THE JOURNAL OF
INVESTING

A PUBLICATION OF INSTITUTIONAL INVESTOR, INC.

VOLUME 9 NUMBER 2 SUMMER 2000

New Ideas in Performance Measurement

Efficiency Ratio: A new Methodology for Performance Measurement

Laurent Cantaluppi and Ruedi Hug

Efficiency Ratio: A New Methodology for Performance Measurement

LAURENT CANTALUPPI AND RUEDI HUG

For a long time, performance measurement simply meant computing the historical returns of portfolios.

LAURENT CANTALUPPI is a partner at Cantaluppi & Hug, a company that specializes in financial software. He holds a M.S. in Mathematics from the Swiss Federal Institute of Technology, Lausanne, and a Ph.D. in Operations Research from Stanford University.

RUEDI HUG is a partner at Cantaluppi & Hug. He holds a M.S. in Mathematics and a Ph.D. in Computer Science from the Swiss Federal Institute of Technol-ogy, Zurich.

This task, although simple in its formulation, is not trivial because of the presence of inflows and outflows. Their consideration in the computation was not standardized, resulting in spurious performance comparisons. Then, standardized definition of the time-weighted rate of returns (TWR) put some order into the matter.

After the work of Markowitz [1952], it became clear that performance measurement must take into account not only the return but also the risk. The use of risk as an integral part of the performance made it even more difficult to compare portfolios, since two-dimensional measures offer only a partial ordering. Sharpe succeeded in reducing this dimensionality with introduction of the security market line, based on equilibrium theory and the capital asset pricing model (CAPM). The Sharpe ratio has found broad acceptance, and continues to be today's world standard for risk-adjusted performance, although it is not immune to criticism.[1]

The Sharpe ratio considerably improves the fair comparison of portfolios, which is one of the main goals of performance measurement. In fact, performance comparison is so fundamental that both methods and presentation have been standardized.[2]

The *efficiency ratio* methodology that we introduce is a contribution toward more transparency and universality in performance measurement and performance comparison. All comparisons accomplished with today's methods are relative in nature; they tend to give an answer to the question: "What is the performance of a portfolio relative to other portfolios?" The efficiency ratio methodology tends to answer the question: "Which performance could have been achieved by the portfolio?"

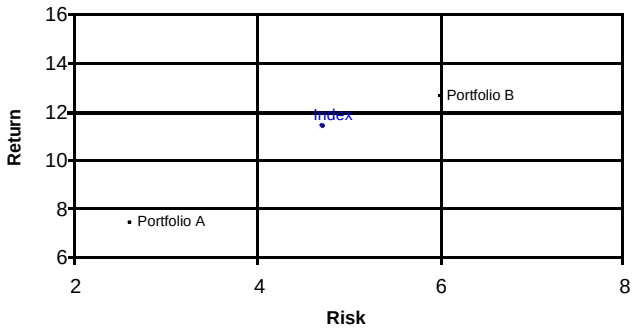
Of course, the "best possible" portfolio must be defined with great care. It is not sim-ply the asset displaying the highest return during the performance period. It must be a portfolio in the same investment universe, of the same risk level, and satisfying all the investment constraints imposed on the portfolio manager.

A simple example shows the considerable transparency that the efficiency ratio pro-vides. In particular, we will see that its orientation toward the return potential of the investment environment of the portfolio is crucial. Exhibit 1, Panel A, illustrates a historical risk/return display of Portfolios A and B and of a comparison index. This graph provides us very little guidance as to the performance comparison of the portfolios relative to one another, or relative to the index.

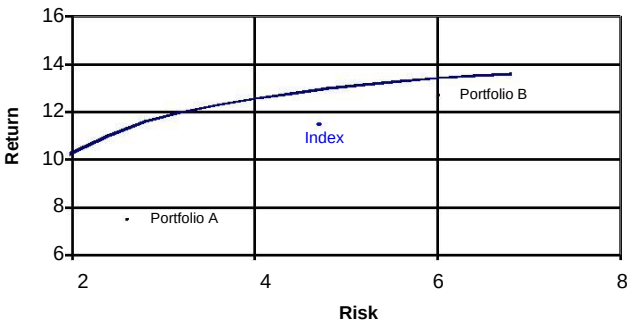
We now compute the highest historical return that could have been achieved for all risk levels. Panels B and C display two different possible resulting ex post efficient frontiers. In Panel B, Portfolio B is clearly better than Portfolio A. Conversely, the performance of Portfolio A in Panel C is definitely better than that of Portfolio B.

