TRR) = 0.692 (unwinsorised TRR, verified from regression_dataset_QS_0815.xlsx) (Pearson r = 0.680): high-TRR firms carry high book-to-market ratios, which independently predict higher COE through the established value premium and may proxy for distress or commodity-cycle exposure. Frisch–Waugh orthogonalisation (Table 7) shows that a TRR signal survives purging both size and B/M, but it cannot establish that TRR carries information strictly beyond sector, value, or distress. Third, with 19–20 effective degrees of freedom, conditional identification of a ceteris-paribus TRR premium is not achievable at conventional power. The appropriate reading is therefore: *rank-order association between TRR and implied COE is established across two independent implementations; the OLS results are directionally consistent with that association under permutation inference; neither constitutes identification of a pricing premium.* The decisive test requires the pooled sample at N $\approx$ 76.

Table 5: H₁ Regression Results — GLS Implied COE, N = 25

Variable	Spec 1: TRR only	Spec 2: Full Controls	Spec 3: +D_resource	Spec 4: Log-Ratio
TRR (winsorised)	0.00436** † (0.044; FL 0.055)	0.00392 (0.199; FL 0.149)	0.00590* ‡ (0.077; FL 0.045) ‡	—

Variable	Spec 1: TRR only	Spec 2: Full Controls	Spec 3: +D_resource	Spec 4: Log-Ratio
ln(1+TRR)	—	—	—	0.02572 (0.119; FL 0.091)
Beta	—	0.0297 (0.278)	0.0301 (0.232)	0.0322 (0.180)
ln(Mkt Cap)	—	0.0080 (0.391)	0.0147 (0.223)	0.0051 (0.552)
Book-to-Market	—	0.0392 (0.432)	0.0764 (0.114)	0.0180 (0.668)
Leverage	—	0.0276 (0.653)	0.0702 (0.427)	0.0191 (0.759)
D_resource	—	—	-0.0570 (0.214)	—
N	25	25	25	25
R ²	0.336	0.433	0.514	0.477
Adj. R ²	0.307	0.284	0.352	0.339
Bootstrap 95% CI (TRR)	[+0.0014, +0.0083]	[-0.0038, +0.0088]	[-0.0027, +0.0104]	[-0.0149, +0.0456]
Implied $\lambda^* = \beta_1 \times \bar{D}$	7.0% (at $\bar{D} = 16.1$ yrs)	6.3%	9.5%	— (ln spec)
Pástor, Stambaugh and Taylor (2024) λ range	1.0%–2.7%	—	—	—
⚠ NOTE: $\bar{D} = 16.1$ yrs from Bams (2026) Vlerick slides. Confirm from your Dechow-Sloan-Soliman implementation. $\lambda^* = \beta_1 \times \bar{D}$ is a rescaling only — no re-run needed.				
Spearman $\rho(\text{COE}, \text{TRR})$	0.608 (p = 0.001)			
Spearman ρ — independent impl.	0.783 (p < 0.001)	††		
Pearson $r(\text{COE}, \text{TRR})$	0.558 (p = 0.004)			

Notes: HC3 p-values in parentheses alongside Freedman–Lane conditional permutation p (FL; 100,000 draws, seed 42; Freedman and Lane, 1983). **, * = HC3 5%/10%

significance; † = FL-p < 0.10; ‡ = FL-p < 0.05. Bootstrap 95% CI from 10,000 pairwise resamples, seed 42. All VIFs < 2.2. TRR winsorised at 5th–95th percentile. Corrected dataset. †† Yahoo Finance COE (larger cross-sectional spread); independently verified: all four specifications positive and significant under outcome-label permutation in the Yahoo Finance implementation (Sun, 13 August 2026). Reading-rule outcome per Section 4.3: No conditional OLS specification clears all three thresholds under the paper’s own pre-stated rule. Spec 1 has HC3 p = 0.044 and bootstrap CI excluding zero, but FL-p = 0.055 exceeds the pre-stated 0.05 threshold. Specs 2–4 not supported under any method on the primary MH GLS data. All specifications are treated as directional sensitivity evidence, not confirmatory inference — see main text.

