The Benchmark Inclusion Subsidy

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Abstract

We study the impact of evaluating the performance of asset managers relative to a benchmark portfolio on firms' investment, merger and IPO decisions. We introduce asset managers into an otherwise standard asset pricing model and show that firms that are part of the benchmark are effectively subsidized by the asset managers. This "benchmark inclusion subsidy" arises because asset managers have incentives to hold some of the equity of firms in the benchmark regardless of the risk characteristics of these firms. Contrary to what is usually taught in corporate finance, we show that the value of an investment project is not governed solely by its own cash-flow risk. Instead, because of the benchmark inclusion subsidy, a firm inside the benchmark would accept some projects that an identical one outside the benchmark would decline. The two types of firms' incentives to undertake mergers or spinoffs also differ and the presence of the subsidy can alter a decision to take a firm public. We show that the higher the cash-flow risk of an investment, the larger the benchmark inclusion subsidy; the subsidy is zero for safe projects. We review a host of empirical evidence that is consistent with the implications of the model.

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1 Introduction

The asset management industry is estimated to control more than $70 trillion worldwide. Most of this money is managed against benchmarks. For instance, S&P Global reports that as of the end of 2017 there was just under $10 trillion managed against the S&P 500 alone.[1] Existing research related to benchmarks has largely been focused on asset pricing implications of benchmarking. Instead we look at the implications of benchmarking for corporate decisions. We argue that firms included in a benchmark are effectively subsidized by asset managers and so should evaluate investment opportunities differently.

Our analysis runs counter to what is usually taught to MBAs regarding investment decisions. Standard theory states that the appropriate cost of capital depends purely on the characteristics of a project and *not* on the entity that is considering investing in it. More precisely, the "asset beta" computed by the capital asset pricing model (CAPM) is presumed to be the correct anchor for computing the discount factor used in evaluating a project's risk. We show that when asset managers are present and their performance is measured against a benchmark, this presumption is no longer true. Instead, we find that firms that are part of a benchmark will have a different cost of capital than similar firms outside the benchmark. To be specific, when a firm adds cash flows, say, because of an acquisition or by investing in a new project, the increase in the stockholder value is larger if the firm is inside the benchmark. Hence, a firm in the benchmark is willing to attract cash flows with lower mean and/or larger variance than an otherwise identical non-benchmark firm.

The underlying reason for this result is that when a firm is part of a widely-held benchmark, asset managers are compelled to hold some shares of that firm's equity *regardless* of the characteristics of the firm's cash flows. So when a firm adds cash flows, the market demand for them is higher and hence the increase in the stockholder value is also higher if the firm is inside the benchmark rather than outside. We call this the "benchmark inclusion subsidy." The firm, therefore, should take this consideration into account in deciding on its investments, acquisitions and spinoffs.

Here is how the model works. We take a standard asset pricing model and allow for heterogeneity, where some investors manage their own portfolios and others use asset

[1] As of November 2017, Morgan Stanley Capital International reports that $3.2 trillion was benchmarked against its All Country World Index and $1.9 trillion was managed against its Europe, Australasia and Far East index. Across various markets, FTSE-Russell reports that at the end of 2016 $8.6 trillion was benchmarked to its indices.

managers. An asset manager's compensation depends on the absolute performance of his portfolio and its relative performance compared to a benchmark portfolio. We show that the asset manager's optimal portfolio is a combination of the mean-variance portfolio and the benchmark portfolio—the latter appearing because of the relative performance component of the manager's compensation. Specifically, asset managers hold a fixed part of their portfolio in benchmark stocks regardless of the stocks' prices and characteristics of their cash flows, in particular, irrespective of cash-flow variance. As a result, the equilibrium stock price of a benchmark firm is less adversely affected by the same cash-flow risk than would be that of an otherwise identical firm that is outside the benchmark.

For instance, consider a benchmark and a non-benchmark firms contemplating investing in a risky project. When the benchmark firm invests, the extra variance of its cash flows resulting from the project will be penalized less than that of an identical non-benchmark firm. Thus investing in a project increases the firm's stock value by more if the firm is in the benchmark. Put differently, investment is effectively subsidized for the benchmark firm. Because the subsidy is tied to cash-flow risk, however, the two firms will still value risk-free projects identically.

To demonstrate these results in the most transparent way, we construct a simple example that makes the main points. The example contrasts the values of three uncorrelated securities in a world with and without asset managers. The example shows that when asset managers are present, firms inside the benchmark are more likely to engage in mergers.

We then turn to an extended model that considers a wider set of assets with an arbitrary correlation structure and allows us to study the effect of the benchmark inclusion subsidy on new investments, as well as on mergers and divestitures. The model can also be used to analyze incentives for a firm to go public. We show that the intuition from the example carries over and demonstrate how the benchmark inclusion subsidy should change a number of corporate decisions. The extended model also allows us to analyze the variables that influence the size of the benchmark inclusion subsidy. We show that the higher the cash-flow risk of an investment, the larger the benchmark inclusion subsidy. Furthermore, the subsidy is the largest for projects that are clones of a firm's existing assets; as the correlation of a project's cash flows with the existing assets drops, so does the benchmark inclusion subsidy. Finally, the size of the subsidy rises as the asset management sector grows in size.

The model implies that benchmarking alters payoffs so that the benchmark becomes a factor that explains expected returns. Hence, in our model both the benchmark and the usual market portfolio matter for pricing assets. The right model for the cost of capital in

our environment is therefore not the CAPM, but its two-factor modification that accounts for the presence of asset managers.

Finally, it is worth noting that our model applies to both active and passive asset management. We show that the effect is stronger when more asset managers are passive rather than active.

We review existing empirical work that relates to the model's predictions. Past research confirms, to varying degrees, the predictions regarding the propensity to invest and engage in acquisitions for benchmark vs. non-benchmark firms, the factor structure of returns, as well as the size of the benchmark inclusion subsidy being increasing in assets under management.

The remainder of the paper is organized as follows. In the next section, we explain how our perspective compares to previous work. Section 3 presents the example, and Section 4 studies the general model. Section 5 reviews related empirical evidence. Section 6 presents our conclusions and suggestions for future areas of promising research. Omitted proofs are in the appendix.

2 Related Literature

The empirical motivation for our work comes from the index additions and deletions literature. Harris and Gurel (1986) and Shleifer (1986) were the first to document that when stocks are added to the S&P 500 index, their prices rise. Subsequent papers have also shown that firms that are deleted, experience a decline in price. The findings have been confirmed across many studies and for many markets, so that financial economists consider these patterns to be stylized facts.[2] The estmated magnitudes of the index effect vary across studies, and typically most of the effect is permanent. For example, Chen, Noronha, and Singal (2004) find the cumulative abnormal returns of stocks added to the S&P 500 during 1989-2000, measured over two months post announcement, to be 6.2%.

Several theories have been used to interpret the index effect. The first is the investor awareness theory of Merton (1987). Merton posits that some investors become aware of and invest in a stock only when it gets included in a popular index. It is unclear why investor awareness declines for index deletions, although there is evidence of a decrease in analyst coverage. The second theory posits that an index inclusion conveys information about

[2]See, e.g, Beneish and Whaley (1996), Lynch and Mendenhall (1997), Wurgler and Zhuravskaya (2002), Chen, Noronha, and Singal (2004), Petajisto (2011), and Hacibedel (2018).

a firm's improved prospects. This theory has difficulty explaining the presence of index effects around mechanical index recompositions (see, e.g., Boyer, 2011, among others).

The third theory can be broadly described as the price pressure theory, proposed by Scholes (1972). Scholes' prediction is that prices of included stocks should rise temporarily, to compensate liquidity providers, but should soon revert back as investors find substitutes for these stocks. Subsequent literature has argued that the price pressure effects could be (more) permanent, driven by changing compositions of investors. Our model is broadly consistent with the price pressure view. Our benchmarked asset managers exert a permanent pressure on prices of stocks in the benchmark. They *do not* substitute away from these stocks even if they are overpriced; holding a substitute stock is costly for an asset manager because this entails a (risky) deviation from her benchmark.

Our work is also related to a theoretical literature in asset pricing that explores the effects of benchmarking on stock returns and their comovement. The first paper in this line of research is Brennan (1993), who, like us, derives a two-factor CAPM in an economy with asset managers. Cuoco and Kaniel (2011), Basak and Pavlova (2013), and Buffa, Vayanos, and Woolley (2014) show how benchmarking creates additional demand for stocks included in the benchmark index, generating an index effect. Basak and Pavlova also derive excess comovement of index stocks. This literature focuses on asset prices, taking stocks' cash flows as given, and does not explore the real effects of benchmarking.

Our paper is perhaps most closely related to Stein (1996). He also studies capital budgeting in situations where the CAPM does not correctly describe expected stock returns.[3] He assumes, however, that the deviations are temporary and arise because of investor irrationality. If market participants fail to appreciate risk and will allow a firm to issue mispriced equity, he explains why rational managers may want to issue equity and invest, even if the CAPM-based valuation of a project is negative. In Stein's setup, the horizon that managers use for making decisions is critical, and those that are short-term oriented will potentially respond to mispricing if it is big enough. In our model, all managers of firms in the benchmark should account for the subsidy (for as long as the firm remains in the benchmark).

Stein's paper led to a number of follow-on studies that look at other potential behavioral effects that could be associated with inclusion in a benchmark. Classical finance maintains

[3]In a recent work, Da, Guo, and Jagannathan (2012) point out that the presence of real options invalidates the use of the CAPM for capital budgeting, because even if the CAPM holds for the assets in place, it does not hold for options on those assets. Their empirical analysis that adjusts for real options, however, concludes that nevertheless the CAPM provides a reasonable estimate of a project's cost of capital.

that being in a benchmark is largely irrelevant (aside from the considerations raised by Scholes, 1972); the behavioral literature challenges that conclusion. For example, Barberis and Shleifer (2003) propose a theory of style investing, in which stocks are classified in groups based on investment styles. Benchmark membership could be interpreted as an investment style. They study how stock returns could be affected when investors switch styles. See Barberis and Thaler (2003) (section 8) for a survey of the associated behavioral literature. In our model, the asset managers create persistent effects and whether one describes this a behavioral effect would depend on what one thinks about the motivation for the benchmarking in the first place.

Finally, there is recent literature on mistakes that managers make in project valuation. Survey evidence from Graham and Harvey (2001) shows that a large percentage of publicly traded companies use the CAPM to calculate the cost of capital. In addition, they seem to use the same cost of capital for all projects. Krüger, Landier, and Thesmar (2015) document that this tendency appears to distort investments by diversified firms. In particular, they appear to make investment decisions in non-core businesses by using the discount rate from their core business. Interestingly, in our model, the benchmark inclusion subsidy applies to the entire firm so there is a basis for having part of the cost of capital depend on that firm-wide characteristic.

3 Example

To illustrate the main mechanism, we begin with a simple example with three uncorrelated assets. We first consider an economy populated by identical investors who manage their own portfolios. We then modify the economy by introducing another group of investors who hire asset managers to run their portfolios. Asset managers' performance is evaluated based on a comparison with a benchmark. We show that the presence of asset managers invalidates the standard approach to corporate valuation.

