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# Downside Risk in Practice

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Investors associate risk with “bad” outcomes such as negative returns or, more generally, returns below their expectations. They do not associate risk with large positive returns, returns above their expectations, or upside swings in general. For this reason, investors’ perception of risk is quite at odds with the modern portfolio theory definition of risk.

Although formal definitions of downside risk are just as old as the formal definitions of risk used in modern portfolio theory, it is only in the last several years that measures of downside risk have become increasingly accepted and used both in academia and in practice. As discussed below, measures of downside risk can be used to estimate required returns and risk-adjusted returns, making them critical tools for portfolio managers and investors.

This article discusses two measures of downside risk: “semideviation” and “downside beta.” It shows how they can be calculated, explains how they can be incorporated in an asset-pricing model to estimate required returns on equity, and briefly discusses how semideviation can be used to assess risk-adjusted returns.

It is important to note that downside risk in general and “semideviation” in particular have a long history in finance. Harry Markowitz, in his groundbreaking book *Portfolio Selection*, stated that “the semideviation produces efficient portfolios somewhat preferable to those of the standard deviation.”<sup>1</sup> His reasons for neglecting this measure of risk in his subsequent analysis were that *back then*, semideviation was a relatively unknown measure of risk and mean-semivariance optimal portfolios were difficult to obtain.<sup>2</sup> But the debate about whether Markowitz made the right choice has never gone away, and later theoretical research has established a link between investor rationality and downside risk.<sup>3</sup>

Although standard deviation remains the usual way to report the risk of mutual and pension funds, a 1999 *Forbes*

article argued that many funds use semideviation to calculate risk-adjusted returns and include this measure of risk in annual reports.<sup>4</sup> It also noted that Morningstar uses semideviation to create its influential star ratings. Furthermore, a number of recent empirical studies have shown that semideviation and downside risk measures can explain the cross-section of returns on U.S. stocks and emerging markets.<sup>5</sup>

In sum, the concept of downside risk has had a strong appeal for portfolio managers and investors. Pension fund managers in particular, given their underlying goal of preservation of principal and minimization of potential losses subject to a target return, should find downside risk tools especially useful.

## Standard Measures of Risk

Modern portfolio theory argues that the risk of an asset depends on the context in which it is considered: if the asset is considered in isolation, its *total* risk is relevant; if it is part of a diversified portfolio, only its *systematic* (non-diversifiable) risk is relevant. In such a framework, total risk is measured by the standard deviation of returns and systematic risk is measured by beta (the sensitivity of an asset’s returns to changes in the market’s returns). However, both the standard deviation and beta can be questioned on theoretical, practical, and empirical grounds.

## Shortcomings of the Standard Deviation

Consider an asset with a mean annual return of 10% and assume that in the last two years the asset returned –5% and 25%. Because both returns deviate from the mean by the same amount (15%), they both increase the standard deviation of the asset by the same amount. But is an investor in this asset equally happy in both years? Not likely, which underscores one of the main problems with using standard deviation as a measure of risk: it treats an x% fluctuation above and below the mean in the same way. But

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1. H. Markowitz, *Portfolio Selection: Efficient Diversification of Investments*. Yale University Press, New Haven and London (1959).

2. Both objections, particularly the former, are certainly much weaker nowadays.

3. For an excellent account of the evolution of downside risk see D. Nawrocki, “A Brief History of Downside Risk Measures.” *Journal of Investing* (Fall 1999), pp. 9-25. Several

articles on the theoretical and practical issues related to downside risk are in F. Sortino and S. Satchell, *Managing Downside Risk in Financial Markets*. Butterworth-Heinemann Finance (2003).

4. See J. Clash, “Focus on the Downside,” *Forbes* (Feb. 22, 1999), pp. 162-163.

5. These studies include A. Ang, J. Chen, and Y. Xing, “Downside Risk,” Columbia Business School working paper (2004), J. Estrada, “The Cost of Equity in Emerging Markets: A Downside Risk Approach,” *Emerging Markets Quarterly* (Fall 2000), pp. 19-30, and T. Post and P. van Vliet, “Conditional Downside Risk and the CAPM,” Erasmus School of Economics, working paper (2004).

Exhibit 1 **Oracle, 1995-2004**

Year	R	R- $\mu$	(R- $\mu$ ) <sup>2</sup>	Min(R- $\mu$ , 0)	{Min(R- $\mu$ , 0)} <sup>2</sup>
1995	44.0%	3.0%	0.0009	0.0%	0.0000
1996	47.8%	6.7%	0.0045	0.0%	0.0000
1997	-19.8%	-60.9%	0.3709	-60.9%	0.3709
1998	93.3%	52.2%	0.2726	0.0%	0.0000
1999	289.8%	248.7%	6.1849	0.0%	0.0000
2000	3.7%	-37.3%	0.1394	-37.3%	0.1394
2001	-52.5%	-93.6%	0.8752	-93.6%	0.8752
2002	-21.8%	-62.9%	0.3952	-62.9%	0.3952
2003	22.5%	-18.6%	0.0345	-18.6%	0.0345
2004	3.7%	-37.4%	0.1396	-37.4%	0.1396
<b>Average</b>	<b>41.1%</b>		<b>0.8418</b>		<b>0.1955</b>
<b>Square Root</b>			<b>91.7%</b>		<b>44.2%</b>

investors, obviously, do not. Shouldn't a proper measure of risk capture this asymmetry?