Rank-order association. The Spearman rank correlation between TRR and GLS-implied COE is 0.608 (p = 0.001, N = 25) under the primary MH GLS implementation and 0.783 (p < 0.001) under the independent Yahoo Finance implementation — both significant and directionally identical. That the independent implementation yields a larger Spearman reflects the wider COE spread in Yahoo Finance forecasts (particularly for energy firms), not a difference in TRR: the correlation between the two COE vectors is 0.875. This is the paper’s most defensible pricing statement, invariant to the level concerns about implied COE raised in Section 4.3 and invariant to any monotone transformation of COE.

Table 5A: H₁ Regression Results — Book-Asset-Deflated Harm, N = 25 [TO BE INSERTED]

△ NOTE FOR JOURNAL VERSION: COMPUTATION NEEDED — Table 5A. Re-run OLS of GLS COE on $\text{harm}_i / \text{BookAssets}_i$ (winsorised 5–95), β , $\ln(\text{BookAssets}_i)$, leverage [Spec 2B]; add D_{resource} [Spec 3B]; harm_i alone [Spec 1B]. Same HC3/FL/bootstrap protocol as Table 5. Compute: $\text{harm}_i = \text{TRR}_i \times 0.022 \times \text{FV}_i$; $\text{BookAssets}_i = (\text{B/M})_i \times \text{MktCap}_i + \text{NetDebt}_i$. Estimated effort: ~1–2 hours. This is the primary fix for the share-price ratio problem.

Conditional OLS: applying the reading rule. The TRR coefficient is positive in all four specifications. Applying the three-method reading rule from Section 4.3: no conditional OLS specification clears all three thresholds under the paper’s own pre-stated rule. Spec 1 (parsimonious) has HC3 p = 0.044 and a bootstrap CI [+0.0014, +0.0083] that excludes zero, but Freedman–Lane p = 0.055, which exceeds the pre-stated 0.05 threshold. Specs 2–4 are not supported under any method on the primary MH GLS data: HC3 p-values are 0.199, 0.077, and 0.119 respectively; FL p-values are 0.149, 0.045, and 0.091; and bootstrap CIs all contain zero. Spec 3’s FL-p of 0.045 is notable — once the resource-sector binary absorbs the industry composition effect, the residual TRR signal approaches but does not cross the 5% threshold under HC3 or bootstrap. The honest summary is that conditional OLS is informative about direction but not confirmatory at N = 25: the TRR coefficient is positive across all four specifications under permutation inference, and we describe OLS as directional sensitivity evidence rather than confirmatory inference. The decisive test requires the pooled sample. Note: earlier draft versions reported permutation p-values of 0.0025 / 0.0049 / 0.0001 / 0.0006 across all four specs; as documented in Table 5 footnote, those values reflected a different permutation implementation (Yahoo Finance COE) and could not be

reproduced on the primary MH GLS data; all permutation inference in this version uses the Freedman–Lane procedure applied to the primary dataset.

Size and value channels. With $r(\ln mcap, TRR) = -0.498$, the size control works against rather than for the TRR coefficient; the Frisch–Waugh rows in Table 7 show TRR orthogonalised against $\ln(\text{market capitalisation})$ remains permutation-significant (perm-p = 0.009). The book-to-market confound is more material: $r(B/M, TRR) = +0.680$ (Spearman 0.692 with unwinsorised TRR; 0.723 with winsorised TRR as used in Table A1) under the primary implementation. TRR orthogonalised against both size and B/M remains permutation-significant (perm-p = 0.033) and strengthens with the resource indicator (perm-p = 0.005). One interpretation, offered for discussion rather than asserted, is that the market may already reflect externality exposure partly through the value channel; the alternative — that TRR is simply proxying for value and distress — cannot be excluded at $N = 25$ and is the central question the pooled sample must answer.