3.1 Baseline Economy

Consider the following environment. There are two periods, $t = 0, 1$. Investment opportunities are represented by three risky assets denoted by 1, 2, and y, and one risk-free bond. The risky assets are claims to cash flows D_i realized at $t = 1$, where $D_i \sim N(\mu_i, \sigma_i^2)$, $i = 1, 2, y$, and these cash flows are uncorrelated. The risk-free bond pays an interest rate that is

normalized to zero. Each of the risky assets is available in a fixed supply that is normalized to one. The bond is in infinite net supply. Let S_i denote the price of asset $i = 1, 2, y$.

There is measure one of identical agents who invest their own funds. Each investor has a constant absolute risk aversion (CARA) utility function over final wealth W, $U(W) = -e^{-\alpha W}$, where $\alpha > 0$ is the coefficient of absolute risk aversion. All investors are endowed with one share of each stock and no bonds. At $t = 0$, each investor chooses a portfolio of stocks $x = (x_1, x_2, x_y)^\top$ and the bond holdings to maximize his utility, with $W(x) = \sum_{i=1,2,y} S_i + x_i(D_i - S_i)$.

As is well-known in this kind of setup, the demand x_i for risky asset i and the corresponding equilibrium price S_i will be

$$x_i = \frac{\mu_i - S_i}{\alpha \sigma_i^2},$$
$$S_i = \mu_i - \alpha \sigma_i^2$$

for $i = 1, 2, y$, where the second equation follows from setting the number of shares demanded equal to the supply (which is 1).[4]

When either asset $i \in \{1, 2\}$ and y are combined into a single firm, the demand for the combined firm's stock and the corresponding equilibrium stock price are

$$x_i' = \frac{\mu_i + \mu_y - S_i'}{\alpha(\sigma_i^2 + \sigma_y^2)},$$
$$S_i' = \mu_i + \mu_y - \alpha(\sigma_i^2 + \sigma_y^2) = S_i + S_y.$$

Notice that the combined value of either firm is exactly equal to the sum of its initial value plus the value of y. This is a standard valuation result that says that the owner of an asset does not determine its value. Instead, the value arises from the cash flows (and risks) associated with the asset, which are the same regardless of who owns them.

3.2 Adding Asset Managers

Now we extend the example by considering additional investors who hire asset managers to manage their portfolios. There are now three types of agents in the economy, the same investors as before who manage their own portfolios and whom we refer to as "conventional"

[4] We omit derivations for this simple example, but the analysis of our main model contains all proofs for the general case.

investors from now on (fraction λ_C of the population), asset managers (fraction λ_{AM}), and shareholders who hire those asset managers.[5] All agents have the same preferences (as in the example).

Shareholders can buy the bond directly, but cannot trade stocks; they delegate the selection of their portfolios to asset managers. They receive compensation w from shareholders. This compensation has three parts: one is a linear payout based on absolute performance of the portfolio x, the second piece depends on the performance relative to the benchmark portfolio, and the third is independent of performance.[6] Suppose that the benchmark is simply the stock of firm 1. Then

$$w = ar_x + b(r_x - r_{\mathbf{b}}) + c = (a+b)r_x - br_{\mathbf{b}} + c, \tag{1}$$

where a, b and c are positive constants, $r_x = \sum_{i=1,2,y} x_i(D_i - S_i)$ and $r_{\mathbf{b}} = D_1 - S_1$. For simplicity, we assume that a, b, and c are set exogenously.[7]

A conventional investor's demand for asset i continues to be

$$x_i^C = \frac{\mu_i - S_i}{\alpha\sigma_i^2}, \quad i = 1, 2, y.$$

An asset manager's demands are

$$\begin{aligned} x_1^{AM} &= \frac{1}{a+b}\frac{\mu_1 - S_1}{\alpha\sigma_1^2} + \frac{b}{a+b}, \\ x_i^{AM} &= \frac{1}{a+b}\frac{\mu_i - S_i}{\alpha\sigma_i^2}, \quad i = 2, y. \end{aligned} \tag{2}$$

As usual, a conventional investor's portfolio is the mean-variance portfolio, scaled by his risk aversion α. Asset managers' portfolio choices differ from those of the conventional investors in two ways. First, they hold a scaled version of the mean-variance portfolio, the same one held by the conventional investors. The reason for the scaling is that as we can see from the first term in (1), for each share that the asset manager holds, she gets a fraction $a + b$ of the total return. Thus the asset manager scales her asset holdings by $1/(a + b)$ relative to those of a conventional investor.

Second, and more importantly, the asset managers are penalized by b for underperform-

[5] We assume that each shareholder employs one asset manager, so that $\lambda_{AM} = \lambda_S$. Furthermore, $\lambda_C + \lambda_{AM} + \lambda_S = 1$.

[6] This part captures features such as a fee linked to initial assets under management.

[7] Kashyap, Kovrijnykh, Li, and Pavlova (2018) endogenize optimal linear contracts for asset managers.

ing the benchmark. Because of this penalty, the manager always holds $b/(a+b)$ shares of stock 1 (or more generally whatever is in the benchmark). This consideration explains the second term in (2). This mechanical demand for the benchmark will be critical for all of our results. In particular, the asset managers' incentive to hold the benchmark index (regardless of the risk characteristics of its constituents) creates an asymmetry between stocks in the index and all other stocks.

Given the demands, we can now solve for the equilibrium prices. Using the market-clearing condition for stocks, $\lambda_{AM} x_i^{AM} + \lambda_C x_i^C = 1,\ i = 1, 2, y$, we find

$$S_1 = \mu_1 - \alpha\Lambda\sigma_1^2 \left(1 - \lambda_{AM}\frac{b}{a+b}\right), \tag{3}$$

$$S_2 = \mu_2 - \alpha\Lambda\sigma_2^2, \tag{4}$$

$$S_y = \mu_y - \alpha\Lambda\sigma_y^2,$$

where $\Lambda = [\lambda_{AM}/(a+b) + \lambda_C]^{-1}$ modifies the market's effective risk aversion.

For concreteness, suppose that $\mu_1 = \mu_2$ and $\sigma_1 = \sigma_2$ so that the return and risks of stocks 1 and 2 are identical. Our first noteworthy finding is that the price of asset 1 (that is inside the benchmark) is higher than that of its twin that is not in the benchmark. This happens because asset managers automatically tilt their demand towards the benchmark, effectively reducing the supply of this stock by $b/(b+a)$. The lower the supply of the stock (all else equal), the higher must be its equilibrium price. Another way to understand the result is that the asset managers' mechanical demand for the index means that the adverse effects of variance that typically reduce the demand for any stock, are less relevant for the assets in the benchmark.

Next, consider potential mergers. Suppose first that y is merged with the non-benchmark asset 2. The new demands of conventional investors and asset managers for the stock of firm 2 are

$$x_2'^C = \frac{\mu_2 + \mu_y - S_2'}{\alpha\left(\sigma_1^2 + \sigma_y^2\right)},$$

$$x_2'^{AM} = \frac{1}{a+b}\frac{\mu_2 + \mu_y - S_2'}{\alpha\left(\sigma_1^2 + \sigma_y^2\right)}.$$

The new equilibrium price of firm 2's stock is

$$S_2' = \mu_2 + \mu_y - \alpha\Lambda\left(\sigma_2^2 + \sigma_y^2\right) = S_2 + S_y.$$

As before, the combined value of firm 2, continues to be the sum of the initial value plus the value of y.

Suppose instead that asset y is acquired by firm 1, which is in the benchmark. Re-normalizing the combined number of shares of firm 1 to one, the demands for the stock of the combined firm is

$$x_1'^C = \frac{\mu_1 + \mu_y - S_1'}{\alpha\left(\sigma_1^2 + \sigma_y^2\right)},$$
$$x_1'^{AM} = \frac{1}{a+b}\frac{\mu_1 + \mu_y - S_1'}{\alpha\left(\sigma_1^2 + \sigma_y^2\right)} + \frac{b}{a+b}.$$

Our second major conclusion is that there is a benchmark inclusion subsidy. Specifically, the new price of firm 1's shares is

$$S_1' = \mu_1 + \mu_y - \alpha\Lambda\left(\sigma_1^2 + \sigma_y^2\right)\left(1 - \lambda_{AM}\frac{b}{a+b}\right) = S_1 + S_y + \alpha\Lambda\sigma_y^2\lambda_{AM}\frac{b}{a+b}, \qquad (5)$$

which is strictly larger than the sum of S_1 and S_y. So when a firm inside the benchmark acquires asset y (which had been outside the benchmark), the combined value exceeds the sum of the initial value plus the value of y. This occurs because asset managers' demand for the benchmark is partially divorced from the risk and return characteristics of the benchmark, and thus this kind of acquisition raises the value of the target firm. You can see this by noting that the last term in (5) is proportional to the variance of y, σ_y^2. This is because when y is acquired by firm 1, a portion of asset managers' demand for this asset is now inelastic and is independent of its variance. Hence the market discounts the variance of y's cash flows less when they are inside firm 1 rather than firm 2.

In contrast, notice that if the stand-alone asset y had started out inside the benchmark, then S_1' would be exactly equal to the sum of S_1 and S_y. In that case, the inelastic demand for the stock would already have been embedded in its price. So the the extra value of acquisition that accrues to firm 1 relative to firm 2 arises only from the increase in the price y when it becomes part of the benchmark.

Finally, the impact of asset managers can also work in the other direction, reducing valuations of spinoffs and divestitures. If y had been part of a firm inside the benchmark and were sold to a firm that was outside, then the value of y would drop when it is transferred.

In the next section, we consider a richer version of the setup that allows us to analyze

several additional questions. Based just on this extremely simplified example, however, we already have seen two empirical predictions. First, consistent with the existing literature on index inclusions, we see that there should be an increase in a firm's share price when it is added to the benchmark. We view this as a necessary condition for the existence of the benchmark inclusion subsidy. In our framework, the stock price increase would remain present for as long as the firm is part of the benchmark.

The other prediction related to acquisitions (and spinoffs) and is the one we would like to stress. If a firm that has not previously been part of the benchmark is acquired by a benchmark firm, its value should go up purely because of moving into the benchmark. This breaks the usual valuation result that presumes that an asset purchase that does not alter any cash flows (of either the target or acquirer) should not create any value. Alternatively, if a firm was spun-off so that it moves from being part of the benchmark to no longer belonging to the benchmark, its value should drop even though its cash flows are unchanged.

4 The General Model

We now generalize the example studied in Section 3 in several directions. All results from the previous section hold in this richer model. To analyze a new implication for investment, we will assume that y is not traded initially, so that it can be interpreted as a potential project.

We will only describe elements of the environment that differ from those described in the previous section. There are n risky stocks, whose total cash flows $D = (D_1, \ldots, D_n)^\top$ are jointly normally distributed, $D \sim N(\mu, \Sigma)$, where $\mu = (\mu_1, \ldots, \mu_n)^\top$, $\Sigma_{ii} = \text{Var}(D_i) = \sigma_i^2$, and $\Sigma_{ij} = \text{Cov}(D_i, D_j) = \rho_{ij}\sigma_i\sigma_j$. Stock prices are denoted by $S = (S_1, \ldots, S_n)^\top$. For simplicity of exposition and for easier comparison to Section 3, we normalize the total number of shares of each asset to one. However, all of our proofs in the appendix are written for the general case with asset i's total number of shares being equal to $\bar{x}_i$.

