

Appropriate Policy Allocation for Alternative Investments

A factor approach and simulation techniques.

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Pension plan sponsors, endowments, and other institutional investors have included non-traditional investments in their portfolios for many years. Larger, more aggressive funds, in particular those with longer investment horizons, have over time increased their allocations to venture capital, real estate, hedge funds, and other assets that fall outside the realm of regularly priced and traded securities.

One of the greatest problems institutional investors face in evaluating these alternative investments is determining policy allocations: which alternative investments to include and in what proportions. We evaluate the investments appropriate for a typical institutional investor, and suggest a policy mix based on long-term return and risk characteristics as well as other factors unique to alternative investments.¹

Typically, analysis of policy mix alternatives is based on historical data (e.g., Amin and Kat [2001]). Such an approach is acceptable for conventional assets, which are frequently traded and have observable prices in the market, if the forward-looking period is proxied adequately by the historical data set. For alternative investments, it is tempting to use historical data for policy analysis purposes simply because such data are available; in fact, there are a number of considerations that obviate their use in determination of policy allocations.

The return and risk assumptions used for policy mix analysis across conventional and alternative investments must be both *forward-looking* and *consistent* in reflecting the true underlying economic exposures of the assets. His-

torical data are biased on both counts.

We first consider the biases embedded in historical return data, and demonstrate the impact that such data have on standard efficient frontier policy mix analysis. In a second step, we show how risk and return can be better estimated. And finally, we provide an alternative to standard portfolio optimization, which is seriously flawed when alternative investments are involved.

TRADITIONAL APPROACH: MEAN-VARIANCE OPTIMIZATION BASED ON HISTORICAL RETURNS AND COVARIANCES

To determine policy allocations, whether to conventional or alternative investments, it is appropriate to use *long-term* return and risk characteristics. These estimates should not be conditional on the current or near-term market and business cycle, but instead focus on the characteristics relevant for the portfolio over a long horizon.

Policy studies are often performed using risk and return inputs derived from long time series of historical data. Exhibit 1 shows historical returns, volatilities, and correlations for asset classes as conventionally defined by U.S. institutional investors: U.S. and non-U.S. equities, U.S. and non-U.S. bonds, and alternative investments.²

According to these numbers, the returns, volatilities, and correlations for the alternatives appear to offer a free lunch—disproportionately high return for their risk. Yet it is well known that the risks of alternative investments are understated, as we do not have frequent observable market prices.³

In the absence of traded market prices, various methodologies are used to deduce periodic returns; these lead to an understatement of the risk characteristics of

alternative investments. This can be illustrated for two major alternative investment types: real estate and venture capital.

- Appraisal processes, such as those used in real estate, introduce a smoothing of returns. The infrequent nature of price updates in the alternative world induces a significant downward bias to the measured risks and correlations of the assets.
- Because committed venture capital is drawn down over time, investors observe returns only upon realization of a sale; thus, there is little in the way of shorter-term volatility to be measured. The internal rate of return computations typically used for venture capital tend to mask asset return volatility.⁴

When both conventional and alternative investments are included in an unconstrained optimization, the efficient portfolio with the same volatility as a 60% U.S. equity/40% U.S. bond portfolio includes *only* alternative investments. Although this domestic portfolio is close to the benchmark or normal policy for many U.S. investors, we will use a globally diversified analogue henceforth. A portfolio with 65% global equity and 35% global fixed-income has similar volatility to the domestic-only, but a moderately higher Sharpe ratio due to the increased diversification.⁵

Discomfort with this “all alternatives” result leads investors to impose artificial or ad hoc constraints on the maximum allocation to alternative investments in the optimization. Such constraints in most cases simply predetermine the resulting policy allocation to the alternatives. This type of analysis thus does not answer the question of the appropriate allocation to alternative investments.⁶