The λ estimates and the ASX–US comparison. Converting the slope estimates from Table 5 gives $\hat{\lambda}$ in the range 3.3%–9.5% across specifications and robustness variants, compared with Pástor, Stambaugh and Taylor's (2024) range of 1.0%–2.7% for US carbon burden. Every specification exceeds the Pástor et al. upper bound. Three explanations warrant consideration. First, Australian investors may price a genuinely larger fraction of externality exposure, consistent with this sample's concentration in coal, iron ore, hydrocarbons, and coal-fired generation — sectors facing the sharpest near-term policy pressure under the Safeguard Mechanism. Second, our TRR captures all negative environmental and social externalities, not only greenhouse gases; the broader base may command a broader premium than carbon alone. Third, TRR capitalises annual harm at $r_s = 2.2\%$, substantially below investors' own required returns; if TRR is thereby overstated relative to the measure investors would use, the slope is compressed and $\hat{\lambda}$ is biased upward. The firm-specific capitalisation diagnostic below addresses this. Distinguishing these three explanations requires the pooled sample.

Sensitivity to the capitalisation rate. TRR capitalises annual harm at $r_s = 2.2\%$, while under H_1 investors price future internalisation risk at their own required returns. The theoretically appropriate regressor for the pricing test is $\text{harm}_i / \text{COE}_i$ rather than harm_i / r_s . Recomputing TRR using each firm's own GLS-implied COE gives $\text{TRR_firm}_i = \text{TRR}_i \times r_s / \text{COE}_i$ — substantially reducing TRR for high-COE firms (Whitehaven: from 34.2 to approximately 5.1; Qantas: from 11.8 to approximately 1.5; Bams, 2026). The Spearman rank correlation between COE and TRR_firm falls to approximately 0.392 ($p = 0.053$) from $p = 0.608$ in the primary specification. We report this as a diagnostic, not an alternative primary specification: because COE_i appears on the left-hand side, including it in the TRR denominator creates a different form of mechanical dependence. The gap between $p = 0.608$ and $p \approx 0.392$ is informative about the contribution of the discount-rate gap to the rank association.

⚠ NOTE FOR JOURNAL VERSION: COMPUTATION NEEDED — firm-COE diagnostic: compute $\text{TRR_firm}_i = \text{TRR}_i \times 0.022 / \text{COE_GLS}_i$ for each firm; run Spearman $\rho(\text{COE_GLS}, \text{TRR_firm})$ and report p-value. Estimated effort: ~15 minutes.

Bams's figure ($p \approx 0.392$, $p = 0.053$) can be cited from discussion slides pending your own recomputation.

Table 6: Leave-One-Sector-Out Robustness (Spec 2)

Sector dropped	n	R ²	TRR coef.	HC3 p	Perm p
Consumer Staples & Services	21	0.439	0.00432	0.151	0.0056 ‡
Energy & Utilities	20	0.712	0.00548	0.410	0.0001 ‡
Healthcare & Technology	19	0.545	0.00299	0.211	0.0362 ‡
Industrials & Infrastructure	21	0.542	0.00213	0.474	0.0597 §
Materials	19	0.094	0.00259	0.647	0.1138

‡ FL- $p < 0.05$; § FL- $p < 0.10$. Freedman–Lane conditional permutation (100,000 draws, seed 42, corrected dataset). TRR survives in sectors where sufficient COE variation remains after removing Materials. When the entire Materials sector (six firms, the highest-TRR group) is removed, FL- p rises to 0.114 and R^2 collapses to 0.094 — the remaining cross-section carries insufficient COE variation to establish a conditional signal. This confirms that Materials-sector dependence is the binding constraint.

Table 7: Robustness Battery (Spec 2 base)

Variant	n	TRR coef.	HC3 p	Perm p	Note
Excl. Santos (takeover)	24	0.00349	0.298	0.0089 ‡	Signal robust
Excl. APA & Transurban (trusts)	23	0.00276	0.279	0.0268 ‡	Signal robust
Excl. James Hardie (Azek)	24	0.00403	0.177	0.0041 ‡	Signal robust
Excl. Whitehaven (TRR outlier)	24	0.00366	0.242	0.0175 ‡	Not outlier-driven
Excl. Rio Tinto (DLC)	24	0.00357	0.220	0.0092 ‡	Signal robust
Excl. all flagged firms	19	0.00207	0.515	0.1224	Power-constrained at n=19
Frisch–Waugh: TRR $\perp$ $\ln(\text{Mkt Cap})$	25	0.00369	0.124	0.0089 ‡	Size channel purged
Frisch–Waugh: + D_resource	25	0.00556	0.047	0.0002 ‡	Strengthens
Frisch–Waugh: TRR $\perp$ $\ln(\text{Mkt Cap}) + \text{B/M}$	25	0.00377	0.171	0.0329 ‡	Size and value purged
Frisch–Waugh: joint + D_resource	25	0.00540	0.082	0.0048 ‡	Strengthens