EXHIBIT 1
The Efficiency Ratio

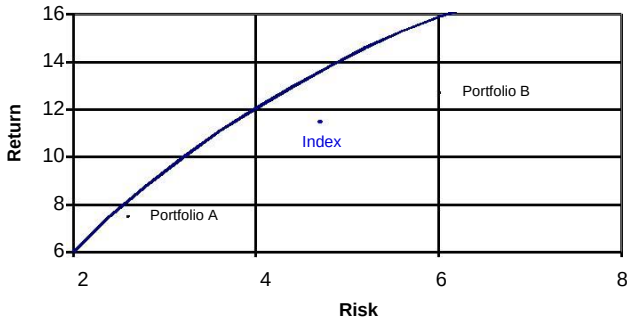
Panel A. Historical Risk/Return



Panel B. Risk Level 1



Panel C. Risk Level 2



This simple example demonstrates the information value provided by the ex post efficient frontier: The same portfolios A and B are judged completely differently, depending on the shape of the ex post efficient frontier. Other performance methods, such as the Sharpe ratio, do not yield this differentiation because they are based on the relative differences in risk/return, and not on the absolute risk/return potential.

EFFICIENCY RATIO METHODOLOGY

The computation of a mean-variance optimal portfolio according to the modern portfolio theory of Markowitz proceeds as follows. First, the investment universe is defined; it can consist of investment categories (e.g., for an international asset allocation) or of individ-ual securities. The investment horizon is then deter-mined with corresponding estimations for future returns, risks, and correlations for the assets in the universe. Finally, an efficient frontier is computed on the basis of these esti-mations and the relevant investment restrictions. An opti-mal portfolio is then chosen on this efficient frontier, depending on the risk aversion of the investor.

The idea behind the efficiency ratio methodology is simple: This ex ante process can be carried out ex post for performance purposes. The computations are per-formed with historical values for the returns, risks, and correlations computed for the given performance inter-val. Of course, the investment restrictions are also taken into account for the calculation of the efficient frontier.

This process is actually not new. It has been used in various studies. Examples are Kandel and Stambaugh [1995] in a validity investigation of the capital asset pricing model and in Rudolf and Zimmermann [1997] in an analysis of the influence of currency hedges on performance.

Assume that a portfolio manager has ex ante-perfect foresight of returns, risks, and correlations over the per-formance interval and is invested in a mean-variance opti-mal portfolio. The ex ante and the ex post efficient frontiers being identical, the portfolio of our clairvoyant portfolio manager, as expressed by its risk and return, also lies on the ex post efficient frontier. Such a portfolio earns the best possible performance score, since it is not possible to perform better. Portfolios under the efficient frontier do not attain the full return potential and therefore obtain a lower mark.

The efficiency ratio builds on this consideration, i.e., the distance to the ex post efficient frontier. We explain how to compute this distance, and examine some properties of this methodology.

THEORETICAL AND PRACTICAL PROPERTIES

Takes Risk and Return into Consideration

The efficiency ratio takes risk and return into account, as a modern performance measurement method should do. A higher risk must be compensated with a higher return in order to get the same performance (a higher risk without a higher return implies a greater distance to the efficient frontier, resulting in a lower performance score).

The concept of distance to the efficient frontier has the advantage of bringing risk into play without increasing the dimensionality of the measure. The efficiency ratio pro-vides a total ordering, so that a comparison of any two investments is always possible, at least in a mathematical sense.

Takes Return Potential into Consideration

Like most performance measures, the efficiency ratio allows a relative performance comparison. For example, the performance of a portfolio and its benchmark can always be computed and compared. But the efficiency ratio methodology achieves much more; it takes the return potential into account. We can answer how much extra return a portfolio could have achieved without increasing its risk: the return loss, i.e., the vertical distance to the ex post efficient frontier. Similarly, the "surplus risk," i.e., the horizontal distance to the efficient frontier answers the question "by how much could the risk of the portfolio have been reduced without decreasing its return?" Even the quality of the portfolio benchmark can be assessed by computing its efficiency ratio. This is particularly important, since the performance of a port-folio is essentially given by its long-term strategy.[3]

Notice that the computed ex post efficient frontier does not define an absolute boundary that can never be exceeded. It defines the best performance for buy-and-hold portfolios. An outstanding timing strategy could lead to a portfolio that lies above the efficient frontier in the risk/return graph.