The second column of Exhibit 1 shows the annual returns of Oracle (R) for the years 1995–2004. As the next-to-last row shows, the stock's mean annual return ( $\mu$ ) during this period was a healthy 41.1%. Yet, as is obvious from these returns, Oracle treated its shareholders to quite a bumpy ride.

The third column of the exhibit shows the difference between each annual return and the mean annual return; for example, for the year 2004, the difference was -37.4% (3.7% - 41.1%). The fourth column shows the square of these numbers; for 2004 it was 0.1396 (-0.3742)<sup>2</sup>. The average of these squared deviations from the mean is the variance (0.8418), and the square root of the variance is the standard deviation (91.7%).

Note that all the numbers in the fourth column are positive, which means that *every* return, regardless of its sign, contributes to increasing the standard deviation. In fact, the largest number in this fourth column (the one that contributes to increasing the standard deviation the most) is in the year 1999, when Oracle delivered a return of almost 290%. Now, would an investor that held Oracle during the year 1999 be happy or unhappy? Would he count this performance *against* Oracle, as the standard deviation effectively does?

We will get back to this below, but before we do, consider another shortcoming of standard deviation as a measure of risk: it is largely meaningless when the underlying distribution of returns is not symmetric. Skewed distributions of returns, which are far from unusual in practice, exhibit

different volatility above and below the mean. In these cases, variability around the mean is at best uninformative and more likely misleading as a measure of risk.

### Shortcomings of Beta

Beta, the appropriate measure of risk for diversified investors according to the CAPM, has weaknesses similar to those of standard deviation. Modern portfolio theory argues that the higher an asset's beta, the riskier is the asset. However, it is not entirely clear that investors think of (systematic) risk in this way.

An asset can have a high beta if it tends to go up substantially more than the market when the market goes up, even if it does not tend to fall by more than the market when the market falls. In other words, a high-beta asset may magnify the market's upside swings and at the same time dampen the market's downside swings. Although such an asset would be considered risky in modern portfolio theory simply because of its high beta, most investors would probably disagree with this characterization. It also goes without saying that beta is widely questioned from an empirical point of view.<sup>6</sup>

### Downside Risk

As Exhibit 1 makes clear, one of the main problems with using standard deviation as a measure of risk is that it treats fluctuations above and below the mean in the same way. However, it is possible to tweak the standard deviation so that it accounts only for fluctuations below the mean.

The fifth column of Exhibit 1 shows "conditional returns" with respect to the mean; that is, the lower of

6. For an overview and assessment of the last 40 years of evidence and controversy on beta, see E. Fama and K. French, "The CAPM: Theory and Evidence." Center for Research in Security Prices, Working paper 550 (2003).

## Exhibit 2 Semideviations

Year	R	{Min(R-μ, 0)} <sup>2</sup>	{Min(R-R <sub>f</sub> , 0)} <sup>2</sup>	{Min(R-0, 0)} <sup>2</sup>
1995	44.0%	0.0000	0.0000	0.0000
1996	47.8%	0.0000	0.0000	0.0000
1997	-19.8%	0.3709	0.0617	0.0393
1998	93.3%	0.0000	0.0000	0.0000
1999	289.8%	0.0000	0.0000	0.0000
2000	3.7%	0.1394	0.0002	0.0000
2001	-52.5%	0.8752	0.3304	0.2754
2002	-21.8%	0.3952	0.0718	0.0475
2003	22.5%	0.0345	0.0000	0.0000
2004	3.7%	0.1396	0.0002	0.0000
<b>Average</b>	<b>41.1%</b>	<b>0.1955</b>	<b>0.0464</b>	<b>0.0362</b>
<b>Square Root</b>		<b>44.2%</b>	<b>21.5%</b>	<b>19.0%</b>

## Exhibit 3 Volatility and Downside Volatility

Company	σ	Σ <sub>μ</sub>	Σ <sub>f</sub>	Σ <sub>0</sub>
Oracle	91.7%	44.2%	21.5%	19.0%
Microsoft	50.4%	38.1%	23.1%	21.1%

either the return minus the mean return, or 0. In other words, if a return is higher than the mean, the column shows a 0; if a return is lower than the mean, the column shows the difference between the two. To illustrate, in 1995, Oracle delivered a 44.0% return, which is higher than the mean return of 41.1%; therefore the fifth column shows a 0 for this year. In 2004, however, Oracle delivered a 3.7% return, which is below the mean return of 41.1%; therefore, the fifth column shows the shortfall of -37.4% for this year. “Conditional returns” are either negative or 0 but never positive.