‡ $FL-p < 0.05$; § $FL-p < 0.10$. All rows: HC3 SE with Freedman–Lane conditional permutation p (FL; 100,000 draws, seed 42, corrected dataset). Frisch–Waugh rows: TRR (winsorised) is first regressed on the stated size/value variables; the residual then enters the Spec-2 control set. The signal survives every single-firm exclusion, including removal of the extreme-TRR observation (Whitehaven), and every orthogonalisation; the joint exclusion of all six flagged firms ($n = 19$) is the only variant below conventional thresholds. Note: perm- p values in Table 7 are HC3- t -based Freedman–Lane conditional permutations (see Section 4.3), which supersede the outcome-label permutation p -values in prior draft versions.

5.3 Post-Implementation Return Comparison: A Null Diagnostic

The AASB S2 effective date of 1 January 2025 is not a clean information event: it was widely anticipated, the first disclosures arrived in Q1 2026 (15 months later), and the 13-month post-period absorbs commodity cycles and interest-rate movements unrelated to any S2 information arrival. We therefore present the following strictly as a long-horizon exploratory return association, not as a causal test or event study. Specification details: market model estimated on monthly total returns (including dividends, adjusted for corporate actions) against the S&P/ASX 200 over February 2020–December 2024; firm-level CARs cumulated from January 2025–January 2026; median TRR split at the sample median (TRR = 1.690, APA Energy); no firms were delisted or trading-suspended during the window. Full firm-level CAR data are available from the corresponding author. We estimate a market model over a 59-month pre-implementation window (February 2020–December 2024) and compute cumulative abnormal returns (CAR) over January 2025–January 2026. Splitting at the median TRR, high-TRR firms earned a mean CAR of +7.4% and low-TRR firms –33.1% (Welch $t = 3.21$, $p = 0.006$; Mann-Whitney U $p = 0.006$; permutation $p = 0.002$). This sign is the reverse of what a risk-repricing narrative would predict, but as the sector analysis below shows, it is entirely attributable to sector composition rather than TRR; the framing as a causal diagnostic of any kind is therefore not warranted. The association disappears with sector controls: whether estimated with sector fixed effects or a resource-sector indicator, the TRR coefficient is indistinguishable from zero while the sector indicator remains strongly significant (full regression specification available from the corresponding author). The univariate TRR–CAR association is entirely attributable to sector composition. This is not evidence against the measurement framework; it is evidence that the date is unsuitable for a pricing test. By contrast, Schramade, Schoenmaker, Wiedemann and Marijnissen (2026), using the German Constitutional Court climate ruling of 29 April 2021, find a positive FR effect and negative TRR effect — consistent with a binding, unexpected legal shock. The Safeguard Mechanism Reform (effective 1 July 2023), which imposed binding emissions caps on Australia’s largest industrial emitters including several sample firms, is the closer Australian analogue and is identified in Section 6.4 as the preferred event for future work.

6. Discussion, Implications, and Conclusion

6.1 What the Results Mean

The central contribution is measurement transparency under difficult conditions. The corrected estimates document large, economically interpretable dispersion in integrated value across 25 economically material ASX firms: a value-weighted FR of -2.029 , a gross negative externality burden of approximately 4.05 times aggregate financial enterprise value, and a concentrated negative tail in coal, iron ore, hydrocarbons, and coal-fired generation, against a healthcare/technology group above unity. Those magnitudes are conditional on the maintained shadow prices, discount rate, attribution factors, and accounting boundaries; what the FR adds relative to a proprietary sustainability score is that every one of those choices is visible, inspectable, and replaceable. In the current Australian setting — first-year mandatory disclosure, heterogeneous reporting, and a resource-heavy index — that is the property that matters, and it is what allows the exposure to be located by flow type, by reported-versus-imputed status, and by driving assumption rather than collapsed into a binary label.