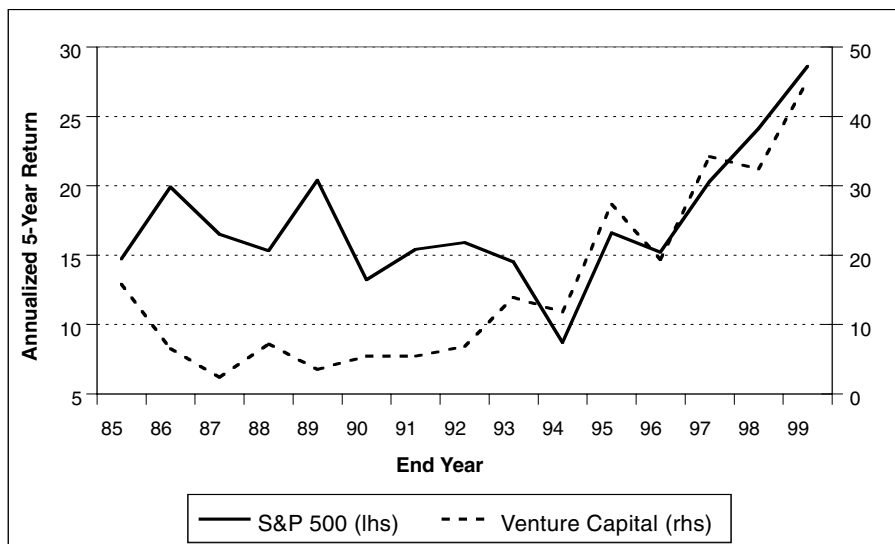
EXHIBIT 1

Conventional and Alternative Investments—Historical Return, Volatility, and Correlation Characteristics*

		Return	Volatility	1	2	3	4	5	6	7	8
1	U.S. Equity	14.8%	12.8%	1.00	0.55	0.35	0.24	-0.46	-0.01	0.33	0.71
2	Ex-U.S. Equity	13.2	16.7	0.55	1.00	0.14	0.29	0.00	0.39	0.25	0.52
3	U.S. Fixed-Income	10.5	7.0	0.35	0.14	1.00	0.73	-0.47	-0.05	0.17	0.31
4	Ex-U.S. Fixed-Income	10.7	6.0	0.24	0.29	0.73	1.00	-0.10	0.23	-0.08	0.14
5	Private Equity	20.7	10.5	-0.46	0.00	-0.47	-0.10	1.00	0.47	-0.53	-0.30
6	Real Estate	7.8	5.9	-0.01	0.39	-0.05	0.23	0.47	1.00	-0.51	-0.18
7	Natural Resources	18.3	8.8	0.33	0.25	0.17	-0.08	-0.53	-0.51	1.00	0.23
8	Hedge Funds	18.2	9.4	0.71	0.52	0.31	0.14	-0.30	-0.18	0.23	1.00

*Based on annual logarithmic excess returns 1981-2000 (Natural Resources 1987-2000). Sources: Wilshire, MSCI, Salomon, NCREIF, Venture Economics, Ibbotson Associates, Adams Street Partners, UBS Global Asset Management, hedgefund.net.

EXHIBIT 2 Venture Capital and U.S. Equity—Simple Comparison



It is a fact that institutional investors do not hold the overwhelming share of their portfolios in alternative investments as would be recommended by optimizations based on historical data. This observation is by no means new. Numerous authors, such as Brown, Goetzmann, and Park [1999], Swensen [2000], and Asness, Krail, and Liew [2001], have criticized the historical return and risk parameters used in such analyses.

The availability of historical data and the difficulty of creating forward-looking risk estimates that are intuitively correct and consistent are nevertheless strong incentives to use constrained optimizations and historical data in policy mix analyses.

ESTIMATING TRUE RISK EXPOSURES

Swensen [2000] suggests that assets with the same fundamental and economic drivers have similar risk characteristics that reflect the underlying economic risk exposures. To make our risk estimates for conventional assets and alternative investments consistent, we thus want to put both investment types on an equal footing. One way to do this is to consider the long-term risk characteristics of each asset. This risk can be thought of as the uncertainty of the ending wealth level produced by that asset. In similar fashion, the long-term correlation between two assets can be viewed as the correspondence between their respective ending wealth levels.

In Exhibit 2, we construct a venture capital analogue from publicly traded equity. The S&P 500 index is bought in each vintage year, and then held for a five-year period, when its terminal value is used, with interim cash flows, to compute the internal rate of return. These returns to the “private” S&P are calculated in the same manner as venture capital returns and are compared to the corresponding five-year venture capital vintage returns.

A simple indication of volatilities can be seen in the range of returns. In fact, the venture capital volatility may be on the order of two times that of the U.S. equity market. Further, there has been a relatively close relationship between these two series since 1980; any assumption that the correlation between the S&P 500 and venture capital is zero or only slightly positive is probably highly suspect. Clearly, the higher-frequency historical data would be significantly misleading for policy allocation analysis.