Consistency with Modern Portfolio Theory

The efficiency ratio is by definition consistent with modern portfolio theory. Going back to our example of the clairvoyant portfolio manager, we see that she would get the best possible score for her portfolio, since it lies on the efficient frontier. This would not be the case for most performance measures.

Takes Restrictions into Consideration

Most performance measures do not take restrictions into account. Portfolios can be compared only with other portfolios or benchmarks that are themselves subject to the same restrictions. This is completely different with the efficiency ratio; it directly takes restrictions into account. Restrictions are an integral part of the measure and influence the ex post efficient frontier, i.e., the return potential of the investment environment.

Exhibit 2 illustrates this point. Two portfolio managers A and B have reached the same result as measured by the risk/return of their respective portfolios. Portfolio manager A, however, has much stricter investment restrictions than portfolio manager B, which is illustrated by the efficient frontiers A and B. The performance of portfolio manager A will therefore be better than the performance of portfolio manager B.

COMPARISON WITH THE SHARPE RATIO

The Sharpe ratio is today's world standard for risk-adjusted performance measurement. The Sharpe ratio takes risk and return into account, and allows the comparison of any pair of investments, since it reduces the dimensionality of the measure by adjusting the return to the risk that is taken. It does not, however, take the return potential into account and is not consistent with modern portfolio theory, except under the unrealistic assumptions of equilibrium underlying the CAPM.

The consequences of these negative properties are clearly illustrated in Exhibit 3. Portfolio A earns in this

---

EXHIBIT 2
Efficiency Ratio with Investment Restrictions

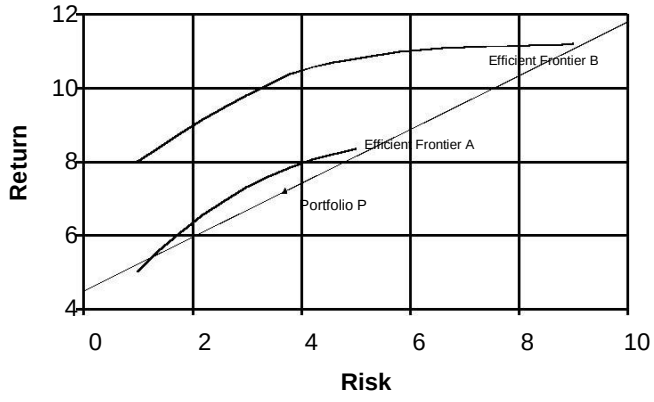
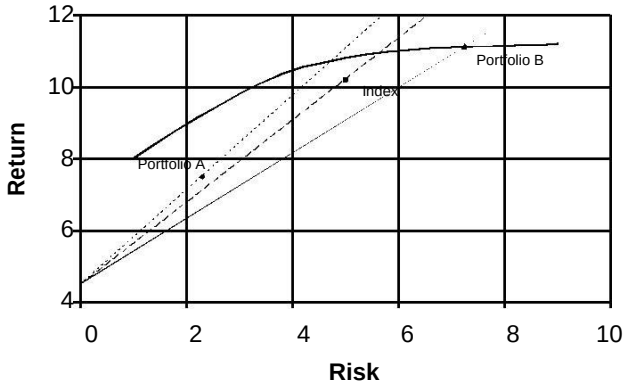


EXHIBIT 3

Efficiency Ratio versus Sharpe Ratio



example a higher Sharpe ratio than the index, and even a higher Sharpe ratio than Portfolio B, although Portfolio B lies on the efficient frontier, i.e., is optimal. Thus the manager of Portfolio B, who achieves "perfect" performance, will be penalized simply because Portfolio B has a higher risk level than Portfolio A. But if this risk level were defined in agreement with the investor (which we assume), the portfolio manager should obtain the best possible performance mark, which is the case with the efficiency ratio.

This demonstrates the inconsistency of the Sharpe ratio with modern portfolio theory. The efficiency ratio allows a fairer performance comparison than the Sharpe ratio. Moreover, the Sharpe ratio does not take investment restrictions into account, which makes it impossible to compare investments having different constraints.