Some stocks are part of a benchmark. We order them so that all shares of the first k stocks and none of the remaining $n-k$ are included. Denote $\mathcal{B} = \{1, \ldots, k\}$. Thus, the ith element of the benchmark portfolio equals the total number of shares of asset i times $\mathbf{1}_i$, where $\mathbf{1}_i = 1$ if $i \in \mathcal{B}$ and $\mathbf{1}_i = 0$ if $i \notin \mathcal{B}$. Denote further $\mathbf{1_b} = (\mathbf{1}_1, \ldots, \mathbf{1}_n)^\top$.

We follow the convention in the literature (see, e.g., Buffa, Vayanos, and Woolley, 2014) by defining $r_x = x^\top(D - S)$ to be the performance of portfolio $x = (x_1, \ldots, x_n)^\top$ and

$r_{\mathbf{b}} = \mathbf{1}_{\mathbf{b}}^{\top}(D - S)$ to be the performance of the benchmark portfolio. Then the compensation of an asset manager with contract (a, b, c) is $w = ar_x + b(r_x - r_{\mathbf{b}}) + c$.[8]

Denote by $x^C = (x_1^C, \ldots, x_n^C)^{\top}$ and $x^{AM} = (x_1^{AM}, \ldots, x_n^{AM})^{\top}$ the optimal portfolio choices of a conventional investor and an asset manager, respectively.

Lemma 1 (Portfolio Choice). *Given asset prices S, the demands of a conventional investor and an asset manager are given by*

$$x^C = \Sigma^{-1}\frac{\mu - S}{\alpha}, \tag{6}$$

$$x^{AM} = \frac{1}{a+b}\Sigma^{-1}\frac{\mu - S}{\alpha} + \frac{b}{a+b}\mathbf{1}_{\mathbf{b}}. \tag{7}$$

The demands generalize those from the example exactly as would be expected. In particular, the conventional investors opt for the mean-variance portfolio and the asset managers choose a linear combination of that portfolio and the benchmark. The fact that part of the asset managers' portfolio is invested in the benchmark regardless of prices or other characteristics of these assets will again be crucial for our results below.

An extreme form of our asset manager is a passive manager—someone who faces a very high b, which incentivizes her to hold just the benchmark portfolio and severely punishes any deviations from it. We will discuss this special case further in subsection 4.4.

Using (6)−(7) and the market-clearing condition $\lambda_{AM}x^{AM} + \lambda_C x^C = \mathbb{1} \equiv (1, \ldots, 1)^{\top}$, we have:

Lemma 2 (Asset Prices). *The equilibrium asset prices are*

$$S = \mu - \alpha\Lambda\Sigma\left(\mathbb{1} - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_{\mathbf{b}}\right). \tag{8}$$

Equation (8) is a generalization of equations (3)−(4). As before, the price of a benchmark firm is higher than it would be for an otherwise identical non-benchmark firm. The reason is that as Lemma 1 shows, asset managers demand a larger amount of the stock in the benchmark.

Importantly, as Lemma 3 below demonstrates, the standard CAPM does not hold in our environment. It applies only in the special case in which no asset managers are present

[8] In Appendix B we repeat all of the analysis for the case where a manager's compensation is tied to the per-dollar return on the benchmark, rather than the per-share return (performance).

($\lambda_{AM} = 0$ and $\lambda_C = 1$). Otherwise, the stocks' expected returns depend on *two factors*, the usual market portfolio and the benchmark.[9]

Lemma 3 (Two-Factor CAPM). *Asset returns* $R_i = D_i/S_i$, $i = 1, \ldots, n$, *can be characterized by*[10]

$$E(R_i) - 1 = \beta_i^{\mathbf{m}} \gamma_{\mathbf{m}} - \beta_i^{\mathbf{b}} \gamma_{\mathbf{b}}, \ i = 1, \ldots, n, \tag{9}$$

where

$$\beta_i^{\mathbf{m}} = \frac{Cov(R_i, R_{\mathbf{m}})}{Var(R_{\mathbf{m}})}, \ \beta_i^{\mathbf{b}} = \frac{Cov(R_i, R_{\mathbf{b}})}{Var(R_{\mathbf{b}})}, \ i = 1, \ldots, n,$$

where $\gamma_{\mathbf{m}} > 0$ *and* $\gamma_{\mathbf{b}} > 0$ *are the market and benchmark risk premia, and* $R_{\mathbf{m}}$ *and* $R_{\mathbf{b}}$ *are the market and benchmark returns, respectively, reported in Appendix A.*

The benchmark portfolio emerges as a factor because asset managers are evaluated relative to it. Stocks that load positively on this factor have lower expected returns because asset managers overinvest in the benchmark, which drives down the expected returns on its components. Stocks outside the benchmark that covary positively with the benchmark also have lower expected returns because conventional investors who desire exposure to the benchmark buy instead such cheaper, non-benchmark stocks, pushing up their prices. Lemma 3 demonstrates this formally.

The two-factor CAPM is not intended to be a fully credible asset pricing model. We know it fails to account for some relevant theoretical features and also has no chance at explaining certain well-known features of returns. Rather, we emphasize that the prevailing corporate finance approach to valuation based on the "asset beta" coupled with the standard CAPM does not apply in our economy. Lemma 3 implies that the cost of capital for firms inside the benchmark is lower than for their identical twins that are outside. Therefore, the usual conclusion that the value of a project is independent of which firm adopts it does not hold.

4.1 Investment

Suppose there is a project with cash flows $Y \sim N(\mu_y, \sigma_y^2)$, and $\text{Corr}(Y, D_i) = \rho_{iy}$ for $i = 1, \ldots, n$. Investing in this project requires spending I. If firm i (whose cash flows are

[9] This result has been obtained in Brennan (1993).

[10] The left-hand side of equation (9) contains the return in excess of the (gross) return on the risk-free bond, where the latter is normalized to one in our model.

D_i) invests, its cash flows in period 1 become $D_i + Y$. Let $S^{(i)} = \left(S_1^{(i)}, \ldots, S_n^{(i)}\right)^\top$ denote the stock prices if firm i invests in the project. The firm finances investment by issuing equity. That is, we assume if firm i invests in the project, it issues δ_i additional shares to finance it, where $\delta_i S_i^{(i)} = I$. We also assume that if $i \in \mathcal{B}$, then the additional shares enter the benchmark.

Suppose firm i (and only firm i) invests in the project. Let $\mathcal{I}_{j=i} = 1$ if $j = i$ and $\mathcal{I}_{j=i} = 0$ otherwise. Then the new cash flows $D^{(i)} = \left(D_1^{(i)}, \ldots, D_n^{(i)}\right)^\top$ are such that $D_j^{(i)} = D_j + D_y \mathcal{I}_{j=i}$. The vector $D^{(i)}$ is distributed according to $N\left(\mu^{(i)}, \Sigma^{(i)}\right)$, where $\mu_j^{(i)} = \mu_j + \mu_y \mathcal{I}_{j=i}$, $\Sigma_{jj}^{(i)} = \sigma_j^2 + \left(2\rho_{jy}\sigma_j\sigma_y + \sigma_y^2\right)\mathcal{I}_{j=i}$, $\Sigma_{j\ell}^{(i)} = \rho_{j\ell}\sigma_j\sigma_\ell + \rho_{jy}\sigma_j\sigma_y$, $j, \ell = 1, \ldots, n$, $j \neq \ell$. Denote $\mathcal{I}^{(i)} = \left(\mathcal{I}_{1=i}, \ldots, \mathcal{I}_{n=i}\right)^\top$.

Lemma 4 (Post-Investment Asset Prices). *The equilibrium stock prices when firm i invests in the project are given by*

$$S^{(i)} = \mu^{(i)} - \mathcal{I}^{(i)} I - \alpha\Lambda\Sigma^{(i)}\left(\mathbb{1} - \lambda_{AM}\frac{b}{a+b}\mathbf{1_b}\right). \tag{10}$$

The change in the stockholder value of the investing firm i, $\Delta S_i \equiv S_i^{(i)} - S_i$, is

$$\begin{aligned}\Delta S_i = \mu_y - I - \alpha\Lambda\left(\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y\right)\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right)\\ -\alpha\Lambda\sum_{j=1}^{n}\rho_{jy}\sigma_j\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right).\end{aligned} \tag{11}$$

The last term on the first line of (11) includes $\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y$. This captures the penalty for the incremental cash-flow volatility that firm i suffers from taking on the project. The importance of this factor is lowered if i is part of the benchmark, so it is subject to the benchmark inclusion subsidy that we have already seen in the example in Section 3.

Notice the terms on second line of (11) do *not* depend on i, meaning that they are the same regardless of the identity of the investing firm. When any firm i adopts project y, the overall correlation of its cash flows with those of asset j rise by $\rho_{jy}\sigma_j\sigma_y$. The effect of this extra correlation on the share value of the investing firm is smaller if asset j is in the benchmark. This is a separate, though related, force from the benchmark inclusion subsidy. We discuss it further at the end of this subsection.

To understand things further, consider incentives of firm i to invest in a project. It will

do so if its stockholder value goes up as a result of the investment, that is, if $\Delta S_i > 0$.[11] Consider two firms i_1 and i_2, one in the benchmark and the other is not. Suppose that their cash flows with and without the project are identical; specifically, $\sigma_{i_1} = \sigma_{i_2} = \sigma$ and $\rho_{i_1 y} = \rho_{i_2 y} = \rho_y$. The difference in the incremental stockholder value created by the investment for the two firms is

$$\Delta S_{i_1} - \Delta S_{i_2} = \alpha\Lambda(\sigma_y^2 + \rho_y\sigma\sigma_y)\lambda_{AM}\frac{b}{a+b}. \tag{12}$$

This is the analytical expression for the benchmark inclusion subsidy.

Assumption 1. $\sigma_y^2 + \rho_y\sigma\sigma_y > 0$.

So long as Assumption 1 holds, the expression in (12) is positive, and the increase in the stockholder value for benchmarked firm i_1 is larger than that for firm i_2, which is not in the benchmark.

In practice one would expect Assumption 1 to hold for most investments. A typical project that a firm undertakes is similar to its existing activities. Even if a project is diversifying, it is still typically positively correlated with the firm's original cash flows.

A more general structure that we consider in this section allows us to fully characterize the benchmark inclusion subsidy in (12) and to derive a number of additional implications relative to Section 3. First, the higher correlation of the project's cash flows with the firm's assets (ρ_y), the higher the benchmark inclusion subsidy. So a firm inside the benchmark gets the largest subsidy for projects that are clones of its existing business. Second, the benchmark inclusion subsidy is increasing in the the variance of the firm's assets in place (σ^2). Third, the higher the cash-flow risk of an investment (σ_y^2), the bigger the benchmark inclusion subsidy. The intuition is that all these three forces increase the resulting cash-flow variance of the investing firm, and for the benchmark firm this variance is penalized less by the market.

The presence of the benchmark inclusion subsidy translates into different investment rules for firms inside and outside the benchmark. We formalize this result in Proposition 1 below.

