Online Appendix to "Oversight Risk: How Investment Committees Shape Portfolio Performance"

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This appendix provides the full mathematical development and simulation details underlying the results in the main paper. Section 1 develops the model of portfolio choice under committee oversight. Section 2 derives closed-form expressions for standard performance metrics under both channels of oversight risk. Section 3 describes the simulation design, data, and calibration.

1 Model of Portfolio Choice under Committee Oversight

Consider a set of overseers $i \in \{1, \ldots, I\}$, each with mean-variance preferences characterized by risk aversion γ_i and beliefs $\boldsymbol{\mu}_i$ about expected returns on N risky assets. The risky assets have true expected returns $\boldsymbol{\mu}$, covariance matrix $\boldsymbol{\Sigma}$, and risk-free rate r_f. Each overseer's individual portfolio problem has the solution

$$\boldsymbol{x}_i = \frac{1}{\gamma_i}\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu}_i - r_f\mathbf{1}). \tag{1}$$

The random weight ϕ_i reflects overseer i's current influence in committee deliberations, with $\boldsymbol{\phi}$ denoting the vector of influence weights summing to one. The portfolio manager is modeled as choosing portfolio weights $\boldsymbol{x}$ to maximize the influence-weighted average of committee member utilities:

$$\max_{\boldsymbol{x}} \sum_{i=1}^{I} \phi_i \left[r_f + \boldsymbol{x}'(\boldsymbol{\mu}_i - r_f\mathbf{1}) - \frac{\gamma_i}{2}\boldsymbol{x}'\boldsymbol{\Sigma}\boldsymbol{x} \right]. \tag{2}$$

We study two channels of oversight risk separately: risk aversion volatility (Section 1.1) and belief volatility (Section 1.2).

1.1 Risk Aversion Volatility

We first isolate the effect of fluctuating risk preferences by assuming all committee members agree on expected returns ($\boldsymbol{\mu}_i = \boldsymbol{\mu}$ for all i) but differ in their risk tolerance. Each overseer i has mean-variance utility

$$U_i(\boldsymbol{x}) = r_f + \boldsymbol{x}'(\boldsymbol{\mu} - r_f\mathbf{1}) - \frac{\gamma_i}{2}\boldsymbol{x}'\boldsymbol{\Sigma}\boldsymbol{x}, \tag{3}$$

and the manager solves

$$\max_{\boldsymbol{x}} \sum_{i=1}^{I} \phi_i \left[\boldsymbol{x}'(\boldsymbol{\mu} - r_f\mathbf{1}) - \frac{\gamma_i}{2}\boldsymbol{x}'\boldsymbol{\Sigma}\boldsymbol{x}\right]. \tag{4}$$

The first-order condition yields the optimal portfolio:

$$\boldsymbol{x} = \frac{1}{\boldsymbol{\phi}'\boldsymbol{\gamma}}\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1}), \tag{5}$$

where $\boldsymbol{\phi}'\boldsymbol{\gamma} = \sum_{i=1}^{I} \phi_i\gamma_i$ is the influence-weighted average risk aversion. The portfolio has exactly the same composition as the optimal portfolio of a single manager with correct beliefs—the same relative weights across assets—but is scaled by $(\boldsymbol{\phi}'\boldsymbol{\gamma})^{-1}$ rather than by a fixed γ^{-1}.

Variance decomposition. Define $V = (\boldsymbol{\phi}'\boldsymbol{\gamma})^{-1}$ and $\boldsymbol{w} = \boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})$, so that portfolio excess return is $r_p - r_f = V\boldsymbol{w}'(\boldsymbol{r} - r_f\mathbf{1})$. Since both V (through fluctuating influence weights) and $\boldsymbol{r}$ (through market randomness) are random, the variance of portfolio returns is:

$$\sigma_p^2 = \boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w} + \sigma^2(V) + \operatorname{cov}(\boldsymbol{w}'\boldsymbol{r}, V). \tag{6}$$

In a model without oversight risk the variance would be simply $\boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w}$. The additional terms

$$\sigma_{or}^2 = \sigma^2(V) + \operatorname{cov}(\boldsymbol{w}'\boldsymbol{r}, V) \tag{7}$$

represent the variance contribution of oversight risk. The term $\sigma^2(V)$ captures the direct effect of fluctuating committee preferences. The covariance term captures the interaction between market returns and committee dynamics: if more risk-averse overseers tend to gain influence when portfolio returns are poor, this covariance is positive and adds further volatility.

Result 1. *When a portfolio is subject to oversight risk in risk aversion:*

(i) Volatility in effective overseer risk aversion increases the volatility of fund returns by increasing the volatility of trading positions.