EFFICIENCY RATIO AND INDEX COMPARISON

The efficiency ratio methodology allows a fair comparison of investment performance, even for portfolios in different risk classes. In particular, the usual performance comparison with an index also gives more meaningful results than with prevalent methods, especially when the portfolio and the index exhibit quite different risks. With the efficiency ratio methodology, it is unnecessary to artificially split portfolios with the same investment environment into different risk categories for the purpose of performance comparison. The resulting proliferation of indexes is also superfluous (e.g., one index for each of the risk classes "income," "balanced," and "growth"). This considerably improves the transparency of the results, since all portfolios with a given investment environment can be compared to the same index.

The handling of cash positions also occasions problems for index comparison. The cash holdings of portfolios vary considerably and cannot be taken into account in indexes. There is no such difficulty with the efficiency ratio methodology; the inclusion of the cash market (in the base currency of the investor) in the computation of the ex post efficient frontier provides an elegant solution. The low-risk part of the efficient frontier can only be achieved with a high proportion in cash, and this pro-portion drops to zero as we move to the right-most point of the efficient frontier. The whole range of possible cash weights will thus be automatically taken into account.

The index comparison within the efficiency ratio methodology offers much more than a simple judgment of whether a portfolio performs better than the index or not. The performance of the index itself can be computed and analyzed, with the help of the return potential. More-over, the slope and the concavity of the efficient frontier give information on the return potential relative to the incurred risk. That is, could it have paid to take more risk, i.e., would the return potential be significantly higher? or conversely, is the incurred risk too high, i.e., would the return potential be practically unchanged with less risk?

Another problem, the weighting of securities in the index, is avoided with the efficiency loss methodology. The usual weighting schemes are equal-weighting and (the more modern) market value-weighting. These schemes are perfectly justified for broad indexes or large-cap indexes. In the case of a small-cap index, however, weighting by market value is questionable, since high capitalization is a criterion for exclusion from the index, but at the same time a weighting factor for the index. This introduces an artificial discontinuity that should be avoided.

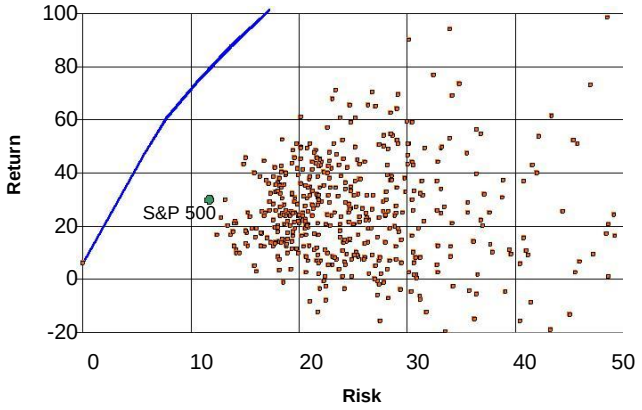
EFFICIENCY RATIO CURVES

The given properties of the efficiency ratio do not depend on any particular computation method. A distance measure in the usual sense would have the draw-back that "better" portfolios would earn a lower score than "worse" portfolios, which could lead to incorrect interpretation of the results. The efficiency ratio reverses this ordering.

The investment to be appraised has a level of risk that in turn determines a maximum potential excess

EXHIBIT 4

Ex Post Efficient Frontier of U.S. Stock Market



return (total return minus riskless rate of return). The efficiency ratio is then defined as the percentage of this excess return that is actually achieved by the investment. An efficiency ratio of 100% is assigned to a mean-variance optimal portfolio; an efficiency ratio of 0% is given to an investment whose return equals the riskless rate of return.

The efficiency ratio can also be interpreted as the quotient of the Sharpe ratio of the investment and the optimal (with the same risk level) Sharpe ratio. This performance measure is actually identical with that of Kandel and Stambaugh [1995], under the assumption that the riskless investment is part of the universe when computing the efficient frontier. In that case, the minimum-risk point of the efficient frontier coincides with the riskless investment.

The efficiency ratio must be extended to portfolios that have a higher risk than the right-most point of the efficient frontier. The maximum attainable return with the same level of risk is not defined for those portfolios. Therefore they must be compared with the right-most point of the efficient frontier. Accordingly, we define the efficiency ratio of such an investment as the quotient of its Sharpe ratio to that of the right-most point of the efficient frontier. In the risk/return graph, this is equivalent to an extension of the efficient frontier to the right with a straight line corresponding to points having the same Sharpe ratio as its right-most point.

This method takes only the "return loss" into account, i.e., the vertical distance to the efficient frontier. Other methods could take into account the "surplus risk" (the horizontal distance to the efficient frontier) as well. Such a method could, for example, penalize more heavily a portfolio under a relatively flat part of the efficient frontier, following the principle "why take so much risk if it does not bring any return potential?"