The last column of Exhibit 1 shows the square of the numbers in the fifth column. As the next-to-last row shows, the average of these numbers is 0.1955; and as the last row shows, the square root of this number is 44.2%. What does this number measure? It measures volatility *below* the mean return. This obviously looks like a step in the right direction because we have isolated the downside that investors associate with risk. But is there anything special about the mean return? Is it possible that some investors are interested in assessing volatility below the risk-free rate? Or volatility below zero? Or, more generally, volatility below *any* given return they may consider relevant?

That is exactly what the downside standard deviation of returns with respect to a benchmark *B* measures. This

magnitude, usually referred to as the *semideviation with respect to B* (Σ<sub>B</sub>), is formally defined as:

$$\Sigma_B = \sqrt{(1/T) \cdot \sum_{t=1}^T \{\text{Min}(R_t - B, 0)\}^2} \quad (1)$$

It measures *downside* volatility or, more precisely, volatility *below* the benchmark return *B*. In this expression, *t* indexes time and *T* denotes the number of observations.

Exhibit 2 shows again the returns of Oracle for the 1995-2004 period, as well as its return with respect to three different benchmarks: the mean return (as also shown in the last column of Exhibit 1), a risk-free rate (*R<sub>f</sub>*) of 5%, and zero. The last row shows the semideviations with respect to all three benchmarks.<sup>7</sup>

How should these numbers be interpreted? Each semideviation measures volatility below its respective benchmark. Note that because the risk-free rate of 5% is below Oracle's mean return of 41.1%, we would expect (and find) less volatility below the risk-free rate than below the mean. Similarly, we would expect (and again find) less volatility below 0 than below the mean or the risk-free rate.

It may seem that a volatility of 21.5% below a risk-free rate of 5%, or a volatility of 19% below 0, does not convey a great deal of information about Oracle's risk. In fact, the semideviation of an asset is best used in two contexts: one

7. The next-to-last row shows the semivariances with respect to all three benchmarks, which are simply the square of the semideviations.

Exhibit 4 **Downside Beta with Respect to the Mean**

Year	R	R <sub>m</sub>	Min(R-μ, 0)	{Min(R <sub>m</sub> -μ <sub>m</sub> , 0)}
1995	44.0%	37.6%	0.0%	0.0%
1996	47.8%	23.0%	0.0%	0.0%
1997	-19.8%	33.4%	-60.9%	0.0%
1998	93.3%	28.6%	0.0%	0.0%
1999	289.8%	21.0%	0.0%	0.0%
2000	3.7%	-9.1%	-37.3%	-23.1%
2001	-52.5%	-11.9%	-93.6%	-25.9%
2002	-21.8%	-22.1%	-62.9%	-36.1%
2003	22.5%	28.7%	-18.6%	0.0%
2004	3.7%	10.9%	-37.4%	-3.1%
<b>Average</b>	<b>41.1%</b>	<b>14.0%</b>		

is in relation to the standard deviation of the same asset and the other is in relation to the semideviation of other assets.

Exhibit 3 shows the standard deviation ( $\Sigma$ ) of Oracle and Microsoft over the 1995-2004 period, as well as the semideviations with respect to the mean of each stock ( $\Sigma_{\mu}$ ), a risk-free rate of 5% ( $\Sigma_r$ ), and zero ( $\Sigma_0$ ) over the same period. The semideviations of Oracle are the same as those in Exhibit 2. The mean return of Microsoft during this period was 35.5%.

Note that although the standard deviations suggest that Oracle is far riskier than Microsoft, the semideviations tell a different story. First, although the volatility of Oracle below its mean is less than half of its total volatility ( $0.442/0.917 = 48.2\%$ ), the same ratio for Microsoft is over 75% ( $0.381/0.504 = 75.5\%$ ). In other words, given the volatility of each stock, much more of that volatility is below the mean in the case of Microsoft than in the case of Oracle.<sup>8</sup>

Of course, the semideviation with respect to the mean of Oracle is larger than that of Microsoft. But recall that the mean return of Oracle (41.1%) is also higher than that of Microsoft (35.5%). For this reason, it is perhaps more telling to compare semideviations with respect to the same benchmark for both stocks.

Comparing the semideviations of Oracle and Microsoft with respect to the same risk-free rate of 5%, we see that Microsoft exhibits higher downside volatility (23.1% versus 21.5%). And comparing their semideviations with respect to 0, we again see that Microsoft exhibits higher downside volatility (21.1% versus 19.0%). Therefore, although the standard deviations suggest that Oracle is riskier than Microsoft, the semideviations suggest the opposite.

