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Asset Prices and Institutional Investors†

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We consider an economy populated by institutional investors alongside standard retail investors. Institutions care about their performance relative to a certain index. Our framework is tractable, admitting exact closed-form expressions, and produces the following analytical results. We find that institutions tilt their portfolios towards stocks that compose their benchmark index. The resulting price pressure boosts index stocks. By demanding more risky stocks than retail investors, institutions amplify the index stock volatilities and aggregate stock market volatility and give rise to countercyclical Sharpe ratios. Trades by institutions induce excess correlations among stocks that belong to their benchmark, generating an asset-class effect. (*JEL* G12, G23)

A significant part of the trading volume in financial markets is attributed to institutional investors. Trades by retail investors constitute only a small fraction of the trading volume. In contrast, the standard theories of asset pricing stipulate that prices in financial markets are determined by households (or by the "representative consumer" aggregated over households) that seek to optimize their consumption and investment over their life cycle. This approach leaves no role for important considerations influencing institutional investors' portfolios such as, for instance, compensation-induced incentives or implicit incentives arising from the predictability of inflows of capital into the money management business. This underscores the importance of studying how the incentives of institutional investors may influence the prices of the assets they hold.

In this paper, we take institutional investors to be institutional/professional asset managers. These managers have a mandate to manage a portfolio for a mutual fund, a hedge fund, a pension fund, an endowment, an asset management team in a bank or insurance company, etc. In our analysis, we focus on perhaps the most prominent feature of professional managers' incentives: concern about own performance vis-à-vis some benchmark index (e.g., S&P 500). This characteristic is what induces institutional investors to act differently from retail investors. Relative performance

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matters because inflows of new money into institutional portfolios and payouts to asset managers at year end depend on it, or simply because managers care about their standing in the profession (status). Our goal is to demonstrate how, in the presence of such incentives, institutions optimally tilt their portfolios towards the stocks in their benchmark index, influencing the performance of the index, and in the process how they exacerbate leverage in the economy as well as stock market volatility and boost the correlation among the stocks that are included in the index.

We consider a dynamic general equilibrium model with two classes of investors: "retail" investors with standard logarithmic preferences and "institutional" investors who are concerned not only about their own performance but also about the performance of a benchmark index. The institutional investors have an additional incentive to post a higher return when their benchmark is high than when it is low, in an effort to outdo the benchmark. Formally, their marginal utility of wealth is increasing with the level of their benchmark index. Towards that we take a reduced-form approach in our specification of the institutional investor's objective function that captures the above salient features and admits much tractability. In our model, there are multiple risky stocks, some of which are part of the index, and a riskless bond. The stocks are in positive net supply, while the bond is in zero net supply. The model is designed to capture several important empirical phenomena and to provide the economic mechanisms generating these phenomena. One major advantage of our model is that it delivers exact, closed-form expressions for all quantities which are behind our results described below.

We first examine the tilt in the portfolios of the institutional investors which is caused by the presence of the benchmark indexing. We find that, relative to the retail investor, the institution increases the fraction of index stocks in the portfolio so as not to fall behind when the index does well. To finance this additional demand for index stocks, the institution takes on leverage.[1] So the institutions in our model always end up borrowing funds from the retail sector, to the extent allowed by the size of their assets under management that serve as collateral. As institutions continue to do well and accumulate assets, they increase the overall leverage in the economy, but only up to a certain point determined by the lending capacity of the retail sector.

We next investigate how the presence of institutions influences asset prices. Our first finding is that institutions push up the prices of stocks in the benchmark index. In the economy with institutional investors, the index stock prices are higher both relative to those in the retail investor–only economy and relative to their (otherwise identical) nonindex counterparts. This is because institutions generate excess demand for the index stocks. This finding is well supported in the data: such an "index effect" occurs in many markets and countries.[2]

[1] Our institutions may be interpreted as mutual funds. Due to regulation, most mutual funds choose to be long-only, although some do use leverage (e.g., the 130/30 funds). Other, less regulated, institutional investors can use leverage (closed-end funds, hedge funds, etc.). We further note that leverage is inevitable in a model with heterogeneous agents and a zero-net supply riskless bond. However, it is not essential for our mechanism; what is essential is that institutions have excess demand for index stocks. In online Appendix C, we present a variant of our model without leverage. In that model there are only (positive net supply) risky stocks available for trading, and there is no riskless bond. Typically the investors are long in all stocks. They have an excess demand for index stocks, and they finance this additional demand by reducing their portfolio weights in nonindex stocks.

[2] Starting from Harris and Gurel (1986) and Shleifer (1986), a series of papers documents that prices of stocks that are added to the S&P 500 and other indices increase following the announcement, and prices of stocks that are deleted drop. For example, Chen, Noronha, and Singal (2004) find that during 1989–2000, the stock price increased

We also find that the price pressure from the institutions boosts the level of the overall stock market in addition to the index. This is because the institutions have a higher demand for risky assets than retail investors do. Since the stocks are in fixed supply, the index stocks have to become less attractive for markets to clear. This translates into higher volatilities and lower Sharpe ratios for the index stocks and the overall stock market. The presence of institutions also induces time variation in these quantities—in particular, makes Sharpe ratios countercyclical. This is because the institutions are overweighted in the risky assets. They therefore benefit more from good cash flow news than retail investors, and so become more dominant in the economy. This amplifies the cash flow news and pushes down the Sharpe ratios. As the size of institutions increases, their influence on equilibrium also becomes more pronounced. Therefore, the Sharpe ratios are lower in good times than in bad times. In light of these findings, one can attempt to examine the effects on asset markets of several popular policy recommendations put forward during the 2007–2008 financial crisis. We make no welfare comparisons here; we simply highlight the side effects of some policy recommendations. One such recommendation was to impose leverage caps on institutions, excessive leverage of which had arguably caused the crisis. In our model, when institutions do not control the dominant fraction of wealth in the economy, a leverage cap brings down the riskiness of their portfolios (an intended effect), but it also brings down the level of stock prices, creating an adverse side effect.

Finally, we examine the correlations among stocks included in the index and stocks outside the index. We find that the presence of institutions that care explicitly about their index induces time-varying correlations and generates an "asset-class" effect: returns on stocks belonging to the index are more correlated amongst themselves than with those of otherwise identical stocks outside the index. This asset-class effect is, of course, absent in the retail-investor-only benchmark economy: there, the correlation between any two stocks' returns is determined simply by the correlation of their fundamentals (dividends). The additional correlation among the index stocks is caused by the additional demand of institutions for the index stocks: the institutions hold a hedging portfolio, consisting of only index stocks, that hedges them against fluctuations in the index. Following a good realization of cash flow news, institutions get wealthier and demand more shares of index stocks relative to the retail-investor-only benchmark. This additional price pressure affects all index stocks at the same time, inducing excess correlations among these stocks. Empirical research lends support to our findings; asset-class effects have now been documented in many markets.[3] We get the time-varying correlations in the presence of institutions for the same reasons as for the time-varying volatilities.

by an average of 5.45 percent on the day of the S&P 500 inclusion announcement and a further 3.45 percent between the announcement and the actual addition. The corresponding figures for the S&P 500 deletions are −8.46 percent and −5.97 percent, respectively. Moreover, the index effect has become stronger after 1989. While there are possible alternative explanations to this phenomenon, the growth of the institutions that benchmark their performance against the index remains a leading one.

[3] For example, Barberis, Shleifer, and Wurgler (2005) show that when a stock is added to the S&P 500 index, its beta with respect to the S&P 500 goes up while its non-S&P 500 "rest of the market" beta falls; and the opposite is true for stocks deleted from the index. Moreover, these effects are stronger in more recent data. Boyer (2011) provides similar evidence for BARRA value and growth indices. He finds that "marginal value" stocks—the stocks that just switched from the growth into the value index—comove significantly more with the value index; the opposite is true for the "marginal growth" stocks. Consistent with the institutional explanation for this phenomenon, Boyer finds that the effect appears only after 1992, which is when BARRA indices were introduced.

It is somewhat surprising that despite extensive empirical work showing that institutions have important effects on asset prices and despite the 2007–2008 financial crisis that has made this point all too obvious, we still have little theoretical work on equilibrium in the presence of professional money management. Brennan (1993) is the first to attempt to introduce institutional investors into an asset pricing model. Brennan considers a static mean-variance setting with constant absolute risk aversion (CARA) utility agents who are compensated based on their performance relative to a benchmark index. He shows that in equilibrium expected returns are given by a two-factor model, with the two factors being the market and the index. More recent related, also static, mean-variance models appear in Gómez and Zapatero (2003), Cornell and Roll (2005), Brennan and Li (2008), Leippold and Rohner (2012), and Petajisto (2009). CARA utility, as is well known, rules out wealth effects, which play a central role in our article.

Cuoco and Kaniel (2011) develop a dynamic equilibrium model with constant relative risk aversion (CRRA) agents who explicitly care about an index due to performance-based fees. In a two-stock economy, Cuoco and Kaniel show that inclusion in an index increases a stock's price and illustrate numerically that it also lowers its unconditional expected return and increases its unconditional volatility. However, in an exercise more closely related to the one we perform in this article, they show numerically that, in contrast to our work, the conditional volatilities of the index stock and aggregate stock market decrease in the presence of benchmarking. In another closely related paper, He and Krishnamurthy (2012a) consider a dynamic single-stock model with CRRA (logarithmic) institutions, in which institutions are constrained in their portfolio choice due to contracting frictions. They show that in bad states of the world (crises), institutional constraints are particularly severe, causing increases in the stock's Sharpe ratio and conditional volatility and replicating other patterns observed during crises. This literature remains sparse due to the modeling challenges of tractably solving for asset prices in the presence of wealth effects and multiple assets. We overcome this challenge by modeling institutions differently: our model has the tractability of CARA-based models but it additionally features wealth effects. This tractability not only allows us to elucidate the mechanisms through which institutions influence asset prices, but also to extend our setting to multiple risky stocks, permitting an analysis of the "asset-class" effect. The closest theoretical model that exhibits the "asset-class" effect is by Barberis and Shleifer (2003), whose explanation for this phenomenon is behavioral. By providing microfoundations for investors' demand schedules, we can establish a set of primitives that give rise to the asset-class effect and discuss what these primitives imply for other equilibrium quantities (time-varying volatilities, Sharpe ratios, leverage, risk tolerance, and others). Moreover, the correlations of stocks within an asset class in our model are time-varying due to wealth effects.