[11] As customary in corporate finance, here we use a criterion for the project adoption based on the change in the stockholder value. Alternatively, one can compare welfare of a stockholder who internalizes the fact that after the investment, he will trade the stocks in the asset market. Mas-Colell, Whinston, and Green (1995) (chapter 19) discuss conditions for when the two approaches are equivalent. In our set up, these conditions do not hold. However, if we use the welfare approach, we obtain similar expressions, and the statement of Proposition 1 below holds without change.

Proposition 1 (Project Valuation). *A firm in the benchmark is more likely to invest in a project than a firm outside the benchmark if and only if Assumption 1 holds. More precisely, all else equal, firm $i_1 \in \mathcal{B}$ accepts projects with a lower mean μ_y, larger variance σ_y^2, and/or larger correlation ρ than firm $i_2 \notin \mathcal{B}$ if and only if Assumption 1 holds.*

Proposition 1 is at odds with the textbook treatment of investment taught in basic corporate finance courses. The usual rule states that a project's value is independent of which firm undertakes it and is simply given by the project's cash flows discounted at the project-specific (not firm-specific) cost of capital.[12] The usual rule presumes that the correct way to evaluate the riskiness of a project is to use the CAPM. That is not true in our model. In our model, the compensation for risk is described by a two-factor CAPM (Lemma 3), which accounts for the incentives of asset managers.

The reason why a project is worth more to a firm in the benchmark than to one outside it is because when the project is adopted by the benchmark firm, it will be incrementally financed by asset managers regardless of its variance. So the additional overall cash-flow variance that the project generates is penalized less in a firm inside the benchmark. To further understand the importance of the variance, consider a special case where the project is risk free, i.e., $\sigma_y^2 = 0$. Then Assumption 1 fails and we can see that the project would be priced identically by all firms (with the same ρ_{iy} and σ_i).

Remark 1 (Risk-Free Project). *If $\sigma_y^2 = 0$, then a firm's valuation of project y is independent of whether this firm is included in the benchmark or not.*

In fact, we can build further intuition about the model by contemplating what happens with the inequality in Assumption 1 is reversed. This happens if the project is sufficiently negatively correlated with the assets, that is, if $\rho_y \leq -\sigma_y/\sigma$. To see why the result of Proposition 1 reverses in this case, suppose that the project has $\mu_y = 0$, low (enough) σ_y relative to σ, and is perfectly negatively correlated with the existing cash flows D_i. Then if firm i adopts this project, conventional investors will increase their demand for stock i because its risky initial cash flows are now hedged via the addition of the project. For asset managers, a portion of their demand for stock i will not be affected if the stock is in the benchmark. So the price of stock i will increase less if i is in the benchmark than if it is not. Consequently, the benefit of investing in a project that sufficiently hedges the existing cash flows is lower for a benchmark firm than for a non-benchmark firm.

[12] See for example Jacobs and Shivdasani (2012) or Berk and DeMarzo (2014), chapter 19.

Figure 1 uses a numerical example to display the investment regions for a benchmark- and a non-benchmark firm as a function of μ_y, σ_y, and ρ_y (for a fixed σ). On the left panel, ρ_y is held constant, and σ_y and μ_y vary along the axes. On the right panel, σ_y is kept constant, and ρ_y and μ_y vary along the axes.

From the left panel we can see that holding everything else fixed, a benchmark firm will invest in projects with a lower mean, μ_y, and/or higher variance, σ_y^2, than a non-benchmark firm. The right panel illustrates that compared to a non-benchmark firm, a benchmark firm prefers to invest in projects that are more correlated with its existing cash flows.

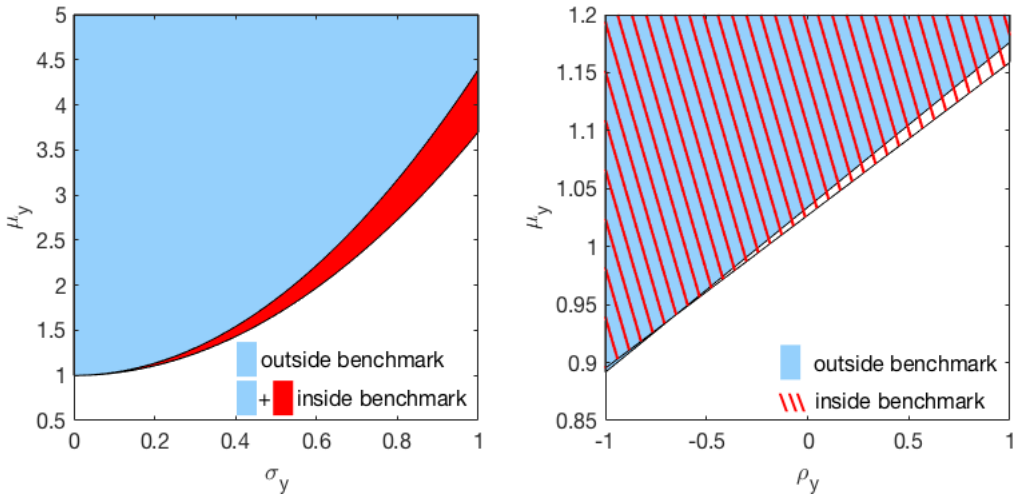


Figure 1: **Investment regions.**

Parameter values: $n = 5$, $k = 3$, $\mu_i = 1.05$, $\sigma_i = 0.15$, $\rho_{ij} = 0$, $j \neq i$, $i = 1, \ldots, n$, $\rho_{jy} = 0$ for $j \neq i_1, i_2$, $\alpha = 2.7$, $\lambda_{AM} = 0.3$, $a = 0.24$, $b = 0.52$. On the left panel, $\rho_y \equiv \rho_{i_1 y} = \rho_{i_2 y} = 0.5$. On the right panel, $\sigma_y = 0.1$.

Finally, as we briefly mentioned earlier, our model also implies that projects correlated with assets inside and outside the benchmark are valued differently (by firms both inside and outside the benchmark). Notice from (11) that for any firm, investing in a project that is positively correlated with a component of the benchmark is more beneficial than if the project had the same degree of correlation with an asset outside of the benchmark. This is because the adverse effect of the correlation on the investing firm's stock price is penalized less by the market if that asset belongs to the benchmark.

To illustrate this insight graphically, Figure 2 plots the change in the stockholder value ΔS_i given by (11) as a function of ρ_{jy}, where the solid line corresponds to some asset j inside the benchmark, and the dashed line to some j outside the benchmark. On the

figure, for concreteness the investing firm i is in the benchmark, but the lines would look the same except shifted down in parallel if i was outside the benchmark. The figure shows that the change in the stockholder value ΔS_i is decreasing in the correlation coefficient ρ_{jy}. However, if j is in the benchmark, then the slope of the downward sloping line is flatter. Moreover, the solid line is above the dashed one for positive correlations and below for negative ones. This is because positive/negative correlation of the project with an asset in the benchmark is penalized/rewarded less than the same correlation with an asset outside the benchmark.

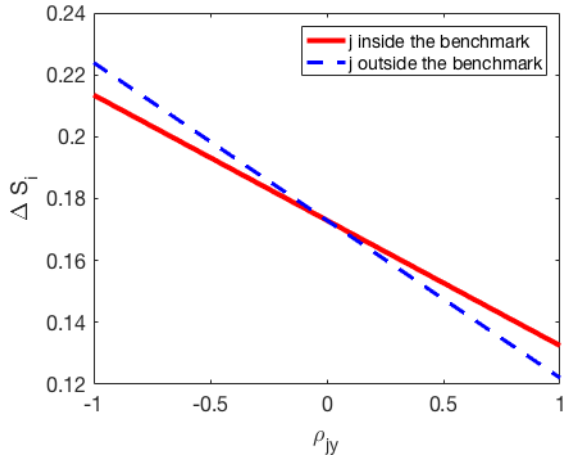


Figure 2: **Change in the stockholder value, ΔS_i, as a function of correlations of project y's cash flows with cash flows of assets inside and outside the benchmark, ρ_{jy} for some $j \in \mathcal{B}$ and some $j \notin \mathcal{B}$.**
Parameter values: $n = 5$, $k = 3$, $\mu_j = 1.05$, $\mu_y = 1.2$, $I = 1$, $\sigma_j = 0.15$, $\sigma_y = 0.1$, $\rho_{jy} = 0$ unless it is plotted on the horizontal axis, $\rho_{j\ell} = 0$, $\ell \neq j$, $j = 1, \ldots, n$, $\alpha = 2.7$, $\lambda_{AM} = 0.3$, $a = 0.24$, $b = 0.52$. Investing firm: $i = 1$. Solid line: $j = 2$. Dashed line: $j = 4$.

4.2 Mergers and Acquisitions

As we have already seen in the example considered in Section 3, the model can also be used to think about mergers and acquisitions.

Proposition 2 (**Mergers and Acquisitions**). *Suppose firm i considers acquiring firm y that is outside the benchmark, and suppose that $\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y > 0$. Then firm i is more likely to acquire y if firm i is inside the benchmark than if it is outside.*

The logic behind this statement is identical to the reasoning that leads to the bias in investment. If a benchmark firm acquires y, it gets the benchmark inclusion subsidy. Again this result is in contrast to the conventional wisdom about the role of financing synergies in the evaluation of potential acquisitions. For example, if a firm has unused debt capacity, it might choose to use more debt financing than otherwise to buy another firm. The usual view is that the discount rate used to value the cash flows of the target firm should not be altered by the availability of the extra debt funding. The case for not adjusting the discount rate is that the same additional debt funding could have been used for any other potential acquisition. So it would be a mistake to say that any particular target company is a more attractive firm to acquire just because some low-risk debt could be issued to finance the purchase.

In our setup, there is a more fundamental synergy that is responsible for lower financing costs. Because the asset managers will want to purchase part of any stock that is issued to undertake the transaction, those savings should be accounted for. The size of the subsidy will depend on the parameters that appear in Assumption 1. Thus, for example, all else equal, the higher is a correlation of the cash flows of the target firm with the acquiring benchmark firm, the larger will be the financing advantage associated with that acquisition. Conversely, a hedging acquisition by a firm in the benchmark, where the target firm's cash flows are negatively correlated with acquirer's, always comes with a lower subsidy.

Proposition 2 works in reverse for spinoffs and divestitures. Specifically, assuming that the condition $\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y > 0$ is satisfied, a division y is worth more if it is part of a firm inside the benchmark than if it is spun off and trades as a separate entity outside the benchmark or is sold to a firm outside the benchmark. We stress that it matters whether the parent is inside the benchmark or outside, because of the benchmark inclusion subsidy.

4.3 IPOs

Suppose y is now a standalone firm, which is held privately by conventional investors and is considering an IPO. We demonstrate that y's incentive to go public depends on whether it will be included in the benchmark.

We consider two scenarios. In the first scenario, when firm y becomes public and it gets included in the benchmark, no other firm leaves the benchmark. Most of the best known stock indexes in the world have a fixed number of firms. In the second scenario, if y joins the benchmark, then firm k is removed, so that the number of firms in the benchmark

remains constant.

Proposition 3 (IPOs and Benchmarks). *Consider a privately-held firm y considering an IPO.*

(i) Firm y is always more likely to proceed with an IPO if it gets included in the benchmark and no other firm leaves the benchmark.

(ii) Firm y is more likely to proceed with an IPO if it gets included in the benchmark and firm k is removed from the benchmark, if and only if $\sigma_y^2 - \rho_{ky}\sigma_k\sigma_y > 0$.

