
Morningstar Style Box™ Methodology

Morningstar Methodology

October 2020

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Introduction

The Morningstar Style Box™ was introduced in 1992 to help investors and advisors determine the investment style of a fund. Different investment styles often have different levels of risk and lead to differences in returns. Therefore, it is crucial that investors have a tool to measure their style exposure. The style box provides an intuitive visual representation of style that helps investors build better portfolios and monitor them more precisely.

Morningstar classifies funds as being large-cap, mid-cap, or small-cap based on the market capitalization of the fund's stock holdings. Morningstar classifies funds as being value, blend, or growth based on the value-growth orientation of the fund's stock holdings. The nine possible combinations of these characteristics correspond to the nine squares of the style box: Size is displayed along the vertical axis, and style is displayed along the horizontal axis.

Morningstar's original style box model for equity funds used the median market cap of the underlying stocks to determine a fund's average size. The original model measured value-growth orientation based on two price ratios (price/earnings and price/book for U.S. equity funds and price/book and price/cash flow for non-U.S. equity funds). In the original model, all non-U.S. stocks and funds were measured against a single set of breakpoints.

The style box model uses 10 factors—five for value and five for growth—to measure a stock's value-growth orientation. The multifactor approach produces more accurate and stable stock and fund style assignments. To measure size, the model uses flexible rather than static breakpoints between large-, mid-, and small-cap stocks. The methodology also measures stocks in the context of a geographic style zone rather than grouping all non-U.S. stocks together.

The methodology starts at the stock level and therefore fosters a shared analytical framework that can also be applied to fund research, portfolio assembly, and market monitoring. In the United States, Morningstar introduced the enhanced 10-factor model for U.S. stocks and U.S. equity funds in May 2002 and for non-U.S. stocks and global funds in March 2004. Outside of the U.S., the 10-factor model was introduced in various markets starting in March 2004. Morningstar applies the same methodology to all types of equity managed products, such as open-end mutual funds, closed-end funds, separate accounts, and so on. Further enhancements were made in October 2020 to provide a more normal distribution of Style Scores across the Scoring Groups.

Morningstar places all global stocks within one of seven style zones:

Style Zones

United States

Latin America

Canada

Europe (Stocks from African countries are scored with European stocks)

Japan

Asia ex Japan

Australia/New Zealand

Within each style zone, stocks are assigned to the rows of the Style Box as follows:

Large-cap	Stocks within the top 70% of the cumulative market cap of each style zone
Mid-cap	70%-90% of the cumulative market cap of each style zone
Small-cap	90-100% of the cumulative market cap of each style zone

The style box uses 10 factors for style:

Value Score Components and Weights Growth Score Components and Weights

Forward-Looking	Forward-Looking
1. Price/Projected Earnings*	1. Long-Term Projected Earnings Growth
Historical-based measures:	Historical-based measures:
2. Price/Book*	2. Book Value Growth
3. Price/Sales*	3. Sales Growth
4. Price/Cash Flow*	4. Cash Flow Growth
5. Forward Dividend Yield	5. Historical Earnings Growth

* The calculations are done with the yield form of these variables (that is, with price in the denominator of the fraction).

This paper explains the theories and methodology behind the 10-factor style box. The first section explains how size and style scores are calculated for each stock. The second section explains how stock style is used to determine the style placement for a mutual fund or other portfolio.

Driving Principles

The Morningstar Style Box is applicable in all equity markets. A geographic framework ensures that stocks are compared with their closest peers and that style assignments are relevant to local investors everywhere. World equity markets are divided up into seven style zones: United States, Latin America, Canada, Europe, Japan, Asia ex Japan, and Australia/New Zealand.

The first premise of this model is that stock size breakpoints should be flexible and responsive to changing market conditions. Instead of using fixed dollar breakpoints to classify securities as large-cap, mid-cap, or small-cap, the model bases that distinction on each stock's position in the cumulative capitalization of its style zone. Large-cap stocks are those that together account for the top 70% of the capitalization of each style zone; mid-cap stocks represent the next 20%; and small-caps represent the balance.

The second premise of this model is that a stock's value-growth orientation should be relative to a peer group, or scoring group, as defined by the style zone of the stock and its capitalization (for example, Latin America large-cap). A Japanese small-cap stock performs quite differently than a European large-cap stock, and the two should not be scored relative to each other. Therefore, two stocks may have similar financial ratios and growth prospects, but they may be given different value-growth assignments if they are in different scoring groups.

The third premise of this model is that a stock's value orientation and growth orientation are distinct measures. As such, they are estimated using related but separate variables. Once estimated (Overall Value and Overall Growth scores), they are combined into a single net value-core-growth, or VCG, score.

- ▶ A high Overall Value score indicates that a stock's price is relatively low, given the anticipated per-share earnings, book value, revenues, cash flow, and dividends that the stock provides to investors. A high price relative to these measures indicates that a stock's value orientation is weak, but it does not necessarily mean the stock is growth-oriented.
- ▶ A high Overall Growth score indicates that a stock's per-share earnings, book value, revenues, and cash flow are expected to grow quickly relative to other stocks in the same scoring group. A weak growth orientation does not necessarily mean a stock has a strong value orientation.
- ▶ It follows that an individual stock may have any combination of strong or weak growth and value characteristics. Where one set of characteristics is dominant, the stock can be classified accordingly. Where the stock's growth and value characteristics are similar in strength, the stock will be given a "core" style assignment. For stocks, the central column of the style box represents the "core" style. For funds, both value and growth managers often hold core stocks for diversification; therefore, the central column of the style box for funds represents the "blend" style.