Other related papers that have explored equilibrium effects of delegated portfolio management include He and Krishnamurthy (2013), in which poor performance of fund managers triggers portfolio outflows due to contracting frictions; Dasgupta and Prat (2008); Dasgupta, Prat, and Verardo (2011); Vayanos and Woolley (2013); Malliaris and Yan (2010); Guerreri and Kondor (2012), in which outflows following poor performance are due to learning about managerial ability; and Vayanos (2004) and Kaniel and Kondor (2013) in which outflows occur for exogenous reasons, dependent on fund performance. They show that, similar to our findings, flow-based considerations amplify the effects of exogenous shocks on asset prices. All of these papers model various agency frictions. In our model, we simplify this aspect but offer a richer model of a securities market. We view these papers as complementary to our work. Our article is also connected to the literature on relative wealth concerns and asset prices (Galí 1994). For example, in DeMarzo, Kaniel, and Kremer (2004, 2008), where such concerns arise endogenously, agents care about their relative wealth in the community which causes them to overinvest in stocks held by other members of their community. In our model, the institutional investors end up over-investing in the index stocks.

Finally, there is a related literature on the effects of fund flows and benchmarking considerations on portfolio choice of fund managers, at a partial equilibrium level. For example, Carpenter (2000); Basak, Pavlova, and Shapiro (2007, 2008); Hodder and Jackwerth (2007); Binsbergen, Brandt, and Koijen (2008); and Chen and Pennacchi (2009) show that future fund flows induce a manager to tilt her portfolio toward stocks that belong to her benchmark. These papers demonstrate that there is a range over which such benchmarking considerations induce her to take more risk. The main difference of our article from this body of work is that we examine the general equilibrium effects of benchmarking.

The remainder of our article is organized as follows. Section I presents a simplified single-stock version of our model for which we establish a number of our results in the clearest possible way. Section II discusses the index effect, institutional risk-taking, wealth effects, and the resulting policy implications. Section III presents the general multistock version of our model and focuses on the asset-class effect, and Section IV summarizes our key predictions and empirical implications. Online Appendix A contains all proofs, online Appendix B generalizes the analysis to nonzero dividend growth and interest rate, online Appendix C presents the stocks-only version of our model, and online Appendix D provides an agency-based justification for the institutional objective function.

I. Economy with Institutional Investors

A. *Economic Setup*

We consider a simple and tractable pure-exchange security market economy with a finite horizon. The economy evolves in continuous time and is populated by two types of market participants: retail investors, $\mathcal{R}$, and institutional investors, $\mathcal{I}$. In the general specification of our model, there are N stocks, M of which are included in the index against which the performance of institutions is measured, as well as a riskless bond. In this section, however, we specialize the securities market to feature a single risky stock, henceforth referred to as the stock market *index*, and a riskless bond. The index is exposed to a single source of risk represented by a Brownian motion ω. The main reason for considering the single-stock case is expositional simplicity. It turns out that a number of key insights of this paper can be illustrated within the single-stock economy. We then build on our baseline intuitions and expand them (Section III) to demonstrate how our economy behaves in the general case in which there are multiple stocks and multiple sources of risk.

Investment Opportunities.—The stock market index, S, is posited to have dynamics given by

$$dS_t = S_t[\mu_{St}\,dt + \sigma_{St}\,d\omega_t], \tag{1}$$

with $\sigma_{St} > 0$. The mean return μ_S and volatility σ_S are determined endogenously in equilibrium (Section II). The bond is in zero net supply. It pays a riskless interest rate r, which we set to zero without loss of generality. This is equivalent to using the riskless bond as the numeraire and denoting all prices in terms of this numeraire. Such an assumption is innocuous because our model does not have intermediate consumption. In other words, there is no intertemporal choice that would pin down the interest rate. Our normalization is commonly employed in models with no intermediate consumption (see, e.g., Pástor and Veronesi 2012, for a recent reference). In online Appendix B, we incorporate a nonzero (constant) interest rate. This change modifies our formulae but leaves our economic insights unchanged. The stock market index is in positive net supply. It is a claim to the terminal payoff (or "dividend") D_T, paid at time T, and, hence, $S_T = D_T$. This payoff D_T is the terminal value of the process D_t, with dynamics

$$dD_t = D_t[\mu\,dt + \sigma\,d\omega_t], \tag{2}$$

where μ and $\sigma > 0$ are constant. The process D_t represents the arrival of news about D_T. We refer to it as the *cash flow news*. Equation (2) implies that cash flow news arrives continuously and that D_T is lognormally distributed. The lognormality assumption is made for technical convenience. For expositional purposes, we set $\mu = 0$, as this simplification does not alter any of our economic insights. Online Appendix B generalizes the analysis to incorporate a nonzero dividend growth rate and demonstrates that all our predictions remain equally valid. Moreover, in related analysis (not presented here due to space limitations), we relax the lognormality assumption and show that the bulk of our results remain valid for more general stochastic processes, but the characterization of our economy becomes more complex.

Investors.—Each type of investor $i = \mathcal{I}, \mathcal{R}$ in this economy dynamically chooses a portfolio process ϕ_i, where ϕ_i denotes the fraction of the portfolio invested in the stock index, or the *risk exposure*, given the initial assets of W_{i0}. The wealth process of investor i, W_i, then follows the dynamics

$$dW_{it} = \phi_{it} W_{it}[\mu_{St}\,dt + \sigma_{St}\,d\omega_t]. \tag{3}$$

The (representative) institutional and retail investors are initially endowed with fractions $\lambda \in [0, 1]$ and $(1 - \lambda)$ of the stock market index, providing them with initial assets worth $W_{\mathcal{I}0} = \lambda S_0$ and $W_{\mathcal{R}0} = (1 - \lambda)S_0$, respectively.[4] The parameter λ thus

[4] We do not explicitly model households that delegate their assets to institutions to manage but simply endow the institutions with an initial portfolio. The households that delegate their money to the institutions can be thought of, for example, as participants in defined benefit pension plans (worth \$3.14 trillion in the United States as of June 2009 according to official figures and significantly more according to Novy-Marx and Rauh 2011).

represents the (initial) fraction of the institutional investors in the economy—or equivalently, how large the institutions are relative to the overall economy. It is an important comparative statics parameter in our analysis, which allows us to illustrate how the growth of the financial sector (or, more precisely, funds managed by institutions) can influence asset prices.

The retail investor has standard logarithmic preferences over the terminal value of her portfolio:

$$u_{\mathcal{R}}(W_{\mathcal{R}T}) = \log(W_{\mathcal{R}T}). \tag{4}$$

In modeling the institutional investor's objective function, we consider two noteworthy features of the professional money management industry that make institutions behave differently from retail investors. First, institutional investors care about their benchmark index. This can be due to implicit or explicit incentives. The implicit incentives to perform well in relative terms come in the form of inflow/outflow of funds in response to relative performance. The fee of practically any type of an institutional asset manager includes a fraction of funds under management. Institutional asset managers therefore seek to perform well relative to their peer group so as to attract more new funds than their less successful peers. This positive flows-performance relation is a prevalent finding in asset management, as documented by Chevalier and Ellison (1997) and Sirri and Tufano (1998) for mutual funds, Agarwal, Daniel, and Naik (2004) and Ding et al. (2010) for hedge funds, and Del Guercio and Tkac (2002) for pension funds. For the purposes of highlighting explicit incentives of fund managers, it is important to distinguish between external and internal managers. External managers (working for, e.g., large pension funds or endowments) typically have mandates that get reviewed every one to five years by the trustees. These reviews are based to a large extent on their performance relative to passive benchmarks, and these managers win/lose mandates as well as attract inflows based on their relative performance (Bank for International Settlements (BIS) 2003). With the exception of hedge funds, internal managers receive bonuses that are linked to performance relative to their benchmarks (e.g., BIS 2003; Ma, Tang, and Gómez 2012). Such explicit and implicit incentives make both types of managers care about their relative performance. This discussion leads us to the second feature of professional asset management that we attempt to capture: money managers strive to post a higher return when their benchmark is high than when it is low, in an effort to outdo their benchmark. Putting this formally, their marginal utility of wealth is increasing in the level of their benchmark index. This feature can also be microfounded using an agency-based argument, following the ideas of Holmström (1979, 1982). In online Appendix D, we employ the approach of Edmans and Gabaix (2011) to demonstrate it formally. Accordingly, we formulate the institutional investor's objective function over the terminal value of her portfolio as being given by

$$u_{\mathcal{I}}(W_{\mathcal{I}T}) = (a + bS_T)\log(W_{\mathcal{I}T}), \tag{5}$$

where $a, b > 0$. We set $a = 1$, since by homogeneity only the ratio b/a matters in the ensuing analysis. In this one-stock economy, the manager's benchmark index coincides with the stock market.

There are, of course, multiple alternative specifications that are consistent with benchmark indexing, but the empirical literature to date is unclear as to what the exact form of the dependence on the benchmark index should be. An interesting recent attempt to estimate the form of a money manager's objective function is by Koijen (forthcoming). In (5) we have chosen a particularly simple affine specification, which renders tractability to our model. This specification is as tractable as CARA utility, but it behaves like CRRA preferences, inducing wealth effects. In future work, it is certainly desirable to extend our specification to a more general class of functions.

REMARK 1 (Alternative Specifications for Institutional Objective): A natural, alternative specification of our institutional objective function is $u_{\mathcal{I}}(W_{\mathcal{I}T}) = (1 + bS_T/S_0)\log(W_{\mathcal{I}T})$, which is defined over the return on the index as opposed to the level of the index. Since S_0 is endogenously determined in equilibrium, this specification is more difficult to analyze. Nonetheless, we demonstrate that all our main implications remain valid under this specification, and our model continues to deliver closed-form solutions (see Remark 4).

One may be concerned that our institutional objective function is increasing in the index level, whereas contract theory (see online Appendix D) and common sense suggest that it should instead be decreasing. To alleviate this concern, it is important to note that for the purposes of deriving asset pricing implications, what really matters is the marginal utility of wealth. Our objective function can be made decreasing in the index level if we subtract from it a sufficiently increasing function of S_T, such as, e.g., $\log S_T$. This transformation does not impact the marginal utility of the institutional investor, and, hence, none of our expressions changes.

Finally, we note that our specification of the institutional objective function is not the only one that delivers the property that the marginal utility is increasing in the index level. One alternative specification satisfying this property is $u_{\mathcal{I}}(W_{\mathcal{I}T}) = \log(W_{\mathcal{I}T} - S_T)$, or a variant of this utility that penalizes gains and losses differently. While this is certainly a valid specification to consider, it loses its tractability with multiple stocks and asset classes. For CRRA investors with the objective defined over $\alpha + \beta W_{\mathcal{I}T} + \gamma(W_{IT} - S_T)$, Cuoco and Kaniel (2011) obtain numerically a subset of our results for a two-stock economy, which is a valuable robustness check for our findings. Under the CARA objective $-e^{a(W_{\mathcal{I}T} - S_T)}$, Brennan (1993) and subsequent literature are able to tackle the multiple-stock case analytically. This literature, again, provides an important robustness check, but our implications are richer because of the presence of wealth effects. The key property that unites the objective functions that have been proposed in this related literature is that the marginal utility is increasing in the index level.