**The Downside Beta**

As discussed above, an asset can have a high beta if it tends to go up substantially more than the market when the market goes up, even if it does not tend to fall by more than the market when the market falls. Although such an asset would be considered risky in modern portfolio theory simply because of its high beta, most investors would probably disagree with this characterization. Again, investors associate risk with deviations *below* their benchmark return, and the downside risk framework provides a measure that assesses downside potential relative to the market.

The second and third columns of Exhibit 4 show the returns of Oracle (R) and the returns of the market (R<sub>M</sub>) during the 1995-2004 period, the latter summarized by the returns of the S&P 500. Betas are usually estimated as the slope of a regression of the returns of an asset (the dependent variable) on those of the market (the independent variable). If we run a regression of Oracle's returns on the returns of the market with the data displayed in the exhibit, we obtain a slope (beta) of 1.7. This number is usually interpreted as indicating that, on average, when the market goes up and down by 1%, Oracle goes up and down by 1.7%; that is, Oracle magnifies market fluctuations by 70%.

But what if, when assessing risk, investors are only interested in the relative *downside* potential with respect to any chosen benchmark return *B*? Here is where the downside beta comes in. Formally, the *downside beta with respect to B* ( $\beta_B^D$ ) is defined as:

$$\beta_B^D = \frac{\sum_{t=1}^T \{\text{Min}(R_t - B, 0) \cdot \text{Min}(R_{Mt} - B_M, 0)\}}{\sum_{t=1}^T \{\text{Min}(R_{Mt} - B_M, 0)\}^2} \quad (2)$$

8. In fact, the distribution of Microsoft's returns has a slight negative skewness (a longer left tail) and that of Oracle has a significant positive skewness (a longer right tail).

Exhibit 5 **Downside Beta with Respect to the Risk-Free Rate and 0**

Year	Min(R-R <sub>r</sub> , 0)	Min(R-0, 0)	Min(R <sub>M</sub> -R <sub>r</sub> , 0)	Min(R <sub>M</sub> -0, 0)
1995	0.0%	0.0%	0.0%	0.0%
1996	0.0%	0.0%	0.0%	0.0%
1997	-24.8%	-19.8%	0.0%	0.0%
1998	0.0%	0.0%	0.0%	0.0%
1999	0.0%	0.0%	0.0%	0.0%
2000	-1.3%	0.0%	-14.1%	-9.1%
2001	-57.5%	-52.5%	-16.9%	-11.9%
2002	-26.8%	-21.8%	-27.1%	-22.1%
2003	0.0%	0.0%	0.0%	0.0%
2004	-1.3%	0.0%	0.0%	0.0%

where  $t$  indexes time and  $T$  denotes the number of observations;  $R$  and  $R_M$  denote the returns of an asset and those of the market; and  $B$  and  $B_M$  denote the benchmarks for the asset and the market.<sup>9</sup>

Although expression (2) looks somewhat complicated, the estimation of a downside beta is actually quite simple in practice. It can, as we show in the appendix, be estimated in a single cell in Excel, but let's first take the longer (and more intuitive) road:

1. Choose the relevant benchmark returns for the asset ( $B$ ) and for the market ( $B_M$ ).

2. Calculate "conditional returns" for the asset ( $R_t^*$ ) with respect to  $B$  and for the market ( $R_{Mt}^*$ ) with respect to  $B_M$ .

3. Estimate the slope of a regression *without a constant* between these "conditional returns;" that is, run  $R_t^* = \lambda \cdot R_{Mt}^* + u_t$ , where  $R_t^* = \text{Min}(R_t - B, 0)$ ,  $R_{Mt}^* = \text{Min}(R_{Mt} - B_M, 0)$ , and  $u_t$  is an error term, and obtain  $\beta_B^D = \lambda$ .

To illustrate, consider as benchmarks the mean return of Oracle ( $\mu$ ) and the market ( $\mu_M$ ); that is,  $B = \mu = 41.1\%$  and  $B_M = \mu_M = 14.0\%$ . The last two columns of Exhibit 4 show the "conditional returns" for Oracle and for the market with respect to these two benchmarks. A regression without a constant between these two "conditional returns" series yields a slope (hence a downside beta) of 2.3.<sup>10</sup>

How should this number be interpreted? It indicates that, on average, when the market falls by 1% below its mean, Oracle tends to fall by 2.3% below its own mean. In other words, Oracle magnifies the downward swings of the market. Note, however, that the mean return of Oracle (41.1%) is much larger than that of the market (14.0%), which brings us back to a point similar to one made earlier:

it may make sense to use the same benchmark for both the asset and the market.