Any *individual* alternative investment may have a low correlation with the other assets in the portfolio. But when investors build *well-diversified* alternative investment programs, the systematic influences—underlying economic and fundamental drivers—become more significant, and the residual noise diminishes.⁷

Hence, the more diversified the private equity, real estate, natural resource, or hedge fund portfolio, the more correlated it is likely to be with public markets.

FACTOR APPROACH TO GENERATE THE COVARIANCE MATRIX

The process for setting the consistent, forward-looking, equilibrium covariance matrix must address two issues. First, it needs to reflect the fact that true covariances are understated in historical data. Second, it must provide a means to easily integrate these fundamental views into the covariances and returns. The approach we use is based on *factor modeling*.

We have chosen 12 primary factors that capture systematic risk characteristics and provide the foundation for building a correlation matrix of all assets.⁸ The factors are aggregates of traded asset markets (equity, fixed-income, and currency) and a real estate factor to properly account for the various real estate subcategories. The pairwise correlations are generated from the assets' sensitivities to these 12 factors or risk drivers.⁹ Consistency in the factor matrix then ensures consistency in the full asset risk matrix.

After defining the factor matrix, the sensitivities of each individual asset category—alternative or conventional—are set in relation to the risk factors. Key to this process is determination of factor influences on the asset classes in a way that is consistent with their common underlying risk exposures. Finally, all volatilities and the entire alternative investment correlation matrix, shown in Exhibit 3, are generated from the primary factor covariance properties and the asset class sensitivities. The aggregate asset class risks and correlations are shown in Exhibit 4.

RISKS AND RETURNS UNDER EQUILIBRIUM CONDITIONS

Looking ahead, a financial landscape that may differ markedly from events of the past is easily imaginable. Reflecting the unique assessments of economic environment and capital market structures in a small number of primary factors is straightforward compared to trying to ensure the consistent application of these views across a large number of assets.

For example, in the U.S. fixed-income market, we may not feel that the inflationary period of the late 1970s–early 1980s and the subsequent disinflationary period of the middle and latter 1980s are in any way representative of the future environment. Because we do not believe that this sort of environment is likely to recur, we will not want to base our risk assessment strictly on historical volatility.

The equilibrium risk and correlation matrix allows

us to tackle the first and most difficult dimension of alternative investments that renders most policy mix analysis useless—the misrepresentation of risk through the analysis of historical data.

Before we can conduct a policy analysis using the equilibrium risk data, we must build a consistent set of forward-looking risk premiums. We use a procedure we developed for conventional asset classes in Singer and Terhaar [1997]. It enables us to generate risk premiums from a consistent, forward-looking covariance matrix. The framework is similar to the capital asset pricing model (CAPM), but allows for varying degrees of world capital market integration to be priced into risk premiums. At one end of the spectrum, we assume that assets are fully integrated, and each risk premium is determined solely relative to a world market portfolio—the Global Investment Market (GIM) portfolio—of conventional and alternative assets.¹⁰

To determine the fully integrated risk premiums, the beta of each asset with respect to the GIM is derived from the equilibrium covariance matrix. These betas indicate the systematic risk that would be compensated in a fully integrated, equilibrium, capital market. It is only the contribution of the asset's risk to the world market portfolio that is compensated.

At the other end of the spectrum, a market could be fully segmented from the rest of the world. Local assets are then priced relative to their local market; hence the risk that is compensated is the total risk of the local market, not its contribution to world risk.

The assumption that assets are priced in a fully integrated global context is probably too strong, not only for alternative investments but also for many conventional assets. In fact, the assumption that alternative investments are priced in a fully integrated manner seems at odds with the boutique nature of private equity, real estate, natural resources, and hedge fund management.¹¹

It would be too restrictive to assume complete segmentation. In between full integration and full segmentation, we posit that the marginal investor requires compensation for systematic risk relative to a “home-biased” portfolio (HBP), skewed to the investor's country of domicile. Assets in a country or region would be priced relative to a home-biased “market” portfolio.

Risk premiums would generally be lower in a fully integrated world than in a partially or fully segmented world. The greater the integration of the global capital market, the more of a typical asset's risk will be diversified away by other assets in the broader market portfolio.