REMARK 2 (Status Interpretation): One may alternatively interpret the objective function of our institutional investor as that of an agent with a preference for status. Building on the ideas of Friedman and Savage (1948) and developing them more formally, Robson (1992) has proposed to model status concerns by introducing an additional argument in the utility function. This additional argument captures the aggregate wealth/consumption of the comparison group. In finance, a related paper exploring this idea is DeMarzo, Kaniel, and Kremer (2004). In particular, similarly to us, these authors argue that the marginal utility of consumption should be increasing with the level of community consumption. DeMarzo, Kaniel, and Kremer discuss how such status concerns may induce agents to overinvest in the assets that are correlated with the status variable. In our model, the institutional investor overinvests in the index—a benchmark for his performance evaluation within the investment management community.

The view that an institutional investor's desire to do well relative to an index may not be entirely due to monetary incentives but is instead driven by social esteem considerations is supported by the experimental/behavioral evidence on status concerns. Ball et al. (2001) present evidence from a lab experiment demonstrating that subjects care about status and that the preference for status affects economic outcomes. They argue further that status has to be publicly observable to influence outcomes. This is one of the reasons why status concerns are particularly important in labor markets, in which one's standing in the profession is easier to observe (as also argued by, e.g., Ellingsen and Johannesson 2007; Heffetz and Frank 2011). In professional money management, status is associated with a fund's relative performance, a publicly observable characteristic for most funds.

Direct empirical support for the status-based interpretation of our model is provided in Hong, Jiang, and Zhao (2012), who adopt the formulation in this section as a basis for their analysis. Using Chinese data they argue that status concerns of residents of wealthier provinces in China influence their risk exposure and affect asset prices, in directions as predicted by our model.

REMARK 3 (Alternative Interpretation): The objective function then has another interpretation: the institutional investor has an incentive to perform well during bull markets (high S_T). This is plausible since empirical evidence indicates that during bull markets payouts to money managers are especially high. For example, there are higher money inflows into mutual funds following years when the market has done well (e.g., Karceski 2002), and so fund managers have an implicit incentive to do well in those years so as to attract a larger fraction of the inflows. Managers guided by these incentives would perform worse in bad times, but fund outflows are typically a lot less responsive to poor relative performance (e.g., Sirri and Tufano 1998).

The mechanism through which the institutional managers' payouts are computed is unfortunately complex and opaque, but vast anecdotal evidence suggests that bonuses are higher in good years, especially for those managers who have done well in those years. One could also draw inferences from the CEO compensation literature documenting that payouts are positively correlated with the stock market returns (e.g., Gabaix and Landier 2008).

B. *Investors' Portfolio Choice*

Each type of investor's dynamic portfolio problem is to maximize her expected objective function in (4) or (5), subject to the dynamic budget constraint (3). Lemma 1 presents the investors' optimal portfolios explicitly, in closed form.

LEMMA 1: *The institutional and retail investors' portfolios are given by*

$$\phi_{\mathcal{I}t} = \frac{\mu_{St}}{\sigma_{St}^2} + \frac{b\,D_t}{1 + b\,D_t}\,\frac{\sigma}{\sigma_{St}}, \tag{6}$$

$$\phi_{\mathcal{R}t} = \frac{\mu_{St}}{\sigma_{St}^2}. \tag{7}$$

Consequently, the institution invests a higher fraction of wealth in the stock market index than the retail investor does, $\phi_{\mathcal{I}t} > \phi_{\mathcal{R}t}$.

The first term in the expression for the institutional investor's portfolio is the standard (instantaneous) mean-variance efficient portfolio. It is the same mean-variance portfolio that the retail investor holds. The wedge between the portfolio holdings of the two groups of investors is created by the second term in (6): the hedging portfolio. This hedging portfolio arises because the institution has an additional incentive to do well when his benchmark does well, and so the hedging portfolio is positively correlated with cash flow news (D_t). The instrument that allows the institution to achieve a higher correlation with cash flow news is the stock market index itself, and so the institution holds more of it than does the retail investor. This implies that the institution ends up taking on more risk than the retail investor does. We are going to demonstrate shortly (Section IIB) that in equilibrium, the institution finances its additional demand for the stock by borrowing from the retail investor. So the higher effective risk appetite of the institutional investor induces her to lever up. One can draw parallels with the 2007–2008 financial crisis, in which leverage of financial institutions was one of the key factors contributing to the instability. Excessive leverage has often been ascribed to the bonus structure of market participants. While we do not dispute the conclusion that an option-like compensation function can generate excessive risk taking, we would like to stress that a simple incentive to do well when the stock market index is high, which we model here, also leads to a higher effective risk appetite.

We here note the resemblance of the results in 1 to those of Brennan (1993). In a static setting, Brennan argues that an investor who is paid based on performance relative to an index has an additional demand for the index portfolio. A similar observation is made in the portfolio choice literature studying the behavior of mutual funds (e.g., Basak, Pavlova, and Shapiro 2007; Binsbergen, Brandt, and Koijen 2008). Cuoco and Kaniel (2011) make a related point in the context of a dynamic equilibrium model and provide explicit solutions for the case of investors compensated with fulcrum fees, though their mechanism is different, and it does depend on the nature on the fees. In particular, the managers' equilibrium portfolios are buy-and-hold, while our managers in equilibrium buy in response to good cash flow news and grow in the importance in the economy (Figure 2), which is central to our mechanism.

II. Equilibrium in the Presence of Institutional Investors

We are now ready to explore the implications of the presence of institutions in the economy on asset prices and their dynamics. As we have shown in the previous section, institutions have an incentive to take on more risk relative to the retail investors, and, hence, their presence increases the demand for the risky stock. In this section, we demonstrate how these incentives boost the price and the volatility of the risky stock and how they affect the behavior of all market participants.

Equilibrium in our economy is defined in a standard way: equilibrium portfolios and asset prices are such that (i) both the retail and institutional investors choose their optimal portfolio strategies, and (ii) stock and bond markets clear. We will often make comparisons with equilibrium in a *benchmark economy* in which institutions are not concerned about the index (i.e., $b = 0$) and so behave as retail investors. We refer to this economy as the economy without institutional investors.

A. *Stock Price, Volatility, and Index Effect*

PROPOSITION 1: *In the economy with institutional investors, the equilibrium level of the stock market index is given by*

$$S_t = \overline{S}_t \frac{1 + bD_0 + \lambda b(D_t - D_0)}{1 + bD_0 + \lambda b\,(e^{-\sigma^2(T-t)}D_t - D_0)}, \tag{8}$$

where $\overline{S}_t$ is the equilibrium index level in the benchmark economy with no institutional investors given by

$$\overline{S}_t = e^{-\sigma^2(T-t)}D_t. \tag{9}$$

Consequently, the stock market index level is increased in the presence of institutional investors, $S_t > \overline{S}_t$. Moreover, it increases with the fraction λ of the institutional investors in the economy.

The presence of institutions generates price pressure on the stock market index. Recall that institutions in our model have a higher demand for the risky stock than retail investors. Therefore, relative to the benchmark economy, there is an excess demand for the stock market index. The stock is in fixed supply, and so its price must be higher. As the fraction of institutional investors goes up (λ increases), there is more price pressure on the index, pushing it up further. This is the simplest way to capture the "index effect" in our model. (This result is generalizable to the multi-stock case. In that case, only the stocks included in the index trade at a premium due to the excess demand for these stocks by the institutions; prices of the nonindex stocks remain unchanged. See Section III.) Finally, it is worth noting that the expressions for asset prices that we derive here and below are all simple and in closed form. This is a very convenient feature of our framework, which allows us to explore the economic mechanisms in play within our model and comparative statics without resorting to numerical analysis.

Since institutional investors affect the level of the index, it is conceivable that they also influence its volatility. They demand a riskier portfolio relative to that of the retail investors, and so one would expect them to amplify the riskiness of the index. Proposition 2 verifies this conjecture.

PROPOSITION 2: *In the equilibrium with institutional investors, the volatility of the stock market index returns is given by*

$$\sigma_{St} = \overline{\sigma}_{St} + \lambda b \sigma \frac{(1 - e^{-\sigma^2(T-t)})(1 + (1-\lambda) b D_0) D_t}{\big(1 + (1-\lambda) b D_0 + \lambda b e^{-\sigma^2(T-t)} D_t\big)(1 + (1-\lambda) b D_0 + \lambda b D_t)}, \tag{10}$$

where $\overline{\sigma}_{St}$ is the equilibrium index volatility in the benchmark economy with no institutions, given by

$$\overline{\sigma}_{St} = \sigma.$$

Consequently, the index volatility is increased in the presence of institutions, $\sigma_{St} > \overline{\sigma}_{St}$.

In the benchmark economy with no institutional investors, the index return volatility is simply a constant. In the presence of institutional investors, it becomes stochastic, and in particular, dependent on the cash flow news. It also depends on the fraction of institutional investors in the economy, λ. The notable implication here is that institutional investors make the stock more volatile. In other words, the effects of cash flow news are amplified by institutional investors. This is again due to the institutions' higher risk appetite. The institutions demand a riskier portfolio, but the risky stock market is in fixed supply. Hence, to clear markets, the stock market must become relatively less attractive in the presence of institutions. In our framework, that is achieved by the market volatility increasing relative to the benchmark economy with no institutions.

Figure 1 depicts the equilibrium index volatility as a function of the size of the institutions in the economy (λ) and the stock market level (S_t). As institutions become larger, they constitute a larger fraction of the economy, and, hence, the risk appetite in the economy increases. Along with that comes an increase in the total leverage taken out by the institutions and an increase in the volatility of index returns. However, the institutions' ability to lever up depends on the lending capacity of retail investors, who in equilibrium provide a counterparty to the institutional investors in the market for borrowing/lending. As the fraction of institutions increases further, there is lesser lending capacity that can be provided by the retail investors. This in turn forces the institutional leverage to go down in equilibrium, pushing down the index volatility along with it. This explains the peak in the volatility in panel A of Figure 1. Turning to panel B of Figure 1, depicting the behavior of the stock market index volatility as a function of the stock market level, we see that for most values of the stock market, the volatility increases in response to a decreasing stock market. This is consistent with the empirical evidence that the stock market volatility increases in bad times (Schwert 1989; Mele 2007). We note from both panels of Figure 1 that the magnitudes of our volatility effects are fairly small. This is perhaps not so surprising given that we employ logarithmic preferences. We conjecture that to obtain larger magnitudes of the stock market volatility in our model, one would need to employ higher levels of risk aversion or add habits to the objective functions (as in, e.g., Campbell and Cochrane 1999).