(ii) Committee power dynamics that encourage more conservative investment after periods of poor returns and additional risk-taking after periods of high returns add an additional level of performance volatility above that found in (i).

Effect on expected returns. If the committee's effective risk aversion were constant at γ, the expected excess return would be $\gamma^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})$. With fluctuating influence weights, the expected excess return depends on $E[V] = E[(\boldsymbol{\phi}'\boldsymbol{\gamma})^{-1}]$. By Jensen's inequality, $E[V] = E[(\boldsymbol{\phi}'\boldsymbol{\gamma})^{-1}] \geq (\boldsymbol{\phi}'\boldsymbol{\gamma})^{-1}$ when $\boldsymbol{\phi}'\boldsymbol{\gamma}$ is random.

Effect on the Sharpe ratio. The Sharpe ratio of the portfolio is

$$S = \frac{E[V]\,\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1})}{\sqrt{\boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w} + \sigma^2(V) + \operatorname{cov}(\boldsymbol{w}'\boldsymbol{r}, V)}}. \tag{8}$$

The denominator grows with oversight volatility, so the Sharpe ratio falls as oversight risk increases. Although risk aversion scales the portfolio without altering relative asset weights at any given moment, the correlation between the scaling factor V and market returns creates a market-timing effect. When the committee's risk tolerance moves pro-cyclically—scaling up in rising markets and down in falling markets—the resulting convex payoff pattern manifests in a linear CAPM regression as slightly lower beta paired with positive alpha. The reverse concave pattern under counter-cyclical risk tolerance produces slightly higher beta and negative alpha.

Portfolio beta. The portfolio's beta relative to the market portfolio is

$$\beta_{p,m} = \frac{\operatorname{cov}(r_p, r_m)}{\sigma_m^2} = \frac{\frac{1}{\boldsymbol{\phi}'\boldsymbol{\gamma}}\boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})/\boldsymbol{x}_m'\boldsymbol{\Sigma}\boldsymbol{x}_m}{\frac{1}{\gamma}\boldsymbol{x}_m'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})/\boldsymbol{x}_m'\boldsymbol{\Sigma}\boldsymbol{x}_m}. \tag{9}$$

Treynor measure.

$$T = \frac{E[r_p - r_f]}{\beta_{p,m}} = \frac{E[V]\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1})}{\frac{1}{\boldsymbol{\phi}'\boldsymbol{\gamma}}\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1})/\boldsymbol{x}_m'\boldsymbol{\Sigma}\boldsymbol{x}_m}. \tag{10}$$

Jensen's alpha.

$$\alpha = E[r_p - r_f] - \beta_{p,m}\,E[r_m - r_f] = E[V]\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1}) - \frac{1}{\boldsymbol{\phi}'\boldsymbol{\gamma}}\frac{\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1})}{\boldsymbol{x}_m'\boldsymbol{\Sigma}\boldsymbol{x}_m}\,\boldsymbol{x}_m'(\boldsymbol{\mu} - r_f\mathbf{1}). \tag{11}$$

Information Ratio.

$$\begin{aligned} IR &= \frac{E[r_p - r_b]}{\sigma_{p-b}} \\ &= \frac{E[V]\boldsymbol{w}'(\boldsymbol{\mu} - r_f\mathbf{1}) - \boldsymbol{x}_m'\boldsymbol{\mu}}{\sqrt{\left[\frac{1}{(\boldsymbol{\phi}'\boldsymbol{\gamma})^2} - \frac{2}{\boldsymbol{\phi}'\boldsymbol{\gamma}} + \frac{1}{\gamma^2}\right](\boldsymbol{\mu} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})}}. \end{aligned} \tag{12}$$

1.2 Belief Volatility

Now suppose committee members share a common risk aversion γ but differ in their beliefs about expected returns. Let $\boldsymbol{M} = [\boldsymbol{\mu}_1, \ldots, \boldsymbol{\mu}_I]$ be the $N \times I$ matrix of member-specific expected return vectors. The committee's *effective beliefs* are the influence-weighted average $\boldsymbol{y} = \boldsymbol{M}\boldsymbol{\phi}$, and the manager solves

$$\max_{\boldsymbol{x}} \sum_{i=1}^{I} \phi_i \left[\boldsymbol{x}'(\boldsymbol{\mu}_i - r_f\mathbf{1}) - \frac{\gamma}{2}\boldsymbol{x}'\boldsymbol{\Sigma}\boldsymbol{x}\right] = \max_{\boldsymbol{x}} \left[\boldsymbol{x}'(\boldsymbol{y} - r_f\mathbf{1}) - \frac{\gamma}{2}\boldsymbol{x}'\boldsymbol{\Sigma}\boldsymbol{x}\right]. \tag{13}$$