EXHIBIT 4
Asset Class-Level Equilibrium Risks and Correlations

	U.S. Equity	Ex-U.S. Equity	U.S. Bonds	Ex-U.S. Bonds	Private Equity	Real Estate	Natural Resources	Hedge Funds	Risk
U.S. Equity	1.00	0.71	0.30	0.25	0.91	0.38	0.35	0.58	15.8%
Ex-U.S. Equity	0.71	1.00	0.22	0.28	0.62	0.28	0.25	0.42	14.3%
U.S. Bonds	0.30	0.22	1.00	0.67	0.25	0.19	0.10	0.19	4.6%
Ex-U.S. Bonds	0.25	0.28	0.67	1.00	0.21	0.15	0.09	0.16	4.0%
Private Equity	0.91	0.62	0.25	0.21	1.00	0.35	0.32	0.59	31.1%
Real Estate	0.38	0.28	0.19	0.15	0.35	1.00	0.14	0.23	10.0%
Natural Resources	0.35	0.25	0.10	0.09	0.32	0.14	1.00	0.21	14.0%
Hedge Funds	0.58	0.42	0.19	0.16	0.59	0.23	0.21	1.00	6.9%

EXHIBIT 5
Risk Premiums for Varying Degrees of Segmentation

	Compensated Risk	Risk Premium
Fully Integrated	$\rho_{i,GIM} \sigma_i$	$\rho_{i,GIM} \sigma_i(SR)$
Home-Biased	$\rho_{i,HBP} \sigma_i$	$\rho_{i,HBP} \sigma_i(SR)$
Fully Segmented	$\rho_{i,i} \sigma_i = \sigma_i$	$\sigma_i(SR)$

Using the equilibrium covariance matrix with a CAPM-like, single-factor, model, we can derive risk premiums that reflect various degrees of integration.

Exhibit 5 shows the formulas used to derive risk premiums from the equilibrium covariance matrix, given varying degrees of assumed segmentation.¹²

An asset's correlation with itself ($\rho_{i,i}$) is one, so the fully segmented risk premium would be the highest. The correlation of an asset with the GIM ($\rho_{i,GIM}$) tends to be lower than with a home-biased portfolio ($\rho_{i,HBP}$), so the fully integrated risk premium is generally the lowest. Usually, the home-biased risk premium falls between the fully integrated and fully segmented cases.¹³

We can use this relationship to set bounds on the equilibrium risk premium for each alternative investment. In general, the equilibrium risk premiums are set nearer to the home-biased risk premiums, and reflect greater segmentation for alternative investments than for conventional asset classes.

Exhibit 6 displays the equilibrium risk premiums of conventional and alternative asset classes relative to their betas. Plots of the integrated risk premiums versus the betas would result in all the points lying on the straight line shown on the chart. The extent to which an asset's price

is segmented determines the additional segmentation premium and thus its vertical positioning above the line.

According to our analysis, private equity provides the greatest segmentation premium and is the farthest above the line. The segmentation premium offers more return for a given level of systematic or beta risk.

LIQUIDITY PREMIUM

The integration/segmentation distinction characterizes liquid assets fairly well, but for alternative investments we need to model illiquidity compensation as well. Compensation for illiquidity can be derived from recognizing that a one-period Sharpe ratio is an inappropriate measure of the compensation for risk when assets cannot be liquidated after one period (see Staub [2002]).

Consequently, the liquidity premium is a function of an asset's time horizon and the corresponding multi-period Sharpe ratio (MPSR). It can be shown that the MPSR of an asset, i.e., the asset's multiperiod wealth in excess of the wealth generated by the risk-free investment (i.e., compounded return over compounded cash return) is a non-linear function of time (see Hedges, Taylor, and Yoder [1997]).

Exhibit 7 shows the equilibrium excess returns for conventional and alternative investments, including consideration of equilibrium risks and correlations, differential segmentation, and illiquidity. The risk premium estimates come from the calculations in Exhibit 5.