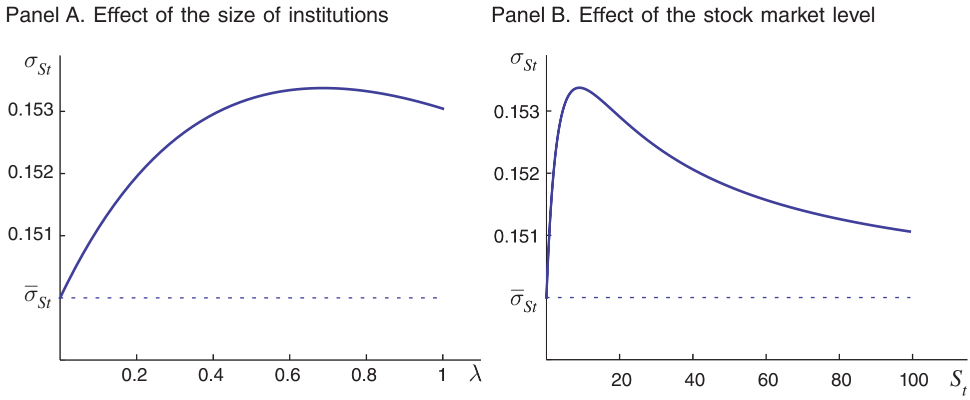

Figure 1. Equilibrium Index Volatility

Notes: This figure plots the index volatility in the presence of institutions against the fraction of institutions in the economy λ and against the stock market index level S_t. The dotted lines correspond to the equilibrium index volatility in the benchmark economy with no institutions. The plots are typical. The parameter values are: $b = 1$, $D_0 = 1$, $\sigma = 0.15$, $t = 1$, $T = 5$. In panel A $D_t = 2$, and in panel B $\lambda = 0.2$.

B. *Risk Taking, Leverage, and Wealth Effects*

To further understand the underlying economic mechanisms operating in our model, we look more closely at the investors' portfolios in equilibrium. Towards that, we also look at the investors' portfolios in terms of the number of shares in the risky stock, i.e.,

$$\pi_{\mathcal{I}t} = \phi_{\mathcal{I}t}\frac{W_{\mathcal{I}t}}{S_t}, \qquad \pi_{\mathcal{R}t} = \phi_{\mathcal{R}t}\frac{W_{\mathcal{R}t}}{S_t},$$

where as before ϕ_{it} denotes the fraction of investor's wealth invested in the index. This is to enable us to explicitly identify the nature of the wealth effects in the economy, i.e., who buys or sells in response to cash flow news. Proposition 3 reports the investors' equilibrium portfolios, as well as an important property of the institutional portfolio holdings.

PROPOSITION 3: *The institutional and retail investors' portfolios in equilibrium are given by*

$$\pi_{\mathcal{I}t} = \lambda\frac{1 + bD_t}{1 + (1-\lambda)bD_0 + \lambda bD_t} \times \left(1 - \frac{\lambda bD_t}{1 + (1-\lambda)bD_0 + \lambda bD_t}\frac{\sigma}{\sigma_{St}} + \frac{bD_t}{1 + bD_t}\frac{\sigma}{\sigma_{St}}\right), \tag{11}$$

$$\pi_{\mathcal{R}t} = (1-\lambda) \times \frac{1 + bD_0}{1 + (1-\lambda)bD_0 + \lambda bD_t}\left(1 - \frac{\lambda bD_t}{1 + (1-\lambda)bD_0 + \lambda bD_t}\frac{\sigma}{\sigma_{St}}\right), \tag{12}$$

where σ_{St} is as in Proposition 2.

Consequently, for $\lambda \in (0, 1)$ *the institutional investor is always levered,* $W_{\mathcal{I}t}(1 - \phi_{\mathcal{I}t}) < 0$.

To better highlight the results in Proposition 3, Figure 2 plots the institutional investor's equilibrium portfolios against the size of the institution (λ) and cash flow news (D_t). We see that the institution always "tilts" her portfolio towards the index stock, as compared to an otherwise identical benchmark investor who does not directly care about the index (Figure 2, panel A). Indeed, in the benchmark economy with no institutions the investor puts all his wealth in the stock market ($\overline{\phi}_{\mathcal{I}} = 1$). Here, the institutional investor holds a higher fraction of his wealth in the stock market. In order to be able to finance this additional demand, the institution borrows from the retail investor and so it always levers up in equilibrium (Figure 2, panel B). The bell-shaped plot in Figure 2, panel B is an important illustration of how leverage in the economy depends on the size of the institutional sector. One extreme is when the size of the institutional sector is zero ($\lambda = 0$). In that case, all agents in the economy are retail investors with identical preferences, and so no one is willing to take a counterparty position in the market for borrowing and lending (recall that the bond is in zero net supply). The bondholdings of all investors are then equal to zero. The other extreme is when there are no retail investors in the economy ($\lambda = 1$). Again, there is no heterogeneity to induce borrowing and lending in equilibrium, and the bondholdings are zero. In the intermediate range, $0 < \lambda < 1$, the institution borrows from the retail investor, using its initial wealth as collateral. The budget constraint always forces the borrower to repay; the higher the initial wealth, the more leverage the borrower is able take on. This is why we see an increase in the overall leverage as the size of the institutional sector starts to increase (λ increases). At a certain point, however, it peaks and then starts to fall. This is because, as the institutional sector becomes larger, the size of the retail sector $(1 - \lambda)$ shrinks, and therefore the lending capacity of the retail sector progressively reduces. This, in turn, reduces the equilibrium leverage in the economy.

In Figure 2 panel C we illustrate the response of the institutional investors' equilibrium portfolios to cash flow news. Rebalancing following positive cash flow news is simply a "wealth effect" (as highlighted by, e.g., Kyle and Xiong 2001). In equilibrium, both types of investors have positive holdings of the risky stock, and so good cash flow news translates into higher wealth for each investor. As the investors become wealthier, they want to increase the riskiness of their portfolios, which in this model implies buying more shares of the risky stock. Of course, for the stock market to clear, both investors cannot be buying the stock simultaneously; one of them has to sell. To determine who is buying and who is selling, one can look at the change in the wealth distribution in the economy. In this case, as positive cash flow news arrives (D_t increases), the wealth distribution shifts in favor of the institutional investor. Intuitively, this is because the institutional portfolio is overweighted in the risky stock relative to that of the retail investor, and so good news about the stock produces a higher return on the institutional portfolio relative to that of the retail investor.[5] Hence, following good cash flow news,

[5] We show formally that the institution becomes wealthier relative to the retail investor following good cash flow news, i.e., $W_{\mathcal{I}t}/W_{\mathcal{R}t}$ increases with D_t, in the proof of Proposition 3 in online Appendix A. In particular, we show that the wealth distribution is given by

$$\frac{W_{\mathcal{I}t}}{W_{\mathcal{R}t}} = \frac{\lambda}{1-\lambda}\frac{1+bD_t}{1+bD_0}.$$

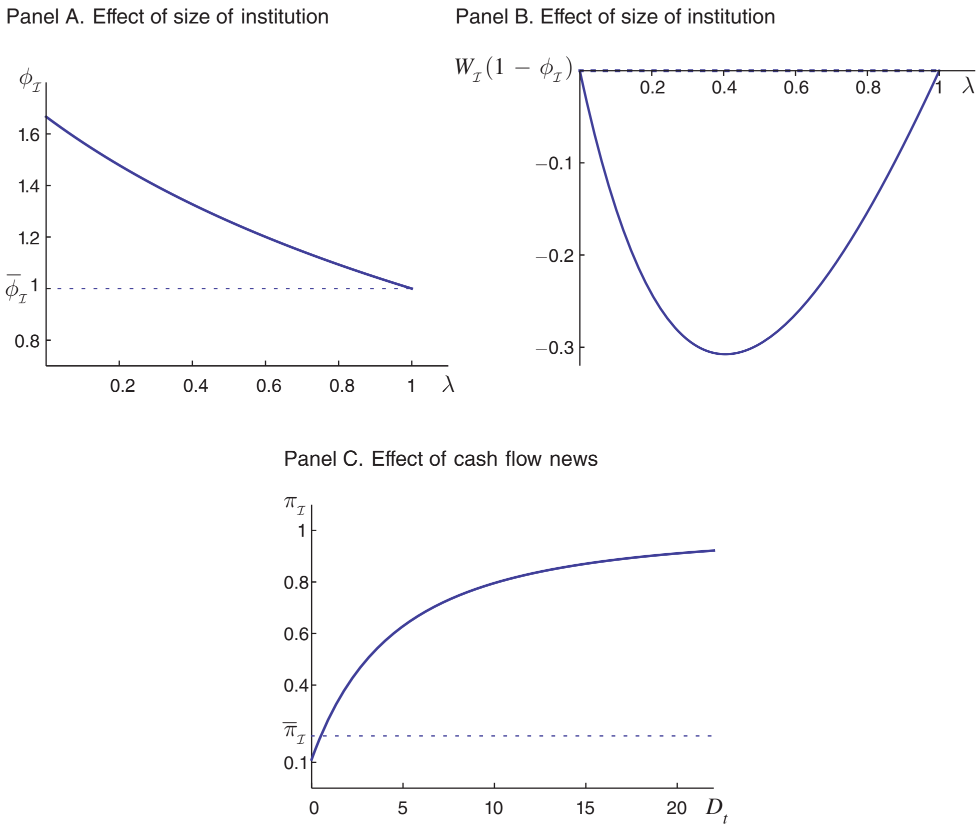

Figure 2. The Institutional Investor's Portfolio Holdings

Notes: Panels A and B of this figure plot the institution's fraction of wealth invested in the index $\phi_{\mathcal{I}}$ and the bond holdings $W_{\mathcal{I}}(1-\phi_{\mathcal{I}})$against the size of the institution λ. Panel C plots the institution's holdings of the shares of the index $\pi_{\mathcal{I}}$ against cash flow news D_t. The lines for $\bar{\pi}$ correspond to the holdings of an otherwise identical investor in the benchmark economy. The plots are typical. In panels A and B $D_t = 2$, and in panel C $\lambda = 0.2$. The remaining parameter values are as in Figure 1.

the institution buys from the retail investor (Figure 2 panel C). This wealth effect is an important part of the economic mechanisms that operate in our model. It is useful to stress at this point that the bulk of the related literature, developed in the framework in which investors have CARA preferences, is not able to capture wealth effects. The assumption of CARA utilities is made, of course, for tractability. In our model, tractability is achieved through alternative channels, which we highlight in this section and the next.