The optimal portfolio is

$$\boldsymbol{x} = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}(\boldsymbol{y} - r_f\mathbf{1}). \tag{14}$$

The formulation $\boldsymbol{y} = \boldsymbol{M}\boldsymbol{\phi}$ can be read as a multivariate analog of the Social Judgment Scheme (SJS) model of Davis (1996), which characterizes group consensus on continuous quantitative outcomes as a weighted combination of individual member judgments. In the SJS model, each member's influence weight decreases with the distance between that member's position and the positions of other members—a majority-influence rule. The principal departure from the SJS framework is that we treat $\boldsymbol{\phi}$ as an exogenous random process capturing the committee's changing power dynamics, preserving tractability while enabling the volatility analysis that is the paper's main contribution.

Unlike the risk aversion channel, where fluctuations scale the entire portfolio up or down, fluctuations in effective beliefs alter the *composition* of the portfolio—shifting weights across asset classes in ways that may or may not reflect genuine information about future returns.

Portfolio weight variance. Assume the random vector $\boldsymbol{y}$ has mean $\boldsymbol{\mu}_y$ and covariance matrix $\boldsymbol{\Sigma}_y$. The variation in portfolio weights is

$$\boldsymbol{\Sigma}_{\boldsymbol{x}} = \frac{1}{\gamma^2}\boldsymbol{\Sigma}^{-1}\boldsymbol{\Sigma}_y\boldsymbol{\Sigma}^{-1}. \tag{15}$$

Excess returns for fixed beliefs. For a given set of effective beliefs $\boldsymbol{y}$, the excess return to the portfolio is

$$r_p - r_f = \frac{1}{\gamma}(\boldsymbol{y} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{r} - r_f\mathbf{1}). \tag{16}$$

The expected excess return conditional on $\boldsymbol{y}$ is

$$E[r_p - r_f \mid \boldsymbol{y}] = \frac{1}{\gamma}(\boldsymbol{y} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1}), \tag{17}$$

and the conditional variance of returns is

$$\sigma_p^2(\boldsymbol{y}) = \frac{1}{\gamma^2}(\boldsymbol{y} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{y} - r_f\mathbf{1}). \tag{18}$$

Beta under fixed beliefs.

$$\beta_{p,m}(\boldsymbol{y}) = \frac{(\boldsymbol{y} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})}{(\boldsymbol{\mu} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1})}. \tag{19}$$

2 Performance Metrics under Random Beliefs

When the effective beliefs $\boldsymbol{y}$ are random, the return to the portfolio is

$$r_p = r_f + \frac{1}{\gamma}(\boldsymbol{y} - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{r} - r_f\mathbf{1}). \tag{20}$$

The randomness of portfolio returns interacts with effective beliefs. We characterize the relationship between returns and effective beliefs by the covariance matrix $\boldsymbol{\Sigma}_{ry} = \mathrm{cov}(\boldsymbol{r}, \boldsymbol{y})$. When the entries of $\boldsymbol{\Sigma}_{ry}$ are positive, the committee's beliefs tend to be optimistic about assets that subsequently perform well, reflecting genuine committee skill.

Expected excess return under random beliefs. Using standard results for the expectation of a bilinear form (Petersen & Pedersen 2012):

$$E[r_p - r_f] = \frac{1}{\gamma}(\boldsymbol{\mu}_y - r_f\mathbf{1})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1}) + \frac{1}{\gamma}\,\mathrm{tr}(\boldsymbol{\Sigma}^{-1}\boldsymbol{\Sigma}_{ry}). \tag{21}$$

The first term is the expected return under constant beliefs $\boldsymbol{\mu}_y$. The second term captures the relationship between beliefs and returns: positive $\boldsymbol{\Sigma}_{ry}$ adds to expected return (committee skill), negative $\boldsymbol{\Sigma}_{ry}$ subtracts from it.

When the committee's beliefs are correct on average ($\boldsymbol{\mu}_y = \boldsymbol{\mu}$), the first term equals the expected excess return of the market portfolio. To understand the second term, consider the case where $\mathbf{\Sigma}_{ry}$ is diagonal with entries $\theta_i = \operatorname{cov}(r_i, y_i)$. Then

$$\frac{1}{\gamma}\operatorname{tr}(\mathbf{\Sigma}^{-1}\mathbf{\Sigma}_{ry}) = \frac{1}{\gamma}\sum_{i=1}^{N}\frac{\theta_i}{\sigma^2_{i|-i}}, \tag{22}$$

where $\sigma^2_{i|-i}$ is the conditional variance of returns to asset i given returns to all other assets (obtained via the Schur complement of $\mathbf{\Sigma}$).