Although the returns are considered unbiased, it is still not appropriate to run these numbers through a mean-variance optimization. Since the risk premiums

EXHIBIT 6
Reward for Risk from Conventional and Alternative Investments

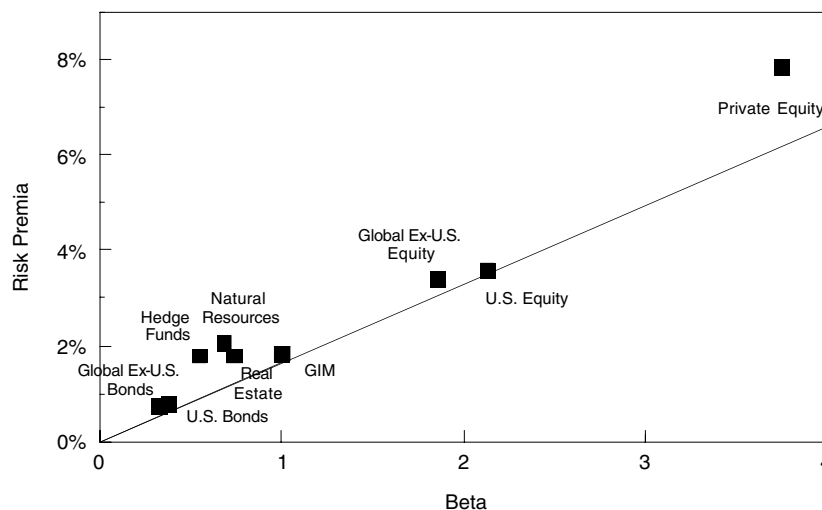


EXHIBIT 7
Excess Returns of Conventional and Alternative Investments

	Risk Premium (%)	Excess Return (%) (Risk Premium + Liquidity Premium)
GIM	1.84	1.97
U.S. Equity	3.59	3.59
Ex-U.S. Equity	3.42	3.42
U.S. Bonds	0.80	0.80
Ex-U.S. Bonds	0.75	0.75
Private Equity	7.88	9.92
Real Estate	1.82	3.06
Natural Resources	2.07	3.88
Hedge Funds	1.82	2.57

can reflect compensation for more than just systematic risk, due to varying levels of segmentation and illiquidity, one would expect a simple mean-variance optimization to result in a disproportionately large allocation to the more-segmented and illiquid alternative investments. This is precisely what occurs.

The real issue, however, is that simple optimization is typically a single-period approach. Conventional and alternative investments should not be evaluated using a single-period model due to extreme differences in availability of liquidity. The single-period assumption forces the evaluation of illiquid assets into a shorter investment time period, implicitly assuming liquidity similar to conventional assets. But in fact the real portfolio rarely matches policy because of the impossibility of rebalancing.

SIMULATION APPROACH

For the liquidity reasons, we approach the policy-setting exercise using a simulation framework. The objective is to identify a high-return, middle-risk, middle-liquidity policy portfolio suitable for a typical institutional investor. By “middle risk” we mean a portfolio that is approximately the same risk level as the 65/35 global balanced policy, i.e., just over 10% risk.

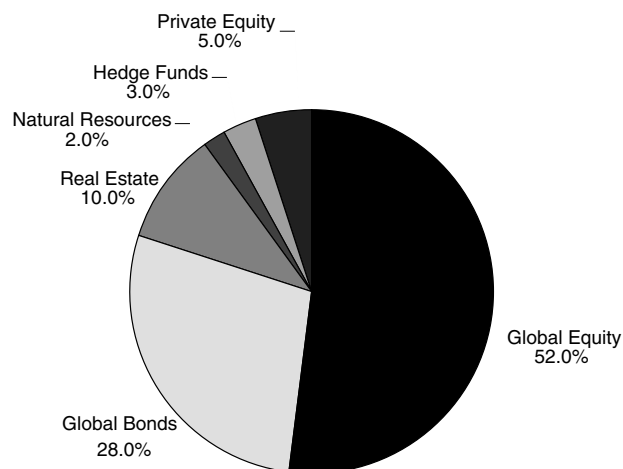
Simulations permit the inclusion of both the cost of illiquidity (allowing rebalancing only to the extent possible in practice) and the benefit of illiquidity (the liquidity premium). The multiperiod simulation is constructed with a standard Monte Carlo return-generating process, with a number of standard if arbitrary assumptions.¹⁴

We begin the simulation with a relatively low alternative asset allocation. The allocation is increased in subsequent simulation runs (a run is 1,000 20-year iterations) until we arrive at a policy portfolio with a volatility level similar to that of the global balanced policy; the volatility of the balanced, traded securities-only portfolio is 10.1% per year. Also, the moderate tolerance for illiquidity is translated into an upper limit on the realized or actual alternative investment allocation set at 30% of the total portfolio.¹⁵

The policy mix that fulfills these volatility and liquidity objectives includes a 20% allocation to alternative investments. The remaining 80% of the portfolio is held in a diversified global securities portfolio as shown in Exhibit 8.