The argument for the result in part (i) is the same as for other results in the paper—firm y gets the benchmark inclusion subsidy if it joins the benchmark. In part (ii) where y pushes another firm out of the benchmark, there is an additional consideration, as firm y loses part of the benchmark subsidy coming from its correlation with that firm. In other words, when firm y is included in the benchmark and firm k is pushed out, firm y's correlation with the benchmark increases by σ_y^2 because firm y is correlated with itself (and it enters the benchmark), and is reduced by $\rho_{ky}\sigma_k\sigma_y$ because firm k drops out of the benchmark. The net subsidy is therefore proportional to $\sigma_y^2 - \rho_{ky}\sigma_k\sigma_y$.

4.4 Passive Asset Management

As we mentioned earlier, a limiting case of our setup with $b \to \infty$ can be thought of as passive management. In this case, it is easy to see that passive asset managers hold the benchmark, i.e, $x^{AM} = \mathbf{1_b}$. A generalization of our model would be to include both active and passive asset managers. If we denote the fractions of them in the economy by λ_{AM}^A and λ_{AM}^P, then the equilibrium stock prices would be

$$S = \mu - \alpha\Lambda\Sigma\left(\mathbb{1} - \left[\lambda_{AM}^A \frac{b}{a+b} + \lambda_{AM}^P\right]\mathbf{1_b}\right).$$

All of our results extend to this case. Passive asset managers hold benchmark stocks irrespective of their characteristics, and they invest nothing in the mean-variance portfolio. Therefore, with passive managers the benchmark inclusion subsidy becomes even larger. For example, the additional value from investing for a firm in the benchmark given by $\alpha\Lambda(\sigma_y^2 + \rho_y\sigma\sigma_y)\left[\lambda_{AM}^A b/(a+b) + \lambda_{AM}^P\right]$, which is a generalization of (12), is larger when $\lambda_{AM}^P/\lambda_{AM}^A$ is larger.

4.5 Comparative Statics with respect to λ_{AM}

In this subsection we analyze the benchmark inclusion subsidy as a function of the size of the asset management sector. Consider (12), and rewrite it recognizing that $\Lambda = [\lambda_{AM}/(a+b) + \lambda_C]^{-1}$ and $\lambda_C = 1 - 2\lambda_{AM}$:

$$\Delta S_{i_1} - \Delta S_{i_2} = \alpha \left[1 + \frac{1 - 2\lambda_{AM}}{\lambda_{AM}}(a+b)\right]^{-1} b(\sigma_y^2 + \rho_y \sigma \sigma_y), \tag{13}$$

where $i_1 \in \mathcal{B}$ and $i_2 \notin \mathcal{B}$. Notice that this expression is strictly increasing in λ_{AM}. This means that the effects described in this paper related to the difference in valuations by a firm inside the benchmark relative to a firm outside the benchmark become larger as the size of the asset management sector increases.

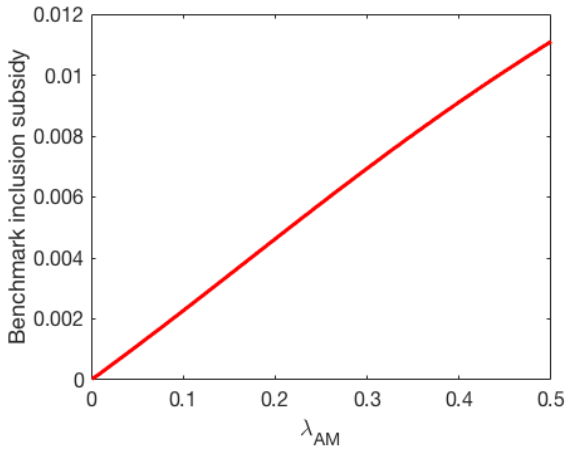


Figure 3: **The benchmark inclusion subsidy, $\Delta S_{i_1} - \Delta S_{i_2}$, as a function of the size of the asset management sector, λ_{AM}.**
Parameter values: $n = 5$, $k = 3$, $\mu_i = 1.05$, $\sigma_i = 0.15$, $\sigma_y = 0.1$, $\rho_{ij} = 0$, $j \neq i$, $i = 1, \ldots, n$, $\rho_{jy} = 0$ unless plotted on the horizontal axis, $\alpha = 2.7$.

If the contract parameters a and b were endogenous, chosen optimally by shareholders, then a and b in (13) would implicitly depend on λ_{AM}. In a companion paper (Kashyap, Kovrijnykh, Li, and Pavlova, 2018) we analyze optimal contracts chosen by shareholders in a similar environment. Deriving analytical results for λ_{AM} as a function of the contract parameters in (13) is difficult in general, so we use a numerical example to study the relationship. Figure 3 displays the results of comparative statics of (13) with respect to λ_{AM} in the example. As we can see, the difference in valuations is increasing in the size of the asset management sector even if a and b are endogenously determined.

5 Related Empirical Evidence

We now turn to the empirical evidence that is related to the predictions of our model. In keeping with the presentation in the last section, we organize the discussion around the four main predictions of the model. The first implication of our model is that upon inclusion in a benchmark there should be an increase in a firm's share price. The second one is that firms inside the benchmark should be more prone to invest and to engage in mergers. Third, there should be a two-factor CAPM that reflects the benchmark inclusion subsidy. Finally, the subsidy should be higher when there are more assets under management. To the best of our knowledge there are no direct tests of our other prediction, that IPOs should be more likely when the firm going public can more easily qualify to be included in a benchmark portfolio. That would be a useful direction for future work.

5.1 Benchmark Effect

Consistent with the empirical evidence, our model generates an index effect. Stock price changes are symmetric for index additions and deletions and the effect persists for as long as the stock is in the index. We also have a more subtle prediction: the share price response should depend on becoming part of a benchmark and not just because of being added to an index. In most cases, separating the effect of being in the index and benchmark is challenging. One exception arises for firms that operate in so-called "sin" industries, such as alcohol, tobacco and gaming. Large firms in these industries would be included in indices such as either the S&P 500, Russell 1000 or FTSE 100, but are deemed odious by some investors. Hence, there are benchmarks that keep almost all of the firms in the index but exclude these firms.

According to the U.S. Social Investment Forum, as of year-end 2015, $8.72 trillion of assets were managed according to some sort of social screen, and $1.97 trillion were in funds that specifically avoid investing in alcohol and tobacco. Hence, these kinds of exclusion are common enough to be detectable.

Hong and Kacperczyk (2009) study the returns of these so-called sin firms. Their motivation is behavioral, but the empirical results can also be interpreted as a test of our model. Their headline result is that sin firms earn higher expected returns than comparable firms by about 28 basis points per month. Their matching process controls for four factors commonly thought to determine expected returns—the market portfolio, firm size, the book to market ratio, and a momentum proxy. They also find similar results for a set

of sin stocks in Canada, France, Germany, Italy, the Netherlands, Spain, Switzerland and the United Kingdom. In the international sample, the sin stocks outperform their peers about 21 basis points per month. Hong and Kacperczyk's results about sin stocks have also subsequently been confirmed in several studies.[13]

5.2 Changes in Corporate Actions Following Benchmark Inclusion

There are some papers that attempt to assess whether the model predictions regarding investment and mergers hold for benchmark firms versus non-benchmark firms. This is challenging because ideally one wants to control for both the selection into the benchmark and all the other factors that influence these kinds of expenditures.

There are three papers that we are aware of that attempt to measure these effects and all find some evidence in favor of our model's predictions. Massa, Peyer, and Tong (2005) compare 222 firms that were added to the S&P 500 with a control set of firms who prior to the addition were similar with respect to size, market-to-book, the number of analysts following them, and the percentage of stock owned by institutional investors. They treat the benchmark inclusion as an exogenous factor that can be used an instrument for the firms' cost of capital. They then test for effects of the (instrumented) cost of capital on investment and equity issuance. They find that inclusion is associated with higher levels of equity issuance and more investment, with a substantial portion of the investment coming via increased mergers.

Vijh and Yang (2008) attempt to directly test the idea that firms included in the S&P 500 are more prone to undertake acquisition than firms outside the index. They study all the acquisitions of firms that are tracked by the Center for Research on Securities Prices between 1980 and 2004. They are motivated to test the hypothesis that benchmark inclusion brings more analyst and news coverage and hence could lead to better governance and decision-making. Nevertheless, the basic statistical analysis can also be used to test the predictions from our model. The main challenge for this type of exercise is that S&P 500 firms are very different than non-index firms, and they also acquire different firms. For instance, the median acquiring firm in the S&P 500 index is about 15 times larger (measured by assets) than the non-index acquirers and has significantly higher levels of

[13] See Fabozzi and Oliphant (2008), Statman and Glushkov (2009), and Kim and Venkatachalam (2011) for evidence of superior performance of sin stocks, as well as Blitz and Fabozzi (2017) who caution that the performance of sin stocks can be explained by two new quality factors.

cash flows to assets, return on assets and Tobin's Q. The index firms also tend to acquire larger firms, those with higher value of Tobin's Q, and more profitability. They find that firms in the S&P500 do undertake significantly more acquisitions, in line with our model's predictions. These findings hold after they account (as much as they can) for observable differences in target and acquirer characteristics, though it is hard to know whether the controls are truly adequate.

The third and perhaps most convincing piece of evidence comes from Bena, Ferreira, Matos, and Pires (2017). They study differences in investment and employment for firms across 30 countries between 2001 and 2010. Their basic regression relates capital expenditures relative to assets (or the number of employees) to institutional ownership by foreign investors and a host of firm-level controls (including sales, Tobin's Q, and cash holdings). Importantly, they instrument for the ownership variable using additions to the MSCI ACWI index. They find large, statistically significant effect of the benchmark additions on both investment and employment. The results are also present when they restrict the analysis to firms that are close to the cutoff for inclusion in the index and when they estimate the effects of inclusion using a difference-in-difference experimental design.

5.3 Variation in the Subsidy Size

The comparative-statics prediction that as the demand for shares by asset managers rises, the inclusion effect should rise too, is also supported by some recent studies. This prediction has been tested in two ways.

One looks at whether the size of the subsidy is higher in situations where more assets are under management. One way of doing this is to compare the estimated size of inclusion (or exclusion) effects over time. It is relatively straightforward to calculate the announcement return (computed over one or two days) associated with the news that a stock will be added or subtracted from an index—typically the S&P 500. However, to infer the permanent effect of that change, a subsequent return must be computed to account for any reversal, and that requires a decision on how long the window should be. See Patel and Welch (2017) for a good discussion of this issue.

Our reading of the evidence is that the announcement effects from the 1980s through the early 2000s were rising, see, e.g., Wurgler and Zhuravskaya (2002). Since the early 2000s there are many fewer studies on the S&P 500. Patel and Welch (2017) argue that the announcement effect is smaller and the post-announcement reversal is larger since 2005.