Variance of returns under random beliefs. Assuming $\boldsymbol{y}$ and $\boldsymbol{r}$ are jointly normally distributed, using standard results for the variance of a bilinear form of jointly normal random variables (Petersen & Pedersen 2012):

$$\sigma_p^2 = \frac{1}{\gamma^2}(\boldsymbol{\mu}_y - r_f\mathbf{1})'\mathbf{\Sigma}^{-1}(\boldsymbol{\mu} - r_f\mathbf{1}) + \frac{1}{\gamma^2}\operatorname{tr}(\mathbf{\Sigma}^{-1}\mathbf{\Sigma}_y) + \frac{1}{\gamma^2}\operatorname{tr}(\mathbf{\Sigma}^{-1}\mathbf{\Sigma}_{ry}\mathbf{\Sigma}^{-1}\mathbf{\Sigma}'_{ry}). \tag{23}$$

The middle term, $\gamma^{-2}\operatorname{tr}(\mathbf{\Sigma}^{-1}\mathbf{\Sigma}_y)$, is the direct contribution of belief variance to portfolio return variance—the formal expression of the second channel of oversight risk. The third term captures the interaction between belief variance and the correlation between beliefs and returns.

Summary of performance metrics. For a portfolio with weights $\boldsymbol{x}$, true expected returns $\boldsymbol{\mu}$, covariance matrix $\mathbf{\Sigma}$, risk-free rate r_f, and market portfolio weights $\boldsymbol{x}_m$:

$$\text{Sharpe ratio} = \frac{\boldsymbol{x}'(\boldsymbol{\mu} - r_f\mathbf{1})}{\sqrt{\boldsymbol{x}'\mathbf{\Sigma}\boldsymbol{x}}}, \tag{24}$$

$$\alpha = \boldsymbol{x}'(\boldsymbol{\mu} - r_f\mathbf{1}) - \frac{\boldsymbol{x}'\mathbf{\Sigma}\boldsymbol{x}_m}{\boldsymbol{x}'_m\mathbf{\Sigma}\boldsymbol{x}_m}\boldsymbol{x}'_m(\boldsymbol{\mu} - r_f\mathbf{1}), \tag{25}$$

$$\text{Information Ratio} = \frac{(\boldsymbol{x} - \boldsymbol{x}_m)'\boldsymbol{\mu}}{\sqrt{\boldsymbol{x}'\mathbf{\Sigma}\boldsymbol{x} - 2\boldsymbol{x}'\mathbf{\Sigma}\boldsymbol{x}_m + \boldsymbol{x}'_m\mathbf{\Sigma}\boldsymbol{x}_m}}. \tag{26}$$

3 Simulation Design and Calibration

3.1 Data

Monthly sector returns and market-capitalization weights are constructed from CRSP data spanning 18 NAICS sectors from March 1970 to December 2025. The monthly risk-free rate is taken from the Fama-French five-factor data file. The NAICS sectors "Public Administration" and "Other Services (except Public Administration)" are excluded because there are spells during the sample period where no data is available for publicly traded firms in these sectors. The sample is restricted to months for which all 18 sectors have complete return data.

The covariance matrix of excess returns is estimated at each month using a 60-month rolling window.

3.2 Market-Implied Expected Returns

The market-implied expected excess returns are computed at each month t using the Black-Litterman reverse-optimization formula, which inverts the first-order conditions of a mean-variance investor holding the market portfolio:

$$\boldsymbol{\mu}_t - r_{f,t} = \gamma\, \boldsymbol{\Sigma}_t\, \boldsymbol{x}_{m,t}, \tag{27}$$

where $\boldsymbol{x}_{m,t}$ is the vector of market-capitalization weights for the 18 sectors, $\boldsymbol{\Sigma}_t$ is the covariance matrix estimated from the 60-month rolling window, $r_{f,t}$ is the monthly risk-free rate, and $\gamma = 1$ is the market risk-aversion parameter. The resulting vector $\boldsymbol{\mu}_t$ serves as the benchmark "true" expected returns against which committee beliefs are measured throughout all three simulation exercises.