The alternative investment portion of the policy

EXHIBIT 8
Policy Mix for Mid-Risk Institutional Investor



mix is 10% in real estate, 5% in private equity, 3% in hedge funds, and 2% in natural resources. We refer to this policy portfolio as an “appropriate” mix rather than as an “optimal” mix. First, we want to avoid any misleading impression that the policy is the result of any mathematical optimization. And, second, there are any number of portfolios that satisfy the objectives; hence many policies may be appropriate.

Simulations run on the 65/35 global balanced policy portfolio, with no alternatives, produce an average volatility of 10.3%, consistent with the covariance matrix estimate.¹⁶ Since the policy entails only traded securities, we can safely assume that the asset class weights can be rebalanced each period to the target weights. Therefore, at the end of any given period the forecast risk, based on policy weights and the covariance matrix, remains at 10.1% after rebalancing.

Rebalancing certain types of alternative investments is not always possible. Therefore, the actual allocation to each alternative investment and the aggregate share of the

alternatives in the portfolio can differ considerably from the policy target. At those times, the forecasted risk characteristics can diverge substantially from the target risk level of 10.1%, so even over many years, the alternative investment allocation and the portfolio’s expected risk can fluctuate considerably.

When we examine the results of 1,000 ten-year periods, these effects are obvious. While the target policy risk is 10.1%, the expected or forecast risk is above 11.5% in 5.0% of the periods. This increase in expected risk occurs because the actual allocation to riskier alternative investments varies over time, with the constrained ability to rebalance. The actual alternatives weight is greater than 28% in 5% of the periods. This considerable difference is driven in large part by the huge swings in the private equity allocation; while the target allocation is 5%, the actual weight exceeds 14% of the portfolio in 5% of the simulation periods.

Overall, because the returns and risks of some alternative investment classes are high, and liquidity is low, the swings in their policy allocations can be pronounced. This increases the uncertainty of risk for the total portfolio. Investor tolerance for risk must be high enough to withstand the periodically elevated risk levels. The investment horizon must also be long enough to allow for the benefits to offset the costs of illiquid investments.

Using our equilibrium return and covariance assumptions for each asset class, the 65/35 global balanced and global-including-alternatives policy mixes exhibit the characteristics shown in Exhibit 9. The improvement in return from adding alternatives is about 50 basis points, at the same risk level as the global policy mix (excluding alternatives). This results from broadening the portfolio—improving diversification—to include alternative investments and from the additional liquidity premium obtained from holding illiquid alternative investments. The Sharpe ratio increases by 19%, from 0.26 to 0.31.

Please note we are not claiming that adding alter-

EXHIBIT 9
Global Balanced Portfolios With and Without Alternatives

	Return	Average Risk	Sharpe Ratio
Global Balanced Portfolio — Traded Securities Only	7.2%	10.3%	0.26
Global Balanced Portfolio — Including Alternative Investments	7.7	10.1	0.31

natives to a portfolio provides a substantial free lunch to the investor. The improvement in the Sharpe ratio comes from two sources. The first is that the increased diversification of the portfolio and the allocation to more-segmented investments does indeed lead to a better risk-return condition. Second, a good deal of the return improvement is due to the liquidity premium portion of the newly added alternatives. Since the liquidity premium is essentially a compensation for relinquishing the ability to rebalance, there is no free lunch from this component—the compensation is commensurate with the risk. It's simply that illiquidity is not reflected in the volatility risk in the denominator of the Sharpe ratio.

It is also important to note that the policy portfolio highlighted here is just one of many that fulfill the objectives. Varying many of the allocations by small amounts has little effect on the overall outcome.

SUMMARY

Investors have typically relied on rules of thumb and artificial constraints in setting policy weights for alternative investments. Optimizations using historical data series in the alternatives area cannot be relied upon to provide sensible policy mixes. Unconstrained optimized portfolios show unreasonably large allocations to these “low-risk, high-return” investments.

Our framework for considering alternative investments circumvents these data problems, and is consistent with fundamental economic notions of risk and return. The resulting policy mix is grounded in classical theory rather than simply representing a best guess.