The fourth premise of this model is that historical measures alone can rarely fully capture a stock's value-growth orientation. Investors and institutions trade based on historical measures as well as future expectations. Therefore, Morningstar includes both historical and forward-looking financial measures in the model to ensure that all information available to active fund managers is considered. The forward-looking measures are primarily based on third-party analysts' earnings estimates. When forward-looking data is available, it contributes at least 50% of the stock's style assignment.

The fifth and last premise of this model is that once a stock's size and value-growth orientation is determined, these scores can also be used for fund research, portfolio assembly, and market monitoring. Morningstar assigns X- and Y-coordinates for style and size that form the building blocks for this unified framework for holdings-based analysis. This integrated system can help investors and advisors understand the style positioning of funds and construct well-diversified portfolios that are consistent with the investor's return expectations and risk tolerances. Also, in the U.S., investors can monitor the performance of their U.S. portfolios with Morningstar's style-based market indexes, which offer broad coverage of the U.S. market and are based on the same structural foundation as the style box.

Data

Terminology and Notation

The following variables relate to company earnings per share:

e_1 = forecasted EPS for the current fiscal year

e_0 = EPS for the Trailing-Twelve Months (TTM)

e_{-1} = EPS for the TTM period prior to e_0

e_{-2} = EPS for the TTM period prior to e_{-1}

e_{-3} = EPS for the TTM period prior to e_{-2}

e_{-4} = EPS for the TTM period prior to e_{-3}

The same notation is used for book value per share, revenue per share, cash flow per share, and dividends per share except that "b", "r", "c" and "d", respectively, are substituted for "e" in the example above.

When the data is available, the model uses EPS from continuing operations instead of net EPS. The model uses cash flow from operations instead of total cash flow. All financial statement data is supplied from Morningstar, using the most up-to-date information at month-end.

For financials stocks, price/cash flow is not used for the value factor calculation because cash flow from operations data is not meaningful for banks and insurance companies.

The following variables relate to the yield factors that are used in determining a stock's value orientation:

p	=	current stock price per share, from the most recent month-end
e_1/p	=	projected earnings yield (uses third-party estimates for e_1 , where available)
b_1/p	=	book value yield (projected based on historical data)
r_1/p	=	revenue yield (projected based on historical data)
c_1/p	=	cash flow yield (projected based on historical data)
d_1/p	=	forward dividend yield (projected based on historical data)

For the purpose of determining stock value orientation, Morningstar may also use an additional growth measure. When a third-party estimate of e_1 is not available, Morningstar calculates a projection for e_1 based on historical growth rates up through the most recent year, e_0 .

$g(e_1)$ = forecast growth in EPS for the current fiscal year, based on historical growth rates and using e_0 as the end point for growth. Used to calculate e_1 to determine a stock's value orientation.

The same notation is used to forecast growth for book value, revenue, cash flow, and dividends except that "b", "r", "c" and "d," respectively, are substituted for "e" in the example above.

For the purposes of determining stock growth orientation, a different growth measure is used:

$g'(e)$ = historical average growth rate of EPS, based on historical growth rates and using e_0 or e_{-1} as the end point for growth. Used to determine a stock's growth orientation.

The same notation is used for historical average growth rates in book value per share, revenue per share, and cash flow per share except that "b", "r" and "c", respectively, are substituted for "e" in the example above. Because dividends are commonly associated with value-oriented stocks, dividend growth is not one of the five growth factors.

In addition, for earnings growth only, the following notation applies:

$g(e_5)$ = third-party long-term earnings growth forecast (median for U.S. and non-U.S. stocks; if not available, mean is used)

Stock capitalization and company size are treated as synonymous in this document.

Frequency

An individual stock shows continuous short-term variation as its price and other attributes change. To capture the effects of such changes, Morningstar recalculates each stock's style box assignment at the month-end.

The Morningstar Equity Sample

Stock Style Box assignments are based on information drawn from Morningstar's equity sample. The equity sample includes more than 50,000 stocks from 89 different countries.

The following security types are excluded from the original scoring groups:

- ▶ American Depositary Receipts
- ▶ American Depositary Shares
- ▶ Fixed-dividend shares
- ▶ Convertible notes, warrants, and rights
- ▶ Tracking stocks
- ▶ Preferred shares (unless it is the most commonly held share)
- ▶ Mutual funds
- ▶ Over-the-Counter Pink listings

VCG Style Assignments and Capitalization Effects

VCG style assignments can appear inconsistent where stocks are in different scoring groups but are otherwise similar. For instance, if European mid-cap stocks have an average price/earnings ratio of 20 and European large-cap stocks have an average P/E of 16, a European mid-cap stock with a P/E of 18 might be considered strongly value-oriented, whereas a large-cap stock with the same P/E might be considered to have a weak value orientation.