3.3 Monte Carlo Protocol

All three simulation exercises follow the same protocol: for each parameter configuration, 10,000 independent paths through the sample period are drawn. In each draw, optimal portfolio weights are computed at every month in the sample using

$$\boldsymbol{x}_t = \frac{1}{\gamma_t} \boldsymbol{\Sigma}_t^{-1} \boldsymbol{y}_t, \tag{28}$$

and the resulting time series of portfolio returns is used to calculate the Sharpe ratio, Jensen's alpha, and Information Ratio relative to the value-weighted market portfolio.

3.4 Simulation 1: Risk Aversion Volatility

The committee's effective risk aversion $\gamma_t \equiv \boldsymbol{\phi}_t' \boldsymbol{\gamma}$ is modeled as a logistic function of the current month's excess market return:

$$\gamma_t = 0.5 + \frac{1.0}{1 + \exp(-k\,(r_{m,t} - \bar{r}_m))} + \varepsilon_t, \qquad \varepsilon_t \sim N(0,\, 0.01), \tag{29}$$

where $r_{m,t}$ is the excess market return at month t, $\bar{r}_m$ is its sample mean, k is the sensitivity parameter, and ε_t is idiosyncratic noise. The logistic specification keeps γ_t in the range $(0.5, 1.5)$ on average. Positive k implies that risk aversion rises with market returns (counter-cyclical risk tolerance), while negative k implies pro-cyclical risk tolerance. In all periods the committee's beliefs about expected returns are consistent with market beliefs and are equal to $\boldsymbol{\mu}_t$; only the risk aversion fluctuates. The simulation is run for $k \in \{-4, -3, -2, -1, 0, 1, 2, 3, 4\}$.

3.5 Simulation 2: Belief Volatility Without Skill

The committee's effective beliefs at month t are modeled as

$$\boldsymbol{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \sim N(\boldsymbol{0}, \, \sigma^2 \boldsymbol{I}), \tag{30}$$

where σ is the belief noise standard deviation. Noise is drawn independently across sectors and time periods, so the committee's beliefs are correct on average but fluctuate randomly around the market-implied expected returns each month. The effective risk aversion is fixed at $\gamma_t = 1$ throughout. The simulation is run for $\sigma \in \{0.02, 0.04, 0.06, 0.08, 0.10, 0.20\}$.

3.6 Simulation 3: Skill–Noise Tradeoff

The committee's beliefs at month t are constructed to have a target cosine similarity with the next period's market-implied expected returns—a measure of predictive skill. Specifically,

$$\boldsymbol{y}_t = \|\boldsymbol{\mu}_t\| \left(\rho_t \, \hat{\boldsymbol{\mu}}_{t+1} + \sqrt{1 - \rho_t^2} \, \hat{\boldsymbol{u}}_{\perp,t} \right), \qquad \rho_t = \operatorname{clip}(\bar{\rho} + \eta_t, \, -1, \, 1) \,, \quad \eta_t \sim N(0, \, \sigma_\rho^2), \tag{31}$$

where:

- $\hat{\boldsymbol{\mu}}_{t+1}$ is the unit vector in the direction of next-period market-implied expected returns,
- $\hat{\boldsymbol{u}}_{\perp,t}$ is a random unit vector orthogonal to $\hat{\boldsymbol{\mu}}_{t+1}$,
- $\bar{\rho}$ is the target cosine similarity (average skill),
- σ_ρ is the standard deviation of period-to-period variation in realized skill,
- $\operatorname{clip}(\cdot, -1, 1)$ truncates the argument to $[-1, 1]$.

This decomposition separates effective beliefs into a signal component aligned with the direction of future market-implied returns and an orthogonal noise component, while preserving the magnitude $\|\boldsymbol{\mu}_t\|$ in every period. The cosine similarity between the committee's beliefs and next-period returns is a natural measure of skill: it captures the degree to which the committee's beliefs are directionally aligned with future returns, independent of the magnitude of those beliefs.

The simulation is run for

$$\bar{\rho} \in \{0.0, 0.1, 0.2, 0.3, 0.4, 0.5\} \times \sigma_{\rho} \in \{0.00, 0.01, 0.02, 0.03, 0.50, 0.75\}.$$

3.7 Interpretation of Skill Measure

Managers whose beliefs are better aligned with future risk premia can tilt portfolio weights toward sectors that will subsequently outperform, earning higher risk-adjusted returns. The cosine similarity measure separates two dimensions of belief quality:

1. *Direction*: how well the committee's relative sector views align with future relative returns.

2. *Noise*: how much period-to-period variation there is in the realized alignment, even for a committee with a given average skill level.

Skill raises the expected level of portfolio performance (shifts the performance distribution rightward). Noise widens the distribution of outcomes without shifting its center—a "second-moment" effect of particular concern to institutional investors subject to drawdown constraints or performance benchmarking.

References

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