Basing the framework on a factor model lets us set risks and sensitivities in a straightforward and intuitive fashion; all the risks and returns will reflect forward-looking assessments of the underlying economic and fundamental drivers of financial markets. By using this approach, mathematical consistency of the full covariance matrix is also assured. Once risk characteristics are set, appropriate returns are developed, taking liquidity characteristics into account. All these facets of the analysis are brought together in a simulation environment to evaluate portfolio policy allocations.

Recommended portfolio allocations can be developed for a typical institutional investor with moderate liquidity needs and a moderately long investment horizon. Investors with different risk tolerances, investment horizons, and liquidity needs would hold different allocations to the portfolio of alternative investments, and have

different allocations within the portfolio of alternatives. The longer the investor's horizon, and the lower the need for liquidity, the greater will be the allocation to the illiquid alternative investments.

ENDNOTES

Bruno Solnik has been extremely generous with his time and has provided numerous comments that have greatly benefited this article. The authors also express gratitude for the considerable assistance and input provided by colleagues at UBS Realty, UBS Timber, Adams Street Partners, UBS O'Connor, and GAM. The opinions in this article should not necessarily be taken to represent the opinions of UBS Global Asset Management or any subsidiaries.

¹We generally distinguish between alternative assets and alternative strategies. The returns of alternative assets are primarily a function of passive or systematic market characteristics. Alternative strategies, on the other hand, produce returns that are largely a function of active management; that is, they are hedge funds. Here we use the term “alternative investments” to denote both alternative assets and strategies.

²Internally, the domestic-foreign distinction has been superseded by global and bottom-up considerations. For instance, in equity risk assessment, a simultaneous sector-market approach is used to maintain consistency with the investment process. In the interest of providing analytical results consistent with most policy-setting practice and avoiding unrelated home country bias and risk discussions, we maintain the U.S./non-U.S. distinction in parts of this article.

³Attractive return expectations are often derived from analysis of historical data. Since performance data for alternative investments are limited, they are skewed by self-selection and survivorship biases.

⁴We refer here to the time series characteristics of IRR computations. Great dispersion *across managers or funds* within a given period of time is another matter.

⁵We do not want to mislead readers who may be inclined to view our results below as applying only to U.S. investors.

⁶Another alternative to straight mean-variance optimization is to include another constraint in the objective function—mean-variance tracking error optimization. Because the purpose here is to determine the policy, i.e., the benchmark, optimizing with the additional tracking error variable does not solve this problem, as it requires presupposition of the benchmark itself.

⁷This is why we come to a conclusion different from Peng, Baierl, and Kaplan [2002]. They conclude that the correlation between U.S. venture capital and the U.S. equity market is low, as they investigate it on an *individual fund* basis, while we use *aggregated* venture capital.

⁸Given the potentially huge size of a correlation matrix,

it becomes impossible to maintain consistency—either mathematically or in terms of forward-looking views—by considering pairwise correlations individually.

⁹More precisely, $V = LFL' + R^2$, where L is the matrix of all markets' factor exposure, F is the factor covariance matrix, and R is the diagonal matrix of all markets' idiosyncratic risks, i.e., the portion of the market risks not attributable to the factors.

¹⁰The capitalization-weighted global market portfolio is composed of 44% traded equities, 50% fixed-income, and 6% alternative assets.

¹¹Limited integration of alternative investments in the investment process also arises from lack of transparency, investments in blind private equity pools, and limited availability of investment alternatives.

¹²The risk premium is derived through straightforward algebraic manipulation of the CAPM formula.

¹³We assume in these derivations that the price of risk, or conversely the marginal investor's risk aversion, is the same in both integrated and segmented pricing.

¹⁴These assumptions include: 1) annual (one-year) periods; 2) a one-year lag between the decision to change any alternative investment position and the start of actual execution of that change; 3) alternatives rebalanced over time either by redeployment of their cash distributions (liquidation) or through new contributions; and 4) a dual-volatility regime. During the high-volatility state, which occurs 15% of the time on average and when the market return is below its equilibrium return, we assume that alternative investment liquidity dries up, so rebalancing decisions are essentially impossible to execute. This results in return distributions that exhibit real-world characteristics such as fat tails.

¹⁵Given the probabilistic nature of the simulation returns, the 30% maximum is expressed as the level we did not want breached more than 5% of the time.

¹⁶Note that the simulations discussed here include the dual-volatility regime discussed earlier. As a result, the average volatility level of 10.3% differs slightly from the 10.1% risk forecast using the policy allocation and the covariance matrix.

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