C. *Sharpe Ratio and Further Discussion*

We now explore the behavior of the Sharpe ratio (or market price of risk), stock mean return per unit volatility $\kappa_t \equiv \mu_{St}/\sigma_{St}$, in the presence of institutions in equilibrium. It has been well documented in the data that this quantity is countercyclical. It is of interest to explore the nature of the time variation in the Sharpe ratios that the presence of institutions may induce.

PROPOSITION 4: *In the economy with institutional investors, the Sharpe ratio is given by*

$$\kappa_t = \frac{1 + (1 - \lambda)\, b\, D_0}{1 + (1 - \lambda)\, b\, D_0 + \lambda\, b\, e^{-\sigma^2(T-t)} D_t}\,\overline{\kappa}, \tag{13}$$

where the benchmark economy Sharpe ratio is $\overline{\kappa} = \sigma$.

Consequently, in equilibrium:

(*i*) *the Sharpe ratio is decreased in the presence of institutions;*

(*ii*) *the Sharpe ratio decreases with the fraction* λ *of institutional investors in the economy;*

(*iii*) *the Sharpe ratio decreases following good cash flow news.*

In the benchmark economy with no institutions, the Sharpe ratio is constant. As revealed by Proposition 4, the presence of institutions causes the Sharpe ratio to decrease and to become countercyclical. As with the volatility effects, this is due to the institutions demanding a riskier portfolio. However, since the risky stock is in fixed supply, it must become less attractive in the presence of institutions to clear markets. So, the stock market Sharpe ratio decreases, and its volatility simultaneously increases, relative to the benchmark economy with no institutions. The decrease in the Sharpe ratio is more pronounced with more institutions in the economy (Figure 3 panel A and property (ii) of Proposition 4). The countercyclicality of the Sharpe ratio is due to wealth transfers between institutions and retail investors. Because the institutions are overweighted in the risky stock relative to the retail investors, good cash flow news always produces a wealth transfer from the retail investors to the institutions (footnote 5). So, the higher the prospects of the economy D_t, the bigger the share of wealth managed by the institutions, and, hence, the higher is their impact in equilibrium. The Sharpe ratio is therefore decreasing in D_t (Figure 3 panel B, property (iii) of Proposition 4).

A similar price-pressure intuition applies to the expected (excess) stock market index return in the economy, μ_S. However, the comparative statics for μ_S is more complex. This is because by no arbitrage $\mu_{St} = \kappa_t\, \sigma_{St}$, and, as we have shown in Propositions 2 and 4, the Sharpe ratio κ always decreases in the presence of institutions while the volatility σ_S always increases. For all reasonable calibrations of our model, the first effect dominates, and so the expected stock return behaves analogously to the Sharpe ratio. It is, however, theoretically possible that the volatility effect dominates, and the expected return actually increases in the presence of institutions when the size of the institutional sector is small. This occurs, for example, for $T = 50$ —a calibration that does not appear plausible given that the typical length of a mandate of an institutional asset manager is one to five years, depending on the country and industry sector (BIS 2003).

Regarding stationarity, we would like to recall that our model is cast in finite horizon T. In order to have a stationary framework, we would need to develop a version of our current model with an infinite horizon and intertemporal consumption and to

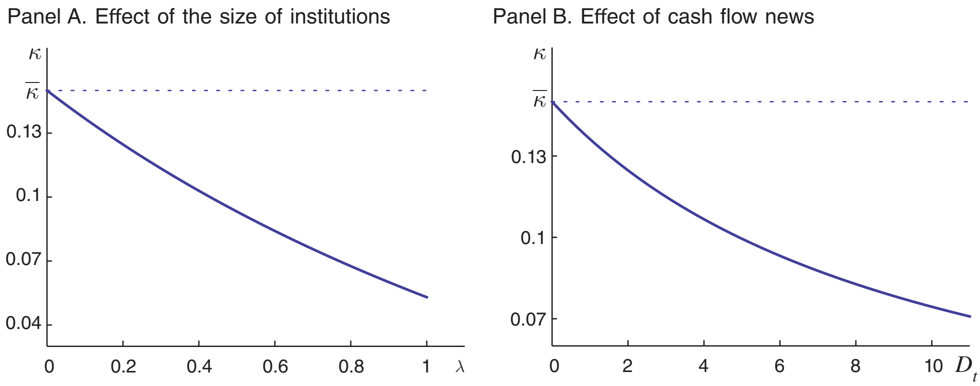

Figure 3. Sharpe Ratio

Notes: This figure plots the equilibrium Sharpe ratio in the presence of institutions against the fraction of institutions in the economy λ and against the cash flow news D_t. The dotted lines correspond to the equilibrium Sharpe ratio in the benchmark economy with no institutions. The plots are typical. The parameter values are as in Figure 1.

ensure that neither class of investors dominates the economy in the long run. Such a framework appears considerably more complex to solve since now the equilibrium stock price and state price density (defined in online Appendix A) processes would need to be simultaneously determined. Consequently, one may need to resort to numerical analysis as much of the tractability of our framework may be lost.

REMARK 4 (Alternative Specification for Institutional Objective): As highlighted in Remark 1, a natural alternative for our institutional objective function is $u_{\mathcal{I}}(W_{\mathcal{I}T}) = (1 + bS_T/S_0)\log(W_{\mathcal{I}T})$, where the institution now strives to do well relative to the index return S_T/S_0. Following the analysis of Section IB and online Appendix A, for this objective function, we derive the institutional investor's optimal portfolio to be

$$\phi_{\mathcal{I}t} = \frac{\mu_{St}}{\sigma_{St}^2} + \frac{bD_t/S_0}{1 + bD_t/S_0}\frac{\sigma}{\sigma_{St}}.$$

We again obtain the tilt in the institutional portfolio towards the index, arising due to the institution's desire to perform well as compared to the index return. Moving to equilibrium, similarly to Section IIA, we determine the equilibrium market index level as

$$S_t = \overline{S}_t \frac{1 + bD_0/S_0 + \lambda b(D_t/S_0 - D_0/S_0)}{1 + bD_0/S_0 + \lambda b\,(e^{-\sigma^2(T-t)}D_t/S_0 - D_0/S_0)}, \tag{14}$$

where $\overline{S}_t$ is the equilibrium index level in the benchmark economy as in (9). The endogenous initial index level S_0 solves (14), and it can be shown that the unique strictly positive solution is given by

$$S_0 = D_0 \frac{\sqrt{B^2 - 4b\,e^{-\sigma^2 T}} - B}{2},$$

where $B = b - e^{-\sigma^2 T} + \lambda b(be^{-\sigma^2 T} - 1)$. Comparing with Proposition 1 of the earlier analysis, we see that under this alternative specification, we have a very similar index level expression. The main difference is that the index cash flow news quantity D is now expressed per unit of the initial index level. More importantly, the price pressure from the institutions increases the stock index level, as before. Similarly, all other results and intuitions, including the index volatility, Sharpe ratio, go through for this alternative specification, with similarly modified expressions.

D. *Asset Pricing Implications of Popular Policy Measures*

The two main policy measures we would like to consider in the context of our model are the effects of deleveraging (a mandate to reduce leverage) and the effects of a transfer of capital to leveraged institutions. These two policy instruments have widely been employed during the 2007–2008 financial crisis. The objective, of course, was to improve the balance sheets of individual institutions in difficulty. But these policy actions, given their size and scope, inevitably had an effect on the overall economy, including asset prices. In this article, we have nothing to say about the welfare consequences of these policies; in future research it would be interesting to address this question. Our goal here is to simply analyze the spillover effects of the popular policy measures on asset prices in our model.

At this point, we also draw a distinction between long-only institutions ("real money") and leveraged institutions ("leveraged money"). So far we have only dealt with the latter category. We model long-only institutions, $\mathcal{L}$, in a very simple form: these institutions do not solve any optimization problem but simply buy and hold the risky stock they are endowed with. The initial endowments of the retail investors, leveraged institutions, and long-only institutions are now $W_{\mathcal{R}0} = (1 - \lambda)S_0$, $W_{\mathcal{I}0} = \lambda\theta S_0$, and $W_{\mathcal{L}0} = \lambda(1 - \theta)S_0$, respectively. That is, the endowment of the retail investors is as before, but the endowment of institutions is now divided between the leveraged institutions and long-only institutions in proportions θ and $1 - \theta$, respectively. The new parameter $\theta \in (0, 1)$ then captures the mass of "leveraged money" as a fraction of funds held (initially) by institutions. By reducing θ we can model a transfer of assets from leveraged institutions to long-only, or deleveraging.

Denote by λ' the endowment held by the leveraged institutional investors relative to the combined endowment of all active investors (the retail and leveraged institutional investors), so that

$$\frac{\lambda'}{1 - \lambda'} = \frac{\lambda\theta}{1 - \lambda}.$$

Proposition 5 summarizes how asset prices and equilibrium portfolios in our model are affected by the introduction of this new class of institutions.

PROPOSITION 5: *The equilibrium index level, volatility, and institutional portfolio in the presence of long-only and leveraged institutions are given by their counterparts in Propositions* 1–3, *but with* λ *replaced by* λ'.

Consequently, the equilibrium

(i) *stock price and volatility are higher in the presence of institutions;*

(ii) *the stock price increases further as the fraction of leveraged institutions, θ, increases.*

We again find it useful to highlight the results of the proposition in a figure. Figure 4 plots the bond and stock holdings of the leveraged institution, as well as the equilibrium stock market index and its volatility, as functions of the size of the "leveraged money" sector θ. The figure confirms that the stock price and the stock holdings of the leveraged institution are unambiguously increasing in θ. The effect of θ on bondholdings (leverage), however, is not necessarily unambiguous. It depends on the total size of the institutional investors (both real and leveraged money) relative to that of the retail investors. If there is enough lending capacity in the economy—the mass of retail investors is high—then the total amount of borrowing always increases with the size of the leveraged money sector. If, however, the mass of retail investors is relatively high, then leverage in the economy can peak for some θ and then start decreasing beyond that point. The economic mechanism generating such a bell-shaped pattern is as in Section IIB, when we discussed the effects of λ on equilibrium leverage. For realistic calibrations of the model, we find, however, that the relevant scenario is the one in which the equilibrium leverage never reaches its maximum (i.e., there are enough retail investors to provide counterparties in the market for borrowing and lending to the leveraged institutions).