The pricing evidence sits one level below. The data are consistent with externality exposure being reflected in implied costs of equity: TRR and COE move together in rank order across two independent implementations (Spearman $\rho = 0.608$ and 0.783), and the TRR coefficient is positive in every OLS specification under permutation inference and robust to sector and single-firm exclusions and to Frisch–Waugh orthogonalisation against size and value. What $N = 25$ cannot deliver is identification: the highest-TRR firms are the Materials firms, TRR is strongly correlated with book-to-market, and the full-control specifications are supported by permutation inference but not by asymptotic or bootstrap inference. We therefore describe the pricing result as a hypothesis-generating consistency check — necessary but not sufficient for transition-risk pricing in the fuller sense — and do not let it bear the paper's practical claims.

6.2 Implications for Investors, Trustees, and Companies

For long-duration institutional investors, the FR provides a forward-looking externality-exposure measure operationally linked to mandatory disclosure. The corrected estimates change the exposure picture materially for several large holdings: BHP (old FR $+1.25$, new -2.82) and AGL Energy (old $+0.61$, new -18.45) now sit firmly in negative territory under the more precise waste and emissions methodology. That is a statement about the scale of shadow-priced externality burden relative to enterprise value, not about a recognised liability; but for an investor whose horizon includes plausible internalisation, the gap between a firm's FR and unity is the quantity that would be at risk, and the FR makes it visible at the parameter level.

The implication for Australian superannuation funds is direct. APRA has required regulated institutions to disclose material climate financial risks under CPG 229 since 2022, with expectations that trustees evidence portfolio-level climate risk exposure metrics. For trustees, the FR provides an auditable link between AASB S2 disclosures and portfolio-level metrics without dependency on third-party ESG rating methodologies

that are not publicly auditable: because FR inputs are physical quantities and shadow prices, disagreement with an estimate can be resolved at the parameter level. That is an architectural property; whether it translates into better prediction of cost of equity or returns is the empirical question the deferred H_2 test is designed to answer.

For company management, decomposing FR into business-unit components identifies which activities contribute to transition opportunity and which generate transition risk. Schramade, Schoenmaker, Wiedemann and Marijnissen (2026) show that integrated balance sheets built from FR components reveal risk-profile differences that conventional leverage ratios miss.

6.3 The FR in a Changing Disclosure Environment

The ESG backlash of 2024–2025 reflects a rejection of a specific measurement paradigm — the subjective, rater-dependent, aggregated score — not of the demand for externality-exposure measurement. The EU Omnibus I Directive narrows CSRD scope while AASB S2 strengthens, producing a global landscape of divergent compliance that places a premium on frameworks whose normative choices are visible and whose inputs travel across jurisdictions. The FR is designed for that environment. The present contribution is to show that it produces economically differentiated and interpretable estimates in a high-externality-intensity market from inaugural mandatory data, and that those estimates are directionally consistent with externality-exposure pricing in the cross-section.

6.4 Limitations and Future Research

We organise the limitations by the two binding constraints stated in Section 1 and by what follows from them, and we state for each what the journal version will do.

Small, purposive sample — a structural ceiling, not a design choice. The sample is bounded by the intersection of first-year mandate coverage, economic materiality, and usable disclosure. It is neither random nor comprehensive, and adding smaller or less-disclosing firms would raise N while lowering comparability and increasing imputation dependence. The paper therefore prioritises a transparent input audit over under-powered inference. With $N = 25$ and four to five regressors, effective degrees of freedom are too low to separate TRR from sector composition, size, and value simultaneously; permutation inference is the appropriate response but does not manufacture degrees of freedom. The negative size–TRR correlation by market value ($r = -0.498$) against the strongly positive correlation by book assets ($r \approx +0.87$) means the choice of size measure remains a structural feature to be tested at higher power.

Non-standard, heterogeneous disclosure. Reporting timing, format, organisational boundaries, Scope 3 completeness, and assurance vary across issuers. Reported and imputed inputs are not equally precise, and firm differences in FR may partly reflect coverage differences. This constrains both firm-ranking precision and econometric interpretation. The journal version will carry a firm-by-flow data appendix with accounting boundary, physical unit, source period, scope, imputation tier, and quality flag for each calculation.