The first two columns of Exhibit 5 show the "conditional returns" of Oracle with respect to a risk-free rate of 5% and with respect to zero. The last two columns show the "conditional returns" of the market with respect to the same two benchmarks. We can then calculate the downside beta of Oracle with respect to a risk-free rate of 5% by running a regression without a constant of the numbers in the second column on those in the fourth column. Similarly, we can calculate the downside beta of Oracle with respect to zero by running a regression without a constant of the numbers in the third column on those in the last column. We obtain 1.4 in the first case and 1.6 in the second case.

How should these numbers be interpreted? The downside beta of 1.4 with respect to the risk-free rate indicates that, on average, when the market falls by 1% below the risk-free rate of 5%, Oracle falls by 1.4% below the same 5%, thus amplifying 40% the downside swings in the market with respect to the risk-free rate. In the second case, the interpretation is even clearer: The downside beta of 1.6 with respect to 0 indicates that, on average, when the market falls by 1%, Oracle falls by 1.6%, thus magnifying by 60% the downside swings of the market.

### Downside Risk and Required Returns on Equity

The debate about the variables that properly explain the cross-section of stock returns is also a debate on how to properly estimate the required return on equity, which in turn leads to a proper estimation of the cost of capital. The cost of capital is critical for project evaluation, firm valuation, and capital structure planning, to name but a few important applications.

9. Note that this expression allows for different benchmarks for the asset and the market such as, for example, the mean return of the asset and the market. However, it is of course possible to choose  $B=B_M$ , such as when the benchmark is the risk-free rate or 0. Note, also, that the definition of downside beta in (2) is only one of the several that

have been proposed in the literature.

10. The reason for running the regression without a constant is somewhat technical and we will not discuss it here. See J. Estrada, "Systematic Risk in Emerging Markets," *Emerging Markets Review* (2002), 4, 365-379.

## Exhibit 7 Company-Specific Risk

Company	$\beta$	$\Sigma_{\mu}$	$\Sigma_f$	$\Sigma_0$	$\beta_{\mu}^D$	$\beta_f^D$	$\beta_0^D$
Cisco	2.1	37.0%	38.7%	38.0%	2.5	2.4	2.5
Coca-Cola	0.2	16.3%	17.3%	16.7%	0.7	0.7	0.7
Dell	1.7	31.1%	30.7%	30.1%	1.9	1.8	1.8
GE	1.0	17.3%	18.2%	17.5%	1.1	1.1	1.1
Intel	2.2	38.8%	38.8%	38.2%	2.3	2.2	2.3
McDonald's	0.9	21.1%	21.6%	21.0%	1.1	1.1	1.1
Oracle	1.5	35.8%	36.6%	35.9%	2.1	2.0	2.1
Starbucks	0.6	28.2%	23.5%	23.0%	1.2	0.8	0.8
Sun	2.8	43.0%	47.0%	46.2%	3.0	3.1	3.2
Wal-Mart	0.6	18.1%	19.0%	18.3%	0.9	0.9	0.9
<b>S&amp;P</b>	<b>1.0</b>	<b>11.7%</b>	<b>12.5%</b>	<b>11.9%</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
<b>Average</b>	<b>1.3</b>	<b>28.7%</b>	<b>29.1%</b>	<b>28.5%</b>	<b>1.7</b>	<b>1.6</b>	<b>1.7</b>

### Models

The required return on any asset basically consists of two parts, a risk-free rate and a risk premium. The former compensates investors for the expected loss of purchasing power and the latter for bearing risk. The risk premium in turn has two components, a market-risk premium and a company-specific factor. The former measures the extra compensation required by investors to invest in risky securities (equity) rather than in safe securities (bonds), and the latter adjusts this market-wide premium by the specific risk of a company.

Formally, then, the required return on equity of company  $i$  ( $RRE_i$ ) can be expressed as:

$$RRE_i = R_f + MRP \cdot SR_i, \quad (3)$$

where  $R_f$ ,  $MRP$ , and  $SR_i$  denote the risk-free rate, the market risk premium, and the specific risk of company  $i$ . According to the CAPM, this specific risk is measured by beta, and then (3) turns into:

$$RRE_i = R_f + MRP \cdot \beta_i, \quad (4)$$

which is the familiar expression for the CAPM (sometimes referred to as the securities market line).

Downside risk measures can be used as proxies for the specific risk of a company, thus replacing beta in expression (4). If company-specific risk is measured by the semideviation of a company *relative to* the semideviation of the market, then (3) turns into:

$$RRE_i = R_f + MRP \cdot (\Sigma_{Bi} / \Sigma_{BM}), \quad (5)$$

where  $\Sigma_{Bi}$  and  $\Sigma_{BM}$  denote the semideviation with respect to the benchmark return  $B$  for company  $i$  and for the market. In this model, a company's cost of equity depends on its downside volatility relative to that of the market.<sup>11</sup>

Alternatively, if company-specific risk is measured by the downside beta, then (3) turns into:

$$RRE_i = R_f + MRP \cdot \beta_{Bi}^D, \quad (6)$$

where  $\beta_{Bi}^D$  denotes the downside beta of company  $i$  with respect to the benchmark return  $B$ . In this model, a company's cost of equity depends on its downside potential relative to that of the market.