For the same reason, stocks that are "borderline" in their size group and vary from month to month between the large- and mid-cap groups, for example, may experience variation in their VCG assignments. This variation may be attributable to the use of different comparison groups in successive months, not to variation in value or growth characteristics.

Stocks may therefore experience changes in their month-to-month VCG style assignment for two separate reasons:

- ▶ Their fundamental characteristics vary from month to month.
- ▶ Their size group varies from month to month, thus changing the scoring group on which Morningstar bases their VCG style assignment.

Assigning Stocks to Scoring Groups

Stocks are first divided into seven style zones based on their country of domicile:

- ▶ United States
- ▶ Latin America
- ▶ Canada
- ▶ Europe
- ▶ Japan
- ▶ Asia ex Japan
- ▶ Australia/New Zealand

Then, capitalization assignments are determined as follows:

1. For all stocks in a style zone, convert the market cap of each stock into a common currency. Order the stocks in each style zone in descending order by size and calculate cumulative capitalization as a percentage of total sample capitalization as each stock is added to the list.
2. The stock that causes cumulative capitalization to equal or exceed 40% of the style zone's total cap is the final one assigned to the giant-cap group.
3. The largest of the remaining stocks are assigned to the large-cap group until cumulative capitalization equals or exceeds 70% of the total capitalization of the style zone.
4. The largest of the remaining stocks are assigned to the mid-cap group until cumulative capitalization equals or exceeds 90% of the total capitalization of the style zone.
5. The largest of the remaining stocks are assigned to the small-cap group until cumulative capitalization equals or exceeds 97% of the total capitalization of the style zone.
6. The remaining stocks are assigned to the micro-cap group.

Within each style zone, giant-cap and large-cap stocks are combined for VCG style scoring. Therefore, there are 21 scoring groups, based on each combination of the seven style zones and the three size groups (large, mid, or small).

Basic Process

Growth rates are the foundation for calculating a stock's growth and value orientation. Within respective scoring groups, growth rates are ranked to measure a stock's growth orientation and used to calculate prospective yields, which are ranked to measure a stock's value orientation.

A stock's growth orientation reflects the rate at which its earnings, book value, revenue, and cash flow are expected to grow; whereas a stock's value orientation reflects the price investors are willing to pay for a share of some combination of the stock's prospective earnings, book value, revenue, cash flow, and forward dividend yield.

Calculating Stock Growth Rates

As many as possible of $g'(e)$, $g'(b)$, $g'(r)$, and $g'(c)$ are calculated for each stock. The example calculation below uses $g'(e)$, but the process is identical for $g'(b)$, $g'(r)$, and $g'(c)$. In addition, if $g(e_5)$ is available from a third party, it is used as a fifth growth rate indicator. Morningstar does not use internal estimates for $g(e_5)$.

The below growth rates are also used to calculate the prospective yield of e_1/p , b_1/p , r_1/p , c_1/p , and d_1/p , which are used to calculate a stock's value-orientation.

$$[7] \quad g'(e)_{-4} = \left(\frac{e_n}{e_{-4}}\right)^{\frac{1}{n+4}} - 1$$

$$[8] \quad g'(e)_{-3} = \left(\frac{e_n}{e_{-3}}\right)^{\frac{1}{n+3}} - 1$$

$$[9] \quad g'(e)_{-2} = \left(\frac{e_n}{e_{-2}}\right)^{\frac{1}{n+2}} - 1$$

$$[10] \quad g'(e)_{-1} = \left(\frac{e_n}{e_{-1}}\right)^{\frac{1}{n+1}} - 1$$

where:

n = the most recent period (0 or -1) in which EPS is positive.

If e_{-1} , e_{-2} , e_{-3} , or e_{-4} is negative, no periodic growth rate is calculated using that data point. If e_0 is negative, prospective yield on that value factor is excluded for that stock. If e_0 and e_{-1} are negative, the growth rate on that growth factor is excluded for that stock. A minimum of one growth rate must be available to calculate e_1/p along with the other value factors; two periodic growth rates must be available to determine $g'(e)$ along with all growth factors.

When all available growth rates have been calculated, average the results:

$$[11] \quad g'(e) = \text{Average}[g'(e)_{-4}, g'(e)_{-3}, g'(e)_{-2}, g'(e)_{-1}]$$

If $n=0$ and if the stock was missing a third-party forecast for e_1 , $g'(e)$ will be the same as the growth rate used in the calculation of the stock's value orientation, $g(e_1)$. Book value, revenue, and cash flow growth rates are calculated in the same way. If the stock has no growth factor data available, the stock is eliminated from the scoring group for calculating growth factor percentile scores.

Calculating Prospective Yields

As many as possible of e_1/p , b_1/p , r_1/p , c_1/p , and d_1/p are calculated for each stock. Because p is known, the method used to forecast e_1 , b_1 , and so on, is key.