Effects of Deleveraging.—In our framework, we model deleveraging as a transfer of assets from leveraged institutions to long-only institutions at time 0. This policy can be interpreted as a requirement that a fraction of leveraged institutions must convert into "real money" long-only investors. In our model, we capture this as a reduction in the fraction of leveraged institutions θ.

Figure 4 panel A reveals that a reduction in the mass of leveraged institutions indeed decreases the total leverage in the economy, with the total amount of outstanding bondholdings going down. Not being able to finance a risky asset position of the same size as prior to deleveraging, the institutional sector reduces its demand for the risky stock, and the stock holdings of the sector fall (Figure 4 panel B). While the deleveraging policy does achieve its desired outcome—the riskiness of the institutional portfolios going down—it does, however, come with side effects. The most notable one is that a reduction in the number of leveraged institutions also brings down the stock market index (Figure 4 panel C). This effect is simply a consequence of the drop in demand for the stock index by the institutions.

Effects of a Capital Injection.—In our model, a capital injection into leveraged institutions at time 0 is equivalent to an increase in the mass of leveraged institutions θ. So the effects of such an injection are the opposite from those of deleveraging. This policy does boost the stock market index (Figure 4, panel C) because a capital injection increases the demand of the institutions for the risky stock and

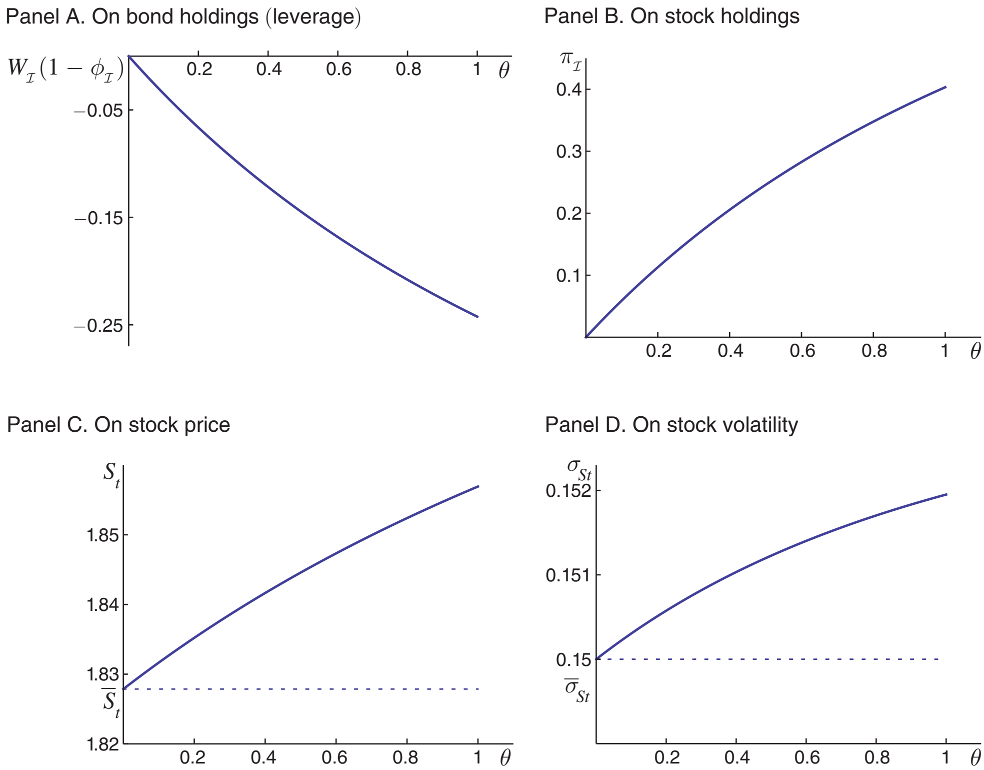

FIGURE 4. THE EFFECTS OF THE SIZE OF THE LEVERAGED INSTITUTIONS IN THE ECONOMY

Notes: This figure plots the leveraged institution's holdings of the the bond $W_{\mathcal{I}}(1-\phi_{\mathcal{I}})$(panel A), the leveraged institution's holdings of the shares of the index $\pi_{\mathcal{I}}$ (panel B), the stock index (panel C), the stock index volatility (panel D) against the size of the institution θ. The plots are typical. The parameter values are: $b = 1$, $D_0 = 1$, $\sigma = 0.15$, $t = 1$, $T = 5$. In panel A $D_t = 2$, and in panel B $\lambda = 0.2$. The remaining parameter values are as in Figure 1.

they purchase more shares of it (Figure 4, panel B). As a result of the stock price increase, everybody in the economy, including retail investors, becomes wealthier. But along with the runup in the stock market comes an increase in the leverage of institutional investors (Figure 4, panel A). When the institutions do not control a dominant fraction of the financial wealth in the economy ($\theta \ll 1$), the stock price volatility also increases (Figure 4, panel D). These side effects could be undesirable.

III. Multiple Stocks, Asset Classes, and Correlations

Our analysis has so far been presented in the context of a single-stock economy. Our goal in this section is to demonstrate how our results generalize in a multi-stock economy and to examine the correlations between stock returns. For the latter, we aim to demonstrate how institutional investors in our model generate an "asset-class" effect—i.e., how they make returns of assets belonging to an index to be more correlated amongst themselves than with those of otherwise identical assets outside the index.

A. *Economic Setup*

The general version of our economy features N risky stocks and N sources of risk, generated by a standard N-dimensional Brownian motion $\boldsymbol{\omega} = (\omega_1, \ldots, \omega_N)^\top$, as well as a riskless bond.[6] Each stock price, S_j, $j = 1, \ldots, N$, is posited to have dynamics

$$dS_{jt} = S_{jt}\left[\mu_{S_j t}\, dt + \boldsymbol{\sigma}_{S_j t}\, d\boldsymbol{\omega}_t\right], \tag{15}$$

where the vector of stock mean returns $\boldsymbol{\mu}_S \equiv (\mu_{S_1}, \ldots, \mu_{S_N})^\top$ and the stock volatility matrix $\boldsymbol{\sigma}_S \equiv \{\sigma_{S_{j\ell}}, j, \ell = 1, \ldots, N\}$ are to be determined in equilibrium. The (instantaneous) correlation between stock j and ℓ returns, $\rho_{j\ell t} \equiv \boldsymbol{\sigma}_{S_j t}^\top \boldsymbol{\sigma}_{S_\ell t} / \sqrt{||\boldsymbol{\sigma}_{S_j t}||^2\, ||\boldsymbol{\sigma}_{S_\ell t}||^2}$, where $||\mathbf{z}||$ denotes the square root of the dot product $\mathbf{z} \cdot \mathbf{z}$, is also to be endogenously determined. The value of the equity *market portfolio*, S_{MKT}, is the sum of the risky stock prices:

$$S_{MKT\,t} = \sum_{j=1}^{N} S_{jt}, \tag{16}$$

with posited dynamics

$$dS_{MKT\,t} = S_{MKT\,t}\left[\mu_{MKT\,t}\, dt + \boldsymbol{\sigma}_{MKT\,t}\, d\boldsymbol{\omega}_t\right]. \tag{17}$$

Additionally, there is a value-weighted *index* (in terms of returns) made up of the first M stocks in the economy:

$$S_{It} = \sum_{i=1}^{M} S_{jt}.$$

This stock index S_I represents a specific asset class in the economy, and we will refer to the first M stocks as "index stocks" and the remainder $N - M$ stocks as the nonindex stocks.

Each stock is in positive net supply of one share. Its terminal payoff (or dividend) D_{jT}, due at time T, is determined by the process

$$dD_{jt} = D_{jt}\, \boldsymbol{\sigma}_j\, d\boldsymbol{\omega}_t, \tag{18}$$

where $\boldsymbol{\sigma}_j > 0$ is constant for all stocks except for the last ones in the index and the market (the Mth and Nth stocks).[7] The process D_{jt} represents the cash flow news

[6] We include the bond to keep the discipline of a standard asset pricing framework, which serves as our benchmark. However, our analysis is equally valid without the bond present and the investment opportunities represented only by risky stocks. Such a variant of our model is perhaps more appropriate for modeling funds, whose investments are typically restricted to a single asset class, e.g., equities. We present the analysis for the stocks-only economy in online Appendix C.

[7] That is, we do not explicitly specify the process of the cash flow news for the last stock in the index and in the market; but, in what follows, we specify processes for the sums of all stocks in the index and in the market. This modeling device is inspired by Menzly, Santos, and Veronesi (2004). It allows us to assume that the stock

about the terminal stock dividend D_{jT}, and $S_{jT} = D_{jT}$. For expositional clarity and the thought experiment that we are going to undertake in this section, assume that the stocks' fundamentals (dividends) are independent. We thus assume that only the jth element of $\boldsymbol{\sigma}_j$ in (18) is nonzero, while all other elements are zero, so that the volatility matrix of cash flow news is diagonal. This implies zero correlation among all stocks' cash flow news, $\boldsymbol{\sigma}_j^\top\, \boldsymbol{\sigma}_\ell = 0$ for all $j \neq \ell$.

The stock market has a terminal payoff $S_{MKT\,T} = D_T$, given by the terminal value of the process

$$(19) \qquad dD_t \;=\; D_t\, \boldsymbol{\sigma}\, d\boldsymbol{\omega}_t,$$

where $\boldsymbol{\sigma} > 0$ is constant. Similarly, the index has a terminal value $S_{IT} = I_T$, determined by the process

$$(20) \qquad dI_t \;=\; I_t\, \boldsymbol{\sigma}_I\, d\boldsymbol{\omega}_t,$$

with $\boldsymbol{\sigma}_I > 0$ constant and having its first M components nonzero and the remainder $N - M$ components zero. The latter assumption is to make $\boldsymbol{\sigma}_I$ consistent with our assumptions about the individual stocks' cash flow news processes. Accordingly, while the index stocks' cash flow news have positive correlation with that of the index, $\boldsymbol{\sigma}_j^\top\, \boldsymbol{\sigma}_I > 0$, $j = 1, \ldots, M$, the cash flow news of the nonindex stocks have zero correlation, $\boldsymbol{\sigma}_k^\top\, \boldsymbol{\sigma}_I = 0$, $k = M + 1, \ldots, N$.