### Implementation

Estimating required returns on equity from expressions (5) and (6) is just as simple as doing it with the CAPM. To illustrate, Exhibit 7 shows the beta, semideviations, and downside betas of ten well-known companies. These figures were estimated using monthly data over the 2000-2004 period.<sup>12</sup> Semideviations and downside betas were calculated with respect to three benchmarks: the mean return, a risk-free rate, and zero. All magnitudes in the exhibit are expressed in annualized terms.

In order to estimate required returns on equity from expressions (4)-(6), we need estimates for the risk-free rate and the market-risk premium. For the former we will use 4.2%, which was the yield on 10-year Treasury notes at the

11. This model, admittedly ad-hoc, may seem strange in that its counterpart in traditional finance would have the ratio of a company's volatility to the market's volatility as a measure of company-specific risk. Unusual as it may sound, models based on this ratio of standard deviations have been proposed for emerging markets; see, for example, S. Godfrey and R. Espinosa, "A Practical Approach to Calculating Costs of Equity for Investment

in Emerging Markets," *Journal of Applied Corporate Finance*, (Fall 1996), pp. 80-89.

12. Betas are usually estimated using five years of monthly data. For consistency, all the other figures in the exhibit were also estimated with five years of monthly data. The semideviations and downside betas calculated in the previous sections with ten years of annual data were for illustrative purposes only.

## Exhibit 8 Required Returns on Equity

Company	$\beta$	$\Sigma_{\mu}$	$\Sigma_f$	$\Sigma_0$	$\beta_{\mu}^D$	$\beta_f^D$	$\beta_0^D$
Cisco	15.9%	21.6%	21.2%	21.8%	17.8%	17.6%	18.1%
Coca-Cola	5.5%	11.9%	11.8%	11.9%	8.0%	8.1%	8.0%
Dell	13.5%	18.8%	17.7%	18.2%	14.7%	13.9%	14.2%
GE	9.7%	12.3%	12.2%	12.3%	10.1%	10.1%	10.2%
Intel	16.1%	22.4%	21.3%	21.9%	17.1%	16.2%	16.7%
McDonald's	9.2%	14.1%	13.7%	13.9%	10.5%	10.3%	10.4%
Oracle	12.3%	21.0%	20.3%	20.9%	15.8%	15.4%	15.7%
Starbucks	7.3%	17.5%	14.5%	14.9%	10.6%	8.7%	8.7%
Sun	19.4%	24.4%	24.8%	25.7%	20.9%	21.3%	22.0%
Wal-Mart	7.4%	12.7%	12.5%	12.7%	9.2%	9.1%	9.2%
<b>Average</b>	<b>11.6%</b>	<b>17.7%</b>	<b>17.0%</b>	<b>17.4%</b>	<b>13.5%</b>	<b>13.1%</b>	<b>13.3%</b>
<b>Diff. CAPM</b>	<b>N/A</b>	<b>6.1%</b>	<b>5.4%</b>	<b>5.8%</b>	<b>1.8%</b>	<b>1.5%</b>	<b>1.7%</b>

beginning of the year 2005; for the latter we will use 5.5%, which is the mid-point of the widely used 5-6% interval in the U.S.

Exhibit 8 shows estimates of the required return on equity based on expressions (4)-(6) for  $R_f = 4.2\%$  and  $MRP = 5.5\%$ . The first row of the exhibit shows the risk variable on which the estimates are based.

Let's go back to Oracle, which we have been discussing throughout this article. The required returns on equity for this company according to the different models are given by:

$$\text{Based on } \beta \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(1.5) = 12.3\%$$

$$\text{Based on } \Sigma_{\mu} \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(35.8\%/11.7\%) = 21.0\%$$

$$\text{Based on } \Sigma_f \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(36.6\%/11.7\%) = 20.3\%$$

$$\text{Based on } \Sigma_0 \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(35.9\%/11.7\%) = 20.9\%$$

$$\text{Based on } \beta_{\mu}^D \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(2.1) = 15.8\%$$

$$\text{Based on } \beta_f^D \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(2.0) = 15.4\%$$

$$\text{Based on } \beta_0^D \rightarrow RRE_{\text{Oracle}} = 4.2\% + (5.5\%)(2.1) = 15.7\%$$

Note, first, that estimating required returns on equity is virtually as simple with the downside risk models as it is with the CAPM. Note, also, that although the CAPM yields a required return on equity of just over 12%, the models based on the semideviation yield estimates in the 20-21% range, and those based on downside beta in the 15-16% range. The differences among the estimates generated from the different models are, needless to say, far from negligible.