If a non-negative third-party forecast of e_1 is available, it is used to calculate the price to prospective yield. If e_1 , b_1 , r_1 , c_1 , or d_1 is forecasted to be negative by a third party, or if e_0 is negative and no third-party forecast is available, prospective yield on that factor is excluded for that stock. If no third-party forecast is available and e_0 is positive, then e_1 is calculated using growth rates as described previously. For prospective yields, internal estimates for e_1 are based on the following straightforward relationship between prospective and current EPS:

$$[1] \quad e_1 = e_0 \times (1 + g(e_1))$$

Calculating Factor Scores for Each Growth and Value Factor

When one or more growth factors and value factors (with or without d_1/p) have been calculated, each stock is assigned a market-cap-weighted percentile score for each factor.

To calculate a percentile score (0-100) for each stock in a scoring group:

1. Rank all stocks in the scoring group by $g'(e)$ or e_1/p in ascending order.
2. Determine the total float market cap of all stocks in the group. Float is defined as the number of shares issued and outstanding, less any shares owned by insiders, 5% owners, and Rule 144 shares.
3. Calculate the float market-cap-weighted average of $g'(e)$ or e_1/p .
4. If all stocks are within 3 weighted standard deviations of the weighted mean, no stocks are trimmed.
5. If not, trim all stocks that are outside 3 weighted standard deviations outside the weighted median. View Appendix A for the trimming algorithm.
6. Recalculate the float-weighted average $g'(e)$, e_1/p for the scoring group and then calculate the Percentile Score for each factor according to the following equation:

$$F_i = 50 \times \left(1 + \frac{x_i - \mu}{3\sigma} \right)$$

where:

- F_i = Percentile score for individual factor
 x_i = Stock factor value
 μ = Float market-cap-weighted factor average
 σ = Float market-cap-weighted factor standard deviation

7. Trimmed stocks are then added back into the Scoring Group and receive the score of lowest- and highest-scoring non trimmed stocks.
8. Percentile scores for micro-cap stocks are assigned based factor averages and standard deviation of the small-cap scoring group for the respective style zone.

Calculating Overall Value and Growth Scores

When all five value factors and growth factors have been scored from 0 to 100, a weighted average Overall Value and Growth score is calculated for each stock. If available, e/p and g'(e) scores are assigned a weight between 50% and 100% of the Overall Value and Growth score, depending upon the availability of the remaining factors. Each of the other factors is assigned an equal share of the remaining weight (either 50% or, if e/p is unavailable, to 100% if it is the sole factor). At least one factor is needed to calculate a Value or Growth Score (no value score is calculated if d₁/p is the only available factor).

For example, if all five value factors are available, the weights are:

Scores	e ₁ /p	b ₁ /p	r ₁ /p	c ₁ /p	d ₁ /p	Overall Value
	50%	12.5%	12.5%	12.5%	12.5%	
Stock A	41	78	73	88	81	61

Similarly, if all five growth factors are available, the weights are:

Scores	g(e5)	g'(b)	g'(r)	g'(c)	g'(e)	Overall Growth
	50%	12.5%	12.5%	12.5%	12.5%	
Stock A	41	78	73	88	81	61

Determining the Stock's Net VCG Score

Each stock now has an Overall Value score and an Overall Growth score; both range from 0 to 100. Morningstar calculates a net VCG score for each stock by subtracting the stock's Overall Value score from its Overall Growth score. The result can range from 100 (for low-yield, extremely growth-oriented stocks) to negative 100 (high-yield, low-growth stocks).

Raw X and Y Coordinates for Stocks

Morningstar uses a system of X and Y coordinates to determine a stock's style box placement. These coordinates also serve as the building blocks for determining the style of a fund or portfolio. Standard Scores of Growth-Value Scores are used for assignment, such as:

$$\text{Raw } X_i = \left(100 \times \frac{S_i - \mu_i}{\sigma_i} \right) + 150$$

where:

S_i	=	$G - V$, Growth-Value Score
G	=	Growth Score
V	=	Value Score
μ_i	=	Scoring group Growth-Value average
σ_i	=	Scoring group Growth-Value standard deviation
$\frac{S_i - \mu}{\sigma}$	=	Standard Score

This ensures:

- ▶ Within a scoring group the stocks with $G - V$ closest to μ_i will have a Raw X score closest to 150.
- ▶ Within a scoring group the stocks with Standard Scores closest to negative 0.5 and positive 0.5 will have Raw X scores closest to 100 and 200, respectively.

Each stock is next assigned a Raw Y score, which represents its placement along the vertical axis of the style box. Morningstar uses the natural logarithm of market cap to measure stock size. This number is scaled so that each mid-cap stock has a raw Y size score between 100 and 200. Hence, given a stock with a market cap of "cap":

$$[13] \quad \text{Raw } Y = 100 \times \left[1 + \frac{\ln(\text{cap}) - \ln(\text{cap}_1)}{\ln(\text{cap}_2) - \ln(\text{cap}_1)} \right]$$

where:

cap_2 = the market cap that corresponds to the breakpoint between large- and mid-cap stocks for the stock's respective style zone

cap_1 = the market cap that corresponds to the breakpoint between mid- and small-cap stocks for the stock's respective style zone

Raw Y is unbounded for large- and small-cap stocks.

When all stocks have been assigned value-growth orientation (Raw X) and size (Raw Y) scores, Morningstar determines the stock's style box placement.