THE EFFICIENCY RATIO AND THE U.S. STOCK MARKET

We demonstrate the efficiency ratio methodology in application to the U.S. stock market. The universe consists of the 500 securities that define the Standard & Poor's 500 composite index at the beginning of June 1998, and a money market investment index in the U.S. dollar, which is the base currency.[4]

The returns are computed over the three-year period May 31, 1995-May 31, 1998. The risks and correlations are computed over the same period, based on monthly returns. All the risk and return numbers are annualized. We assume that the portfolios are not subject to any investment restrictions. Remember that the efficient frontier is computed by considering buy-and-hold portfolios only.

The resulting ex post efficient frontier is displayed in Exhibit 4, together with the securities in the universe and the corresponding index (S&P 500). This graph shows the enormous diversification potential offered by individual securities. Some pairs of securities show a very low correlation, even for companies in the same industry group. As a consequence, the portfolios on the efficient frontier are rather well diversified, even though no restrictions are imposed.

Such a portfolio is shown in Exhibit 5. It includes no fewer than seventeen securities, and none of them exceeds a weight of 15% in the portfolio.

But the purpose of the efficiency ratio methodology is to analyze the performance of portfolios rather than individual securities, so we look at a small sample of mutual funds invested in U.S. stocks. Our purpose is not to judge this arbitrary selection of funds, but rather to show the kind of results that can be derived from the efficiency ratio methodology. Exhibit 6 shows the efficient frontier and efficiency ratio curves, ranging down from 90% to 0%. As we have seen, the S&P 500 is rather inefficient, with an efficiency ratio of a mere 32%. The funds under scrutiny show a broad range of risk values, ranging from 7.86% for the Vontobel Fund U.S. Value Eq to 21.75% for the Glbl Mgr U.S. Geared, rendering the performance comparison of these funds quite difficult, or even unfair with conventional methods.

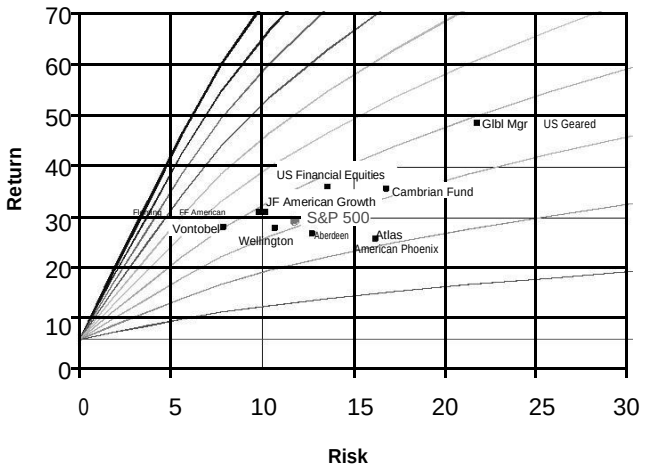
EXHIBIT 5

A Portfolio on the Efficient Frontier

Security/Portfolio	Weight	Return	Risk
Monsanto	14.70	60.73	20.24
Clear Channel Commun	13.58	89.37	30.29
Conseco	10.32	64.42	27.19
Tyco International	9.63	67.33	23.17
Gap Incorporated	8.48	68.93	29.30
Pioneer Hi-Bred Intl	7.92	44.75	24.23
Dell Computer	7.29	196.61	55.74
Pfizer	7.13	70.51	23.49
Williams Companies	5.96	45.21	15.21
USAir Group	3.00	97.94	48.59
Bristol-Myers Squibb	2.84	52.12	18.53
Hershey Foods	2.40	41.24	19.98
Owens Illinois	1.98	50.19	27.52
Biomet	1.79	25.20	27.88
Columbia Gas System	1.11	42.62	14.98
Meredith	1.06	45.95	30.11
Warner Lambert	0.80	69.66	26.87
Portfolio	**100.00**	**74.01**	**10.47**
S&P 500		29.47	11.77

EXHIBIT 6

Ex Post Efficient Frontier of U.S. Stock Market



To show the value of our new methodology, Exhibit 7 provides a comparison of the efficiency ratios and Sharpe ratios for these funds. The ranking implied by the two methods is not identical. In particular, funds with a higher risk level rank better according to the efficiency ratio than according to the Sharpe ratio. Note now that the fund Glbl Mgr U.S. Geared has an efficiency ratio that puts it in third position, very close to the two leaders, and substantially higher than the S&P 500 index. The Sharpe ratio ranks the same fund in sixth position, slightly lower than the S&P 500 index. It simply does not take return potential into account, i.e., the concavity of the ex post efficient frontier.