One further confounding problem is that as the inclusion effect has become better known, sophisticated investors (e.g., hedge funds, and, more recently, some ETF and index funds) have started buying a portfolio of stocks shortlisted for index inclusion prior to the announcement day. Such front-running creates a pre-announcement drift in stock prices. For example, Patel and Welch (2017) document that deleted stocks lose 12% of their value in 42 days preceding the announcement. The front-running that precedes additions and deletions also creates a hidden cost of indexing to passive investors who only make substitutions when the additions and deletions go into effect. For example, Petajisto (2011) estimates the hidden costs of rebalancing for index funds as 21–28 bps annually for the S&P 500 and 38–77 bps annually for the Russell 2000. He stresses that these estimates are lower bounds because his measurement window does not fully account for front-running, which is especially relevant in the later part of his sample.

An alternative test that we find more quite compelling is to look at differences in total assets managed against different benchmarks. This has two advantages. First, the rebalancing is typically not triggered because a corporate action occurred (such as a recent merger) that might not only necessitate the addition to the index, but also change a firm's cash-flow properties. Second, these events are not subject to the alternative interpretation offered by Merton (1987) that addition to an index brings increased analyst coverage and other forms of attention. If a stock is already part of the index then that type of attention should already be at least partially present.

Perhaps the cleanest of these studies uses changes that move a stock around the boundary of being above and below the 1000th largest stock in the U.S. For firms that move from just below rank 1000 to just above, they move out of the Russell 2000 benchmark and into the Russell 1000 (and vice versa). Chang, Hong, and Liskovich (2015) study these transitions. The interesting thing is that the firm whose fortunes improve move from the widely-benchmarked Russell 2000 index to the less-benchmarked Russell 1000. So although their fundamentals are improving, the demand by asset managers will have declined. The authors find that despite the improved fundamentals, their share price drops by about 5% from the rebalancing. Conversely, firms that fall into the Russell 2000 see price increases by about 5%.

5.4 Asset Pricing Tests

Finally, an alternative way to assess the existence of the benchmark inclusion subsidy is to see whether inclusion in a benchmark shows up as a factor that helps explain the cross section of stock returns. Two direct tests of the specification equivalent to our two-factor CAPM in Lemma 3 are presented in Gómez and Zapatero (2003) and Brennan, Cheng, and Li (2012), who arrive at conflicting conclusions.

Gómez and Zapatero (2003) use the S&P 500 index as a proxy for the index factor. They test the model on the universe of stocks that were included in the S&P 500 for the entire duration of their sample. They find that the index factor is priced and that the risk premium on the factor is sizeable and of the correct sign. Moreover, the size of the risk premium on the index factor and its statistical significance is growing through their sample. Gómez and Zapatero argue that this trend is consistent with the growth of the asset management industry (growth in λ_{AM} in our model).

Brennan, Cheng, and Li (2012) also use the S&P 500 index as a proxy for the index factor, but expand the universe of risky assets to all CRSP stocks and include size (market cap) as a control in their tests. These two changes to the test end up significantly reducing the risk premium on the index factor, making it very small and virtually undetectable. The index factor comes out both economically and statistically significant only for a subsample of large stocks, consistent with the results of Gómez and Zapatero (2003). Furthermore, when they allow for the possibility of multiple indexes, with the remaining indexes representing value and size indexes and proxied for by the Fama and French (1992) HML and SMB factors, the index factor loses significance even for large stocks.

One challenge for both papers (and any other attempt) to identify an index factor is the presence of multiple benchmarks. The critical consideration governing relative returns in our model is the relative demand for different stocks by all asset managers. So in either of these papers the presence of additional benchmarks (e.g. the FTSE Russell 1000 or 2000) will confound the tests. It is possible that markets other than the U.S., where a single benchmark could be dominant, might be better suited for testing for a benchmark factor.

6 Conclusions

We have seen that the inelastic demand by asset managers lowers the cost of capital for firms that are part of their benchmark. This creates a subsidy that could alter investment,

merger, and IPO decisions. While there is empirical evidence that speaks to some of the model's predictions, there are others that have yet to be tested. One obvious direction for future work would be to fill in these gaps.

For instance, there are many claims by practitioners (e.g. McKinsey on Finance, 2004) that a strong motive for undertaking an IPO is to become part of a benchmark. We believe no one has tested this hypothesis. Despite the practitioner attention, this implication is not part of the very long list of commonly cited reasons by economists that are usually considered. As Celikyurt, Sevilir, and Shivdasani (2010) observe, "in theory, an IPO creates liquidity for the firm's shares, provides an infusion of capital to fund growth, allows insiders to cash out, provides cheaper and ongoing access to capital, facilitates the sale of the company, gives founders the ability to diversify their risk, allows venture capitalists and other early stage investors to exit their investment, and increases the transparency of the firm by subjecting it to capital market discipline." So there would be some novelty value to confirming the model prediction.

More importantly, international differences create variation that would make it possible to cleanly uncover the effect that is predicted. Specifically, not only do different exchanges have different requirements about how many shares have to be floated, but the relevance of benchmarks also varies across markets. So the ease of qualifying for a public listing is not hard-wired to match the size of the subsidy implied by our theory.

It would also be interesting to test the model's predictions about how the presence of benchmarks can alter the incentives regarding mergers. We saw that the benchmark inclusion subsidy is larger (smaller) for targets whose cash flows are more positively (negatively) correlated with the acquiring firm. While there is a large literature studying merger patterns, we believe this somewhat unusual prediction of our theory has not been investigated.

Finally, our analysis also provides a novel take on benchmark design. The literature on the hidden costs of index funds (e.g., Petajisto, 2011) implies that the hidden costs to passive investors resulting from index rebalancing (additions and deletions) are zero only if all stocks were included in the index. Our paper shows that there are also benefits of wider benchmarks for the real economy: having a wider benchmark removes the distortion whereby some firms benefit from the benchmark inclusion subsidy while others do not.

Appendix A

Suppose stock i has the total supply of $\bar{x}_i$ shares (in the main text, this is normalized to one). The per-share cash flow of asset i is then $D_i/\bar{x}_i$.

Proof of Lemma 1. Denote by $\hat{x}_i^\ell$ the fraction of shares of asset i that agent $\ell \in \{C, AM\}$ holds, i.e., $\hat{x}_i^\ell = x_i^\ell/\bar{x}_i$. Let $\hat{x}^\ell = \left(\hat{x}_1^\ell, \ldots, \hat{x}_n^\ell\right)^\top$, $\ell \in \{C, AM\}$, and $\bar{x} = (\bar{x}_1, \ldots, \bar{x}_n)^\top$. Then the maximization problem of a conventional investor with $\hat{x}^C = z$ is the same as the maximization problem of an asset manager with $(a+b)\hat{x}^{AM} + b\mathbf{1_b} = z$ and can be written as

$$\max_z -E\exp\{-\alpha(z(D - \bar{x}^\top S)\}.$$

It is well known that CARA preferences with normal returns are equivalent to mean-variance preferences. Thus the above problem is equivalent to

$$\max_z z^\top(\mu - \bar{x}^\top S) - \frac{\alpha}{2} z^\top \Sigma z,$$

and the optimal solution is

$$z = \Sigma^{-1}\frac{\mu - \bar{x}^\top S}{\alpha}.$$

Thus we have

$$\hat{x}^C = \Sigma^{-1}\frac{\mu - \bar{x}^\top S}{\alpha}, \tag{14}$$

$$\hat{x}^{AM} = \frac{1}{a+b}\Sigma^{-1}\frac{\mu - \bar{x}^\top S}{\alpha} + \frac{b}{a+b}\mathbf{1_b}. \tag{15}$$

When $\bar{x} = \mathbb{1} \equiv (1, \ldots, 1)^\top$, $\hat{x}^\ell = x^\ell$ for $\ell \in \{C, AM\}$ and we have equations (6) and (7) in the paper. □

Proof of Lemma 2. Using the market-clearing condition $\lambda_{AM}\hat{x}^{AM} + \lambda_C\hat{x}^C = \mathbb{1}$, we have the vector of the total share value of the firms

$$\bar{x} \cdot S = \mu - \alpha\Lambda\Sigma\left(\mathbb{1} - \lambda_{AM}\frac{b}{a+b}\mathbf{1_b}\right), \tag{16}$$

where $\bar{x} \cdot S = (\bar{x}_1 S_1, \ldots, \bar{x}_n S_n)^\top$. This gives us (8) when $\bar{x} = \mathbb{1}$. □

Proof of Lemma 3. Let $\omega_i^{\mathbf{m}} = \bar{x}_i S_i / \sum_{j=1}^n \bar{x}_j S_j$, $i = 1, \ldots, n$, denote the market portfolio weights and let $\omega_i^{\mathbf{b}} = \mathbf{1}_i \bar{x}_i S_i / \sum_{j=1}^n \mathbf{1}_j \bar{x}_j S_j$, $i = 1, \ldots, n$, denote the benchmark portfolio

weights. We have the market and benchmark returns equal to

$$\begin{aligned} R_{\mathbf{m}} &= \sum_{j=1}^{n} \omega_j^{\mathbf{m}} \frac{D_j}{\bar{x}_j S_j} = \frac{\sum_{j=1}^{n} D_j}{\sum_{j=1}^{n} \bar{x}_j S_j}, \\ R_{\mathbf{b}} &= \sum_{j=1}^{n} \omega_j^{\mathbf{b}} \frac{D_j}{\bar{x}_j S_j} = \frac{\sum_{j=1}^{k} D_j}{\sum_{j=1}^{k} \bar{x}_j S_j}. \end{aligned}$$

To show (9), recall that $E(R_i) = \mu_i/(\bar{x}_i S_i)$. Take the ith row of (8), divide both sides by S_i and rearrange terms to get

$$\begin{aligned} &E(R_i) - 1 = \alpha\Lambda \sum_{j=1}^{n} \bar{x}_j S_j \mathrm{Cov}(R_i, R_{\mathbf{m}}) - \alpha\Lambda\lambda_{AM} \frac{b}{a+b} \sum_{j=1}^{k} \bar{x}_j S_j \mathrm{Cov}(R_i, R_{\mathbf{b}}) \\ &= \frac{\mathrm{Cov}(R_i, R_{\mathbf{m}})}{\mathrm{Var}(R_{\mathbf{m}})} \mathrm{Var}(R_{\mathbf{m}}) \alpha\Lambda \sum_{j=1}^{n} \bar{x}_j S_j - \frac{\mathrm{Cov}(R_i, R_{\mathbf{b}})}{\mathrm{Var}(R_{\mathbf{b}})} \mathrm{Var}(R_{\mathbf{b}}) \alpha\Lambda\lambda_{AM} \frac{b}{a+b} \sum_{j=1}^{k} \bar{x}_j S_j \\ &= \beta_j^{\mathbf{m}} \gamma_{\mathbf{m}} - \beta_j^{\mathbf{b}} \gamma_{\mathbf{b}}, \end{aligned}$$

where $\gamma_{\mathbf{m}} = \mathrm{Var}(R_{\mathbf{m}}) \alpha\Lambda \sum_{j=1}^{n} \bar{x}_j S_j$, and $\gamma_{\mathbf{b}} = \mathrm{Var}(R_{\mathbf{b}}) \alpha\Lambda \sum_{j=1}^{k} \bar{x}_j S_j \lambda_{AM} b/(a+b)$. □

Proof of Lemma 4. Suppose firm i adopts the project. Then the total number of shares of asset j becomes $\bar{x}_j^{(i)} = \bar{x}_j + \delta_i \mathcal{I}_{j=i}$, where $\delta_i S_i^{(i)} = I$.