Small	Raw Y < 100	Value	Raw X < 100
Mid-cap	$100 \leq \text{Raw Y} \leq 200$	Core	$100 \leq \text{Raw X} \leq 200$
Large	$200 < \text{Raw Y}$	Growth	$200 < \text{Raw X}$

Note: See Rescaling section for the differences between raw X and Y and rescaled X and Y for stocks.

Raw X and Y Coordinates for Funds

The style box assignment for a fund or portfolio is based on the asset-weighted average of the raw X and raw Y scores for the underlying stocks. Morningstar calculates each fund's style box assignment upon receipt of a new portfolio of holdings. Morningstar uses stock scores from the same date as the fund portfolio date in order to determine the fund's style box assignment.

Let:

$raw \bar{X}$ = the asset-weighted average of the raw X scores of the stocks in a fund

$raw \bar{Y}$ = the asset-weighted average of the raw Y scores of the stocks in a fund

X_i = the raw X score for stock "i"

Y_i = the raw Y score for stock "i"

N = the number of stocks in the fund

w_i = the fraction of the fund's stock assets held in an individual stock "i"

so that:

$$[14] \quad raw \bar{X} = \sum_{i=1}^N w_i X_i$$

$$[15] \quad raw \bar{Y} = \sum_{i=1}^N w_i Y_i$$

This method of assigning fund style involves blending raw X and raw Y scores that were generated in different style zones or size groups. These style and size scores may correspond to different net VCG style scores or market caps, but they can be blended together into the fund-level score, because they represent each stock's relative size and style.

The center column of the style box for funds ("blend") is a little different than the center column for stocks ("core"). Few or no funds contain only stocks with extreme value-growth orientation scores, and both value and growth managers often hold core stocks for diversification or other reasons. As a result, funds show less variation than stocks do on the x-axis; that is, funds tend to cluster nearer the middle of the x-axis.

It follows that the threshold points between value, blend, and growth funds are closer to the center of the x-axis than are the threshold points between value, core and growth stocks. Therefore, the value and growth areas are expanded toward the center for funds, and the remaining "blend fund" area is narrower than the "core stock" area.

Let γ denote the ratio of the width of the blend fund area to the width of the core stock area. Then,

[5] value-blend breakpoint =

$$150 \times \left(1 - \frac{\gamma}{3}\right)$$

[6] blend-growth breakpoint =

$$150 \times \left(1 + \frac{\gamma}{3}\right)$$

Currently Morningstar sets $\gamma = 0.5$ so that a fund is considered to be value if Raw X < 125, growth if Raw X > 175, and blend if $125 \leq \text{Raw X} \leq 175$ (in contrast to core stocks, which have raw X scores between 100 and 200).

A fund's style box assignment is based on its raw X and Y coordinates.

Small	Raw Y < 100	Value	Raw X < 125
Mid-cap	$100 \leq \text{Raw Y} \leq 200$	Blend	$125 \leq \text{Raw X} \leq 175$
Large	$200 < \text{Raw Y}$	Growth	$175 < \text{Raw X}$

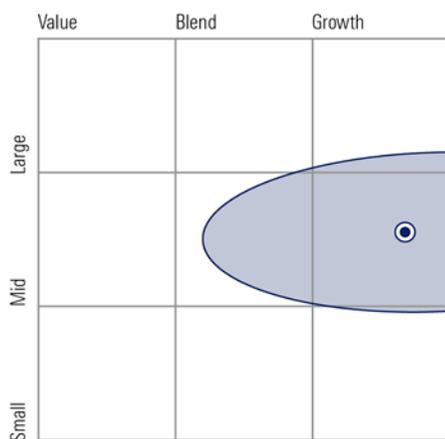
Note: See Rescaling section for the differences between raw X and Y and rescaled X and Y for funds.

Morningstar Ownership ZoneSM

The style and size scores for stocks and funds are the building blocks for the Morningstar Ownership ZoneSM. A portfolio's Ownership Zone is derived by plotting each stock in the fund's portfolio within the proprietary style box. The shaded area represents the center 75% of the fund's assets, and it provides an intuitive visual representation of the area of the market in which the fund invests. A "centroid" plot in the middle of the Ownership Zone represents the weighted average of all the fund's holdings.

The Ownership Zone can be illustrated on the familiar nine-square grid.

Exhibit 1 The Ownership Zone



Source: Morningstar.

The style box can also be expanded to a 25-square grid. This version of the Ownership Zone often includes individual plot points for each stock. This provides investors with more detail and allows them to better differentiate between giant-cap, micro-cap, deep-value, and high-growth stocks. The Ownership Zone helps investors visually evaluate the investment style of a fund or a portfolio. It can also be helpful for monitoring style drift, a fund's tendency to change its style over time.

Rescaling

In order to graphically distribute the X and Y coordinates evenly across the width and height of the style box grid, Morningstar established a system of rescaling for stocks and funds (see Appendix B for exact rules).

- ▶ Rescaling is for graphical presentation only. All in-house calculations (for example, fund style box, Morningstar Category™) use raw scores.
- ▶ Rescaling does not change the style assignment for a stock or fund.
- ▶ The same rescaling rules can be used for stocks and funds.