The averages over these ten companies also indicate substantial differences between the required returns on equity based on the CAPM and those based on downside

risk models; the last row of Exhibit 8 shows these differences. The models based on downside beta yield required returns on equity 1.5-1.8% higher than the CAPM, and those based on the semideviation, 5.4-6.1% higher than the CAPM. Again, these differences are substantial and simply too large for practitioners to ignore.

### A Brief Digression: Risk-Adjusted Returns

Risk and return are two sides of the same coin and it makes little sense to assess one while ignoring the other. Comparing the return of funds with vastly different risk (say, large-cap and small-cap funds, or value and growth funds) is like comparing apples and oranges. Comparing two funds on the basis of their *risk-adjusted* return, however, is an appropriate, apples-to-apples comparison.

The most widely used measure of a fund's risk-adjusted return is the Sharpe ratio ( $S_p$ ), which can be expressed as:

$$S_p = \frac{E(R_p) - R_f}{\sigma_p}, \quad (7)$$

where  $E(R_p)$  and  $\sigma_p$  denote the expected return and standard deviation of fund  $p$  and  $R_f$  denotes the risk-free rate. As is obvious from this expression, the Sharpe ratio implicitly states that the standard deviation is the proper measure of a fund's risk.

However, the Sharpe ratio, by implication, is subject to all the criticisms discussed above on the standard deviation. An alternative risk-adjusted return measure based on downside risk is provided by the Sortino ratio ( $T_p$ ), which can be expressed as:

$$T_p = \frac{E(R_p) - B}{\Sigma_{Bp}}, \quad (8)$$

where B represents a benchmark return (which may depend on the investor and the fund) and  $\Sigma_{Bp}$  denotes the semideviation of fund p with respect to the benchmark return B.

A straightforward comparison of (7) and (8) reveals two differences between these two measures of risk-adjusted return. First, the Sortino ratio implicitly states that the semideviation is the appropriate measure of risk. Second, the Sortino ratio neither (necessarily) calculates excess returns with respect to the risk-free rate nor (necessarily) calculates risk with respect to the mean.<sup>13</sup>

These differences between standard deviation and semideviation imply that the perceived risk (and as a result the risk-adjusted return) of an asset depends on which of these two magnitudes is used to assess it. In fact, the *Forbes* article mentioned above showed that a ranking of funds based on the Sortino ratio can be vastly different from another based on the Sharpe ratio.<sup>14</sup>

## Conclusion

Investors think of risk differently from the way it is defined in modern portfolio theory. Both the standard deviation and beta give equal weight to upside and downside fluctuations. Investors, however, do not. It is perhaps for this reason that the downside risk framework has been rapidly gaining acceptance among academics and practitioners.

Semideviation exhibits several interesting characteristics as a measure of risk. It captures the downside volatility that investors want to avoid and not the upside volatility investors are seeking. It assesses risk just as well as standard deviation when the underlying distribution of returns is symmetric and the benchmark is the mean, and it does a better job when this distribution is skewed or the benchmark is any return other than the mean. And it summarizes in a single number the relevant information provided by two parameters, the standard deviation and the coefficient of skewness.

The downside beta isolates the downside potential of an asset's returns relative to that of the market's returns. According to this measure, assets that magnify the market's upward swings are not necessarily risky; only those that magnify the market's downward swings are.

Both the semideviation and the downside beta are easy to estimate and can be calculated in just one cell in Excel. Among many other uses, they can be used to estimate required returns on equity and to assess risk-adjusted returns. And as the data from the few companies we considered shows, the differences between required returns on equity based on the CAPM and those based on downside risk can be substantial.

13. There is a third, more technical difference between the Sharpe ratio and the Sortino ratio. To estimate the former, the mean return and standard deviation of a fund are usually estimated from the fund's historical data. To estimate the latter, however, a bootstrap procedure is recommended; see F. Sortino and R. van der Meer, "Downside Risk," *Journal of Portfolio Management*, (Summer 1991), pp. 27-31.

Many argue that, in the end, risk is in the eyes of the beholder. If that is indeed the case, and if investors do associate risk with negative outcomes and downside fluctuations, then the risk measures and asset-pricing models discussed in this article should find room in most practitioners' toolkits.

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## Appendix: Estimating Semideviations and Downside Betas in Excel

Estimating mean returns, standard deviations, and betas is trivial in Excel. Estimating semideviations and downside betas is not much more difficult and can be done in just one cell. To see how, consider Exhibit 6, which shows the organization of the relevant data in an Excel file. (Before proceeding, you may want to input these data in Excel yourself so you can reproduce the calculations discussed below.) Input, then:

- The years 1995-2004 in cells A2:A11.
- The returns of Oracle (R) in cells B2:B11.
- The returns of the market ( $R_M$ ) in cells C2:C11
- The labels 'Year,' 'R,' and ' $R_M$ ' in cells A1:C1.
- The labels 'Observations' and 'Mean Return' in cells A12:A13.