Each type of investor $i = \mathcal{I}, \mathcal{R}$ now dynamically chooses a multidimensional portfolio process $\boldsymbol{\phi}_i$, where $\boldsymbol{\phi}_i = (\phi_{i1}, \ldots, \phi_{iN})^\top$ denotes the portfolio weights in each risky stock. The portfolio value W_i then has the dynamics

$$(21) \qquad dW_{it} \;=\; W_{it}\, \boldsymbol{\phi}_{it}^\top\, [\boldsymbol{\mu}_{st}\, dt \;+\; \boldsymbol{\sigma}_{st}\, d\boldsymbol{\omega}_t].$$

The retail investor is initially endowed with $1 - \lambda$ fraction of the stock market, providing initial assets $W_{\mathcal{R}0} = (1 - \lambda) S_{MKT0}$, and has the same objective function as in the single-stock case: $u_{\mathcal{R}}(W_{\mathcal{R}T}) = \log(W_{\mathcal{R}T})$. The institutional investor is initially endowed with λ fraction of the stock market and, hence, has initial assets worth $W_{I0} = \lambda S_{MKT0}$. In this multi-stock version of our economy, the objective function of the institution is given by

$$(22) \qquad u_{\mathcal{I}}(W_{\mathcal{I}T}) \;=\; (1 \;+\; bI_T)\, \log\,(W_{\mathcal{I}T}),$$

where $b > 0$ and $I_T = S_{IT}$ is the terminal value of the index (composed of the first M stocks in the economy). Here, the institutional investor has a benchmark that is distinct from the overall stock market. He now strives to perform particularly well

market and the index cash flow news follow geometric Brownian motion processes (equations (19) and (20)), which improves the tractability of the model considerably. In related analysis, we find that one may alternatively not assume a geometric Brownian motion process for the index cash flow news but instead assume that stock M's dividend follows a geometric Brownian motion process. In that case, the analogs of the expressions that we report below are less elegant, and several results can be obtained only numerically.

when a specific asset class, represented by the index S_I, does well. One can think of this asset class as value stocks, technology stocks, or the stocks included in the S&P 500 index.

B. *Investors' Portfolio Choice*

We are now ready to examine how the results derived in the earlier analysis extend to the multi-stock case. We start with Lemma 2, which reports the investors' optimal portfolios in closed form.

LEMMA 2: *The institutional and retail investors' optimal portfolio processes are given by*

$$\phi_{\mathcal{I}t} = (\boldsymbol{\sigma}_{st}\,\boldsymbol{\sigma}_{st}^{\top})^{-1}\,\boldsymbol{\mu}_{st} + \frac{b\,I_t}{1 + b\,I_t}(\boldsymbol{\sigma}_{st}^{\top})^{-1}\,\boldsymbol{\sigma}_I, \tag{23}$$

$$\phi_{\mathcal{R}t} = (\boldsymbol{\sigma}_{st}\,\boldsymbol{\sigma}_{st}^{\top})^{-1}\,\boldsymbol{\mu}_{st}. \tag{24}$$

Moreover,

(*i*) *The institutional investor's hedging portfolio, the second term in* (23), *has positive portfolio weights in the index stocks* $j = 1, \ldots, N-1$, *but zero weights in the nonindex stocks in equilibrium*;

(*ii*) *The institutional investor invests a higher fraction of wealth in the index stocks* $j = 1, \ldots, N-1$ *than the retail investor, while holding the same fractions in the nonindex stocks as the retail investor*.

The investors' portfolios in (23)–(24) are natural multi-stock generalizations of the single-stock case. Again, the institutional investor holds the mean-variance efficient portfolio plus an additional portfolio hedging her against fluctuations in her index. In our single-stock economy, the hedging demand of the institutional investor generates a tilt in her portfolio towards the risky stock, as compared to the retail investor. The multi-stock economy refines this implication. It is not the case that the institutional investor simply desires to take on more risk; rather, she demands a portfolio that is highly correlated with her index. This is why she has the same demand for the nonindex stocks as the retail investor but demands additional holdings of index stocks, so as to not fall behind when the index does well. As we will see shortly, this excess demand for index stocks by the institution is the key driver of the index effect in our model.

From Lemma 2, we also see that the institution's optimal portfolio satisfies a three-fund separation property, with the three funds being the mean-variance efficient portfolio, the intertemporal hedging portfolio, and the riskless bond. The importance of this decomposition will become apparent later, when we discuss the asset-class effect in Section IIID. For now, we just note that the hedging portfolio has positive portfolio weights in the index stocks, and when the institution gets wealthier—following, for example, good cash flow news—she demands more shares of the index stocks (a wealth effect). This additional price pressure (beyond the standard increase in demand for the mean-variance portfolio) is applied to all index stocks simultaneously. There is no additional demand for the nonindex stocks.

Our implications for the higher risk-taking by institutions, who take on leverage in order to finance the hedging portfolio, remain the same as in our earlier analysis. We do not repeat them here and proceed to exploring the additional insights that a multiple stock environment is able to offer.

C. *Stock Prices and Index Effect*

Proposition 6 reports the equilibrium stock prices in closed form and highlights the effects of institutions on stock prices.

PROPOSITION 6: *In the economy with institutional investors and multiple risky stocks, the equilibrium prices of the market portfolio, index stocks $j = 1, \ldots, M - 1$, and nonindex stocks $k = M + 1, \ldots, N - 1$ are given by*

$$S_{MKT\,t} = \bar{S}_{MKT\,t} \frac{1 + bI_0 + \lambda b(I_t - I_0)}{1 + bI_0 + \lambda b\left(e^{-\sigma_I^\top \sigma (T-t)} I_t - I_0\right)}, \tag{25}$$

$$S_{jt} = \bar{S}_{jt} \frac{1 + bI_0 + \lambda b\left(e^{\left(-\sigma_I^\top \sigma + \sigma_j^\top \sigma_I\right)(T-t)} I_t - I_0\right)}{1 + bI_0 + \lambda b\left(e^{-\sigma_I^\top \sigma (T-t)} I_t - I_0\right)}, \tag{26}$$

$$S_{kt} = \bar{S}_{kt}, \tag{27}$$

where $\bar{S}_{MKT\,t}$, $\bar{S}_{jt}$, and $\bar{S}_{kt}$ are the equilibrium prices of the market portfolio, index, and nonindex stocks, respectively, in the benchmark economy with no institutions, given by

$$\bar{S}_{MKT\,t} = e^{-\|\sigma\|^2 (T-t)} D_t, \qquad \bar{S}_{jt} = e^{-\sigma_t^\top \sigma (T-t)} D_{jt}, \qquad \bar{S}_{kt} = e^{-\sigma_k^\top \sigma (T-t)} D_{kt}. \tag{28}$$

Consequently, the market portfolio and index stock prices are increased in the presence of institutional investors, while nonindex stock prices are unaffected.

Proposition 6 generalizes our earlier discussion in the single-stock case and underscores the index effect occurring in our model. The direction of the effect is as before—the price pressure from the institutions raises the level of the index relative to that in the economy with no institutions. But now we can also make cross-sectional statements. If a stock j is added to the index I and a stock k is dropped, the price of stock j gets a boost, while that of stock k falls.[8] This is precisely the empirical regularity

[8] Barberis and Shleifer (2003) obtain a similar implication within a behavioral model in which investors categorize risky assets into different styles and move funds among these styles according to certain (exogenously

that is robustly documented in the data. In our model, however, we cannot make finer predictions which separate announcement-date returns and inclusion-date returns; our results concern only the announcement date. To generate inclusion-date abnormal returns, one could introduce passive indexers who buy at the inclusion date.

Figure 5 presents a plot of the price of an index stock relative to that of an otherwise identical nonindex stock. The plot is drawn as a function of the size of institutions λ. As expected, we see that the stock price is increasing with λ. This is due to the additional price pressure on index stocks as the institutional sector becomes larger. We also observe that the magnitudes are reasonable for our calibration. Chen, Noronha, and Singal (2004) find that during 1989–2000, a stock's price increases by an average of 5.45 percent on the day of the S&P 500 inclusion announcement and a further 3.45 percent between the announcement and the actual addition. The effects that we find are smaller, but roughly in line with these figures.

D. *Stock Volatilities*, *Correlations*, *and Asset-Class Effects*

We now turn to examining the implications of our model for stock return volatilities and correlations. We report them in the following proposition in closed form.

PROPOSITION 7: *In the economy with institutional investors and multiple risky stocks*, *the equilibrium volatilities of the market portfolio*, *index stocks* $j = 1, \ldots, M-1$, *and nonindex stocks* $k = M+1, \ldots, N-1$ *are given by*

$$\boldsymbol{\sigma}_{MKT\,t} = \bar{\boldsymbol{\sigma}}_{MKT\,t} + \lambda b \boldsymbol{\sigma}_I \frac{\left(1 - e^{-\boldsymbol{\sigma}^\top \boldsymbol{\sigma}_I (T-t)}\right)(1 + (1-\lambda) b I_0) I_t}{\left(1 + (1-\lambda)\, b I_0 + \lambda b e^{-\boldsymbol{\sigma}_I^\top \boldsymbol{\sigma}(T-t)} I_t\right)\left(1 + (1-\lambda) b I_0 + \lambda b I_t\right)}, \tag{29}$$

$$\boldsymbol{\sigma}_{S_j t} = \bar{\boldsymbol{\sigma}}_{S_j t} + \lambda b \boldsymbol{\sigma}_I \times \frac{\left(1 - e^{-\boldsymbol{\sigma}_j^\top \boldsymbol{\sigma}_I (T-t)}\right)(1 + (1-\lambda) b I_0) e^{\left(-\boldsymbol{\sigma}_I^\top \boldsymbol{\sigma} + \boldsymbol{\sigma}_j^\top \boldsymbol{\sigma}_I\right)(T-t)} I_t}{\left(1 + (1-\lambda)\, b I_0 + \lambda b e^{-\boldsymbol{\sigma}_I^\top \boldsymbol{\sigma}(T-t)} I_t\right)\left(1 + (1-\lambda) b I_0 + \lambda b e^{\left(-\boldsymbol{\sigma}_I^\top \boldsymbol{\sigma} + \boldsymbol{\sigma}_j^\top \boldsymbol{\sigma}_I\right)(T-t)} I_t\right)}, \tag{30}$$

$$\boldsymbol{\sigma}_{S_k t} = \bar{\boldsymbol{\sigma}}_{S_k t}, \tag{31}$$

where $\bar{\boldsymbol{\sigma}}_{MKT\,t}$, $\bar{\boldsymbol{\sigma}}_{S_j t}$, *and* $\bar{\boldsymbol{\sigma}}_{S_k t}$ *are the equilibrium market portfolio, index stock, and nonindex stock volatilities, respectively, in the benchmark economy with no institutions, given by*

$$\bar{\boldsymbol{\sigma}}_{MKT\,t} = \boldsymbol{\sigma}, \qquad \bar{\boldsymbol{\sigma}}_{S_j t} = \boldsymbol{\sigma}_j, \qquad \bar{\boldsymbol{\sigma}}_{S_k t} = \boldsymbol{\sigma}_k. \tag{32}$$

specified) rules. In a two-stock economy, Cuoco and Kaniel (2011) numerically obtain similar implications within a rational model for the case of managers being compensated with fulcrum fees. They also provide numerical results for the effect of benchmarking on the conditional volatilities of an index and a nonindex stock—the quantities that we consider in the next section—but because the mechanisms are different, our models differ in their implications.