Of course, the efficiency ratio is based on a return potential that can be achieved only with perfect foresight. This return potential must be considered as a yardstick rather than a goal to reach.

CONCLUSION

The efficiency ratio is more than a performance ranking tool. Information about return potential is an important part of the measure. While it is more complex to compute than the Sharpe ratio, our examples show that the extra information and the achieved fairness are worth the effort.

Its future use depends on the widespread availability of ex post efficient frontiers for different markets and universes. The performance information would then reach unprecedented transparency.

The efficiency ratio adjusts itself automatically to the potential of the investment environment of the portfolio; it is automatically scaled. The performance comparison of portfolio managers with different investment environments is therefore possible. The universality of such a comparison has to be precisely investigated, but we would assert that the efficiency ratio methodology extends it notably compared to prevalent methods.

ENDNOTES

[1]The Sharpe ratio was first introduced in Sharpe [1966] under the name "reward-to-variability ratio." It has been extended in numerous publications. Sharpe [1994] summarizes its extensions and its application potential. Other risk-adjusted performance methods include Jensen's alpha or the Treynor ratio.

Roll [1978] points out some inconsistencies of performance measures based on equilibrium theory such as the CAPM. Banz [1997] summarizes the possible misuses of the Sharpe ratio.

[2]The Association for Investment Management and Research (AIMR) publishes performance presentation standards that are recognized worldwide.

EXHIBIT 7

Efficiency Ratio versus Sharpe Ratio

	Risk	Return	Efficiency Ratio	Rank	Sharpe Ratio	Rank
S&P 500	11.77	29.47	0.3199	-	2.0018	-
Vontobel	7.86	28.23	0.4066	1	2.8399	1
Fleming FF American	9.84	31.24	0.3902	2	2.5743	2
Glbl Mgr U.S. Geared	21.75	48.59	0.3870	3	1.9624	6
JF American Growth	10.18	31.23	0.3800	4	2.4874	3
US Financial Equities	13.61	36.21	0.3718	5	2.2264	4
Wellington	10.70	28.09	0.3211	6	2.0730	5
Cambrian Fund	16.80	35.81	0.3196	7	1.7799	7
Aberdeen Atlas	12.71	26.98	0.2713	8	1.6579	8
American Phoenix	16.21	25.95	0.2195	9	1.2364	9

[3]Brinson, Singer, and Beebower [1991] show, for exam-ple, that more than 90% of the performance of American mutual funds can be attributed to their long-term strategy. The contribution of timing and selectivity is relatively minor.

[4]The data sources are Datastream International Ltd. for the securities and Standard & Poor's Micropal for the mutual funds.

REFERENCES

Banz, R.W. "Editorial: Zero Correlation between Theory and Practice in Financial Economics." *Financial Markets and Port-folio Management*, 11 (4) (1997), pp. 383-391.

Brinson, G.P., B.D. Singer, and G.L. Beebower. "Determinants of Portfolio Performance II: An Update." *Financial Analysts Jour-nal*, May/June 1991, pp. 40-48.

Kandel, S., and R. Stambaugh. "Portfolio Inefficiency and the Cross-Section of Expected Returns." *Journal of Finance*, 50 (1) (1995), pp. 157-184.

Markowitz, H.M. "Portfolio Selection." *Journal of Finance*, 7 (March 1952), pp. 77-91.

"Performance Presentation Standards." AIMR, (1993).

Roll, R. "Ambiguity When Performance is Measured by the Security Market Line." *Journal of Finance*, 33 (1978), pp. 1051-1069.

Rudolf, M., and H. Zimmermann. "An Algorithm for International Portfolio Selection and Optimal Currency Hedging." In T.W. Ziemba and J.M. Mulvey, eds., *Worldwide Asset and Liability Modeling*. Cambridge: Cambridge University Press, 1997.

Sharpe, W. "Mutual Fund Performance." *Journal of Business*, 39 (1966), pp. 119-138.

——. "The Sharpe Ratio." *Journal of Portfolio Management*, Fall 1994, pp. 49-58.