Measurement uncertainty and the scope of the completed sensitivity. Scalar multipliers of $\pm 30\%$ and $\pm 50\%$ applied to the two novel mining-waste pricing choices — the WA MRF Class 1 mineral-rock rate and the bottom-ash tailings proxy — move the value-weighted FR from -1.910 (-50%) to -2.147 ($+50\%$), a range of 0.237 or 11.7% of baseline; the response is linear, and sign, every firm ranking, and every conclusion are unchanged. Decomposition attributes 95.5% of the range to the tailings proxy, which rests on a published CE Delft price, and 4.5% to the novel WA MRF rate. Only the six firms with mining-waste terms are affected; the other nineteen FRs are unchanged to full precision. Combined with the algebraic result in Section 3.1 (rankings invariant to the social discount rate and to uniform shadow-price rescaling), this supports a limited conclusion: the headline dispersion is *robust to the reported mining-waste sensitivity and to the discount-rate choice*, not “robust” without qualification. Non-uniform assumptions — the carbon shadow price, Scope 3 quantities and attribution factors, sales-volume conversions, sector intensity benchmarks, geographic valuation, and organisational boundaries — have not been jointly stressed. The journal version will report joint scenario and Monte-Carlo sensitivity across these dimensions with rank intervals rather than point ranks, leave-one-peer-out benchmarks for Mineral Resources, and an explicit welfare mapping (or separation) between rehabilitation liability and social externality for the mineral-rock stream.

Perpetuity assumption and emissions-path sensitivity. Equation (3) capitalises FY2025 annual value flows as a perpetuity at $r_s = 2.2\%$ — a maintained assumption whose consequences are large and now explicitly reported in Table 3 Panel A. At $r_s = 2.2\%$, the multiplier is 45.5 years. Under a 2%-per-year uniform decline (multiplier 23.8 years, 52% of perpetuity), the value-weighted FR rises from -2.03 to -0.59 and gross harm falls from $4.05\times$ to $2.1\times$ FV. Under a linear decline to zero by 2050, Paris-aligned (multiplier ~ 10.0 years, 22% of perpetuity), FR reaches $+0.33$ and gross harm falls to $0.9\times$ FV. On the comparators' own falling-path assumptions, the ASX result (-0.59 to $+0.33$) is directly comparable to the DAX-AEX reference of $+0.20$ (Schramade et al., 2026) and falls below the US $1.31\times$ carbon burden (Pástor, Stambaugh and Taylor, 2024). The large headline figure of -2.03 reflects the perpetuity assumption as much as Australia's sectoral composition. Company rankings are unchanged across all three path assumptions. The journal version will implement firm-specific finite-horizon scenarios using disclosed reserve-life data and transition-plan horizons for extractive firms, with rank intervals rather than point estimates.

Exploratory COE design. Implied COE is model- and forecast-input dependent (Section 4.3): six primary GLS estimates lie below the risk-free rate, and two implementations differ by 1.9 percentage points on average. The rank-order result is invariant to these level issues; the OLS coefficients are not. The journal version will freeze a dated forecast-input file, pre-specify model-failure and composite rules, report GLS/PEG/OJ/composite regressions separately, and add residual-permutation and wild-bootstrap inference alongside HC3.

Sample timing and the disclosure date. The 30 June 2025 valuation date precedes the Q1 2026 arrival of first Group 1 reports; the design is an ex post FY2025 measurement anchored to a common financial date, and mandatory disclosure

functions as a data source rather than an information event. The AASB S2 effective date cannot identify repricing (Section 5.3). The Safeguard Mechanism Reform (effective 1 July 2023), which imposed binding emissions caps on several sample firms (BHP, Rio Tinto, Fortescue, Whitehaven Coal, Origin Energy), is the closest Australian analogue to the German Constitutional Court ruling used in Schramade, Schoenmaker, Wiedemann and Marijnissen (2026); a pre-specified cross-sectional design around that date, with firm-level CARs regressed on TRR, TOR, and FR, is the preferred future identification vehicle.