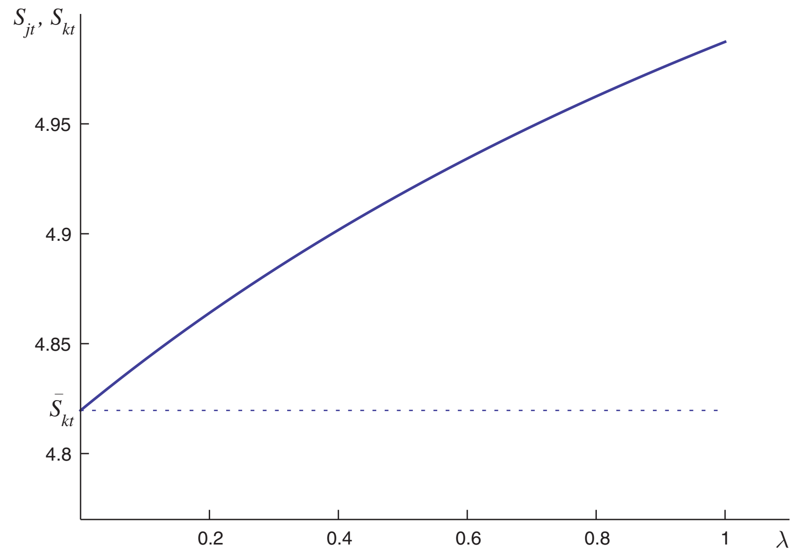

Figure 5. An Index Effect

Notes: This figure plots the prices of an index stock S_j (solid line) and a nonindex stock S_k (dotted line) in the presence of institutions against the fraction of institutions in the economy λ. The plot is typical. The parameter values are: $M = 3$, $N = 6$, $j = 1$, $k = 4$, $\boldsymbol{\sigma}_j = 0.15\ \mathbf{i}_j$, where $\mathbf{i}_j$ is an N-dimensional unit vector with the jth element equal to 1 and the remaining elements equal to 0, $\boldsymbol{\sigma}_k = 0.15\ \mathbf{i}_k$, $\boldsymbol{\sigma}_I = 0.15 \sum_{j=1}^{M} \mathbf{i}_j/\sqrt{M}$, $\boldsymbol{\sigma} = 0.15 \times \mathbf{1}/\sqrt{N}$, where $\mathbf{1}$ is an N-dimensional vector of ones, $I_0 = 1$, $I_t = 2$, and $D_t = 5$. The normalizations by $\sqrt{M}$ and $\sqrt{N}$ are adopted so as to keep $\|\boldsymbol{\sigma}_I\|$ and $\|\boldsymbol{\sigma}\|$ constant as we vary the number of stocks. The remaining parameters are as in Figure 1.

Consequently, in equilibrium:

(*i*) *The market portfolio and index stock volatilities are increased in the presence of institutional investors, while nonindex stock volatilities are unaffected;*

(*ii*) *The correlations between index stocks are increased in the presence of institutional investors, while the correlations between nonindex stocks and between index and nonindex stocks are unaffected.*

As one could expect from our earlier analysis, only the volatilities of the index stocks change in the presence of institutions; the volatilities of the nonindex stocks remain unchanged. The index stocks become riskier for the same reason as in the single-stock economy: the risk appetite in the economy is higher in the presence of institutional investors.

The multiple stock formulation offers additional insights, allowing us to explore how the presence of institutions affects the correlations of stock returns. These results, based on fully analytical closed-form expressions, are reported in Proposition 7. Consistent with the empirical evidence on asset-class effects, we find that the presence of institutions increases the correlations among the stocks included in their index. The intuition is as follows. In the benchmark retail investor–only economy, the cash flow news on all stocks are independent, and the stock returns turn out to be independent as well. Now consider the economy with institutions. As we have established in the single-stock case in Section IIB, following a good realization of cash flow news, institutions demand more shares of the index. This is simply a wealth effect. In the multi-stock case, the institutions demand more shares of *all* index stocks. This is a consequence of the three-fund separation property, discussed in the context of Lemma 2. It is important to keep in mind that the additional price pressure affects all index stocks, but not the nonindex stocks because the third fund, the hedging portfolio, consists only of index stocks. Hence, as compared to the retail investor–only benchmark, following good cash flow news, all index stocks get an additional boost, and following bad news, they all suffer from an additional selling pressure. This mechanism induces the comovement between index stocks, absent in the retail investor–only benchmark. The correlation between the nonindex stocks is still zero, as in the benchmark, because these stocks are not part of the hedging portfolio of institutions, and so there is no additional buying or selling pressure on these stocks relative to the benchmark. The same is true for the correlations between the index and nonindex stocks. Figure 6 illustrates these effects. So summing this up, consistent with the empirical evidence, the returns of stocks belonging to an index are more correlated amongst themselves than with those of otherwise identical stocks outside the index.

Figure 6, panel B depicts the time-variation in the index stock correlations. The pattern here is similar to the one observed for the conditional volatilities of the stocks (Figure 1). The institutions are overweighted in the index stocks, and therefore good index cash flow news creates a wealth transfer from the retail investors to the institutions. In good states of the world (high I_t), the institutions dominate the economy, and in bad states (low I_t) the retail investors control a larger share of total wealth. The correlations peak when the investor heterogeneity is the highest. To the right of the peak, the correlations decline, which resemble their behavior in the data.

IV. Summary of Key Predictions and Empirical Implications

Institutions and the incentives they face feature prominently in models of corporate finance and banking, but they have largely been ignored in the standard asset pricing theory. In this article, we develop an asset-pricing model that incorporates incentives of institutional investors to do well relative to their index. We demonstrate that this simple ingredient has profound implications for asset prices. In particular, it generates index effects and creates excess correlations among stocks belonging to an index (an asset-class effect). It also increases volatilities of index stocks and the overall market volatility. Moreover, the presence of institutions decreases the market Sharpe ratio, making it countercyclical.

It is difficult to obtain differential predictions for index and nonindex stocks within (heterogeneous-agent) consumption-based asset pricing models. For a standard model to deliver similar results, one would require that either (i) risk aversions "with respect to different stocks" are different, or (ii) capital constraints are more stringent for nonindex stocks than for index stocks, or (iii) agents have more optimistic beliefs about index stocks than nonindex stocks. Within a standard asset pricing model, these assumptions appear somewhat contrived, and we believe that benchmarking considerations represent a more plausible explanation.

Empirical literature lends support to all our key predictions. The extensive literature on index effects growing out of Harris and Gurel (1986) and Shleifer (1986)

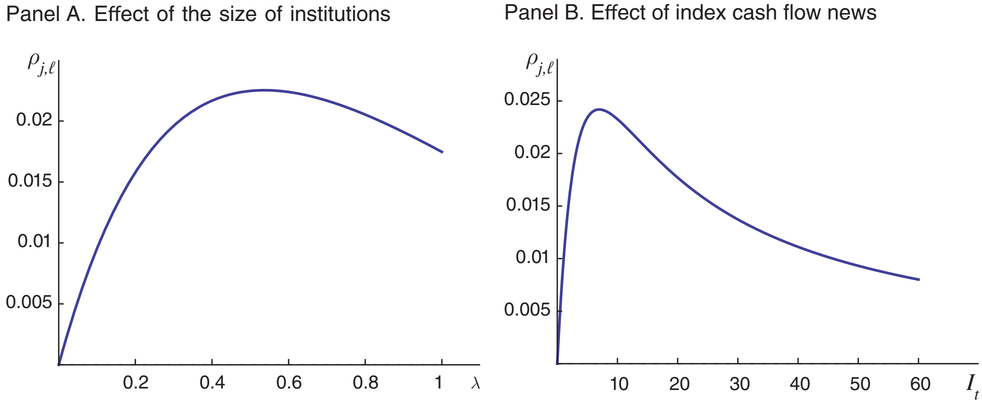

Figure 6. An Asset-Class Effect

Notes: This figure plots the correlation between two index stock returns (solid plot) and the correlation between two nonindex stock returns (dashed line) in the presence of institutions against the fraction of institutions in the economy λ and against index cash flow news I_t. The two index stocks are stocks 1 and 2, and the two nonindex stocks are stocks $M+1$ and $M+2$. The plots are typical. For all these four stocks j we set $\boldsymbol{\sigma}_j = 0.15\,\mathbf{i}_j$. In panel A $I_t = 2$, and in panel B $\lambda = 0.2$. The remaining parameter values are as in Figure 5.

has now confirmed in many countries and many markets that stocks rise when added to an index (e.g., Wurgler and Zhuravskaya 2002; Chen, Noronha, and Singal 2004; Greenwood 2005). The presence of asset-class effects has been documented by, e.g., Barberis, Shleifer, and Wurgler (2005) and Boyer (2011) for stocks, Rigobon (2002) for sovereign bonds, Tang and Xiong (2012) for commodity futures. There is a large literature documenting that institutional ownership increases stock volatility (e.g., Bushee and Noe 2000; Sias 1996). Recently, Greenwood and Thesmar (2011) linked this finding to the asset-class effect. Gabaix et al. (2006) argue that institutions amplify volatility by examining trades of very large institutional investors. Our finding that the Sharpe ratio is countercyclical is also well documented in the literature (see, e.g., Lettau and Ludvigson 2010). Our model also predicts that the Sharpe ratios of index stocks are lower than those of nonindex stocks—this is a testable implication that future research might explore. Finally, Asparouhova et al. (2010) provide experimental support in favor of our model by documenting significant effects of money managers on asset prices in a large-scale experimental setting.

We left for future research several unexplored implications and potential extensions of our model. The presence of institutions may generate momentum of stock returns. Recently, the link between institutional fund flows and momentum has been established theoretically by Vayanos and Woolley (2013) and empirically by Lou (2012). The explanation in Vayanos and Woolley relies additionally on delayed reaction of traders; it would be interesting to see whether our model can also generate momentum and whether one needs to assume further that traders cannot immediately rebalance. Another fruitful avenue to explore is to endogenize the reward for good performance relative to an index (as in, e.g., Berk and Green 2004).

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