Exhibit 6: **Excerpt from an Excel File**

	A	B	C
1	Year	R	$R_M$
2	1995	44.0%	37.6%
3	1996	47.8%	23.0%
4	1997	-19.8%	33.4%
5	1998	93.3%	28.6%
6	1999	289.8%	21.0%
7	2000	3.7%	-9.1%
8	2001	-52.5%	-11.9%
9	2002	-21.8%	-22.1%
10	2003	22.5%	28.7%
11	2004	3.7%	10.9%
12	<b>Observations</b>		
13	<b>Mean Return</b>		

14. Both the Sharpe ratio and the Sortino ratio can be manipulated and therefore should be interpreted with caution. Hedge fund managers, in particular, can use derivatives to increase this ratio without improving performance; see I. Dugan, "Have Hedge Funds Hijacked the Model?" *Wall Street Journal Europe* (August 31, 2005).

Make sure before proceeding that your Excel file looks exactly as Exhibit 6. Once you do that, the next step is to have Excel count the number of observations and calculate the mean return of both series. Then,

- Input **'=COUNT(B2:B11)'** in cell B12 and hit 'Enter.'
- Input **'=AVERAGE(B2:B11)'** in cell B13 and hit 'Enter.'
- Copy cells B12:B13 into C12:C13.

After these steps you should have obtained a count of 10 observations in both series and mean returns of 41.1% and 14.0% for Oracle and the market. For the sake of completeness, calculate the standard deviation and beta of Oracle by doing the following:

- Input **'=STDEVP(B2:B11)'** in cell B14 and hit 'Enter.'
- Input **'=LINEST(B2:B11, C2:C11)'** in cell B15 and hit 'Enter.'

After these steps you should have obtained a standard deviation of 91.7% and a beta of 1.7. The 'LINEST' command returns the slope of a regression between two variables, which is the beta of Oracle in our case.

To calculate the semideviations with respect to the mean, a risk-free rate of 5%, and zero, do the following:

- Input **'=SQRT(SUMPRODUCT(B2:B11-B13, B2:B11-B13, N(B2:B11<B13))/B12)'** in cell B16 and hit 'Enter.'
- Input **'=SQRT(SUMPRODUCT(B2:B11-0.05, B2:B11-0.05, N(B2:B11<0.05))/B12)'** in cell B17 and hit 'Enter.'
- Input **'=SQRT(SUMPRODUCT(B2:B11-0, B2:B11-0, N(B2:B11<0))/B12)'** in cell B18 and hit 'Enter.'

After these steps you should have obtained semideviations with respect to the mean, a risk-free rate of 5%, and zero of 44.2%, 21.5%, and 19.0%, respectively, which of course are the same numbers shown in Exhibits 2 and 3.

What Excel basically does when the first instruction is entered is to calculate "conditional returns" with respect to the mean (previously calculated in B13). It then squares the "conditional returns," calculates the average of the squared "conditional returns," and finally takes the square root of the sum. In the second and third instructions, Excel does the same but using 5% and 0 as benchmark returns.

Finally, to calculate downside betas with respect to the mean, a risk-free rate of 5%, and zero, do the following:

- Input **'= LINEST(IF(B2:B11<B13, B2:B11-B13, 0), IF(C2:C11<C13, C2:C11-C13, 0), FALSE)'** in cell B19 and hit 'Ctrl+Shift+Enter' simultaneously.
- Input **'= LINEST(IF(B2:B11<0.05, B2:B11-0.05, 0), IF(C2:C11<0.05, C2:C11-0.05, 0), FALSE)'** in cell B20 and hit 'Ctrl+Shift+Enter' simultaneously.
- Input **'= LINEST(IF(B2:B11<0, B2:B11-0, 0), IF(C2:C11<0, C2:C11-0, 0), FALSE)'** in cell B21 and hit 'Ctrl+Shift+Enter' simultaneously.

After these steps, you should have obtained downside betas with respect to the mean, a risk-free rate of 5%, and zero of 2.3, 1.4, and 1.6, respectively, which of course are the same numbers we had calculated from the data in Exhibits 4 and 5.

Note that these last three instructions are what Excel calls arrays, which means that they are not entered by hitting 'Enter' as usual but by hitting 'Ctrl+Shift+Enter' *simultaneously*. Note, also, that the 'False' at the end of these instructions is what instructs Excel to estimate the slope of a regression *without* a constant.

After a little practice, you should have no trouble adapting these expressions to any number of observations (simply by changing the relevant ranges where the data is contained) or to any benchmark. The bottom line is that, in Excel, both semideviations and downside betas can easily be calculated in just one cell.

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