Adopting (16) for this case, we have

$$\bar{x}^{(i)} \cdot S^{(i)} = \mu^{(i)} - \alpha\Lambda\Sigma^{(i)} \left(\mathbb{1} - \lambda_{AM} \frac{b}{a+b} \mathbf{1}_{\mathbf{b}} \right).$$

Finally, using the definition of $\bar{x}^{(i)}$, we have

$$\bar{x} \cdot S^{(i)} = \mu^{(i)} - \mathcal{I}^{(i)} I - \alpha\Lambda\Sigma^{(i)} \left(\mathbb{1} - \lambda_{AM} \frac{b}{a+b} \mathbf{1}_{\mathbf{b}} \right), \tag{17}$$

which simplifies to (10) when $\bar{x} = \mathbb{1}$.

The ith element of $\bar{x} \cdot S$ is

$$\bar{x}_i S_i = \mu - \alpha\Lambda \sum_{j=1}^{n} \rho_{ij} \sigma_i \sigma_j \left(1 - \lambda_{AM} \frac{b}{a+b} \mathbf{1}_j \right) \tag{18}$$

and the ith element of $\bar{x} \cdot S^{(i)}$ is

$$\bar{x}_i S_i^{(i)} = \mu + \mu_y - I - \alpha\Lambda\left(\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y\right)\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right) - \alpha\Lambda\sum_{j=1}^{n}\left[\rho_{ij}\sigma_i\sigma_j + \rho_{jy}\sigma_j\sigma_y\right]\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right). \tag{19}$$

Subtracting (18) from (19), obtain

$$\bar{x}_i \Delta S_i = \mu_y - I - \alpha\Lambda\left(\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y\right)\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right) - \alpha\Lambda\sum_{j=1}^{n}\rho_{jy}\sigma_j\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right), \tag{20}$$

which is (11) when $\bar{x}_i = 1$. For $i_1 \in \mathcal{B}$ and $i_2 \notin \mathcal{B}$ we have

$$\bar{x}_{i_1}\Delta S_{i_1} - \bar{x}_{i_2}\Delta S_{i_2} = \alpha\Lambda(\sigma_y^2 + \rho\sigma\sigma_y)\lambda_{AM}\frac{b}{a+b}. \tag{21}$$

□

Proof of Proposition 1. Follows immediately from (12) (or its analog (21)). □

Proof of Proposition 2. The only difference with the proof of Lemma 4 that implies Proposition 1 is that when firm y is traded before the merger, then (18) becomes

$$\bar{x}_i S_i = \mu - \alpha\Lambda\left[\sum_{j=1}^{n}\rho_{ij}\sigma_i\sigma_j\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right) + \rho_{iy}\sigma_i\sigma_y\right].$$

Subtracting this from (19), we have that (20) in this case becomes

$$\begin{aligned}
\bar{x}_i\Delta S_i &= \mu_y - I - \alpha\Lambda\left[\left(\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y\right)\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right) - \rho_{iy}\sigma_i\sigma_y\right] \\
&\quad - \alpha\Lambda\sum_{j=1}^{n}\rho_{jy}\sigma_j\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right) \\
&= \mu_y - I - \alpha\Lambda\sigma_y^2 + \alpha\Lambda\left(\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y\right)\lambda_{AM}\frac{b}{a+b}\mathbf{1}_i \\
&\quad - \alpha\Lambda\sum_{j=1}^{n}\rho_{jy}\sigma_j\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_j\right).
\end{aligned}$$

Thus (21) in this case is

$$\bar{x}_{i_1}\Delta S_{i_1} - \bar{x}_{i_2}\Delta S_{i_2} = \alpha\Lambda\left(\sigma_y^2 + \rho_{i_1 y}\sigma_{i_1}\sigma_y\right)\lambda_{AM}\frac{b}{a+b},$$

where $i_1 \in \mathcal{B}$, $i_2 \notin \mathcal{B}$, and $\bar{x}_{i_1}\Delta S_{i_1} > \bar{x}_{i_2}\Delta S_{i_2} \iff \sigma_y^2 + \rho_{i_1 y}\sigma_{i_1}\sigma_y > 0$. Notice also that unlike in Proposition 1, we do not need to assume that $\sigma_{i_1} = \sigma_{i_2}$ and $\rho_{i_1 y} = \rho_{i_2 y}$. □

Proof of Proposition 3. (i) Suppose firm y issues $\bar{x}_y$ shares when it goes public (in the main text we normalized $\bar{x}_y$ to one). The stock price of firm y if it does not get included in the benchmark is

$$\bar{x}_y S_y^{out} = \mu_y - \alpha\Lambda\left[\sigma_y^2 + \sum_{i=1}^{n}\rho_{iy}\sigma_i\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right)\right].$$

The price of firm y if it enters the benchmark and no other firm leaves it, is

$$\bar{x}_y S_y^{in} = \mu_y - \alpha\Lambda\left[\sigma_y^2\left(1 - \lambda_{AM}\frac{b}{a+b}\right) + \sum_{i=1}^{n}\rho_{iy}\sigma_i\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\mathbf{1}_i\right)\right].$$

Taking the difference,

$$\bar{x}_y\left(S_y^{in} - S_y^{out}\right) = \alpha\Lambda\sigma_y^2\lambda_{AM}\frac{b}{a+b} > 0.$$

(ii) The price of firm y if it replaces firm k in the benchmark is

$$\bar{x}_y\hat{S}_y^{in} = \mu_y - \alpha\Lambda\left[\sigma_y^2\left(1 - \lambda_{AM}\frac{b}{a+b}\right) + \sum_{i=1}^{k-1}\rho_{iy}\sigma_i\sigma_y\left(1 - \lambda_{AM}\frac{b}{a+b}\right) + \sum_{i=k}^{n}\rho_{iy}\sigma_i\sigma_y\right].$$

Taking the difference,

$$\bar{x}_y\left(\hat{S}_y^{in} - S_y^{out}\right) = \alpha\Lambda\left(\sigma_y^2 - \rho_{ky}\sigma_k\sigma_y\right)\lambda_{AM}\frac{b}{a+b} > 0.$$

Thus $\hat{S}_y^{in} > S_y^{out} \iff \sigma_y^2 - \rho_{ky}\sigma_k\sigma_y > 0$. □

Appendix B

In this appendix we explore the robustness of our model to an alternative specification where a manager's compensation is tied to the per-dollar returns on the fund's and benchmark portfolios as opposed to the performance measure used in the main text.

Define $R_i = D_i/(\bar{x}_i S_i)$, $i = 1, \ldots, n$ and let $R = (R_1, \ldots, R_n)^\top$ be the vector of (per-dollar) returns. It is distributed normally with mean $\mu_R = (\mu_1/(\bar{x}_1 S_1), \ldots, \mu_n/(\bar{x}_n S_n))$ and variance Σ_R, where

$$(\Sigma_R)_{ij} = \frac{\rho_{ij}\sigma_i\sigma_j}{\bar{x}_i S_i \bar{x}_j S_j},\ i = 1, \ldots, n,\ j = 1, \ldots, n.$$

It is now more convenient to specify investors' portfolio optimization problem in terms of fractions of wealth under management θ_i , invested in stock i, $i = 1, \ldots, n$, with the remaining fraction $1 - \sum_{i=1}^n \theta_i$ invested in the bond. Denote $\theta = (\theta_1, \ldots, \theta_n)^\top$.

Let us start by considering the problem of a conventional investor. Let W_0^C denote the initial wealth of each conventional investor. Let $\mathbb{1} = (1, \ldots, 1)^\top$ be the vector of ones. As in main model, CARA preferences with normal returns are equivalent to mean-variance preferences. Then the conventional investor's problem can be written as

$$\max_\theta (\theta^\top \mu_R + 1 - \mathbb{1}^\top \theta) W_0^C - \frac{\alpha}{2}\theta^\top \Sigma_R \theta \left(W_0^C\right)^2.$$

The optimal solution is

$$\theta^C W_0^C = \Sigma_R^{-1} \frac{\mu_R - \mathbb{1}}{\alpha}.$$

Now consider asset managers. Suppose each asset manager is given W_0^{AM} amount of money to manage, which is all or part of the shareholder's initial wealth. The asset manager's compensation is

$$w = [aR_\theta + b(R_\theta - R_{\mathbf{b}})]W_0^{AM} + c,$$

where $R_\theta = \theta^\top R + 1 - \mathbb{1}^\top \theta$ is the return on the asset manager's portfolio, and $R_{\mathbf{b}} = \omega^\top R$ is the benchmark return, with benchmark weights ω defined in what follows.

Let $\mathbf{1}_i$ be an indicator function, with $\mathbf{1}_i = 1$ if $i \in \mathcal{B} = \{1, 2, \ldots, k\}$ and 0 otherwise. Denote $\mathbf{1_b} = (\mathbf{1}_1, \mathbf{1}_2, \ldots, \mathbf{1}_n)^\top$. As in the proof of Lemma 3, we define the benchmark

weights to be

$$\omega_i = \frac{\mathbf{1}_i \bar{x}_i S_i}{\sum_{j=1}^{n} \mathbf{1}_j \bar{x}_j S_j},$$

and $\omega = (\omega_1, \ldots, \omega_n)^\top$. Then the asset manager's compensation can be written as

$$w = \left[(a+b)(\theta^\top R + 1 - \mathbb{1}^\top \theta) - b\omega^\top R\right] W_0^{AM} + c,$$

and the asset manager's problem is

$$\max_{\theta} \left[(a+b)(\theta^\top \mu_R + 1 - \mathbb{1}^\top \theta) - b\omega\mu_R\right] W_0^{AM} - \frac{\alpha}{2}[(a+b)\theta - b\omega]^\top \Sigma_R [(a+b)\theta - b\omega] \left(W_0^{AM}\right)^2.$$

The optimal solution is

$$\left[(a+b)\theta^{AM} - b\omega\right] W_0^{AM} = \Sigma_R^{-1} \frac{\mu_R - \mathbb{1}}{\alpha}.$$

Equating total demand with total supply, $\lambda_{AM}\theta^{AM}W_0^{AM} + \lambda_C \theta^C W_0^C = \bar{x} \cdot S$, and rearranging terms, we arrive at the following representation of the stocks' expected returns:

$$\begin{pmatrix} \frac{\mu_1}{\bar{x}_1 S_1} - 1 \\ \vdots \\ \frac{\mu_n}{\bar{x}_n S_n} - 1 \end{pmatrix} = \alpha \Lambda \begin{pmatrix} \frac{\sigma_1^2}{\bar{x}_1^2 S_1^2} & \cdots & \frac{\rho_{1n}\sigma_1\sigma_n}{\bar{x}_1 S_1 \bar{x}_n S_n} \\ \vdots & & \vdots \\ \frac{\rho_{1n}\sigma_1\sigma_n}{\bar{x}_1 S_1 \bar{x}_n S_n} & \cdots & \frac{\sigma_n^2}{\bar{x}_n^2 S_n^2} \end{pmatrix} \left(\begin{pmatrix} \bar{x}_1 S_1 \\ \vdots \\ \bar{x}_n S_n \end{pmatrix} - \lambda_{AM} W_0^{AM} \frac{b}{a+b} \omega \right).$$