Primary path to journal quality — a pre-specified pooled analysis. The decisive test of H_1 , the re-examination of TOR, and the H_2 incremental-information test against aligned ESG scores all require more cross-sectional variation than one first-year national sample can supply. The planned pooled analysis of approximately 76 firms (52 DAX–AEX firms from Schramade et al., 2026, plus the 25 ASX firms here) — extendable to further markets as ISSB-aligned mandatory disclosure matures — makes sector fixed effects feasible and allows TRR to be separated from size, value, and sector. Its requirements are valuation-date alignment, COE harmonisation on a single frozen forecast source, a documented sector classification, a disclosed sample frame with coverage thresholds, and pre-registration of specifications, inference plan, and expected signs. A machine-readable replication package — raw disclosed inputs with source pages, transformations, imputation code, the reconciliation log, forecast provenance, and all tables generated from code — will accompany that submission; for the conference version, the data, code, audit trail, and reconciliation log are available from the corresponding author.

Global South and shadow-price equity. King, Pucker and Colman (2025) note that OECD-calibrated shadow prices may systematically undervalue harms accruing to non-OECD communities. For an ASX sample with significant extractive operations outside Australia (BHP in Chile, Canada, and Sub-Saharan Africa; Rio Tinto in Guinea and Madagascar; South32 in South Africa, Mozambique, and Colombia) this is not marginal. Recalibrating shadow prices to the income levels of directly affected communities would raise TRR and lower FR for the major resource exporters — reinforcing rather than undermining the measured pattern. The magnitude is beyond the present scope and is a methodological priority for the pooled analysis.

6.5 Conclusion

This paper offers an early, transparent application of the Futureproofing Ratio to 25 economically material ASX firms using the best currently practicable disclosure and public data under Australia's inaugural AASB S2 regime. Its contribution is an explicit account of what can — and cannot yet — be measured from first-year, heterogeneous reporting in a resource-intensive market, and a documented methodology (tiered Scope 3 imputation; four-stream mining-waste classification) for doing so. Under the stated assumptions the estimates display material sectoral dispersion and a concentrated negative-externality tail: a value-weighted FR of -2.029 and a gross negative externality burden of approximately 4.05 times aggregate financial enterprise value, robust to the reported mining-waste sensitivity and, by construction, to the discount-rate choice.

The externality-exposure pricing evidence is retained as exploratory, directional evidence: TRR is positively rank-correlated with implied COE across two independent implementations, and the TRR coefficient is positive in every specification under permutation inference. It cannot be separated at $N = 25$ from sector composition and book-to-market, and it is presented as a consistency check that motivates — and does not substitute for — a pooled, pre-specified test with harmonised data, broader sensitivity analysis, and credible separation of externality exposure from conventional risk characteristics. TOR is not interpreted in the regressions for the same reason, and the post-implementation return comparison is an honest null explained by sector composition. Framed in this way, the paper is a measurement contribution with a candid pricing diagnostic, and a foundation for the pooled research programme that follows.

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Appendix A: Pairwise Correlation Matrix

Table A1: Correlations — corrected dataset (Pearson lower triangle, Spearman upper triangle), N = 25

	TRR	TOR	COE (GLS)	Beta	ln(Mcap)	B/M	Lev.
TRR	1.000	0.567***	0.608***	−0.318	−0.257	0.723***	0.130
TOR	0.336	1.000	0.520***	−0.290	0.087	0.221	−0.302
COE (GLS)	0.558***	0.294	1.000	0.098	−0.102	0.544***	0.212
Beta	−0.171	−0.354*	0.144	1.000	0.001	−0.363*	0.010
ln(Mcap)	−0.498**	0.001	−0.250	−0.028	1.000	−0.377*	−0.141
B/M	0.680***	0.070	0.486**	−0.290	−0.311	1.000	0.079
Lev.	−0.028	−0.271	0.017	−0.140	−0.194	−0.041	1.000

**** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Corrected dataset: ResMed B/M 0.137 (was 1.365) and ln(Mcap), and Rio Tinto ln(Mcap), corrected per Section 4.1. Primary implementation uses MH GLS COE with TRR winsorised at 5th–95th percentile. Key readings: $r(\text{TRR}, \text{COE}) = 0.558$ (Spearman 0.608) — rank-order association under the primary implementation (the 0.611 appearing in earlier draft appendices was a

typographic error; 0.608 is the canonical value from the regression workbook); Spearman rises to 0.783 under the independent Yahoo Finance implementation (see Section 4.3 and Table 5 † note). $r(\ln \mathbf{Mcap}, \text{TRR}) = -0.498$ — negative size–TRR relationship, opposite to the European pattern; $r(\text{B/M}, \text{TRR}) = 0.680$ (Spearman 0.692 with unwinsorised TRR; 0.723 with winsorised TRR as used in this table — see note below) — the value-channel confound discussed in Section 5.2. Note on winsorisation: Section 5.2 uses unwinsorised TRR for the B/M correlation (0.692), whereas this table uses the same winsorised TRR (5th–95th percentile) that enters the regressions, giving Spearman 0.723. Both are correct for their respective contexts; the difference is due to TRR transformation, not a data error. Spearman $\rho(\text{TRR}, \text{TOR}) = 0.567$ but Pearson $r = 0.336$ — modest linear cross-contamination between the risk and opportunity metrics. Independent implementation (Sun, 15 August 2026) additionally reports: Spearman $\rho(\text{TRR}, \text{Sustainalytics ESG Risk Rating}) = 0.738$ ($p < 0.001$); Spearman $\rho(\text{COE}, \text{ESG Risk Rating}) = 0.543$ ($p = 0.005$); consistent with H_2 test motivation (Section 3.2).*

Appendix B: What Is and Is Not Established — A Reader's Guide

Table B1: Claims, supporting evidence, and stated limits

Claim	Evidence in this paper	Status and limit
Externality exposure is large and highly dispersed across economically material ASX firms.	Table 2: VW FR -2.029 ; VW TRR 4.046 ; VW TOR 1.017 ; all six Materials firms below FR = 0 ; all six H&T firms above 1 ; median FR ≈ 1.002 .	Established as a measurement result conditional on stated shadow prices, $r_s = 2.2\%$, attribution, and boundaries. Not a market-implied or recognised liability.
The dispersion is not an artefact of the two novel mining-waste pricing choices.	$\pm 50\%$ multipliers move VW FR by 11.7% with every ranking unchanged; 95.5% of range from tailings proxy (published price), 4.5% from WA MRF rate.	Established for the reported mining-waste sensitivity. Carbon price, Scope 3, attribution, and boundaries not jointly stressed (journal version).
Rankings are robust to the social discount rate.	Algebraic: r_s enters as a uniform scalar (Section 3.1).	Established by construction for TOR, TRR, FR orderings and the sign of $(\text{FR} - 1)$. Does not extend to non-uniform parameter changes.
TRR and implied COE are positively rank-correlated.	Spearman $\rho = 0.608$ ($p = 0.001$) primary; 0.783 ($p < 0.001$) independent implementation, different forecast source.	Established as an association. Invariant to COE level issues. Not a ceteris-paribus premium.
The TRR coefficient is positive in conditional OLS.	Positive in Specs 1–4; FL-p $0.055 / 0.149 / 0.045 / 0.091$; Spec 1: HC3 $p = 0.044$ and bootstrap CI $[+0.0014, +0.0083]$ excluding zero.	Directional: No specification clears all three thresholds under the pre-stated rule. Spec 1 has HC3 $p = 0.044$ and bootstrap CI excluding zero, but FL-p $= 0.055 > 0.05$. Specs 2–4 not supported under any method (HC3 p

Claim	Evidence in this paper	Status and limit
		0.199/0.077/0.119; FL-p 0.149/0.045/0.091; bootstrap CIs include zero). Described as directional sensitivity evidence, not confirmatory inference. Not separable from sector (LOSO Materials: FL-p 0.114, R^2 0.094) or B/M ($p = 0.692$).
TRR carries information beyond ESG ratings (H_2).	$\rho(\text{TRR, Sustainalytics}) = 0.738$; $\rho(\text{COE, Sustainalytics}) = 0.543$ vs. $\rho(\text{COE, TRR}) = 0.783$ (independent impl.).	Not tested. Motivational only; deferred to pooled study with aligned ESG data.
Markets repriced around the AASB S2 effective date.	High-TRR CAR +7.4% vs. low-TRR -33.1%; disappears with sector controls (TRR indistinguishable from zero; sector indicator strongly significant).	Null diagnostic. Date is not an information event. Safeguard Mechanism Reform (1 July 2023) is the preferred future event.