Each raw value for style and size (raw X and Y) is rescaled onto a grid that runs from negative 100 to 400 (rescaled X and Y). For example, during one month, the raw Y scores for stocks ranged from negative 555 to 397 (the smallest numbers represent the micro-cap universe). These Y scores were squeezed and stretched and redistributed between negative 100 and 400.

The breakpoints for the rescaled values are as follows:

Stock Scores

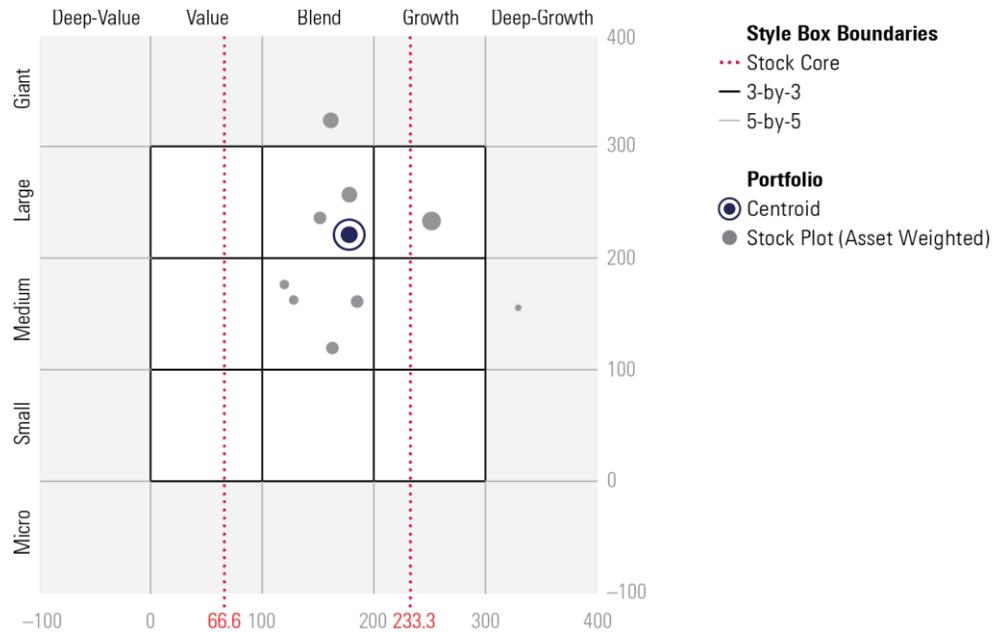
Small	Rescaled Y < 100	Value	Rescaled X < 67
Mid-cap	100 ≤ Rescaled Y ≤ 200	Core	67 ≤ Rescaled X ≤ 233
Large	200 < Raw Y	Growth	233 < Rescaled X

Fund Scores

Small	Rescaled Y < 100	Value	Rescaled X < 100
Mid-cap	100 ≤ Rescaled Y ≤ 200	Blend	100 ≤ Rescaled Y ≤ 200
Large	200 < Rescaled Y	Growth	200 < Rescaled X

The rescaled X and Y scores can be plotted on the style box. Each square of the grid represents 100 rescaled units.

Exhibit 2 Style Box Rescaled



Source: Morningstar.

As with the raw scores, the size of the center column for stocks (“core”) is wider than the center column for funds (“blend”).

Rescaling does not change the style assignment for a stock or a fund. Raw X scores of 100 and 200 (the raw boundaries for core stocks) get rescaled to 67 and 233, respectively. Raw X scores of 125 and 175 (the raw boundaries for blend funds) get rescaled to 100 and 200, respectively.

Conclusion

The Morningstar Style Box has become the industry standard for categorizing and tracking managed investment portfolios. It describes securities in terms of their relative size and value-growth orientation in an intuitive, visual tool. It is based on a robust methodology that includes forward-looking and historical components and 10 different factors to measure value-growth orientation.

Because different investment styles often offer different risk/reward patterns, it is important for individuals to understand the investment style of a stock, fund, or portfolio. This understanding can help investors and advisors construct portfolios that are consistent with the investor’s return expectations and risk tolerances.

The style box lays the groundwork for better portfolio assembly and monitoring and is a useful tool for individual and professional investors. It provides a logical, completely integrated system and philosophy for analyzing stocks, funds, and portfolios.

Appendix A: Z-Score-Based Data Trimming Algorithm

The following describes two processes related to calculating percentile scores for each of the 10 factors: 1) Test whether trimming should be applied to datasets for individual factors; 2) If so, determine what values to trim.

w'_i is calculated as follows:
$$w'_i = \frac{w_i}{\sum_{j \in \Omega} w_j}$$

We define the following statistics:

Weighted mean:
$$\mu = \sum_{i \in \Omega} w'_i x_i$$

Weighted standard deviation:

$$\sigma = \sqrt{\sum_{i \in \Omega} w'_i (x_i - \mu)^2}$$

Minimum and Maximum:
$$\begin{aligned} \text{Min}[x] &= \text{Min}\{x_i | i \in \Omega\} \\ \text{Max}[x] &= \text{Max}\{x_i | i \in \Omega\} \end{aligned}$$

where:

- N = the number of securities
- x_i = the variable in question for security i
- w_i = the weight on security i for the full set of N securities
- Ω = the set of securities that have not been trimmed
- $\bar{\Omega}$ = the set of securities that have been trimmed
- w'_i = the weight on security i for $\bar{\Omega}$

Weighted Median

To calculate the weighed median:

1. Sort the values of $x_i, i \in \Omega$ from lowest to highest. Let M = the number of elements of Ω . Let (m) denote the index for the m^{th} lowest value of x_i so that $x_{(1)} \leq x_{(2)} \leq \dots \leq x_{(M)}$.
2. Find the smallest value of m^* such that that $\sum_{m=1}^{m^*} w'_{(m)} \geq \frac{1}{2}$.
3. The median is $\text{Med } \text{Med}[x] = x_{(m^*)}$.

Weight in Untrimmed Set

$$p = \sum_{i \in \Omega} w_i$$

We set a threshold for p , $p^* = 0.95$

The Algorithm:

1. Set $\Omega = \{1, 2, \dots, N\}$ and $\bar{\Omega} = \emptyset$.
2. Calculate μ , σ , $Min[x]$, $Max[x]$, $Med[x]$, and p .
3. If $(Min[x] \geq \mu - 3\sigma$ and $Max[x] \leq \mu + 3\sigma)$ OR $p \leq p^*$, go to step 6.
4. For each $i \in \Omega$, if $x_i < Med[x] - 3\sigma$ or $x_i > Med[x] + 3\sigma$, move i from Ω to $\bar{\Omega}$.
5. Go to step 2.
6. For each $i \in \bar{\Omega}$, for replace any $x_i < Min[x]$ with $Min[x]$, and any $x_i > Max[x]$ with $Max[x]$.

Calculating the Score

Using the values of μ and σ from the final iteration of the algorithm, the score of each stock i is:

$$S_i = 50 \left(1 + \frac{x_i - \mu}{3\sigma} \right)$$

Appendix B: Rescaling Rules

In order to graphically distribute the raw X and Y coordinates evenly across the width and height of the style box grid, Morningstar established a system of rescaling for stocks and funds. The following rescaling rules are applied to the raw X and Y coordinates for both stocks and funds. Rescaling does not change the style assignment for a stock or fund.

Parameters for Y

There are different rules for rescaling Y scores, based on the style zone and size of each stock. First, six parameters must be defined for each style zone.

The four parameters y_0 , y_1 , y_2 , and y_3 are the raw Y scores for the smallest stocks in the small, mid-, large-, and giant-cap groups, respectively, for each style zone. The parameter y_{bot} defines the lower boundary of the micro-cap group (although it is not necessarily the raw Y score of the smallest stock in the micro-cap group). The parameter y_{top} defines the top boundary of the giant-cap group (although it is not necessarily the raw Y score of the largest stock in the giant-cap group).

First, determine y_0 and y_3 for each style zone. Then, calculate y_{bot} and y_{top} .

- y_0 = The raw Y score for the smallest stock that falls into the small-cap group. This is the raw Y score for the first stock that meets or exceeds the top 97% of cumulative market cap in each style zone. y_0 changes every month. See below for derivation.
- y_1 = This is always 100.
- y_2 = This is always 200.
- y_3 = The raw Y score for the smallest stock that falls into the giant-cap group. This is the raw Y score for the first stock that meets or exceeds the top 40% of cumulative market cap in each style zone. y_3 changes every month. See below for derivation.
- β_{micro} = The ratio of the slope of rescaled Y for small-cap stocks to the slope of rescaled Y for micro-cap stocks. Currently, this is set to 2 and does not change every month.
- y_{bot} = $y_0 - \beta_{\text{micro}} * (y_1 - y_0)$
- y_{top} = $2y_3 - y_2$

Finding y_0 and y_3

The most straightforward way to find y_0 and y_3 for each style zone is to insert the monthly market-cap breakpoints into the equation for raw Y:

$$[1] \quad \text{raw Y} = 100 \times \left[1 + \frac{\ln(\text{cap}) - \ln(\text{cap}_1)}{\ln(\text{cap}_2) - \ln(\text{cap}_1)} \right]$$

Exhibit 3 Example for the U.S.

	Breakpoint	\$USD million	ln	Raw Y	
cap3	between giant- and large-cap stocks	49,250	10.80	298	y_3
cap2	between large- and mid-cap stocks	8,435	9.04	200	y_2
cap1	between mid- and small-cap stocks	1,391	7.24	100	y_1
cap0	between small- and micro-cap stocks	361	5.89	25	y_0

Source: Morningstar.

For funds, use an average of the style zone values for y_0 , y_3 , y_{bot} , and y_{top} .

Rescaling Y

Once these six parameters are defined for each style zone, the raw y values can be rescaled according to the calculations below.