Simplifying further, we have

$$\begin{pmatrix} \mu_1 - \bar{x}_1 S_1 \\ \vdots \\ \mu_n - \bar{x}_n S_n \end{pmatrix} = \alpha \Lambda \begin{pmatrix} \frac{\sigma_1^2}{\bar{x}_1 S_1} & \cdots & \frac{\rho_{1n}\sigma_1\sigma_n}{\bar{x}_n S_n} \\ \vdots & & \vdots \\ \frac{\rho_{1n}\sigma_1\sigma_n}{\bar{x}_1 S_1} & \cdots & \frac{\sigma_n^2}{\bar{x}_n S_n} \end{pmatrix} \left(\begin{pmatrix} \bar{x}_1 S_1 \\ \vdots \\ \bar{x}_n S_n \end{pmatrix} - \lambda_{AM} W_0^{AM} \frac{b}{a+b} \omega \right),$$

which after plugging in

$$\omega = \frac{1}{\sum_{i=1}^{n} \mathbf{1}_i \bar{x}_i S_i} \begin{pmatrix} \mathbf{1}_1 \bar{x}_1 S_1 \\ \vdots \\ \mathbf{1}_n \bar{x}_n S_n \end{pmatrix}$$

gives us an implicit expression for share values:

$$\bar{x} \cdot S = \mu - \alpha \Lambda \Sigma \left(\mathbb{1} - \lambda_{AM} \frac{b}{a+b} \frac{W_0^{AM}}{\sum_i \mathbf{1}_i \bar{x}_i S_i} \mathbf{1}_\mathbf{b} \right). \tag{22}$$

Notice that (22) is identical to our expression for share values (16) in the main model with $\mathbf{1}_\mathbf{b} W_0^{AM} / \sum_i \mathbf{1}_i \bar{x}_i S_i$ instead of $\mathbf{1}_\mathbf{b}$.

Notice that the value of assets under management, W_0^{AM}, itself depends on asset prices. In general, (22) cannot be solved in closed form. Consider a special case when W_0^{AM} consists only of the benchmark stocks, i.e., $W_0^{AM} = \sum_i \mathbf{1}_i \bar{x}_i S_i$. Then (22) becomes exactly (16).

Lemmas 1–3 from the main text extend straightforwardly to the considered extension. The extension of Lemma 4 is a bit more tricky in general. We perform it in two special cases. In the first case we assume that $W_0^{AM} = \sum_i \mathbf{1}_i \bar{x}_i S_i$ as discussed above. In the second case we assume that the value of asset under management is independent of equilibrium stock prices, which happens, e.g., when the endowment of shareholders is in terms of bonds only. Finally, for simplicity we assume that investment is financed by internal funds (or, equivalently, with the risk-free bond). Then the cost of investment to any firm is I (which is also true in our original model). We discuss briefly at the end what happens if investment is financed by equity instead.

In this case, if firm i invests, we have $\bar{x} \cdot S^{(i)}$ and $\bar{x}_i \Delta S_i$ given exactly by (17) and (20), respectively. So Lemma 4 extends to this case. Performing the same analysis as in the main text, we get Proposition 1. The results about mergers and acquisitions and IPOs extend in the same way.

The second special case is the value of asset under management is fixed, independent of equilibrium stock prices (which happens, e.g., when the endowment of shareholders is in terms of bonds only).

Denote $T = \sum_i \mathbf{1}_i \bar{x}_i S_i$ as the total value of firms that are in the benchmark. Multiplying both sides of (22) by $\mathbf{1}_\mathbf{b}^\top$ and taking the positive root of the resulting quadratic equation

$$T = \mu^\top \mathbf{1}_\mathbf{b} - \alpha \Lambda \mathbf{1}_\mathbf{b}^\top \Sigma \mathbb{1} + \alpha \Lambda \mathbf{1}_\mathbf{b}^\top \Sigma \mathbf{1}_\mathbf{b} \lambda_{AM} \frac{b W_0^{AM}}{(a+b)T},$$

we have

$$T = \frac{\mu^\top \mathbf{1}_\mathbf{b} - \alpha \Lambda \mathbf{1}_\mathbf{b}^\top \Sigma \mathbb{1} + \sqrt{\left(\mu^\top \mathbf{1}_\mathbf{b} - \alpha \Lambda \mathbf{1}_\mathbf{b}^\top \Sigma \mathbb{1}\right)^2 + 4\alpha \Lambda \mathbf{1}_\mathbf{b}^\top \Sigma \mathbf{1}_\mathbf{b} \lambda_{AM} W_0^{AM} b/(a+b)}}{2}.$$

Then we have an explicit expression for asset prices given by

$$\bar{x} \cdot S = \mu - \alpha\Lambda\Sigma \left(\mathbb{1} - \lambda_{AM} \frac{b}{a+b} \frac{W_0^{AM}}{T} \mathbf{1_b} \right).$$

If firm i invests,

$$\bar{x} \cdot S^{(i)} = \mu^{(i)} - \mathcal{I}^{(i)} I - \alpha\Lambda\Sigma^{(i)} \left(\mathbb{1} - \lambda_{AM} \frac{b}{a+b} \frac{W_0^{AM}}{T^{(i)}} \mathbf{1_b} \right).$$

where $T^{(i)} = \sum_j \mathbf{1}_j \bar{x}_j S_j^{(i)}$ is given by the positive root of

$$T^{(i)} = \left(\mu^{(i)} - \mathcal{I}^{(i)} I \right)^\top \mathbf{1_b} - \alpha\Lambda \mathbf{1_b}^\top \Sigma^{(i)} \mathbb{1} + \alpha\Lambda \mathbf{1_b}^\top \Sigma^{(i)} \mathbf{1_b} \lambda_{AM} \frac{b W_0^{AM}}{(a+b) T^{(i)}}.$$

The corresponding change in firm i's value is

$$\begin{aligned} \bar{x}_i \Delta S_i =& \mu_y - I - \alpha\Lambda \sum_{j=1}^{n} \left[\rho_{jy}\sigma_j\sigma_y + (\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y)\mathcal{I}_{j=i} \right] \left(1 - \lambda_{AM} \frac{b}{a+b} \frac{W_0^{AM}}{T} \mathbf{1}_j \right) \\ & - \alpha\Lambda \sum_{j=1}^{n} \left[\rho_{jy}\sigma_j\sigma_y + (\sigma_y^2 + \rho_{iy}\sigma_i\sigma_y)\mathcal{I}_{j=i} + \rho_{ij}\sigma_i\sigma_j \right] \lambda_{AM} \frac{b}{a+b} W_0^{AM} \mathbf{1}_j \left(\frac{1}{T} - \frac{1}{T^{(i)}} \right). \end{aligned}$$

Suppose we have two firms i_1 and i_2, $i_1 \in \mathcal{B}$, $i_2 \notin \mathcal{B}$ that are otherwise symmetric, i.e., $\sigma_{i_1} = \sigma_{i_2} = \sigma$, $\rho_{i_1 y} = \rho_{i_2 y} = \rho$ and $\rho_{i_1 j} = \rho_{i_2 j} = \rho_j$ for all $j \neq i_1, i_2$. Then the analog of (12) in the main text is

$$\begin{aligned} \bar{x}_{i1}\Delta S_{i_1} - \bar{x}_{i2}\Delta S_{i_2} =& \left[\sigma_y^2 + \rho\sigma\sigma_y \right] \alpha\Lambda \frac{b}{a+b} \lambda_{AM} \frac{W_0^{AM}}{T^{(i_1)}} \\ & - \frac{T^{(i_1)} - T^{(i_2)}}{T^{(i_2)}} \alpha\Lambda \frac{b}{a+b} \lambda_{AM} \frac{W_0^{AM}}{T^{(i_1)}} \sum_{j=1}^{n} \left(\rho_{jy}\sigma_j\sigma_y + \rho_j\sigma\sigma_j \right) \mathbf{1}_j. \end{aligned} \tag{23}$$

The first term is positive by Assumption 1. The second term comes from the fact that the sum of benchmark weights is different depending on whether the investing firm is inside or outside the benchmark. It captures the fact that by investing, the firm grows and effectively reduces importance of other firms in the benchmark. Notice that $T^{(i_1)} - T^{(i_2)} = o(T)$ when project y is small relative to T ($T^{(i_1)}$, $T^{(i_2)}$, and T are all of the same order). So the term $\left(T^{(i_1)} - T^{(i_2)} \right) / T^{(i_2)}$ is $O(1/T)$ and $o(1)$. The rest of the second term, $\alpha\Lambda(b/a+b)\lambda_{AM}(W_0^{AM}/T^{(i_1)}) \sum_{j=1}^{n} \left(\rho_{jy}\sigma_j\sigma_y + \rho_j\sigma\sigma_j \right) \mathbf{1}_j$, is of the same order as $\bar{x}_{i_1} S^{(i_1)}$. So

the second term is $O(\bar{x}_{i_1} S^{(i_1)}/T^{(i_1)})$, i.e., of the order of the benchmark weight ω_{i_1}.

Consider a special case when project y is risk free, i.e., $\sigma_y = 0$. It is easy to show that $T^{(i_2)} = T$ for $i_2 \notin \mathcal{B}$. Moreover, suppose that $I = \mu_y$ so that there are no arbitrage opportunities. Then $\mu^{(i_1)} - \mathcal{I}^{(i_1)} I = \mu$ and $\Sigma^{(i_1)} = \Sigma$, and thus $T^{(i_1)} = T$ for $i_1 \in \mathcal{B}$. As a result, for the risk-free project with $\mu_y = I$ we have $\Delta S_{i_1} - \Delta S_{i_2} = 0$, i.e., both firms evaluate it equally.

Finally, if I is financed by issuing $\delta_i = I/S_i^{(i)}$ additional shares, then instead of $T^{(i)} = \sum_i \mathbf{1}_j x_j S_j^{(i)}$ we have $T^{(i)\prime} = \sum_{j\neq i} \mathbf{1}_i \bar{x}_j S_j^{(i)} + \mathbf{1}_i S_i^{(i)}(\bar{x}_i + \delta_i) = \sum_j \mathbf{1}_i \bar{x}_j S_j^{(i)} + \mathbf{1}_i I$. Then $T^{(i_1)\prime} = T^{(i_1)} + I$ for $i_1 \in \mathcal{B}$ and $T^{(i_2)\prime} = T^{(i_2)}$ for $i_2 \notin \mathcal{B}$.

The equation for the benchmark inclusion subsidy is now

$$\begin{aligned}\bar{x}_{i1}\Delta S_{i_1} - \bar{x}_{i2}\Delta S_{i_2} = {} & \left[\sigma_y^2 + \rho\sigma\sigma_y\right] \alpha\Lambda \frac{b}{a+b} \lambda_{AM} \frac{W_0^{AM}}{T^{(i_1)} + I} \\ & - \frac{T^{(i_1)} - T^{(i_2)} + I}{T^{(i_2)}} \alpha\Lambda \frac{b}{a+b} \lambda_{AM} \frac{W_0^{AM}}{T^{(i_1)} + I} \sum_{j=1}^{n} \left(\rho_{jy}\sigma_j\sigma_y + \rho_j\sigma\sigma_j\right) \mathbf{1}_j.\end{aligned}$$

So the additional effect coming from the change in the total index value that we have seen in (23) is stronger when the investment is financed by equity.

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