Raw Y	Rescaled Y
$\text{raw } Y < y_{\text{bot}}$	-100
$y_{\text{bot}} \leq \text{raw } Y \leq y_0$	$100 \times \left(\frac{y - y_0}{y_0 - y_{\text{bot}}} \right)$
$y_0 \leq \text{raw } Y \leq y_1$	$100 \times \left(\frac{y - y_0}{y_1 - y_0} \right)$
$y_1 \leq \text{raw } Y \leq y_2$	$100 \times \left(1 + \frac{y - y_1}{y_2 - y_1} \right)$
$y_2 \leq \text{raw } Y \leq y_{\text{top}}$	$100 \times \left(2 + \frac{y - y_2}{y_3 - y_2} \right)$
$y_{\text{top}} < \text{raw } Y$	400

Limited Rescaled Scores to the 9-Square Style Box

The nine-square style box grid is scaled from 0 to 300. When stocks or funds are displayed on this grid, any rescaled X or Y values that are below 0 or above 300 should be trimmed to 0 and 300, respectively.

Appendix C: Major Countries in Each Style Zone

Exhibit 4 Major Economies Map to the Seven Style Zones

United States	United States			
Latin America	Argentina	Mexico		
	Brazil	Peru		
	Chile	Venezuela		
	Colombia			
Canada	Canada			
Europe	Austria	France	Luxembourg	Slovakia
	Belgium	Germany	Macedonia	Slovenia
	Croatia	Greece	Netherlands	Spain
	Cyprus	Hungary	Norway	Sweden
	Czech Republic	Ireland	Poland	Switzerland
	Denmark	Italy	Portugal	Turkey
	Estonia	Latvia	Romania	United Kingdom
	Finland	Lithuania	Russia	

African stocks are scored with the European stocks. They represent only 2% of the total capitalization of the style zone.

Japan	Japan			
Asia ex Japan	Bahrain	Israel	Pakistan	Taiwan
	China	Jordan	Philippines	Thailand
	Hong Kong	Kuwait	Singapore	
	India	Lebanon	South Korea	
	Indonesia	Malaysia	Sri Lanka	
Australia/NZ	Australia			
	New Zealand			

Source: Morningstar.

Appendix D: Long-Term Style Trend: The Morningstar Category™

While the Morningstar Style Box represents a snapshot in time for a fund or portfolio, Morningstar also performs holdings-based analysis of long-term style trends. The Morningstar Category™ reflects the primary investment focus of the portfolio over the past three years. Categories for equity funds can be based on style, country/regional exposure (for example, Japan stock), or economic sector focus (for example, specialty technology).

In the U.S., Morningstar uses 14 style-based categories. Nine of these categories are for diversified U.S. equity funds, and the category names correspond to the nine squares of the style box (large-value, mid-blend, and so on). The remaining five style-based categories are used for diversified non-U.S. equity funds (foreign large-value, foreign small/mid-growth, and so on). Some of Morningstar's international operations also classify funds based on style.

Morningstar reviews category assignments semiannually, incorporating all portfolio data over the prior three years up through the most recent quarter-end. The process is partially quantitative: A program calculates the three-year averages for various statistics and makes a recommendation about the appropriate category for the portfolio. The process is also qualitative: Morningstar's fund analyst team will review the suggestions from the quantitative program and, based on the analysts' unique knowledge of the funds, will make a recommendation about whether the changes should be overruled or upheld. These results are then communicated to the fund company.

Funds are assigned to style-based categories based on their three-year average raw X and raw Y scores. The three-year average is the simple average of three 12-month averages, using the portfolio files that were received over that period.

An example of the three-year average calculation is below:

Exhibit 5 Example of The Three-year Average Calculation

Year 1 (April 2003-March 2004)			Year 2 (April 2002-March 2003)			Year 3 (April 2001-March 2002)		
Date	Raw X	Raw Y	Date	Raw X	Raw Y	Date	Raw X	Raw Y
5/31/03	105	297	6/30/02	110	296	5/31/01	106	295
7/31/03	116	290	9/30/02	118	289	9/30/01	111	287
9/30/03	132	284	12/31/02	117	295	12/31/01	121	279
1/31/04	134	286	—	—	—	3/31/02	124	286
Average	122	289	Average	115	293	Average	116	287

Source: Morningstar.

Three-year average raw X = $(122 + 115 + 116)/3 = 117$

Three-year average raw Y = $(289 + 293 + 287)/3 = 290$

Style-specific category assignments are based on the fund's three-year average raw X and raw Y scores, using the same raw breakpoints for value, blend, and growth that are used for the fund style box.

Small	Raw Y < 100	Value	Raw X < 125
Mid-cap	100 ≤	Blend	125 ≤ Raw X ≤ 175
Large	200 <	Growth	175 < Raw X

When there are fewer funds in certain investment styles, Morningstar may support only two categories across the value-growth spectrum. For example, in the U.S., there are two categories for smaller foreign style funds: foreign small/mid-value and foreign small/mid-growth. In these cases, funds with three-year average raw X scores < 150 are placed in the value category, and funds with three-year average raw X scores \geq 150 are placed in the growth category.

Some Morningstar operations may use some discretion or buffering mechanisms during the category review process. These methods ensure that a fund does not undergo a category change unless it has exhibited a strong and sustained shift into a new investment style. That is, a fund may not necessarily experience a category change if the three-year average has landed just over a breakpoint by a small amount. (These buffering mechanisms are for category placement only and do not apply to style box assignments.) 